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INTERNATIONAL RESEARCH CONFERENCE

13TH INTERNATIONAL RESEARCH CONFERENCE

HOLISTIC APPROACH TO NATIONAL GROWTH AND SECURITY

15TH - 16TH OCTOBER 2020

Built Environment and Spatial Sciences

PROCEEDINGS

General Sir John Kotelawala Defence University

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BUILT ENVIRONMENT AND SPATIAL SCIENCES

PROCEEDINGS

General Sir John Kotelawala Defence University

Ratmalana, Sri Lanka

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Welcome Address

Major General Milinda Peiris RWP RSP USP ndc psc

Vice Chancellor, General Sir John Kotelawala Defence University

Honurable Minister of Education, Professor G L Peiris, the Chief Guest , Keynote Speaker, Secretary to the Ministry of Education, Professor Kpila Perera, Secretary to the Ministry of Foreign Affairs, Admiral Prof. Jayanath Colombage, Deputy Vice Chancellor (Def & Admin) Brig. Nanda Hathurusinghe, Deputy Vice Chancellor (Academic) Prof. Jayantha Ariyarathne, Deans of the respective Faculties, Directors of Centres, Academics, Senior Military Officers, Administrative Staff, Students and all distinguished guests who are connected with us in the cyber space.

First and foremost, let me very warmly welcome our chief guest, Hon Professor GL Peiris, Minister of Education for very kindly accepting our invitation and for gracing this occasion as the chief guest of this inaugural session of our international research conference 2020.

Sir, we consider your presence here this morning, as one of the most renowned scholars the country has ever produced in the field of Law, as a great honour to KDU. Let me also warmly welcome our keynote speaker, Prof Kapila Perera, Secretary to the Ministry of Education, who is having a very close affinity with KDU as an illustrious member of our alumni association.

Then I also welcome Admiral Professor Jayanath Colombage, Secretary to the Ministry of Foreign Affairs, and other distinguished guests and invitees participating on line as well. KDU, from its inception, was instrumental in handing down the core values of security to the development paradigm in Sri Lanka.

This year's theme 'Holistic Approach to National Growth and Security" highlights the importance of maintaining a harmonious blend in security and development in all national projects. As you are aware, this year's conference is taking place amidst very challenging circumstances, so much so that, it becomes a landmark event of KDU in terms of its resolution to ensure the continuity of events at KDU even under the most trying circumstances. And this conference is also significant because the year 2020 marks 40 years of existence of KDU since its inception in 1980.

KDU, initially established as a tri-service academy known then as KDA or Kotelawala Defence Academy, marked a significant diversion in 2008 with its renaming as General Sir John Kotelawala Defence University. Since then, with the guidance and vision of His Excellency the President Gotabaya Rajapakse, as the then Secretary to the Ministry of Defence and the Chairman of our Board of Management, KDU kept a giant leap forward to become a fully-fledged university with nine academic faculties and a University Hospital with state-of-the-art facilities. With this phenomenal change, KDU began expanding its horizon to provide its high-quality higher educational opportunities to civilian students, thereby reducing the burden on other state universities of the country in supplying for the higher educational demand in the country. Today, the University is ready to march forward steadfastly contributing to the national needs combining the national security domain with higher educational needs of the country.

Ladies and gentlemen, KDU international research conference has been attracting local and foreign presenters, participants and more importantly renowned scholars and professionals of the highest caliber both locally and internationally. However, in this year, the global pandemic situation has restricted having them physically present at KDU. But many of our invitees will join us on line to enrich the deliberations through this novel experience of having the conference on a virtual platform.

I reckon that this is a blessing in disguise for us to travel on untrodden paths for new discoveries. KDU IRC has been instrumental in establishing and strengthening the much needed research culture not only at KDU but also in the whole country.

We have been attracting papers from almost all universities, from many research institutions and other organizations representing even Batticaloa and Jaffna, which I reckon is a very encouraging sign. And the impact of the growing research culture was evident during the first breakout of Covid 19 earlier this year, where our staff and students were researching day and night for creating various products and inventions of our own to help the fight against Corona. So, it is heartening to note that in this year's conference, there are many research papers reaching the conference secretariat, which involve the student community of our nine faculties.

Therefore, we are proud that we have created a platform for emerging researchers and scientists for showcasing their research outcomes at KDU research conference. And it is our fervent belief that inculcating and fostering the research culture and enhancing the quality and quantity of research in various disciplines in the country can raise the resilience levels of society and the nation as a whole.

This year's conference has attracted six hundred and fifty plus paper submissions, which I believe is a very clear indication of the right enthusiasm growing in the country towards research, particularly in development and security domains. So we are proud as a university to be able to stand up resolutely to fulfill the needs of the nation, especially at a time when such efforts are very much needed. I believe the efforts of security-based education aiming at strengthening national development should be more cooperative in the future and KDU has always facilitated any research efforts that strengthens the national security of our nation. We urge the academic community of Sri Lanka to join hands with us in all our future endeavours to support the nation especially through productive research in diverse disciplines.

The organizers of the KDU international research conference intend to set the tone to initiate more collaborative research at national and global levels. This research conference is an ideal platform to make connections. I hope that authors of KDU and various other local and international universities will take the opportunity to interact and develop friendly relationships, establish networks and to explore win-win situations.

I wish all the very best for the presenters and hope you will enjoy every moment of this academic fusion taking place on two whole days.

Finally, let me once again welcome our chief guest and the keynote speaker on behalf of all KDU staff. I wish that presenters and participants would have all the courage to continue their pursuits with determination to link up with the international community and work towards national growth and development through their research.

Thank you.

Chief Guest Speech

Prof. GL Peiris

Honourable Minister of Education, Government of Sri Lanka

Major General Milinda Peiris, Vice Chanceller of the Sir John Kotelawala Defence University of Sri Lanka, Admiral Professor Jayanath Colombage, Secretary to the Ministry of Foreign Affairs, Professor Kapila Perera, Secretary to the Ministry of Education, Deputy Vice Chancellors, Deans of Faculties, Heads of Department, members of the staff and students of this university, friends well wishers, ladies and gentlemen. I am delighted to be present with you on this occasion for the 13th International Research Conference. I am no stranger to these surroundings. I have been consistently associated with your work during the progress of your university until you have reached the stature that we all are proud of at this time. There is no doubt that with the nine fully-fledged faculties that you already have and your plans further to expand this university particularly bearing in mind the priorities of this country at this moment. I am particularly happy about your plans for the establishment of a Faculty of Criminal Justice. I think that is certainly an area that is worthy of focus and attention. So you have always assessed, evaluated very accurately the needs and priorities of our country in the field of Higher Education. And you have been very quick to respond to those needs. That innovative approach is much to be admired. And these are among the reasons why I have particular pleasure in joining you in these deliberations. There is one another matter that I would like to mention. It is this that you are having this conference for the 13th consecutive time. It is our experience in this country that many good things are planned and inaugurated. It is much more difficult to follow through. So the fact that you have been able to do this without interruptions for 13 years adding to your expertise as you go alone improving and expanding towards what you are attempting. It is greatly to be admired the sense of perseverance and determination that is greatly required in this country at this moment and your performance is an inspiring example of what we all need to carry the country forward to even greater heights.

Now the theme that you have chosen for this 13th International Conference is extremely appropriate from many points of view. You have heard representation from many countries as Major General Milinda Peiris, Vice Chancellor explained a moment ago. You are holding this conference in exceedingly challenging circumstances. Again you have been to adapt to difficult circumstances.You are resorting to modern technology to include and involve foreign participants in these deliberations even though they are unable to present with us physically on this occasion. The topic that you have chosen is the holistic approach to national growth and security. I think that is extremely relevant to present day needs in Sri Lanka today.

The first point I would like to make is that there is an intimate connection between national growth and security. It is fanciful to talk of any kind of national growth without the assurance of security. Security is a necessary and indispensable foundation. Without security it is impossible to achieve growth in any sector of the economy. The celebrated Political Scientist the late Professor Harold Laski of the London School of Economics said that the basic duty of a state is to provide security for its people. That is the ultimate reason for the existence of the nation state. The theory of the Social

Contract which has been developed by writers like Lock and Rousseau emphasizes the fact that the public have given the authority to state principally for the reason to create conditions in which life can go on in an orderly and frank manner so that the citizens of that state can realize their fullest potential as human beings, develop themselves and develop the community in which they live. In order to do this the essential condition is security. Without it nothing at all can be accomplished. Now we have seen empirical evidence of this in the recent past of our country through the 30-year conflict with the Liberation Tigers of Tamil Eelam. It was impossible to attract substantial investment into this country. Every facet of Sri Lanka's economy suffered grievously during that period. How can you attract investors into a country which has been thrown asunder by a ferocious war? Investment, international trade all this was affected by the ongoing conflict. I would also like to make a reference to the concept of reconciliation which became very relevant and important after the end of the war in 2009. There was then naturally the feeling that we have to leave the pain and anguish of the war behind us. We have to emphasize unity and the solidarity and bring together all the people of our cherished land irrespective of caste, creed, ethnic or religious identity to emphasize the oneness of the nation. That was the pith and substance of the concept of reconciliation. But it all went wrong during the *Yahapalana* administration of 2015 to 2019. And it is worth examining in an objective spirit the reasons why that endeavour failed so miserably. I think the basic reason is that the authorities at that time forgot the sentiments, the feelings and aspirations of the majority community. Reconciliation of course bases emphasis on minority aspirations to make them comfortable, to convey to them in definite terms the impression, the conviction that they are very much part of the country. They belong, the sense of belonging so that confidence should be imparted to minorities, and at the same time, it is absolutely necessary to carry the majority community with you. If you lead them behind if you engender in the lines of the majority community that they are not important, they can be sidelined, they do not matter, such an exercise in reconciliation is doomed to failure as empirical experience in those 4 years convincingly demonstrated. What happened during that period? I think the most alarming spectacle that we are seeing in this country today is evidence that is transpiring in daily basis before the Presidential Commission that is going into the catastrophic phenomenon of the Easter Sunday Attack. Evidence has been given by one witness after another, the Inspector General of Police, the Secretary to President, the Secretary of Defence, all these people. Their evidence emphasizes the total breakdown of this security apparatus in the country. It is not mere debilitation or weakening of security apparatus it was total collapse of it. There was no security apparatus functioning in this country at all in any realistic sense. So it led to the loss of 265 valuable lives of this country and crippling of many other citizens of our land. Why did this happen?

When the present President, His Excellency Gotabaya Rajapaksa was Secretary to the Ministry of Defense, there was a very close collaboration between the intelligence arm and immigration. Whenever an application was made by a foreign preacher somebody who wants to come and teach in this country, when visa was requested a very thorough background check was done. As Admiral Professor Jayanath Colombage would bear witness the antecedent of the person applying for the visa was thoroughly examined. And if there was anything unsavory in the past of that person, if he has been involved in any activity which led to

disharmony among communities, then the immigration authority in close consultation with the intelligence arm would turn down such a request for visa in this country. That whole apparatus was consciously and deliberately dismantled. It did not happen unwittingly or inadvertently. It was deliberate government policy. So intelligence personnel were made to feel that they were in embarrassment. The less that heard from them, the less they were seen the better. That was the environment which prevailed at that time.

Surely, if you are talking of national growth and security, the first thing to ensure is that funds that are coming from abroad had to be brought into the country through proper channels. We have in this country such an established conduit. The conduit is the External Resources Department of the Central Bank of Sri Lanka. Of course resources are welcome. But they must come through the External Resources Department. We must know the source, the origin of these fundsand where are these funds coming from? We must know the purpose for which these resources are going to be applied, who is going to manage these resources? There must be an auditor accounts. All of these were dispensed. You had a situation where a university was built. What is the purpose for a university to come up in Kattankudy. The facilities, the buildings that are constructed, they are better than the buildings that you have here at the Kotelawala Defence University. They are superior to the quality of the infrastructure in the universities of Colombo and Peradeniya. If you go to Kattankudy blindfolded if the blindfold is taken off when you get there, you will feel that you were in the Middle East. The Palmyra trees, the architecture the overall environment. The sums of money involved are colossal. There is no exposure, visibility or accountability. It is that brought about a situation that culminated in the total collapse of this security establishment. Madrasas can be all over the country. There are no Sunday Schools. They are providing many of them on daily basis. Nobody examines the curricula. There is no regulatory mechanism at all. So the seeds of racial hatred are sown by those institutions. Of course there must be freedom with regard to imparting instruction. But clearly there must be some supervision, some control, some regulation. That was totally lacking. So the country then paid the supreme price for the neglect of security in pursuit of narrow and particent and political objectives to placate aggressive minorities, not law abiding members of minority communities, but people who were intent on the destruction of the very social fabric of the country. So that was our sad experience.

This is true not only within the country, but also in the conduct of our foreign relations. What happened there? Sri Lanka is unique among the nations of this world in committing to a resolution in 2015 in the UN Human Rights Council. Sri Lanka became a co-sponsor of a resolution in condemning its own armed forces accusing its armed forces of the gravest crimes under international law and under the international humanitarian law because the preamble to resolution 13/1 of the 1st of September 2015 acknowledged with appreciation the report of the High Commissioner for Human Rights. And the High Commissioner's report makes the most damaging allegations against the armed forces of this country. And the government of Sri Lanka endorsed all of them and called for a thorough investigation at the international level. The resolution gave responsibility to the Human Rights Council and to the Commissioner for Human Rights to keep Sri Lanka under constant review. So here was a government which consciously, voluntarily, deliberately submitted the country to adjudication and assessment in respect of its armed forces to international tribunals

where justice considered the inanity of what happened. There were pledges given. In resolution 13/1 and 34/1 which are clearly contrary to the highest law of this country, the constitution of Sri Lanka operating para 6 of the first resolution 13/1 recommended that foreign judges of Commonwealth and other foreign judges should be entrusted with the task of judging our armed forces and of course, members of the civilian population. This is not possible under Sri Lanka's constitution because foreigners cannot exercise judicial power in respect of our citizens. And then the High Commissioner for Human Rights, Prince Hussein publicly conceded that in respect no other country has a Human Rights Council based in Geneva adopted so intrusive approach – so intrusive, interfering directly with domestic policy in that country. To what extent did this go? The resolutions involved matters which are clearly within the domain of the Sri Lanka's parliament not the business of foreigners. It called for constitutional reform. It called for devolution of greater powers to provincial councils. It called for thorough overhaul of Sri Lanka's armed forces and the police. It called for the repeal of the prevention of terrorism Act and its replacement by alternative legislation. Members of the Sri Lankan armed forces and the Sri Lankan police force were to be subjected to special criteria when they applied to join UN Peacekeeping forces abroad and even to enroll for programmes of training. So this is the extent to which national dignity and pride was compromised in order to placate foreign interests whose aims and objectives were incompatible with the well-being of this nation.

So this attitude which destroyed the very foundations of our national security manifested itself both in respect to domestic policy and the conduct of country's foreign relations during that period 2015 to 2019. In such a situation you cannot possibly have national growth. You cannot have economic advancement because security has broken down entirely.

Just one another point I want to make before I conclude, and that is the reference to militarization in the current political discourse. Non-governmental organizations and elements of the opposition as well as some prejudiced and biased foreign commentators are finding fault with the role of the military in the conduct of national affairs in Sri Lanka at this time. But no objective observer of the Sri Lankan scene can doubt the fact. When it came to the control of COVID-19, this country could not possibly have achieved what it did without the vigorous involvement and cooperation of the armed forces, particularly the intelligence arm. We were able to control the pandemic because the armed forces were able to identify those who have been infected, first the immediate circle and then the outer periphery. That is still being done, yesterday today it is being done. And the role of the armed forces is indispensable. Without them the situation would be far worse than it is. Why is there this kind of hostile attitude towards armed forces? I think people who subscribe to that point of view failed to distinguish between the culture of east and west in this regard. Cultural attitudes, assumptions and values are in critical significance in this area. The attitude in this country, the attitude of the public, of ordinary people, to the armed forces is not what prevails in some western countries. The armed forces are not looked upon with fear. They are not regarded as instruments of oppression. On the contrary, after the war ended in 2009, it is in effect the armed forces, they got involved very intimately, very vigorously in uplifting the social conditions in the people affected in areas. They built houses. They made water available. They played a role in restoration of agriculture. And I know personally because I have seen in

my own eyes that armed forces of this country even helped in the constructions of latrines, of toilets in that part of the country. These are not regular functions of the armed forces. But because of the culture of our country the social morals the value system based upon empathy and compassion which is the hallmark of Sri Lanka's culture. That was the nature of the role that was performed by the Sri Lankan military. It is this fundamental fact that is not taken into account. In critiques of the present scene who find fault with the armed forces forget their involvement in national activity on broader scale.

So these are some of the remarks that I would like to make to you on this occasion. I am very happy that you are having this 13th International Research Conference. I am very happy that you have chosen a topic that is extremely appropriate. You have chosen a more relevant topic for this time. As the Minister of Education also with the responsibility for higher education in this country, I am very proud of the achievements of your institution, what you have been able to accomplish within so brief a time span. The needs of higher education in this country are very urgent when more people are clammaering for access to higher education, in our ministry, with the active system of Professor Kapila Perera who is rendering a yeoman service in that regard, we are trying to bridge the gap between education and employment opportunity. We are talking to the major Chambers of Commerce they provide the jobs in the private sector to ascertain from them the employment opportunities that will be available in their institutions during next three or four years, what are the skills which we are looking for? Because they are telling me it is not that we do not have jobs to offer. We have jobs. But when we interview people we find that they don't have the skills which we want in our institutions. So we don't want to enhance a reservoir of angry and frustrated young people. We want to ensure that there is a co-relation between the education that is imparted in our institutions and the skills for which there is an identifiable demand in the market place. So these are some of the adventures that we have embarked upon. We are also looking critically at our curricula which are obsolete and anachronistic. They have not been revisited for a very long period. There must be in line with the needs of our society methods of teaching. There is far too much emphasis on rote learning in memory that students have required to commit their notes to memory, retain in the memory and reproduce it at the examination that is antithetic of the education. Education comes from Latin words '*educate*' which is draw out not to force in vast volume of actual material into mind of the students. So purpose of the education is to develop the analytical and the critical faculty of the student to encourage him or her to think for himself or herself and apply that volume of knowledge to face the challenges of life. So in the midst of all of this, in confronting the formidable challenges, I am very confident that your institution, Sir John Kotelawala Defence University will render an invaluable service. So I congratulate to you on your achievements of the past and I wish you well for the future. I know that you will continue to do your country proud. And I thank you sincerely for the honour that you have bestowed upon me by inviting me as the Chief Guest for these deliberations.

Thank you

Keynote Speech

Prof. Kapila Perera

Secretary, Ministry of Education, Government of Sri Lanka

Ayubowan! Wanakkam! Assalamu Alaikum! The Vice Chancellor of General Sir John Kotelawala Defence University, Major General Milinda Peiris, the Chief Guest today my honorable Minister, Ministry of Education, honorable Professor G.L. Peiris, Deputy Vice Chancellors, Deans of the Faculties, Heads of the departments, the Secretary to the Ministry of Foreign Affairs, Professor Admiral Jayanath Colombage, all the foreign participants who are joining this 13th International Research Conference at KDU, all the presenters, moderators, session chairs and all the distinguished invitees. Thank you very much for inviting me to deliver the Keynote Speech under the theme 'Holistic Approach to National Growth and Security.' I am indeed honored and privileged to be here having witnessed the very first one 13 years ago, and it happened to be General Milinda Peiris who was the Vice Chancellor then as Major General and we witnessed the presence of the Chief Guest as the Ministry of Higher Education, Ministry of Research and Technology.

I would like to start with this quote from the Chief Guest, "We do not want to have a reservoir of angry uncontented people." I was one who had gone through in 1971, of course not in the country in 1988 -1989 and then in then 1983 as a university student, and many times during my academic career where there were disruptions to education, holding back the desire to fulfill or acquire knowledge with my colleagues, peers and the rest of the people due to the lack of security. I know how I felt then as a student. I think I was in grade 4 in 1971, and then in 1983 in my second year at this very same premises, the education of ours were disrupted. And the feeling of those delays due to the lack of security, and the Cheif Guest elaborated in deep sense of comprehension how security is important for the national growth. If I look at what is this traditional approach that is often based on defensive security policies as we had during my time at different ages. We had always defensive security policies. However, the persistence of strong security measures generates inecure feelings. I hope you agree with me. If there are strong security measures that generate insecure feeling as it reveals the presence of threats. So these are some of the things that people quote. Then again the democracy, well-being and freedom are some of the elements that we feel that we reduce this feeling of insecurity by reducing both threats and activities that we feel. Even if you take a house if you feel this insecureness due to lack of security this might not allow you to think, generate analytical skills. You are always worried about the security. How to provide security to your children and for yourself? And then it hinders and it slows down entire process of nurturing, acquiring knowledge. And then that it is halting the growth. so you start from the small households or individuals then if you take as a whole family, a village, a township and then provinces as a country, it basically retards the national growth. So, therefore, we need to have this thinking of holistic approach to national growth and as you and I understand there are necessary and essential conditions when we learn mathematics for certain things. The Cheif Guest emphasized repeatedly the essential elements and in our academic mathematics there are sufficient and necessary conditions or essential conditions for forming mathematical theories there are certain

things. Likewise, it is essential to have security for national growth.

When it comes to economics, always and even for decades, the GDP strongly criticizes the measure of development. Still the role of economic systems neglecting the goal of global capabilities and expansion holds this economic growth or national growth. But the concession of development based on the glorification of individual success and the pushed capital accumulation hardly allows reducing insecurity and increasing freedom. So security becomes an individual good and relies upon ineffective defensive policies that we have practiced in the past unlike in the present. So development, well-being, security and freedom are strictly interrelated. Individual capabilities imply collective capabilities. Even in free market economies often human needs such as food, housing, employment, health care, family policies, fresh water, security and safety can be put in a market under regulation or collective governance, and those things even the Chief Guest highlighted. The need for water, need for food, how the security-- food security and water security ensure the getting this national security when you combine all these types of security the national growth under war conditions. So these goods are often under political debate as they are critical for development and social cohesion. The more they are shared among the large part of the population the less we experience social conflict and political instability. Security hardly is achievable individually. It is the result of more holistic thinking. Individual security and freedom implies the security and freedom of all. As I mentioned before these are interrelated. And if you look at or if you study research and in future research all these studies can help in understanding human capabilities and pathways towards collective security and enhance development. So instances of participation in definition of security needs would make citizens able to feel at the center of development goals. So therefore, unlike in the past where we did not think holistically and the interrelations between the security and the national growth. Then we will fail. Even the theories in the literature highlights this one.

As far as Sri Lanka is concerned the contemporary security concerns that we face as an Indian Ocean country are broader and more complex, that need not be elaborated, than any state in our history. This will continue to exist. We can't say that this will stop today, tomorrow, next year or in ten years' time because the geopolitics and the race for the arms business and economic development, all these things will continue to grow, sometimes exponentialy. So therefore, national security cannot be neglected and cannot be just let it go as the Cheif Guest mentioned, even in a fraction of a second, it is very important. Otherwise there won't be any growth. As the Secretary to the Education, in the present context the role played by ensuring a secure environment for the student to go and sit the examination. They are not in a position to concentrate on answering the questions if the place is not secure. So if we are not able to hold the exams and continue to postpone, then we cannot achieve and we cannot predict national growth. So in this context the role played by the national security is to be commended as the Ministry of Education. I know personally the quick response to ensure secure examination centers for all of us for the future of Sri Lanka. Under these conditions even the identification of COVID origin in the recent past, you have to have peace of mind to concentrate on everything. That is basically if you only think of one place, one center out of 2,646 examination centers, then there will be lack of security in different centers. So therefore, you have to think holistically. Only the one aspect of securing

one place will not enable for us to continue this one and therefore the results will come in future in terms of national growth. So the range that concerns arise from threats to system that allows society to control intergroup and interpersonal conflict to more recently reorganized concerns associated with threats to social and economic systems. Once these events start to influence the policy and the economy of a country with a national resilience, that country will perish. One way of addressing this emerging situation is by promoting more and more research and development.

KDU, boasting with diverse nine faculties and through two new faculties to come, the Faculty of Criminal Law and the Faculty of Technology, is going to expand and provide opportunities and platforms for you to think, ponder in a military environment and inviting day-scholars giving the signal that is very important for you to mix each other understand the role of the military or security for the civilians, 22 million people in this country, how important the national security and the training in a military set up to achieve the common goal of national growth. So the KDU is at the forefront of researching the development and security related problems holistically. A holistic approach is needed to understand contemporary complex situations and circumstances. University education could inculcate co-values of security and development such as human dignity, integrity, democratic participation, sustainable development, economic equity, mutual understanding and respect and equality of opportunity. The three flags that are behind bring all three forces together, thanks to the KDA then, and how important this mutual understanding in the war was understood and it helped to coordinate things in a better manner. You trained officer cadets together and they understand the security roles in the air, at sea, on land. I am sure that it could have been the catalyst then. Now you bring the third aspect the day-scholars. So this is holistic thinking. Like I started at the beginning it was not there then. We had three academies that did not know each other, but how had it come during the time when the national security was at risk. So ultimately the beneficiary is national growth. The honorable Minister, the Cheif Guest mentioned how difficult it was for Sri Lanka to attract foreign direct investments. As I think Minister of Enterprise Development, Foreign Minister, Foreign Secretary. If you don't have security and thrust, nobody would come. But when you train together military and civilians with hand and hand, it would provide an ideal platform. The importance of civil-military relations and how KDU is instrumental in developing the above mentioned areas is to be commended. By promoting civil-military relations through education, a country could raise the resilience levels, like I mentioned, of communities. Honorable Minister spoke at length and elaborated that you have to have a strong commitment and the political will to ensure the security of this country. If these elements, instruments fail, the first thing that is going to effect is the education of the future generations. Even for me, the Oxford graduate, Rohdes scholar, I am a pupil. And this has provided opportunities and the responsibility to the government to ensure the security. So all spheres of activity will simultaneously grow ultimately culminating in national growth.

These are the few thoughts that I have to share with you. I would like to extend my gratitude on behalf of the Ministry of Education for having me and inviting me to deliver the Keynote address and set the platform for the next two day deliberations. And I wish all the success in the deliberations and creating more networks and have future directions for years to come in this context of national security that you have chosen today.

Whatever that you are going to do, base national security at the forefront. So divided we lose together we win. And I wish all the very best and thank you very much for all the participants and the people who have submitted papers, presenters, moderators, and session chairs. You are plying a very important role in this context of national security and the national growth.

Thank you very much!

Vote of Thanks

Dr. L Pradeep Kalansooriya

Conference Chair, 13th International Research Conference,
General Sir John Kotelawala Defence University

It is with deep appreciation and gratitude that I present this vote of thanks on behalf of the organizing committee of the 13th International Research Conference of the General Sir John Kotelawala Defence University.

First of all, I convey my heartiest thanks to Professor G.L. Peiris the Minister of Education, a distinguished academic who spared his valuable time with us on this occasion. Sir, your gracious presence amidst busy schedules is truly an encouragement and it certainly added the glamour and value to this important event.

Professor Kapila Perera, the Secretary to the ministry of Education, also a distinguishable academic and a senior military officer is a proud product from our own institute. Sir, I greatly appreciate your willingness without any hesitation to be our Keynote speaker today.

I would also like to take this opportunity to extend my appreciation and gratitude to the Vice Chancellor, Maj. General Milinda Peiris for all his guidance and assistance provided throughout the event and this event wouldn't have been a reality and a great success without your courageous leadership under the current challenging situation today.

I would be falling my duties if I don't mention the exceptional support and assistance provided by the two Deputy Vice Chancellors who were there behind the team guiding us through a difficult time. I also would like to thank the Deans of all the faculties who shared the responsibilities and guided their staff amidst their very busy schedules.

This year's conference has attracted six hundred and fifty plus paper submissions, which is a very clear indication of the right enthusiasm growing in the country towards research, particularly in development and security domains. I take this opportunity to thanks all authors share their studies on National Growth and Security in our conference. I also greatly appreciate our panel of reviewers on the valuable time spent to review this large number of papers. I'm sure that your valuable resnses would tremendeously supports to authors on enhancing their research studies.

Ladies and Gentlemen, as you witnessed, this was a new experience in the new normal, after the present pandemic, and therefore it was huge challenge to organize, coordinate and conduct research conference of this magnitude on virtual platform enabling a wider participation of both local and foreign participants. I thank all our participants attending the conference online despite numerous difficulties encountered due to the present situation.

Further, it is with great pleasure that I acknowledge the tremendous support and assistance provided by academic staff of all the faculties with all the Heads of Departments going beyond their regular duties to make this event a success. Similarly, I take this opportunity to appreciate the contribution of the administrative and non-academic staff whose commitment was essentially required in achieving the overall success.

Our sponsors, the financial support given by our Platinum Sponsors, People's Bank and

Bank of Ceylon and Co-sponsor, Abans Private Limited is highly appreciated.

Last but not least the officer cadets and day scholars who formed a very virtual component of the organizing teams in every sphere and I believe that it was a great learning experience and exposure which would help them tremendously in similar undertakings in the future.

Finally, I have no doubt that all of those attending the two days seminar will make the best use of the opportunity to enhance their horizons and establish new bonds and networking while sharing their own knowledge and experience in a friendly learning environment.

In conclusion, let me take this opportunity to profusely thank my co secretaries, who stood alongside me throughout extending unexplainable support and assistance with exceptional commitment.

Thank you so much. I wish you good luck and all the best.

A Study on Conflict Management Styles for Decision Making in Sri Lankan Construction Projects

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Abstract*:* Traditional project managers believe that the conflicts among project stakeholders are a threat to project deliverables. This is because the traditional project managers believe that the conflicts may bring negative results for the project management success. Though the modern project managers believe that a sustainable decision-making process can assist to achieve the overall project success. In this study the data collected through a questionnaire survey. Final conclusion for the research objectives was achieved by analyzing the collected data from 68 respondents. This research was investigated based on different kinds of approaches and methods when dealing with conflicts with all the counter parts. Further, the research was focused on studying the project conflict management styles which assisted for better decision making for all major stakeholders of organization structure. Stakeholders of Sri Lankan construction projects mostly adopt active strategies to resolve the project conflicts. Further, the project conflict approach is problem solving but without bargain. Hence, most of the stakeholders actively participate to resolve the conflict while more are concerned about the fulfillment of the needs of counterparts. When considering the gender roles in adopting approaches, females have a tendency to adopt a slightly more positive approach than males. Additionally, males adopt the same conflict management approach for every management level; whereas conflict management approach used by females differ according to the counterpart managerial level.

Keywords*: Project Conflict, Conflict Management Approaches & Styles, Decision Making*

Conflict & Conflict Management

In present, the organizations mostly depend on the project teams & their team performance. (DeChurch & Marks, 2001). Further, Boddy (2002, p.108) defined a project team as a temporary multiple organization which consists of two or more members whose having different backgrounds, knowledge levels, responsibilities & objectives. This may lead to possible conflicts due to the group members having different perspectives about tasks & their outputs. As Rahim (2001, p 18) defines the project conflict is a process that the opposing interests or beliefs between individuals or groups which develops through the existing relationships between individuals or groups actions by one or both sides discomforting of others' goals.

The traditional Project Manager considers that the conflicts are barriers when making decisions in organizations (March & Simon 1958). When it comes to modern project management, project managers believe that the project conflicts are one of the sources of information, that provides additional insight regarding how to achieve the best solution to satisfy the requirements of all the stakeholders (Singh & Vlatas,1991). Hughes, Ginnett and Curphy (2009) mentioned that conflicts have several positive effects & negative effects. Further, they explained that the project managers must reduce the negative effects of project conflicts such as reduction in productivity, polarization, decrease harmony & cooperation among organization members. On the other hand, he must enhance the positive effects such as enhanced understanding of others views &

feelings, improved decision making and stimulation of critical thinking.

Moreover, middle managers spent more than 25% of their time to resolve the conflicts in the organization (Hughes, Ginnett and Curphy, 2009). Hence, the time that spent by project managers must utilize effectively for better decision making in an organization. For that, the project manager must improve the understanding of how the conflicts have risen and what the method that assist to resolve the conflict in effective & efficient manner.

Forms Of Conflicts

Sources of Conflicts

According to Rahim (2001, p 21), there are 10 types of sources of conflicts as described below in Table -1

Table 1. Sources of Conflicts

Source of Conflicts	Description
Affective/ Relationship Conflict	Occurs when two or more parties are incompatible about their feelings and emotions about the issues when resolving them.
Cognitive Conflict/ Task Conflict	Occurs when two or more parties disagree on their task or content issues.
onflict of Interest	Occurs when between two or more parties are inconsistency in their preferences for the allocation of a scarce resource.
Conflict of Values	Occurs when two or more parties having different values for certain issues.
Conflicts of Goals	Occurs when between two or more parties are inconsistency with the preferred outcomes or results.
Realistic vs Non-realistic Conflict	Reaslitic conflicts occurs when between two or more parties having incompatibilities in tasks, goals, values, interest. Non-realistic conflict occurs when party's need for releasing tension and expressing hostility, ignorance.
Institutionalized vs. Non - institutionalized Conflict	Institutionalized conflict occurs when involving with day to day activities; Noninstitutionalized conflicts occurs explicit situations.
Retributive Conflict	Situation where the party feels the need for a finish of the conflict to punish the counterpart.
Misattributed Conflict	Occurs when incorrect assignment of causes or wrongly attributed to the counterpart which has done by a third party.
Displaced Conflict	Occurs when the conflicting parties either explore their frustrations to external parties who are not involved in the conflict.

Source: Rahim (2001) pp 21-23

A. Levels of Conflict Analysis

According to Rahim (2001, p 23), there are 4 levels of conflict analysis of conflicts as described below in Table -2.

Table 2. Levels of Conflict Analysis

Levels of Conflicts	Description
Intrapersonal Conflict	Occurs when one has to perform certain tasks and roles that do not align with the expertise, interests, goals, and values.
Interpersonal Conflict	Occurs between two or more parties of the same or different hierarchical levels.
Intragroup Conflict	Occurs among members of a group or between two or more subgroups within a group in connection with rational content.
Intergroup Conflict	Occurs when two or more units or groups within an organization.

Source: Rahim (2001) pp 23-24

Styles of Handling Interpersonal Conflict

In this study, it is focused on how to resolve the interpersonal conflicts & styles of handling interpersonal project conflicts. According to Rahim (2001), there are 4 models of styles for conflict management which are introduced & adopted to resolve the issues throughout its evolution. Namely: model of two style, model of three style, model of four style, model of five style

According to Rahim (2001), in model of two style, there is only a competitive & cooperative style. Purely competitive conflicts are technically identified as zero-sum games because the outcomes are fully positive to one party & negative to the other party. Eventhough, comparatively, cooperative style is an effective conflict management style but two style method has ignored the productivity, performance & outcomes of the conflict management. Nonconfrontation (obliging), solution-orientation (integrating), and control (dominating) are the styles introduced in model of three style. According to Rahim (2001), in this model the main drawbacks were that they haven't a clear theoretical background & the studies were done through single factor analysis.

According to Rahim (2001), model of four style consists of following conflict management styles: yielding, problem solving, inaction, and contending. Though the researchers were able to prove the existence through empirical laboratory test data, they couldn't show the relationship between four styles, job performance & the productivity. Rahim & Bonoma (1979), introduced five style model that assists to resolve the interpersonal conflicts which consists of dual concern to both self & others satisfactions of the concern. It consists of five conflict management styles as follows: Collaboration, Accommodation, Competition, Avoidance, Compromise.

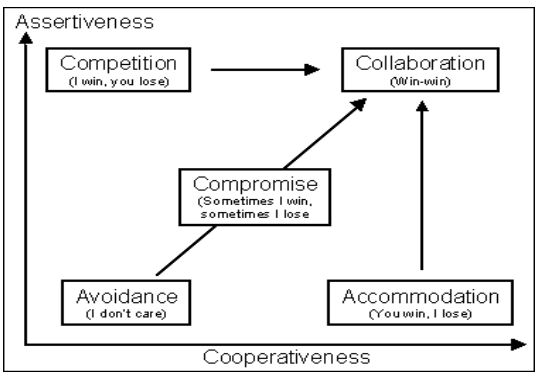

Figure1 - five style model of interpersonal conflict management

Source: Rahim, A., & Bonoma, T. V. (1979)

Collaboration: Prein (1976), has mentioned that confrontation and problem solving are the two main features of collaboration. Confrontation involves open communication which leads to reduce the misunderstanding, and assist in investigating the hidden reason behind the conflict. This is style is adopting solve the conflict with resolving the differences to reach mutual solution. (Hughes, Ginnett and Curphy, 2009)

Accommodation: According to Rahim (2001), it indicates low concern for self-requirements and high concern for others requirements. This style self- sacrifices highly to satisfy the concern of the other party.

Competition: According to Rahim (2001), a competitive person needs to win his objectives and, ignores the expectations of the other party. This style is applied by the people who have self-centered mindset.

Avoidance: According to Rahim (2001), this method applies when postponing the issue is better because time will heal or simplify the complexity of the conflict. This approach does not satisfy any of the parties.

Compromise: According to Rahim (2001), this conflict management style involves in give and-take policy for both parties & come up with a mutually acceptable decision seeking a quick, middle-ground position.

According to Desivilya et al. (2005), identified that the accommodation & avoidance styles are passive strategies; whereas, collaboration, competition & compromise are active strategies to resolve the conflicts. On the other hand, Hughes, Ginnett and Curphy (2009), categorized the collaboration, compromise & accommodation as co-operative strategies & other two styles as non-co-operative

strategies. Further, according to Somech et al. (2009), Desivilya et al. (2005), De Dreu et al. (2004), different kind of characterstics vary according to the conflict management style as per following table 3 (a) & 3 (b).

Table 3 (a):Comparison for Conflicts Managements Approaches

Conflict Management Style	Communication, Knowledge Sharing	Performance & Creativity	Relationship
Collaboration	More	More	Yes
Accommodate	Less	Less	Yes
Competition	No	Yes	No
Avoidance	No	No	No
Compromise	Moderate	Moderate	Yes

Table 3 (b) :Comparison for Conflicts Managements Approaches

Conflict Management Style	Culture consider the issue as	Performance, Creativity
Collaboration	Threat	Negative, Unrelated
Accommodate	Common Issue	Positive, Unrelated
Competition	Common Issue	Positive, Positive
Avoidance	Common Issue	Positive, Positive
Compromise	Threat	Negative, Negative

Approaches of Interpersonal Conflict Management

Problem Solving & Bargaining Dimensions in Conflict Management:

According to Psenicka & Rahim, (1989), stated that the following two equations can be used to evaluate the problem solving & bargain project conflict approach of each person in a conflict situation.

Problem Solving = Collaboration – Avoidance

Bargain Ability = Competition- Accommodation

By applying Problem Solving Equation, the respondent's willingness to resolve the conflict with others can be identified. On the other hand, bargain ability represents the amount of influence that each respondent makes to resolve the problem in favour of his view.

Activeness & Agreeableness in Conflict Management:

According to Chanin & Schneer (1984), the following equations can be applied to identify the activeness & agreeableness of each respondent to the conflict management with their counter parts.

Activeness = (Competition + Collaboration – Accommodation – Avoidance)

Agreeableness = (Collaboration + Accommodation – Competition – Avoidance)

Activeness evaluates implantation of active strategies against passive strategies. Further, agreeableness depicts the amount of concern of fulfilling the others requirements against the fulfillment of self requirements.

Statement of Research Purpose

The main purpose of this research is to identify the most popular & suitable conflict management style for the Sri Lankan construction industry. Moreover, from the results of the study, another purpose that can be identified is that the most appropriate conflict management approach for interpersonal conflicts in the construction industry. The aim of the research is to study appropriate conflict management approach to better decision making in Sri Lankan construction projects.

Following set of objectives are established to achieve the final aim of the study:

to identify the forms of project conflicts & approaches of project conflicts.

to evaluate the project conflict approaches for better decision making.

to evaluate the different between project conflict management according to the gender of the manger.

When this research was progressed, following limitations were encountered; This study was:

focussed on interpersonal conflict management within the construction project teams in Sri Lanka.

carried out to find approaches to resolve the conflicts before it becomes dysfunctional.

focussed on project teams where work is done face to face; not for virtual teams.

not considered about conflicts of multicultural project teams.

Research Methodology

The adopted methodology for this study adheres to research philosophy in the 'research onion" (Saunders et.al., 2012). The adopted research philosophy was post positivism because all questionnaire data was collected based on recent experiences of the respondents regarding their conflict management approach. Study was done through abduction approach as follows: Hypothesis, Research Design, Empirical, and Data Collection & Analysis. The required data was collected through literature surveyors of past researchers & questionnaire surveyor among the diversified, well experienced professionals related from construction industry. Hence adopted methodology choice for the research is simple quantitative method.

The interpersonal group conflict management styles in Sri Lankan Construction industry were ascertained through 28 item Rahim Organizational Conflict Inventory (ROCI-II) (Rahim1983a, 1983b). All the statements were adjusted according to the project intergroup counterparts (peer, subordinate, supervisor). Further, the five-point scale was changed to three-point scales (such as always, sometimes & never) to understand the responses easily & to have more responses for the study.

The study was conducted among 100 different types & levels of project stakeholders in Sri Lanka. The participants were selected through stratified random sampling method. The questionnaires were created by using Google Forms & posted through internet as it is the most cost effective, time saving mass media. The survey hyperlink sent via emails & other social medias such as WhatsApp, Messenger etc. The data was collected through the recent past experience of the respondents; hence time horizon of the study is cross –sectional. The respond rate is 68% from professionals who are having diversified experience & views regarding project conflict management. (See Table 4 & 5)

Table 4. Professions of the Responses

Profession	No. Responses
Project Manager	03
Architect	05
Engineer	12
Quantity Surveyor	33
Contractor	05
Academia	07
Financial Officers	03
Total	**68**

Table 5. Middle Management Experience of the Responses

Middle Management Experience	No. Responses
0- 5 years	50
5 - 10 years	12
10-15 years	02
15-20 years	04
Total	**68**

Then, data was analyzed by using statistical methods such as Mean Rating, Standard Deviation & Co-relationship of project conflict approach for each counterpart. Table 6, 7, 8 provide the summary of the Mean Rating, Standard Deviation & Co-relationship of this study.

Table 6. Mean Rating Conflict Management for Counterpart

Conflict Management Style	Mean Ratings of Respondents				
	Peers	Super-visors	Subor-dinates	Over-all	Over-all %
Collaboration	0.65	0.70	0.65	0.67	25.88%
Accommodate	0.50	0.56	0.51	0.52	20.21%
Competition	0.35	0.34	0.46	0.38	14.78%
Avoidance	0.44	0.50	0.47	0.47	18.25%
Compromise	0.53	0.55	0.53	0.54	20.88%

Table 7. Standard Deviation Conflict Management for Counterpart

Conflict Management Style	Standard Deviation of Respondents		
	Peers	Supervisors	Subordinates
Collaboration	0.65	0.70	0.65
Accommodate	0.50	0.56	0.51
Competition	0.35	0.34	0.46
Avoidance	0.44	0.50	0.47
Compromise	0.53	0.55	0.53

Table 8. Co-Efficiency of Conflict Management Style & Counterparts

Conflict Management Style	Standard Deviation of Respondents		
	Peers	Supervisors	Subordinates
Collaboration	0.9459	0.9777	0.9230
Accommodate	0.4132	0.4105	0.3538
Competition	-0.0476	-0.1857	0.0503
Avoidance	0.3916	0.4499	0.4378
Compromise	0.5659	0.4493	0.4726

Additionally, Table 9 summarizes the analysed data represent the conflict management role of the respondents for its counterparts. Moreover, the analyzed data sample assists to identify the most adopted project conflict management style & its deviation for each counterpart.

Table 9. Role of Respondent with the Counterpart for Interpersonal Conflicts

Role of Conflict Management	Role of Respondent with Counterpart for Interpersonal Conflicts					
	Peers		Supervisors		Subordinates	
	No	%	No	%	No	%
Collaborator	39	57.35 %	45	66.18 %	36	52.94 %
- Accommodator	6	8.82%	10	14.71 %	5	7.35%
Competitor	7	10.29 %	1	1.47%	6	8.82%
Avoider	5	7.35%	4	5.88%	8	11.76 %
Compromiser	11	16.18 %	8	11.76 %	13	19.12 %
Total	**68**	**100.00 %**	**68**	**100.00 %**	**68**	**100.00 %**

Additionally, this study evaluates the prevailing approaches of conflict management in Sri Lankan construction industry. Table 10 & 11 shows the conflict management approach according to problem solving & bargaining approaches, Activeness & Agreeableness approaches, respectively.

Table 10. Problem Solving & Bargaining in Conflict Management Approach with the Counterpart for Interpersonal Conflicts

Types Conflict Management Approach	Conflict Management Approach with Counterpart for Interpersonal Conflicts			
	Peers	Super-visors	Subord-inates	Rank
Problem Solving & Bargain	30.88%	17.65%	32.35%	**2**

Non-Problem Solving & Bargaining	7.35%	4.41%	7.35%	**4**
Problem Solving & Non-Bargaining	54.41%	69.12%	47.06%	**1**
Non-Problem Solving & Non-Bargaining	7.35%	8.82%	13.24%	**3**
Problem Solving	**85.29%**	**86.76%**	**79.41%**	
Bargain	**38.24%**	**22.06%**	**39.71%**	

Table 11. Activeness & Agreeableness in Conflict Management Approach with the Counterpart for Interpersonal Conflicts

Types Conflict Management Approach	**Conflict Management Approach with Counterpart for Interpersonal Conflicts**			
	Peers	**Super-visors**	**Subord-inates**	**Rank**
Activeness & Agreeableness	57.35%	48.53%	50.00%	**1**
Non activeness & Agreeableness	25.00%	36.76%	25.00%	**2**
Activeness & Non agreeableness	16.18%	8.82%	17.65%	**3**
Non activeness & Non agreeableness	1.47%	5.88%	7.35%	**4**
Activeness	**73.53%**	**57.35%**	**67.65%**	
Agreeableness	**82.35%**	**85.29%**	**75.00%**	

Finally, this study examines the conflict management style according to the gender. (See Annexure -I)

Results & Discussions

In the Table 4, the respondents were categorized into seven professional categories & the majority represents the quantity surveying & less contribution from the finance sector. Further, the majority of the respondents are direct stakeholders of the construction industry, which assist to provide insightful views regarding the current conflict management approach in Sri Lankan construction industry. As per the Table 5, when considering the middle management exposure of the sample, more than 70% have less than 5 years' experience. One can consider it as a negative effect on the results. Though, on the other hand, it is a benefit to identify how the young blood of the construction industry copes up with conflicts & it depicts innovative approaches of project conflict management for upcoming years for the country.

Table 6, clearly shows that more than 25% of the sample are willing to resolve the conflicts in a collaborative style, which is the most popular style of all the counterparts. Another highlighted fact is that the accommodation & compromise are almost equally utilized when resolving the conflicts with all the counterpart groups, which is more than 20% from overall. Further, negative conflict management styles are least popular category. Moreover, in the Table 7, summary of the standard deviation of the sample proves that the view regarding the conflict management style is similar in most of categories except the competition conflict management style.

Results of the coefficient - co relationship of conflict management style & counter parts (Table 8) shows that the data sample is highly coefficient with collaborative conflict management style when making decisions. On the other hand, there is a negative or minimum coefficient in competition conflict management in all three categories. Accommodation & Compromising are second & third most coefficient conflict management style in Sri Lankan construction industry.

Table 9 results clearly show that the majority of the respondents are willing to work as collaborators when resolving the issues in all three counter parts. It is mostly utilized in the conflicts with their supervisors. The compromiser role is the second popular style when, there is conflict with a peer or subordinate. Further, the majority of the respondents accommodate their supervisors' view than compromising. It shows that the Sri Lankan construction industry stakeholders adhere to the authority & power that

incorporated to managerial level of traditional organization management.

The results of Table - 10, 11 prove that the majority of (54%,69%,47%) current Sri Lankan construction industry try to resolve the conflict using problem solving approach but without bargaining. Further, the most popular conflict management approach is activeness & agreeability with all three counterparts (57%, 49%,50%). Further, close to 80% of sample is willing to adopt the problem-solving approach across all three categories (85%,87%, 79%) & more than 57% of the sample likes to resolve the problem by using active strategies across all counterparts (73%,57%,68%). Though the Sri Lankan construction stakeholders adopt the problem-solving approach they are less bargaining. Another highlighted point is high percentage of agreeableness in all the categories, which depicts that when resolving the conflicts, the parties are more concerned about the method of fulfilling the needs of their count parts.

The annexure - I represents that, the respondents are almost equally distributed between the two genders. This is a proper platform to explain how the conflicts are managed according to the gender. Most of the time the conflict management style is similar for both genders except in few styles. Females are more concerned about collaborating with their peers than males & on the other hand, males tend to collaborate with their supervisors more, than females. Males accommodate more for their peers & avoid more for their subordinates than females. Females tend to utilize compromising with their counterparts than males.

Conclusions

This study shows that 67% of the stakeholders apply active strategies to resolve the conflicts. Further, among these strategies, the most popular strategy is the collaboration style in Sri Lankan construction conflict management. Another concluding factor that can be derived from this study is that the majority of the stakeholders accommodate their supervisors' view when there is a conflict between them. This is mainly due to the power & authority that gained by the higher level management in traditional organization management.

This study identified that, most of the current construction industry stakeholders adopt problem solving approach without bargain. This depicts that the most of conflicts are resolved by problem solving method. Parallelly, the amount of influence that each individual makes to resolve the problem in favor of his view is less. This results to find the most apt solution for the conflict. Further, when resolving the problem, they involve in high activeness & more concern about their counterparts needs.

Conflict management style which is used by both genders is similar, but females adopt positive approach a little higher percentage than males. Additionally, males are not concerned about the level of their counter parts when adopting their approach; whereas, females tend to change their approach for their counterpart according to the managerial level of the counterpart.

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Discourse Process and Discursive Practices in the Profession of Quantity Surveying in Sri Lanka

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Abstract: The discourse on profession of quantity surveying exhibits a multi-dimensional role in the construction industry. The defined vital role entails the significance of mounting the scope in contrary to the traditional role with stressing the contribution provided by quantity surveyors through the means of discourse process and associated power relations. Consequently, the present research aims at examining the discourse process and discursive practices allied in profession of quantity surveying in Sri Lanka. In the process, the study has adapted a qualitative research approach while proceeding on data collection through unstructured interviews focusing on 15 number of construction professionals at top- level management, bottom level management as well as quantity surveyors distinctly. The findings obtained by the profound content analysis concise a vast use of English language among quantity surveyors and top-level management and consequently the evaluation of discourse on profession of quantity surveying has discovered a considerable influence on the profession caused by use of English language as a verbal communication tool in being creating power relations in the hierarchy of the construction organizations in Sri Lanka. Hence, the research emphasizes the need of enhancing the scope of this profession in being a mediator of discourse with improving the proficiencies of English language and communication to address the defined gaps.

Keywords: Discourse process, Power relations, Quantity Surveying, Sri Lanka.

Introduction

The construction sector is one of the most energetic and receptive fields in that stimulates the economic grown in a state (Giang, D.T. and Pheng, L.S, 2011). The historic advancement of the construction industry in Sri Lanka has convoyed political as well as economic changes during both pre and post economic liberalization periods (Weddikkara and Devapriya,2015). Consequently, the

professions integrated in the industry in general have also affected. The roles of the professions involved in the construction industry, and of quantity surveyors in particular, are also addressing the changes (Ofori and Toor,

2009). Quantity Surveyor was known to offer reactive cost advice that includes cost planning, procurement advice, contract administration and settlement of contractual claims to the client, however, nowadays, the role of Quantity Surveyor has progressed to convert more proactive that has to provide improved value of services to meet customer's desires (Ashworth 2013).

The discourse on profession of quantity surveying exhibits the necessity of a wiser scope in its profession in the modern era in contrary to the traditional role. The study conducted by Harun and Torrance in 2006 advocates that quantity surveyors should not contain themselves within the traditional boundaries of cost management. The findings further demonstrate that the quantity surveyors are required to advance their role in new niches, cultivate new knowledge and break into new zones in order to boost their competitiveness. The quantity surveyors are essential to transfer

from being 'thermometer' (reader of temperature) to being a thermostat' (controller of event) in the 21st century (Ajanlekoko, 2012). Consequently, the profession. The literature on quantity surveying skill and competence illustrates a multiplicity of perspectives (Dada, J.O, *et al.,*

2012).

In emphasizing the need of reforming, developing and implementing by the Quantity Surveyors, the Pacific Association of Quantity Surveyors (PAQS) has introduced eight key skills in the year of 2001, as they even comply with Sri Lankan context. Consequently, communication skill was a major among the interpreted number of skills with emphasising the need in empowering discourse on profession of quantity surveying. The quantity surveying competencies lie in the financial and contractual control of the building project as well as the development of soft skills (Leveson, 1996). The research conducted by Hasbullah S., et ; al, on Soft Skills Competencies of Quantity Surveying professionals in 2014, emphasizes communication as one of the important prerequisites for quantity surveyors in order to utilize the best. The study infers that it is significant to have the abilities in communicating several languages at any scopes, presenting thoughts and information in written as well as verbally and practicing listening with responding. Hence, this study being one of the initial studies with regard to collaborative professional communication in field quantity surveying in Sri Lanka intends to investigate the discourse process and discursive practices among quantity surveying professionals who interact interlingually for strategic communication purposes namely for managing construction projects across multiple actors in a project that includes contractors, sub-contractors, clients and various professionals.

Problem Statement

The discourse process and discursive practices in the profession of quantity surveying entails a multi-dimensional role with multiple actors involved. The the discourse on optimism career suggests enhancing multiplicity perspectives into

construction organizations in Sri Lanka are structured in a hierarchical configuration in common which requires a series of communication events in different strata. A large amount of information generated at the top level of the organization will not reach its anticipated destination because each level within a hierarchy will act as a filter, preventing and distorting information flow as it passes down and up to the next levels (Smith et al, 1997). Hence, this study intends to examine the discourse process and discursive practices in the quantity surveying career in Sri Lankan context and its subsequent impact towards the profession.

Objectives

1. To examine the nature of communication in construction organizations in Sri Lanka.

2. To identify the present discourse process & discursive practices in profession of quantity surveying in Sri Lanka.

3. To evaluate the pros and cons in the discourse process and its subsequent impact.

4. To forecast the learning experiences to enhance the discursive competence of the Quantity Surveying Career in Sri Lanka.

Significance of the Study

The studies on discourse exposed by the researchers' long ages back have found that the discourse is an indication of social conversation. The discipline of discourse studies emphasizes that discursive social interaction can reveal language use and thought, and that real-life, naturally-occurring discourse as language use, communication and interaction in social context can provide insights about the manifestations, enactments and reproduction of such phenomena

as group relations, organizations, institutions, processes, routines and structures (van Dijk, 1997).

Although the previous studies were focused on the theories and concepts of discourse studies and profession of quantity surveying distinctly, no study has surveyed the impact of discourses of integration and communication in construction organizations and associated effects towards the profession of Quantity Surveying in Sri Lanka. Hence, the present study becomes significant as it emphasizes the impact of communication towards the profession of quantity surveying within the Sri Lankan perspective.

Literature Review

Discourse

The interpretation of McArthur in 1996 explicates that, etymologically, the term 'discourse' dates back to the 14th century where it has been formed by the Latin term *'discursus'* which means a '*conversation*'. Although the term 'discourse' is defined as 'a serious speech or piece of writing on a particular subject' in the Longman Dictionary of Contemporary English (2001), the identical term has diverse interpretations in being a social dialogue. Hence, it is considered that the term 'discourse' can be illuminated by the means of different themes. The findings of Carter in 1993 clarifies the term of 'discourse' in major two forms as a reference on topics or languages used in certain frameworks and as a state of written and spoken contexts. As these majors became criticized by several scholars as not well defined, Nuan in 1993 demonstrations that these majors are sometimes used interchangeably and, in many instances, treated differently. The larger units such as paragraphs, conversations and interviews all seem to fall under the rubric of 'discourse' since they are linguistic performances complete in themselves (Touria Drid, 2010).

The discipline of discourse studies emphasizes that discursive social interaction can reveal language use and thought, and that real-life, naturally-occurring discourse as language use, communication and interaction in social context can provide insights about the manifestations, enactments and reproduction of such phenomena as group relations, organizations, institutions, processes, routines and structures (van Dijk, 1997). In drawing considerations into a wiser scope, the study conducted by James Paul in 1991, interprets social languages in term of a tool in addressing the role of language in discourse as "I will use the term "social languages" to talk about the role of language in discourses. But as I said, Discourses always involve more than language" with emphasizing the mean of discourse in a greater extend rather than being just a language.

A more general use of the word 'discourse' has been made to study the broader functional uses of language in social contexts, and the purpose is to come to understand how the language we use is based on the social environments in which we use that language. (Scollon and Scollon 2001).

The analysis by Norman Fairclough in 1989 provides a greater explanation on the perspective of discourse. Consequently, discourses are specified as social conditions of productions and social conditions of interpretation. The author has stressed major levels of social conditions as social situation, social institution and society as a whole. Hence, the following model illustrate the range of discourse in being texts, interactions and contexts. Accordingly, the current research points the discourse process in profession of quantity surveying with prioritizing the discourses that the quantity surveyors are associated with in being a part of the communication process within construction organizations in Sri Lanka.

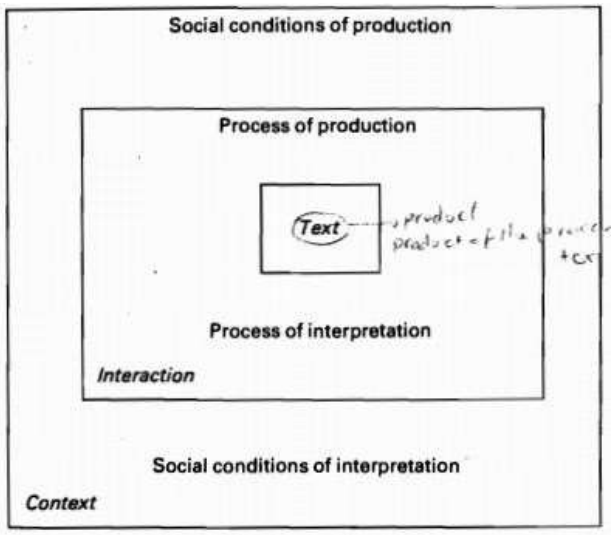

Fig.01: Discourse as text, interaction and content.

Work Place Discourse of Quantity Surveying

In considering the discourse on mandatory key competencies of a quantity surveyor, numerous research studies have discovered the requirement of communication and the use of language as a necessity. The publication on competencies of quantity surveyors required for Assessment of Professional Competence by RICS (2009 and 2012) has evidently designated communication as a leading principle to consider specifically through the areas of construction technology, environmental services and contract administration. In addressing hybridization of communication in context of organizations, Sarangi and Roberts (1999) advocates the need of professionals to display at least three distinguishable but overlapping identities in the profession. The identities are defined by the authors as professional identity, institutional identity and interpersonal identity. The study conducted by Shafie, H.,et al., (2014) revealed a specific gap in communication and interpersonal skills exhibited by the quantity surveyors in between the expected skills and the possessed skills by them. The study further emphasized the significance of adaption of communicational skills into the profession of quantity surveying.

Communication and Language

"The conception of language we need for critical language study is discourse, language as social practice determined by social structures" (Norman Fairclough,

1989). Language is a foremost means of communication, and communication almost always take place within some sort of social context by where the effective communication requires an understanding and recognition of the connections between a language and the people who use it (Amberg and Vause, 2009). Ineffective communication has been identified as a problem that can lead to conflict and subsequent litigation (Emmitt and Gorse, 2003). Quantity surveyors in being in the middle point of organizational hierarchy with relating both upper and bottom levels, and as construction professionals are influenced by the custom of language by the means of communication. Interaction between construction professionals will, to a greater or lesser extent, be independent on the language and codes used and how they are received and interpreted (Emmitt and Gorse, 2003). Hence, the assessment on language used in construction organizations can be considered as a critical factor, in evaluating the impact of communication towards the success of the profession of quantity surveying.

Feldberg's model (1975)

The Feldberg's model (1975) emphasizes communication in the means of a process. Accordingly, it is considered that the presence of a sender and receiver, as well as the function of a massage and a feedback are necessary variables to assess effective communication until the communication terminate. The model further explains the main issues that relates the sender and receiver as followings.

- Needs
- Perceptions
- Goals
- Background

- External pressures
- Expectations and reactions
- Feedback

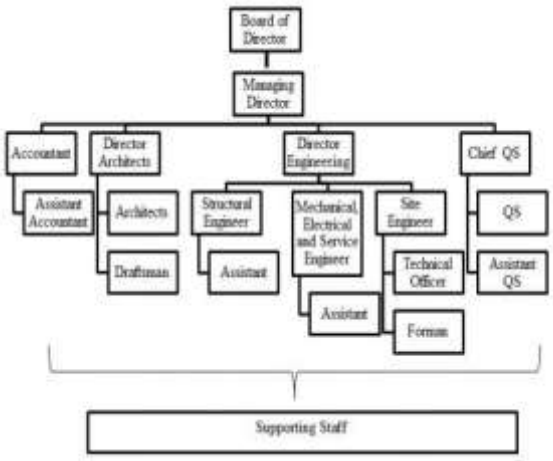

Fig.02: Feldberg's model (1975)

In assessing the requirement of communication that complies with discourse on profession of quantity surveying, Higgin and Jesson, in 1965 have stressed the necessity of communication among the building team in the construction projects in order to develop the custom of interaction. Similarly, the study directed by Lenard and Eckersley (1997) underscored the requirement of having open communications at all levels in the construction organizations. Hence it demonstrates that the quantity surveyors as construction professionals are liable in improving communication the construction process. The efficiency and effectiveness of the construction process strongly depend on the quality of communication (Hoezen *et al;* 2006).

The study directed by Mackinder and Marvin in 1982 revealed a significant fact describing that most of the conflicts in organizations are associated with ineffective communication. Accordingly, the study has found a clear difference between formal and informal communication directions which are used in the organizations with causing conflicts. This study has later been the base to the findings by Hill in 1995 which emphasizing that the divorce of design and production could also be a circumstance of the revealed gap. Similarly it was found that the Opposing interests could lead to hidden agendas with often leading to restricted communications by Brown in 2001. Therefore, the current research has acknowledged the significance of examining the use of communication in construction organizations to determine the perspective of discourse process & practices in the profession of quantity surveying.

Power Relations

The management structure of construction organizations in Sri Lanka exhibits adopting hierarchy of authority with illustrating the state of the quantity surveyors in the middle level in the organizational hierarchy in reference to the the organizational structures observed as follows.

Fig.03: Hierarchy of Construction Organizations in SriLanka

The necessity of effective communication among these levels in the organizational hierarchies has been cautioned by the findings of numerous research studies. Communication is a process of meaningful interactions by which meanings are perceived and understandings are reached among human beings (Monajib Mochachari, 2013). The study conducted by Emmitt and Gorse in 2003 illustrated communication as a central to the organization, with the structure, extensiveness and scope of the organization. Communication is seen as the life blood of organizational management (Ewing in Puth, 1994). The quantity surveyors play a significant role in coordinating the upper and the bottom levels of the organizations in being in the middle level of the hierarchy.

Similarly, the findings of the research conducted by Ruuska in 1996 illustrates that while information is flowed from top level to lower level of the organizational hierarchy, data is flowed conversely by lower level to top level as the figure no.02 emphasizes. Hence quantity surveyors are in the midpoint of where the information and data are trading. The employees at all the levels being at top position senior level, middle level, junior level or the lower level staff all has to communicate properly and has to take communication seriously and should have to communicate by following the hierarchy and preferred channels of the organizations (Luthra and Singh, 2015).

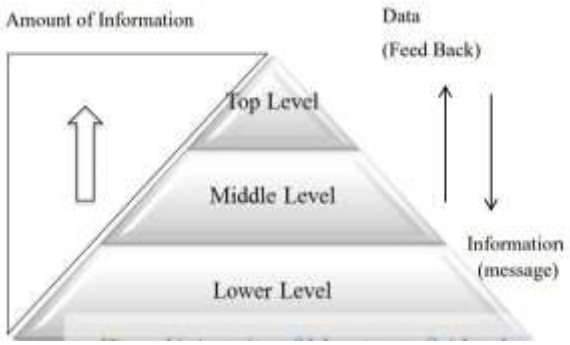

Fig.04 : Process of Communication in Hierarchy

The book of 'Language and Power' published by the great researcher in linguistic, Norman Fairclough (1989) provides a contextual mean on class and power. The author has sharpened that discourse has effects upon social structures, as well as being determined by them, and so contributes to social continuity and social change. In his perspective, the power relations are always relations of struggles whereby social groupings with different interests engage with one another. Subsequently, the explanations reflect the impact of power and power relations on certain social layers by the use of language. Language is both a site of and a stake in class struggle, and those who exercise power through language must constantly be involved in struggle with others to defend or lose their position (Fairclough, 1989). Therefore, this present study aims at examining power relations through the perspective of profession of quantity surveying in the context of Sri Lanka.

Research Gap

The preceding studies have shown a prudent scope in the areas of discourse analysis and subsequently numerous researches have been subjected to the application of discourse and discourse analysis in the areas of philosophy, linguistic and so on. Correspondingly, the past years have shown a greater interest in analyzing discourse process and communication practices in the professional fields such as healthcare, law, offices of land surveying where communication events play a key role in executing the professional duties successfully. The profession of quantity surveying is one such key profession in the field of engineering sciences where the communication plays a pivotal role in determining the successful outcome of their professional roles. No significant study has been done in Sri Lanka in this regard. This study thus sets out to fill this knowledge gap by examining the impact of discourse process and practices, communication events among construction professional's profession of quantity surveying in Sri Lanka.

Research Methodology

Research in modest expressions indicates detection of knowledge and a scientific and systematic exploration for proof on a detailed theme or subject, hence research methodology is a systematic approach that a research adopts to achieve the exploration aims (Creswell, 2009). The present study has adopted a qualitative research approach in demonstrating benchmarks of the theme. The population implies to the population which a researcher intends to generalize the study findings (Kombo & Tromp,

2006) while stratified sampling method measures the overall population parameters with greater precision and ensures an extraction of a representative sample from a relatively homogenous population (Kothari, 2004).

Consequently, the study has exploited the professionals of construction industry in Sri Lanka into the cluster of population while utilizing a sample of 15 number of participants by the top-level management, quantity surveyors and bottom level management in both contractor and consultant construction firms. The data collection process of the study has proceeded through unstructured interviews in being derived by the accessible literature models and theories prescribed specifically by Hoezen, M.E.L et al (2006) and Ofori, G., (2009). The analysis of the data has followed in subject to the mode of a content analysis.

Analysis

The nature of communication within construction organizations in Sri Lanka

The present nature of communication in the construction organizations in Sri Lanka is surveyed with the use of information congregated by interviewing professionals ranked at all hierarchical levels. The nature of the discourse process in the certain organizations is found following two-way communication process throughout the levels of management in overall.

In considering the discursive practices exhibited alone over each level, it is revealed that both verbal and non- verbal practices are major modes in between quantity surveyors and the top level of the management. The assessment of language of which each professional practiced at work displayed a greater degree of using *English* in dealing with non-verbal discursive approaches as well as in majority of verbal manners. A few numbers of professionals in the top level of hierarchy displayed use of *Sinhala* in interacting verbally with quantity surveyors, who are in the middle level in structure.

The discursive practice exhibited among middle and bottom levels of the hierarchy through the flow of information indicated a major use of verbal interactions than non-verbal modes. Moreover, the language of which specifically, majority of the quantity surveyors used to interact with bottom level is found as *Sinhala* while a few practiced *English* language with senior professionals who are in the bottom level of the organization.

In drawing the consideration on the nature of flowing feedbacks within these structures, the present study revealed a progressive flow of feedback from bottom to the middle level. The explanations given by the middle level correspondents pointed that the relationship of which they display with Technical Officers, Site Supervisors and other professionals in the bottom level enabled obtaining feedbacks daily. For an example, some of the construction organizations are having daily team meetings. The evaluation on the use of language in the flow of feedback from bottom to middle levels, has discovered practicing *Sinhala* language as major by the bottom level management to convey feedbacks.

Table 01: Discursive Practices exhibited in Construction Organizations in Sri Lanka

Flow	Hierarchy Levels	Discursive Practices	
		Verbal	Non-Verbal
Flow of Information	Top level to Middle level	• By word • Telephone calls • Meetings	• Emails • Letters • Drawings, Specifications, and other official documents.
	Middle level to Bottom level	• By word • Telephone calls • Team Meetings	• Notices • Drawings, Specifications, and other official documents.
Flow of Feedback	Bottom Level to Middle level	• By word • Phone calls • Team meetings	• Drawings, Specifications, and other official documents.
	Middle level to Top level	• Reports • Board meetings	• Reports • Board meetings

In assessing the next phase in the flow of feedback in these construction organizations, the current study has found the quantity surveyors in being in the middle phase of the hierarchy, provide

feedbacks to the top level by non- verbal discursive modes mostly, with presenting a less priority in practicing verbal interactions. Both non-verbal and verbal modes of discourse are found mostly to be practiced in the language of *English* and some of the explanations given by the correspondents in the midlevel of the organizations indicated that although *English* is used wisely, the use of *Sinhala* in verbally varies based on the nature of the professionals who are in the top level management

Analysis on impact of present discourse process & discursive practices in profession of quantity surveying in Sri Lanka

The findings on the nature of the discourse process revealed in Sri Lankan construction sector provides the base in analyzing the impact of communication towards the discourse on profession of quantity surveying. Consequently, the assessment on degree on the flow of feedback through the key levels of the organizations specified a drop between the flow of feedback from bottom to middle level and middle to top level of the hierarchies. The study revealed that the feedback given by the bottom level to the middle level management of the organizations are much advanced and progressive than the flow of feedback from middle level to the top level. Although the causes for such a gap indicates several facts such as nature of the relationship among different hierarchical phases, leadership style, personal competencies and external influences; the present study has verified the major cause as language proficiency. The correspondent quantity surveyors further indicated the issues and limitations that they had while verbally communicating in the language of English as below.

"We are having issues in dealing in English with our managers and especially in responding to them."

The Feldberg's model in 1975 defines the necessity of feedback within the communication process for any organization. Thus, the appraisal stressed on flow of feedback by the current research underscores a defined gap between above and below the middle level of the hierarchy due to the language proficiency. Hence the study has further analyzed the nature of the language proficiency of all the construction professionals to recognize a common language or a system that would overcome the defined gap. Accordingly, the gradation on language fluency of the professionals examined by the present study explores Sinhala as the language of which majority of professionals in each level are fluent in than English, Tamil and any other language.

In considering the fact of practicing English while exhibiting Sinhala as a common fluent language that majority of the professionals could use specifically for verbal interaction, the research has discovered a tendency of quantity surveyors being indirectly forced to interact in English with the top management of the hierarchy. The following responses obtained by several quantity surveyors, indicate the means as follows.

"We do use English in writing reports, letters and more as the standards that we follow requires to be unique all over, and the verbal communication with senior professionals such as project managers indirectly direct us to use English as a language".

"Quantity surveyors should be fluent in English not only in documentation, but also in verbal communication to survive in the industry as lack of English competencies will cause conflicts by misunderstanding and more on".

The findings of interviewing professionals from the top- level management clearly demonstrates that they are more likely to follow English as an administrative tool and a way of controlling subordinates in an effective manner in major. The statement below indicates one of a response obtained by a project manager, emphasizing the need of language as a part of the culture and as a tool of controlling the hierarchy.

"We assess the level of English fluency in recruiting Engineers, Quantity Surveyors and other subordinates as most of the documentations are

formed in English. Verbal communication is also required to perform by them in the same language, as we have the culture of using it in board meetings and in practice. In other hand, it is a way of tool that control them from being much friendly to maintain the professional status".

Evaluation of pros and cons in the discourse process and its subsequent impact

In addressing the stated gap in the flow of feedback as a necessary fact for an effective communication model, the present research has evaluated the success of having such a custom communication process in practice in Sri Lankan context. Although most of the top managers believe use of *English* language as an effective tool for administration, the middle level management demonstrations a tendency in being resisted to practice *English* as a mode of verbal communication with emphasizing poor skills in it. The study has also stressed the consequences of this gap in resulting being a limitation on discourse. The following statements illustrate the difficulties that quantity surveyors face in verbally communicating with seniors.

"Communicating in English sometimes lead misunderstandings among what we intend to say versus what the managers get due to our poor language proficiency and later of course it makes conflicts." "Sometimes responding back to the boss is not easy because then I will have to argue or explain in English of which I am not much good at".

Hence, the discourse processes in the profession of quantity surveyors are found to be influenced by the language of English not just as a communication tool, but also as a mode of power relation in the construction organizations in Sri Lanka.

 To forecast the learning experiences to enhance the discursive competence of the Quantity Surveying Career in Sri Lanka

The facts discovered by the present study summaries the consequences on use of English as a language. Accordingly, the stressed gap and power relations are subjected on the whole structure of the construction organizations. Based on the dispersion of the subjected matters not specifically on profession of quantity surveying but also in the whole society, the study stresses the need of a social change in deforming the gap and power relations to overcome. In focusing on the profession of quantity surveying specifically, the quantity surveyors are found playing a mediating role in dealing with various degrees of language proficiencies in both top and bottom phases of organizations. Hence, this research emphasizes in extending the scope of the role of profession of quantity surveying to empower the future career. Consequently, the enhancement of English language proficiency and communication is significant. Apparently, the study suggests in enlightening the discursive materials and practices with integrating technology to a wider range in overcoming the descripted gaps.

Conclusion

The assessment on nature of the communication within construction organizations indicates the application of discourse process and discursive practices in each level through both flows of information and feedbacks. The findings emphasizes that quantity surveyors in being at the middle level of the organizational hierarchy is fronting a condition where they have to intermediate the top level and bottom level respectively in English and Sinhala mostly

language proficiency. Moreover, the study has found the use of language by the top levels of hierarchy as a tool of controlling administrative functions where it is emerging as a power relation in the structure of the construction organizations. The evaluation of discourse on profession of quantity surveying has revealed a considerable influence on the profession caused by English language as a verbal communication tool in being creating power relations in the hierarchy of the construction organizations in Sri Lanka.

In reference to the descripted facts in the study, it is concluded that the quantity surveyors are required to enhance the scope of their profession in being a mediator of discourse by improving the proficiencies of English language and in communication to address the defined gaps.

Limitations And Further Study Directions

The study has followed assessing the impact of English

language as a major, thus the use of other languages can be evaluated in further. The research has also focused on the perspective of quantity surveying profession specifically among the other professions in the middle level of the hierarchy. Hence, a study can be directed in focusing on the other construction professions.

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Identification of the Challenges Imposed by COVID-19 Pandemic on Sri Lankan Construction Projects

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Abstract: Coronavirus (COVID-19) is a global pandemic which spreading all over the world which ruining lives of hundreds of people & effect negatively on business matters over the world. This can trigger different kinds of challenges to all the industries while affecting world economy. Thus this paper aims to identify the challenges imposed by COVID-19 pandemic on Sri Lankan construction projects. This research was assessed through detailed questionnaire survey and interviews. The number of distributed questionnaires were 50 and the response rate was 82% which added a positive mark on the research study. Frequency index method & content analysis were used to analyse the collected data. The findings highlighted the main challenges among construction industry due to coronavirus as delay of completion, issues with supply chain management & change the public perception on site. It is recommended to spend the period of working from home fruitfully & to start the site works stage wise with the involvement of less number of labours at the beginning stage. While this research focused on the challenges, further study can be done to investigate about the renaissance & the industry predictions of the construction sector for post COVID-19 world.

Keywords: Coronavirus (COVID-19), Pandemic, Sri Lanka

Introduction

Unforeseeable events always occurs risk to any kind of business (Okema, 2000). Currently the whole world is standstill due to an unpredicted harmful effect which is the spreading of a deadly coronavirus also called as COVID-19 which is a severe health crisis (Chopra and Nagar, 2020). This is an unpredicted situation which impact on every families & business matters around the world.

The daily events of all over the world stopped, airports closed, movements restricted, new regulations has been passed and even some countries are locked-down by imposing curfews for months and a massive quarantine happens across the world. Sri Lanka also effected with this situation and restricted people to stay home & maintain social distance to minimize the exposure & to stop spreading of the virus & advised to work from home.

The enacted new laws and regulations by government will be directly impact on the construction industry because it is more contract with & contrast to the environment & engaged with lot of stakeholders at a once in projects. The main objective of the research study is to identify the challenges imposed by COVID-19 pandemic on the Sri Lankan construction projects, which could be occurred and make suggestions to take the industry to a better place with new phase through a limited forecast on the scenario in Sri Lanka.

By finding the first case from the Wuhan city in China on December 2019, by now (May,2019) the coronavirus almost affect to the whole world

covered nearly 172 nations (Chopra and Nagar, 2020) and the World Health Organization (WHO) marked this situation as a global pandemic and took emergency protocols to manage the situation.

Construction projects need typically everyone at a construction site to be involved with work either to perform a several task, or to supervise & check the work done according to the specifications (Okema, 2000). With the new norm of social distancing the WHO advised people to keep at least 1m distance from each. This will be a difficult task to adopt at once, but for the safety of everyone we have to follow up with the government rules. The government persuade people to work from home, forced to shut down the construction sites and advised only travel if it's essential. Construction projects need at site work & this will be a new challenge for the parties in construction industry because they weren't prepared for this kind of situations (Laing, 2020). Practical reality is to shut down the sites because materials can't be delivered to sites, far away staff members couldn't come for the work places and also issues with maintaining social distance among labours.

Any activities give hands to spread the COVID-19, it should be stop because always safety is the first aspect to consider. Now the investment should be surviving than winning due to the unpredictable bad outcomes which could be happen near future. Hamid (2020) stated that both private & public sectors are messed up due to this public health crisis.

The COVID-19 pandemic is a heavy blow to the construction industry. The situation is up to now under controlled but not fully evacuated. How big this going to be?, how long will this last?, and what are the impacts?, are yet to be discovered until an antidote is found (Chopra and Nagar, 2020).

Construction industry is one of the engine of national economy in Sri Lankan context which has contributed approximately 6.8% to the GDP (Annual Report 2018, Central Bank of Sri Lanka). The heavy blow of this issue will be effect on the construction and it will lead to bad impacts on the global economy (Chopra and Nagar, 2020), and ultimately coronavirus will not only fatal to human lives but also destroy the countries' economy. It is highlighted the importance of preparation to a next wave of the coronavirus. This paper will be beneficial to the parties in construction industry to understand the upcoming key challenges & make suggestions for the betterment of the industry.

Literature Review

An epidemic is an event in which a disease is actively spreading. Generally, it's an outbreak that has grown out of control but is often within one country or location. A pandemic is on a far greater geographic scale that affects a much large number of people (Maital & Barzani, 2020). The Coronavirus (Covid-19) was marked as a global pandemic by the WHO has not only infect on the human life but also effected the global economy which having a potential of destroy the livelihoods, industries, businesses and the entire economy in a larger scale (Laing, 2020). The particular disease evolved like a pandemic with the extensive spread within the number of nations all over the world (Hamid and Huam, 2020).

The first COVID-19 case in Sri Lanka occurred 10th of March 2020 and thereafter the other infected people slowly exposed but no immediate rises. By 25th of March, the total number of cases crossed the 100 & government started to get strong protocols to mediate & control the situation. As a developing country at the beginning stage the testing facilities were limited. With the improvement of the number of tests over the country the escalation of 300 cases discovered within 4-5 days. According to Ministry of Health, Sri Lanka confirmed 847 cases & 09 deaths have been reported till 10th of May 2020.

The construction industry plays an important role in the formation of the country's economy. The blow of COVID-19 pandemic will definitely hit the industries & damage the economic state (Chopra and Nagar, 2020). The experience of this kind of a situation is new to the globe and it will be the biggest challenge the world have to face the most. Nagar (2020) stated that, the quantum of the impact will depend on the time period of the lockdown & the time takes the economy to get back in the line. Narrowly it describes the time & cost which are comes under the main pillars of the construction industry & this emphasize the key issue towards construction sector in long term & could change the shape of the industry (Laing, 2020).

The delay of projects will be a common phenomenal due to this COVID-19 pandemic with the strict behaviour of government. The curfew imposed all over the country & advised people to stay home & make social distance. The less movement of workers engaged in construction activities, and non- availability of inputs during lockdown will also result in delay of projects (Chopra and Nagar, 2020). Work from home concept was adopted to those who are productive at working off-site and the company heads had the power to get the most essential staff members to the organizations, but with the quarantine process, discourage them to travel and lead day to day work processes a mess.

The labours have to be compensated with additional wages for the unexpected situation. Some companies have to ensure their staff safety, giving adequate food, water and sanitary supplies which will indeed add to the extra cost of the project as there is complete ban on the construction activities (Chopra and Nagar, 2020). He further emphasized the issue with the supply chain. Hamid (2020) confirmed the statement, as the lockdown has obstructed the import & export facilities of materials will negatively affect in long-term on construction industry. The steel products, technical construction equipments, electronic equipments will get affected by this condition and the companies will have to pay a higher price to acquire these products in future & delay the time.

This is a global pandemic which is not only effect to Sri Lanka. Both developed & developing countries are seeking to cope with the pandemic & face all the barriers with the limited resource capitals available (Chohan, 2020). The clients of every projects do have to understand about the situation and have to face for the consequences because neither party is responsible for the issues arising along with this COVID-19 pandemic. Davis (2020) stated that in construction everything finally comes to time & money. By considering that fact it's marked the dangerous of how unpredictable the virus will be on the construction industry. The paper will narrow down some of the key challenges & make recommendations how to overcome those based on the professional views.

Research Methodology

The main objective of the research is to identify the key challenges cause to the construction industry due to the coronavirus pandemic. To evaluate the challenges a large range of community which attached to the construction industry in Sri Lanka was targeted. The research was completely evaluated through questionnaire survey and online interviews with the concerned authorities. This was a combination of both qualitative (interviews) and quantitative (a predominant way via questionnaire survey) analysis to confirm & make concrete recommendations based on the views of different parties by several methods.

Data Collection Methods

A web based detailed questionnaire (Google forms) was circulated among professional groups in construction industry, Sri Lanka sent through e-mails to the construction firms. Questionnaires were distributed among professionals in order to

obtain suitable responses to the questions & different viewpoints were ranked accordingly to the "Likert Scale" (Likert, 1932). A total number of questionnaires distributed was 50 (selected by stratified random sampling) & the response rate was 82% including from 05 Project Managers (PM), 15 Quantity Surveyors (QS), 10 Engineers (Eng), 10 Clients (C) and 10 Contractors (CR).

Semi-structured interviews provide the freedom to discuss about numerous areas widely (Naoum, 1998, p.58). A purposive sample was selected for the semi-structured interviews since the objective is to select the partakers who have better knowledge & industry experience in the area of research study. Online interviews were done due to the current situation based on COVID-19 pandemic by maintaining the main norm of stay home & making of social distance because of the curfew & movement barriers around the country. The professionals which covered through the interviews were Quantity Surveyors, Clients, Engineers, Contractors & Project Managers.

Data Analysis Methods

Data analysis was done with the use of Frequency Index (FI) analysis (data gathered through questionnaire survey) which express the frequency of the factors which challenge the Sri Lankan construction industry (Le-Hoai, et al., 2008), and the content analysis was done to analyse the data which gathered through the interviews.

$$Frequency\ Index\ (FI) = \frac{\sum_{i=1}^{5} ai \text{ x } fi}{H \text{ x } N} \quad \text{(Eq: 1)}$$

Where:

i = Score of the factor ranging from "Least Effect =1" to "Mostly Effect =5"

ai = Weight of the response for the ith response

fi = The frequency of the ith response from all respondents

H = Highest ranking available, which is 5 in this survey

N = Total number of respondents who have answered the question

Presentation was in the forms of graphs and tables. A cording system was used to identify the factors separately for the easiness of understanding.

Data Analysis

Construction activity is a complex work item which needs the hand of different parties who specialized in different areas of profession. So it is essential to cover the target population and discuss experience based on their trades.

A. Background Findings

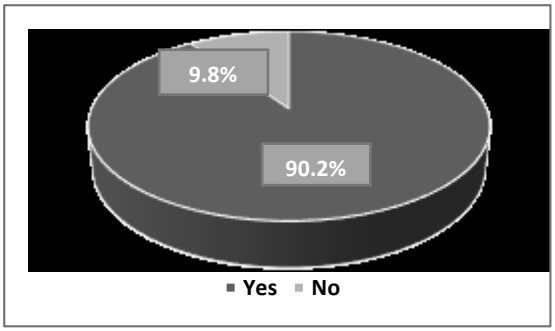

Figure 1. Respondent based on profession

The general information of respondents including their profession and experience in the industry were assessed because based on the perspective of different people the answers to the questions may vary due to their thinking capacity and knowledge. The degree of responses are discussed below.

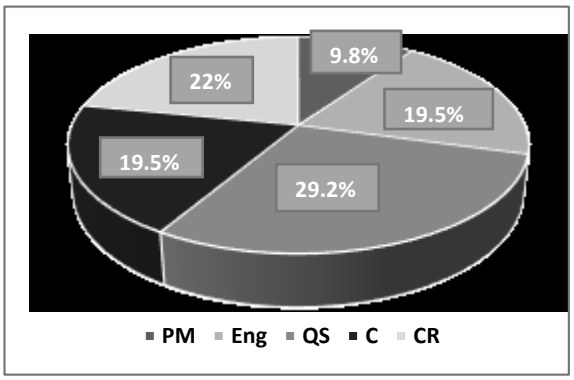

Figure 2. Respond on construction projects stopped due to

Then targeted to find out whether the construction sites which these professionals was working stopped due to this situation. More than 90% of respondents were stated that there sites were shut down because still the curfew has imposed all over the country which highlighted it as a serious problem to the construction industry and the need of identifying the upcoming challenges along with the pandemic & get the necessary solutions.

COVID - 19

The COVID-19 is an unforseen situation. Then target to find out whether the parties have experienced similar kind of situations previously, because good decision making on this type of challenges were purely based on the proper experiences. The majority of the respondents with 75.6% weren't face this kind of similar scenarios at their time period of working which will be a challenge when decision making. Then questioned whether they think that still construction sites can be reopened by following the health guidelines enacted by the government. The majority of them said "No", with the

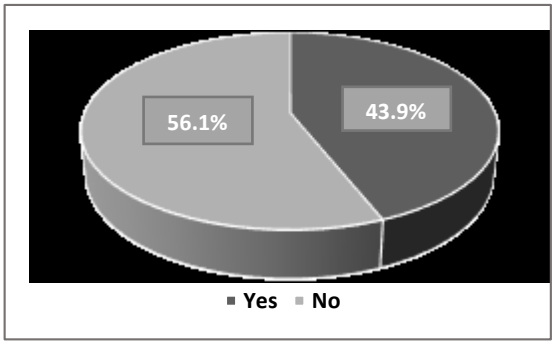

Figure 3. Respond on construction projects can be re-opened by follwing health guidelines

percentage of 56.1% because not having proper experience will lead opening sites to a challenge and the panic due to the deadly virus.

Though the majority was afraid according to the Fig. 3, 43.9% were said that opening sites with necessary precautions are essential because we can't stay lockdown for the rest of the whole year. Practical reality is face to the challenge by adopting proper solutions.

B. Rank the Key Challenges

According to the research there are major 15 challenges which categorized by considering the impact of COVID-19 pandemic on Sri Lankan construction industry. The challenges are identified from the literature survey and mark 15 factors out of them to rank according to the frequency of its impact. The frequency index was computed based on the degree of agreement of the respondents. The scores gained by the respondents in the questionnaire were summed up for each factor. The factors identified based on a coding system for the easy of identification and rank as tabulated below.

Table 1. Ranked challenges causes due to COVID-19 on the construction industry according to the frequency index analysis

Code	Challenge	FI	rank
CH04	Delay of completion of the project	0.932	1
CH01	Damage the Supply Chain with shortage & delay materials	0.815	2
CH05	Change the public perception on site & less confident and laziness among labours	0.707	3
CH14	Global uncertainty, market condition & economic challenge	0.693	4
CH10	Temporary suspension & termination of contracts	0.683	5
CH15	Legal issues & lack of expertise professionals	0.668	6
CH03	Reduce the productivity & production lines standstill	0.659	7

CH02	Workforce problems with shortage of labours	0.654	8
CH11	Feasibility of adopting to new situation & continue site work	0.644	9
CH12	Issues with own organization & co-operate with other stakeholders	0.620	10
CH07	Poor decision making due to not having enough previous experience on similar scenario	0.610	11
CH06	Future funding difficulties	0.551	12
CH13	Demand for the types of projects & fewer clients	0.546	13
CH08	Adoption to mobile works	0.522	14
CH09	Local government shutdowns affect on-site & off-site material stores	0.522	14

According to Table 1, the top rank of the challenge was the delay of project completion (CH04). It's logical to anticipate because of the absenteeism. Many projects are time sensitive because contractors have various projects lined up through the year. Davis (2020) said that if pandemics become a recurring phenomenon, we can anticipate significant population shifts away from dense urban areas which lead shortage of staff along with reducing the working hours (CH02) and get time to recruit new people. An interviewee said that, "*Although COVID-19 is unforeseeable, contractors still be contractually responsible for delays & cost overruns*". The longer completion will be the hardest hit on the industry which aren't go away anytime soon.

The next mostly impacted challenge which rank on 2nd was damaging the supply chain of materials (CH01). The COVID-19 would affect the critical path of the project & obviously paralysed the construction activities. Chohan (2020) also confirmed this as a serious challenge as this will be negatively impact on the material delivery & will have a shortage of material around the world. An interviewee said that, "*Supply chain will affect long after the coronavirus neutralized*". According to the Table 02, the material which on & off site much (CH09) not be mostly effected as it is the least challenge which ranked among others.

The next most challenge will be start up works at site as usual due to the public perception & less confident among labours (CH05). This can be occur due to the lack of Personal Protective Equipments (PPE) at sites and health & safety problems at working places. The mental conditions with new situation make people more angry & anxious and get the work done out of them indeed will be a challenge. Feasibility of adopting to the new situation at site (CH11) will also be a challenge with new health guidelines.

The next challenge is the economic state of the country (CH14) which also confirmed by Chopra and Nagar (2020) as risk of regression will be elevated without arguments. This will effect on construction projects with future funding (CH06) which also ranked as the 12th challenge. Temporary suspension & termination of contracts (CH10) is the 5th most rank which likely to occur due to reduction of the number of workers. An interviewee said that, "*This will negatively impact on construction cost & time of completion because recruiting subcontractors add additional cost & time. On the other hand, the lack of specialist contractors for separate works will damage the quality of the product*".

The next challenge ranked as, Legal issues & lack of expertise professionals (CH15) to consult on these kind of situations. An interviewee stated some of the fields which legal disputes could occur as claims for Extention of Time (EOT) & additional cost, suspention and termination of contracts. When external circumstance create pressure on one, it will effect on all (Lewis, 1988). An interviewee highlighted not having enough experience will lead for poor decision making (CH07). Construction work always go along with contractual provisions. To get a better advice on the situation & to reduce arising of disputes, we have to consult professionals with experience,

which all most lack in the Sri Lankan construction industry.

Issues with own organization & co-operate with other stakeholders (CH12) ranked as the 10th challenge different from the findings of Chopra and Nagar (2020). They highlighted dealing with contractors regarding payment process as the biggest challenge. An interviewee said that, "*Construction always have issues with longest waiting lists for payments. With the economic unstability, this will become a mess and the COVID-19 disaster will be a recipe for this mess*". As tabulated above, demand for the types of projects & fewer clients (CH13) which ranked as a less challenge based on analysed data is contrast with the findings of Hamid and Huam (2020). Their study revealed that clients will be more focused on the healthcare construction, healthcare related modifications on buildings, warehouses, educational & public buildings. Construction of apartments, social housing, hotels, entertainment centres & infrastructures which having the higher demand now, will be the least with time and it will be a great challenge to the industry.

The factors were rank based on the responds of different parties in the construction industry according to their knowledge on COVID-19 relates with construction. Based on results it was revealed that the coronavirus pandemic will be a deadly challenge on construction sector & need to get actions to limit the arising of issues.

Conclusion

The COVID-19 global pandemic may well become the most crucial economic and social failure event in decades. It is continue to impact the construction sector in challenging ways (Laing, 2020). The facing of the challenges cause due to the COVID-19 pandemic will change the construction industry to a modern face with new strategies (Chopra and Nagar, 2020). Social distance will be the new norm by doing less group activities with more clearly defined objectives. This situation will keep labour under controlled environment & reduce the amount of time in the field by adopting to mobile works with new technology & advanced interfaces. This will reduce the more of office work & increase the capability of working from home. But this also made labours & staff lazy, lethargic & stressed in long-term.

The virus pot a spotlight on the importance on labours health & safety and the construction sites will be more clean & safe. With the coronavirus outbreak, the industry could focused on making buildings healthier by improving indoor air quality as well. An interviewee said that, "*Now the all stakeholders will much consider on the contract document provisions on risk management strategies will turn construction in to a new trend*". The Supply chain management will be re-calibrate & enhanced the adoption of off-site construction methods. If we manage the situation properly we can get the maximum opportunity out of this COVID-19 threat confirming the statement that, "Every dark cloud has a silver line".

Recommendations

Construction work always go along with contracts and the contractual matters have to be discussed based on the event. The COVID-19 pandemic is an unforseen event to the industry which more stakeholders doesn't have a better experience & would make conflicts on contractual provisions (Laing, 2020). In a construction project to limit the risk that a future event prevent which performing the contract by either parties include under a clause "*Force Majeure*" (Lewis, 1988). Cary Wright, Construction Lawyer (2003) said that the *force majeure* clause operates as a method of risk allocation. He mentioned that a *force majeure* event must have been unforeseeable & its occurrence must be beyond the control of the concerned parties.

The majority of the interview parties consider this event under *force majeure* because no one is ready for this kind of situation. An interviewee

said that, "*Though the force majeure clause have no specific terms on viruses, it can be considered as an act of God. This is not an epidemic, it's a global pandemic. The ability of non-performance of the contract can be excused because neither party is responsible*". Another interviewee said that this will depend on the contract clauses of the projects & need to be prove with solid evidences that sole cause of damage to the construction project work is COVID-19.

Based on the data analysis the followings were recommended based on two categories to win the challenges of COVID-19 pandemic.

A. Recommendations for the Period of "Work From Home"

Still the situation is continuing & people forced to work from home. Though this is not practical to the construction industry there were some works suggested which can be fruitful in the period of work from home by the professionals.

List out the pre-tasks by understanding the priorities and re-schedule the project planning

Online meeting can be conducted & discuss about the impacts of the situation on the construction process of projects in long-term

Reference of drawing & finding loopholes

Review the contract document to understand the contractual rights and obligations that arise in an unforeseen events

Managing accounts and change orders

Preparation of tender BOQ (Bill of Quantities) compilation

Arrange the IPA (Interim Application Payments) which had piled up due to busy schedules

Consult a professional insurance counsellor on the legal base (to get legal advice) & about contractual matters based on the situation

Make positive attitude behalf of the company & give all the co-operation

Co-ordinate with the subcontractors & discuss about the updated schedules to avoid arising of disputes in future

B. Recommendations for the Sites to be Re-Opened

The COVID-19 pandemic will take time to heal. It might take 2-3 years based on the character of the virus. Until then the country can't be kept locked down. We have to face this challenge by understanding the situation well and follow up the safety precautions as advised by the government. The followings were suggested to follow up when the constructions sites were opened.

Construction sites must be opened stage wise (one phase at a time) according to the trade of the labors (single trade of work at a time) & shift the workers to maintain the social distance

Prepared for the increase of the absenteeism of the labors by training them with many trades as possible by the supervisors

Encourage the industry stakeholders to integrate the work with modern software relates to construction

Supply chain must be re-calibrate & manage with alternative materials & back-up methods

Make situational awareness programs among the site staff & encouraged them to follow up with the safety precautions to avoid the spreading of coronavirus

Increase the effort for the site safety & provide all the staff members & labors with proper Personal Protective Equipment (PPE) kits (including of respiratory masks, safety goggles, hand sanitizers, full body suits, gloves, boots etc) and disinfection of the site

Randomly check the site staff with PCR tests, involved with Ministry of Health, to avoid the risk of been infected to the other members of the project & to assure the particular construction site is free of coronavirus

Improve the mental & physical health of the labors

Proper planning & reschedule the project with addressing the future risk must be done with the guidance of the Project Manager (Avoid the next wave of virus)

Make weekly updates about COVID-19 situation at sites & take necessary actions

Financial support should be given by the government to the construction industry

Future Research Directions

The researchers must do their research regarding the COVID-19 with every possible outcome & effects on the construction sector which will help for the betterment of the industry on behalf of the country's' economy (Hamid and Huam, 2020). While this research focusing on the key challenges on the Sri Lankan construction industry due to COVID-19, further study can be done to investigate about the renaissance & the industry predictions of the construction sector for post COVID-19 world.

Another study can be done to identify how the construction industry can be integrated with modern technology developments and their applications. A similar study can be improved to identify the contractual provisions about construction disputes & application on them in the industry against these kind of unforseen risk events.

Acknowledgment

The special thanks goes to Faculty of Built Environment & Spatial Sciences (FBESS), Southern Campus of General Sir John Kotelawala Defence University (KDU) for their assistant & guidance to the betterment of the research and all the interviewed parties who has given primary data on the selected challenges.

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Pedestrian Movement Tracking and Tracing in Public Space

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Abstract: Population increase in the Urban areas made crowd management a hot topic today. Pedestrian decision making and movement patterns are critical in a variety of application domains. Mass event planning, mass gathering, individual location planning, and public space planning need to know how actual pedestrian movement happens. For planning such areas, architects and planners are keen on understanding empirical data of the pedestrian movements, and it is important for planning and designing public spaces.

The paper discusses the investigation carried out in a workshop to capturing empirical data of pedestrian movements in public space in China. It addressed the outcome of tracking and tracing pedestrian movement in temple premises with traditional methods vs. available technology. Further, this is an attempt to discuss the pros and cons of current trends in technology of movement tracking and tracing and its implication towards Architecture, Urban Design, and Urban Planning.

KeyWords: Pedestrian movement, Public space, Tracking and tracing

Introduction

Public life and Public space

Good Architecture and Urban Planning ensure proper interaction between public life and public space (Jan Gehl, 2013). But it is often forgotten since it is easier to work with form and space where public life is temporary and difficult to describe. With the development of the technology of pedestrian movement tracking, it was no longer abended. The field developed every day, and the requirement of the movement details on-demand

within the research field. Technological innovations such as big datasets, e.g., Global Positioning System(GPS) and Wi-Fi technology, contributed to the people's movement tracking and analysis (Hanzl and Ledwoń, 2017).

Agent-Based Modeling (ABM) and Cellular Automata(CA) have been using for predicting unforeseen situations of human movement. Hence, pedestrian movement-related empirical data used to understand the situation, built up the case, calibrate, and validate the same. Further, pedestrian tracking data used for understanding route selection mechanisms (Ray, 1982), design and planning pedestrian facilities, wayfinding techniques in public spaces (Gallay, 2010), and checking urban guidelines(Willisô, 2004). The pedestrian movement pattern adds another valuable dimension related to planning and designing. It was mostly researched in critical areas such as emergency evacuation, crowd planning, event planning, special space planning, and panic situation planning. Not only that, but many different fields are also interested in capturing real human movement for other purposes.

Whyte (2009) has studied the social life of small urban spaces and how space affects user behavior. Human movements are closely related to urban planning and ordered the spatial structure (Batty M, 2001). Gehl (2013) examines

the state art of the pedestrian movement in Urban Spaces. Further, he discusses several measures using observing and trace, mapping, photographs, test walk, and keeping a diary.

In this paper, researchers focused on capturing pedestrian movement patterns, understand collision negotiation, avoidance of route choices, grouping related differences, and route choices. The workshop was carried out to capture pedestrian movement in traditional public space and to find out Urban planning and designing aspects. Further, this is an attempt to critically review the traditional way of tracking pedestrian movement vs. the latest methods available.

Methodology

To understand the pedestrians movements in a particular location, understanding the pathways and its statistics are equally important. Due to the fast development of technology, there are many different ways of tracking and tracing pedestrian movements. Pros and cons of available technologies are discussed as the first part of the paper.

Through the review, available literature selected a method of Pedestrian Movement tracking for the project. Direct Observation, GPS tracking, and chosen video-based tracking for the project. Accordingly, collected data on the field, after collecting data, process the data for taking the output of human movement pathways.

The second part of the paper discussed about implementing the selected method in the field and compare the outcome with the traditional methods. Further, analysis of the process outcome also covered. Finally discussed the tracking of pedestrian movement and its implications towards the Urban planning and design.

Technologies of pedestrian tracking

Monitoring motion behavior of pedestrians known as tracking pedestrians and convert it to a line known as tracing of the movement. When tracking is done for a considerable time period, known as capturing trajectory data of the pedestrian. The counting of the pedestrian equally important for the project. But this research is focusing on tracking of pedestrian behavior. The data is using for calibrating pedestrian movement as a social force model (Helbing, D., Molnar, P. Schweitzer, 1994).

The pedestrian tracking methods are categorized into instructive and non-instructive approaches based on tracking. The instructive approach requires a pedestrian with tracking device. They are limited to the locations where managing devices are possible. However, Non-instructive approach is to use devices that are already used by the pedestrian (e.g., mobile phone) or without any individual devices; video cameras and visual monitoring methods are some of the examples commonly used.

In recent years a number of pedestrian tracking and counting technology have developed. But pedestrian tracking technology is not mature as pedestrian counting technologies. Further, the accuracy level of tracking technology is even lesser than the pedestrian counting technologies (Timmermans, 2009). In the laboratory environment, the accuracy level is less than 3 cm been achieved. But most of the tracking technology is not developed to deal with real-world situations.

The main objective of this section is to discuss different techniques for tracking and tracing pedestrian movements. The technology will be discussed under the main application of technology, limitation of the technology, and the accuracy and reliability of the technology.

Method Description Tracking /tracing Accuracy Constrain

Shadowing The oldest form of tracking manual Less spatial accuracy Output can be personal bias. Sample size is limited

Video-based tracking Detecting pedestrian movement through videos Tracking and tracing can be automated, but unknown accuracy level More accuracy level where video taken in bird eye view. Clarity of the object and people,

Horizontal laser scanners scanners fixed close to the floor level. Snapshot was taken every 10th second to be on 10 Hz frequency to be used special software The average deviation was amount to 3m the number of cameras and locations also matters in that case.

Passive Infrared based method Use typical temperature of the people in the environment. Passive infrared sensors have been used to detect and localize humans because of their simplicity and less privacy concerns to be used special software accuracy of 0.5 m was achieved by maximum overlap. Number of equipment matter for the

Intrusive localization methods Used to equip people with devices. Such as GPS, WLAN or Bluetooth, and smartphones. to be used special software Accuracy level depending on the equipment used. Laboratory conditions achieved 3cm with GPS. Unique for the equipment used.

Table 01: Pedestrian movement tracking method (Source: Author)

method	Description	Tracking /tracing	Accuracy	Constrain
Shadowing	The oldest form of tracking.	manual	Less spatial accuracy	Output can be personal bias. Sample size is limited
Video-based tracking	Detecting pedestrian movement through videos	Tracking and tracing can be automated, but unknown accuracy level	More accuracy level where video taken in bird eye view.	Clarity of the object and people,
Horizontal laser scanners	scanners fixed close to the floor level. Snapshot was taken every 10th second to be on 10 Hz frequency	to be used special software	The average deviation was amount to 3m	the number of cameras and locations also matters in that case.
Passive Infrared based method	Use typical temperature of the people in the environment. Passive infrared sensors have been used to detect and localize humans because of their simplicity and less privacy concerns	to be used special software	accuracy of 0.5 m was achieved by maximum overlap.	Number of equipment matter for the
Intrusive localization methods	Used to equip people with devices. Such as GPS, WLAN or Bluetooth, and	to be used special software	Accuracy level depending on the equipment used. Laboratory conditions achieved	Unique for the equipment used.

	smartphones.		3cm with GPS.	

selecting of technology for tracking and tracing the pedestrian movement

After studying available technology of pedestrian tracking, considering cost, time, and technological, selected methods for the project as traditional method (Shadowing), GPS method, and video tracking. Shadowing is important to capturing general understanding of the place. Compare to other methods in GPS method processing data is easy and has considerable accuracy level. In video method, output accuracy is more compare to other methods but processing data is complex due to the unknown accuracy level of tracing software.

Project

Project methodology

The traditional way of tracking pedestrian movement was carried out as the first step. Two significant methods were executed to tracking the pedestrian movement. There are direct human observations and questionnaires carried out with the pedestrian. Direct observation is done by two groups using two methods. They are observing from higher ground and by following the pedestrian.

Having compared the available techniques for tracking people's movement, GPS tracking and video tracking were selected as a new technological methods due to the accuracy level, time is taken, resources required, and the cost.

People were employed for GPS tracking. "GPS beacon" (data pusher type), which updating attitude and speed in every 10s interval used for the project. Further, the data extracted from the server of www.gps1314.com. The team members waited at the entrance, and after a short interview with the pedestrian, the GPS given to the pedestrian. Instructed the pedestrian to carry the GPS while they were moving in the premises. Qualitative data regarding the journey and the respected pedestrian data were noted with the interview. Such as reason of the visit, pedestrian profile, time is taken(start time, end time), etc. Subsequently, the data processed using GIS software.

For the video, tracking, use MEVIC pro 2 drones in birds eye view in open space at the premises. The video camera set different timing of the day and different days of the week. Due to the cost and unknown accuracy level of the video processing software, the movement pattern was processed manually.

Selecting site

The project was carried out to tracking pedestrian data under limited site constrain and simple nature of the site. Thus the case selected where non-motorized environment, well-defined entry and exits, and where both open-air and indoor area available. Considering the factors, complexity, and controllable complexity the Longshan temple at Anhai China selected as the case for the project. The place built-in 1896 in Chin dynastic period.

Since it is a traditional place, user behaviour cannot predict easily. The place functions as believers place and also function as a tourist place. Since the nature of the place, four types of users recognized in the place.

Output of the methods and analysis

The output of Direct Observation

Figure 01 shows the output of direct observation. The team waited at the entrance, and the shadowing was done by following the pedestrians. Further, some of the team members

are observed from higher ground and tracking pedestrians. Since it is manually done, the accuracy level is in question. Also, it needs too many people for tracking. Hence it is expensive to carry out this method. This method is not suitable for crowded places since challenging to track when it is crowded.

Figure 01: Direct Observation

Source: Author

The output of video-based tracking

Figure 2 shows the output of video-based tracking. Setting a video camera is challenging for video tracking. The number of cameras depending on the area wanted to cover. Further, it will differ in open areas and covered areas too. The clarity of the video also depending on the hight that the camera sets and the condition of the ground. For the processing of the video, we can use the software. Due to the cost and unknown accuracy level, use manual processing used for the project. Hence it is difficult to trace for the crowd scenarios. Through the method complex task, the route trajectory of pedestrian movement is detailed compared to other methods. Here we used a drone technology that was limited to apply for open space. Accuracy level is more due to slow-motion video play and can play n number according to your need. Less time take, and less workforce compare to other methods. But need more skills to manage technical data related to the method.

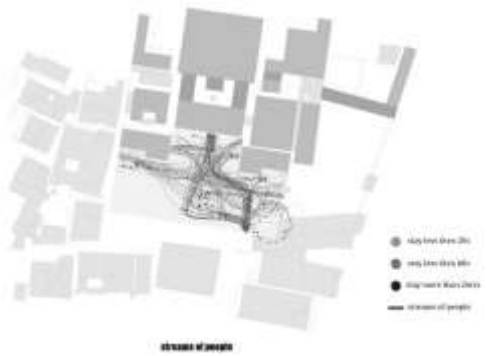

Figure 02: Video output

Source: Author

The output of GPS tracking

Figure 03 a, b, c, and d shows GPS tracking output of Local beleivers pathways. The GPS device gives co-ordination every 10 Sec (Figure 03a). With the help of GIS create connect the pathway of the pedestrian (Figure 03b). Hence the movement pathway is not as smooth as human movement tracking. The device itself has an accuracy level as well as sometimes weather conditions also matter for the tracking. The data can easily process with GIS software.

With the intence of the pathways moderate pathways identified according to the users (Figure 03 C). Further heat maps generated with GIS (Figure 03 d).

The method is flexible to track people in an indoor and outdoor environment both. To maximize the number of output, and collect group movement, tracking needs more number of devices. From a questionnaire before the journey matter to categorized data according to the user category.

Conclusions

This field of research is emerging research and challenging with the new inventions in the field. The main objective of this project is to capturing pedestrian movement, tracing the same for Urban planning and designing. This research will act as the basement to many researches, not only Urban planning and designing but also for the many other fields. The traditional method of pedestrian tracking is compared with other means of monitoring, considering the cost, time, and availability of technologies. The tracking method output result cannot compare due to each method result will depending on time carried out on the project technology itself and the limitations of the methods. But the selected method gave a single form of output, which is

the line diagram of pedestrian movement pathways. Researchers in the strong contensious that the understanding of how space is working will improve the space experience and enhance the quality of space through planning and designing will be possible in the future.

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Geospatial based Land suitability assessment for waste dumping A case study on Kesbewa DSD, Sri Lanka.

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Abstract: In the current context, waste dumping could be identified as the foremost and rising issue of Sri Lanka. Still, Sri Lanka has not followed a proper waste recycling system and as a result, the number of waste dumping sites was increased in nearby suburbs and those locations endangered to nature. Therefore, systematic waste disposal and scientific location selection for waste dumping is a national requirement.

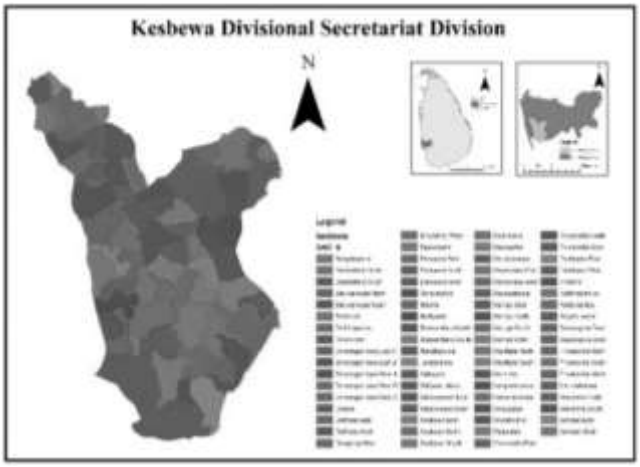
This study investigated the waste dumping problem in the third high populated area in Colombo District, the Kesbewa Divisional Secretariat Division. The suitability of waste dumping of each land parcel was analyzed by utilizing both raster-based and vector-based approaches. Data were collected from Survey Department of Sri Lanka and open-source satellite data platforms. There are eight data layers manipulated over the study such as Building, Land use, Slope, Waterbody, Road, Reservation, and Population. Further, an investigation performed by using the Geographical Information Sciences (GIS) environment with the use of ArcGIS 10.5 software.

Finally, prepared the factor maps and identified the suitability of land parcels for waste dumping. Further, it has revealed that the existing Karadiyana waste disposal site only has 38% of suitability and not in suitable condition for waste dumping. In addition, it directly connected to the nearby Bolgoda river and emphasized as a major warning to human and environment in future. Consequently, in order to overcome that issue identified three suitable locations for waste dumping by the study in the Kesbewa area.

Keywords: GIS, Karadiyana, Kesbewa, Waste dumping

Introduction

The Colombo District includes with 13 local authorities and has three final disposal sites (DS). Among the disposal sites, the Karadiyana DS is



located in the very south of the district and receives waste from Moratuwa Municipal Council, Mount Lavinia – Dehiwala Municipal Council, Sri Jayawardanepura Kotte Municipal Council, Maharagama Urban Council, Panadura Urban Council, Kesbewa Urban Council and Boralegamuwa Urban Council ('Karadiyana Garbage Dump – Environment Foundation (Guarantee) Limited'). The disposal site is operated by the Waste Management Authority of the Western Province and the area of the DS is approximately 10.12ha ('Putrescible Waste

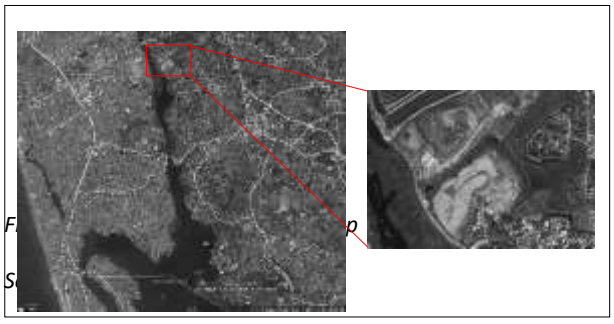
Landfills as Bird Habitats in Urban Cities: A case from an Urban Landfill in the Colombo District of Sri Lanka', 2019) .

Kesbewa Divisional Secretariat Division was the target area for this study. It is situated in the Western Province of Sri Lanka, Colombo District, bordering to Lake Bolgoda, and between Latitude 6°44' to 6°51' North and Longitude 79°54' to 79°58' South (Fernando, G. M. T., Sangasumana, V., & Edussuriya et al., 2015). The division's total land area is of 61.44 square kilometres, and the population is 245,232 (ABS, 2012). Kesbewa DSD is the 3rd highest populated DSD in Colombo district. Therefore, generate high waste loads daily. Garment and agricultural industries (rice and rubber plantation) are the main industries of Kesbewa DSD (Fernando, G. M. T., Sangasumana, V., & Edussuriya et al., 2015).

This study is select a suitable location in Kesbewa Divisional Secretariat Division (DSD) by using suitable criteria and analyse the suitability of the Karadiyana garbage dump in Kesbewa Divisional Secretariat Division.

The Kesbewa Urban Council function solid waste management and sewage treatment activities based on the section 118-120 of the Urban Council Ordinance No. 61 (1939) and the Public Nuisance Ordinance (1863) and they haven't formulated any master plan or action plan relevant to solid waste management yet (Kogyo Co, 2016).

Uncontrolled open dumping and improper waste management causes for various problems such as including contaminating ground and surface water, attracting insects and rodents, increasing flooding due to blocked drainage canals or gullies and generation of toxic, and heavy rainy days residents have to face lot of difficulties due to the waste mixed water flow ('Karadiyana garbage dump becomes threat for area residents _ mirrorcitizen'). Landslide of The Meethotamulla garbage dump, lot of wastes are disposed here. All these problems directly effect on social, environmental sustainability of the ecosystems.



Geographic information system (GIS) is an efficient tool which can do several analyses. It efficiently stores, retrieves, analyses and display information according to our purpose. The software has an ability to manage large amount of spatial data from various sources and its saves time. The objective of this study is to select a suitable site using the GIS and assessment about the Karadiyana garbage dump.

Methodology and experimental design

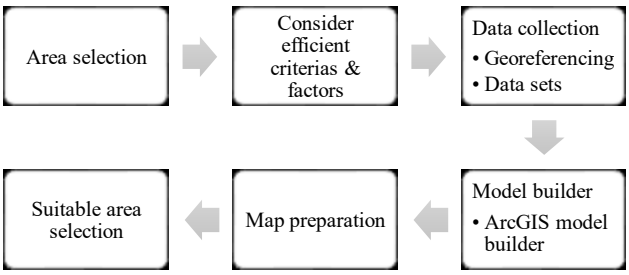


Figure 3. Methodology Flow

Six steps in the methodology which used to select the suitable sites for waste dumping as seen in Figure 5. Firstly, identified the study area. After that consider suitable criteria and factors, and did Data Collection according to developed criteria and factors in this study area for map preparation. In here, used model builder for vector based analysing part by using ArcMap 10.5 licensed software and finally prepared factor maps through the GIS based model and find the suitable areas.

Efficient criteria and considering factors

In this analysis used eight map layers for the study. Building, Land use, natural, River, Road, Place, and Population. And used a DEM to consider the elevation. then want to gain what are the suitable areas. So, considered some factors to fulfil this case study.

Table 1. Criteria and references

Criteria	References
Building	('GIS application in locating suitable sites for solid waste landfills Jayawickrama, N. T. and Weerasinghe, V. P. A', no date)
Land use	(Balasooriya et al., 2014)
Waterbody	('GIS application in locating suitable sites for solid waste landfills Jayawickrama, N. T. and Weerasinghe, V. P. A', no date)
transportation	(Balasooriya et al., 2014)
slope	('GIS application in locating suitable sites for solid waste landfills Jayawickrama, N. T. and Weerasinghe, V. P. A', no date)
Population	(Balasooriya et al., 2014)
Reservation	('GIS application in locating suitable sites for solid waste landfills Jayawickrama, N. T. and Weerasinghe, V. P. A', no date)

Experimental Materials

GIS Software:

GIS Software can produce the graphic displays of geographic information for analysis and presentation. It also can store the geographical features and their characteristics. This software has the many kind of Benefits, such as, better information management, higher quality management, improve the project efficiency etc. in here, used ArcMap 10.5 licensed software.

Model Builder:

This tool allows to access the data stored inside a parent container, Such as fracture classes or tables inside a geodatabase

Results

In the analysing part, analysed those data with raster-based analysis.

In here, recognized what is the most suitable area for the waste dumping in Kesbewa Divisional Secretariat Division, after prepared the factor maps for each criterion.

Using ArcMap 10.5 licenced software and derived the maps

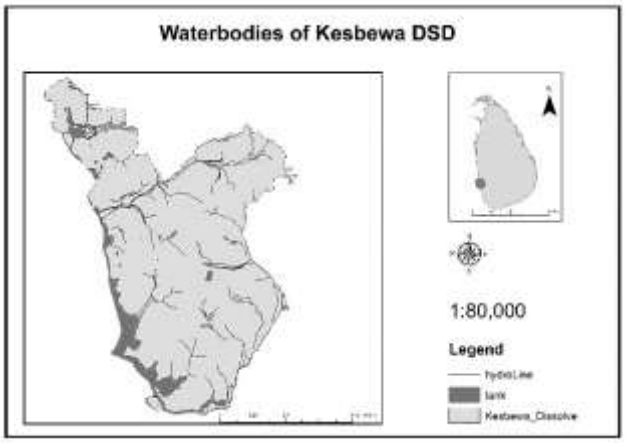


Figure 4. Waterbody Map of Kesbewa DSD

There are some waterbodies in the Kesbewa DSD and had to consider it. Specially, Bolgoda lake is in the Kesbewa DSD. If waste dumping is near for the waterbodies it will directly affect for the ground water coverage. And it will cause for the water pollution and in future, people will have to face some difficulties like lack of pure water.

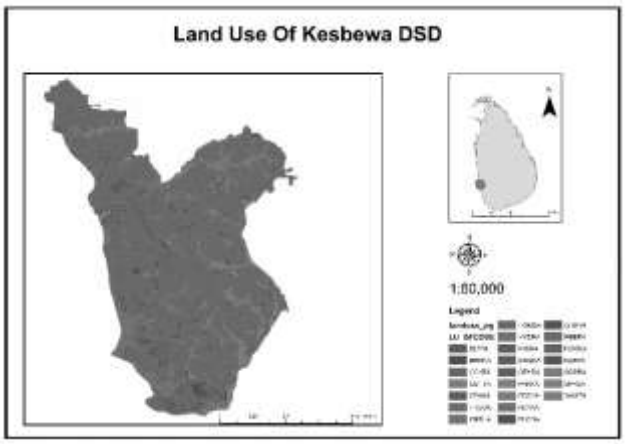


Figure 5. Land Use Map of Kesbewa DSD

People can't waste dumping in some locations like Cultivation area, Forest area, Boggy Area, Rock area, Built-up area, Sand area and water area. Normally suitable locations for waste dumping is

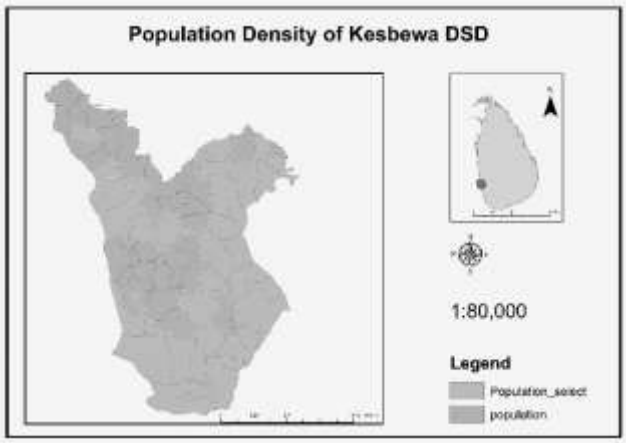


Figure 6. Population Density Map of Kesbewa DSD

Bare area. In here, consider Barren lands, Waste Land, Grassland, Scrub land.

Kesbewa DSD rank as the third highest population density in Colombo District(ABS, 2012). Population density of all GNDs in Kesbewa DSD is higher than 1000sqkm('Divisional Secretariat - Kesbewa - Statistical Information'). Minimum population density value is 1312.209961sqkm and the highest value is 22201.400391sqkm('Divisional Secretariat - Kesbewa - Statistical Information'). So, in here selected population density less than 4500sqkm areas for analysis.

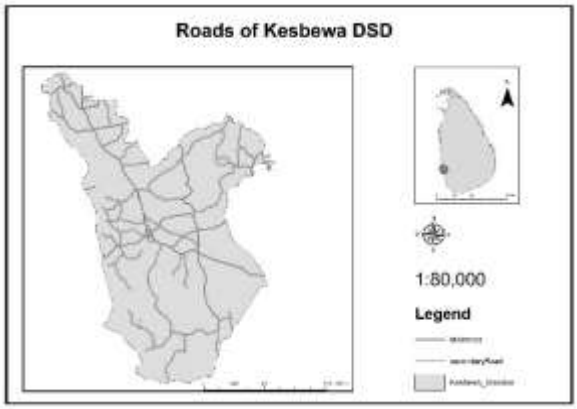


Figure 7. Road Map of Kesbewa DSD

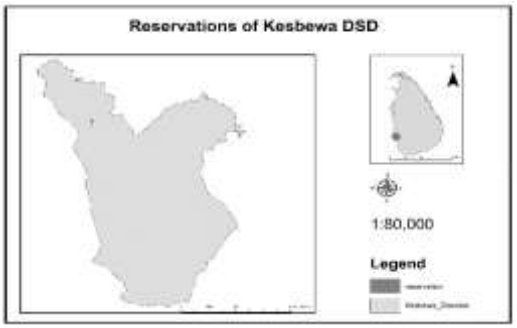


Figure 8. Reservation Map of Kesbewa DSD

Waste dumping site must locate with some distance from the road area. Because Kebewa is populous area. If the suitable location is far away from the transportation network, authority has to disburse more cost for solid waste collection and transportation.

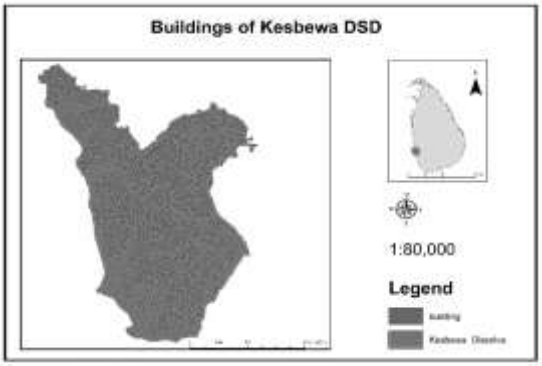


Figure 9. Building Map of Kesbewa DSD

Bellanwila – Attidiya sanctuary is the one of the reservations in Kesbewa DSD

There are lot of buildings in Kesbewa DSD due to the urbanization. But waste disposal site is not in a Build-up area.

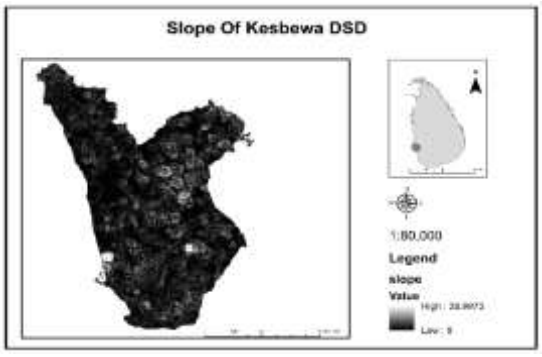


Figure 10. Slope Map of Kesbewa DSD

Normally, Kesbewa DSD is not in high altitude category. It is very close to sea level. This is very important for the waste dumping. If the slope is high, it is not suitable for waste dumping.

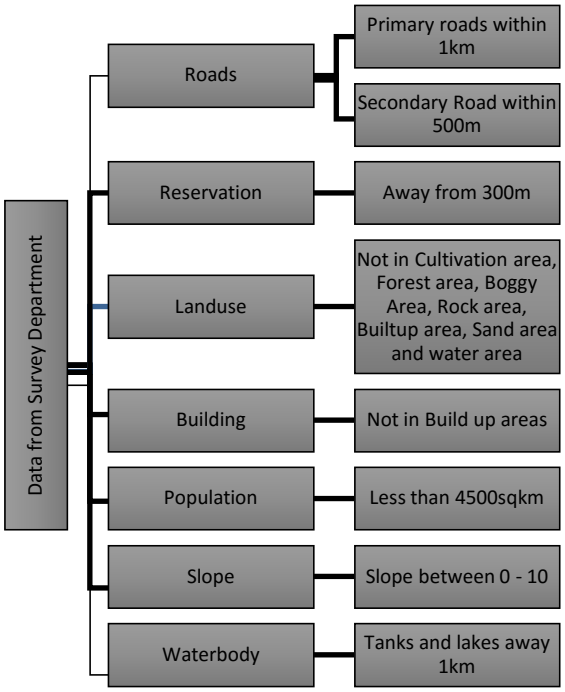


Figure 11. data processing

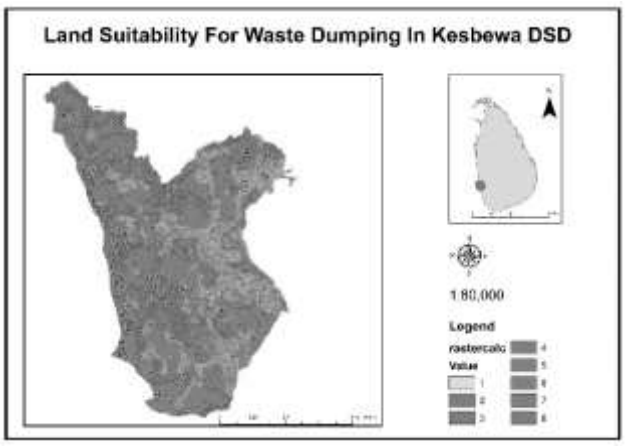


Figure 12. Suitable area for waste dumping

Finally, selected the suitable location intersecting the above criteria at last, by using a Raster format. The output represents with suitable areas and unsuitable areas. Land suitability is representing with a numbering system. E.g. Value No. 1 means only satisfy a one criteria and no.8 means satisfy the all criteria.

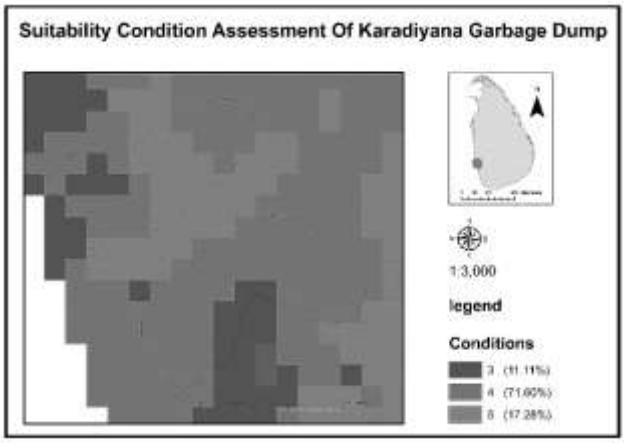
For easiness of the study again reclassify the data; the area which satisfy only five conditions as not suitable areas, the area which satisfy only six conditions as moderately suitable areas, the area which satisfy only seven conditions

Figure 13. Reclassification of the suitable locations

as suitable areas and finally the area which satisfy all conditions as most suitable areas,

Finally, selected the Karadiyana area from Google Earth and Georeferenced to the ArcMap workspace to consider the suitability of Karadiyana Garbage Dump in Kesbewa DSD.

Enlarge karadiyana and only add that area.



According to this analysing, Karadiyana garbage Dump is not in the selected suitable area of Kesbewa Divisional Secretariat Division. The Bolgoda lake is very close to the Karadiyana garbage dump. It is a big issue. Karadiyana garbage dump may be a risk for the residents and directly cause for the contaminating ground and surface water in future Not only human, also it constrained for the animal's lives. It may be affected for the landslide in future.

Analysing the changes in Karadiyana Garbage Dump, can get an idea how the area is changed.

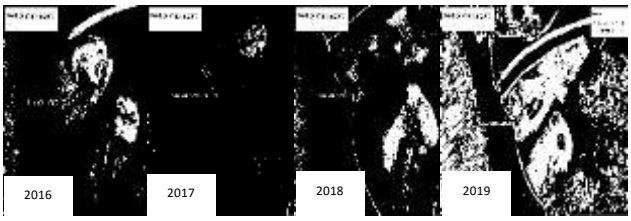


Figure 15. Changes in Karadiyana Garbage Dump

Source: Google Earth

Discussion and Conclusion

This analysis includes how to select a suitable area for waste dumping by using different criteria. The ArcMap licensed software is very useful for the investigation of this study. ArcMap licensed software is convenient for students to use for their project works.

There are several methods for waste disposal; landfill, waste compaction, composting, biogas generation. But unfortunately, in Sri Lanka, mostly use the open dumping landfill method. These areas generally satisfy the minimum requirements for the site selection. If select the suitable areas for waste dumping, it will protect the groundwater as well as surface water for the plantation and human purposes. In this base of Analysis suitable area for waste dumping in Kesbewa DSD was not in the Karadiyana area. However currently karadiyana is use for waste dumping. Although it's not satisfied basic conditions that required (Figure: 14). Under this investigation, we have considered eight Characteristics to select to a suitable location for waste dumping.

Authority can do the landfilling as Open dumping and closed dumping. The most common one is open dumping. According to our analysis, we have found some suitable areas and three of them identified as ideal locations. Actually, authority can use these areas for closed dumping. And recommend using these places as a cycle. One place used as a closed dumping area and rotate to another area. After that rotate each one, the first area that was chosen may be compost and again suitable for waste dumping. Rotating and closed dumping methods are very important because it prevents the landslides of the garbage dump.

Figure 14. Karadiyana Garbage Dump

The progress of the development control needs to be monitored and evaluated annually and to take remedial actions to rectify incompatible development activities. Monitoring the application of the regulation within the zones need to analyse properly by the GIS tool. GIS is very helpful for analysing and make predictions. Zoning and their regulations and promoting or discouraging the activities need to do then and there with the evaluation of GIS.

Acknowledgement

Firstly, I would like to acknowledge the support of Lecture Mrs.Sandamali K.U.J, Department of Spatial Sciences for their supervision and encouragement.

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Remote sensing based habitat mapping of Vankalai coral reef, Sri Lanka

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Abstract: Coral reefs are an important coastal eco-system in Sri Lanka. Current study was conducted on Vankalai area regarding to develop new method of remote sensing technique to mapping and monitoring the particular coral reef eco-system. Downloaded Landsat 8 satellite images were processed under the three headings which are preprocessing, processing and post processing. Image preprocessing is used to eliminate errors in satellite images. Depending upon the source of error, inadequacy revision and imperfection expulsion are separated into two types such as radiometric correction and geometric correction. In radiometric correction the foremost requirement is to conversion of DN values to spectral radiance values. And the next step is conversion of radiance values to Top of Atmospheric (TOA) reflectance which could be identify as a unit less ratio measurement. Normalized difference water index was used to enhance water features and suppress the land area. Different types of bottom substrates were identified using Depth invariant index (DII) for study area and which are classified according to the bottom substrate using unsupervised classification. Five types of different spectral classes were identified using developed method which are coral reef, rough bottom, vegetation cover, sandy bottom and deep muddy area. These spectral classes are related to elevation of benthic habitat. Ultimately map was generated with regarding to the bottom substrate for particular study area using Landsat 8 image. It is an extensive reef area but lack of details yet. This study is the first attempt to use Landsat 8 for coral reef mapping in Sri Lanka.

Keywords: Coral reef, Depth invariant index, Landsat, Vankalai.

Introduction

Coral reefs are important and very sensitive ecosystem. It is a very fragile environment. Coral reefs are rich in diversity and concern as rain forest of ocean. These areas provide shelter for numerous animals and plants. Hence it act as feeding and nursery ground for numerous reef and reef associated organisms. This area is important to protect coast against wave action and as a result create ideal conditions for another coastal ecosystem. Coral reefs are affecting the country's economy and there has lot of benefits for human being.

Including Sri Lanka and in other tropical countries coral reefs are in severe stress due to effect of man-made threatens and natural causes. In Sri Lanka the major causes of reef degradation are coral mining, destructive fishing practices and unplanned tourism & pollution from land based source.

As an island, Sri Lanka enriched with the fringing reefs, bar reefs and barrier reefs around the coast of Sri Lanka. True coral reefs are found which are mostly found as fringing reefs. They are found Island around

the Jaffna peninsula in the North, from Trincomalee to Kalmunai on the East coast, from Tangalle in the South to Akurala in the South western and in the North western area found from Mannar Island southward to Kalpitiya peninsula and Bar reef. There are small coral banks at Kandakuliya and Thalawila on the west coast of Kalpitiya peninsula. In the western coast of Sri Lanka, at three locations barrier type reefs have been identified which are Vankalai, Arippu, Silavathurai and Bar reef. In addition to that corals have also colonized in two under water ridges called, the Great & Little Basses of the South Eastern coast of island (Rajasuriya et al., 1997, Rajasurya and White 1994). In western coast, this barrier type reef is a well-developed eco system (Rajasuriya et al., 1997, Rajasurya and White 1994). But significant factor is no any recent studies have done around this western coast barrier reef of Vankalai, Arippu and Silavathurai area. Hence Vankalai area was selected for the studies in this research study.

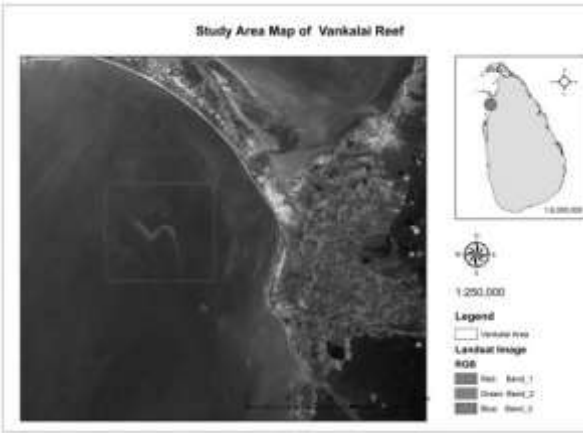

Figure 1. Study area map of Vankalai reef.

Figure 1 illustrates the study area of Vankalai reef. The use and application of this remote sensing technology to study underwater habitats is significantly beneficial. It helps and effects to monitor and protect the environment, resource manage, protect from natural disaster and for the sustainable development of resources and environment. Landsat 8 is a recently launched satellite system under the Landsat Earth Observation program and it contains significant characteristics to provide high quality image. Hence Landsat 8 satellite imageries were used for the studies of this area.

Remote sensing relies on the electromagnetic energy. Incident electromagnetic wave travel twice through the atmosphere as from Sun to the Earth surface and Earth surface to sensor and reflected radiation is representing the information about the surface characteristic of the objects. During this journey, the energy affected to the different interactions. Hence sensor received data is not in accurate to provide the exact real surface reflectance values of the object. Hence before the use of satellite image should have to follow the pre-processing step under the radiometric correction.

Normalized difference water index is used to enhance the open water features and suppress the land area. Also severity of light attenuation is removed using NDWI. Also this is important for the habitat classification. Depth invariant index was used establish the relationship between spectral signatures of similar benthic features at different water depths.

Image classification techniques include two major categories which are supervised and unsupervised classification. Grouping or clustering of pixels with common characteristics is simply known as unsupervised classification. Supervised classification is based on idea of user and it can be applied as individual pixel level or image objects using ground data. Remote sensing satellite techniques are used to study such area under the several factors.

Methodology

Figure 2 illustrates the flow diagram of methodology. The digital image processing was done under the three headings such as Preprocessing, processing and post processing.

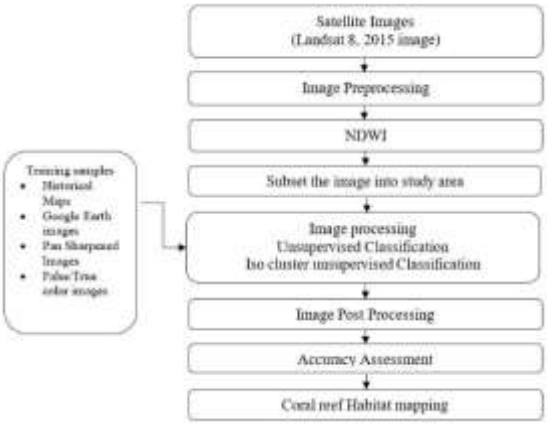

Figure 2. Methodology flow

Image pre processing

Image preprocessing is the most essential requirement to eliminate errors in satellite images. The conventional term for pixel values is Digital Number (DN). It is ordinarily used to portray pixel values that have not yet been aligned into calibrated units. Raw remotely detected image information contains defects or insufficiencies and correction is required proceeding to image processing. Depending upon the source of error, inadequacy revision and imperfection expulsion are separated into two types such as radiometric correction and geometric correction (Minakshi, 1996).

In radiometric correction the foremost requirement is to conversion of DN values to spectral radiance values. Computation of at-sensor spectral radiance is the key advance in changing over image data from different sensors and stages into a regular radiometric scale. Radiometric adjustment of the multi spectral scanner (MSS), thematic mapper (TM), enhanced thematic mapper plus (ETM+) sensors includes rescaling the digital numbers (Q) transmitted from the satellite to calibration (Qcal), which has the equivalent radiometric scaling for all scenes handled on the ground for a particular period. During radiometric calibration, pixel values (Q) from raw, natural satellite image information are changed over to units of absolute spectral radiance using 32-bit floating-point calculations.

$L\lambda = ((LMAX\lambda - LMIN\lambda)/ (Qcalmax - Qcalmin)) \times (Qcal - Qcalmin) + LMIN\lambda$

Where;

$L\lambda$ = Spectral radiance at the sensor's aperture [W/ (m2 sr µm)]

Qcal = Quantized calibrated pixel value [DN]

Qcalmin = Minimum quantized calibrated pixel value corresponding to $LMIN\lambda$ [DN]

Qcalmax = Maximum quantized calibrated pixel value corresponding to $LMAX\lambda$ [DN]

$LMIN\lambda$ = Spectral at-sensor radiance that is scaled to Qcalmin [W/ (m2 sr µm)]

$LMAX\lambda$= Spectral at-sensor radiance that is scaled to Qcalmax [W/ (m2sr µm)]

And the next step is conversion of radiance values to Top of Atmospheric (TOA) reflectance which could be identify as a unit less ratio measurement. When comparing images from different sensors, there are several favorable circumstances for utilizing TOA reflectance rather than at-sensor spectral radiance such as it removes the cosine impact of various sun zenith angle because of the time difference between information acquisitions, TOA reflectance makes up for various estimations of the exo atmospheric sun oriented irradiance emerging from spectral band differences,

TOA reflectance rectifies for the variety in the Earth-Sun distance between various image dates and etc. These varieties can be noteworthy topographically and temporally. The TOA reflectance of the Earth is calculated as follows:

$\rho\lambda = (\pi \times L\lambda \times d2)/ (ESUN\lambda \times \cos \theta s)$

Where

$\rho\lambda$ = Planetary TOA reflectance [unitless]

Π = Mathematical constant equal to ~3.14159 [unitless]

$L\lambda$ = Spectral radiance at the sensor's aperture [W/(m2 sr μm)]

d = Earth–Sun distance [astronomical units]

$ESUN\lambda$= Mean exoatmospheric solar irradiance [W/(m2 μm)]

θs = Solar zenith angle [degrees] (Chander et al., 2009)

Normalized difference water index (NDWI)

Normalized difference water index is designed to maximize reflectance of water by using green wavelength, minimize to low reflectance of near infrared (NIR) by water features and take advantage of high reflectance of NIR by vegetation and soil features. Hence enhance water features and suppress the land area.

NDWI = (Green-NIR)/(Green+NIR)

Depth invariant index (DII)

Sea bottom classifications are depending on the radiance value of the object but which are not represent the actual value due to the effect of attenuation of electromagnetic energy in the water column.

Depth invariant index is used to establish the relationship between spectral signatures of similar benthic features at different water depths. These spectral signatures are modified from water column effect by this index.

Unsupervised image classification

Grouping or clustering of pixels with common characteristics is simply known as unsupervised classification. It is a most basic technique because clustering does not require training data. First, select the region of interest (ROI) area via grouping the pixels turn in to clusters using their properties. To create clusters, analysts could be use image clustering algorithms. After picking particular algorithms select the number of groups or classes which want to generate.

Accuracy assessment

Quantitatively clarification of the accuracy requires for image classification in order to understand the reliability of the classified result. It provides certification for the classified image while describing its reliability and accuracy. Therefore systematic accuracy determination is most essential in image classification approaches (Minakshi, 1996). For the purpose of accuracy determination, we require ground truth samples and then GCPs were obtained by using the Google earth and the historical maps. Random distribution points were collected and evaluated to obtain the accuracy for each image. We used the assessment between the producer and user and the Kappa coefficient to determine the accuracy (Jiang, Stritholt, Frost, & Slosser, 2004) .

Results

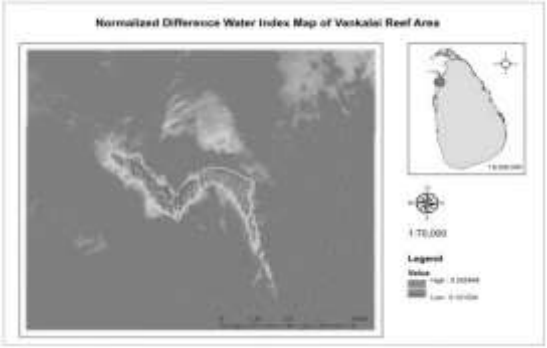

Figure 3. Normalize difference water index of Vankalai reef area.

Figure 3 illustrates the normalized difference water index of Vanakali reef area. After pre processing, NDWI is applied to enhance the water features while suppressing the land area and it represents the relationship between spectral signatures of similar benthic features at different water depths. Comparatively coral reef area represent the high resolution value.

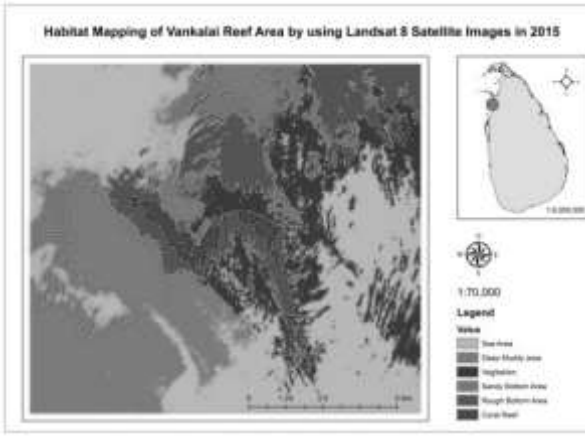

Figure 4. Habitat mapping of Vankalai reef area by using Landsat 8 satellite images in 2015.

Figure 4 illustrates the habitat mapping of Vankalai reef area by using Landsat 8 satellite image. Unsupervised classification is applied to habitat mapping and it's represent five spectral classes in this area which are coral reef area, shallow rough bottom area, sandy bottom area, vegetation and deep muddy area.

Discussion

Habitat mapping was done base on the index variation and these spectral classes are related to the elevation of benthic habitat. Five classes were identified which are coral reef, rough bottom, sandy bottom, vegetation and deep muddy area. Most important thing is such kind of extensive and well-developed reef area is found only around this area in Sri Lanka (Rajasuriya 1988, 1993, 1991). Unfortunately concern about the current status of the coral reefs, reefs are greater threaten than even before (Rajasuriya., 2013). Encountered dynamites fishing activities and use of prohibited mesh gill nets (lyla, surukku nets) for fisheries on coral reef had been caused the coral reef destruction. Unfortunately, no authorities were present to stop them from carrying out their routine dynamiting on extensive shallow coral bank in the area. Hence there were large patches of destroyed coral because of this prohibited fishing operation.

Landsat 8 is a courser resolution satellite system. It means it has medium resolution satellite image and it use for a rough habitat mapping and also roughly estimate the relevant area without having a high resolution satellite image data. Normally high resolution satellite data are used for habitat mapping. But through this study have proven that medium resolution data can used for such approximate habitat classification.

Lack of field data and bathymetry was major limitation of the study. Supervised classification of habitats and accuracy assessment was failed without ground source data. Also this study is cannot identify the exact area due to the low resolution and area is restricted to the small area. The other thing is study area belongs to the sea area. It often results to the changes with current,

waves and wind effects. These factors affect as limitation of this study and as further development of this study have to carry these parts to overcome these issues.

Conclussion

Study area of Vankalai reef area is a well-developed and extensive reef in Sri Lanka. Landsat 8 multispectral satellite image data was used to develop the study area map. Developed method was used to identify the spectral characteristics of benthic habitat of the study area. Ultimately map was generated for the coral reffs around the Vankalai area.

Acknowledgement

We would like to acknowledge every person who helped us in different ways during the research work.

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Vegetation Condition Index based Agricultural Drought mapping over the past decade of Sri Lanka by utilizing the Satellite Remote Sensing

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Abstract: Drought is one of the main disasters that act as a silent killer among Sir Lanka and it is the disaster that affects the highest number of people over the country. Further can identify different types of droughts such as Meteorological drought, Hydrological drought, Agricultural drought, physical Drought, and Socio- economic drought. Under the investigation explored the agricultural drought of Sri Lanka since Sri Lanka is an agricultural nation and it requires systematic and scientific investigation to study the magnitude of the Agricultural drought. Sri Lanka is one of the Asian countries which is often experienced in drought risks, when drought has happened it is constantly changed into disaster making various antagonistic effects on the network. The integration between Remote sensing techniques and Geographic Information Systems (GIS) was used for the investigation which is sophisticated in environmental studies rather than field data collection. Integration between 10 years (2009 to 2019) of Moderate Resolution Imaging Spectroradiometer (MODIS) remote sensing images were utilized for Agricultural drought detection by using the Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI) for the study in ArcMap 10.1 software environment. As a result of the study presented an Agricultural drought risk assessment map for 2019 in Sri Lanka. Rendering to the results, it shows a considerable increase in drought conditions over the past decade of Sri Lanka while showing the dominant type is still no drought condition of 68% from the total area.

Keywords: Agricultural Drought, GIS, NDVI, Remote Sensing,VCI

Introduction

The scientific and geographical identification of weather extremes is an important component in day to day life. This understanding helps to face these weather extremes in an appropriate way. Significant influences of those extraordinary situations on the civilization are more likely to influence through variations of utmost events than through slow fluctuations in mean conditions and which is why hydro-meteorological changes have attracted significant influence on human society within the recent era.

The earthquakes, hurricanes, floods, and droughts were the leading natural hazards that folks remember when the word heard the "hazard". These events act as natural agents who transform a vulnerable human condition into a disaster. Purely hazards themselves aren't considered as disasters.

But the influence of those disasters on the people and their environment causes a disaster situation. Drought is one among the many hazards among common risks to individuals' employments and financial improvement. Drought will, generally, happen less much of the time than different liabilities. Nevertheless, when it does occur, it generally affects a broad area for periods or years at a time. this will cause a much bigger extent of the inhabitants being influenced by drought than by different calamities. Drought may be a natural a part of the climate, in spite of the very fact that it'd be mistakenly considered as an uncommon and arbitrary occasion. It happens certain all intents and purposes every zone, yet its attributes fluctuate essentially starting with one area then onto subsequent. Drought may be a transitory distortion; it contrasts from aridity, which is restricted to low precipitation locales and may be a perpetual component of the climate (UNISDR, 2009). Agricultural drought is characterized all the more ordinarily by the absence of accessibility of soil water to assist harvest and forage development than by the take-off of typical precipitation over some predetermined timeframe. The connection between precipitation and penetration of precipitation into the soil is often not immediate. Penetration rates differ contingent upon precursor dampness conditions, slope, soil type, and therefore the power of the precipitation occasion. Soil qualities likewise contrast. as an example, a couple of soils have a better water-holding limit, which makes them less powerless against drought. Hydrological drought is generally defined by deficiencies in surface and subsurface water supplies relative to average conditions at various points in time through the seasons. Agricultural Drought this type of drought happens when there's not sufficient dampness to assist normal harvest creation on ranches. Albeit farming drought frequently happens during dry, hot times of low precipitation, it can likewise happen during

times of normal precipitation when soil conditions or agrarian strategies require additional water (SAARCDMC, 2010).

Methodology

The satellite or remote sensing methods might be apply to observer this state, previously, throughout or after disaster. they will be utilized to offer pattern information against which future changes are often considered while the GIS systems give an appropriate structure to coordinating and breaking down the various kinds of information sources required for disaster checking. Remote sensing provides land resource data within the sort of digital magnetic types and in several bands of the spectrum. Satellite remote sensing data, with their repetitive nature, have proved to be quite useful in mapping land use and land-cover patterns and changes with time. Quantification of such changes is feasible through GIS techniques albeit the resultant spatial datasets are at different scales/resolutions. This facilitates planners' and researchers' studies of the spatial difference and distinction between various land types from multi temporal satellite data (Muthumanickam et al., 2011). NDVI has become an important indicator for mapping changes in vegetation spread and investigating natural effects. NDVI is employed not only for the precise depiction of land spread, vegetation grouping and vegetation phenology (Exhaust et al. 1982, Tarpley et al. 1984, Equity et al. 1985), but on the opposite hand, is employed adequately for observing precipitation and drought,

assessing crop development conditions and harvest yields ((Bhuiyan et al., 2006)

NDVI= (NIR-RED)/ (NIR+RED)

Where NIR and RED are the reflectances within the close infrared and red bands. NDVI may be a decent marker of green biomass, leaf region list, and samples of creation (Thenkabail & Rhee, 2017; Xiong et al., 2012). NDVI is that the most regularly utilized vegetation record. It fluctuates from +1 to - 1. Since the climate is one among the foremost significant variables influencing vegetation conditions, AVHRR-NDVI information has been utilized to guage climatic and environmental changes at regional and global scales (Navalgund et al., 2007; Pousette et al., 2014; Singh et al., 2003). Vegetation Condition Index (VCI) was first recommended by Kogan in 1997 (Thenkabail & Rhee, 2017) VCI may be a marker of the status of the vegetation spread as a component of the status of the vegetation spread as a component of the NDVI least and maxima experienced for a given environment over numerous years. There have likewise been examinations managing the estimation of grain creation that's extremely indispensable for worldwide nourishment security and exchange (Kogan, 1997). Satellite got drought pointers determined from satellite-inferred surface parameters are generally wont to consider droughts. Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI) may be a portion of the widely utilized vegetation indices.

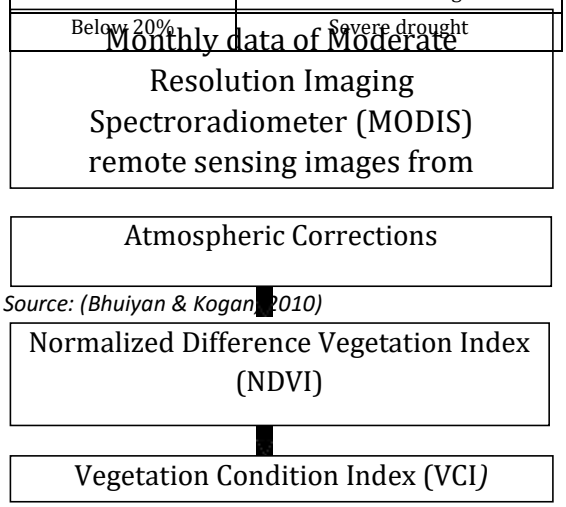
VCIj = (NDVIj- NDVImin)/ (NDVImax- NDVImin) *100

Where NDVImax and NDVImin is decided from an extended term record for a selected month, and j is that the list of this month. The state of the bottom vegetation introduced by VCI is estimated in percent. The VCI esteems between half to 100% demonstrate ideal or better than average conditions while VCI values near zero percent mirror a unprecedented dry month. The examinations recommend that VCI catches precipitation elements better than the NDVI, especially in geologically non- homogeneous territories. Additionally, VCI values show what proportion the vegetation has progressed or weakened in light of climate. it had been finished up from the above examinations that VCI has given an appraisal of spatial attributes of the season, even as its span and seriousness, and were in acceptable concurrence with precipitation designs (Ghaleb et al., 2015).

Table 01: Agricultural drought risk classification using VCI

VCI Range (%)	Drought severity class
Above 40%	No drought
30% to 40%	Slight drought
20% to 30%	Moderate drought
Below 20%	Severe drought

Source: (Bhuiyan & Kogan, 2010)



The overoll workflow of the study can be describe as the following figure 01.

Figure 01:The Complete work flow of the experiments conducted under the study

Results, and Discussion

Agricultural Drought Map of 2019

Agricultural drought relations numerous features of meteorological and hydrological drought to agrarian influences, concentrating on rainfall scarcities, alterations among definite and possible evapotranspiration, soil water shortages, abridged groundwater or tank levels, and so forth. Plant water request be contingent on dominant weather circumstances, organic appearances of the exact plant, its phase of development, and the physical and biological assets of the topsoil.

Agricultural drought has been calculated using MODIS Surface Reflectance data with 1 Km resolution. NDVI was a very sensitive widely used index for vegetation related analysis. Consequently NDVI value was determined for each image using the Red and Near Infrared (NIR) of the MODIS spectral bands. 10 years of monthly MODIS satellite images were implemented for the study which of the 120 satellite images. Annual average NDVI value obtained by averaging monthly NDVI of particular years as in Figure 02.

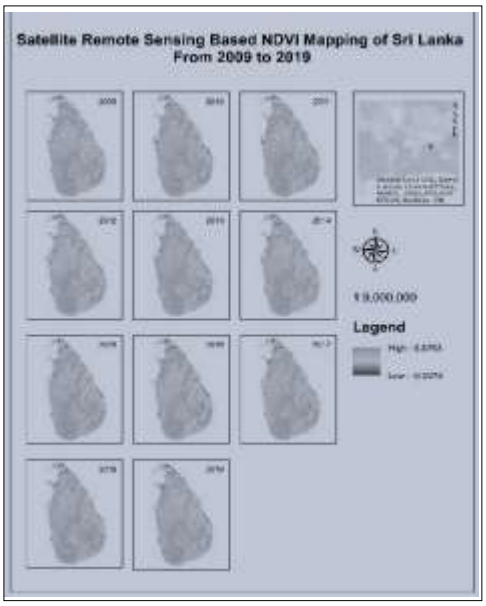


Figure 02: satellite Remote Sensing based Annual NDVI Mapping from 2009 to 2019.

Accurate assessing of condition of vegetation was vital for drought-related studies. Therefore VCI used for the analysis in order to obtain the condition of vegetation according to the NDVI anomalies. Spectral vegetation indices are among the most commonly used satellite data products for evaluation, monitoring, and measurement of vegetation cover, condition, biophysical processes, and changes. Kogan proposed a VCI based on the relative NDVI change with respect to minimum historical NDVI value. The VCI, therefore, compares the current Vegetation Index such as NDVI to the values observed in the same period in previous years within a specific pixel. Hence VCI was calculated for each image by using NDVI variances.

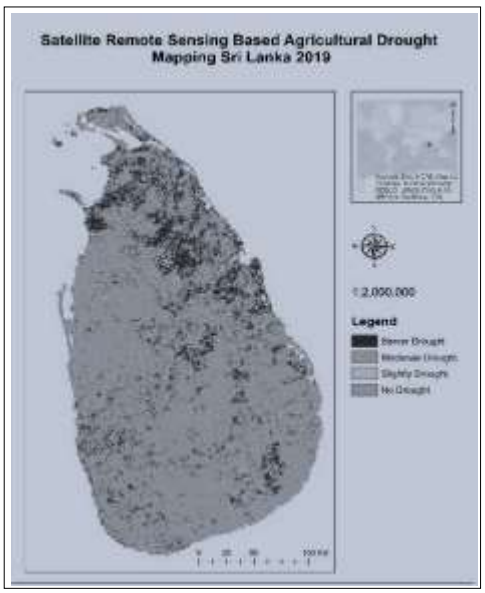


Figure 03:satellite Remote Sensing based Agricultural Drought Mapping 2019

Time series of NDVI anomaly used to detect agricultural drought. The threshold values used in this study to classify agricultural drought risk.

According to the VCI anomaly ranges drought severity was classified into four

severity classesaccording to the percentage of different harshness levels of the drought as shown in Figure 03.

Respective area coverage and percentage distribution of each type of drought in Sri Lanka in the year 2019 can be shown as following Table 02. According to the table, No drought condition could be identified as the dominant agricultural drought type of the country while server, moderate and slight drought has 16.07%, 7.10%, and 8.78% respectively.

Table 02: respective Area coverage of each drought Condition

Drought Condition	Area Coverage	Precentage of Area Coverage
Server Drought	10518 SqKm	16.07%
Moderate Drought	4646 SqKm	7.10%
Slightly Drought	5745 SqKm	8.78%
No Drought	44530 SqKm	68.05%

Because of that, Sri Lanka compromised of many of forests and agricultural lands and less urban and bare lands comparatively, it shows considerable No drought severity due to the agricultural conditions. No drought condition was the mainstream influence on the entire area as observed from the following figure 03. Therefore due to the spatial distribution of vegetation cover agricultural drought of Sri Lanka still in the non-significant severity level. But especially in the areas of the upper part of the country has considerable effect from the drought than the lower portion.

Conclusion and Recommendations

Drought is a natural hazard that involves many factors, including meteorological and climatological parameters, having complex inter-relationships. Drought definitions vary from region to region and may depend upon the dominating perception, and the task for which it is defined. Other than relying on conventional drought event counting method here present most effective method of drought mapping in spatial context by using the remote sensing aspects of agricultural drought.

Identifying patterns of drought and finding its associations with various indices derived from the conventional method and remote sensing techniques are becoming important for monitoring of this natural hazard. Dealing with a large volume of NDVI dataset for a time- series of 10 years make the study not only complicated but make it difficult to analyze. This thesis addresses the need for analyzing and studying the pattern of Agricultural drought by using spatial related time-series datasets. .

Satellite remote sensing was one of the highly developing techniques throughout the world. Currently it becomes a widely used data source for scientific studies and investigations. Most of the free data availability leads to the developing satellite remote sensing technique while having no boundary limitation for free access data worldwide. Hence, there is a lot of research to be carried out in these emerging areas, focusing on its applicability to Image processing and remotely sensed satellite imagery, which will reflect the independent signals from each source, thereby making it easy for analyzing time-series dataset. Further NDVI and VCI provide the best frame for the analysis and the VCI index scientifically suggest the significance of measuring drought by using NDVI anomalies.

GIS could be considered as fast-moving technology with the integration of web-based GIS, open source GIS, and the development of the analysis. Further nowadays it's actually difficult to find the applications where GIS not involved. Hence

GIS used as the interconnecting and analyzing platform for the study while connecting all the data in a scientific and meaningful way. Though the present work deals with satellite and meteorological parameters as well as hydrological parameters to arrive at a combined in a GIS context.

MODIS NDVI is found to be widely and extensively used for the detection and monitoring of the drought phenomenon for almost all regions of the world affected by drought effectively and efficiently. With the existence of such a dataset, it becomes easy and effective to monitor such natural phenomena. But, such datasets generally contain some of the errors introduced to the data by instrumental and data processing. So, in order to identify and remove such unwanted noise and signals from the data, the atmospheric and geometric procession was used. NDVI times-series was subjected to scale to VCI in order to estimate the vegetation health and monitored drought. To monitor drought effectively and for the identification of false alarm regions, drought identified with NDVI helped in monitoring the drought effectively thereby eliminating the false drought detected areas.

In this study it was only considered the agricultural drought and it's a one type of the drought that affect for srilaka. But there are other types of droughts could be identified such as meteorological drought and hydrological drought. Consequently combined analysis of the thse three droughts essential in in detailed drought analysis. Hence as a future development propose to do collective drought analysis while combining Agricultural drought, meteorological drought and hydrological drought.

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Paper ID: 276

Review on National Geodetic Control Network - Sri Lankan Datum 1999 (SLD_99)

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Abstract: Any country in the world has its own geodetic coordinate system and it is very useful in all types of surveying activities. Accuracy of the geodetic control network is very important in every aspect. In Sri Lanka (Early named as Ceylon), the systematic triangulation process began in 1857 and completed in 1885. This network was recomputed with some additional observation done in 1890 due to inconsistencies occurring mainly in the minor triangulation. But later found that, the new introduced fixing values have serious error. A new horizontal control network was established in 1999 with using Global Positioning System (GPS) and there were included thirty two (32) old network points to calculate the transformation parameters between the old local datum (Kandawala Datum) and the new horizontal network. But new system and old system gives different coordinates for same control points.

In this study, Kandawala network is compared with new SLD_99 network to find differences between these two networks. Scaled out figure of the ten secondary control points of SLD_99 were observed with GPS observations and analyzed to perform a network adjustment and for comparison.

Keywords: GPS, SLD_99, Kandawala Datum, Network Adjustment, Triangultion

Introduction

Any country the national geodetic control network is the most important part of their surveying and mapping activity. Sri Lanka (Early named as Ceylon) is an island, which is located in an Indian ocean and having a total area of 65,610 Km2. In Sri Lanka, the systematic triangulation began in 1857 with the measurement of Kandawala to Halgasthota base line and the measurements were made using 8 and 13-inch vernier theodolite. This process was completed in 1885. This network was connected with the Indian triangulation network by using narrow chain in 1887. This narrow chain was run on the Batticaloa – Trincomalie – Manner – Delft area. In 1890, this network was recomputed with some additional observations due to inconsistencies occurring mainly in the minor triangulation. The minor triangulation is the triangulation of first order point triangulation. Using results of these observations the “new fixing values” were introduced and these “new fixing values” were later found to be in serious error. Therefore, this result led to significance review of Sri Lankan geodetic triangulation network. After that the studies were carried out by the Survey Department of Ceylon after 1930 and they used new technologies to evaluate the reliability of the

network that formed the Kandawala Datum and computed values were included in Jacksons report and whole process was completed in 1933 (Jackson, 1933).

After 1996, this network was surveyed by using GPS and Sri Lankan Datum 1999 (SLD_99) was defined as the new datum. This SLD_99 datum has been used since 1999 for surveying and mapping purposes in Sri Lanka and both systems (Kandawala and SLD_99) were used to the requirement and availability.

When defining the Kandawala horizontal datum, the origin was fixed at Kandawala and the orientation was fixed to Halgasthota from Kandawala. For the adjustment of the network Everest ellipsoid was used and following jackson's values for semi major (a) and semi minor (b) axis were used for adjustment (Jackson, 1933).

a = 2091 2931.80 ft (6374261.613 meter)

b = 2085 3373.58 ft (6356108.572 meter)

SLD_99 datum was introduced and released for survey and mapping purposes in 1999 and GPS monument in Institute of Surveying and Mapping Diyathalawa (ISMD) was used as the origin for GPS observations and the network was adjusted by using these observations. Thirty-two (32) old points in Kandawala network were also included for this network for determining the transformation parameters between those two networks. New network is defined with the transformation from the WGS 84 (Geodetic Survey Unit, 2000).

Abeyratne et al., 2010 pointed out that ISMD origin point, GPS surveys and network adjustments that used to form the new datum (SLD_99) are not optimal and have been questioned. They also suggested that the GPS processing and the network adjustment should be re-examined. And also when examine the residuals of the adjusted network from the "Report on Sri Lanka Datum 1999" some evidences are found to be support the above suggestions.

Peculiarities in the national geodetic datum of a country would drastically affect the surveying and mapping system activities in a country. It is necessary to identify and rectify those to upgrade the national network in par with the international acceptance.

The main objective of this research is a thorough review on established and the adjustment of the Sri Lankan national geodetic network SLD_99. And also it is suggested that to carry out an experiment to mimic the GPS observations and the network adjustment of 10 base/secondary base stations of SLD_99 by scaled down geometry of the national network along with performing a GPS network adjustment The limitations of this research are, it is difficult to carry out GPS observations at the places where suspected to be problematic in the national network and also the original GPS data (raw data) which were observed for performing national Datum SLD_99 by Geodetic Survey Unit in Survey Department of Sri Lanka is not available.

Methodology

Firstly, the Report on Sri Lanka Datum 1999 was thoroughly examined to find the accuracy requirements that used to generate the SLD99 Datum.Then using the report data, an experiment was suggested to repeat the GPS observations and perform a network adjustment of base and secondary base stations of scaled down version (1:5000) the geometry of layout of SLD_99 network (base points were set out at a place where suitable for making GPS observations).

Coordinates of base and secondary base stations were collected from Report on Sri

Lanka Datum 1999. The ellipsoidal distances between ISMD base points to secondary base stations were converted to plane distances by using C++ program and this program was used to calculate all azimuths from ISMD base to all other secondary stations. When selecting the location for GPS observation some considerations were taken to minimize the obstacle for GPS observation and selected ground area was large enough to relocate the scaled down figure of the original network. Tree canopy and other obstacles such is high rise buildings, electrical utilities and water bodies should be less to get the maximum precision in GPS observations. Considering those facts, the playground of Saari Puthra Maha Vidyalaya – Imbulpe was selected to carry out the GPS observations. Figure 1 shows the established figure on the ground.

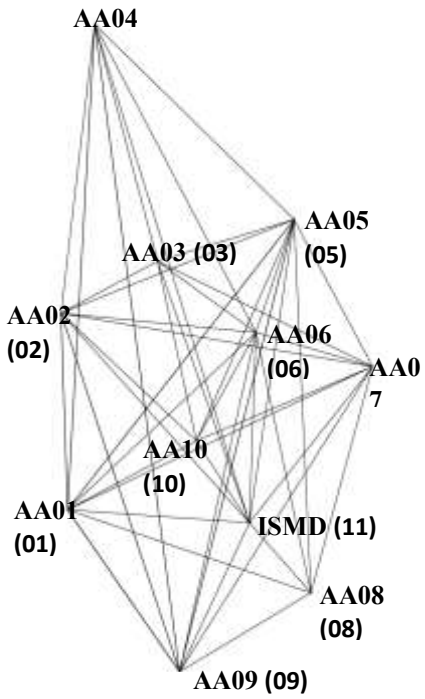
Seventeen (17) numbers of network GPS observation sessions were carried out in those points to cover the whole base lines same as used for obtained the SLD 99 network. Due to the time frame given thirty minutes observations was done in each station.

Observed GPS data was processed using LEICA Geo office software and processed data was used for network adjustment was written using Geolab software for adjust the GPS network. Then comparison was done between the results obtained from adjustment and available in the Report on Sri Lanka Datum 1999.

Results

Residuals of the adjustment of SLD_99 were re-plotted and analyzed. The resultant residuals for both in latitudes and longitudes were shown in figure 2.

The geodetic coordinates of GPS maker were calculated and compared. Here the Cartesian coordinates of WGS 84 coordinates were



obtained from International Doris service (IDS) and comparison of the GPS marker at Survey General Office (SGO) shown in table 1.

Figure 1. Scaled Down all base/ secondary GPS observation points

When the observed GPS data was processed to used network adjustment it was obtained variance factor as 37.9098 and the test was failed.

Report on Sri Lanka Datum 1999 shows, the same type of adjustment was used by Geodetic Survey Unit for Doris point at SGO and ISMD station and it was also failed with variance factor 1343.6393.

Analysis

Figure 2 shows the unpredictable trend of propagation of error throughout the network. Since there are 46 flag residuals in the Report on Sri Lanka Datum 1999 it clearly shows a possible numerical instability in the adjustment of SLD_99

datum and the situation is clearly shows in the figure 2. The international standard allows none flag residuals in a national geodetic network.

Computed coordinates of the GPS marker show in table 1, confirms and further questioned the values of WGS 84 coordinates at the ISMD. Though, it would not be affected to the local surveys, it gives difficulties when computation done with global data. For example, local GPS coordinates are different when working with the Earth geo potential models (EGMs) which are based on WGS 84.

dataset for the network adjustment and to check whether there is a relationship for the geometry and the size. When change the scale, the original shape of the network is remained due to angles are not going to be changed. However, the adjustment with adding distances was failed and further analysis of the adjustment could not be made as done by Report on Sri Lanka Datum 1999.

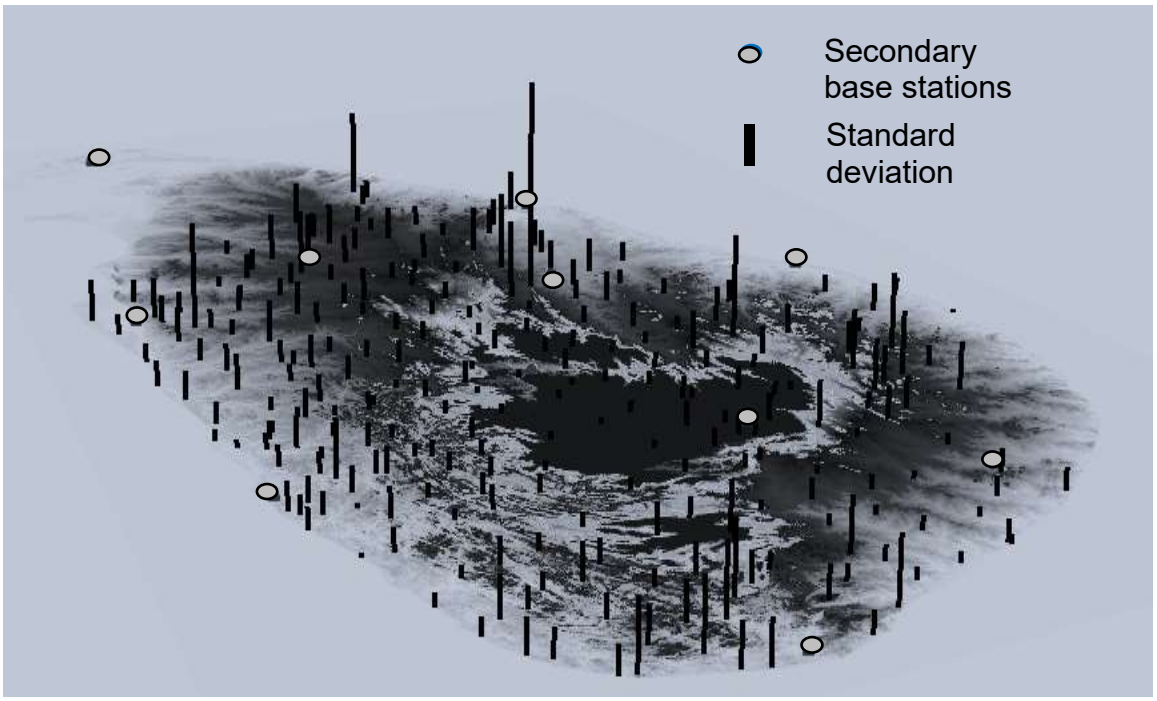


Figure 2: Total resultant residuals – both in latitudes and longitudes

Table 1. Comparison of GPS marker coordinates

Coordinate	IDS values	SGO values	Difference
Longitude	79° 52' 26.314640" E	79° 52' 26.3102" E	0.004440" (0.137 m)
Latitude	06° 53' 30.861133" N	06° 53' 30.8699" N	0.008767" (0.270 m)
Ellip. Height	-75.692 m	-76.238 m	0.454 m

Base and secondary base station network was scaled down to get a similar type of GPS

suggesting that the input variances should be tightened. However, as this adjustment is used for comparison purposes, this result was accepted. One residual was flagged.

Variance factor obtained is 37.9098, but this value should be close to 1.0, when corrected or removed any measurements containing any mistakes or large systematic errors. In contrast to that the same type of adjustment was carried out by Geodetic Survey Unit, Sri Lanka (GSU) for DORIS and ISMD stations and it was also failed with variance factor of 1343.6393.

Conclusion

As a first problem with the realization of SLD_99, COLA has since been identified as one of 17 stations with poor antenna stability and was not recommended for the DORIS core network. As such, the base-station coordinates for the differential GPS baseline to ISMD may not be as precise as they might be.

The original adjustment in SLD_99 was not successful only with GPS data and found to be acceptable when equations added for distances to the adjustment model. This is fundamentally incorrect with Least Squares principle. This situation was not tested during the study due to some practical inconveniences.

The northern part of the network was not densified due to the situation existed during the concerned period. Therefore, four secondary base stations (Jaffna, Puttalam, Anuradhapura, and Trincomalee) were established in order to facilitate densification without compromising accuracy. The final accuracy of the network may adversely be affected due to this situation. Since the sub-bases have been highly constrained during the adjustment geometrically weaker areas may be having significant residuals as we can see in the figure 2.

The effect of heights has not been studied during the experiment and observed the behavior of the residuals of the horizontal coordinates only. This experiment was done due to unavailability of the original GPS data belonged to SLD_99.

Concerning all the observations made, it is questionable the accuracy mentioned in the Report on Sri Lanka Datum 1999 with all the peculiarities noted during the study.

Following recommendations can be drawn. It is suggested to re-adjust the SLD_99 network using the original raw data under minimal constraints. This allows the network to be adjusted freely. However, the effect of adjustment with stages which performed by SLD_99 should thoroughly be studied before the implementation. The data used for the field experiment in this study can be used to test the effect on the adjustment with adding equations for distances and also be compared the reliability with the adjustment under minimal constraints.

A fresh GPS survey should be carried out in the areas where showing high residuals by using different bases and the result should be compared with the SLD_99.

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I am Manuranga KP, Have obtained B.Sc in Surveying Sciences (Specialized in Surveying & Geodesy). I would like to do my further research regarding in geodesy, GNNS and LIDAR. My research interests are all related to surveying and geodesy and I like to find out solutions for the problems in those fields.

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A GIS- Based Approach for 2D Noise Modeling using 2D City Model

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Abstract: Noise pollution of urban areas is one of serious problem. The local and urban authorities have to consider decision making processes for establishing residential, newly construction of hospitals, schools and maintaining the public places etc. The national environment act, no. 47 of 1980 provides limitation about noise emission of Sri Lanka. Road traffic is a major sources of community noise in metropolitan cities. Road traffic noise mapping is described in this research. The main objective of this research is finding the noise levels where it is less than 63dB and sub objective is finding the suitable interpolation technique for road traffic noise mapping. Noise maps can be used to monitor the issues of noise effects. Most of the noise maps are available today in two dimensional (2D) in which noise effect is presented in x, y plane. The preparing of noise map is depending on noise calculation model and 2D city model. The noise calculation model is based on amount of vehicles and speed, road type and noise absorption from the air etc. But in here considers only number of vehicles, speed of vehicles and noise reduction with the distance for the calculation of noise levels. Digital data layers which are digitized from satellite images, are used to prepare the 2D city model. The spatial analysis methods of GIS (Geographical Information Science) can play an important role to control noise pollution. GIS provides framework to integrate noise calculation models with spatial data. IDW (Inverse Distance Weighted) and Kriging interpolation techniques are used for the interpolation of noise levels. When checking the accuracy of noise levels with sample points, it recognized the IDW which better interpolation technique for noise mapping. There are 73% area is more than 63 dB sound levels and those area can't be used for as silent areas in urban planning.

Keywords: GIS, 2D City Model, Noise Mapping

Introduction

Environmental Pollution such as air, water, hazardous waste and noise pollution always been affecting for the human health. Managing the environmental pollution is a challenge although there are many management techniques the problem remains still same. One of the major environmental pollution is noise pollution. Noise pollution in urban areas and large cities harm for the human health such as sleeping, reading, speaking, communication and human mental works etc. Noise pollution can be categorized as traffic noise, industrial noise, activity noise etc. Road traffic is one of the major source of community noise in metropolitan cities. Most of researches say noise Pollution of a city is 80% in road traffic and so this research is focused only for road traffic noise pollution and preparing the

noise map. dB is the unit which used for calculating the noise. There are some rules and regulations for the noise emission in Sri Lanka. It is describing in under "THE NATIONAL ENVIRONMENT ACT, NO. 47 OF 1980". It says that day time noise level which can't be exceeded of urban city about 63dB.When preparing the road traffics noise map, it is based on creating 2D city model, 2D noise model and interpolation technique. The main objective of this research is preparation of 2D noise map for town planning by using GIS as a tool and the sub objective is introducing a better spatial interpolation technique for noise mapping.

Figure 1. Nugegoda City

Source: Google Earth

The Nugegoda city has high density of motor traffic and this area is highly noise pollution area other than closer cities such as Maharagama and Homagama in Colombo district because of highly urbanize and density of buildings. When considering Nugegoda junction there is highly noise pollution since most of vehicles are passing this junction while travelling to Colombo. When establishing new hospitals, new schools, the engineers face some problems with the noise level in this area.

2D noise map is built with the traffic noise levels. The noise levels are travelled to the every direction of the space. It is important to develop 3D noise maps that can be shown influence of noise in all directions. But mapping the traffic noise is very difficult as 3D. It must be considered the heights of the buildings and preparing the noise observation points in 3D space are very cost effective and time consuming process. So 2D noise levels are only considered here for preparing a 2D noise map. Traffic noise is generated from engine of vehicles, the friction between ground and the air. Generating of noise levels are depended on traffic volume, type and speed of vehicles, roads and the noise reflectance. For avoiding such kind of complex situations, vehicle are grouped as light, medium and heavy vehicles and assumed that traffic noise level for an observation point is effected by only speed of vehicles and traffic volume.

Methodology

The digital data layers of survey department are used for preparing the 2D city model of Nugegoda area. GIS is used as a tool for preparing the 2D city model. The noise observation points are designed with respect to the 2D city model. The validation noise model is formed from the dBvision‟s noise expert Mr. Henk de Klujijver on December 15, 2011, model. The number of vehicles, speed of vehicles and noise reduction with the distance are considered for noise levels. The IDW and Kriging interpolation methods are used for preparing the noise interpolation. Risk analysis is done for using GIS techniques and high risk noise area and low risk noise area is found under The National Environment Act, No. 47 of 1980.

Figure 3. Road Layer
Source: Survey Department, 2012

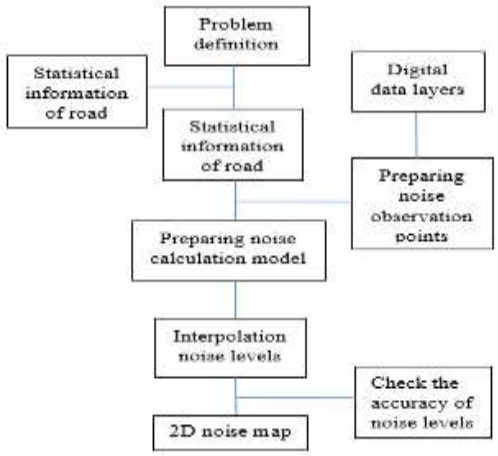


Figure 2. Flow Chart

2D city map was obtained from using 1:10000 digital data layers in GIS vector format. Considering the vector format of road, land use and building layer were very easy for overlapping and finding the relationship between the layers using GIS as a tool. Figure 3, 4, 5 describe the road layer, building layer and land use layer of Nugegoda city.

A. Digital Data Layers

Figure 4. Building Layer
Source: Survey Department, 2012

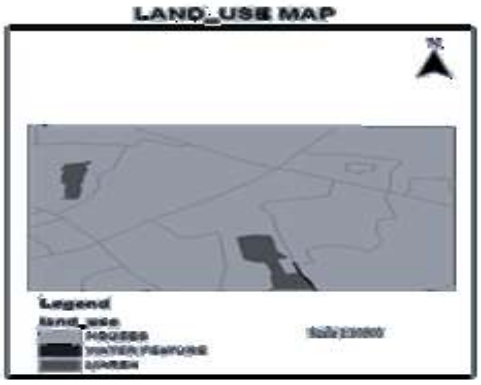


Figure 5. Land Use Layer

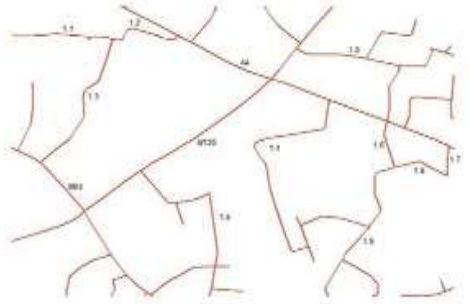
Source: Survey Department, 2012

B. Statistical Information of Road

It is very important for designing the 2D noise map which Vehicle amount, vehicle

	A4	B120	B84	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
L	4623	2995	2674	128	46	32	52	21	167	12	8	6	9
M	726	402	264	60	27	23	36	9	56	7	5	4	3
H	391	297	106	4	3	0	5	1	12	0	0	0	0

speed and vehicle type were taken to the account to solve the problems. Vehicle amount was collected under three categories like as light, medium and heavy vehicles. Light vehicles were considered which engine capacity is less than 2000cc (cc is the measurement of vehicle engine capacity) engine and three wheels and motor bikes were not considered for this research since dB value of them is not more effected for the noise pollution . Cars were taken to the account of light vehicles. Medium vehicles were considered which engine capacities are 2000cc-3000cc. Vans, cabs, jeeps were taken as the medium vehicles. Heavy vehicles were considered which engine capacity is more than 3000cc. Statistic data about vehicles (vehicle amount and speed) were taken from manually about eight days from 7.00am to 10.00am. The entire statistic data were taken for every Monday morning because of highly vehicle traffic is occurred on Monday. Then



average vehicle amount was taken of a day from 7.00am to 10.00am. Figure 6 describes the road network of the Nugegoda city and roads were identified using numerical numbers.

Figure 6. Road Network Nugegoda
Source: Survey Department, 2012

Number of vehicles were counted by manually and average speed of vehicles in Nugegoda city were observed by using a vehicle speed gun.

Table 1. Number of vehicles

L-Light Vehicles, M-Medium Vehicles, H-Heavy Vehicles
Table 2. Average Speed of vehicles

	A4	B120	B84	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
	Speed(kmh^{-1})												
L	15	17	18	15	15	15	15	15	15	15	15	15	15
M	12	15	16	13	13	13	13	13	13	13	13	13	13
H	10	11	13	10	10	10	10	10	10	10	10	10	10

L-Light Vehicles, M-Medium Vehicles, H-Heavy Vehicles

C. Preparation of Road Traffic Noise Model

Noise calculation is not very easy. The main problem is how to identify a suitable noise model. The noise computation methods are designed to give an accurate traffic noise levels and can be implemented for any area for noise simulation. Kalutara North area was selected for preparing the road traffic noise model. Speed of vehicles and number of vehicles were considered here. Vehicles were categorized into three groups .Eight vehicles were used for each group for preparing road traffic noise model. Vehicle speed was observed using Vehicle Speed Gun. Figure 7, 8, 9 describe the Noise Levels with speeds.

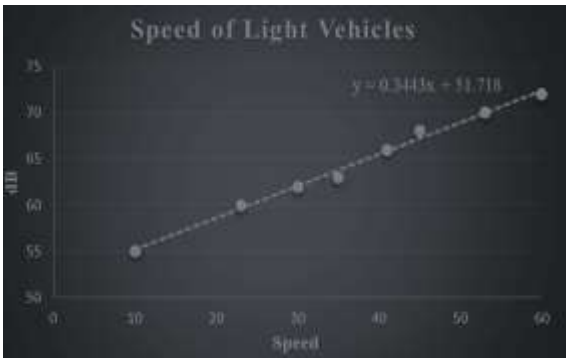


Figure 7. Speed of Light Vehicles

Figure 8. Speed of Medium Vehicles

Figure 9. Speed of Heavy Vehicles

Figure 10. Noise Reduction with Distance

By using statistical information of roads and noise reduction with distances the following noise calculation model was prepared.

L =Light Vehicle, M = Medium Vehicle, H = Heavy Vehicle, Average Speed of Light Vehicles =LV Average Speed of Medium Vehicles =MV, Average Speed of Heavy Vehicles =HV, dB Levels from Light Vehicle =dB (L), dB Levels from Medium Vehicle=dB (M), dB Levels from Heavy Vehicle =dB (H), Total Light Vehicles =TL, Total Medium Vehicles =TM, Total Heavy Vehicles =TH

dB (L) = 0.3443(LV) + 51.718...(1)

dB (M) = 0.4278(MV) + 59.173...(2)

dB (H) = 0.3382(HV) + 68.693...(3)

Total Light Vehicles =TL

Total Medium Vehicles =TM

Total Heavy Vehicles =TH

dB Levels from Total Light Vehicles = dB (TL)

dB Levels from Total Medium Vehicles =dB (TM)

dB Levels from Total Heavy Vehicles =dB (TH)

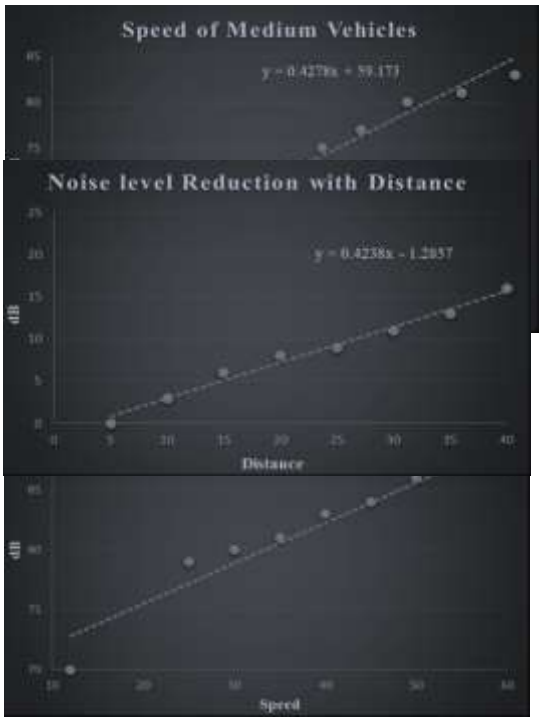
Decibel adding equation for same noise sources..(*)

$= L_s + 10 \log (n)$..(*)

n = number of sources, L_s = signal level from each single source (dB)

dB (TL) = dB (L) + 10Log10 (TL)...(4)

dB (TM) = dB (M) + 10Log10 (TM)...(5)



dB (TH) = dB (H) + 10Log10 (TH)...(6)

Substituting values for dB (L), dB (M) and dB (H) from equations (1), (2) and (3)

dB (TL) = (0.3443 (LV) + 51.718) +10Log10 (TL)...(7)

dB (TM) = (0.4278 (MV) + 59.173) + 10Log10 (TM)...(8)

dB (TH) = (0.3382 (HV) + 68.693) + 10Log10 (TH)...(9)

Decibel adding equation for different noise sources...(**)

$$E = 10\mathrm{Log}\left(10^{\frac{E_{lv}}{10}} + 10^{\frac{E_{mv}}{10}} + 10^{\frac{E_{hv}}{10}}\right) \quad ...(**)$$

Calculating noise levels from all Light, Medium and Heavy Vehicles by using equation (7), (8), and (9)

dB (T) = dB (TL) + dB (TM) + dB (TH)

dB (T) =10Log10(10(dB (TL)/10) + 10(dB (TM)/10) + 10(dB (TH/10))

dB Levels Reduction with Distance = dB (R)

Distance from center line of road to noise observation points = D

dB (R) = 0.4238(D) - 1.2857...(10)

Final noise levels of observation point = F (dB)

F (dB) =dB (T) – dB (R)....(***)

D. Preparation Noise Observation Points

Noise observation points were designed parallel to the road and for designing high density of points the small gaps were maintained between the observation points.

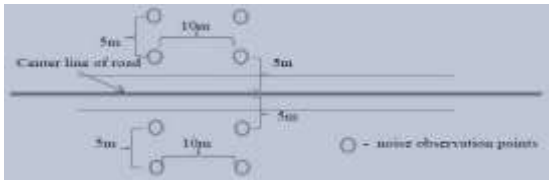


Figure 12. Dimension of Noise Observation Points

Assumed that noise is not penetrated through the cement walls and buildings. So it was considered when design noise observation point with respect to the 2D noise model.

Figure 13. Noise Observation Points in Arc GIS

E. Interpolation of Noise Levels

The noise levels were found using noise model which was created by MATLAB software. The Kriging and IDW interpolation techniques were used for noise interpolation. The output cell size was taken 1m.

F. Validation of 2D Noise Map

In noise calculation model all the noise levels were calculated by using MATLAB program. But it must be considered with the actual noise levels (check points) in the field. To plot the check points which were directly collected from the field used coordinates of them. The hand held GPS was used for collecting the check points. By using check points, the accuracy of IDW and Kriging interpolation values were compared. The RMSE (Root Mean Square Error) of IDW and Kriging was taken with respect to the check points.

Results and Discussion

The Kriging and IDW provide the raster surface as final result. The power of interpolation function was used as two degree. If it was used higher order polynomial function the surface will be so smooth but unpredictable oscillations will be occurred. To reduce those problems higher order polynomial function was not used. For preparing noise interpolation which Kriging and IDW method is better because of high density of noise observation points and those techniques give continuous and more exact surfaces. The noise levels were categorized as four classes like as 30-50, 50-70, 70-90, 90-110.When comparing the IDW and Kriging Interpolation noise levels with check

Figure 14. Final Noise Map

points the RMSE (Root Mean Square Error) was as Rmse IDW=1.923 and Rmse Kriging=2.837.

For the final noise map the IDW interpolation noise map was reclassified in to 2 classes such as less than 63dB and more than 63dB.When considering the final noise map the total area is 639072m^2 and 105064m^2 is less than 63 dB area. The 16.44% area is less than 63 dB noise emission from study area.

Conculsion

Because of considering only the Speed and number of vehicles and noise reduction with the distances, the Rmse value was high. If considering the environmental conditions for noise levels such as wind speed, pressure and reflectance noises from the buildings the accuracy of the noise levels may be increased. The 2D city model is mostly used for the noise mapping because of it is very flexible method for the noise interpolation. The Preparing 2D city model is less time consuming and cost effective method. The roads, buildings and land uses are considered for the 2D city noise model. Normally the 3D city model gives the good cartographic visualization than 2D city model. The fly over in Nugegoda city was not considered here because of 2D city model was used here.2D noise map provides some facilities for developing urban planning. The high risk, medium risk and low risk noise area can be abstracted from the 2D noise map along the horizontal surfaces. When creating newly schools, hospitals, libraries in Nugegoda city area, the <63dB area can be used. When examining the noise map there are high noises in road junctions so those area can be used only for the commercial activities. Major roads have high noise pollution and minor roads have low noise pollution. If the road traffic is reduced it can be helped for reducing the noise pollution.

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I would like to thank lectures of faculty of Geomatics in Sabaragamuwa university of Sri Lanka. It is time to remind the remarkable contribution of GIS branch of Survey department for giving all digital data layers for creating 2D city model. Finally, I wish to express my sincere thanks & gratitude to all the people who helped us in many ways.

Author Biography

I have Studied BSc Surveying Sciences (GIS and Cartography). I have an interest for visualizing environmental problems by using GIS and cartography. Arc GIS provides very important mapping environment with cartographic visualization for spatial mapping. Here I have prepared a 2D noise map for urban planning. In future I will hope for preparing 3D city noise map for the purposes of urban planning.

Paper ID: 278

Assessing the Accuracy of Terrestrial Laser Scanner Against the Total Station for Surveying Applications in Sri Lanka.

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Abstract: 3D laser scanning or terrestrial lidar instruments have been in used in surveying task since the 1990's but it is very new technology for the Sri Lankan surveying field. Terrestrial laser scanners have been proven to be a very versatile surveying instrument with applications in many sectors of use like, Detail topographic survey, Road & Railway survey, Construction Site, Volumetric Survey/ Mining Survey, Monitoring Survey, Critical location survey, Crime Scene, Accidents, Tunnel Survey, BIM – Building Information Modelling & EMP – Electrical Mechanical Plumbing and Archaeological site survey.

The results of any surveying task must meet specific conditions to provide the required accuracy. Therefore, any surveying work includes not only the relative positions of points and objects but also an accuracy of the results. It is imperative that a new technology like terrestrial laser scanning instrument before been use in the actual field data collection to go under accuracy analysis for Sri Lankan field conditions.

One of the fundamental theories is "Practical is up on proven principal" in accordance with this theory the accuracy of the terrestrial laser scanner is going to be analysed against the most commonly used surveying instrument in the field the Total station.

The comparison will be done in normal Sri Lankan field condition with weather, heat, and pressure to get much better accuracy comparison.

The experiments are designed in the following way, two traverses from both the Total Station and the Terrestrial Laser Scanner are going to be run on the same set of ground points then 3D error of each measurement is going to analyse using adjustment theory. The calculation will be done using and computer algorithm.

Key words: 3D laser scanning, 3D

Introduction

Surveying is the technique, profession, art and science of determining positions of features of the ground and the distances and angles between them and as to construct a map, plan, or numerical output of it. But the traditional technical definition of surveying can be expressed as follows,

"Surveying has been traditionally defined as the science and art of determining the relative positions of points above, on, or beneath the surface of the earth, or establishing such points."

Surveying is the second oldest professions in the world today. The history of surveying starts in the 1400 B.C. Egypt where Egyptians first used it to accurately divide land into plots for the purpose of taxation. From that

surveying has developed along with the time and surveying field has sub divided into many division like Engineering, Cadastral, Hydrography, Remote sensing, geographic information system etcetera. With the development of the technology, the surveying instruments have also developed along with the time and method used for the survey.

In 120 B.C Greeks developed the first piece of surveying equipment (Diopter). Then the chain was developed in 1800 A.D. with the Beginning of the industrial revolution. At that time people thought that the chain is the most accurate instrument but later with the industrial revolution a lot of technologies for the surveying field were developed like the theodolite. With the introduction of the theodolite to the world and to the surveyors. The theodolite became the most popular angle measuring instrument among the land surveyors for last two centuries. It is a descendent of rudimentary angle measuring equipment such as optical square, sextant and astrolabe used to obtain vertical or horizontal angle measurements using graduated circle. Gradually the concept of the theodolite was developed which could measure horizontal and vertical angles simultaneously. The idea was appeared in the appendix of Magarita Philosophica by Gregorios Reisch published in Starasborg in 1512. Martin Waldseemuller, a germen topographer, and a cartographer made the device in 1512 and called the instrument as "polimetrum". The first occurrence of the word "Theodolite" was found in the surveying textbook "A Geometric Practice" by Leonerd Gigges. Later many technical developments made the theodolite precise easy to use vertical and horizontal angle measuring equipment to be a surveyor's choice in the field of land surveying.

Then Erik Bergstrand, the inventor of the Geodimeter, was made a radio receiver in the early days of broadcasting. In 1939 he got a position as geodesist at the Geographical Survey Office in Stockholm and invented a new type of instrument to measure distances by using the light signals, knowing the speed of light. Bergstrand however chose the Kerr cell method used by e.g. Karolus in Germany and Anderson, United State of America. Bergstrand had chance to join the new Nobel Institute of Physics and then he built an experimental model to measure the distance between two stations by using both light and radio signals. That was the introduction of the EDM to the world.

In 1960's with the digital revolution another technological breakthrough happened that was the introduction of the total station. Total stations are equipped with internal electromagnetic distance meter fixed aligned with the line of sight of the digital theodolite. It also equipped with a microprocessor to compute coordinates and other surveying related functions, internal memory to store data digitally, and alpha numeric keypad and a display unit as input and output devices.

In 1960's the Light Detection And Ranging (LiDAR) technology has been introduced and used for air borne surveys and the LiDAR instrument was mounted on air plane for air borne survey activities.

When presenting the first Total Station in 1968, nobody could foresee the profound effect this instrument would have on measurement and data-collection techniques. This instrument was the ZEISS RegELTA 14. With the new generation of equipment, the ELTA 2 and ELTA 4, it becomes obvious that the concept of that first instrument - namely combination of an electronic theodolite and optical rangefinder, automatic recording of the data and

connection to the computer - is still fully valid today.

Then in 1980's United State Department of Defense introduced the satellite-based positioning system called GPS. The Global Positioning System (GPS) is consists of 24 satellites placed into orbit by the U.S. Department of Defense. This technique was originally used for military applications. In late 1980's, the government made the system available for civilian use. In early 1990's land surveyors start using the GPS system for land surveying and it was significant improvement for some field surveying tasks like horizontal control setting.

In late 1980's with the introduction of commercially viable GPS for the surveying works it was combined with the LiDAR instruments and then the LiDAR data became a useful tool for providing accurate geospatial data for the survey activities.

Then moving on to today, one of the most modern terrestrial surveying instruments is the Terrestrial Laser Scanner. A primary aspect of this study is to find the accuracy of the ground-based Light Detection and Ranging (LiDAR) systems, known as "Terrestrial Laser Scanning (TLS)". TLS instruments emit a pulsed laser signal and then it made to be detected its return signal by the instrument. Time travel of the light beam calculate the distance between the instrument and the reflected object surface, and the pulsed signal is rapid enough that thousands of points can be recorded in seconds. Each point is recorded as three-dimensionally, with an attribute relating to intensity of the returning signal. These observed points are known as a "Point Cloud". These point clouds having tens of thousands of points in a one scan station that are having rich detail of the scene as viewed from the instrument. These scans contain all manmade and natural features that can be "seen" from the instrument's viewing angle.

If think about the data collection modes of the TLS some instrument provides interactive data collection, and others operate in a point-and-shoot mode. Operator identification of targets and detail scanning of specific regions are examples of possible operator intervention during the scanning collection. Different types of TLS provide different range or distance the and the horizontal and vertical viewing angle within an individual scene. Newest versions of laser scanners collect a digital image of the scene in addition to the point clouds.

The results of any surveying task must meet specific conditions to provide the required accuracy. Therefore, any surveying work includes not only the relative positions of points and objects but also an accuracy of the results. In traditional surveying and photogrammetry where defined targets are observed, least squares adjustment based on overdetermination usually yields reliable information concerning the accuracy of the results as well as the accuracy of the observations. If the number of observations is not sufficient for an adjustment, one may estimate the accuracy of the results by propagating the errors of the observation instruments to the results. In this case, the accuracy of the measurement device must be known.

In the case of TLS, tens of thousands points with three dimensional coordinates on a surface of the object is measured in a very short time. Relevant object features, such as corner points or edges, are not directly recorded; instead, they must be modelled from the point clouds in a separate process. So, the problem is that all the existing surveying instruments have many different

levels of accuracy depending up on a wide range of factors ranging from instrument type to atmospheric conditions. Before a survey instrument can be used in a survey, surveyor need to have good idea about the accuracy of the instrument. Laser scanner in new instrument to Sri Lanka according to the information there is only one instrument in whole of Sri Lanka. Before it can be used for surveying in Sri Lanka it is important that we identify the capabilities and the accuracy of the laser scanner compare to its rival instrument in the actual field that is been used to surveying work.

3D scanning instrument is a new technology to Sri Lanka, most of the Sri Lankan surveyors do not know about the applications of this Terrestrial Laser Scanner and as well as the accuracy of the instrument.

Terrestrial Laser Scanner

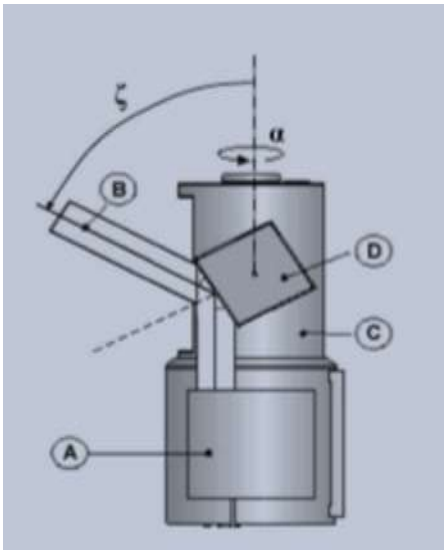
These TLS are primarily based on the "time-of-flight" principle of lidar. That is, a precise electronic time interval meter (TIM) marks the on the time a laser pulse exits the lidar sensor's transmitter, then calculate the duration (commonly in milliseconds) that passes because the laser pulse travels from the transmitter, to the target, and returns as a reflection detected by means of the sensor's receiver. The distance to the target d, is computed by using the equation (Conforti, 2017)

$$d=c.t/2$$

t - Flight time

c – The velocity of light

TLS being a lidar based instrument. It works on the main principle of lidar. Principal of lidar is that we know the speed of the light through the atmosphere and if we are able to calculate the time which it takes a light beam to travel some distances we can easily calculate those distances. This principle is used in most of the Remote Sensing instruments and some early EDM devices. Conforti describes the same principle in the sense of TLS measurements very clearly.



A TLS needs a two axis that are capable of freely rotating in two different planes like modern TS for surveying a different part of the target in different planes. These two-rotation axis directions can be simply explained as the vertical and horizontal.

Figure 3 Principle of TLS (Fangi et al, 2001; Pinarci, 2007)

The modulated laser light plus travels from the electronic unit (Figure 1, A) and hits the optical prism (Figure 1, D) which is rotating at high angular velocity. The surface of this optical unit (which act like a mirror) the plus is reflected and exits the TLS at a specific angle ζ (Figure 1, B). After the scanner has completed acquiring this ζ-profile, the upper part of the Terrestrial Laser Scanner (Figure 1, C) rotates at a very small angle (Δα) around the vertical axis in order to start capturing the next, adjacent ζ-profile. For each view profile, a huge point clouds are obtained, each and every point is defined through polar coordinates α, ζ and d

(measured distance to the spot of the reflected beam on the object) (Vozikis et al, 2004). The microprocessor inside the TLS calculates Cartesian coordinates (X, Y, Z) of the points scanned by polar coordinates. The other data that is recorded is the intensity of the reflected laser pulse. (Fangi et al, 2001; Pinarci, 2007).

The working principle is not enough when we are considering the surveying principal of TLS Technology. To get a 3D coordinate of a position it is not enough to have and distance measuring instrument. As the author explains to 3D coordinate of a target the instrument needs the vector from the instrument station to the target. Vector simply means the bearing and the distance. Distance measured using the lidar principal and the bearings are measured using two angle measurement units fixed on to the TLS. They are the horizontal and the vertical angle measurement units as same as a modern TS. But there is a main difference between the two instruments according to the author that is in the modern TS EDM is rotating in the bouth directions but in this case of Terrestrial Laser Scanner EDM stationery because it would be impossible to move the EDM speeds which it requires to collect dense datasets in little time. For that in TLS they use a fixed EDM and a rotating optical element which is basically a mirror that is rotating at very high velocities. The modulated light beam that emits from the EDM (Electronic Unit) hits the rotating optical element and is reflected by it at a specific angle in one vertical circle. After the instrument is done scanning the vertical circle the upper part of the scanner rotates a very small amount to scan the next vertical circle. Using this method TLS can scan a pre-set area around it and collect very dense 3D point dataset. Each and every point obtained is uniquely described by 3D polar coordinates. The internal microprocessors convert values from the polar coordinates to the cartesian coordinates. A special note is that with every measurement light intensity data is recorded of the returning laser pulse. It can be used to calculate the physical properties of the target from using this data. In the same way as the aerial lidar instruments do.

Experimental Design

The best method of analysing the accuracy of TLS is to complete a practical surveying task and find out the accuracy of the resultant data set. Because if we test the accuracy of the Terrestrial Laser Scanner inside a laboratory under controlled conditions we cannot anticipate the effect of the natural factors that common to most of the surveys conducted in the field like temperature, humidity, light condition, weather etc. So, the research method was designed to do in the field by using regular traverse survey method. with the exception of conducting a verification survey in order to verify the data set that have been collected from the TLS. As the verification survey method, the Total Station (TS) survey method (EDM traversing method) have been chosen because it is a proven Terrestrial serving method use by many surveyors around the world.

Methodology

The methodology of this research can be divided in to two main parts they are

i. Field work

ii. Office work

Filed Work

As the first step of the field procedure reconnaissance survey have been done and a prospection diagram was drown indicating

all the traverse points. Then the locations for the ten instrument stations were identified on the prospection diagram were marked on the real ground by wooden pegs that were driven into the ground. To mark the instrument stations that are located on cement floor or in tile floor a permanent marker was used. All the instrument stations were set up in a way that they have a clear line of sight.

Table 1: Instruments Used

No	Hardware/ Software	Amount	Type
1	Terrestrial Laser Scanner	1	GLS-1000
2	Total Station with accessories	1	Sokkia CX-101
3	Prism Targets	3	Sokkia
4	Prism Poles with prism	2	~
5	Sheet targets	As needed	~
6	Tri Pod (Wooden)	3	~
7	50M Steel Tapes	1	~
8	Gig Umbrella	1	~
9	Hammer	1	~
10	Topcon Scan-master or Collage-Software	1	Topcon
11	Sokkia Link Software	1	Sokkia

As the first step of the field procedure reconnaissance survey have been done and a prospection diagram was drown indicating all the traverse points. Then the locations for the ten instrument stations were identified on the prospection diagram were marked on the real ground by wooden pegs that were driven into the ground. To mark the instrument stations that are located on cement floor or in tile floor a permanent marker was used. All the instrument stations were set up in a way that they have a clear line of sight.

Even the instrument stations inside the building were set up according to the above mention principle. Then as the first task the TS traverse using the arbitrary coordinate system was ran covering all the instrument stations. Then again TLS was used to traverse using the same coordinate system. From that coordinates of all the instrument station were collected from both methods. For both traverses a three tripod with two prism system was used.

Office Work

When considering the office work there were two main parts

Data processing

Data visualization

Data processing

The data collected by the TLS downloaded as a point cloud to the processing workstation computer with scan-master software that is capable of processing 3D point clouds that are collected from Topcon laser scanners. The coordinates of the traverse points were extracted from the travers data.

The data collected from the TS was download on to the processing workstation computer using a pen drive. Then the coordinates of the instrument station were processed using the Sokkia link software.

Data visualization

From this part visualization of the data collected from the TLS is done. And the points were exported as CAD drawing files by the scan master software and those exported files were open on the CAD.

Analysis

As described in the methodology and the research design, traverse by TLS which verified by the TS were used for checking the accuracy. For the error analysis and to have a result coordinates obtained from the TS are considered corrected values and values that are obtained from the Terrestrial Laser Scanner are considered as the measured values.

Error = Measured Value – True Value

Starting points for both instruments used the same coordinates therefore error that station becomes 0.0000m.

Traverse point and the error on each traverse point are given on the below table.

Table 2: Error comparison for both TLS and TS

Station Number	Error (m)
Stn 2	0.0004
Stn 3	0.0003
Stn 4	0.0007
Stn 5	0.0005
Stn 6	0.0004
Stn 7	0.0007
Stn 8	0.0004
Stn 9	0.0006
Stn 10	0.0004
Stn 11	0.0004

Discussion

The modern TS and the TLS both use the nearly the same working principal so both instruments have the nearly the same amount of accuracy. But with the new software and better hardware TLS allows the user to apply the basic surveying methods in many applications. Some of them have been not possible before the introduction of the TLS. As example to survey small cracks in concrete and other structures in order measure the deformations.

While analysing the above table, station 4, 7, and 9 shows higher errors. When selecting the target stations through the TLS monitor this can be happen. Because Topcon TLS has measured only 2mm points on the targeted object. Therefore, while selecting the target it is better to zoom the target very clearly trough the TLS monitor. All other stations are having small amount of error, that means TLS can be used for surveying works and can be obtained higher accuracy.

Conclusion

As conclusion it is possible to say that Terrestrial laser Scanner can be used in Sri Lankan Surveying industry with high accuracy. The digital data collection from the Terrestrial Laser Scanner is much efficient than the existing terrestrial surveying methods.

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Author Biography

I would like to do my further studies in geodesy, GNNS and LIDAR. My research interests are all related to surveying and earth sciences and I like to find out solutions for the problems in those fields.

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An Assessment of Wave Climate Variability Using Energy Flux Method: A Case Study in the Coastal Area of Negombo to Wadduwa

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Abstract: Wave climate can be described as the distribution of wave characteristics averaged over a period of time and for a particular location. Coastal erosion has significant impact from the change of wave climate. The West coast of Sri Lanka is identified as a severely eroding coastline according to the Master Plan for Coast Erosion Management in 2006. This study quantifies the wave climate variability in the West coast of Sri Lanka using ECMWF (European Centre for Medium-Range Weather Forecasts) wave data, in particular, ERA 5 collected over the years from 1979 – 2019. The occurrence of wave classes in the study area and the temporal changes in the wave parameters such as significant wave height, wave period, wind speed and sea surface temperature were analysed. Then significant change in long-term wave climate variability (1979-2019) and short-term wave climate variability (2010-2019), and the variation of wave energy in the study area were assessed. The significant increment has been happened in occurrences of wave classes and the wave parameters of the study area within the short term of period. Results of wave energy computations clearly indicate increase in the residual changes of wave energy flux in the short-term period during the Southwest monsoon. In addition, the occurrence of wave heights events which are greater than 2m have increased during the short-term of period than in long-term period. The changes in wave parameters and subsequently the coastal retreats in study area and possible measures are discussed in the paper.

Keywords: wave climate, wave parameters, energy flux, coastal erosion

Introduction

In recent years, coastal construction projects are rapidly arisen around the Sri Lankan coast line, especially in the Western coastal stretch. As examples, Colombo Port development with the extension of breakwaters, reclamation of 269 hectares of land from the ocean known as Colombo International Financial City, and upcoming construction of a beach reclamation called Beach Front project. Moreover, this coastline is the most invested coastline in Sri Lanka and the city of Colombo which is the country's front door, also located in this coastline.

Waves are the vital contributor that controls the where and how coastal structures are constructed and it is a sudden occurrence of or increase in a phenomenon that usually created by the wind with an undulation of the sea surface (Pinet, 2011). Wave height, wave period, and wave direction are the three different characteristics that necessary for

coastal studies (Dodet, Bertin and Taborda, 2010). Wave climate is the distribution of wave characteristics averaged over a period of time and for a particular location (Kummu et al., 2016). The energy flux is known as rate of transfer of energy through a surface. The energy flux method is related to the longshore transport rate. It is based on the concept of wave energy flux, where the wave calculate the energy flux recorded for each wave in a wave time series (Galvin et al., 1973; Benedet et al., 2016).

Basically, the wave climate in Sri Lanka is mainly controlled by monsoon seasonality. Northeast monsoon (December to February) and Southwest monsoon (May to September) are the two main tropical monsoon periods that can be categorized according to the seasonal change of Sri Lankan weather (Gerritsen and Amarasinghe, 1976). When Compared with the Northwest monsoon, the Southwest monsoon is more probable to have higher wave events in the western coast of Sri Lanka (Jayathilaka and Fernando, 2019). Sri Lanka's Western coastline shows severe erosion under stormy conditions during the Southwest monsoon period (Lakmali et al., 2017).

The West coast of Sri Lanka is identified as erosion prone area during last decades (CCD plan, 2006,2004; Jayathilaka, 2015). Possible reasons for ongoing coastal erosion are coastal intervention, sea level rise, river sand mining and offshore dredging and wave climate change. The engineering aspects for coastal erosion were analysed by Amarasinghe (1971), Genitsen (1974) and Wickramaratne (1985). The effect of sand mining for coastal erosion were analyzed by CCD (2004, 2006). The impact of sea level rise with coastal erosion and inundation of West coast of Sri Lanka was discussed by Palamakumbure et al. (2020) and Wijayawardane et al. (2013). In the context of Sri Lanka, the studies of wave climate impact on the West coast of Sri Lanka indicated are hardly found. The proper assessment of wave climate is so indeed to control coastal erosion. (Gunarathna, Ranasinghe and Sugandika, 2011). Therefore, the influences of the probability of occurrence of wave events on the near-shore wave climate thus coastal erosion in the West coast have to be well studied.

As per the previous studies conducted by The National Aquatic Resources Research and Development Agency (NARA) have revealed that the land area along the coastline Pitipana and Wedikanda have experienced severe sea erosion every year during the Southwest monsoon. Coastal conservation department have expended millions of rupees to mitigate the coastal erosion problems in the area (CCD plan). Sand mining in the rivers and coastal areas, coastal construction and the wave climate change are identified as contributory factors that govern the coastal erosion (CCD plan 2006). Understanding the wave climate change in this coastline is vital for mitigating the ongoing coastal erosion problem. Consequently, this study would help to take required management decisions and mitigation strategies for such future constructions in the West coast of Sri Lanka.

Research Design

A. Data Collection

The ECMWF (European Centre for Medium-Range Weather Forecasts) wave data was used in this study. In particular, ERA 5, the most recent reanalysis of wave data was collected from 1979 to 2019.

B. Methodology

Data was collected from Negombo to Wadduwa based on the locations of Pitipana and Wedikanda. First, occurrence of wave

classes were assessed. Then long term (1979-2019) and short term (2010-2019) wave climate variability was analysed with wave, wind, temperature parameters and the wave energy variation was evaluated considering the Southwest and Northeast monsoon periods through the energy flux method.

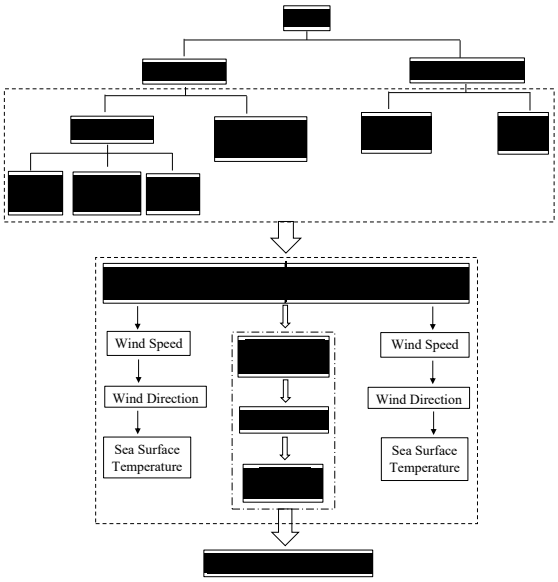

Figure 4: The overview of the research methodology used in the study

C. Energy Flux Method for wave climate

The method is based on the concept of wave energy flux, where the wave calculate the energy flux recorded by each wave in a wave time series and used the following equation;

$$Ef = (\rho\, g\, Hs2/8)\, Cg$$

Where ρ is the water density, g is the gravity acceleration, Hs is the significant wave height and Cg is the group wave celerity, in deep water (Benedet et al., 2016).

Results and Discussion

A. Analyse the wave classes

In prior, the occurrence of wave classes in the study area were analysed.

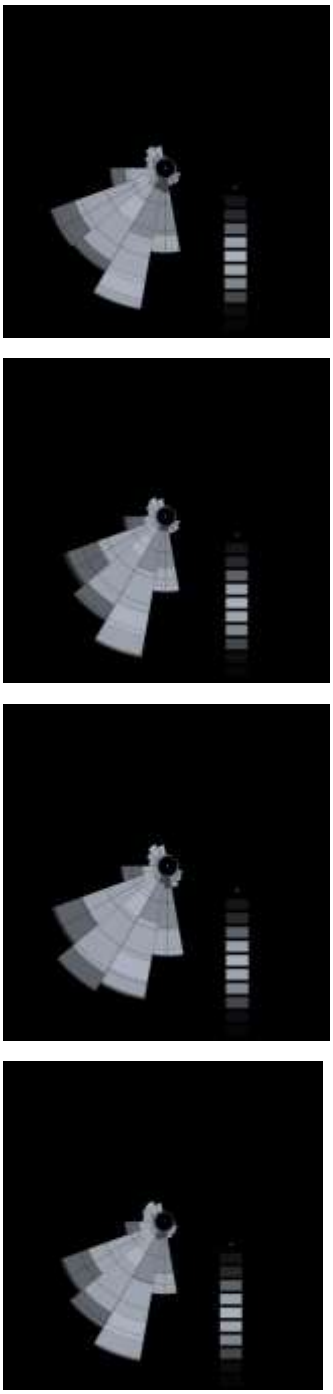

Figure 5: Comparison of Significant Wave Height(SWH) classes with wave roses in study area between 1979 – 2019

In here the colour of each cell represents the Significant wave height and the alignment of each the arm gives the direction that wave coming while the length of the arms of the wave roses represents the percentage of occurrence of the wave classes. According to

the 40 years of wave data analysis with wave rose diagrams (Figure 2), the occurrence of Significant wave height classes was increased between 1989 to 1999 than 1979 to 1989. But within 1999 to 2009 the occurrence of Significant wave height classes was comparatively decreased. Again, within the nearest decade (2009 - 2019), the occurrence of Significant wave height classes were increased. But, when consider the overall occurance of Significant wave heights, it can be said that the significant increment has been happened in occurrence of wave classes within the short term (2009-2019) of period.

B. Analyse the wave climate variability

Wave climate analysis indicates Significant wave height varies from 0.5 m to 3 m. The most probable wave height is about 1.5 m. Wave direction distribution is mainly in 210^0–250^0 during the Southwest monsoon. According to the wind climate in the study area from May to September, the wind direction is Southwest and the wind direction distribution is between 220^0-240^0. During the Southwest monsoon, the wind speed varies between 7-11 m/s. (Jayathilaka and Fernando, 2019).

To analyze long-term wave climate variability and short-term wave climate variability, the yearly maximum, minimum and average of parameters from wave, wind and temperature data sets were analyzed in the study area from 1979 to 2019 and from 2010 to 2019 respectively. Wave height, wave period, wave direction and wind direction for Southwest monsoon season, wind speed, temperature, wave energy and erosion were taken as parameters to observe long-term (1979 – 2019) wave climate variability and short-term (2010 – 2019) wave climate variability.

Based on the below observations (Table 1);

- An increment can be seen in long term yearly maximum of significant wave height and a slightly improvement can be seen in yearly average of significant wave height within short term of period.
- Change the value in yearly maximum of wave period is not revealed, but yearly minimum and yearly average values are slightly increased within the short term.
- To the study area, the effect of Southwest monsoon is highly considered (Lakmali et al., 2017; Jayathilaka and Fernando, 2019). Therefore, the effect of Northeast monsoon is not considered for this study. The effect of yearly average of wave direction is slightly decreased and wind direction is slightly increased towards the study area within the short-term period.
- Within that short-term of period the yearly maximum wind speed and yearly average wind speed is increased. The yearly minimum value is not applicable.
- While the yearly maximum and average sea surface temperature is increased, the minimum value has decreased within short term of period.
- The yearly average of wave energy in short term is considerably increased than the yearly average of wave energy in long term.
- The yearly average of short-term erosion rate is higher than the yearly average of long-term erosion rate.

Table 2: Long term (1979-2019) and short term (2010-2019) wave climate variability

	1979-2019			2010-2019		
Parameter	Yearly maximum	Yearly minimum	Yearly average	Yearly maximum	Yearly minimum	Yearly average
Significant wave height(m)	3.8101	0.4788	1.3850	3.2712	0.4788	1.3925
Wave period(s)	15.1885	5.0131	8.8386	15.1885	5.3645	8.8581
Wave direction (SW monsoon) (⁰)	NA	NA	233.5	NA	NA	233.3
Wind speed (m/s)	10.90	NA	4.44	11.25	NA	4.50
Wind direction (SW monsoon) (⁰)	NA	NA	248.2	NA	NA	248.3
Sea surface temperature (C)	30.3080	26.6809	28.32222	30.5389	26.5597	28.4527
Wave Energy (Kw/m)	NA	NA	2.2778e+05	NA	NA	2.2992e+05
Erosion (m/year)	NA	NA	Low	NA	NA	High

Figure 4: Residual change between short term and long-term wave energy flux.

NA – Not Applicable

Accordingly, it was found that the significant increment in yearly average of wave parameters such as significant wave height, wave period, wind speed, wind direction changes, sea surface temperature and wave energy.

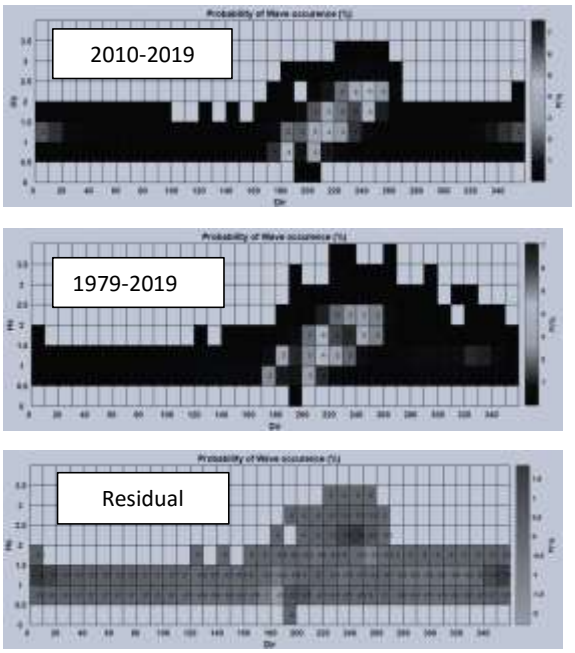

Figure 3: Residual change between short term and long-term wave occurrence probability

This complies the increased of coastal erosion rate during the short term (2010-2019) study conducted by NARA.

The residual change between short term and long-term wave occurrence probability (%) was analysed (Figure 3). It is clear that the short-term wave height bins which are more than 2m have increased their occurrence probability comparing with the long-term trend. Most of the higher probabilities occur in the Southwest monsoon period.

B. Evaluate the variation in Wave Energy

Figure 4 illustrates that as per the residual changes, it is clear that during the Southwest monsoon the wave heights which are greater than 2m have increased the wave energy within the short term of

period and the wave heights which are less than 2m have reduced the wave energies. Also, some waves between the heights of 1-1.5m appear during the Northeast monsoon in the short term period though it was not experienced in long term period.

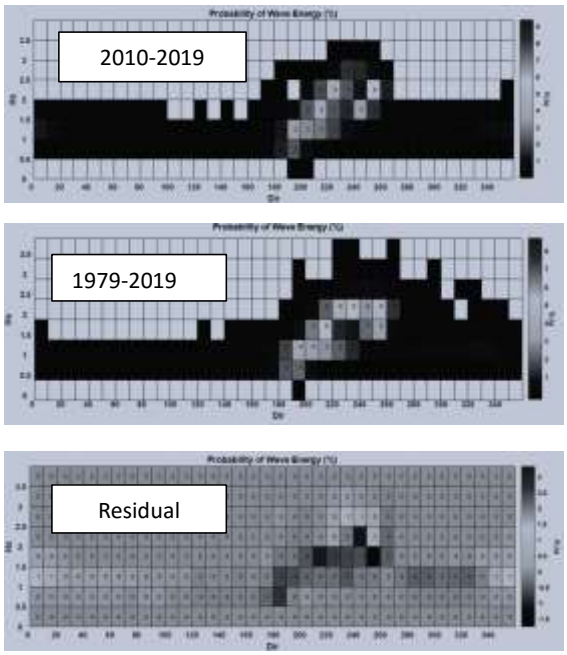

Figure 4: Residual change between short term and long-term wave energy flux.

Conclusion and Recommendation

In prior asses the occurance of Significant wave heights of the study area with fourty years wave data. Therefore, it can be said that the significant increment has been happened in occurrences of Significant wave height classes of the study area within the short term (2010-2019) of period. Furthermore, wave heights which are greater than 2m have been increased during the Southwest monsoon therefore the wave energy during short term period have been increaed. Also the wave heights less than 2m have reduced the wave energies and some waves between 1-1.5 m appears during the Northeast monsoon through the short term period which was not experienced within long term period. Hence, it can be concluded within the short term of period the wave energy fluxes have been comparatively increased. This will be another major reason that increases the wave power in the study area. In overall the short term (2010-2019) wave climate has been increased in the study area. Therefore, the influences to the probability of increment in short term (2010-2019) wave climate variability, triggered to the coastal erosion in the West coast of sri Lanka.

Coastal stretch of West, Sri Lanka was stabilized by introducing several hard-structural solutions. All of these major stabilization projects were implement prior to the Colombo South Port Development and Port City Development. The principal causes of erosion in West coast includes; natural process due to monsoon generated wave attacks, to evaluate the rate of erosion due to the change of wave climate, a comprehensive modelling studies are recommended through the long term and short term. Also it is recommended to maintain the coastline's natural appearance and preserves natural shoreline dynamics by preventing seafront development. Removes structures/people from the hazard zone, making it a highly effective method of minimizing property damage due to coastal erosion and tie the setback policy to exist land use and building regulations.

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Construction workers Motivation and Skill Development: A strategy for improving Construction Produtivity in Sri Lanka

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Abstract: Human factors are important sources of increasing efficiency and performance in the construction industry which contribute to project success Human resource today has a strategic role for productivity increase in construction projects and this makes it superior in the industrial competition. This stems from the limited success in terms of completing projects in time, within approved cost and to a satisfactory quality. The study examines motivation and skill development factors as a strategy for construction productivity in Sri Lanka, whilst there are other human behaviour factors that could influence construction productivity. Descriptive research methodology using questionnaires to collect data was used. 35 behaviour factors of motivation and skills development were identified and investigated for improved construction productivity. The results showed that although all 35 factors are very significant and are more likely to exert a higher influence towards positive behaviours, there were 4 factors found to be extremely significant and the highest ranked factor was a motivation factor; on-time payment. Only one skill development factor was identified as exteremely significant according to respondents' perspective. Conclusions drawn from this study are that when the 35 sub factors are present in a construction environment, they influence worker behaviours, thus improving construction productivity. Therefore it may be necessary to consider these factors as a way of increasing success and productivity. Investigating these factors could thus be seen as a way of unlocking human potential to enhance productivity because these factors reinforce behaviour that in turn contributes to project success.

Keywords: Skill development factors, motivation factors, construction productivity

Introduction

Improving and enhancing construction productivity was the most challenging issue in the construction imdustry during the last decade. Human resource is an important factor in the development of the construction industry and improve construction productivity. The concept to link human behaviour factors with the success or failure in construction projects has been researched extensively. For example Steyn, Basson, Carruthers, Krugar, Pienaar, Van Eck and Vissar (2009:215) identified that people are important in a building construction project environment and add, ―Many projects have revealed frustration caused not by deficiencies in the methodology or poorly constructed schedule methods, but rather by the people involved in the project.

Today the construction projects based on project objectives, strategic goals, work plans, budget, time, technology, policies, what are not being focused on are the human behaviour factors (Orando, 2013). The performance of the people who involve in a construction project is affected by number of

factors and usually linked to the performance of time, cost , quality, work pressure, safety measures. Lack of safety, lack of skills, lack of quality of materials, lack of wages, communication barriers mainly create psychological stress on the workers. Therfore human behaviour factors are critical sources in increasing performance and efficiency in the construction industry which contribute to the project success.

According to Parkin et al, (2009:107) motivation may only improve construction productivity if the worker has the abilities and skills needed for the job. This would emphasize that both skill and motivation factors are major requirements for influencing positive behaviors for the construction productivity. For example an unskilled worker, although motivated may not have the required ability to perform well and improve construction productivity.

Though there are many human behaviour factors which influence the construction productivity,the main aim of this study is to determine the influence of motivational and skill development fators on construction productivity in Sri Lanka. To achieve this, the study sought to investigate the perception of respondents regarding the influence of motivation and skills development factors on construction productivity. Thus, it is necessary to identify and investigate human behaviour factors as a way to unlocking human potential to enhance productivity. These factors may reinforce behaviour that in turn contributes to project success.

Literature Review

Construction industry is an essential contributor to the process of development of the built environment. An enhanced productivity has a positive effect on the Gross Domestic Product (GDP) of every country. The immense size and the significance of the construction industry to the economies of most countries, its productivity is one of the controversial factors (Otali M and Ujene, 2015). Productivity has been an essential contributor to success, because its direct translation into cost savings and profitability (Mojahed, 2005). Therefore it is evident that the construction productivity links with the success or failure of the construction projects.

According to Gratton (2003) in the 21st century, the new sources of sustainable competitive advantage for organizations are people at the centre, because its their talent and creativity, their inspiration and their excitement that give organization a competitive advantage. Human capital therefore is a big asset for success of any organization. Human factors are the driving forces behind project success. When there is no motivation and no respect for human factors the project would be fail. When people are in conflict or forced to fit into processes, the tremendous opportunity is lost but when intellectual and emotional needs are met, enormous human energy and productivity are created (Wong, 2007).

The term motivation is derived from the Latin word‗movere', meaning; to move. Motivation is a concept used to explain the action of an organism to direct the behaviour (Petri,1981). Some researchers generally regards motivation as a force and may attribute the force to availability of rewards. The presence of a ‗reward' must be some reason for the workers to be motivated. Usually the reward may be a positive outcome or an avoidance of a negative outcome (Parkin et al, 2009). Construction productivity largely depends on construction labor force and their creativity and efforts and construction productivity may not be achieved without good human management practices, which motivate construction labors (Chan and Kaka, 2007). Motivation factors may vary from worker to worker; different workers may be motivated by

different motivational factors and strategies, which, may improve construction productivity (Jason E. Barg et al,2014). According to Jarkas et al,(2015:165-194) critical motivational factors affect productivity and they were identified as related to incentives (Payment delay and lack of financial incentive scheme), related to work environment and realated to management (unrealistic scheduling, performane,incompetent supervisorsandshortage of materials on site). Therfore this study aims to determine the influence of motivational factors which may vary from worker to worker in the construction projects. Job satisfaction is usually related to the motivation and may be related to the personal feelings of achievement, workers' job satisfaction is correlated with the breadth of their work abilities, which play an important role in the workplace (Shevchuk, Davis, S.N; 2019).

Erasmus et al (2016) indicate that the task given should be relevant to the job that the worker performs, it implies that the training experiences by the worker directly relates to the duty and tasks performed in the job situation, so this relationship motivates the worker to train and eventually perform better.

According to Kazaz et al, (2008) ineffective management is the major cause for poor construction productivity rather than unmotivated or unskilled workers. This would suggest that both motivation and skill are requirements for improving construction productivity. An unskilled worker although motivated does not have ability to perform well to contribute to project success. From management perspective, motivation is important along with the workers abilities (Vroom and Deci, 1970).

Skill is important in work situations, it may allow a worker to study work details in order to understand the work properly. With the necessary skill, a worker may evaluate the alternative processes of performing the task (Hackman & Oldham,1980). According to Kazaz et al, (2008) construction workers in developing countries have low level of education and are generally unskilled. Threfore it is necessary to train construction workers to acquire skill in order to improve the onstruction productivity. Contractors need two types of training to develop their capacity and efficiency; management skills and technical skills training. The technical skills such as formwork, masonary work, concrete work and steel work could be acquired through on job training programms. Management skills on the other hand, are required when contractors take on more complex tasks as they need to read and interpret drawings, manage their risks, financial control, bids for contracts and train the wokforce (International Labor Organization, Building, Civil Engineering and Public Works Committiee, 1983). Hewage and Ruwanpura (2006) identified workers issues in the construction industry of Canada. The results of that study indicate that worker motivation and worker training are required to improve skills such as management, communication and problem solving. This also may suggest that worker skills are important to sharing information and problem solving in order to improve productivity.

According to Isabriye and A.K (2018), a good educational background in construction and skill attitude of a worker is very important for work productivity improvement in South Africa and it also envisaged that the construction project organizations could incorporate the identified skills in their organizations to build capacity and that government could also use the identified factors in the strategies and policies for skill development.

Construction workers should be trained and educated by contractors on their roles and precautionary measures they have to take while doing various activities in site. Construction workers are given the chance to get actively involved in the enhancement process, then it becomes an incredible source of motivation. Construction clients should stimulate the safety of workers by adding extra clauses which ensure the safety in practice (Risath A.L.M , Sivatharasan S; 2017).

The important studies mentioned above suggest that skill factors such as supervision , experience and training on the job may influence worker skill for improving construction productivity. When these facors are lacking, skill may lack. These training skills may enable workers to be skilled to share knowledge at work, to solve work problems and to plan and work independently. The training and learning experience by the worker directly relates to the duties and tasks performed in the job situation and it is the relationship that motivates the worker to train and eventually perform better. Therfore it is evident that the motivational and skill development factors directly contribute to the success or failure of the project in order to improving construction productivity.

Methodology

According to Leedy and Ormrod (2002) it is necessary to identify the human behaviour factors influencing construction productivity. There are many behaviour factors influencing construction productivity but this research was limited to construction workers' motivational and skill development factors in construction industry. The research covers both public and private sector work, building projects and civil engineering work within Sri Lanka. The population consists of construction operatives in the construction industry in Sri Lanka. The targeted sample consists of contractors, consultant professionals, construction workers, totalling 100 in number, examing the construction workers' situation as it was, a descriptive survey technique was employed to gather data from construction industry operatives. These samples have been obtained purposively as per these ratios; Projects Managers (15%), Architects (8%), Civil Engineers (19%), MEP Engineers (13%), Quantity Surveyors (27%), Safety Officers (4%) and others (14%). It is presumed that, the whole population of construction operatives are geographically widely dispersed.

The research design is based on knowledge gathered from extensive review of literature on motivaton and skill development factors and case studies of similar researches. The data obtained was evaluated using a Likert scale of one to five as developed by Kazaz et al (2008), where one represent strongly disagree and five reperesent strongly agree. Thirty five factors were developed to measure construction workers' perception with regard to identified motivation and skill development factors. Two statistical methods were used to analyse the data provided by the questionnaires. First was to acquiring percentage values by the frequencies of the answers received and second is to calculate a relative importance index (RII) of the motivational and skill development factors. A combination of this methodology, using the Statistical Package for the Social Sciences (SPSS), was applied in this research.

Table 1. The evaluation scale for the data

Level of significance	Level of importance	Scale value
Not Significant (NS)	Not Important (NI)	≥ 1.80
Somewhat Significant (SS)	Somewhat Important (SI)	1.80 ≤ 2.60
Significant (S)	Important (I)	2.60 ≤ 3.40
Very Significant (VS)	Very Impomtant (VI)	3.40 ≤ 4.20
Extremely Significant (ES)	Extremely Important (EI)	4.20 ≤ 5.00

Analysis

The data from the results of the motivational and skill development factors, which influence construction productivity in Sri Lanka are described below.

The results of motivational behaviour factors significance level is presented in Table 2 below. Using the Table 2 evaluation scale presented and adapted from Kazaz et al. (2008:98), 17 motivational behaviour factors were evaluated. Three of the 17 factors identified and evaluated, as shown in the Table 2, were found to be extremely significant (mean index more than 4.20). While 15 of the 17 motivational factors were found to be very significant (mean index of more than 3.40). This would suggest that the 17 motivational behaviour factors are all more than significant and are of the similarity of the sameness,as such they all required and exceptionally important for influencing positive behaviours.

From the literature review it is apparent that motivational factors could influence positive worker behaviour only if workers have the capability to execute work.The development of worker skill and the confidence to accept roles, to perform tasks well are important factors which contribute to positive worker behaviours.

Table 2. Motivation factors

Motivation Factors	Rank in tot	Effect lev	Min	Max	Mean	SD
On-time payments	1	ES	1	5	4.37	1.056
Being given due value and respect	2	ES	1	5	4.29	0.821
Comfortable work environment	3	ES	1	5	4.21	0.983
Salary	4	VS	1	4	3.99	0.938
Adequate material supply	5	VS	1	4	3.96	0.818
Health & safety at work	6	VS	1	4	3.94	1.077
Quality of equipment	7	VS	1	4	3.93	0.942
Being praised	8	VS	1	4	3.91	0.956
Participation in decision making	9	VS	1	4	3.87	0.886
Rewards/ promotion	10	VS	1	4	3.85	1.069
Money incentives	11	VS	1	4	3.82	1.086
Transport for workers	12	VS	1	4	3.81	1.011
Challenging work tasks	13	VS	1	4	3.76	0.740
Long-term employment contracts	14	VS	1	4	3.74	1.09
Feedback	15	VS	1	4	3.73	0.978
Orientation programs	16	VS	1	4	3.62	0.907
Company staff housing	17	VS	1	4	3.56	1.125

In Table 3 the results of skill development factors‘ significance levels are presented. One of the 18 factors in Table 3 is shown as extremely significant (mean index being more than 4.20), while 17 of 18 factors are

shown as very significant (mean index being more than 3.40). As per the survey the factors are very important for the influence of positive worker behaviour and none of them be disregarded. The most significant factor was identified as staff self-efficacy (ES- 4.24). The least of the very significant factor was identified as task difficulty (VS- 3.59).

Table 3. Skill development factors

Skill factors	Rank in total	Effect level	Min	Max	Mean	SD
Staff self-	1	ES	1	5	4.24	0.701
Staff ability to accept	2	VS	1	4	4.03	0.847
Work quality	3	VS	1	4	3.99	0.844
Staff learning at work	4	VS		4	3.98	0.754
Staff self-esteem	5	VS	1	4	3.97	0.784
Work scheduling	5	VS	1	4	3.97	0.784
Staff training	7	VS	1	4	3.94	0.875
Basic educational level	8	VS	1	4	3.94	0.808
Work econo	9	VS	1	4	3.89	0.914
Staff work	9	VS	1	4	3.89	0.914
Literacy level of	11	VS	1	4	3.89	0.819
Staff montoring	12	VS	1	4	3.86	0.889
Interesting work	13	VS	1	4	3.83	0.928
Task variety	14	VS	1	4	3.77	0.868
Task significan	15	VS	1	4	3.74	0.957
Use of own knowledge &	16	VS	1	4	3.72	0.934
Opportunity to work independen	17	VS	1	4	3.71	0.924
Task difficul	18	VS	1	4	3.59	0.894

The important aspects of the 4 extremely significant out of 35 sub factors as ranked in Table 4 as reviewed below.

Table 4. The ranking only of the extremely significant behaviour sub-factors

Factor	Rank in total	Effect level	Mean
On time payment	1	ES	4.37
Given due value & respect at work	2	ES	4.29
Staff self-efficacy	3	ES	4.24
Comfortable environment	4	ES	4.21

The results indicate that on-time payment (ES-4.37) was ranked as the most effective motivator influencing positive worker behaviour towards construction productivity in Sri Lanka. On-time payment meets physiological needs that are the most basic requirement of people and gives esteem in a society. Despite Herzberg's argument that money is not a satisfier and thus not a motivator. In these studies, it is supported the contention that money is one of the most powerful motivators of construction workers and timely payment is the primary principle of any working agreement.

Being given due value and respect at work has a mean index of 4.29, evaluated as an extremely significant sub factor as shown in Table 4 above. Being given due value and respect at work ranked second of the most important sub factor for influencing positive worker behaviour for improving construction productivity. And it was identified as a social or belonging need, and one of the middle hierarchy needs which are important since a motivated employee may

consistently strive towards an attainable goal or set of goals. The study results show that being given due value and respect at work is an extremely significant factor for improving construction productivity. Self-efficacy has an impact on an individual's emotional reaction and thought pattern. It can also be described as a function of self-belief with which individuals can accomplish a task (Bandura,1986). It can be said that self- efficacy will most definitely lead to increased performance and productivity. The study results also show that staff self-efficacy is an extremely significant factor and it is the third most important factor for improving construction productivity.

Safety and comfortable environment has a mean index of 4.21, evaluated as an extremely significant motivational factor as shown in Table 4 above. The efficiency of a human worker depends on the working condition and the skill level of the worker. The working conditions, in turn depend on the atmospheric condition which is a combination of site location and thermal environment. Uncomfortable conditions in construction work site, restrict the ability of workers to function to full capacity and can lead to lowered job satisfaction and increases in illness symptoms. Therefore it is evident that the safe and comfortable working environment directly affects the positive worker behaviour towards construction productivity.

The last section of the questionnaire concerned any comments the respondents wished to make regarding the research study. There were only twelve comments received and they are summarised. The respondents gave the perception that although the study of worker behaviour for construction productivity is extremely important, construction industry is not adequately employing success factors in construction work sites to ensure that projects are completed successfully. The respondents identified good company values, visions of companies, good social treatment, good co-worker relationship as important to influencing positive worker behaviour for improving construction productivity. The 35 sub factors cover most aspects of these proposed behaviours for improving construction productivity. The comments suggest that the factors and behaviours identified in the literature and subjected to evaluations and investigations are all important for improving construction productivity. The above comments further suggest that although the factors and the behaviours are important, they are not being brought into a work situation in the construction industry. The comments generally support the results of this research and are to reach conclusions and make recommendations from the study.

Conclusion

Improving construction productivity in order to complete the project on time, within budget and to the desired quality, is a major concern of the construction industry in most of the developed countries. For the improvement to be realised, it was necessary to do the research on the human behaviour factors for improving construction productivity with the aim of identifying motivational and skill development factors which impact on positive worker behaviour for improved project performance outcomes, such as improved quality productivity.

The study focused on construction workers' motivational and skill development factors as a strategy for improving construction productivity in Sri Lanka. The research identified 35 motivational and skill development factors that could be incorporated in a workplace environment to improve construction productivity. The research is limited to human work skill development and motivation factors

in construction; though there are other human behaviour factors that influence construction productivity. Analysed data showed that on-time payments, given due value and respect at work, staff self-efficacy and safe and comfortable environment are extremely important factors for construction productivity in Sri Lanka.

Motivation provides the force and desires as well as the wish and determination which activate worker‘s action towards work. As such motivation is more likely to influence the desire and self determination to improve construction productivity through worker positive behaviour, provided the workers are skilled to perform tasks. The motivating workforce can be best achieved by improving motivating factors and eliminating demotivating ones simultaneously, aand the increase of motivation factors should always be accompanied by decrease in demotivation. At this point it is essential to distinguish that, if significant demotivators remain it will be a vain attempt to try to nurture motivating factors. Skill development of workers enable workers to be motivated and to have capability, willingness and confidence to accept work delegation for the proper execution of work tasks. Skill development of workers enables worker to be motivated and to have compatibility with work, willingness and confidence to accept responsibility and acounatbility for the execution of work tasks. Such work skill development should be done through worker training and through good communication. It is important for providing career growth and development for workers, and also motivates and commits workers to the organisation. Staff‘s work conditions and welfare involve the nature of tasks and work environment, including treatment of workers.

More importantly, this study identified the knowledge of motivation and skill development factors and behaviours, which when implemented, may improve productivity. Construction industry practitioners can implement these factors and identify behaviours of their employees to determine whether or not their employees are motivated and satisfied. This observation may give management better insight into the effectiveness of their current management practices in fostering those kind of behaviours which are important. The parameters for determining project success are time, cost and quality, which has been rarely achievable. According to the previous studies this may be because of the human influence factors for improved construction productivity, which were unknown and neglected. To improve the likelihood of improved construction productivity; the project mangers and construction mangers have to pay attention for worker skill development and good remuneration and fringe benefits in their project implenetation regard as a recommendation to put forward to provide some directions for improvement towards construction industry in Sri Lanka.

The construction industry has sometimes been described as adversarial and fragmented because of many stakeholders involved. Issues of dispute and personal conflict may sometimes threaten the improvement of construction productivity. This area of research, despite its relevance and importance, missing from current construction management literature. This study may offer a great potential and a starting point for the study of the attitudes and behaviours of construction workers in construction projects.

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Optimization of Conventional Land Survey Techniques Using Modern Technology

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Abstract: As far as a land surveying project is being considered, the knowledge about the accuracy, precision, time consumption and the cost efficiency are factors that must be equally taken into consideration before conducting the project. The success of any surveying project relies upon all the above components and hence the choose of the most appropriate technique for data collection is vital in the mentioned scenario. In the current situation, the conventional land surveying techniques, GNSS Surveys and Drone surveys have emerged through the society and are widely being used for surveying applications. Yet, their applicability in the most fruitful manner in obtaining the best results is still not known. Hence, the objective of this study is to evaluate and compare the accuracy, precision, time expenditure and cost efficiency of the conventional land surveying techniques, Survey Grade and Mapping Grade GNSS Receivers and Aerial Drone Surveying techniques. This study attempts to investigate the best appropriate technique to be adopted for the surveying projects depending upon the requirements of the survey.The data for this study is accumulated through the field surveys conducted using the considered techniques for a particular area selected. The same plot of land is surveyed using all the different techniques and the accumulated data is then analyzed and compared together in order to understand their accuracy and precision along with the respective time consumption and cost efficiencies. Hence, the most appropriate technique for the relevant surveying project can be investigated based on the project's requirement. Thus, the ultimate objective of this study is to analyze the different surveying techniques so that the best appropriate method of surveying can be inferred in order to yield the maximum harvest from the projects to be conducted.

Keywords: Area Calculation, Drone Survey, GCP, GNSS, RTK

Introduction

Land Surveying has been an essential task since the earliest generations. The techniques that have been used for these various types of land surveys have been advanced and refined over the cause of time from the primitive chain surveys to much advanced new technological instruments. Hence, the conventional land surveying techniques have been now developed up to Global Navigation Satellite System (GNSS) Surveys, Aerial Drone Surveys and other advanced techniques. The accuracy, precision and the productivity of these techniques have said to be more increased and advanced than the conventional methods, yet their productivity has to be addressed in greater extent (Geospatial World, 2020).

As far as the modern technological survey instruments are being considered, they occupy an initial cost which is considerably higher than the conventional survey techniques. The initial cost to be invested when acquiring a Survey Grade GNSS Receiver or a Drone will be comparatively higher than the expenditure to be allocated over a conventional Total Station. Yet, their

productivity is much higher when the consumption of other resources, the consumption of human force and the time expenditure are considered over the conventional land survey techniques (Wingtra, 2020).

This study mainly focusses on the Aerial Drone Surveys and the establishment of the Ground Control Points (GCP) for fixing the surveys conducted by the drones. This establishment of GCPs can be done using either the Total Station or the GNSS receivers (Survey Grade and Mapping Grade). Depending upon the accuracy and precision that is expected through the project, the suitable technique to be adopted can be decided.

Coordinates of the established GCPs is a mandatory requirement for fixing the aerial Imagery of any drone survey and hence, the accuracy and precision of the coordinates of the GCPs will be a strait effect on the output of the survey.

Thus, this study attempts to compare and analyse the accuracy and precision of the land survey techniques along with their cost efficiency and time consumption in proving coordinates for the established GCPs used for drone surveys, which will subsequently examine the productivity of the surveying project conducted. This will hence enable the surveyors to fruitfully incorporate and organize the project in a satisfactory manner depending upon the project requirements. So that the maximum advantage can be obtained minimizing the desolation of physical and human resources along with the minimum consumption of time as applicable.

Hence, the conventional land surveying techniques, RTK and Mobile Mapper are to be applied together with the Drone Imagery in calculating the extent of land through this study and is attempted to investigate the best appropriate technique to be adopted for such surveying projects depending upon the requirements of the survey.

Methodology and Experimental Design

This research was conducted using the field data collection using the conventional land survey technique also known as Total Station Surveys where the whole area was surveyed only using the Total Station and the area is calculated precisely. Next, drone surveys will be conducted in the same area, for which the GCPs were established according to our preference and coordinates were provided for the established points independently using Total Station, Survey Grade GNSS Receivers (GNSS RTK), Hand-Held GPS Receiver (Mobile Mapper).

The data for this were accumulated using the field surveys conducted at the 'Diyatha Uyana' in the Western Province of Sri Lanka. 'Diyatha Uyana' which is currently a leisure and recreational park of Sri Lanka, contains a very undulation when the shape of the plot is considered. This undulated shape of the plot was the basic reason for selecting this study area as the surface area of this plot can be a convenient measure to compare the accuracy and the precision of the techniques that are being used.

Hence, the following field practicals were conducted in the plot for data collection. Initially, the whole plot was surveyed using a Ground Survey from Total Station and the extent of the land was kept for the future reference of the extent of the plot.

Next, GCPs were established for fixing the drone image and the coordinates were provided for the established Points using a Total Station Traverse, GNSS RTK and Mobile Mapper independently. Table 1 elaborates the coordinates obtained using each technique.

Table 1 : GCP Coordinates

SN	Total Station		RTK		Mobile Mapper	
	North	East	North	East	North	East
A	489368.052	404658.380	489368.041	404658.398	489370.264	404655.934
B	489340.975	404645.671	489341.002	404645.693	489343.673	404642.945
C	489343.480	404640.381	489343.501	404640.369	489345.374	404642.573
D	489364.117	404688.325	489364.098	404688.348	489366.079	404695.914
E	489373.922	404663.742	489373.948	404663.76	489376.391	404660.967
F	489379.237	404665.600	489379.212	404665.58	489382.143	404663.465
H	489327.376	404684.530	489327.401	404684.551	489324.755	404682.652
I	489359.874	404699.976	489359.894	404699.955	489357.971	404702.343
J	489357.174	404705.581	489357.156	404705.559	489358.269	404702.985

After, the drone survey is conducted, these three sets of coordinates were separately used for fixing the Aerial Image.

Figure 1 : Processed Drone Image

The following table (Table 2) will more elaborately discuss the technical specifications of each instrument used for the above purpose.

Table 2 : Techniques & instrument Details

Technique	Instrument Specifications		
Total Station	Total Station		Sokkia IM50
Drone with Total Staion	Drone	Drone Model	Phantom 4
		Flying Height	100m
	Total Station		Sokkia IM50
Drone with RTK	Drone	Drone Model	Phantom 4
		Flying Height	100m
	RTK		HI-Target v60
Drone with Mobile Mapper	Drone	Drone Model	Phantom 4
		Flying Height	100m
	Mobile Mapper		Spectra MM50

Next, the extent of the plot was calculated using all the three fixed images and the output results was analysed together with the consumed time and the cost that was associated with the respective techniques. For this analysis, the expenditure for the survey instruments, the other required human resources and number of labour force needed along with their expenditure were taken into proper consideration.

Figure 2 : Area Calculation

Results and Discussion

After the plot is being surveyed using the Drone Survey, the accuracy and precision of the survey were analysed and evaluated using the calculated extent of the plot. The respective time consumptions, expenditure for physical and human resources were also taken into consideration for the three techniques used in providing coordinates.

The results of the area calculation of the drone survey and the details about allocated time and the required cost expenditure are depicted in the below tables.

Table 3 : Time and the Required Cost Expenditure

Technique	Instrument	Initial Cost	Rental Cost (Per Day)	No of Labours	Labour Cost (Per Day)	Duration
Total Station	Total Station	800,000	25,000	6	12,000	3 Days
Drone with Total Staion	Drone	320,000	20,000	8	16,000	1 Day
	Total Station	800,000	25,000			
Drone with RTK	Drone	320,000	20,000	3	6,000	5 hr
	RTK	1,600,000	25,000			
Drone with Mobile Mapper	Drone	320,000	20,000	3	6,000	4 hr
	Mobile Mapper	80,000	5,000			

Hence, it is undoubtedly evident that the area calculated using the coordinates provided by the Total Station, Survey Grade GNSS Receivers contains a precision less than 7 m2. At the same time when compared with the extent obtained from the initial survey conducted using the Total Station, which is

the currently considering area calculation techniques of Sri Lanka, the Drone Survey associated with Survey Grade GNSS Receiver shows an accuracy of 6 m2 and the Drone Survey associated with Total Station shows and accuracy of 1 m2. Thus, it is evident that for any small-scale map smaller than 1:1000 scale, using of any of the above methods will be equally accurate. Yet, if the purpose of the survey is, preparation of map larger than 1:1000 scale, the two methods will show a relatable difference in the generated output.

Table 4 : Area Comparison

Technique	Area	Area Deviation with respect to Total Station
Total Station	18038.819 m^2	-
	1.803882 ha	-
Drone with Total Staion	18039 m^2	0.181 m^2
	1.8039 ha	0.000018 ha
Drone with RTK	18032.19 m^2	6.629 m^2
	1.803219 ha	0.000663 ha
Drone with Mobile Mapper	18024 m^2	14.819 m^2
	1.8024 ha	0.001482 ha

Thus, when the required amount of human, physical and other resources are concerned, it is clear that the survey Grade GNSS Receivers allow the surveyors to obtain the results using very limited human and physical resources and with the lowest requirement of time than conducting a drone survey associating a total station. Thus, it is much obvious that GNSS RTK technique can be adopted to obtain a proper accuracy for an Aerial Survey using the minimum wastage of resources for any small-scale survey. But the initial cost for acquiring these instruments will be higher than the expenditure on a Total Station. The depicted approximate rental costs will also provide a specific notion about the cost for the survey to be conducted.

Once the Mobile Mapper is considered, the results undeniably prove that the expenditure for the survey will be much lower compare to any other land survey technique. Thus, this cost is much manageable for any surveyor. Still, with the comparison of its accuracy in the area calculation compared to the Initial Ground Survey using the Total Station, it should be highly noted that this technique should not be used for instances where a pinpoint accuracy will be needed. This can be applied for surveys and projects with the purpose of preparing smaller scale maps more productively as this contains the lowest amount of human, physical, financial and other resources.

Conclusion and Recommendation

After the decent analysis conducted using the conventional Land Survey Technique, Aerial Surveys associated with GNSS RTK and Mobile Mapper, it is evident that these modern technologies can be optimized over the conventional land survey techniques depending on the requirements of the survey. The needed accuracy range, precision, scale of the prepared output should be considered vitally along with the allocated time frame, available physical, human and financial resources for the relevant project when selecting the land survey technique to be used. Thus, in order to obtain the maximum benefit through the land survey project to be conducted, it is recommended to optimize the modern technological methods of surveying over the conventional techniques with proper consideration about the scale of the output, the required accuracy and precision of the work to be conducted. Hence, the most applicable technique can be selected with the prior consideration of the requirements of the survey and the available human, physical and financial resources.

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Architectural attributes which affect the rehabilitation and reintegration of juvenile correctional facilities

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Abstract: The process of reintegrating juvenile delinquents to society from correctional facilities is as important as the process of rehabilitation. If the rehabilitation process is not conducted properly it would rather be difficult to control the reconvicted /recidivism rates. Hence the correctional methods must adhere to certain attributes relating to the rehabilitation process, one key aspect being the built environment of the correctional facilities. Humans by nature have an undeniable connection with their environment through physical, mental, emotional and spiritual means. This connection is what helps keep a balance within ourselves. Most of the time, unlike adults' juvenile delinquents commit crimes without their consent. It is paramount that this is understood and they are attended with the required special attention in rehabilitation process. At stage of admission to the correctional facilities, these youngsters are more likely to be in a very weak state of mind, with the need of protection, self-value, freedom and to obtain the sense of belonginess in the society as they are reintroduced. This requires improvement of interpersonal and intrapersonal skills before leaving the correctional facility to avoid the reconviction /recidivism. The rehabilitation process influenced via architectural attributes followed at this research would be to understand level of lighting, usage of colours, enclosure of the space, outdoor-indoor relationships, level of privacy, architectural character of space and semiotics would lead to proper reintegration to the society.

KeyWords: Juvenile Delinquents, Rehabilitation, Architectural Attributes

Introduction

The term delinquency refers to a large variety of disapproved or, antisocial behaviour of children and adolescents, which the society does not approve of, and, for which the punishment or corrective measures are justified in the public interest. (Jain, 1995) The term juvenile in common dialect could be defined as a child or young person. It also can defined as a child or an adolescent between childhood and man/womanhood. Therefore, juvenile delinquency means a special category of offences created for children and adolescent persons.(Niriella) In the correction institutions there are juvenile delinquents for causing large variety of offences. The type of correction method and the correctional institute for the offender decide according to the committed offence. In Sri Lanka juvenile delinquency variety of offences, petty offences to serious crimes such as, begging, vagrancy, sale of tobacco, prostitution, petty stealing, assault and simple hurt, criminal force, selling and possessing of excisable articles/narcotic drugs, robbery, grievous hurt, murder, offence against state, terrorism. Most of the time these children became juvenile delinquents without their willingness, in Sri Lanka they became juvenile delinquents because of following facts. Disintegration of the family and laxity in parental control over children, motherless home environment, the rapid changing patterns in modern living, the associational impact, modern technology , failure in the school life/truancy, poverty, cultural conflicts, biological factors. Besides the following causes, illiteracy, child labour, squalor and disobedience can also be

considered as the other contributing factors aggravating juvenile delinquency.

The vision of Juvenile Correctional Centres is to provide spiritual guidance to the juvenile delinquents incarcerated and to make sure that those incarcerated do not feel like they are all alone in this world. If juvenile offenders don't heal, they are probable worse burdens dropped into the society. Hence it is certainly a concern to look into without ignoring them and it is very essential to heal through rehabilitation. The result of healing can be a cure to a health challenge, but one can heal without being cured.

At present in Sri Lanka, there is an increment in the number of juvenile delinquents and Juvenile Correctional Centres have become only a temporary lodge. It has become unfavourable or some other word as prisoners who re-enter to the society, commit a minor fault to re-enter to the prison. That fact shows that Juvenile Correctional Institutes are not able to achieve the main goal at the present situation.

There are facts which related to healing of juvenile delinquents such as development of both physical and mental health, relationship between others, and the context of the institution.

There for architectural attributes of those correctional institutes can effect for the rehabilitation and healing process of the juvenile delinquents. Aim of the research is to identify those architectural attributions which relate with rehabilitation process in correctional institutions.

The research will comprise a study of healing environment and its effect on juvenile offenders' behaviour at the correctional institutes. Therefore it will pave the way to achieve rehabilitation of juvenile delinquents physically through architecture and how it will contribute psychologically for their rehabilitation. Research will aid in addressing what is the social responsibility of architects in juvenile correctional centre design and the long-term contribution of this research will be having proper rehabilitation system which reduce re-offending juveniles as prisoners and it will contribute to the development of the country.

Objectives

- To identify the psychological characteristics of juvenile delinquents
- To identify the relation between architecture and psychological behavior
- To identify architectural attributes which effect the correctional and rehabilitation process at the correctional institutes

Research Methodology

This research has done in main two phases. In the first phase, it has been done for identify the psychological characteristics of juvenile offenders. What are the physical and psychological aspects that they need to improve. The first phase can be done by the literature review and interviews.

The second phase has been done for identify the architectural aspects which affect the rehabilitation process within correctional institutes. And study the role of following architectural attributions on rehabilitation process. Four selective case studies were studied under this phase to identify architectural aspects that has been used in those cases.

Foreign case studies has been studied to identify the architectural attributes. These case studies were designed following specific architectural concepts which can improve the considering psychological aspects of the inmates. Therefore the reasons to select these specific case studies were those architectural concepts which try to improve the psychological characteristics of the inmates.

a. the Yargas inmates at correctional centre Orlando, Florida

Orange County commissioned Architects Design Group of Florida to master plan and design the 33rd Correctional Centre in Orlando, and their concept was to create a correctional facility aimed to satisfy the needs and wants of the criminals, by using their own participation in the determination of the design. Therefore the firm interviewed prison inmates in small groups, without officer present. Then they gathered data on colour preferences and the psychological effects of colour, became convinced of its impact, and designed the Orlando jail with chromatic emphasis.

Therefore this case study help to collect data on impact of colours to rehabilitation process.

b. Juvenile Services Centre at San Luis Obispo, California

Merriam, Deasy and Whisenant Inc., San Luis Obispo, California Designed a juvenile shelter and detention services facility located on a 15 acres site. It consists of 39 beds, kitchen, classrooms, courtroom, and probation offices. The area of the building is 20,000 square feet having a space per occupant of 500 square feet. The main objective was to create a "homey" atmosphere by the creation of open spaces, free circulation and non-obstructive circulation within the facility.

c. South Central Correctional Institution at Anchorage, Alaska

A medium security detention located on 207 acres of land at Anchorage, Alaska. The area of the building is 72,000 square feet. The capacity of the building is for 100-180 inmates. The designer's main goal was to achieve a thoroughly residential character, both inside and out, without compromising security requirements.

Both b and c case studies project is help to identify impact the architectural (Homey) atmosphere of the building for the rehabilitation process.

d. Metro Toronto West Regional Detention Centre at Etobicoke, Ontario, Canada

A detention centre for the Ontario ministry of government services. The facility is on a 17 acres lot. The area of the building is 152,300 square feet, with a capacity for 216 inmates. Concept of the design is to create a secure but aesthetic environment, maximizing privacy without excluding communal spaces.

These case study help to identify the architectural attributes which can enhance the privacy levels of the inmates and the connection and relation between other inmates in communal spaces.

Data Analysis

Understanding the mental health difficulties of juvenile offenders are important to avoid the later offending behaviour and delinquency. Therefore those mental issues need to be controlled and cured at the correctional institutes. These juvenile delinquents are more likely to display anger, irritability and hostility and mood disorders, mostly depression. The irritable mood that often accompanies depressive disorders increases youths' probability of inciting angry responses from others, thereby increasing their risk of engaging in more physically aggressive acts that get them arrested. At the custody because of adolescent's mood disorder cause altercations with others or increase the risk of anger at oneself, resulting in self-injurious behaviours. Typically, anxiety disorders in youth result in less aggressive behaviours with the exception of posttraumatic stress disorder (PTSD). Children and adolescents with PTSD are liable to respond to perceived threats aggressively and unexpectedly. There is a multitude of evidence for the benefits of treating youth in acute distress due to mental illness. According to Grisso (2008), the most

common and effective treatments include professional clinical care, psychopharmacology as needed, and the structuring of an environment to protect youth as well as reduce stress while in crisis. Therefore they need to feel sensation of wellbeing, sense of belongingness, Freedom of movement, Sense of security and sense of freedom within the correctional institutes.

According to the Yargas inmates at correctional centre Orlando, Florida they disliked steel intensity because it sapped their strength, and they hated colours that applied to the spaces such as cream and institutional colours. Therefore they gathered data on colour preferences and the psychological effects of colour, became convinced of its impact, and designed the Orlando jail with chromatic emphasis. Blue, believed to have a calming effect, is used in inmate day rooms. Red, which increases brain wave activity and prolongs the perception of time, is used in visitation spaces. Various shades of orange, tending toward peach, salmon, and brown, are found in dining areas because they seem to enhance appetite. And yellow, which makes building elements seem less massive, tints heavy window mullions.

The whole building of Juvenile Services Centre at San Luis Obispo, California was created as a big house by having a huge living area right next to the sleeping areas. High ceilings give a sense of openness to the place. An open courtyard is adjacent to the main living area, and access to it is not restricted. Circulation flow between these three areas (dormitory, living and courtyard) is not restricted. Security devices like cameras are totally out of sight and an open control room is strategically located to have a complete view of the three areas. The building relates to the site with its forms. Creating a homely look even from the exterior.

South Central Correctional Institution at Anchorage, Alaska was design to achieve a thoroughly residential character, both inside and out, without compromising security requirements.

Provision of a variety of levels of living spaces, Programs and activities to achieve as a comfortable environment as possible. The natural site is handled to maximize its use within security. They achieved this by maximizing the use of open courtyards and also by providing for openings in the walls and ceilings for viewing and for natural lighting.

Residential units are linked to the rest of the facility by enclosed hallways. These hallways though, expose the surroundings through windows along them. This provides for an open and comfortable transition between living units and the rest of the facility.

Metro Toronto West Regional Detention Centre at Etobicoke, Ontario, Canada designed the concept with, to create a secure but aesthetic environment, maximizing privacy without excluding communal spaces.

The living units maximize privacy by providing small groupings of 10 rooms with a day room, restrooms and lounge area. These small areas were created for privacy. Dining, educational and recreational activities are separated from the dormitory areas. This separation is very noticeable differentiating the private spaces from the communal ones.

Conclusion

According to the data the children in correctional institutes are not like the other ordinary children there for they need special curing and rehabilitation process rather than punishment. Not like the adult offenders they need rehabilitation and reintegration process, rather than having period of punishment in a correctional institute. Beside professional clinical care, and psychopharmacology needs and the

structuring of an environment to protect youth as well as reduce stress while in crisis.

There are many architectural attributes that can follow to structuring of an environment to cure and rehabilitate the juvenile delinquents.

The security and the protection has to be ensued and enhanced by the structure and the inmates should not feel that they are admitted into a jail or enclosed area therefore the architectural character is very important to improve their mental condition. Homely building character can maintain to avoid enclosure feeling of the inmates.

The connection between indoor and outdoor spaces are also important, the openings and uses of view in each space can enhance the quality of the space. Privacy of the inmates need to ensure in the facility. Therefore maintain hierarchy of the spaces according to the privacy level is important.

Light condition and the views from the spaces are also important. Natural lighting conditions need to improve and the level of ventilation is also important. There should not be dark areas or corners inside the building. And the long monolithic corridors and the huge clean facades can also can be avoided.

And the usage of colours is also important. Using colours with the data on colour preferences and the psychological effects of colour is important. Blue colour can used for day rooms for get calming effects. Red colour increases brain wave activity and prolongs the perception of time and can used for visitation spaces. Dining areas can be coloured with using various shades of orange, tending toward peach, salmon, and brown to enhance appetite. Yellow colour can be used for tints heavy window mullions to makes building elements seem less massive.

And the use of materials to the spaces are also important, use of metals for the spaces can be deduce and rustic and pointy textures can be reduce from the spaces.

Through the research, the objectives have been overcame and the attributes which can affect on juvenile rehabilitation process within juvenile correctional facility have been identified.

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Paper ID: 374

Principle factors which affect to the proper functioning of urban public gathering spaces with special reference to recreational parks in Colombo city

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Abstract: Rapid urbanization and change of lifestyles require more public open spaces in cities to fulfill different socio, economic and environmental needs of the city. The urban park is a breathing space in a highly dense urban fabric for the public to recreational activities as well as physical health activities. The successful functionality of recreational parks in urban context will be determined by citizens' acceptance. A Sociologist and urbanist, William H. Whyte is the mentor who did long time research on public gathering spaces. Based on the research, he identified a set of principal factors behind the successful functionality and social acceptance of public gathering spaces. This paper will be discussed the applicability of Whyte's Principles in Sri Lankan urban context. For this research, theoretical knowledge of urban public spaces, recreational parks, principle factors of Whyte's theory will be discussed through a comprehensive literature survey. Basically, the data collection was done by self-observation, photography survey and a semi structured questionnaire. Semi structured questioner was helped to have more requests and ideas from the visitors. Finally, the data will be presented through photographs, graphs and charts to have better clarification about the collected data. In the conclusion, effect of Whyte's theory on the function of these parks and the things which have to be improved will be discussed.

Keywords: Urban public gathering spaces, Whyte's theory, Urban parks in Sri lanka

Introduction

Urban public gathering spaces, especially recreational parks became more popular in Sri Lanka within last few years after long term civil war. Pedestrian pathways, markets, squares, parks had acted as public places in Sri Lanka. These places gave a considerable contribution to enhance the relationship of people and also between the natural environment and people("A Critical Look at Central Park's Design," 2012). These recreational parks had been designed with the consideration of human activities and their behaviour. As a result of rapid development of urban cities, human lifestyle became more stressed and complex. They didn't have much time to move with other people and engage with recreational activities except their daily routing. And also, urbanization had directly affected to the natural environment and it was regularly got replaced from high rises and huge buildings. Because of the induction of the population and deficiency of the lands, people had to live in very small plots within a limited space. Therefore, they didn't have enough space to spend their lives freely with nature. In present, people are looking for the places where they can spend their valuable time with their family and friends leisurely while they build up human interaction, feel the natural environment with improving their mental and physical satisfaction. Necessity of public gathering spaces with recreational activities emerged with this demand. The way of addressing to human

needs and spatial qualities should highly considerable in recreational parks.

Whilliam.H.Whyte did a research on urban public gathering places in New York city about why some urban public places successfully work and why others don't. In a city, there were faultless places where people can enjoy themselves. According to Whyte's findings, people were used to pass the time while sitting around fountains, ledges and along the streets as well as in mini parks and plazas. People were gathered around mini parks, public squares, plazas and streets. He had noticed, that these places got more crowded in special times in a day such as lunch hours, evenings or in weekends. And also, he had recognized some of these public places were totally empty. Throughout his research he had discussed about the principle factors which had caused to proper functioning of a public gathering place as well as the drawbacks which were caused to create a dead place. These places function because of the people. Therefore, the place should be comfortable and attractive for them. Whyte had identified sitting spaces, water, trees, sun, wind, food, streets (accessibility), desirable and triangulation as the affective principle factors for a better functioning of an urban public gathering space.

The problem that I'm going to address through this research is why some parks are functioning well when others are not. With the rapid development of Colombo city after civil war, lots of neglected lands were converted to public gathering places, especially for recreational parks. Most of them are functioning well and some of them are not. Though the amount of people that uses these parks

varies significantly, all these parks were designed with one main purpose in mind. But the problem is why some parks work successfully and others don't? What are the attributes that are affecting for the functioning of these parks? Were they designed according to a principle or followed any proper method?

Research Problem

One of the best theories to study about urban public gathering space is Whyte's theory. The research question that we are going to address in this paper is whether the application of Whyte theory had led to the proper functioning of the recreational parks in Colombo city.

In this study, theoretical knowledge of urban public spaces, recreational parks, principle factors of Whyte's theory will be discussed through a comprehensive literature survey. This theoretical knowledge was assisted to conduct an analysis of collected data. Selected recreational parks around Colombo city were taken as case studies to collect data. When selecting parks, functioning of the park and basic arrangement is considered to do a successful and efficacious analysis. Basically, the data collection was done by self-observation, photography survey and a semi structured questionnaire. Observation is based on the principle factors which had been identified from Whyte's theory. Before doing the observations, check list had to be prepared. Things need to be observed had to listed out carefully by considering the needed data. To present the observed data, photographs were taken. For take more data regarding selected factors, semi structured questionnaire was presented. From each park, 90 people were selected from different age groups and different gender. Questionnaire was done throughout the day during several time period to take an average data. By a semi structured questionnaire, with the response of the visitors more data were collected by adding more questions. And also, that was helped to have more requests and ideas from the visitors. Finally,

the data will be presented through photographs, graphs and charts to have a better clarification about collected data. Data of all three parks will be presented as a comparison. As the conclusion, effect of the Whyte's theory on the function of these parks and the things which have to be improved will be discussed.

Most of the researches has been done about the impact of the social, physical and mental factors of urban parks. Less number of researches has been done about the designing factors of a public gathering space. Whilliam.H Whyte has done A research about the principle factors which are affected to the well-functioning of an urban public gathering space. And We have studied about three well- functioning recreational parks in global context. These three parks also have been used the principles which have been identified by Whilliam Whyte.

Discussion

For case studies we have taken three well – functioning recreational parks around Colombo city. Diyatha Uyana, Viharamaha devi Park and Nawala Wetland park had selected among all the recreational parks around Colombo city considering about its function and context. Thus, these three parks comparably crowded than other recreational parks, conceptually the layout and the functions of the parks were different.

First, we observed the purpose of visit to these parks. According to the observations, purpose of the visiting had varied with the time of the day and age groups.

Above table mentioned that mostly people visited the park to relax, enjoy and entertainment. Secondly highest number of people came to buy food. In Diyatha Uyana park, less number of people visited to meet a person. Considerable percentage of people had visited for exercises.

Purpose of visit at Viharamahadevi park

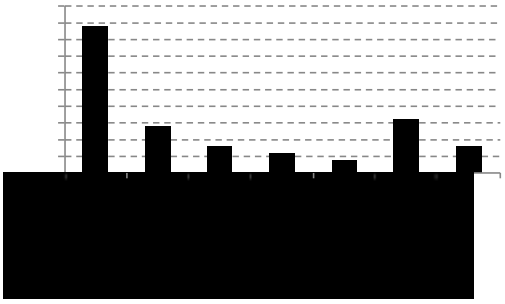

Figure 1: Survey results of main purpose to visit Diyatha Uyana

Purpose of visit at Viharamahadevi park

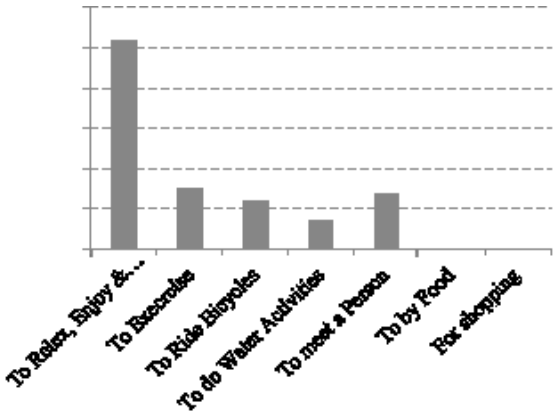

Figure 2: Survey results of main purpose to visit Nawala Wetland Park

As mentioned in above graph highest number of people visited for recreational activities as same as Diyatha Uyana. Minimum number of people came for do water activities. Though there is a food court in this park, anyone had not purposely came there for buy food. But as we observed lots of people had their meal in the park which had taken from outside.

Purpose of visiting to Nawala wetland park was varied within few purposes. As same as above mentioned parks, people came to this park also mainly for relaxing, enjoying and entertainment. Less number of people came to ride bicycles.

Purpose of visit at Nawala Wetland park

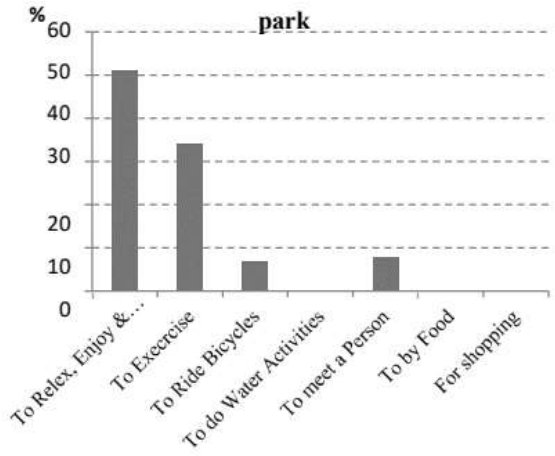

Figure 3: Survey results of main purpose to visit Viharamahadevi Park

According to the observations and data, people were gathered to these public open gathering spaces which had categorized as recreational parks for different purposes. category of the people had varied with the time and the age group. As the main purpose of visiting, relaxing, enjoying and entertaining marked as highest. Though it was the main purpose, they participate to other functions as well. Such as having food, boat rides, buying goods. All these functions were joined together in a park. As mentioned in Whyte's theory, people had gathered to public places basically for relaxation and recreational activities.

A. Seating places

Seating arrangements had been designed according to the defined activities in Diyatha uyana. Soon after entering to the park, there is an aquarium designed with benches around it under a shading. While walking forward, food court had designed as a pitched roof building which exposed to the outside. Either sides of the food court had designed with benches and tables for dining under a shading of a tree canopy.

Food court was elevated few steps, and people used to sit on the ledge which had created from the food court boundary. Either sides of the walking path also designed with seating spaces as short benches. Benches had arranged throughout the bank of Diyawanna Oya. And also, people allowed to sit on the grassed land too. All those seating places were lit up during the night time for ensure the security.

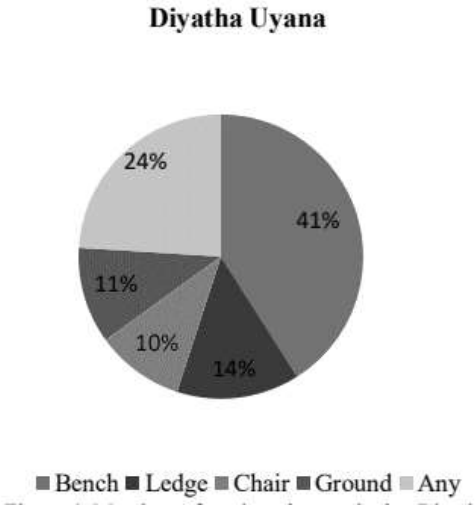

Figure 4: Mostly preferred seating method at Diyatha Uyana

This chart shows the preferability of seating method in Diyatha Uyana. most people had preferred to sit on benches. Secondly, 24% of people had no any special preference of the seating method. Minimum number of people had preferred to sit on chairs.

According to the observations in Viharamahadevi park, there were ample number of seating places designed throughout the park. Along the boundary of the park there were benches and ledges provided seating facilities for the pedestrians as well as for the visitors of the park. There were unevenly placed seating arrangements with a shelter as summer huts. And also, a small area of the park has been designed as a study area with benches and working tops. During day times number of people used to come this place for their studies as well as for have their lunch. As we observed most of the people preferred to sit under the trees or in the ground area.

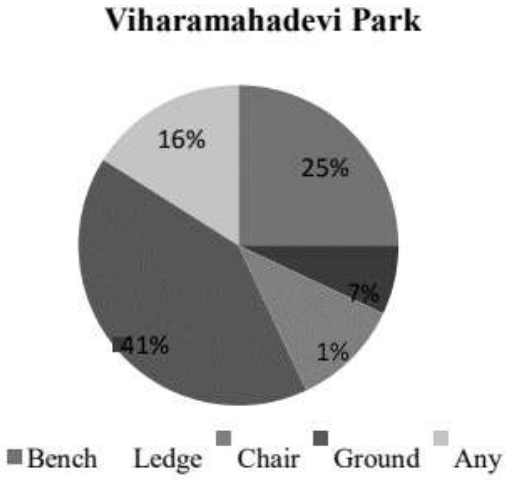

Figure 5: Mostly preferred seating method at Viharamahadevi Park

Above depicted shows the visitor's most preferable seating method in Viharamahedevi park. Most of the people had preferred to sit on the ground. Less number of people had preferred sit on the ledge. Secondly most preferred seating method was benches. In this park also 11% of people had asked for chairs.

Nawala Wetland park was designed with a continuous ledge going through the park. It was demarcated the path of the park from the beginning to the walking track. Either sides of the ledges were decorated with landscape. These ledges were used for seating under the shading of trees. By the side of the walking track also bordered by benches faced to the cannel. By designing seating spaces as continuous ledge, considerable amount of people can be sitting in a once. And also, there are some benches designed especially for physical training.

Above chart shows the seating methods which visitor's are mostly prefered in Nawala Wetland park. Highest number of people had prefered to sit on ledges. Secondly highest number of people had prefered to sit any where which available to sit. Less number of people had prefered to sit on the ground.

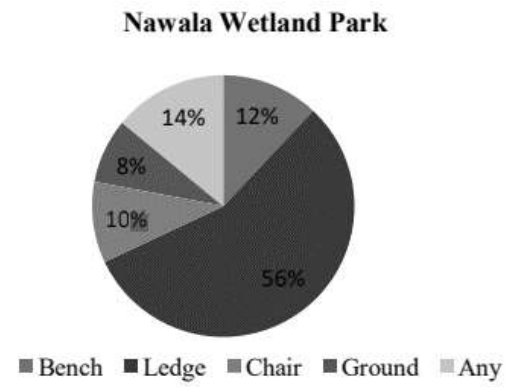

Figure 6: Most preferred seating method at Nawala Wetland Park

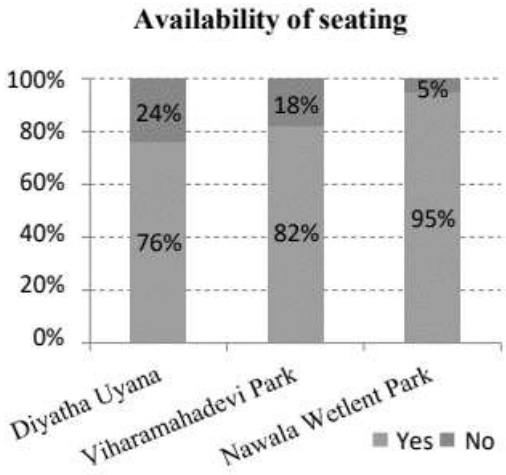

Figure 7: Survey results of availability seating in three main parks

Above graph shows the availability of seating in all three parks, whenever visitor's required. As shown, Nawala wetland park has the highest availability of seating. In every park, few number of people didn't get seating places everytime they visited. That because they didn't get a seat as they prefered. Such as for a couple, group of people. But, most of the people got a seat at any time they required.

According to the observations, all those three parks were consist of seating arrangement. Comparing with Diyatha uyana and Viharamadevi park, Nawala wetland park got more seatings available due to its design of ledges. at viharamahadev park, most of the people prefered to sit on the ground under the shading. People had faced more

difficulties without the handrest and the backrest of benches. At Diyatha Uyana, there were no any bench with a handrest and a backrest. Individual seating arrangement were used rarely in diyatha Uyana. Only Viharamadevi park got every type of seating arrangements. As example; benches, ledges and chairs. According to above data, considereble seating places had available in every park with various seating methods. As mentioned in Whyte's theory, availability of seating is a main factor for a better functioning of a park. All these three parks had consist with considerable seating capacity in different seating methods

B. Sun, wind and trees

In Diyatha Uyana, seating area of the food court which had faced to the car parks was showered with direct sun in the afternoon. Temperature of that side was comparingly higher than the other side which was faced to the aquarium under the shade of trees. Temperature and the comfortability were varied with the trees. Outdoor dining was laid under the shadings of trees. And also, food court was naturally ventilated by designed with low height walls by exposing to the outside tactically. That cause to merge the inside and outside atmosphere. Walking path directed under a canopy with the shading and cool breeze. During the afternoon people gathered around the shadings under the trees. With the sun set more people attracting to this place with their families and friends. Most of them prefer to sit around Diyawanna Oya, because they can feel the cold breeze in the evening.

Viharamahadevi park is located in the area which known as the green patch of Cinnamon Garden. That because this park was filled with various type of huge trees and stands as a canopy. It provides a shade for whole park with cool breeze. This place can easily identify in this busy town because of its special feature of ample number of trees. Most of the people were attracted to this place looking for shading with cool breeze in an urban area. People were looking for sitting places under a shading. Throughout the park which covered with the canopy provide comfortable seating with cool breeze. And also, it cut off the direct sun light coming in to the ground.

Similar to the Viharamahadevi park, Nawala wetland park also filled with large trees. Ledges for seating had designed under the shading of trees. And also, the walking track was shaded with a canopy. Some areas of the park had opened to the direct sun light while the rest of the area had functioned under the cool breeze with shading of canopy. From the cannel, cool breeze flows through the park. According to observations, most of the people had gathered around shadings. Most of the places under the shading were crowded. Open spaces converted to comfortable places by making trees. Food courts and other spaces had ventilated by natural ventilation. As mentioned in Whyte'stheory sun, 70% 60% 50% 40% 30% 20% 68% 88% 72% wind and trees are also a main factor for the better function of a park. As he discussed in his theory people gathered around shading areas in these parks. And most of the people perefered to sit under trees.

C. Water

As mentioned before Diyatha Uyana park had based on Diyawanna Oya. Therefore, most of the area had bounded with the water body. Boat rides are taken place to attract people to the park. And also, way to Diyatha Station gives a different experience for the visitors. Diyatha station had designed in the opposite river bank to the Diyath Uyana and the journey to the station was led by boats. As this was a marshy land, some parts of the park had converted to ponds with live features as flowers. Walking track ended with a small path which laid on the water body and covered with trees. Boundary of the Diyawanna oya had covered with a fence to

restrict the accessto the water. Also there is a water fountain in the center of Diyatha Uyana. It was designed with landscape elements to increase the attraction. At night this water fountain lit up with seiries of colours. This works as a land mark as well.

There is a chain of water fountains align with the Buddha statue and municipal council in Viharamahadevi park. This is used as a design feature as well as a land mark for the visitors to identify the place where they are. And also, there is another water body which has used for boat rides. Families, couples, young crowd and etc. can be seen enjoying this activity. Thus, there is a long bridge above the water body to cross the lake and to experience the view of the park. Small water fountains along the ledges can be seen in front of the Buddha statue. It demarcates the boundary of the statue. And also, this fountain creates an entrance with a welcome to the park.

Either the side of the Nawala wetland park, there is a cannel flow along the walking track. People do their physical training on the bank of the channel with the view and cool breeze. Seating places also have arranged along the cannel. There is a special boat which arranged for special events. people can use that for parties and event for have a different experience. And also, there is a water fountain inside the park. Walking path is laid around the fountain by demarcated from ledges while providing seating spaces faced to the fountain.

According to the above bar chart, majority had not satisfied with water activities. Highest number of people has not satisfied with water activities in Viharamahadevi park comparing with other two parks. Few people had satisfied with activities which are available in all three parks.

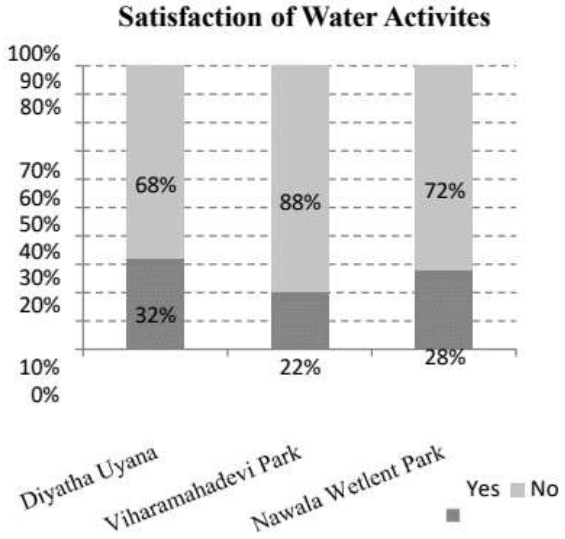

Figure 8: Results of the survey of the level of satisfaction among the people on Water activities in these parks

According to the observations and collected data, all three parks had a functioning water body. Swan boat rides are the available activity in these parks. At Nawala Wetland park there is no any recreational activity in water body than the boat which arranged for events. Every time even a one boat had a ride in Diyatha Uyana and Viharamahadevi park. But most of the people had not satisfied with the remaining activities. They had asked for more activities with different experiences. And also, people used to gather around water fountains. As mentioned in Whyte's theory, water bodies make an attraction for the visitors.

D. Food

During lunch hours and evening most people had attracted to Diyatha uyana to have their meal. This park had located in neighbourhood of lots of administrative buildings. Therefore, during lunch hours Diyatha uyana food court was getting rushed and crowded. Outdoor dining tables were arranged either sides of the food court. There is no place for dine during rainy times. Some people deliberately visit the Diyatha uyana station to experience the outdoor dining. There are two other restaurants including Diyatha Station additionally to the main food

court. Variety of foods can be seen in the food court and the expenses are bearable. Restaurant located inside Diyatha Uyana was used by most of the people for special functions. Diyatha Station is also a different experience for visitors.

According to the observations, places were marked by food vendor in Viharamahadevi park. Niche market was already taken place around the park. People were used to have their meal on benches, arranged benches with tables or on the ground. And also, there is a cafeteria in the park with a dining place. People who came from long distances to visit Colombo are gathered to this park to have their meals. But the people who are in Colombo are very less visit to this park purposely for have their meal. That is because these is no any proper food corner in this park with varieties. Ice cream carts can be seen taken place here.

There is no any food corner or a niche market can be seen in Nawala wetland park. In the morning there is only one stall of "kola kanda" supplier in front of the park.

Except Nawala wetland park, other two parks had a food corner. From those two parks, food corner and the restaurant at diyatha uyana functioning well due to its varieties of food and availability. At viharamahadevi park, food vendors got a prominent place. Some people visited to diyatha uyana purposely for had their meal. And majority of the people who come for any other reason also try to have a refreshment if there is available. Therefore, availability of food is main factor which affected to the function of the park. As mentioned in Whyte's theory, if food is available in a place people had used to gather in those places. A community of people created around food stalls.

E. Streets

Diyath Uyana park was directly opened visually to the main road without any fence or a barrier. This matter to enhance the visual connection with space and to enhance the attraction. But there is only one main entrance and most of the area had bounded with Diyawanna Oya. One side of the park which had opened to the main road was barriered with a slop and a small channel. A part of the park which faced to the main road was barriered with a short fence to restrict entering people from there. That because of the security purposes while maintain the transparency. Diyatha Uyana is located faced to a main road. Therefore, people can easily get close to the park. And also, layout of the park helps to lead the visitors without any guide or help. Streets inside the park were connected each other. Either sides of the walking track were defined with huge trees and some parts were defined from the Diyawanna oya and seating arrangements. People can easily identify their location of inside the park because of the interconnection of the streets. Walking track of Diyatha Uyana is consist of 3D paintings. People can enjoy themselves and have a different experience by taking photographs while walking. Paved path had designed for walking and bicycle track had located in the middle of walking tracks.

Viharamahadevi park had renovated by removing the fence by making more accesses to the park. That had created a link between the park and all the main streets around the park. People can easily access to the park from any side. Boundary of the park was defined with trees, bushes and benches. Here also transparency of the park was high. people move in to the park without any doubt while having a basic idea of the character of this park. Paved and carpet pathways connected and behave as guiders in the park. Either sides of the pathways also defined from trees and bushes. Jogging track and bicycle track are laid on the periphery of the park. around the park, street had busy with food vendors.

Two sides of Nawala wetland park was opened to the main streets. Rest of the area was bounded with a cannel. This park is located away from a main town. Park was defined from the street by paving and landscapes. As this was not spread through a wide area people won't face any difficulties to find the directions. People allow to entered to the park from any place which opened to the street. The boundary was defined with some flower pots to demarcate the boundary while maintaining the transparency. after entered to the parking area, the way directed in to the park by three main entrances. All those three pathways connected to the walking track. Therefore, people can easily find the way.

According to the observations, all three parks had designed perfectly to keep the visual connection with roads. Every park had used natural elements such as trees, bushes, water fountains to define the paths. Transparency of the park, motivate people to visit. All three parks have similar qualities in boundary defining, landscaping, designing the connections of pathways inside the park. According to Whyte's theory streets had being designed really well and this has a significant impact on the proper functioning of the three parks that I had considered in this study.

F. Undesirables

Everywhere in Diyatha Uyana, they have placed security people for maintain the well behaviour. They have to be checked all the vehicles from the main entrance. Around the parking area, aquarium, shops and food court there were people from the forces and ecurity. Therefore, undesirables were not allowed coming in to the park. People can have food only around the food corner and they don't allow to take food inside to the park. Because of this high security, people can't use anything like liquor or drugs inside the park. There were very few dark spaces under the security and most of the spaces are well functioned. But in the night time stalls are empty. Those places are available for desirables. Benches in this park are too short for sleep. Therefore, they don't prefer to sleep on benches in this park. And also, there were CCTV cameras placed everywhere in the park for better security.

Viharamahadevi park was secured by military people. There are checkpoints around the park. All the maintainers also were done by them. Therefore, undesirables can't get in to the park and make any disturbance for the visitors. But after around 6 in the evening, those kinds of people started to move in to the park. This was happened because most of the area of park getting darker and emptier in the evening.

Location and the layout of the Nawala Wetland park suppressive undesirables getting in to the park. There are few security people as well. There is no any place in this park which distrust for the visitor. Each and every corner functioning well. Therefore, winos don't get any chance to get in to the park during day time. During the night time also this park functioning well. But, to this park also undesirables come in midnight because the park getting empty and there are spaces to sleep.

Diyatha uyana and Viharamahadevi park has a good security comparing with Nawala Wetland park. Due to the dead of functions at Viharamahadevi park, desirables get chance to entering to the park in the night. And also, design of the benches creates a comfortable place for them. As a solution for that, at Diyatha uyana all the benches were designed as short benches. But the stalls are available for them during night time. Nawala Wetland park also provide places for desirables. That because of the benches and ledges which make a comfortable place for sleep. After midnight this park also getting empty. When considering to the Whyte's theory most of the recreational parks have a room of improvement in managing the undesirables.

G. Triangulation

Triangulation is one of the main principle factors which affect to the gathering of people. There are lots of recreational activities in Diyatha Uyana. Fish therapy stall, mobile film stall, street 3D paintings and children's park cause to aggrandize the attractive of the park. These activities cause to create connections between people. These places were crowded in evening and during the weekends. Some people visit this place purposely to take

3D photos. And also, the business area had given a major support for triangulation. There is no any sculpture can be seen in this park. But people used to gather around the water fountain which had designed at the centre of the park.

Viharamahadevi park was famous from long time for recreational activities. Various events like food festivals, carnivals, outdoor musical shows make this place more attractive. Viharamahadevi park act as a main gathering point. There is an outdoor open-air theatre for events. Usually once a week there are various events happening in open air theatre. During seasons there are number of events taken place in Viharamahadevi park. Such as Vesak lantern exhibitions, Christmas carols, "bakthi Geetha" events. One side of the park which faced to the Green path was filled with paintings. And also, there is children's park which was functioning well during evening and weekends. Next to the children's park, considerable area allocated for business activities. They have designed huts with benches and a work top. And also, horse rides and outdoor gym was supported to keep the attraction of the park while making a gathering point as well as enhancing the social interaction. Monuments and statues have been given an identity for the park while it works as a landmark for the visitors. And also, people had used to gather around those statues.

Nawala Wetland park is less in triangulation. There is a children park for small children. There is lack of activities happening there. people just gathered only for physical activities, family gatherings and specially for events happening in the boat.

Diyatha uyana and Viharamahadevi park has a high density of triangulation than Nawala Wetland park. Those two parks were designed basically for recreational purpose. People do enjoy the events and functions happening. Some people purposely come for participate to those events. As mentioned in Whyte's theory, these parks had used different activities, events and functions to maintain the triangulation. Nawala wetland park should improve capitalising on this principle factor of triangulation.

Conclusion

By considering the comprehensive analysis done on the data gathered through a questionnaire, self-observation and photography survey was used to derive the conclusion in this study. The conclusion of this study is that application of principle factors in Whyte's theory had led to a significant impact for the proper functioning of the recreational parks in Colombo city. When considering the three recreational parks that I had chosen for this study Viharamahadevi park, Diyatha uyana and Nawala wetland park, the principle factors of Whyte's theory had complied and applied to varying levels. But as a whole the proper application of the principle factors such as sitting places, water bodies, streets, food and triangulation had led to the proper functioning of the recreational parks.

For further works I would like to extend this study and do more comprehensive analysis on how the principle factors of Whyte's theory would affect to the social behaviour of people who visit to these recreational parks. Apart from that some parks have a lack of

application of certain principle factors and those factors are as follows.

During my study I have observed that some of the qualities has to be improved in these three parks. In Viharamahadevi park there should be a proper food court for the visitors. And more water activities have to be added to make people more engaged. There should be more lighting in Viharamahadevi park to illuminate the dark places and streets.

In Diyatha uyana there is some room for improvement in relate to seating. It would be better if there are more seats with backrest and hands rests. There should be better access to the water body. Around the food court it would be better to have more lightning. And also, in a situation of raining there is no proper shelter for the visitors to be. In Nawala wetland park there should be more activities to make people more engaged in activities to improve the triangulation. There should be more access to water bodies.

And there is a more room for improvement in the security side. There is no proper place for the people to eat in Nawala wetland park. Therefore, it would be better to have a food court.

Acknowledgement

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Evaluation of Urban Compactness Indicators and Solar Potential in the Urban Environment

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Abstract: One viable solution for clean on-site energy production and utilisation is Building Integrated Photovoltaics (BIPV). The available area for installation may not be sufficient to meet the building energy demand in high-rise urban buildings in tropical climates, although rooftops are ideal for photovoltaic (PV) module integration. This causes a requirement for the utilisation of facades. Furthermore, the unplanned urbanisation in Colombo has resulted in a difficulty in quantifying urban compactness and solar potential in urban environments. Therefore, there exists a requirement to assess the applicability of urban compactness indicators in quantifying solar irradiation on building envelopes in the urban contexts. This paper attempts to evaluate the credibility of several urban compactness indicators in relation to solar potential and establish the most applicable indicators in regard to the context of Colombo. The results showed that the roof to envelope area ratio provides optimum accuracy for predicting solar potential in the urban context of Colombo, Sri Lanka, whilst the average heights ratio exhibited the lowest. These results are significant for urban planners and developers when considering urban design guidelines.

Keywords: Urban; Solar Potential; Compactness

Introduction

In recent years, conventional energy saving and the use of unconventional renewable energy (NCRE) have become issues of great importance. Energy costs have increased due to the utilisation of fossil fuel or non-renewable energy, where solar energy is a renewable energy source with great potential, which may become the world's main source of electricity by 2050 (IEA, 2014). Recently, the architectural form in the urban environment has been changing to taller high-rise buildings, thereby further increasing the demand for energy. Sri Lanka's construction industry is growing and currently accounts for 35% of the country's energy consumption (Kumanayake et al., 2018; SLSEA, 2014). After realising the necessity to change to clean energy, the country has been moving towards a green economy and is implementing policies to reduce Sri Lanka's dependence on imported non-renewable energy (Ministry of Power and Energy, 2015). This tropical island is located towards the north of the equator and is on the receiving side of a lot of solar radiation all year round. In this case, building integrated photovoltaics (BIPV) are ideal solutions because they can generate electricity on-site, thereby reducing losses caused by grid conversion and transmission. In addition, they are a renewable and carbon dioxide neutral energy system (MacDowell et al., 2010). Through the use of building envelopes for photovoltaic module integration, BIPV can capture and convert solar energy on-site in urban areas. The application of BIPV on the facade of modern buildings is already common in high latitude countries (Xu et al., 2014; Zhang et al., 2012; Taleb and Pitts, 2009; Roberts and Guariento, 2009; Unnewehr et al., 2012) due to the positive inclination towards solar irradiation and the vast area available for the installation of PV modules. Office buildings are best for BIPV applications because the panels generate electricity at roughly the same time

that the building is in function (Lam et al., 2003). Even when used with materials with low emissivity, it is generally not recommended to use the structure of all-glass curtain walls in tropical locations (Halawa et al., 2018), unless it is used in conjunction with additional shading strategies. Tropical areas are more suitable for rooftop photovoltaic installations, but high-rise buildings may not be able to meet the energy needs of such buildings because the roof area may be insufficient. This has brought about the need to optimise external photovoltaic integration in tropical environments.

Previously, solar potential research has been carried out based on urban form (Compagnon, 2004; Robinson, 2006; Cheng et al., 2006a; Cheng et al., 2006b; Li et al., 2015; Sarralde et al., 2015) from the building and neighbourhood scale to the urban scale (Montavon, 2010; Pessenlehner and Mahdavi, 2003; Kanters et al., 2014; Wiginton et al., 2010). These are based on the investigation of the influence of different layouts in vertical and horizontal forms of building forms on solar energy potential and solar utilization (Cheng et al., 2006a), as well as the influence of various parameters indicating the shape and density of the city, including but not limited to plot ratio, site coverage, and building density (Morganti et al., 2017). Similarly, some studies have focused on assessing the solar potential of existing urban layouts (Kosir et al., 2014), but these studies were based on characteristic architectural forms, with few variations. Others only considered residential buildings (Li et al., 2015; Hachem et al., 2011), and some of them made use of solar radiation by suggesting optimized building shapes and urban layouts, and thus proposed urban space design guidelines. (Morganti et al., 2017). However, many of these studies have been related to using general and characteristic urban layouts to explore the impact of urban form on solar energy potential (Mirkovic et al., 2017), but have not been applied to actual case studies. In addition, despite the detailed analysis of independent buildings, due to the adverse effects of neighboring buildings and mutual occlusion, urban blocks cannot capture as much solar radiation as independent buildings. Therefore, the study of the influence of urban form on the solar potential is an area that has attracted increasing attention (Mohajeri et al., 2016).

A major problem in the Colombo architectural environment is the rapid spread of urban sprawl due to rapid urbanization (Amarawickrama et al., 2015). The combination of unplanned urban development and the lack of zoning plans have led to the random development of urban areas and the randomization of urban forms throughout the city, with no quantifiable forms or functions. Urban blocks in Sri Lanka often have multiple functions, with residential, commercial, government and industrial buildings coexisting in the same urban space. Therefore, it is difficult to conduct research in the city based on the function of city blocks. One of the most commonly used indicators of urban form is urban compactness (Mohajeri et al., 2016). However, in the real built environment, research on assessing the full impact of urban compactness on solar energy potential is limited. Researchers have studied compactness in many ways, but there is a lack of knowledge about how compactness in existing communities affects the solar potential of buildings (Li et al., 2015; Sarralde et al., 2015; Tsai, 2005; Mendis et al., 2020a; Mendis et al., 2020b).

Therefore, this paper attempts to assess the solar energy incident on urban building envelopes based on urban compactness in Colombo in terms of urban compactness indicators, where ten random blocks in the city are evaluated with the goal of

determining their respective urban compactness indicators, and how these indicators affect the solar energy incident upon the central building.

Methodology

A. Urban Block Type

This study made use of ten city blocks. Colombo is the financial capital of Sri Lanka, and unplanned rapid development in the past couple of decades has led to an rise in urban block functions taking on a mixed form along with urban expansion. This has brought about an inefficient use of available resources, including land, and has created an abundance of problems to the general public, including inefficient transportation means, pollution, and other services. Due to this, the city blocks that were selected are primarily of mixed form, where residential, commercial, and government regions exist together within the same urban block. However, for the purposes of this study, the focal point of analysis is upon the central building within the urban block. The definition of compactness is carried out by using the urban compactness index calculations, and these are related to the urban block's density in relation to specified standards. Several urban compactness indicators (UCIs) were used in this study, which include: (a) site coverage ratio, (b) volume to area ratio (V/A), (c) building density, (d) open space ratio, (e) building density, (f) ratio of average heights, (g) the area to perimeter ratio, (h) compacity ratio, (i) ratio of floor area to site area ratio, (j) ratio of roof area to the building envelope area. The V/A ratio is the volume of all buildings in the block against the total site area of the block; site coverage is the total building footprint area of all buildings in the block divided by the area of the block; The plot ratio is the total building floor area of all buildings in the block divided by the area of the block; the building density is the total number of buildings in the block divided by the site area of the block; the open space ratio is the open space area on the site divided by the total building area in the site; compacity is the building envelope area divided by the building volume; the ratio of the roof to the building area is the total roof area divided by the total building area; the roof and the envelope structure area is the ratio is the total roof area divided by the total building envelope area; the average heights ratio is the sum of the heights of the buildings divided by the number of buildings. Figure 1 below shows the ten urban blocks that were selected for evaluation. These were selected randomly from different regions of Colombo ranging from the city centre to surrounding areas, and Tables 1 and 2 provide a breakdown of the blocks by their parameters and urban compactness indicators from Blocks 1-5 and Blocks 6-10, respectively.

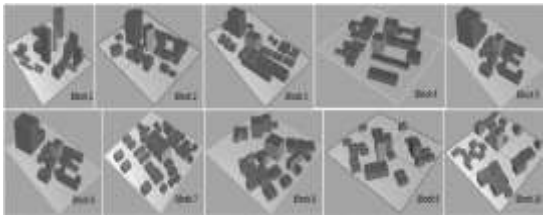


Figure 1. Urban blocks in Colombo

Table 1. Blocks 1-5 analysed by urban compactness indicators

Block Parameters	Block 1	Block 2	Block 3	Block 4	Block 5
Site area (m^2)	108026	46689	120637	65611	36318
Volume (m^3)	706025	187160	340871	188434	252883
Footprint (m^2)	22283	10116	18072	16994	9576
Floor area (m^2)	235342	62387	113624	62811	84294
No. of buildings	23	17	27	25	18
V/A Ratio	6.5357	4.0087	2.8256	2.8720	6.9631
Site coverage	0.2063	0.2167	0.1498	0.2590	0.2637
Plot ratio	2.1786	1.3362	0.9419	0.9573	2.3210

Building density	0.0002	0.0004	0.0002	0.0004	0.0005
Open space ratio	0.3643	0.5862	0.9027	0.7740	0.3172
Area to perimeter ratio	3.9112	3.0533	3.1919	3.1113	2.8719
Compacity	0.1650	0.2128	0.1746	0.2434	0.1654
Roof to floor area ratio	0.0947	0.1622	0.1591	0.2705	0.1136
Roof to envelope area ratio	0.1912	0.2540	0.3037	0.3706	0.2290
Average heights ratio	0.0141	0.0150	0.0058	0.0101	0.0162

Table 2. Blocks 6-10 analysed by urban compactness indicators

Block Parameter	**Block 6**	**Block 7**	**Block 8**	**Block 9**	**Block 10**
Site area (m^2)	27294	28457	26477	29874	29677
Volume (m^3)	56185	79853	72968	53586	62374
Footprint (m^2)	6492	8810	6755	4823	6772
Floor area (m^2)	18728	26618	24323	17862	20791
No. of buildings	29	31	25	21	26
V/A Ratio	2.0585	2.8061	2.7559	1.7937	2.1018
Site coverage	0.2379	0.3096	0.2551	0.1614	0.2282
Plot ratio	0.6862	0.9354	0.9186	0.5979	0.7006
Building density	0.0011	0.0011	0.0009	0.0007	0.0009
Open space ratio	1.1107	0.7381	0.8108	1.4025	1.1016
Area to perimeter ratio	1.8753	2.1682	2.0810	1.8971	2.0240
Compacity	0.3595	0.3021	0.3101	0.3263	0.3411
Roof to floor area ratio	0.3467	0.3310	0.2777	0.2700	0.3257
Roof to envelope area ratio	0.3214	0.3652	0.2985	0.2758	0.3183
Average heights ratio	0.0156	0.0148	0.0169	0.0125	0.0146

B. Solar Irradiation Analysis

The solar radiation modeling was carried out through a proven method and model that could take into account the effects of time, location, climatic conditions and shadows. From the literature review, a variety of validated models can be found that are capable of evaluating solar radiation on the ground in urban environments. Some of these models include Daysim, RADIANCE, and ArcGIS Solar Analyst (Byrne et al., 2015; Freitas et al., 2015). RADIANCE is an accurate ray tracing software, which has been validated many times in previous research and can apply the Perez diffusion model (Perez et al., 1987; Perez et al., 1990), and considers both diffuse reflection and specular reflection. It has even been used for curved geometries (Ward, 1994), and has been successfully used in many applications to determine solar irradiation on building surfaces. The simulation engine is controlled by Rhinoceros 6, which is utilised as a plug-in. Rhinoceros is a 3D modeling software that has the ability to bring forth the Grasshopper interface - a visual programming environment and language. Ladybug and Honeybee are opensource tools which are installed in the Grasshopper environment. These help to investigate and evaluate environmental performance. Ladybug can import standard EnergyPlus weather files into Grasshopper (Roudsari, 2013). Then, the Ladybug tool maintains the initial phases of the decision-making and design procedure via the provision of a range of interactive 3D

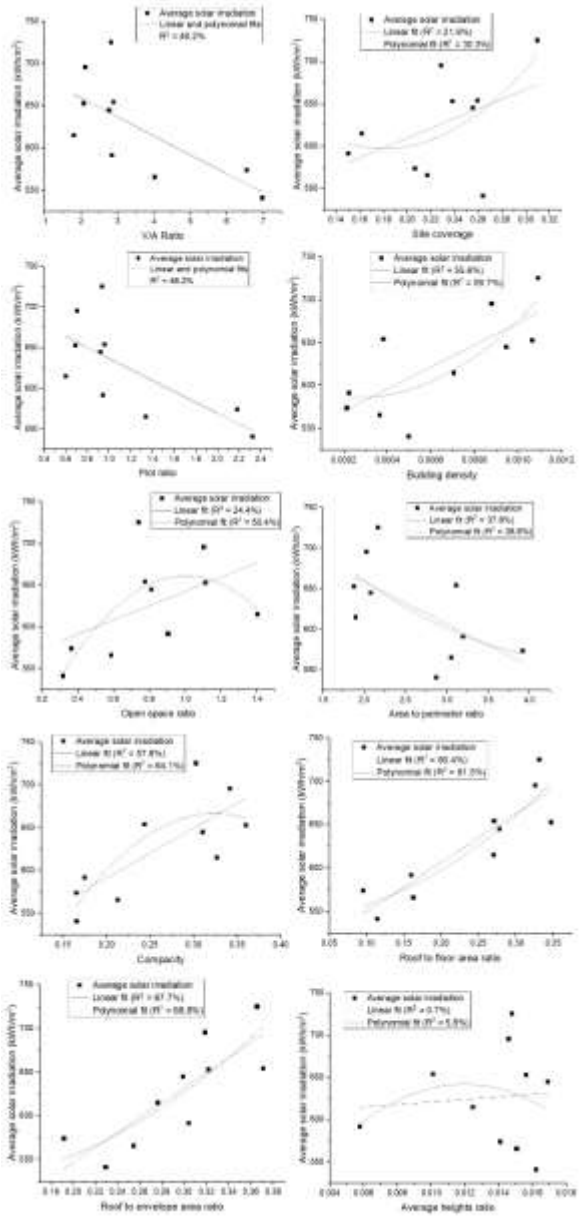
graphics. The Honeybee tool connects a visual programming language with four proven simulation engines that evaluate the building energy demand or consumption, thermal comfort levels and daylighting of buildings: EnergyPlus, RADIANCE, Daysim and OpenStudio (Roudsari, 2013). Therefore, validated environmental data sets and simulation engines are coupled with adaptable, component-based visual programming interfaces through these plug-ins. Thus, the suggested method for carrying out this study is to make use of the Rhinoceros and Grasshopper interfaces and the Ladybug and Honeybee tools, which will work as centers for radiation simulations using RADIANCE.

By using the RADIANCE simulation engine, a solar radiation simulation was performed in the urban environment of Colombo, Sri Lanka, where a selection of ten individual blocks were used, including a combination of block functions, such as commercial, residential, and government. The initial steps of the analysis include assessing the amount of solar radiation incident on the PV based on the average annual solar radiation (kWh/m2). This allows a better understanding of the solar radiation intensity available on the PV surface without having to consider the total annual solar radiation in kWh.

Results

The results found from the solar radiation simulation utilising RADIANCE demonstrate the value (kWh/m2) of the average annual solar radiation (façade) incident on the outer wall of the central commercial building in each block. Firstly, the solar energy potential of the block is analysed according to the radiation incident on the facade according to the respective city compactness indicators of the blocks. The preliminary results are based on V/A ratio, site coverage, building density, plot ratio, OSR, APR, compacity, RFAR, REAR, and the average heights ratio. The results obtained are shown in Figure 2 below.

Figure 2. Graphs of the average annual solar irradiation against the compactness indicators



The results obtained show that there is a debatable trend in the building density and site coverage graphs in comparison with those achieved in previous research, whereas those obtained for V/A ratio, plot ratio and APR appear to follow previous trends.

In addition, the coefficient of determination (R2) is calculated for the trend line of the solar potential within the block to determine

the degree of fit of the model to the data. Generally, the higher the R2 value, the higher the accuracy of the data fitting the trend line. It can be seen from the obtained results that for the polynomial fit, that the roof to floor area ratio has obtained the greatest coefficient of determination, and for the linear fit, its coefficient of determination is the highest at 80.4%. This is followed by the REAR. The polynomial fit for the RFAR is 68.9%, and the compacity is 64.1%, whereas the lowest coefficient of determination is shown by the site coverage (which obtained 21.9% linear fit and 30.3% polynomial fit) and average heights ratio (which obtained 0.7% linear and 5.8% polynomial). It can be inferred that urban compactness indicators with low R2 values cannot accurately predict the solar potential in the urban environment of Sri Lanka. This research evaluates the solar irradiation in the block based on the solar irradiation incident on the central high-rise building. If the surrounding buildings are lower-rise and placed more densely (which in turn increases the site coverage and building density) in Sri Lanka, the linear fit line may not be entirely accurate. This is due to the fact that the city block with tall buildings is hemmed in by numerous low-rise buildings, which not only increases the floor space and added density of the buildings and the block, but also raises the amount solar radiation incident upon the central high-rise buildings. This could create an anomality in the results. It can be suggested that, in the setting of Sri Lanka, or rather Colombo, when taking into account the solar energy potential of central buildings in relation to a surrounding urban block, the more consistent means to assess the existing urban form based on the urban compactness indicator would be to consider the roof to floor area ratio (RFAR), since it considers for the actual verticality (i.e. building heights) of the amount of built area within the block. The RFAR also shows signs of a high coefficient of determination (R2) when compared with other urban compactness indicators (for instance, building density or site coverage), since these only account for the absolute building footprint of the total surround number of buildings within the block. It can be stablished that the latter two indicators (i.e. site coverage and building density) are not a reliable method of predicting solar potential in urban blocks with ranging levels of verticality.

Conclusions

This research was conducted to establish the ways in which different urban block types of various compactness affect the solar irradiation (which in turn affects the PV generation potential) on building envelopes within the urban block in Colombo, Sri Lanka. The means involved the evaluation of ten different urban blocks on the basis of their urban compactness indicators, where the UCIs were calculated separately for each block. Next the solar irradiation incident on each central building was simulated using RADIANCE and assessed against the respective UCI. The main contributions presented in this paper include the establishment of the most appropriate urban compactness indicators for assessment and predication of solar potential in the urban context of Colombo. It was identified that the roof to floor area ratio presents the most accurate means of predicting solar potential in the urban context of Colombo. Based on these results, further research could be conducted to estimate the solar irradiation potential of random urban blocks in Colombo and compare against simulated results in order to establish the accuracy of this method.

This research carries many benefits, including design guidelines and further understanding to aid authorities, urban planners, and designers with urban plans, in educating them on how urban compactness affects solar potential within the built

environment, and how these parameters can be taken into account for sustainale urban design.

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Reconsidering Shophouse Architecture for Contemporary Times

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Abstract: The shophouses were the elegant buildings that lined along the Sri Lankan streets from the past. The very fact that the shophouses and their proportions contribute to the growth of the evolution of tropical architecture is phenomenal feature. The shophouse is a development of the basic house from in Sri Lanka, it is not a new, alienated concept, and instead the basic house form has evolved to cater needs of the society during the different periods of history. These buildings are used for both the commercial and residential purposes. However, in the contemporary world these shophouses are diminishing in number and there need to be efforts done to preserve this beautiful historic building. This research investigates on the manner in which the evolution of the shophouse architecture is appreciated-the traditional and the modern variant of the shophouse is examined through a typo-morphological architectural analysis, as they justify the new urbanism principles when designing cities. Thus, proving that the shophouses can be reconsidered as it has evolved for contemporary times in creating sustainable townships.

Keywords: shophouses, sustainable, new urbanism

Introduction

"The shophouse were usually two storey structures with shops, ateliers and stores at the ground level with living accommodation above and were usually fronted by verandas and balconies under overhanging roofs"(Anjalendran, 2016). These were the beautiful yet simple buildings that lined the streets of Sri Lanka from the past, especially along the old Galle Road.

In the contemporary world, these shophouses tend to be threatened due to rising land prices and widening of roads. The need to retain these shophouses should be looked into as we are rapidly losing our traditional buildings - the rate of change of society in the contemporary world is very quick- material commerce has taken over. "There is more than just the architecture to preserve in the community. If these old buildings are demolished, the people will go, so will the lifestyle and culture" (Sirisrisak, 2013).

The shophouse typology in Sri Lanka is not a very new concept- it is an evolved version of the basic, simple house unit, through the periods of history, starting from the Anuradhapura Period, where, "the houses were "rectangular and entered at one end. Inside there is a simple open volume divided into two by a thin screen" (Lewcock, Sansoni,Sennanayake1998). According to (Bandaranayake,2012), there were not much of evidence of the urban domestic buildings during the Anuraphapura Period, due to the use of perishable organic building materials such as timber and clay . " The only confirmatory evidence of an early street architecture that resembles at least in principle the traditional terrace housing of the 18th,19th centuries which can be broadly related to urban descriptions in literature is the poorly built foundations of row houses

unearthed in early excavations at Anuradhapura" as shown in Figure 1.

This evidence portrays that the row houses

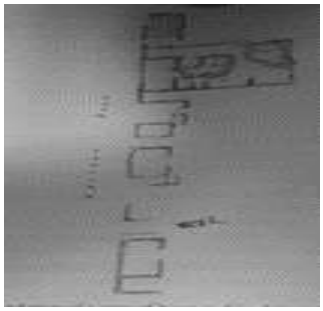

Figure 6: Foundation of Row houses, Citadel, A'Pura, Senake Bandaranayake, 2012

of Anuradhapura is a reflection of 18th, 19th century colonial period street architecture, which constituted of shophouse architecture.

It could be attributed that with time, during the colonial period the economic structure of Sri Lanka constituted high levels of trade- during this time the shophouse was put into full potential in terms of social and economic context. "Busy sea-junction compromised of a single mainstreet where the storehouses and Bangasals were located "(Brohier, Raheem, 1984). According to (Maharoof, 1986), the present days Bankshall Street gets its name from Bangasals and indicates the location of the old Muslims trading settlements. The Muslims lived in compact communities, the merchant quarters, the market place and the mosques were clustered around these Bangasalas" (Azzez. 1986). The present day Colombo- Kandy road was constructed in 1825 by the British. These "roads were built to serve the transport needs of the plantation areas" (Jayawardene, 2007). According to (Perera 1998) the Singhalese used bullocarts which took six to eight days to transfer goods in the 1850s. (Perera 1998) states that "British did not have more efficient means of transport in Ceylon than did the Ceylonese. This advantage was immediately captured by the Ceylonese as a means of becoming entrepreneurs". Perera further states that the locals then began to invest this system of transport, hence making them rich over the years. This similar idea is expressed in the book by Kumari Jayawardene, Nobodies to Somebodies- in short, these quick rich class of people were first nobody then they eventually became somebody.

Within these changed services in the economy, a new building typology called the shophouses emerged, places where the traders broke their journey. With the setting up of these shophouses the system of trade became efficient and they became centers where people could buy and sell cash crops and other goods. The traders ended up residing in these shophouses. These aspects are noted by (Wijethunge, 2016).

Most of the shophouses in Sri Lanka have been demolished as they have been acquired by the merchant class who does not place a great store by traditional values since they enterprise quantity over quality. The UDA in Sri Lanka has decided that the De Soysa building(a shophouse) in Slave Island will be brought down and a new one with the same façade would be erected a distant over, this is done due to the road expansion. Architect Ismeth Raheem had stated and this was published in the Sunday times that the building is a "remarkable gem of colonial architecture and a century old building". The Sunday times newspaper mentions that "It is one of the earliest examples of shophouses in Sri Lanka; shops at the bottom, homes in top". The newspaper further states this- "Last year, the same was said of the salmon-hued, chipper Castle Hotel…But the gleaming white structure that rose there- and which now houses the Tata project office is nothing like the Castle Hotel". However The Ena De Silva House had a positive ending- the property was sold to Durdans Hospital, the management of which intended demolishing it to create a modern car park. Fortunately aesthetic conservatives and local architects dismantled the building brick by brick and

reassembled it in Lunugaga in order to preserve it for posterity. This same level of effort needs to be taken when restoring the Colonial period shophouses.

Although the shophouses have been demolished, there are sights of its evolution of it into the contemporary world- such as in the New Town of Digana and the Mellenium City Shophouses, to name a few. These shophouses yield a sustainable way of building town dwellings with relation to the urban fabric. When people start experiencing the built environment to the fullest they develop an understanding of the meaning of the space according to (Rapaport 1982).

Methodology

The case studies are done under two parts-

- An architectural appreciation of the Traditional Shophouse- Two case studies are taken from Ambalangoda, a costal town and Hingula, which is along the Colombo-Kandy Road.
- An architectural appreciation of the contemporary Shophouse- The case study of the Digana Town is taken and a shophouse which is converted to a Lodge in the Galle Fort is taken.

A typo- morphological analysis is done to study the shophouse architecture, ie- a study that details the physical and the spatial structure based on architectural form and elements.

These are the aspects which are analysed in the case studies- Space Formulations, Walls, Other Architectural Elements- columns, doors and windows.

The case studies chosen reflect on the traditional shophouse and how it has led to the evolution of the contemporary shophouse. Thus, these case studies prove that the shophouses could be considered for contemporary times.

The final part if the research points out the sustainable path of creating our streets using the shophouse concept. The shophouses in the case studies are justified with the New Urbansim Principle to provide a sustainable approach to build town dwellings.

Results

The Architectural appreciation of the Traditional Shophouse

For the architectural appreciation of the traditional shophouses, three shophouses from Ambalangoda and one shophouse from Hingula. The shophouses are the ones that still retain their colonial identity in terms of their architecture, however several of these shophouses have undergone minute changes with the passage of time. All these shophouses constitute of similar architectural qualities and vary very little in terms of from, space formulation, ornamentation and sense of place.

Space Formulation- The plan form and the section form of all these shophouses are very simple and it adheres to the golden proportions in terms of measurements. There is a verandah, living area and towards the rear there is a kitchen space. As Figure 2 indicates, a timber staircase is niched in a limited space which corresponds to more of a ladder than a conventional stairway as the

Figure 2: The ladder- like staircase, Source- Author

Figure 3: Upper Floor, Source- Author

ground floor provides a more prominent space for business activities and storage to take place. The upper floor is a solar which opens into the balcony (Figure 3).

Walls- The walls of these shophouse are all load bearing with a thicknesses varying

between 20"-25". These walls stand on rubble foundations which were of two and a half feet in width and depths up to one and half feet. The Dutch constructed these walls out of coral stones with lime mortar which provided coolness into the interiors. Most of the wall plasters have been exposed in the present state of this shophouse. The walls also symbolizes a form of ornamentation- ornamentation in terms of flat surfaces such as paintings, wall color- the exterior walls of this shophouse are of orange and pink, in the present day the colors have peeled off (Figure 3,4). It is evident that bright colors would have been used during the colonial period for the walls as they become beacons for attracting vendees to carry out commerce.

Figure 4- Bright coloured walls- Source- Author

Figure 5- Interior walls in pink, Source-Author

Doors- A row of doors each four sashed align at the entrance in the verandah. Two of these doors had an arched fanlight with several bars introduced on the top.These fanlights originated during the Dutch period and were carried through into the British period,

Figure 6: The arched fanlight above the doors, Source- Author

Figure 7: Iron door hinges, Source-Author

providing light and ventilation into the interiors. Since shophouses were the houses of the poor there was not much decoration on the fanlights. Massive door hinges, a Dutch feature are visible in some of the doors of the shophouses.

Other Architectural Elements- There are continuous columns from the ground floor to the first floor. The columns are attached onto a pole plate to bare the weight.Out of the three case studies,one shophouse had some exquisitely crafted columns. Basically these are two columns joined together.There is a wider bottom part and then there is a tapering with moldings. Then the column head of the first column acts as the base for the extension of the upper column. In this way these columns do not have bases, this aspect highlights the roof (Fig8).There is a pilakottae, on one side wall embedding a part of the column in the verandah which creates an in-built seat. (Fig 9). These features enhance social actions of people.

Figure 8- the beautifully carved column, Source Author

Figure 9- Pila kotuwa in the verandah-Source- Author

Doors in the interior have ornamentation on their fanlights, these decorations portray traditional Sinhalese designs in the form of timber carvings such as Liyawal (Fig 10). There is a decorative valence board which

Figure 10- windows with liyawal designs on the fanlights- Source Author

Figure 11- Liyawal designs on the valence boards Source- Author

depicts the cravings of the traditional Sinhalese designs of Liyawal (Fig 11).

There is a shop already in existent in the verandah of one of the shiophouses. However for the purpose of collecting information for this research this shophouse was visited thrice and during the course of time changes could be visible. During the last visit the shop in front was being re-built. Changes such as the earlier lattice grills were replaced by glass could be seen (Fig 12,13).

Figure 12- the lattice grills of the shop is visible Source- Author

Figure 13 the grills have been replaced with glass Source- Author

The Architectural appreciation of the Modern Variant of the Shophouse

The next phase of this essay presents a case study of a shophouse in Galle Fort which validates how an existing shophouse has been put into new use in the modern day. However in the earlier days in the Galle Fort the verandahs of these houses were not used as shops.

As the form is retained the spatial organization is very similar to an original shophouse. It is simple and linear.It consists of a verandah, living area, courtyard, bedroom, dining, and a rear kitchen. The spaces are in the same progression as the earlier case studies.

These are very thick walls (20”-25”) constructed of lime mortar and cement by the Dutch.There is a 20 inch niche created which is being used hold ornaments, the size of the niche indicates the massive thickness of the walls back then. (Fig 12). The use of coral stone and then the thickness of the walls provides a very good level of thermal comfort. The plastered surface of one wall has degenerated, however the rubble brown texture underneath the plaster is very striking and this wall has been used as a feature wall. (Fig 13). These features go on to show that the novelty of colonial architectural never fades off. There is a seating, resembling a pilla kottae which allows to comprehend with the narrow street.

Figure 12: Niche created within the wall-.Source- Author

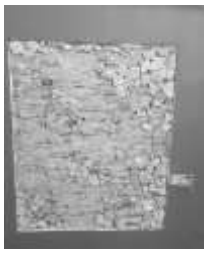

Figure 13: the rubble textured wall. Source- Author

The final case study is done on the shophouses of Digana- this a town in the contemporary times which was inspired by the shophouse concept, designed by Ulkrik Plesener and Nihal Perera, with simplistic zoning of spaces for their functions. As mentioned earlier the upper floors were manipulated by the owners themselves.

The edges of the roofs of these shophouses were not clearly defined whereas in the Ambalangoda and Hingula shophouses the gable edges were very well defined. In the Digana shophouses the rafters can be seen and there is something unfinished as the eave is extended and it is propped up with timber struts (Fig 14). This extension of the eave creates an awning to cut off the glare and also it shelters the walkway.These shophouses prove that the designers understood the principle of the colonial shophouses in terms of the roof and used it intelligently in a modern concept, effectively creating an arcade for people

Figure 14-undefined gable ends Source- Author

Figure 15-there is no balcony, props used, Source- Author

Unlike the Ambalangoda and Hingula shophouses where there a few columns on the verandah these shophouses have just two enormous standing columns on the two edges supporting the structure above. These shophouses don't have a balcony in particular, however the props are fixed at an angle as it supports the extended eave of the roof. So if the trellised window is open there is a sense of feeling that corresponds to a feeling at a balcony(Fig 15).

Discussion

The shophouses could be proved sustainable through its analysis with the new urbanism principles –

The first two principles are walkability and connectivity. The shop fronts are narrow with verandahs and there are many shophouse units along the street so this implies that the people walking could cover more units per stroll comfortably. The long verandahs of the shophouse units in diagna signify this and also the verandahs of the shophouses of Ambalangoda (if the original rows of shophouses were present)would justify the walkability. The comfortable experience is enhanced as the walkway provides protection from the rain the sun. The rear lanes of these shophouses are kept free of motor traffic creating paths for people to walk on. These rear lanes are independent from the main street on the front as seen in the case studies especially in Digana were the back lanes constitute of the drain lines. However the network of dual lanes provides a sense of connectivity as their density is high.

The third and fourth principles are *mixed use and diversity* and *Mixed Housing*. These two principles could be justified by the function of a shophouse as traditionally the shop owners lived on the upper quarters. This shows the mixed uses of the shophouses. For successful housing flexibility is key as the internal space arrangements with column free interiors (case studies 1, 2, 3, 4) provide optimum flexibility of spaces for activities of many purposes to take place.

The fifth principle include Quality Architecture and Urban design. The shophouses uses the natural lighting and ventilation system effectively. This done by its linear form allows light and ventilation in from openings such as doors and windows. The use of local materials for the walls and floors brings a sense of coolness. The overhanging roof also prevents the direct sunlight from hitting the walls and the lime wash coating on the walls further cools the walls and the interiors through evaporation. These houses are naturally ventilated compared to modern houses which achieve comfort through air conditioning. This proves that the quality of the architecture of the shophouse is adaptable to the tropical urban environment of Sri Lanka.

The sixth principle is a Traditional Neighborhood Structure. The shophouses in Sri Lanka are of the colonial period of our history. So these shophouses echoes a sense of colonial tradition in the modern streetscape. The seventh principle is increased density, with the walkways of these linear shophouses created for walking attracts people (more shophouses per unit stroll) and creates a very livable space.The eight principle is smart transport, with its walkable nature and the mixed use reduce the number of motors needed for transport. This is seen in Digana as the motor traffic is quite less compared to other towns without

shophouses. The ninth principle is sustainability, the shophouses are built using traditional materials for all the shophouses, such as timber rather than modern construction materials. This creates naturally ventilated structures with carbon-free interiors which need low maintenance and are long lasting.

The final principle is the Quality of life, these shophouses in the past catered a traditional way of life with a quality of its own. In terms of thermal comfort these simple structures have very livable interiors due to the massive thickness of their walls and these finished off with a lime wash coating bringing coolness inside through evaporation. With natural ventilation prevailing through their inner courtyards, balconies (present in case studies 1, 2, 3, 4) and verandahs (present in all case studies) these shophouses combat the high humidity levels extremely well. The shophouses although small in scale could outclass modern interior which achieve these same comfort levels through

Conclusion

The very fact that the shophouses and their proportions contribute to the growth of the evolution of tropical architecture is phenomenal feature. Most of the shophouses in Ambalangoda, Hingula and the down South have been destroyed due to street widening as people cannot afford to live in a house at such an edge of the street due to sky rocketed land prices, people prefer modern buildings with concrete and glass as they believe that owning a traditional dwelling as being a symbol of poor these days. The shophouse is a development of the basic house form which was developed through the periods of history to cater the social and economic needs of the people. If these shophouses are completely destroyed we would not have a gene pool. We need an area in which these shophouses thrive, posterity would be understood, we need to reconsider these shophouses for the contemporary times. Thus there is a continuity from the past to the present. Although the shophouses have been` demolished there are sights of evolution of it into the contemporary world-towns such as Digana has been inspired by the shophouse concept. These shophouses yield a sustainable way of building town dwellings with relation to the urban fabric.

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Biography

My name is Nathasha Kudasinghe and I completed my Bachelors in Architecture from the General Sir John Kotelawala Defence University in the year 2019.

The Impact of Living in High-rises for the Cognitive Development of Early Childhood in Sri Lanka

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Abstract: High-rise buildings have become a popular strategy for accommodating population growth in urban areas in Sri Lanka. Each and every building has different characters and personalities that offer different experiences to a person in their daily lives, but the most vivid to sharpen their psychological and social behavioral qualities is their home or permanent living space and surrounding characters. Different factors such as age, gender, educational level, economic status and social cultural background can be considered to categorize people. The main consideration in this research is the age. Childhood, puberty, adulthood and old age are the four main stages of human life. This study has been carried out to find the impact of living in high-rises during the early childhood. The age category was addressed throughout this analysis will be the age group from 1 to 5 years. Purpose for the gathering information three well-known nurseries were evaluated under Interview guideline for teachers and list of activities for children. Collected data were analyzed by case study approach and presented through descriptive statistics. Findings of this research indicate that living in high-rises during early childhood impacts negatively for the physical, psychological and psych-social development of the child. Recommended options that future architects can follow to minimize above issue have suggested in the end of this thesis.

Keywords: High-Rises, Sri Lanka, Cognitive Development, Early Childhood

Introduction

The way how architecture can manipulate human qualities and experiences is fascinating. Some environment predictability affects human behavior. It is difficult to prove the psychological effects of architecture, but difficulty does not dilute the value of a building that hits the right notes and creates a sense of wonder. Each and every building has different characters and identities which provide different experiences to a person during day to day life, but his home or permanent living space and characters of its surrounding are the most vibrant to sharpen his qualities of psychological and social behavior.

Always human sensors include the eyes, ears, nose, skin and tongue are tracking and seeking different variables such as heat, light, sounds, color, noise, movements and more. Although we do not have much realization, our mind always guided with the volumes and characters of the place wherever we stand. Those various characters will affect the experience of a person which directly going through in a decision making process in day to day activities. As well as the same volume or living space will provide a vibrant feeling or an expression to various people in a different manner.

Categorization of people can be done with the consideration of different factors such as age, gender, educational level, economic status and social cultural background. In this research the main consideration is age. Childhood, adolescence, adulthood and old age are the main four stages in human life which provides the basement to experience

and enjoy his living space as the person desire. Out of them "childhood" is one of the critical stages in every human being.

The characters of living in high-rises can directly affect either positively or negatively to their psychological level, expressions and feelings. The experience from living in high-rises and surroundings may affects for the rest of their life. High rise buildings have become a popular strategy for accommodating population growth in urban areas in Sri Lanka. Hence, most families have chosen apartments as their permanent residences. High rises are basically located higher from ground level and different type of special experiences and qualities are included. Simply this study examines the relationship between living in high-rise buildings and self-rated health of children whom represent early childhood and whether there is an impact of living in high-rise buildings for the cognitive development of early childhood in Sri Lanka. This study will be with reference to pre-school children which provide more knowledge about how living in high rises will effect to the life of children. For that first, it is necessary to understand about impact of living high-rises, link between environment and children, child psychology.

a) Impact of living in high-rise buildings

High rises do generate both positive and negative consequences. It provides extraordinary views (at least to upper-level inhabitants, except if their view is hindered by other elevated structures), and relative urban security. Their usual central urban location is an additional advantage for those who prefer it. Numerous services and transportation options can be found to close to the residence. But most the researchers believe that high rises are unnatural which leads to fear, dissatisfaction, stress, behavior problems, suicide, poor social relations, reduced helpfulness and hindered child development (Gifford, 2007). High rises have been accused of causing many unpleasant out-come such as,

Residents themselves, a friend or family member or a neighbor will fall or jump from a high window.

Paradoxically, a few residents dread that they might be caught inside during a fire or blast; it for the most part takes more time to arrive at the road from a high-rise staying than from dwelling of a couple of stories.

Residents in spots with dynamic structural plates stress over the whole building falling due to an earthquake.

The sheer number of individuals who live in One Big Residence implies that it might be said, outsiders share your home, in any event.

The sheer number of individuals in a single structure may expand the dread of winding up sick from transmittable diseases generated by others.

Rather than families living in low-density suburban territories, most families like to live in apartment lodging in high urban area, since they valued that lofts offered affordable housing near employment. Be that as it may, above situations legitimately powerful to both kids and grown-ups who lives in elevated structures. Later parents discover the design is challenging for bringing up kids ((Andrews, 2018).

b) Link between Environment and Children

''At first it may be wandering just a few feet away on the playground. Later it means going out to play by them. That's much easier when a mother can look out the window and see the child playing outside than it is in an apartment. "The British psychoanalyst John Bowlby has analyzed the association among young child's explorations and psychological growth. He said that between the ages of 2 and 7, a child needs to make trips into the world with the security of having the option

to come back to the safety of the guardian. During this interaction among independence and reliance, Dr. Bowlby stated, the child bit by bit builds up a feeling of ability and autonomy. (Goleman, 1987))

Living in a high-rise apartment can interfere with the smooth progression flow of this process, Dr. Hart said. "High-rise housing denies both caretaker and child the opportunity to see, hear or otherwise contact each other at will when the child is outside and the caretaker inside,'' he said. ''This results in an all-or-nothing approach. Both the parents relinquish care and let their children play anywhere they wish, or they take the overprotective route of keeping them inside the apartment all of the time.''

Access to the outdoors usually does not become an issue for parents until their child requests for the very first time, ''Can I go out to play?'' ''One study of children living in New York City high-rises found that most were not allowed out to play by themselves until they were 10,'' said Kim Blakely, who works with Dr. Hart in the Children's Environments Research Group, which has studied children living in high-rise apartment. (Goleman, 1987)

Various examinations say that kids have issues in high-rise apartments; none recommend benefits for them. Early audits are clear. One statement says, "For...families with small children, the evidence demonstrate that high-rise living is an unsuitable form of accommodation" (Conway & Adams, 1977, p. 595.) Another concludes that "high-rise housing does not provide an appropriate living environment for preschool or school-age children because too few of the attributes of a single-family house have been accounted for..." (HOGUE, 1976) Despite the fact that the authors softened that by inferring that high-rise residence have both positive and negative highlights for young people. This has not changed much with time. Two of the later Israeli investigations found that bringing children up in tall structures, particularly on the higher floors, is problematic (Yaran, 2016)

The issues extend from key child development issues to everyday activities such as play. For instance, a Japanese investigation (Masaaki ODA, 1989) concluded that the development of children raised above the 5th floor in high-rise buildings is delayed, compared to those raised below the 5th floor. The improvement of various abilities, for example, dressing, helping and appropriate urination was slower. Children who live on higher floors also rarely go outside to play. A study in India perceived that difficulties of children are not exclusively an element living in high rises (OKE, 1999). As the authors put it, "The ecological constraints of crowding, the high-rise buildings, unsafe streets, scarce open spaces, the preoccupation with the "idiot-box," all seem to conspire against the urban child's natural propensity to play with joyous spontaneity"

Learning Children's play clearly is affected, as parents in apartments either keep their kids inside more frequently, which means close security or over-assurance in an indoor situation or permit them outside, numerous floors away, which can result in under-supervision. One result is that kids in high structures, on balance, invest more energy playing alone and in limited play (Gittus, 1976). Maybe this is the reason there is proof that high-rise brought up kids to have a lower ability of motor skills than kids who raised in single-family abodes.

c) Understanding Child Psychology

There are two types of psychological theories to understand the psychological level of children. Those theories are:

1. Piaget's Theory of Cognitive Development

2. Theory of Psycho-Social Development

Piaget's Theory of Cognitive Development is one of the most persuasive figures in the study of child development by Swiss cognitive theorist Jean Piaget. He built up his cognitive-developmental theory based on the possibility that kids effectively build information as they investigate and manipulate their general surrounding. Piaget was interested in the development of "thinking" and how it relates to development throughout childhood. His theory consists of four stages of cognitive development, first exhibited in the middle of 20th century, is one of the most famous and widely acknowledged theories in child psychological improvement right up 'till the present time.

Piaget believed that as children grow and their brains and mind develop, they move through four stages that have been characterized by considering differences in thought the process. In his research, he observed children and presented them with problems to solve that were related to object permanence, reversibility, deductive reasoning, transitivity, and assimilation/absorption. Each stage builds upon the experience and knowledge learned in the previous stage. Piaget's four stages correspond with the age of the children and those stages are;

1. Sensorimotor stage
2. Pre-operational stage
3. Concrete operational stage
4. Formal operational stage

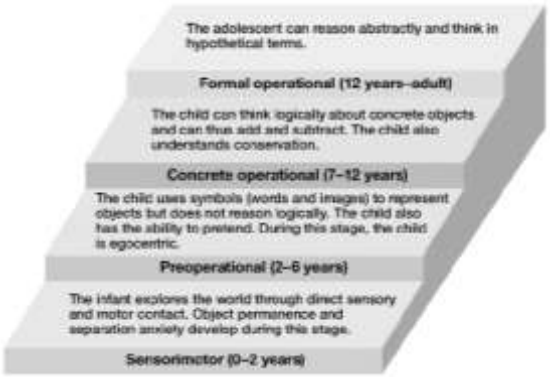

Figure 7 Piaget's Stages of Cognitive Development (Source: Google)

Erik Erikson's theory of psychosocial development is an extraordinary theory of personality in psychology. Much like Sigmund Freud, Erikson believed that personality creates and develops in a series of stages. Unlike Freud's theory of psychosexual stages, Erikson's theory portrays the effect of social experience over the entire life expectancy. One of the main components of Erikson's psychosocial stage theory is the development of ego identity.

Ego identity is simply the cognizant sense that we create through social connection. As per Erikson, our ego of self-personality is always showing signs of change because of new experience and data we obtain in our day by day communications with others. Addition ego identity, Erikson likewise accepted that a feeling of ability additionally persuades practices and activities.

Each phase in Erikson's theory is considered about getting to be capable of an everyday issue. If the stage is dealt with well, the individual will feel a feeling of dominance, which he referred to as ego strength or ego quality. There are 8 stages in Erikson's stages of psychosocial development; it can be shown in figure 2.

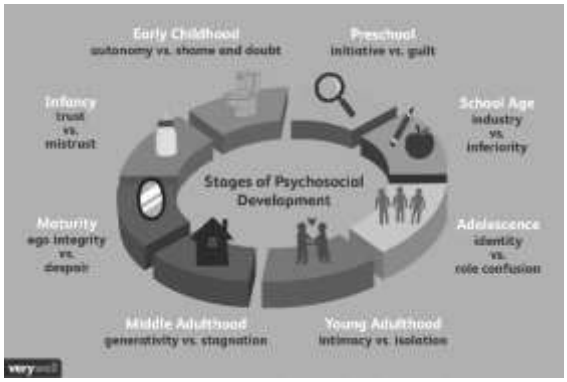

Figure 8 Erikson's stages of psychosocial development (Source: Google)

The age category which will be discussed throughout this study will represent the age group of 1year to 5 years. According to Pioget's theory of cognitive development and Erikson's theory of psycho-social development represent two main stages in childhood named, the sensory motor stage (age: 0-2) and pre-operational stage (age: 2-7). During these two stages child has the main requirement of developing through the experiences, observations and movement of five senses. It starts with simple reflects and that behavior develops as a habit. Then it converts to do things intentionally. The key milestone in sensory motor stage is the development of working memory and the realization of objects permanently. Children has the 100% curiosity to explore everything they desire, as an example smelling flowers, tasting foods, talking with strangers can be considered.

But the question is the amount of support that high-rises provide to improve and fulfill these requirements, whether it provides great sources to get sufficient experiences for children and to improve physical ability that they need to do basic movements such as: sit, crawl, stand, walk and run. During the pre-operational stage, Lots of fantasies have been created in child's mind and they are highly enriched by the surrounding details. At this stage, the size of fantasy is the key point hence, we must think whether high-rises provide sufficient atmosphere to children for develop their cognitive development. If not what would be the impact that should be considered. Then children use to speak, understand words and variety of people. So the social exposure with number of neighbors and piers is a must. But it should be also considered whether that social exposure can be taken in high-rises apartments.

The curiosity of children at around age 4 develops lots of questions in their mind and they try to grab knowledge through that. Therefore, more experiences lead more questions in child's mind. The possibility of having such experiences to a child who spend lot of time in a high-rise residence is again questionable point.

"High-rise housing denies both caretaker and child the opportunity to see, hear or other-wise contact each other at will when the child is outside and the caretaker inside" (Goleman, 1987)

Psychologist Daniel Corppon writes in the Canadian journal of public health, that high-rises keep children and elderly from getting the exercise the extra effort it takes to get outside encourages them to stay at home and flip on the TV. Now it is highlighted that the problem is remain to consider and investigate that the impact of living in high rises for the cognitive development of early childhood. And also the consequences of that should be identified as soon as possible for the next generation of urban cities.

The objective of this study;

- To identify how living in high rises would effect for the cognitive development of early childhood in Sri Lanka.

Most of previous studies have been conducted concerning about people in all ages. But this study specifically limited in to the age group of 0-5 which represent the early childhood. According to the Sri Lankan education system at the age of 6 children will

start schooling but during the age of 0 to 5 years they have highly restricted to their residences and pre-school is the first most place that they expose their personality, which has been taken from their home environment to the society.

And the study directly focuses the attention on cognitive development of children. For that both gross motor skills and fine motor skills will be tested.

Methodology

This research methodology is based on Interview and observation through activities, which has a qualitative approach. Interview carried out among teachers to identify the impact of living in high-rises for the cognitive development of early childhood in Sri Lanka. Observation process was done by following a set of activities for pre-school children. This explains the population concerned for the purpose of the study, followed by how data will be gathered and focused on the research objectives and research questions. The population of this research represent children in the age group of 0-5 years, living in high-rises apartments in Sri Lanka. The sample group consists of 15 pre-school children coming from high-rises apartments and another 15 pre-school children not from high-rises apartments. More over the selected sample group has chosen from three leading preschools in Colombo and all of them are under the age group of 0 to 5 years. In addition to that 25 preschool teachers are questioned through in-depth interview by an Interview guideline made by the researcher. Probability sampling or non-probability sampling methods can be considered as the two ways of sampling designs. In probability sampling, each element of the population has an equal chance of being selected. In contrast, non-probability sampling is based on personal judgments of the researcher and each element in the population does not have an equal chance of being chosen (selected). According to above information we have selected non probability sampling design to continue this research.

The main source of information which was gathered for this research is based on both primary and secondary data. Data collection method is conducted basically using set of activates done with 15 children living high rises and 15 children living in ground area from selected 03 nurseries (all together 90 children). Also, through an interview guideline 25 preschool teachers were interviewed. Interview guideline were made according to the variables of the research. Set of activities are designed under the supervision of child psychologists. Then it will be conducted as workshops with the sample group in their respective preschools and children will be assessed individually through observations. More over through an in-depth interview was conducted with the teachers of that particular preschools for the collection of necessary primary data. Secondary data will be collected through referring past records, registers, children's working books and earlier assessments done by those respective preschools about these children. Figure 03 review the methodology of current study.

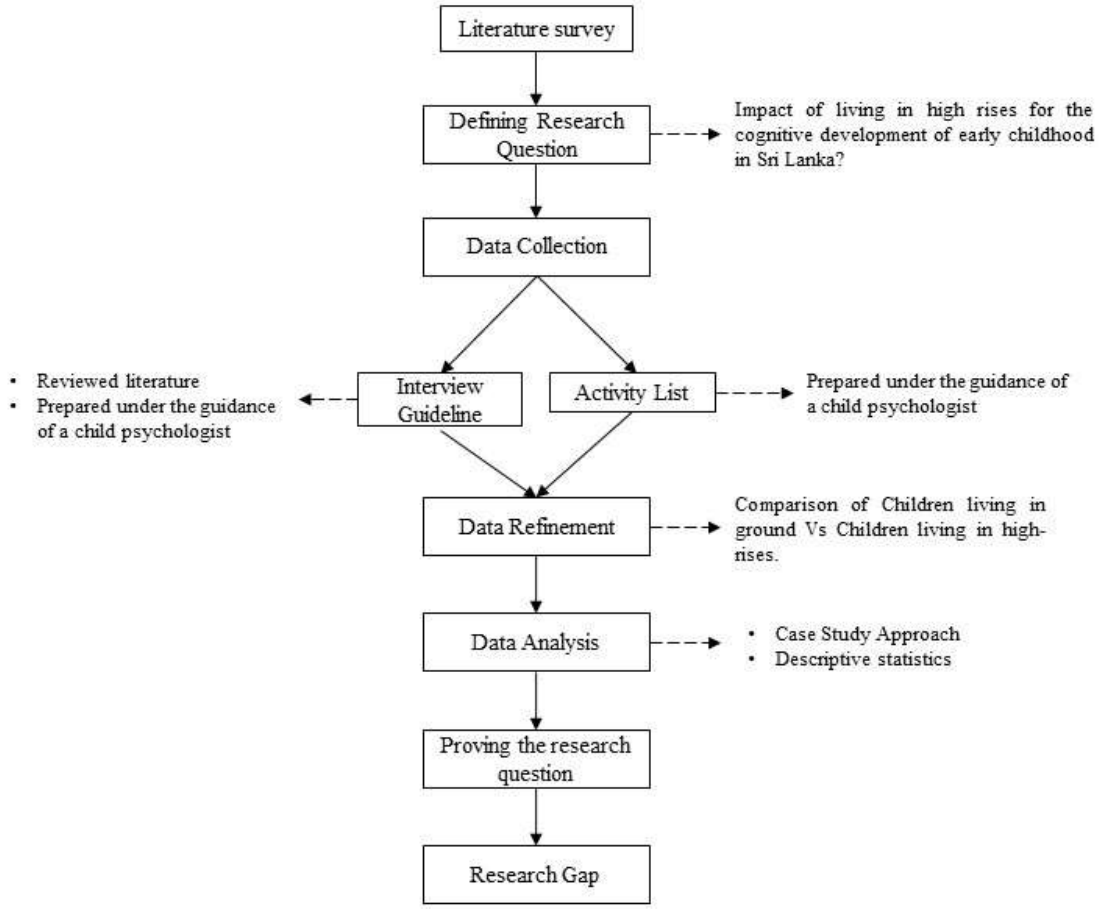

Figure 9 Methodology of the study (Prepared by the researcher)

Data Analysis

The information gathered through interview guideline from 25 teachers in three different nurseries were interpreted by the Researcher. During this process the relevant data initial thoughts and ideas noted down and recorded according to the Interview guideline since this is considered an essential stage in the analysis. The transcribed data was then read and re-read several times and, in addition, the recordings were listened to several times to ensure the accuracy of the transcription. The data researcher gathered from the interview guideline has been intrepid by using Case study approach and Descriptive statistics. This process of ''repeated reading'' (Braun & Clarke, 2006) and the use of the recordings to listen to the data, results in data immersion and refers to the researcher's closeness with the data. Following on from this initial stage and building on the notes and ideas have been generated from 25 teachers of selected 03 nurseries regarding impact of living in high rises for the cognitive development of early childhood in Sri Lanka through answering questions from each case. Researcher managed to conduct set of activities with 15 children living high rises and 15 children living in ground area from each selected nursery. Collected data were tabulated according to each case. Results will be intrepid through case study approach and descriptive statistics. All cases were developed according to the features of the data that the researchers were pertinently collected relevant to the research questions.

a) Case Study Approach

b) Descriptive Statistics

Findings and Discussion

During the process of analyzing interviewed data, researcher found out from the group of children from high-rises apartments;

- 60% of teachers agreed that there were language barriers, speech delays.
- 59% of teachers agreed that there was a unique behavioral patterns.
- 60% of teachers agreed on that there were more give up moods.
- 60% of teachers agreed on that there were more hyperactive behaviors.
- 60% of teachers agreed on that there were nervousness than the others.
- 57% of the respondent believes that children are not very socially competent.
- 65% of the teachers believes that children are pretty competent academically.
- 46% of the Teachers believe that target group of children are sometimes has sudden changes in moods.
- 55% of the teachers believe that target group of children do not feel or complain that no one loves,
- 60% of teachers believes that target group of children are too fearful or anxious.
- 44% of teachers believe that target group of children are bullies or is cruel or mean to others.
- 44% of the teachers believe that sometimes target group of children are unwilling to feel sorry after (he/she) Misbehaves.
- 44% of the teachers believes that sometimes target group of children have trouble getting along with other children.
- 60% of the respondent believes that Target group of children are sometimes are not impulsive, or acts without thinking.
- 76% of the teachers believes that target group of children have lot of difficulty getting mind off certain thoughts.
- 60% of the teacher believes that Target group of children are sometimes are restless or overly active, cannot sit still.
- 72% of teachers believes that target group of children are sometimes are stubborn, sullen, or irritable when comparing to other children.
- 76% of the teachers believes that Target group of children sometimes those children are unhappy, sad or depressed.
- 72% of the teachers believes that Target group of children sometimes are breaking things on purpose or deliberately destroy (his/her) own or other's things.

Psychological and psycho-social components of a child can be considering factors such as language barriers, unique behavioral patterns, give up moods, hyperactive behaviors, nervousness, social competency, academic competency, changes in moods, complaining, being fearful or anxious, being bullies or cruel, unwillingness to apologize, trouble with getting along, acts without thinking, cannot stay still, stubborn and depressed. In above paragraph those factors have been evaluated considering the experiences faced by teachers of selected nurseries. Results show that children living in high rises partially have psychological and psycho-social development issues when comparing to children in ground areas. Hence living in high rises during early childhood stage may negatively impact both psychologically and psycho-socially.

Analyzed data from the set of activities designed for children by the researcher also shows how living in high rises during early childhood would effect for the psychologically and psycho-socially in children's perspectives.

In this research the main objective was to examine to identify how living in high rises would effect for the cognitive development of early childhood in Sri Lanka. Under those objectives other two sub-objectives are connecting with above two research questions. Those objectives are, to find out whether there is an impact of living in high rises in early childhood for the physiological development of a child and to find out whether there is an impact of living in high rises in early childhood for the psychosocial development of a child.

During the process of analyzing interviewed data researcher found out from the group of children from high-rises apartments;

- 60% of teachers agreed that there were language barriers, speech delays.
- 59% of teachers agreed that there was a unique behavioral patterns.
- 60% of teachers agreed on that there were more give up moods.
- 60% of teachers agreed on that there were more hyperactive behaviors.
- 60% of teachers agreed on that there were nervousness than the others.
- 57% of the respondent believes that children are not very socially competent.
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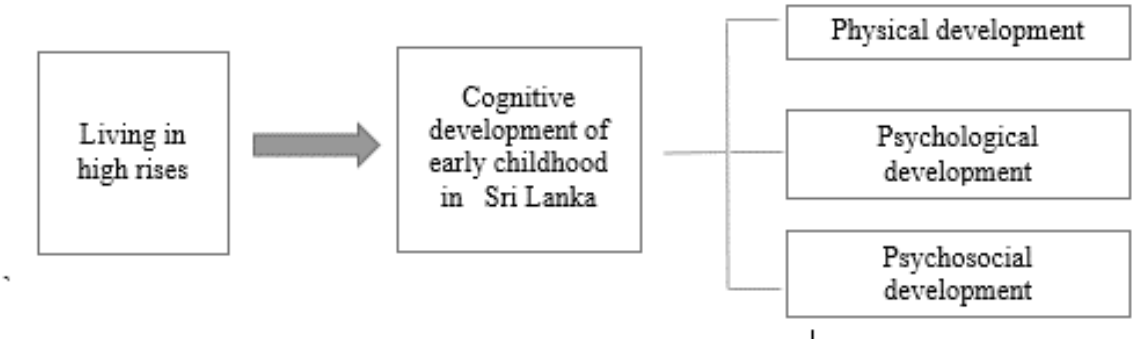

Figure 10 Theoretical framework (Prepared by the researcher)

Psychological and psycho-social components of a child can be considering factors such as language barriers, unique behavioral patterns, give up moods, hyperactive behaviors, nervousness, social competency, academic competency, changes in moods, complaining, being fearful or anxious, being bullies or cruel, unwillingness to apologize, trouble with getting along, acts without thinking, cannot stay still, stubborn and depressed. In above paragraph those factors have been evaluated considering the experiences faced by teachers of selected nurseries. Results show that children living in high rises partially have psychological and psycho-social development issues when comparing to children in ground areas. Hence living in high rises during early childhood stage may negatively impact both psychologically and psycho-socially.

To identify how living in high-rises during early childhood would impact on their physical development was the one of sub-objectives of this research. During the process of analyzing data from the interview guideline for pre-school teachers, researcher found out;

64% teachers agreed that target group of children had not any difficulties in their eye-hand coordination, during activities from target group of children than the others.

76% of teachers believe that children are not very competent physically when comparing to the children living the ground. This proves that teacher's do not think that living in high-rises would impact negatively on physical development of the child.

Analyzed data from the set of activities designed for children by the researcher also shows how living in high rises during early childhood would affect physically. Researcher evaluated whether sample group can throw a ball between two cones, walking on a straight line and walking while keeping an objective on the head. Results showed that children living in ground areas have more ability to do physical activities when comparing to children living in high-rises.

Even though teachers believe that living in high-rises have no impact negatively on physical development of the child, children reactions towards the activities showed that children living in ground areas have more ability to do physical activities when comparing to children living in high-rises. Somehow the results were quite questionable; it gives a hint that there is a slight negative impact for child's physical development.

The primary objective of this research was to identify how living in high rises would effect for the cognitive development of early childhood in Sri Lanka. Throughout this paper researcher explicit that cognitive development of early childhood consists of three phrases called; Physical, Psychological and Psycho-social. During the data collection covered each and every element and while

data analyzing almost all the elements were evaluated. Those analyzed data proved that there is a negative impact for early childhood living in high-rises physically, psychologically, psycho-physically. That statement proves the main objective and the first research question of this study.

Above theoretical framework made by the researcher helps to prove the validity of above research findings. It shows that living in high-rises would effect on cognitive development of early childhood in Sri Lanka and cognitive development can be measured from physical, Psychological and psycho-social development of the child. Although living in high-rises generate negative impacts for children, still parents would select to live in high- rises due to many reasons. Hence following suggestions may support to overcome the negative impact of living in high-rises during early childhood.

Recommendations

Data that the researcher has collected; proves that living in high-rises generate many consequences for the cognitive development of early childhood. To overcome those issues necessary architectural solutions should be taken. Since it is a huge part that needed to be consider under another topic, those architectural solutions will not be implemented by this study.

Through this essay certain lapses that may occur with living in high-rises during early childhood were explicated and proved under scientific investigation. Recommendations to overcome regarding issues, necessary areas that architects should consider will be introduced. According to the findings of this research;

- Children have physical problems. Lack of space to play to and do physical activities could be a reason, lack of opportunities to build relationships with piers and specially with environment. Also they might lack of having obstacles to clear during playing and lack of having hard works with environment also a major issue.
- When considering psycho-social and psychological problems, it proved that most children had language barriers, unique behavioral patterns, give up moods, hyperactive behaviors, nervousness, social competency, academic competency, changes in moods, complaining, being fearful or anxious, being bullies or cruel, unwillingness to apologize, trouble with getting along, acts without thinking, cannot stay still, stubborn and depressed. Those behaviors could be a result of lack of subordinates, piers, interaction with people, lack of opportunities to share experience with others, lack of experiences to understand others and work with them, limited exposure to the environment, trees, animals and limited talk time with parents and etc.

Somehow, above issues should be considered and to overcome regarding issues taking necessary architectural actions is a must. Future studies should focus on creating environmental friendly areas, play grounds and necessary architectural spaces should be implemented within future high rises.

Conclusion and Research Gap

High-rise buildings have become a popular strategy to accommodate population growth in Sri Lanka's urban areas. Every building has different characters and personalities that offer a person different experiences in their daily lives, but their home or permanent living space and surrounding characters are the most vivid to sharpen their psychological and social behavioral qualities. Different factors can be considered to categorize people, such as age, gender, educational

level, economic status and social cultural background. The age is the main consideration in this analysis. The four main stages of human life are childhood, adolescence, adulthood and old age. This study was conducted to determine the impact of early childhood living in high-rises. Throughout this study, the age category will be the age group from 1 to 5 years. The aim of gathering information was evaluated in three well-known nurseries under Teacher's Interview Guidelines and Children's Activity List. By the case study method, the collected data were analyzed and presented using descriptive statistics. Findings from this research suggest that early childhood living in high-rises has a negative impact on the child's physical, psychological and psych-social development. Recommended options suggested by future architects at the end of this study to mitigate the above problem.

Most of previous studies have been conducted concerning about people in all ages. But this study specifically limited in to the age group of zero to five which represent the early childhood. According to the Sri Lankan education system at the age of 6 children will start schooling but during the age of 0 to 5 years they have highly restricted to their residences and pre-school. It is the first place that they expose their personality, which has been taken from their home environment to the society.

Child's behavior may depend on Number of members of the family. Maximum members of each selected family was 05 or less than 05. Children of selected pre-schools were coming from the same financial background. According to the researcher's assumption sample group represent the same financial background.

Anyhow, the main intention of this study is to understand the impact of living in high-rises for the cognitive development in early childhood in Sri Lanka. Final outcome of this research would be an opportunity to enhance the quality of the living in high-rises by identifying basic requirements, parents would be benefited to identify the problems that their children facing and get opportunity to follow necessary solutions and finally, the field of architecture will be also benefited to have clear identification of gaps in high-rises. This research might help to architects to design solutions to overcome those failures and upcoming high rises to have more advancement features. Finally, the end result of this research would be a secondary source for some other researches in both fields of architecture and psychology.

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Impact of Covid -19 Pandemic to Construction Industry in Sri Lanka

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Abstract: Covid -19 is a highly contagious global pandemic. Social distancing measures are the most successful tactic in combating the diseases. Due to the disease itself and local and global pandemic combating measures, businesses have been compelled to operate in a new environment. Infrastructure investments are down worldwide. This research was focused in identifying the risks posed by the pandemic to construction industry in Sri Lanka. A questionnaire survey was done to identify major risk factors in the construction industry in Sri Lanka. Disruption in supply chain, prophylactic absenteeism, regional lockdowns, fear of a second wave and decrease in investments were identified as the risk factors. Disruption to supply chain is the highest risk factor. Construction industry in Sri Lanka is highly rely on the local and global supply chains. Organizations need to foster transiency in their supply chains – the ability to restore some processes and change quickly. Dependence on external entities and regions should be managed by reducing the dependency or at least increase their predictability. Prophylactic absenteeism – due to government regulations is the second most influential factor. It disrupts the movement of people. Associated issues have arisen due the disruptions of supply chain and prophylactic absenteeism.

Keywords: Covid- 19, Supply chain, Prophylactic absenteeism

Introduction

Global pandemics of diseases are not a new phenomenon. Several regional and global pandemics of diseases have emerged in different scales throughout the history. During the last century, the world has experienced Spanish Flu in 1918, Asian Flu in 1957, Hong Kong Flu in 1968 and more recently SARS in 2002, swine flu in 2009 and Ebola in 2014. In large scale pandemics, the impact is severe and wide across regions due to two reasons: either because the infection itself is widespread, or because the trade and market integration, eventually propagate the economic shock across the map (Stephany et al., 2020 and Jorda et al 2020). Covid - 19 is a global pandemic with severe economic and social impact due to travel warnings, border and store closures, regional lockdowns and social distancing measures. There is a significant uncertainty about the economic and social effects of the pandemic.

The study presented here investigates the risk factors of the pandemic in the construction industry and the gravity of them. Covid-19 is a new and an unexpected pandemic. Consequently, construction industry, a non-essential industry is affected due to government policies to curtail the pandemic and pandemic itself. The literature review investigates the economic impact of the pandemic and risk factors encountered in a pandemic situation. There was limited literature about the behaviour of the construction industry in a pandemic situation. In the analysis, the identified factors were applied to the construction industry in Sri Lanka. Applicability of the risk factors to the Sri Lankan construction industry was analyzed.

Literature Review

Economic impact

Planning for pandemics is important. Appropriate measures have to be taken to minimize the mortality, morbidity and economic impact associated with pandemics (Keogh-Brown et al, 2009). Maintaining business as usual and encouraging social distancing are the key factors in managing the economic impact and health related impact of a pandemic (Smith et al, 2009). It would be beneficial to estimate the cost of the disease itself, the distribution of this cost across sectors, and the cost of policies that may be used to mitigate the pandemic.

Covid –19 would be the second most devastating pandemic after Spanish flu (Stephany et al., 2020 and Jorda et al 2020). Economic impact of Covid – 19 could be dramatic (Rio-Chanona et al, 2020 cited Baldwin and Weder di Mauro, 2020).

As per Smith et al, 2009 economic-wide impact of an influenza to the economy of United Kingdom (UK) would be 0.5% - 1% of Gross Domestic Production (GDP) for low fatality scenarios, 3.3% - 4.3% for high fatality scenarios and 6% - 9.6% for extreme scenarios. Keogh-Brown further explains that the impact for economies with higher exports is slightly higher, since exports are adversely affected by the influenza shock.

The world bank estimates a baseline forecast envisions a 5.2 % contraction in global GDP in 2020. Rio-Chanona et al 2020 cited Barrot et al. (2020) suggests that six weeks of social distancing would bring GDP down by 5.6%. The impacts of the pandemic last for decades. Central bank of Sri Lanka also expected to see economic growth of 4.5% – 5% following Easter Sunday attack but now it expects an economic growth of 2.2%.

As per French statistical office by March 26 at around 65% of normal level of the economy was in operation (Rio-Chanona et al 2020).

As per Stephany et al, 2020 in United States of America (USA) from the end of January 2020 an increasing number of companies had started identifying Covid – 19 as a potential risk: 70% of companies in manufacturing sector, 78% of retail sector and 72% in hospitality sector.

As per Smith and et al, 2009, in the UK economy meat and livestock, processed foods, textiles/paper/plastics, manufacturing, and transport and communications sectors might get the highest impact while the extraction sector (mining, quarrying, forestry and fishing) followed by crops, utilities and construction, and health and non-health services might get a lower impact. Shock will transmit throughout the economy over time, different sectors will get the impact at different stages of the pandemic (Stephany et al, 2020). Fernandes (2020) has observed that in China infrastructure investment was down in the first two months of 2020 (30% from a year earlier).

Risk factors

Shutting down the non-essential business operations would affect the whole economy. Studies have showed that shutting down in economic powerhouses would cause a loss of output in other parts of the economy through supply chain linkages, and estimate that after a month, daily output would be 86% lower than pre-shock (Rio-Chanona et al, 2020 cited Inoue and Todo (2020). China represents 16% of the global economy, any activity in Chinese economy is strongly felt throughout the world. China is currently the world's largest importer and exporter. In many individual industries, China is the main supplier of parts. Thus, disruption in China highly influence global supply chain (Fernandes, 2020). Fernandes (2020) further investigates that according to the U.S. Institute for Supply Management, 75% of companies report disruptions in their supply chains.

Black death pandemic induced labour scarcity in the European economy and pushed real wages up (Jorda et al, 2020). Deaths (permanent impacts on the working population) and absenteeism (temporarily impacts on working population), due to social distancing measures and regional lockdown influence the quantity and quality of working population of the economy (Keogh-Brown et al, 2009).

Prophylactic absence highly influences on working population and economic activities (Keogh-Brown et al, 2009 and Smith, 2009). Due to social distancing measures, school closures and prophylactic absence were observed worldwide. Direct illness impact of a pandemic is low, but school closures and prophylactic absenteeism, whether imposed by the government or as the result of fear of infection in the population could make a great impact on the economy.

Many sectors are experiencing issues on the supply-side, as governments curtail the activities of non-essential industries (Rio-Chanona et al, 2020). Delays and failures in the supply chain would disrupt the production processes. The retail and manufacturing sector in USA expect the highest number of risks due to the failures in supply chain and production (Stephany et al, 2020).

Bloom et al, 2005 states that historical data have shown that even during an epidemic outbreak, the public soon adapts to the situation and the disease and economic activity continues. A pandemic is likely to affect consumer confidence and change consumption and social behaviour. It will also affect investor confidence and reduce investments in the future. In the long run, poverty will be increased.

As per Harinarain and Haupt, 2014 South African construction industry is vulnerable to Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) pandemic because the industry encompasses numerous companies of various sizes and discourages permanent employment by encouraging subcontracting and labour only subcontracting. Construction industry is also particularly vulnerable to the pandemic because it employs a constantly changing labour force that works on short-term contracts and permanent employees who move between projects across the country. The fragment nature of the construction industry might promote spreading of the disease.

Research methodology

This research is focused on identifying the impact of the new pandemic, Covid – 19 for the construction industry in Sri Lanka. In order to gain an in-depth knowledge about the research area, a quantitative approach was taken.

A literature survey was done to investigate the economic impact and potential risk factors. There was limited literature about Covid -19 situation, therefore, literature on other pandemics was also considered. Risk factors that influence the economy in a pandemic situation were identified through the literature survey. Then, a questionnaire survey was done with a sample of 35 professionals in the construction industry. Results were analyzed to investigate the gravity of each risk factor in Sri Lankan context. Further, some new factors factors were identified through the survey. Those factors were associated factors of the risk factors, identified.

Data Analysis and Results

Risk factors were identified through the literature survey on Covid -19 and other recent pandemics. The study began with 07 risk factors. Additionally, 09 factors were identified through the survey.

Risk factors identified through the literature survey were common factors for pandemics.

Therefore, the intention was to investigate the relevance of them to the construction industry in Sri Lankan context and the severity of each factor.

Additional factors of impact identified through the survey

- Damages to existing materials
- Some materials have been already used. But those materials currently cannot be sourced.
- Payment to employees without work
- Payment delays by clients
- Rental cost for office buildings and hired plants and machineries
- Risk of bankruptcy
- Risk of termination of projects
- Risk of termination of staff employment

Disruptions to supply chain is a highly influential factor, 46% of participants have identified it as a high-risk factor and 17% as an extremely high-risk factor. It can be categorized as a high-risk factor to the construction industry. Government policies to curtail the disease and regional lockdown worldwide have disrupted the global supply chains. As a result of the disruptions, acquiring more supply of materials, that has already been acquired was disrupted. Since in ongoing projects, the materials have been already selected and a part of the consignment has been delivered, it is essential to acquire the same material. It is difficult to go for a new material to avoid a bottleneck in the supply chain.

Prophylactic absenteeism was analyzed under three categories; due to government policies phobia and school closure. Prophylactic absenteeism was mainly observed due to social distancing measures; curfew and curtailing the non-essential operations. Industry has identified this issue as a high-risk factor. In the construction industry, people work very closely and a large number of people are involved in a project, therefore there is a possibility of spreading the disease. Different health measures were encouraged; social distance, splitting shifts, disinfection of the premises,working from home, discouraging non-essential activities, monitor health of people and quarantine. These factors are not favorable factors for the construction industry. Thus, it was compelled to halt the operations of many construction projects.

School closure was identified as a factor for a prophylactic absenteeism during recent pandemics. But it has been not identified as an influencing factor for the construction industry. The rationale behind the prophylactic absenteeism and school closure is that once the schools are closed, one parent has to stay home to attend the children; mostly the mothers. Sri Lankan

Table 1: Risk factors and the impact

	Percentage					
	Not applicable	Low	Medium	High	Extremely high	Total
Disruptions to supply chain	0%	9%	29%	46%	17%	100%
Prophylactic absenteeism – Due to government regulations	0%	17%	23%	26%	34%	100%
Prophylactic absenteeism – Due to phobia	6%	11%	29%	40%	14%	100%
Prophylactic absenteeism – Due to school closure	23%	57%	20%	0%	0%	100%
Regional lockdowns	0%	0%	26%	29%	46%	100%
Fear of a second wave	71%	29%	0%	0%	0%	100%
Decrease in new investments	0%	29%	31%	17%	23%	100%

construction industry is a highly male dominant spectrum. Thus, the school closure is not an applicable factor.

Regional lockdowns affect every aspect of businesses. It is a high-risk factor for the construction industry. Almost all the countries have gone for some degrees of lockdown. Lockdowns are in two ways; local lockdown within the country, Colombo, Kaluthara, Gampaha, Puttalam, Jaffna and Kandy districts went for longer lockdowns and global lockdowns. Border crossings were prohibited during the lockdown period. Supply chain and movement of people have been disrupted. Continuous supply of materials and influx of people at different stages of projects are essential conditions in the construction projects. Once the normality is interrupted, the pace of project is also interrupted.

World is experiencing the first wave of Covid -19. Three waves were reported in Spanish flu between 1918 – 1920. A second and a third wave of Covid – 19 are also expected. But the industry is not much concerned. But since the danger is obvious, it is a factor to be considered in making investment decisions and in project management.

Decrease in new investment is also high-risk factor. Because there is an uncertainty of business operations worldwide. Thus, investors are much concerned about their investment. Other than the decrease of the new investments, there is another risk of the termination of existing projects.

As a result of the risks created by the pandemic, industry experience additional risks; termination of staff employment, risk of bankruptcy, damages to existing materials, payment to employees without work and rental cost for office building and hired plants and machineries, risk of claims and payment delays by clients.

Conclusion

World Health Organization (WHO) named Covid-19 as a global pandemic. Repercussions of the pandemic are in different degrees to different countries. Out of the risk factors identified, disruptions to supply chain is the most influential factor. Regional lockdowns and government policies to curtail the pandemic contributed the disruption. Supply chain is essential for the progress of construction projects. Spanish flu lasted for three years. Covid – 19 pandemic would also last for a similar period. Thus, new techniques of supply chain are something to be developed. Organizations need to foster transiency in their supply chains – the ability to restore some processes and change quickly. Dependence on external entities and regions should be managed by reducing the dependency or at least increase their predictability.

Absenteeism – due to government regulations is the second most influential factor. It influences both supply chain and movement of people. In Sri Lanka, curfews were eased from mid of May 2020. Thus, restrictions to movements within the country have been lifted. But global supply chains have not rebounded to pre-covid situation.

Covid -19 is an unknown unknown, though world had experienced great pandemics nobody had ever thought of it. New pandemics and catastrophizes are yet to come. Risk management teams worldwide were unable plan for this pandemic. The job of risk management teams is to foresee and analyze all the types of risks. But nobody could prepare a plan for a pandemic.

Pandemics can alter power dynamics. Thus, we may encounter new dynamics in supply and demand. As a result of that, new sources of suppliers and supply chains may emerge. This research can be extended to identify

new dynamics in the supply chains in the construction industry.

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Mapping & Classifying Paddy Fields Applying Machine Learning Algorithms with Multi-temporal Sentinel-1A in Ampara district

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Abstract: In Sri Lanka, Seasonal paddy field area mapping is still doing based on the traditional methods with poor technologies. Therefore this research focuses on the machine approach of mapping paddy fields area accurately on remote sensing data taken from the satellite. Multi-temporal Sentinel-1A Synthetic Aperture Radar(SAR) data was used to map the spatial distribution of the secretary's divisions paddy area in the Ampara district during the period from April 2019 to September 2019. The classifying algorithms were mainly used under the multi-temporal spectral filter classification with 11 dual-polarization(VH/VV) SAR using SNAP, QGIS, ENVI tools. The Time series model was used for each VH and VV bands separately. According to minimum and maximum value of both VH and VV bands, paddy field area was classified using deference of min and max value respectively The overall precision of paddy fields is shown to be 0.92 Also use random forest classification method to processed images with ENVI and It shows 0.86 accuracy rate. Each divisional secretary area showed accurate paddy classification according to non-remote sensing data provided by the district agriculture office of Ampara. This method can easily be used to classify paddy cultivation areas than its traditional methods. Also, it is low cost and very fast method. As further development, Rice prediction model is proposed using the same classified area with vegetation indexes of Sentinel 2 imagery.

Keywords: Rice Yield, Sentinel-1A, Nearest Neighbour, SAR, VV, VH, Time Series.

Introduction

Agriculture is regarded as one of the most important factors of human existence. When it comes to Sri Lanka, Rice is a main agricultural product and widely consumed product. Paddy crops are cultivated in wet-land in every district. There are two main seasons to cultivate paddy in Sri Lanka, which are Yala and Maha. Two seasonal monsoons are greatly affecting the existence of paddies. According to Paddy statistics of 2019 of Yala season which was published by the department of census and statistics, (*Paddy statistics 2018/2019*, 2019) total harvested paddy extent in Sri Lanka was 855,000 acres. Also, paddy production was 1,519,00MT and was 4,896Kg per net hectare. In present, the Agriculture section uses various kinds of technologies. But Sri Lanka still not using its latest remote sensing mechanisms for agriculture field. So that surveys take too many times to provide results about agricultural facts. Almost all document related to surveys was published after the crop cutting. It is not useful for irrigation section and other crop prediction models. Because important data are very helpful for getting the actual situation of agriculture and to take rapid decisions. Lack of real-time information about the

agriculture field affects the country's economy. Most of the Researchers used NDVI and its related vegetation indexes based classification for mapping paddy fields. (Filgueiras *et al.*, 2019) Most of the time, its accuracy was very low when considering satellite data imagery which not be in particular harvested time. Also, the accuracy of MODIS satellite data-based researchers is low. (Dammalage and Shanmugam, 2018) Because the resolution is only 200m. thus Sentinel 1 based SAR time series model is more suitable for that purpose. Considering about Yala season in Sri Lanka, There is 8 district mainly participate in the paddy production in Sri Lanka. Among them is Ampara, which is the second-highest paddy production district. It is provided considerable paddy yield compares with other districts. It has 138,515 acres of gross extent sown area, 136,196 acres of gross extent harvested area, and 130,163 acres of net extended harvest. Most of the paddy yields were cultivated from Mahaveli project's water and tanks water in Yala season.

This research is focused on a mapping paddy field in an accurate method. It's more helpful for decision-makers to get real-real time solutions for the affecting problem of paddy. Also Its helpful to forecast actual production of rice. Remote sensing was chosen for that purpose. Paddy life cycle is too small because it is very easy to identify deference in a shorter time duration. It's life cycle changes within 3 months or 4 months. In that case, a suitable way to measure paddy area is to use time serious algorithms collecting much-related satellite imagery. Sentinel-1A is the optimal solution for measuring this kind of changes using many of imagery. Considering the difference between those imageries, it can be a mapped paddy area.

Methodology and Experimental design

A. Study Area

This study area location in Sri Lanka. The district of Ampara falls in the eastern province in the southeast of Sri Lanka. It occupies an area of 4415 square kilometres (1,705 sq mi). (Department of Census & Statistics, 2015) It is bordered by northern districts of Batticaloa and Polonnaruwa, eastern Indian Ocean, south Hambantota district, south-east Badulla and north-western districts of Matale and west-south Monaragala. Paddy production in Ampara District was accounted for 19% of paddy production of the country. (*Paddy statistics 2018/2019*, 2019) It is the second-largest paddy production in a particular season. The winters of Ampara are short, dry, muddy, and mostly gloomy and humid during the year. Ampara's summits are hot and rainy. Temperature common during the year ranges between 24 °C and 34 °C and rarely reaches 22 °C or 36 °C. (*Average Weather in Ampara, Sri Lanka, Year Round - Weather Spark*, no date) The site of the study covers mainly an agricultural zone in which 12.7% of the research area is occupied by paddy. Furthermore, there are also built-up areas and other minority crops. In this analysis, the classification is considered only for the principal land area. The remaining groups are classified as "other." The location of the study area is shown in Figure 1.

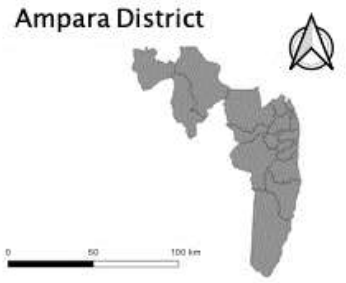

Figure 1. Safe Area

B. Datasets used in the study

The simulation model for process-oriented crop growth uses input variables for crop, weather and soil parameters. Data were

accessed and incorporated into the model from various sources and platforms, such as satellite, weather observations and in situ crop data. This section describes the data sources and pre-processing used in the approach suggested.

Satellite Data: In the Copernicus Programme, the ESA(European Space Agency) launched the Sentinel-1 satellite. The Sentinel-1 mission consists of two satellites that operate on C-band Synthetic Aperture RADAR (SAR), day and night, which allow them to obtain imagery regardless of any weather aberration. The instrument Sentinel-1A SAR works at 5.405 GHz (C-band of approx. 5.6 cm RADAR wavelength), includes 12 day revisits with VH and VV polarizations, and spatial resolution of 5 m by 20 m, respectively, in the range and azimuth directions. The picture size is equal to five looks and 10 meters. We accessed Google Earth Engine(GEE) Sentinel-1A backscatter images. The GEE set comprises the scenes of the S1 Ground Range, calibrated, and updated with the use of the Sentinel-1 Toolbox. For thermal noise reduction, radiometry calibration and terrain correction, each scene is pre-processed with a toolbox from the Sentinel-1. By log-scaling, the final terrain corrected values are converted into decibels (dB). We used VV and VH polarization in this analysis. The pictures S-1A and S-1B from 1 April onwards. 2019 to 30 September. 2019 to 30 September. Downloaded satellite imagery of Sentinel 1A shows below(Table 1)

Ground Truth and other Data: This research was mainly focused on paddy data of Ampara district. It was collected paddy field area and paddy harvest extent related to each district divisional area of Ampara. Paddy statistic information was got from an annual report provided by the department of census and statistics in Sri Lanka. (*Paddy statistics 2018/2019*, 2019) CTDroid Sri Lanka application collected GPS co-ordinates

Table 3. Downloaded sentinel 1A imagery details

DATE	Days different	DOY(2019)	Track	Orbit
2019.05.26	-	146	27	27924
2019.06.07	12	158	27	27924
2019.06.19	12	170	27	27924
2019.07.01	12	182	27	27924
2019.07.13	12	194	27	27924
2019.07.25	12	206	27	27924
2019.08.06	12	218	27	27924
2019.08.18	12	230	27	27924
2019.08.30	12	242	27	27924

for the paddy fields and forest on mobile phones and collected about 60 paddy samples. (Dammalage and Shanmugam, 2018) For the classification, the ground truth data were used and Google Earth application established paddy area and sample collections (approx. 35 samples) of the remaining areas.

As previously mentioned, Ampara district was selected for this research as an area for mapping paddy fields. It is the second-largest district in Sri Lanka and produces a higher amount of paddy yield. It has 19 Divisional Secretary's divisions. So this research focuses on mapping paddy areas for every division and validates accuracy with every district. Also, use google earth to identify sample paddy fields and validate those field classifications. Paddy area related pixels have a very high variety of value than other every object. Because paddy has changed with more variety in their low life cycle duration. Minimum paddy variety value can be selected using non-remote sensing data collected from the district agriculture office in Ampara. For mapping paddy fields, I used multi-temporal Sentinel-1A Synthetic Aperture Radar(SAR) with dual

polarization(VH/VV). The whole data set is between April 2019 to September 2019. So Remote sensing data includes 11 imagery which includes these ranges. Considering Sentinel 1 Imagery, There was no need for cloud removal because sIt is not affected with cloud cover. But it needs to deferent preprocessing mechanism according to the selected task.

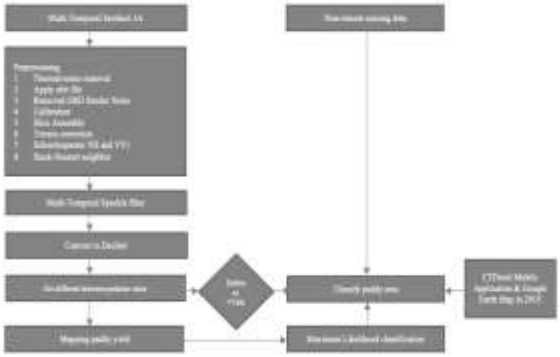

Figure 2. Flowchart of mapping and classification model

C. Sentinel 1 Pre-processing

The preprocessing chain for the correction of the SAR products was needed once the images had been downloaded. Because of speckle noise, SAR images must be corrected radiometric, terrain corrected and filtered. An additional step to quantify a relationship between the spread radiation of the VH and VV bands has also been added to this pre-processing chains. The entire process is carried out with the Sentinel1 products' intensity bands. The Sentinel Application Platform (SNAP) program that is used for this process is supplied without charge by the ESA. Below figure() displayed preprocessing steps for sentinel 1.

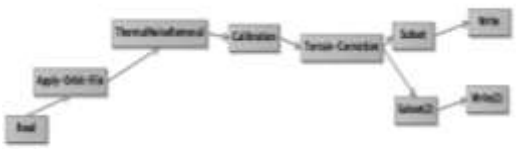

Figure 3. Sentinel 1 Preprocessing Steps

Subsets: Sentinel 1 Preprocessing imageries are subset as VV and VH separately in this process. Finally, it has 22 imagery with dual bands. Those two types of imagery band was stack separately using NEAREST NEIGHBOUR resampling type.

Multi-Temporal Speckle filter: For this study, the Lee sigma filter was used. The preference is based on previous studies showing that the Lee Sigma algorithm has a better performance than other filters for speckles. (Rahman and Thakur, 2018) Most of the researchers were using Multi-Temporal Speckle filtering before the terrain correction. But Ampara district is a flat area. so it is not affected to accuracy.

Conversion to dB scale: Due to the high dynamic range of SAR imagery such as the large range of value, Both stacks of satellite imageries are converted to dB scale. The decibel transformation is used to improve visualization and data analysis.

D. Paddy Area Mapping

Paddy mapping is a critical step in this research. (Mohite *et al.*, 2019) Considering about paddy, It specializes than other crops. Paddy only has a small life cycle such as 2 or 3 months. During this time, It has a large variety of colour and other facts. Sentinel 1 imagery backscatter can easily identify those values with more variation. Helping this scenario it provides more accurate paddy classification than NDVI paddy classification. Thing is NDVI classification is difficult to classify paddy area only. In that case, it must use Random forest or related classification for mapping. Mainly used those two stacks which are VV and VH time-series imagery sets. Separately calculate VV max and VV min values and VH min and VH max values. It can compare the different value of VV and VH and find extract paddy area. When considering the differences between those who value in time series can find real paddy area in Ampara district. The false colour composition was helpful to visualize a more

colourful image to identifying paddy field in Ampara district.

E. Paddy Area Classification

Paddy classification of Ampara district mainly uses two types in this research.

Classifying using Divisional Secretary Division: Mapping images accuracy check considering whole divisional district area. There is 19 divisional district area which are Ampara, Alayadivembu, Padiyathalawa, Nintavur, Sainthamaruthu, Pottuvil, Lahugala, Karaitivu, Navithanveli, Mahaoya, Tirukkovil, Sammanthurai, Uhana, Dehiattakandiya, Damana, Kalmunai, Irakkamam, Akkaraipattu, Addalaichenai. Paddy area with manual way considering all divisional district crop yield value.

Supervised Classification: Mapping image classifying with ENVI tool with Maximum Likelihood classification. Polygon based and pixel-based classification using this with validating data respectively sample paddy area and CTDroid based geo-locations. Also, use Google earth and LULC map related to 2014 paddy area field. The best classification with great precision was chosen. The percentage and hectares areas were measured by each divisional district area, the precision measurements were evaluated and if accuracy levels were determined.

F. Accuracy assessment

Both classification methods use different methods for accuracy assessment.

Classifying using DSD(Divisional Secretary Division): The consistency of rice areas mapped with the S1A data was also checked in the district by simple regression techniques at the level of the division. A district's total rice area was determined by multiplying the number of crops per year with the harvested area of rice cultivation systems. This method based on 2019 paddy production of Ampara district related to all divisional district area which is provided from the Ampara district agricultural office. It used a trial and test method. Individually check all accuracy level of each area. Considering the suitable value of most accuracy level.

Supervised Classification: Maximum likelihood classification which is the type of Supervised classification assumes that the statistics are usually distributed for each class in each band and calculates the likelihood of the pixel belonging to a particular grade. All pixels are labelled unless choosing a likelihood threshold. [15] The class with the highest probability (i.e., the Maximum likelihood) is allocated to each pixel. The pixel remains unclassified when the overall likelihood is less than one threshold that defines. ENVI implements Maximum likelihood classification by computing for each pixel of the image the following discriminant features [16], [17] This method based on sample paddy area and geo-location-based paddy and non-paddy point to assess the accuracy of paddy, water and non-paddy based LULC classification.

Results

A. Interpretation of paddy rice backscatter temporal profile

The average time back-scatter profiles for selected rice fields for both VH and VV polarization are shown in Fig. 4. Results showed that the VV polarization was higher than VH for the selected rice fields as observed in previous studies. (Mansaray et al., 2017) In the backdrop of paddy rice fields, it revealed a persistent variance in the temporal profile of the VH polarisation. The accuracy of the backscatter was a measure of the number of cycles. For the VV polarization that reached a peak during the polarization process, it was not the same. This steady increase in VH polarization channel's temporal backscatter profile may be attributable to the signals being less

influenced by changes in surface area, which makes it a more accurate channel for characterizing rice growth conditions. On the other hand, as a consequence of increased attenuation of the vertical cylinder (i.e. stems and leaves) with this channel, the sensitivity of VV polarizations to watertight surfaces is easily detected. Regardless of these distinct patterns of rice crop growth conditions, both give variations in backscatter time, which can make an enormous contribution to paddy rice field mapping, with VH and VV polarization in Figure 4 and 5. Although this research has not followed a method, the advantage of using both polarization channels is exemplified in the classification process. The contribution of multi-temporal VH and VV polarization to the process of classification as one method was evaluated in this review.

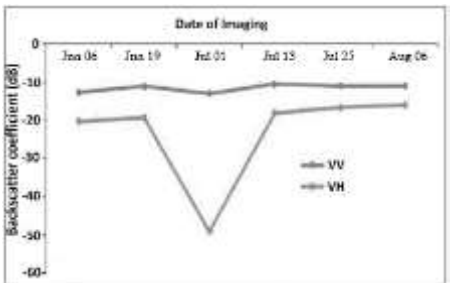

Figure 4. Temporal backscatter profiles of paddy rice fields for both polarizations (VH and VV) of Sentinel-1A imagery

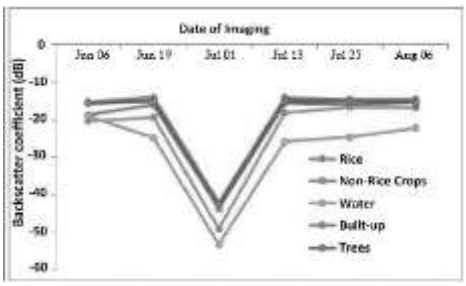

Figure 5.Temporal backscatter profiles of rice and other objects

B. Paddy Area Mapping

Paddy field mapping is very critical things using remote sensing. Using whole 11 satellite imagery, getting actual deferent among those value, because of highest changing value items are the actual paddy area. it can be easily identified using false-colour composition value, In Fig. 6, It shows the paddy area related to yellow colour.

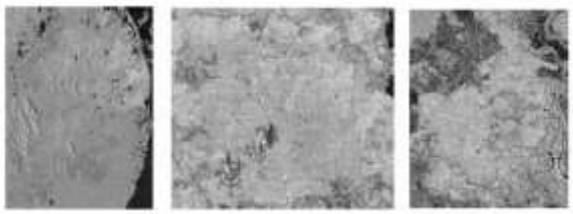

Figure 6. False-colour compositions images in sample paddy fields and mapping paddy area in yellow colour

Using this it can easily identify a particular area. but it can't be classifying accurate value, so getting separately different of dual polarize value can be classifying accurate crop field. VH and VV band can be calculated as VVmin, VVmax, VHmin, VHmax. Deferent of VV and VH value(VVmax-VVmin and VHmax-VHmin) mapping above selected area. Paddy area classifies as considering particular value related to deferent of VV and VH band value. Figure 7 shows that considering the table.

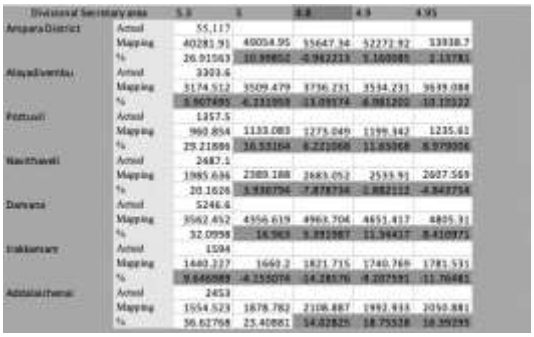

Figure 7. VH and VV deferent band value related unique value to classifying real paddy area

The research was choosing deferent value related to paddy fields' accuracy. The accurate band value for deferent of VH band is 4.8. Total district mapping accuracy is 92% & and another individual Divisional area was changing with low deferent. Ampara district actual paddy area is 55,117ha, so predicted area is 55, 647.34ha. Figure 3 shows a sample of two paddy field classification. For identifying the paddy field, use google earth imagery and mapping it with false-colour

composition. Finally using paddy classification model, Classifying only paddy area in Ampara district and also divisional secretary area. Figure 8 show deferent between google earth sample paddy area, mapping paddy area(with false-colour compositions) and classifying paddy area. This classifying paddy area can be used to predict paddy production using sentinel 2 vegetation index values. SAR images are very sensitive to identifying surface objects. VV and VH dual-polarization value range included separately with deferent values to identifying that. Time series of Sentinel 1 imageries are more accurate than single imagery for this kind of task. Because changing band value related to the crop age is possible in Sentinel 1. Higher and lower range band value of time series shows the actual different within sowing and harvesting related to paddy area. A value which is above 4.8 shows higher accuracy related to providing sample paddy area details.

Figure 8. Google Earth imagery, False colour composition value, Classification paddy with value 4.8 show respectively

C. Supervise classification

In Supervised Classification, it used Maximum likelihood classification. Using this classification it used mainly three classes. There are Paddy, NonPaddy, Water. Classification can be displayed as below.

Figure 9. Maximum likelihood classification for Sentinel 1

Classification is done with ENVI software and accuracy assessment also done with that software. Table 2 shows the accuracy assessment report of maximum likelihood classification

Table 4. Classification details of the sample area

Class Name	References totals	Classification Totals	Number correct	Produces Accuracy	User Accuracy
Unclassified	0	0	0	0	0
Paddy	100	92	91	91%	98.9 %
Non-Paddy	100	110	82	82%	74.5 %
Water	40	38	35	87.5 %	92.1 %
Total	240	240	208		

The overall accuracy of the classification is 86%. And overall kappa statistics is 0.85.

Discussion and Conclusion

Sri Lankan government and farmers are facing a lot of problems, because of the lack of yield statistics before harvest. There are no standard methods to getting statics of agriculture during the cultivation period. Real-time mapping method should be included for helping those problems. So, This research tries to focus to solve that kind of problems. When considering those non-remote sensing data which get from the District Agricultural department of Ampara is not more accurate. Because some paddy data of non-remote sensing data are not accurate because manual processing uses previous year data when they can't find real value related to the particular year. Total accuracy of this research is 92%. And Ampara district error is 0.96. It Mapped paddy field in every DS divisions and most of the paddy classifying paddy area validate with google earth imagery. Maximum Likelihood classification which is the part of Random Forest classification is used to this research as another method classifying and validating mapping image. It shows 86% accuracy for mapping area. Research can added predicted model using NDVI and other vegetation indexes with Sentinel 2 imagery

as further development for predict Harvest in the whole district.

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J. Abbreviations and specific symbols

DOY-Day of the year

ESA-European Space Agency

EVI2-Two-band Enhanced Vegetation Index

GRD-Ground Range Detected

NDVI-Normalized Difference Vegetation Index

NIR-Near Infra-Red

RADAR-Radio Detection And Ranging

RGB-Red-Green-Blue

SAR-Synthetic Aperture RADAR

SNAP-Sentinel Application Platform

SPOT-Satellite Pour observation de la Terre

UTM-Universal Transverse Mercator

VI-Vegetation Index

WGS-World Geodetic System

ANN-Artificial Neural Network

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Paper ID: 599

A Geo-Physical Investigation into the Colombo Port Seabed using Sub Bottom Profiler

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Abstract: Traditionally, seabed layers were determined by using conventional mechanical methods like boreholing, which retrieved the strata at a single point at one time. Later it was developed to various acoustic remote sensing techniques which can determine layers robustly, with less cost. Sub Bottom Profiler (SBP) is an effective method used to identify and describe the layers of sediments under the seabottom. SBP is almost similar to an echo sounder, but portion of the sound pulse is penetrating beneath the seafloor and reflected off of the strata layers. These refracted acoustic signals will show any sort of density disturbance. Sub bottom systems have been used to detect and measure the thickness of sediment deposits, identify buried objects, and define the bedrock layer of a basin. Transducer frequency and pulse length are the key aspects on the SBP system performance. Absorption losses are proportional to the transmitting frequency. Long sound pulse lengths required more energy and resulting deeper penetration but decreasing the system resolution. The Stratabox HD is a pinger type SBP having the capability of detecting the soft sediment layers in high resolution. The objective of this study was to carry out a geo-physical investigation of the Colombo Port using the SBP. Data was collected at the Jaya Container Terminal (JCT) basin. Sub-bottom fence diagrams were generated with Hypack software and results were validated using the existing borehole samples. The initial sub bottom soft layers were closely matched with the borehole sample data.

Keywords: Sub Bottom Profiler, Sediments, Geo Physical Investigation, Coastal Engineering

Introduction

Sub bottom profiler (SBP) is a widely used geophysical technique, which is used to distinguish and depict different strata of sediment below the bed of water bodies. Sub bottom profiler is used in many fields such as under water terrain measuring, terrain mapping, buried object investigation and hidden status exploration have been the most common usages of the SBP. While, sedimentary materials cannot be identified from sub bottom profiler directly, different layers can be distinguished according to the penetration of acoustic impedance with respect to different layers (Gutowski et at, 2004; Wheeler, 1998) SBP is based on vertical reflection similer to seismic profiling (Figure 1). Basically SBP are used in shallow reflection seismic profiling. Usually SBP transmitted its echostic wave around a central frequency and their bandwidths varied from system to system. SBP used acoustic wave source and one or several receivers. Lower frequencies are used in SBP to penetrate bottom strata. They developed significantly during the past few decades with different capabilities.

The pinger type SBP is a shallow penetration profiling system designed to provide high resolution results up to 30m in soft materials. Shorter wavelengths allows for

fine details in the shallow subsurface (Uncles & Mitchell, 2017).

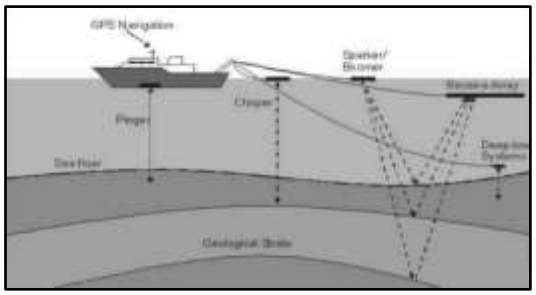


Figure 1. Various SBP techniques.

The main purpose of this study was to assess the performance of StrataboxHD SBP in bottom strata classification.

Methodology

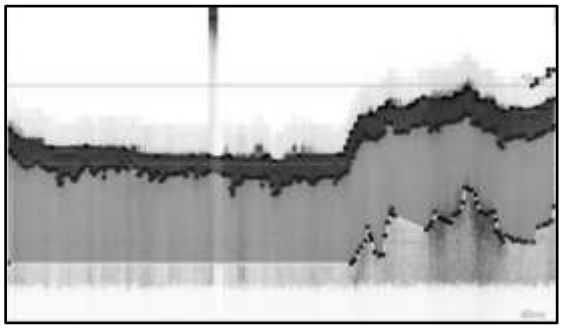
Sub-bottom data was collected at the Colombo Port using the Stratabox HD subbottom profiler. The frequency of the transducer was 10kHz. Data was collected & processed using Hypack software and results were compared with the third party borehole samples of the same area obtained from the Ports Authority. Further, collected grab sample data were also used to classify the first layer of the strata.

Figure 2. Collected SBP Data and Sample Locations.

Results

In Colombo Port, mainly two sub bottom layers were identified from the StrataboxHD SBP (Figure 3). Top layer was a soft silty clay layer varying from 1 to 3m deep and the second layer was a moderate clay layer ranging from 2-10m after the top layer. This was further verified by the existing borehole sample data (Figure 4). The average penetration depth was about 20m from the system.

Figure 3. Classified SBP layers Fence Diagram.



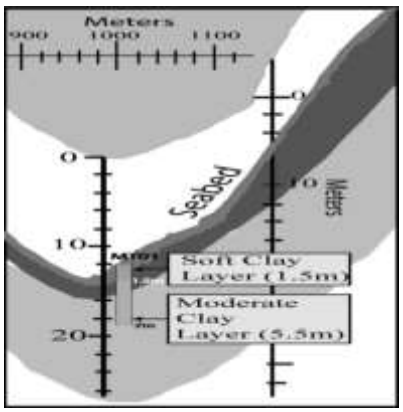


Figure 4. Comparision of SBP data with Borehole

Conclusion

StrataboxHD SBP is capable of successfully distingulish the soft bottom layers and they and closely matching with the existing borehole data in the vicinity. However, the bottom penetration depth is about 20m as we used the 10kHz transducer. For better penetration, it is recommended to use lower frequencies like 3 kHz. Further, this system is successfully be used in detection of burried objects like pipelines. But, the reception sensitivity must be correctly adjusted as the background noises is also playing an important role in obtaining better results.

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Paper ID: 615

Livability of Vertical Apartments: A Study of the Relationship between Environmental Psychological Satisfaction and Height of Living with Special Reference to Low Income Apartments

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Abstract: This study investigates the liveability of low income vertical apartments in Colombo, by means of finding the relationship between environmental psychological satisfaction and height of living. The main objective of this study is to find out to what extent the environmental psychological satisfaction correlates with the height of living of the low-income apartments. A total of 144 individuals (36 from each apartment and 3 from each floor level) from different age groups were employed as participants among the residents of four selected low income apartments located in Colombo. The primary data were collected using a structured questionnaire and the secondary data were collected by using layouts, floor plans and photographs of the apartment buildings. A Stratified random sampling method was used to select the participants. Safety, friendship and relationship with neighbours, basic residential infrastructure, attachment of residential area, open natural spaces, privacy, personal spaces and territoriality are the determinants that were used as the basis of the questionnaire. The primary data were analysed by using SPSS (Statistical package for Social Science) and the study employed estimation methods of OLS (Ordinary Least Square) estimation. As the final outcome, the level of environmental psychological satisfaction was identified in relation to the height of living and the aspects of design response were emphasized and impacted on it.

Keywords: Liveability, environmental psychological satisfaction,, low income vertical apartments, Colombo

Introduction

Colombo is the commercial capital of Sri Lanka. Since 2015, 555031 inhabitants have been occupying 103408 housing units and 13928 slums in Colombo (Colombo Municipal Council, 2015). The urban population of Colombo city has risen from 21% to 32% in the period from 1971 to 2001. Since2001, the urban population of Colombo city has not increased in considerable numbers (Statistical Hand Book-2018, Department of census and statics). Thus, during the time period of 1971 to 2001, excessive population has created irregular constructions and informal environment in the city.

According to the Urban Development authority records, a total number of 68812 families live in 1499 community clusters. Thus, the government has attempted to find a solution for this underserved settlement. As a solution, the government has introduced vertical apartments for the low income category. “Sahaspura” is the first attempt of introducing low-income high-rise apartments launched by the government in

2001. Wijesinghe (2010) has emphasized that among the 651 families which were relocated in Sahaspura, 161 families refused to live and about 100-150 families have sold their houses and gone back to their previous places. According to his study, he has implied that reasons for the failure of Sahaspura is, social fabric factors which are not considered in resettlement process and loss of their income opportunities.

After the Sahaspura low income project, the government decided to launch a program for construction of 60,000 housing units for low-income people. (UDA, 2011). UDA has launched vertical low-income apartments in three phases. In the first phase there were fourteen projects including 400sqm units in each apartment and the second phase consisted of eleven projects including 500sqm units in each apartment. Third phase consisted of eight projects.

The government has launched many low-income vertical apartments to acquire the high valuable lands in Colombo city. Before moving into vertical apartments, those people lived-in single-story houses. After the resettlement programs, they had to live in vertical apartments. According to the previous research, some residents left their new vertical living environment. Thus, there is a problem of the height of living and environmental psychological satisfaction of the low-income category.

Thus, the primary objective of this study is to find out to what extent that environmental psychological satisfaction is correlated with height of living in the low-income apartment buildings. The secondary objective is to find out how architectural implications impact on environmental psychological satisfaction and height of living, using the architectural layout and design response of the apartments. Identified case studies are constructed after the failure of the first low income apartment named "Sahaspura". Most low income apartments are going to be constructed in future and these selected case studies will be a directory samples.

The study was focused on only low income apartments. Further, the social, economic and political impact on livability of those vertical apartments was not focused. The research was based on environmental psychological satisfaction of residents. Environmental Psychological determinants are limited to which show a relationship with height of living in the building.

Background and Literature Review

A "house" is one of the place that fulfil the physiological needs and it can be transformed into a "home" with fulfillment of the physiological needs as well as psychological needs. At present, the home concept has become more complex in urban areas with vertical apartments. In the Sri Lankan context, low income vertical apartment complexes are emerging in urban areas as resettlement projects specially in the Colombo district.

Livability is the environmental psychological aspect of spaces. Mitchell (2000) has emphasized six livability qualities including health, safety, personal development, community development, natural resources, goods and services, and the physical environment. Concept of home has a deep relationship with its spaces and livability. It has a cognitive relationship with the environment. "Home is our corner of the world, our first universe a real cosmos in every sense of the world, home is the "territorial core" preferred space and fixed point of our daily activities." (Gaston Bashlard. 1969, p.4) House became home with its livable spaces.

Environmental Psychology can be defined as the core relationship between physical environment and human behaviour. Height of living has become one of the most effective factors with urban settlements. "The conquest of the horizontal transformed into

vertical, according to the normal process of evolution. Finally wrenched us away from earth's gravity to hurl us into planetary space. Perhaps, we are suffering from vertigo." (Marc. 1972, p.89).

Environmental psychological satisfaction can be demonstrated according to the spaces in building with its qualitative aspect and behaviour of occupants. "Environmental psychological satisfaction in building studies involves the subjective appraisal of the objective qualities of a given environment, indicating how much the given environment meets the expectations and needs of the inhabitants" (Ibemet. al, 2013, p.179). As cited by Reser et.al (2010) residential satisfaction is based on many determinants, and values, including stage of life, socioeconomic status, hopes for the future, norms for one's peers, and relationships with neighbours which belongs to the Environmental Psychological Satisfaction.

Building heights are directly impacted on fresh air, light, sun, a view and quiet because of distance from the ground (Jephcott, 1971; Adams and Conway 1975; Cooper-Marcus and Hogue, 1976). According to above the surrounding can have peaceful area with pure air which shows a lovely environment background.
Churchman (1984) has cited that main disadvantages of height are commonly accepted to be dependent on the elevator. The restrictions which as a result are placed on children's outdoor play worry about children falling-out of windows (Jephcott, 1971). Having very high buildings will be a problem for the safety of people.

Sommer (1959) has described the term "personal space"(PS) as an emotionally tinged zone around the human body that people feel is "their space" according to the social psychological literature. "As environmental psychologists have begun to study the natural as distinct from the human-made environment, the heuristic value of evolutionary explanations has become more evident" (Kaplan,1992).

Namazian1 et.al (2013) has mentioned that territories provide social interaction and help to stabilizing the social system. He has explained that homes are the primary territories where this function well. Environmental design needs to focus on ways to create and define secondary and public territories because it is difficult to recognize in clear terms. It will help to identify the different levels of territory that can correctly viewed by users and visitors. Thus, territoriality emphasizes the feeling of ownership of the place.

Wood et al (2007) has cited that people prepare in any environment if they have a need for social contacts. In some environments, this action is done easily. There are many reasons for desirable social interaction. The main reason is there should be mutual social interaction and sense of belonging.

Namazian1et.al (2013) has explained that the environment emphasizes only either very little interaction or a great deal of interaction is too static. It will not be responsive to changing privacy needs, so environmental designers should try to create environments that permit different degrees of control over contact with others.

Golant (2012) has described characteristics of the environment which explain the attachment to the place. Those factors are, specific to housing, both inside and outside the dwelling, the socio-demographic characteristics of the residents, psychological factors linked to the inhabitants' past housing situation, needs and expectations of living space, how the available space is lived in, Past and present experience of the place. These characteristics emphasized that attachment to a place

depends on personal experience, fulfilment of needs and features of the place.

The field of environmental psychology also studies the natural contents that contribute to the aesthetic qualities of settings, namely (calm) water features and vegetative elements. There is a significant amount of overlap between environmental psychology and biophilic design. Joye (2007) has described that there is psychological relation with natural environment and natural elements (e.g., vegetation and water features) are also found to contribute to the restoration.

Safety is denoted as one of the fundamental issues that the liveable environment should have. "high-rise housing is a distinct residential form that most people are living off the ground, so there are some special safety problems". (Gifford,2007).

Raw.G et al. (2001) shows the infrastructure system of high-rise housing is directly related with residents' essential living needs and is a necessity for the liveable residential environment. For high-rise housing, the water supply system consists of domestic water supply and fire water supply.

Methodology

The government has launched low income vertical apartments according to three phases (400sqm units, 500sqm units) and study focused on first phase apartments namely Siyapathsewana housing apartments at Dematagoda, Sisirauyana housing apartments at Wanathamulla, Lakmuthisewana housing apartments at Mayuraplace, Methsandasewana housing apartments at Henamulla.

A total of 144 individuals (36 from each apartment) from different age groups were used as participants among the residents who lived in each level of apartment. Primary data were collected using a researcher made questionnaire regarding the factors related to environmental psychological satisfaction as mentioned below.

Safety

1. Friendship and Relationship with Neighbours
2. Basic residential Infrastructure
3. Attachment of residential area
4. Open natural spaces
5. Privacy
6. Personal spaces
7. Territoriality

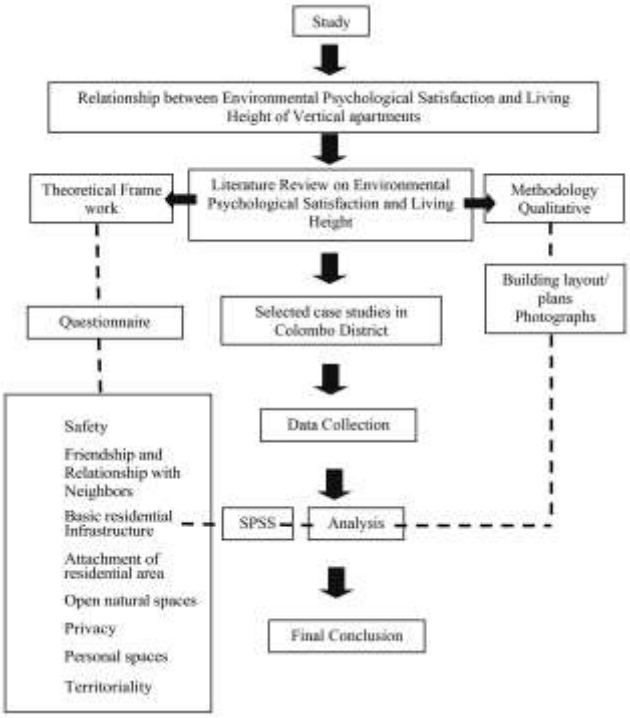

Figure 11: Framework of the Study
Source: by Author

The primary data analysed by using SPSS (Statistical package for Social Science) and the study used estimation methods of OLS (Ordinary Least Square) estimation. In the regression, used the dependent variable as floor level and set of Environmental psychological satisfaction as independent variables that mention as follows:

1. Floor level = Friendship and Relationship between Neighbours

(Level of communication + friendliness + Level of exchanging help + Satisfaction of common gathering Spaces)

2. Floor level = Open and Natural Spaces
(Satisfaction with open spaces (windows, doors) + Satisfaction with natural Light and ventilation + Satisfaction with natural environment + Satisfaction with outside view)

3. Floor level = Basic residential Infrastructure
(Infrastructure facilities + Satisfaction with using elevators)

4. Floor level = Safety
(Feeling of safety + Safety about children falling from upper level)

5. Floor level = Attachment to Residential Area
(Attachment to previous living place + Attachment to present living place)

6. Floor level = Privacy
(Feeling of isolation + Privacy)

7. Floor level = Personal Space
(Feeling of space area + Opportunity of changing Interior)

8. Floor level = Territoriality
(Ownership + Impression of living floor level)

The secondary data were collected by analysing case studies using layout and plans, photographs of four apartments. The data were collected from the following criteria.

Table 1: Secondary Data Collection Method
Source: by Author

Social Determinants	Related Building Spaces
Friendship and Relationship with Neighbors	Semi public and public spatial level/ Common place
Open natural spaces	Door/Window positioned Vegetation/ Green space
Safety	Handrails and space boundary
Basic residential Infrastructure	Elevators facilities and other

The secondary data were analysed descriptively by using layout plans, and photographs of case studies.

Conclusion and recommendation were obtained from using both primary and secondary data analysis.

Results and Discussion

The data were analysed according to the eight determinants as shown in Table 2.

Friendship and Relationship between neighbours.

According to the results, most residents in lower level are satisfied with friendship and relationship between neighbours. Level of communication (95%), friendliness between neighbours (95%) and satisfaction of common gathering spaces (99%), is significantly vary with floor level and level of exchanging help is not significantly dependent on floor height. Overall results shows that residents are satisfied with friendship and relationship between neighbours who live near to the ground floor than upper floors.

Table 2: Regression Results
Source: By Author

Dependent variable: Floor level	Sample Lower level	Sample Upper level
1. Friendship and Relationship between Neighbours		
Level of Communication	0.85 ** (2.24)	0.14 (0.25)
Friendliness	-0.88 ** (-2.29)	0.69 (1.30)
Level of Exchanging Help	-0.43 (-1.47)	-0.97 ** (-2.28)
Satisfaction of Common gathering spaces	-0.59 *** (-3.91)	-0.33 (-1.04)
2. Open and Natural Spaces		
Satisfaction with Openspaces (windows, doors)	-0.15 (-1.23)	-0.03 (-0.17)
Satisfaction with natural Light and ventilation	0.53 *** (4.77)	0.92 *** (3.73)
Satisfaction with Natural environment	-0.51 *** (-4.47)	-0.43 (-1.28)
Satisfaction with Outside View	0.01 (0.10)	0.14 (0.72)
3. Basic Residential Infrastructure		
Infrastructure facilities	-0.59 (-0.90)	-0.06** (-3.26)
Satisfaction with using Elevators	0.03 (0.17)	-0.13 (0.73)
4. Safety		
Feeling of safety	-0.09 (-0.64)	0.06 (0.35)
Safety about children falling from upper level	0.82*** (3.71)	-0.62*** (-3.07)
5. Attachment to residential area		
Attachment to the previous living place	-1.10 *** (-2.42)	-1.10 *** (-2.42)
Attachment to the present living place	0.53 (0.91)	-1.20 ** (-2.30)
6. Privacy		
Feeling of isolation Privacy	-1.90 (-1.41)	-1.52*** (0.37)
Privacy	1.64 *** (-2.64)	-3.87 *** (-2.14)
7. Personal Space		
Feeling of space area	-0.42** (-2.62)	-0.59** (-3.19)
Opportunity of changing Interior	-0.21 (-0.81)	-0.05 (-0.24)
8. Territoriality		
Ownership	0.73** (-3.05)	-0.25 (-1.49)
Impression of living Floor level	-0.43* (-1.68)	-0.04 (-0.27)
R squred	0.8	0.03
Observations	60	84

Note: Dependent variable is floor level: Ground Floor to 11th floor
Figure in bracket represent t: *** Significant at 99%, ** Significant at 95%, *Significant at 90%

Lower level : Ground Floor + 1st Floor to 4th Floor
Higher level : 5th Floor to 11th Floor

Open and Natural Spaces

In the second factor, which is open and natural spaces shows that level of natural light and ventilation (99%) is significantly satisfied with both lower and higher levels. Satisfaction with the natural environment (99%) is significant only at a lower level. Upper level residents are not significantly satisfied with the natural environment. According to the results, satisfaction of open space (windows and doors) and outside view is not at satisfactory level in both lower and upper floors.

Basic Residential infrastructure

In upper level residents are satisfied with basic infrastructure facilities (95%) than lower level residents. According to the response of residents, most lower level residents complain about the garbage disposal problem and garbage stored at ground level which make a bad smell to people who live near to the ground floor. Both lower level and higher-level residents are not satisfied with using elevators. The situation which has no electricity, waiting time in the morning (School days) are the complaints that are presented by them.

Safety

Both lower and upper level residents are significantly (99%) satisfied with safety of children (possibility of falling from upper floors). The feeling of safety is at insignificant level in both lower and upper floor levels.

Attachment to the residential area

Two questions were presented to identify the attachment of the residential area as mentioned in the below.

- No worry about moving from your previous place
- Worry to move out from your present place

According to the results, most lower level residents are not attached with their previous house. Their response is 99% significant. Upper level residents are not attached with the present living place and their response is 95% significant.

Privacy

In the factor of privacy, most residents in both levels have more privacy (99% significant) than previous living places. According to results, the feeling of isolation is significantly (99%) increased in the upper floor level. This implies that feeling of isolation does not impact lower level residents.

Personal Space

Feeling of personal space is significantly (95%) influenced to both levels and they are satisfied with it. the opportunity to change the interior does not significantly vary with living height.

Territoriality

In a case of territoriality, lower level people are satisfied (95%) with the ownership of the house. upper level residents are not satisfied with it. Also, Lower level residents are satisfied (90%) with their living current floor level.

The secondary data were analysed descriptively as below. (Table 03).

Table 3: Descriptive Data Analysis

Source: by Author

Social Determinants	Related Building Space	Design Response
Friendship and relationship between neighbours	Semi public and public spatial level/ Common place	According to the layout plans, there are no proper public places for gathering outdoors. Courtyards are benefited to the residents who living near to ground level. Linear passage is provided access to housing units and do not create gathering pockets in upper levels.
Open natural spaces	Door/Window positioned Vegetation/ Green space	There are no any trees in courtyard areas. Size of the windows are not enough for see outside views. Balcony floor area is not enough as a viewpoint. Residents use it as a place to dry their clothes. In some cases, introverted orientation of the windows makes darkness to the inside.
Safety	Handrails and space boundary	Height of the handrails and boundaries are enough for their safety
Basic residential Infrastructure	Elevators and Other facilities	There is no any proper garbage disposal system. Elevators are not enough for peak time. (school days)

Conclusion and Recommendation

This study revealed that there are environmental psychological determinants which are highly impact on living height. Those determinants are, Friendship and relationship between neighbours, Open and natural spaces, Privacy, Attachment to the residential area, Territoriality. According to the results, other determinants did not significantly impact on the height of the living low-income category. Under the friendship and relationship between neighbours, lower level residents are significantly satisfied with level of communication, friendliness and common gathering spaces. Upper level residents are only satisfied with the level of exchanging help. When considering the open and natural spaces, lower level residents are significantly

satisfied (99%) with the natural environment. In privacy, most upper level residents are felt in isolation (99%). According to the attachment of residential areas, upper level residents are worried about previous living and lower level residents are not worrying about it. Lower level residents are attached to the present residence rather than upper level residents. Lower level residents are satisfied with ownership and impression. of living height. Upper floor level residents are not satisfied with it. Therefore, lower level residents are satisfied in territoriality.

Table 4: Summary of quantitative and qualitative results
Source: By Author

Social Determinents	Lower level	Upper level	Design Response
1. Friendship and Relationship between Neighbours			Ground level courtyards are near to lower floor level range.
Level of Communication	✓	X	There are no any gathering
Friendliness	✓	X	spaces in upper floors.
Level of Exchanging Help	X	✓	Narrow passages are
Satisfaction of Common gathering spaces	✓	X	used to provide access to the housing units.
2. Open and Natural Spaces			Size of the windows are
Satisfaction with Openspaces (windows, doors)	X	X	not enough when considered the eye level.
Satisfaction with natural Light and ventilation	X	X	No enough space for balcony.
Satisfaction with Natural environment	✓	✓	Most of lower level residents are spend their
Satisfaction with Outside View	✓	X	time in courtyard area.
3. Basic Residential Infrastructure			Lower level residents are suffering from improper
Infrastructure facilities	X	✓	garbage disposal system. (all garbage stored in ground level)
Satisfaction with using Elevators	X	X	Elevators are not enough for peak time
4. Safety			
Feeling of safety	X	X	Enough height of
Safety about children falling from upper level	✓	✓	handrails and boundaries
5. Attachment to residential area			
Attachment to the previous living place	X	✓	
Attachment to the present living place	✓	X	✓ Satisfied X Unsatisfied
6. Privacy			
Feeling of isolation Privacy	✓	X	
Privacy	✓	✓	
7. Personal Space			
Feeling of space area	✓	✓	
Opportunity of changing Interior	✓	✓	
8. Territoriality			
Ownership	✓	X	
Impression of living Floor level	✓	X	

When considering all these determinants, quantitative survey results show that residents who live in ground

level and up to 4th floor level (lower level) are psychologically satisfied. Upper level (5th floor to 11th floor) residents are not psychologically satisfied. The qualitative survey was conducted to identify the design response which related to the environmental psychological determinants.

The qualitative results are overlapping with the quantitative results. Table 4 shows the conclusion of both quantitative and qualitative results.

Thus, it is highly recommended to limit vertical low income apartments up to G + 4th floor level wherever possible. Further it is recommended that there should be greenery spaces, common gathering spaces, enough space to see outside views, enough size of building elements etc. in every floor when the number of floors exceeds four (4).

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Causes behind Poor Written Communication Impact on Contractor's Quantity Surveyor Practices in Post Contract Stage

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Abstract: Effective communication among different stakeholders is a vigorous characteristic of successful construction industry practices. Written communication provides documentary evidence for strengthening key contractual relationships among such stakeholders. Compared to other forms of communication, written communication is a source of great comfort to Quantity Surveyor's royalty in the field of construction. Although many researchers discussed the causes behind poor communication in the construction industry, there is a substantial gap in analyzing the causes behind poorly written communication which impact post contract quantity surveying practices. Hence, this research primarily focuses on investigating the significant causes behind poorly written communication which influence contractor's quantity surveyor practices in the post-contract stage. A detailed literature survey was conducted and identified 26 causes behind poor communication in the construction industry. Then, 3 preliminary interviews were conducted and customized the literature findings in line with the contractor's quantity surveyor practices in the post-contract stage. Accordingly, 7 main contractor related causes, 5 sub-contractor related causes, 8 consultant related causes, 4 client related causes, and 4 communication tools related causes were formulated and tested with the use of a detailed questionnaire. Data collection was limited to a census of 60 quantity surveying professionals who were working on construction projects in the Colombo district belongs to ABC major constructing company. 57 of them were responded and the Relative Important Index (RII) method was utilized to analyze the data. The study revealed the communication tools related causes as the significant causes behind poor written communication in post-contract stage contractor's qantity surveying practices.

Keywords: Client, Consultant, Main Contractor, Poor Written Communication, Sub-contractor.

Introduction

Background to Study

Compared to other industries, construction is one of the most diverse and intriguing industries that is rapidly gaining popularity around the world (Gamil and Rahman, 2017). As a result of its nature, the construction industry has become a complicated and critical business (Hussain et al., 2018). According to the views of the number of researchers, unsuccessful data transferring can be depicted as one of the most critical issues experienced in the construction industry (Gamil and Rahman, 2017). Therefore, communication is a consequential and timely heading related to the present day construction process (Hoezen et al., 2006).

Communication is the process by which the sender sends a message to the recipient (Olanrewaju et al., 2017). It takes place through various modes such as written, oral,

non-verbal, or composition of verbal and non-verbal modes (Tipili et al., 2014). Among them, written communication takes a significant status (Prabavathi and Nagasubramani, 2018). Despite the manual consequences of written communication, it is integrated with different technologies in the present day context (Chidiebere, n.d). As further state by Prabavathi and Nagasubramani (2018), the written communication process helps to share information with the support of various documentation methods such as notices, reports, memos, e-mails, letters, text messages, journal articles, etc.

According to the official data presented by Jayamaha (2018), the construction industry is growing year by year progressively in Sri Lanka. However, most of the Sri Lankan construction projects are predominantly suffers from a lack of effective communication among construction parties. Similarly, problems related to poorly written communication negatively impacts the professional role of a Quantity Surveyor (QS) (Chidiebere, n.d). Since, the contribution of a QS to a construction project is very important for producing an economical design (Mbachu, 2015). Moreover, in a country like Sri Lanka where every activity is based on documented procedures, written communication takes an important place. Hence, it is imperative to ensure documentary evidence through systematic written communication between the QS and the project team members.

Though several researchers discussed the causes behind poor communication in the construction industry in general (Abdullahi et al., 2016; Mohammad et al., 2016 and Ishaq et al., 2018), they often fail to discuss the extent of the weaknesses in written communication in the construction industry that impact the post-contract duties of the contractor's QS. The lack of attention of many researchers in this regard is well illustrated by the lack of research reports on this topic. Hence, the researcher intends to conduct this research to fulfill this gap.

The main objective of this research is to investigate the causes behind poorly written communication which significantly influences the contractor's quantity surveyor practices in the post-contract stage with special reference to ABC contracting organization in Sri Lanka. It is one of the leading CS2 building construction companies as per the Construction Industry Development Authority (CIDA) contractor classification system (CIDA, 2009).

Causes behind poorly written communication in the construction industry Gamil and Rahman (2017) identifies 33 causes for poor communication, of which 3 are primarily influenced by poorly written communication. These include poor communication between the construction parties, lack of systematic communication in the construction sector, and poor communication skills between the parties. Valitherm (2014) specifies that the language barrier is one of the main causes of poor communication in the Malaysian construction sector. Moreover, Odine (2015) identifies poor identification of contractual documents as one of the main causes that impact poor communication between the construction team and external parties. Besides, Hussain et al. (2018) state that language impairment, ineffective responsiveness, lack of communication management, insufficient identification of role, and unsuccessful coordination as causes that contribute to poor communication. Also, Soliman (2017) identified five major issues affecting the 19 communication problems in the construction industry. These include the use of old filling systems, the absence of site progress meetings in the workplace, the lack of drawings and documents, the delay in the contractor providing information to

supervisors, and lack of supervisor experience.

Odine (2015) also identifies 17 causes of poor communication. Inappropriate information systems, attitudinal barriers, resistance to change for new communication methods, high workload, cultural background, using wrong communication medium at the wrong time, unfamiliar with the technical terms, physical disabilities such as hearing issues, late information, etc. which affects poorly written communication can be depicted as some of the significant causes identified by Odine (2015). Moreover, Ishaq et al. (2018) and Mohammed et al. (2016) states that many causes which can be effective for the communication between client and contractor during construction projects in Nigeria such as lack of cooperation among the two parties, selfish interest, lack of trust between parties, uncertainty, misunderstanding between the parties, lack of open communication between parties, failure to understand the individuality of each other, unpleasant relationship between the two parties, language barriers, and complexity of the project, etc. Olanrewaju et al. (2017) elaborate poor handling of paperwork and wrong instructions as the highest impacted causes to reduce the quality and accuracy of written communication in the construction industry. Abdullahi et al. (2016) identify three reasons that can influence poor communication among the main contractor, consultant, and client, namely: restricted communication resources, absence of faith between parties, and linguistic problems.

According to Agarwal and Garg (2012) physical barriers, fault of system design, attitudinal barriers of organization staff, poor identification of ambiguity of words/phrases, lack of individual linguistic ability, physiological barriers, poor presentation skills, etc. affect for ineffective communication within construction organizations. Jayasena and Alwis (2011) declare that keeping unsound records and poor baseline updating as basic causes behind ineffective written communication.

All the literature findings that generally affect ineffective communication can be summarized as in Table 1. However, the causes behind poorly written communication were filtered from the identified causes of poor communication by conducting preliminary interviews. During the preliminary interviews, the interviewees were agreed to the identified causes that influence the poorly written communication of ABC construction company's Qs's duties. Moreover, the interviewees suggested a lack of understanding of amended circulars & other amended documents, failure to submit markup drawings on time due to negligence, delay in providing instructions & variation approvals to the contractor, and limited written communication resources for the project as the causes behind poorly written communication addition to the literature findings.

Ultimately, as directed by Soliman (2017), the causes behind poorly written communication categorized into five categories namely; the main contractor related causes, sub-contractor related causes, consultant related causes, client-related causes, and communication tools related causes.

Table 5. Literature findings of the causes behind poorly written communication

Category of Causes	**Causes of poorly written communication**	**References**
Main Contractor related causes	Lack of understanding of job responsibilities & working capacity.	(Barriers to Effective Communication, 2011; Agarwal and Garg, 2012; Odine, 2015 and Hussain et al., 2018)

	Poor time management related to communication procedures.	(Odine, 2015)
	Lack of understanding of contractual provisions, terms & related clauses.	(Barriers to Effective Communication, 2011 and Odine, 2015)
	Complexity of the project generated by foreign contract partners.	(Mohammad et al., 2016 and Ishaq et al., 2018)
	Attitudinal barriers.	(Barriers to Effective Communication, 2011 and Odine, 2015)
	Personal Disabilities (Poor eyesight, Hearing Problems etc.).	(Barriers to Effective Communication 2011; Agarwal and Garg, 2012 and Odine, 2015)
Sub-contractors related causes	Inability to follow required contractual clauses, terms & provisions.	(Odine, 2015)
	Language Barriers.	(Barriers to Effective Communication, 2011; Valitherm, 2014; Abdullahi et al., 2016; Mohammad et al., 2016; Hussain et al., 2018 and Ishaq et al., 2018)
	Personal disabilities (Poor eyesight, Hearing Problems etc.).	(Agarwal and Garg, 2012 and Odine, 2015)
	Failure to discuss about contract agreement openly with main contractor to cover his requirement.	(Mohammad et al., 2016 and Ishaq et al., 2018)
Consultant related causes	Delay in providing instructions & variation approvals to the contractor	(Olanrewaju et al., 2017 and Soliman, 2017)
	Poor time management.	(Odine, 2015)
	Poor attention for contractual provisions, terms & clauses.	(Hussain et al., 2018)
Consultant related causes	Poor attention for the contractor's comments at progress review meetings.	(Barriers to Effective Communication, 2011 and Abdullahi et al., 2016)
	Poor understanding of job responsibilities & working capacity.	(Agarwal and Garg, 2012; Odine, 2015 and Hussain et al., 2018)
	Attitudinal Barriers.	(Odine, 2015)
	Personal Disabilities (Poor eyesight, Hearing Problems etc.).	(Agarwal and Garg, 2012 and Odine, 2015)
	Inaccurate drawings and supportive documents prepared by them.	(Soliman, 2017)
Client related causes	Poor understanding about duties, responsibilities & working capacity.	(Agarwal and Garg, 2012; Odine, 2015 and Hussain et al., 2018)
	Unable to follow contractual provisions, terms & related clauses.	(Odine, 2015)
	Lack of trust between client and other partners.	(Abdullahi et al., 2016; Mohammad et al., 2016 and Ishaq et al., 2018)
	Personal Disabilities (Poor eyesight, Hearing Problems etc.).	(Agarwal and Garg, 2012 and Odine, 2015)
Communic-ation Tools related causes	Using oldest documentary/record keeping methods and equipment.	(Silva et al., 2005 and Soliman, 2017)
	Poor knowledge about new written communication methods and tools.	(Silva et al., 2005; Agarwal and Garg, 2012; Abdullahi et al., 2016 and Soliman, 2017)
	Limited written communication resources for the project.	(Abdullahi et al., 2016 and Chidiebere, n.d)
	Technical errors of written communication tools.	(Agarwal and Garg, 2012; Abdullahi et al., 2016)

Methodology

A mixed-method was utilized in this research. The secondary data for this research was obtained using books, previous research reports, journal articles, conference papers, web sites, etc. published by various researchers. The causes behind poor communication in the construction industry were identified with the use of this secondary data collection technique.

Both interview and questionnaire methods were employed for the primary data collection. Preliminary interviews were conducted among three subject experts who had nearly 10 years of experience in post-contract level quantity surveying practices to demystifying the literature review findings in line with the causes behind poorly written communication in post-contract stage contractors' quantity surveyor practices of ABC contracting company.

As Jupp (2006) and Pierce (2018) stated, the census is the method for collecting data from the overall population when the numbers of repondents are limited. Therefore, a special sample selection technique was not followed, and obtaining questionnaire feedbacks were limited to the quantity surveying professionals belongs to six ongoing construction projects during 2019 in the Colombo district and head office which belongs to ABC contracting company.

As Silva et al. (2005) and Chidiebere (n.d.) followed, ongoing construction projects were selected and questionnaire feedbacks obtained from 60 census population of quantity surveying professionals who were working on the selected construction projects. The total population of respondents comprised of Chartered Quantity Surveyors, Chief Quantity Surveyors, Quantity Surveyors, Assistant Quantity Surveyors, Quantity Surveyor Assistants, and Trainee Quantity Surveyors who were knowledgeable on the role of contractor's QS.

The questionnaire for the survey consisted of two sections: A and B. The first, section A, contains the basic information of the respondents while the second (section B) addresses the causes of poorly written communication. 28 causes under five categories namely, the main contractor related, sub-contractor related, consultant (engineer) related, client-related, and communication tools related causes behind poorly written communication were tested in section B. The Relative Importance Index (RII) method aided the finding of significant causes behind poorly written communication.

$$\text{Relative Important Index (RII)} = \frac{\sum V}{HN}$$

V = Value that the respondent assigns to the variable

H = Highest value assigns the variable

N = Total number of respondents

As Xie et al. (2000) depicted, SPSS Software was used to analyze data. In line with Ishaq et al. (2018), Silva et al. (2005), and Olanrewaju et al. (2017), a 5-digits Likert scale was utilized for this research. Scale consisted with five parameters numerically, 1 = Disagree, 2 = Agree, 3 = Neutral, 4 = Highly Agree and 5 = Strongly Agree.

For further analysis, RII value between 0 and 0.5 was considered as less influential causes of the study. Correspondingly, RII value between 0.5 and 0.75 was reflected little or slightly influential causes while the RII values exceeding 0.75 was measured as a highly influential cause.

Results and Discussion

Basic respondents information

57 among 60 census populations were responded by achieving a 95% response rate as shown in Table 2. Among them, 56.2% of respondents had more than 5 years of experience in the Sri Lankan construction

industry and 94.7% of them had post construct level quantity surveying experience. Besides, 96.5% of respondents engaged with building construction projects.

Table 2. Summary of Responses

	Target Population	Responded Population	Response Rate
Quantity Surveyors	60	57	95%

Data Analysis – Causes for Poor Written Communication

Results related to 7 main contractor related causes, 5 sub-contractor related causes, 8 consultant related causes, 4 client related causes, and 4 communication tools related causes with a total number of 28 causes behind poorly written communication which can be impacted for post-contract practices of contractor's quantity surveyor were analyzed.

Main contractor related causes: By considering the RII values and ranks shown in Table 3, lack of understanding of contractual provisions, terms & related clauses can be depicted as the most influential contractor-related cause which mostly impacts contractor's QS's role (RII - 0.6912). As a result of its RII between 0.5 and 0.75, It can be considered as a somewhat influential cause behind poorly written communication for Contractor's QS's post-contract duties. As Odine (2015) noted, a similar reason affected poor communication in the construction industries of many countries in the world.

Table 3. Summary of the main contractor related causes

Main Contractor Related Causes	RII	Category Rank	Overall Rank
Lack of understanding of job responsibilities & working capacity.	0.6561	3	10
Poor time management related to communication procedures.	0.6632	2	9
Lack of understanding of amended circulars & other amended documents.	0.6421	4	12
Lack of understanding of contractual provisions, terms & related clauses.	0.6912	1	4
The complexity of the project generated by foreign contract partners.	0.6211	5	16
Attitudinal Barriers.	0.5684	6	17
Personal Disabilities (Poor eyesight, Hearing Problems etc.)	0.4632	7	22
RII Mean value			0.6150

Sub-contractor related causes: As stated in Table 4, the main reason behind the subcontractor's involvement for poorly written communication was the inability to follow up on the required contractual clauses, terms & conditions with a high RII value of 0.6667 in the category. It is also vested in the somewhat significant category (RII between 0.5 and 0.75). Odine (2015) also identified it as a significant cause of poor communication in the construction industry. Moreover, the tabulate results portrayed contractor's QS has a somewhat significant impact on its post-contract performance, due to the second-highest rated cause in this category; failure to discuss contract agreement openly with the main contractor to cover his requirement.

Table 4. Summary of sub-contractor related causes

Sub-contractor related causes	RII	Category Rank	Overall Rank
Failure to submit markup drawings on time due to negligence.	0.6386	3	13

Inability to follow required contractual clauses, terms & provisions.	0.6667	1	8
Language barriers.	0.6281	4	15
Physical Disabilities (Poor eyesight, Hearing Problems etc.)	0.4737	5	21
Failure to discuss about contract agreement openly with the main contractor to cover his requirement.	0.6632	2	9
RII Mean value			0.6140

Consultant (The Engineer) related causes: The highest RII value (0.7474) for this category vested on the cause was 'delays in providing instructions and variation approvals' as shown in Table 5. All most all the causes in this category were somewhat impacted for poorly written communication in post-contract stage contractor's quantity surveyor practices for the projects conducted by ABC contracting company that resulted in RII values between 0.5 and 0.75. The results were in line with the findings of Soliman (2017) and Olanrewaju et al. (2017). However, personal disabilities (RII=0.4772) minimally caused poorly written communication due to its RII value below 0.5.

Table 5. Summary of consultant related causes

Consultant related causes	**RII**	**Category Rank**	**Overall Rank**
Delay in providing instructions & variation approvals to the contractor.	0.7474	1	1
Poor time management.	0.6842	3	5
Poor attention for contractual provisions, terms & clauses.	0.6982	2	2
Poor attention to the contractor's comments at progress review meetings.	0.6772	4	6
Poor understanding of job responsibilities & working capacity.	0.6351	6	14
Attitudinal Barriers.	0.5544	7	18
Personal Disabilities (Poor eyesight, Hearing Problems, etc.).	0.4772	8	20
Inaccurate drawings and supportive documents prepared by them.	0.6632	5	9
RII Mean Value			0.6421

4) Client related causes: According to the tabulated results in Table 6, clients' inability to follow contractual conditions, terms & related clauses (RII=0.6772) was the dominant client-related issue behind poorly written communication that somewhat impact (RII between 0.5 and 0.75) for the contractor's quantity surveyor activities in the post-contact stage.

Table 6. Summary of client related causes

Client related causes	**RII**	**Category Rank**	**Overall Rank**
1. Poor understanding of duties, responsibilities & working capacity.	0.6702	2	7
2. Unable to follow contractual provisions, terms & related clauses.	0.6772	1	6
3. Lack of trust between client and other partners.	0.6491	3	11
4. Personal Disabilities (Poor eyesight, Hearing Problems etc.).	0.4912	4	19
RII Mean Value			0.6219

Communication tools related causes: Use of oldest documentary/ record-keeping methods that reached 0.6982 RII value was the leading cause in this category as shown in Table 7. However, it was somewhat influential (RII between 0.5 and 0.75) cause

for poorly written communication for Contractor's QS's post-contract duties.

Table 7. Summary of communication tools related causes

Communication tools related causes	RII	Category Rank	Overall Rank
Using the oldest documentary/ record keeping methods and equipment	0.6982	1	2
Poor knowledge about new written communication methods and tools.	0.6947	2	3
Limited written communication resources for the project.	0.6386	4	13
Technical errors of written communication tools.	0.6632	3	9
RII Mean Value			0.6737

Though it was somewhat influential, the most prominent cause of the study that weakening the written communication and affects the contractor's QS's post-contract works was the consultants' inability to provide timely instructions and approvals to the contractor (RII=0.7474). Subsequently, the consultant's poor awareness of contractual provisions, terms, and related clauses and the use of the oldest documentary/ record-keeping methods and equipment with equal RII values (RII=0.6982) also rated high.

Though Odine (2015), as well as Agarwal and Garg (2012), have identified personal disabilities (RII=0.4737) as a cause of weakening the communication process in the construction industry, this study elaborates its least impact for poorly written communication in ABC construction company.

According to the mean RII values obtained through the analysis, the "communication tools related causes" category can be identified as the highest influential category with 0.6737 RII mean value causes poorly written communication that hampers the post-contract work of ABC company's contractor's QSs. The second most influential category was the consultant-related causes category.

Conclusions

According to the findings, the most significant contractor-related cause, subcontractor related cause, consultant related cause, client-related cause, and communication tools related cause for ABC construction company's written communication weaknesses are lack of understanding of contractual provisions, terms and related clauses, inability to follow the contractual clauses, terms, and provisions, delay in providing instructions and variation approvals to the contractor, unable to follow contractual provisions, terms and related clauses, and using oldest documentary/ record-keeping methods and equipment respectively. Among them, the most prominent reason for the lack of effective written communication at ABC construction company was the "delay in providing instructions and variation approvals to the contractor". Due to the fact, the contractor's quantity surveyor of ABC construction company may not be possible to make variation claims on time. Therefore, it's the responsibility of the Consultant (The Engineer) to provide timely instructions and approvals to improve the effectiveness of the written communication process of ABC construction company.

In addition to consultant related causes, communication tools related causes category substantially influences the poorly written communication. It is therefore worthwhile to the organization to pay attention to the new communication tools and strategies being

implemented by incorporating new technology. Though this result is common to ABC construction company, it may not be the case for other organizations. Therefore, a deep investigation with the support of wider context is required to generalize the findings.

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Significant Causes behind Payment Delays in Public Sector Building Construction Projects in North Western Province of Sri Lanka.

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Abstract: Payment delay is one of the most significant issues experienced in public sector building construction projects. Correspondingly, most of the building construction projects in North-Western Province (NWP) of Sri Lanka are often characterized by delayed payments. Hence, the objective of this research is to identify the significant causes behind delayed payments in public sector building construction projects in NWP; as an initiation to develop a preventive framework for payment delays. First and foremost, a detailed literature review was carried out and identified 28 number of payment delay causes, including seven client related causes, nine consultant related causes, seven contractor related causes, and five other causes. Then a questionnaire was articulated and distributed among 100 (census) population of experienced professionals belong to the NWP Engineering Department and its 7 numbers of divisional engineers' offices in NWP. Sixty-five of them were responded.

The Relative Importance Index (RII) method was used to rank the most significant causes. Results indicated, the client's failure to follow the pre-set procedure as the most significant client-related cause for payment delays. The results further portrayed that delays in subcontractor's interim payment application, errors in contractors' claims, and delay in the valuation of work done by the quantity surveyor as the prominent payment delay causes respectively fit into other, contractor, and consultant related category of causes. Besides, the client-related causes category with highest average RII was identified as the highly influential group of causes behind payment delays in public sector building construction projects in NWP of Sri Lanka.

Keywords: Client, Consultant, Contractor, Payment Delays.

Introduction

Background of the Study

Payment is the lifeblood of the construction industry; construction projects are involving a very large capital outlay (Nassem, 2005). Since large amounts of money disbursed for construction works, the overall cost of the project may vary with payment delays (Ranasinghe, 2019). As indicated in contract conditions, payment delay needs to be identified by a paymaster to pay with certificates on time (McCaffer and Harris, 2003). On-time payment in construction project practices is one of the critical factors induces the success of the project. According to Latham (1994), identification of issues caused by late payments in construction projects is also important.

Most of the public sector building construction projects under the NWP engineering department and thereto engaged divisional engineer's offices predominantly suffer from payment delays in most building construction projects (Ranasinghe, 2019). Hence, it is important to identify and analyze the critical causes behind such payment delays. Therefore, the objective of this research is to analyze the causes behind payment delays of public

sector building construction projects in the North-Western Province of Sri Lanka.

Delays in Construction Industry

The issue of delayed payment in the construction industry is a global phenomenon (Hasmori et al., 2012). Poor payment performance is likely to dispose of late payment culture in the construction industry (Johnston, 1999). Generally, delays can be convinced as the most common, costly, complex, and risky problem faced by construction projects, and it could be liable to put ample pressure on construction time and cost (Ayudhya, 2012).

Syed et al. (2002) present five significant types of delays in the construction industry; non-excusable delays, excusable delays, compensable delays, excusable compensable delays, and concurrent delays. Events for which the contractor assumes the risks of costs and the time consequences involve are "non-excusable-compensable delays." The risk for events for which the contractor is entitled to both time extensions and recovery of extra cost consequential upon the delay; is the "excusable compensable delays." Events for which no party has control over or bears the risks such as acts of God and strikes can be depicted as "excusable non-compensable delays." Concurrent delays are upon both client and the contractor's responsibility for the delay.

Causes for Delayed Payments

Many factors affect the delayed payment in the construction industry (Nazir, 2006). Sambasivan and Soon (2007) indicates 28 significant factors that contributed to the delayed payment and categorizes them under eight major groups namely, client-related, contractor-related, consultant-related, material-related, labor and equipment-related, financial-related, contract-related, and external factors related. Algahbari e tal. (2005) also highlights financial related factor as one of the most critical factors which cause delays in construction projects. Moreover, Rahman and Ye (2010) elaborates 40 common factors causing delayed payments, and the factors categorize into 10 number of groups including cash flow problems due to client's poor financial management, ineffective utilization of funds, lack of capital to finance projects, failure to the source of money from the bank, delay in releasing retention money to contractors, evaluation delay in interim payment certificates (IPCs) and final payments. Ayudhya (2012) identifies the client's poor financial management in terms of adequate funding and errors in Bills of Quantities (BOQ) as the critical causes related to delayed payments. Frimpong et al. (2003) also claims BOQ errors as one of the critical causes of delayed payment. According to Alaghbari et al. (2007), lack of resources in current projects is another significant cause behind delayed payment in public sector construction projects. Besides, Cheng (2006) describes the withholding of payments as a major cause of delayed payments. Similarly, Ameer-Ali (2005) identifies potential causes for delayed payments, such as the client's poor financial management and client's withholding payment. Johnston (1999) also states the client's poor financial management as a prominent cause for delayed payment in public sector building construction projects.

As a summary, there are several causes for payment delays in public sector building construction projects and client, consultant, contractor, and other related factors predominantly behind each cause. During the review of the literature, the researcher identified seven client related causes, seven contractor related causes, nine consultant related causes, and five other factors related causes behind payment delays in the construction industry as further tabularized in Table 1.

Table 1. Delayed payment Causes

No	Causes for delayed payment	References
Client related causes		
1	Unrealistic Cash Flow	(McCaffer and Harris, 2003 and Naseem, 2005)
2	Client's poor financial management	(Johnston, 1999 and Hasmori et al., 2012)
3	Client's failure to follow the pre-set procedure	(Ayodele and Alabi, 2011)
4	Client failure to agree to the Valuation of Work	(Sambasivan and Soon, 2007)
5	Client failure to understand the contract agreement / Payment term	(Sambasivan and Soon, 2007)
6	payment to the contractor unduly by the client	(Sambasivan and Soon, 2007 and Ayodele and Alabi, 2011).
7	Change in the legislation	(Bob, 2005 and Olalusi and Otunola, 2012)
Consultant related factors		
8	Lack of coordination of project team activities	(Aziz, 2013)
9	Inadequate flow of information between the project team	(Danuri, 2006 and Ayodele and Alabi, 2011)
10	Consultant failure in treating claims	(Frimpong et al., 2003)
11	Delay in the certification of work done by an architect or Engineer	(Ayodele and Alabi, 2011)
12	Administration of Consultant's Party	(Danuri et al., 2006)
13	The inability of the consultant to manage funds	(Ayudhya, 2012)
14	Delay in the valuation of work done by the quantity surveyor	(Rahman and Ye, 2010)
15	Poor estimation of the project cost	(Frimpong et al., 2003)
16	Not having the proper idea about payment term / Interest charges	(Ramachandra and Rotimi, 2010)
Contractor related factors		
17	Contractor failure to agree to the valuation of work	(Mohamad and Isah, 2012)
18	Error in contractor claims	(Reeves, 2003 and Bob, 2005).
19	Contractors' failure to follow certain procedures in claims	(Odeyinka and Kaka, 2005)
20	Contractor failure to do work based on BOQ	(Hui and Wong, 2006)
21	Contractors' failure to understand the contract agreement	(Murdoch and Hughes, 1996 and Hasmori et al., 2012)
22	Failure to submit the Interim Payment Application (IPA) within the specified time limit as per the contract	(Rahman and Ye, 2010 and Olulusi and Otunola, 2012)
23	Failure to provide the particulars, backups, measurement sheets/work done approvals	(Rahman and Ye, 2010)
Other related factors		
24	Delay in subcontractor's IPA	(Latham, 1994 and Wu, 2010)
25	Improper choice of the standard form of contract	(Latham, 1994)
26	Unfair contract terms	(Rahman and Ye, 2010)
27	Contract terms which are too complicated to be understood by the parties	(Danuri, 2006)
28	Complex IPA formats approved by the Engineer	(Sambasivan and Soon, 2007)

Methodology

According to Durban University of Technology (2005), a research methodology is used to select a remedy for a significant problem followed by a step by step procedure. In this research, the methodology depicts the arrangement of the research questionnaire, data collection, data analysis, and presentation of results.

Secondary data for this research was gathered from books, academic journals, published research articles, conference papers, etc. available online and in University College Library and articulated the general causes behind payment delays in public sector construction projects. Accordingly, a structured questionnaire was developed to support the primary data collection. The questionnaire was embraced with a five-point Likert scale ranging from zero impact (0) to very high impact (4).

By considering the time limitation, the data collection was limited to the professionals who engaged with the building construction projects handled by NWP Engineering Department and its seven divisional offices in NWP.

Census means the survey method used to collect data from the overall population (Jupp, 2006). There were 100 professionals belongs to the NWP Engineering Department and related seven divisional engineer's offices who made aware of delayed payments of public sector building construction projects in the North-Western Province of Sri Lanka. Hence, a questionnaire survey was conducted among that 100 census population and 65 number of respondents were replied.

As Patil et al. (2016) exercised, the Relative Importance Index (RII) was utilized to rank the causes behind payment delays to determine the significant causes for payment delays. Indexes were ranked for the categories of client, consultant, contractor and other categories of causes. Moreover, group indexes are also obtained by considering the average relative important index of the causes behind payment delays in each group to identify the highly influential category of causes. The researcher adopted Statistical Packages for Social Science (SPSS) software to obtain the index values.

$$\text{Relative Important Index (RII)} = \frac{\sum W}{AN}$$

W = Weight given to each attribute by the respondent

A = Highest Weight

N = Total Number of Respondents

W is the weight which should be given to each factor by a respondent using a 5 point Likert scale ranges from zero (0- no impact) to four (4- very high impact).

Results and Discussion

Analysis of Delayed Payment Causes

An analysis was carried out under four prominent categories of payment delays, namely; client related causes, consultant related causes, contractor related causes, and other related causes.

1) Client Related Causes: According to the tabulated results indicated in Table 2, almost all the causes that depicted >0.5000 RII can be considered as significant. Among the seven number of causes, the most important client-related payment delay cause with the uppermost RII value of 0.9508 was the client's failure to follow the pre-set procedure. Hence, it can be depicted as highly influential client base delay payment cause in public sector building construction projects in the North-Western Province of Sri Lanka, and the result was similar to the results perceived by other researchers such as Ravees (2003), and Alaghbari et al. (2007). Therefore, if clients follow poor pre-set procedures, it is highly caused for the delayed payments. The client's poor financial management was the second most critical issue related to the client with RII of 0.9477. Moreover, unrealistic cash flow (RII=0.9354), followed by the client's failure to agree to the valuation of work (RII=0.9077), payment to the contractor unduly by the client (RII=0.9046), and changes in legislation (RII=0.8892) largely impact the delayed payments respectively.

Client failure to understand the contract agreement/payment term with 0.7692 RII value was the comparatively least impact client-related cause behind payment delays in public sector building construction projects in the North-Western Province of Sri Lanka.

Table 2. Ranking of Client Related Causes

No:	Factor	RII	Rank
1.1	Client's failure to follow pre-set procedure	0.9508	1
1.2	Client's poor financial Management	0.9477	2
1.3	Unrealistic Cash Flow	0.9354	3
1.4	Client failure to agree to the Valuation of Work	0.9077	4
1.5	payment to the contractor unduly by the client	0.9046	5
1.6	Change in the legislation	0.8892	6
1.7	Client failure to understand the contract agreement/Payment term	0.7692	7

2) Consultant Related Causes: Among 09 number of consultant related causes, delay in the valuation of work done by quantity surveyor with RII of 0.9015 was the highly influential delayed payment cause for public sector building construction projects in the North-Western Province of Sri Lanka as stated in Table 3. That result was in line with the findings of Arditi and Chotibhongs (2005) and Ayudhya (2012) related to the delayed payment causes in countries other than Sri Lanka.

Consultant failure in treating claims (RII=0.8985) was considered as the second-highest significant consultant allied factor behind delayed payments in public sector building construction projects in the NWP. Cheng (2006), Sambasivan and Soon (2007), Ravees (2003), and Frimpong (2003) were also agreed with consultant failure in treating claims as one of the most important delayed payment causes. Poor estimation of project cost (RII=0.8954), delay in certification of work done by Architect or Engineer (RI=0.8862), the inability of the consultant to manage funds (RII=0.8769), lack of coordination of project team activities (RII=0.8708) were also indicated as highly impacting delay payment causes connected to consultants of public sector building construction projects. According to the tabulated RII values in Table 3, the inadequate flow of information among the project team (RII = 0.8523), poor awareness of payment term/interest charges (RII=0.8308), and poor administration of the consultant's party (RII=0.8185) represented comparatively less impact for payment delays compared to the other consultant related causes in public sector building construction projects in the NWP of Sri Lanka.

Table 3. Ranking of Consultant Related Causes

No:	Factor	RII	Rank
2.1	Delay in the valuation of work done by the quantity surveyor	0.9015	1
2.2	Consultant failure in treating claims	0.8985	2
2.3	Poor estimation of project cost	0.8954	3
2.4	Delay in the certification of work done by an architect or Engineer	0.8862	4
2.5	Inability of consultant to manage funds	0.8769	5
2.6	Lack of co-ordination of project team activities	0.8708	6
2.7	Inadequate flow of information between project team	0.8523	7
2.8	Poor awareness of payment terms / Interest charges	0.8308	8
2.9	Poor administration of Consultant's Party	0.8185	9

3) Contractor Related Causes: As shown in Table 4, the most important contractor related factor with the uppermost RII of 0.9138 was an error in contractor claims. Cheng (2006), Sambasivan and Soon (2007), Mansfield et al. (1994), Frimpong (2003), and Latham (1994) also elaborated the impact of errors in contractor claims as a predominant cause behind delayed payment in building construction projects of other countries. The study specified, the contractor's failure to follow certain procedures in claims as to the second most important contractor related issue with significant RII of 0.9108.

According to the rest of RII values indicated in Table 4, contractor's failure to understand the contract agreement (RII=0.9046), failure to provide the particulars, backups, measurement sheets/work done approvals (RII=0.9015), contractor failure to conduct the works based on BOQ (RII=0.8985) and contractor failure to agree the valuation of work (RII=0.8923) respectively instigated payment delays in public sector building construction projects. Failure to submit the Interim Payment Application (IPA) within the specified time limit with 0.8769 RII value was the comparatively least impact contractor related delay payment cause in contractor related category.

Table 4. Ranking of Contractor Related Causes

No	Factor	RII	Rank
3.1	Error in contractor claims	0.9138	1
3.2	Contractors' failure to follow the certain procedures in claims	0.9108	2
3.3	Contractors' failure to understand the contract agreement	0.9046	3
3.4	Failure to provide the particulars, backups, measurement sheets/work done approvals	0.9015	4
3.5	Contractor failure to do work based on BOQ	0.8985	5
3.6	Contractor failure to agree to the valuation of work	0.8923	6
3.7	Failure to submit the IPA within the specified time limit as per the contract	0.8769	7

4) Other Related Causes: According to Table 5, the most substantial other related factors with the highest RII value of 0.9323 were the delays in the subcontractor's IPA. The result was similar to the outcomes of researches completed by Hamzah et al., (2011), Latham (1944), Sambasivan and Soon (2007), Ammir-Ali (2005), and Arditi and Chotibhongs (2005). Improper choice of the standard form of contract was ranked as the 2nd cause with high RII of 0.8923 in other related categories. Unfair contract terms (RII=0.8800) and complex IPA formats approved by the Engineer (RII=0.8646) were the other causes behind payment delays that can be made significant impact.

Table 5. Ranking of Other Related Causes

No	Factor	RII	Rank
4.1	Delay in subcontractor's IPA	0.9323	1
4.2	Improper choice of standard form of contract	0.8923	2
4.3	Unfair contract terms	0.8800	3
4.4	Complex IPA formats approved by the Engineer	0.8646	4
4.5	Contract terms which are too complicated to be understood by the parties	0.8462	5

However, contract terms that are too complicated to be understood by the parties (RII=0.8462) were the comparatively least influential other related delayed payment cause in public sector building construction projects in the North-Western Province of Sri Lanka, as in Table 5.

According to the tabulated results of high average RII (avg. RII) values shown in Table 6, client-related causes, contractor related causes, other related causes, and consultant related causes categorically influence the delay payments in the respective order.

Table 6. Ranking of Average RII values of each category

Causes category	Average RII	Rank
Client related causes	0.9007	1
Contractor related causes	0.8998	2
Other related causes	0.8831	3
Consultant related causes	0.8701	4

All the group indexes with high Avg. RII (>0.5000) depicted the significance of each category of causes. However, despite the least comparative impact of consultant related causes category with 0.8701 Avg. RII value, client-related causes category with 0.9007 Avg. RII value demonstrated the highly influential nature of delay payments. Correspondingly, Contractor related causes (Avg. RII=0.8998) also shared high index value while other related causes (Avg. RII=0.8831) reached the 3rd position of group ranking.

Conclusions

As an overview, almost all the causes behind payment delays instigated in the study were significant with high index values. However, the most influential category of causes behind payment delays of public sector building construction projects in the North-Western Province of Sri Lanka was the client related group of causes. Hence, the prime responsibility for the prevention and mitigation of delay payments in the NWP building construction projects carried out by the NWP engineering department is vested over the clients.

Besides, this study suggests the importance of taking corrective action to the client's failure to follow pre-set procedure, client's poor financial management, client's unrealistic cash flows, delay in subcontractor's IPA, errors in contractor claims, and contractor's failure to follow the relevant claim procedure to minimize payment delays in public sector building construction projects initiated by NWP engineering department of Sri Lanka. Subsequently, contractors and consultants also to be shared the responsibility for the reduction of delay payments occurred in the region with greater awareness on contractual terms and associated documentation. However, to generalize the findings of this research, further researches need to be carried out with the support of different types of public sector construction projects belong to various public sector institutions in the Sri Lankan context.

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Factors Influencing the Adoption of E-procurement for Public Sector Works in Sri Lanka: A Case Study Analysis.

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Abstract: Public sector institutes inherently suffer from the information asymmetries, extra time and cost penalties, corruption, transparency issues, anti-competition, and too much documentation with utmost human interventions in traditional paper-based procurement practices. Recently, the Government of Sri Lanka induced public sector institutions to embrace electronic procurement (e-procurement) adoption for their procurement practices. E-procurement is revolutionary digitization of the public procurement process. Despite the potential benefits, a high percentage of public institutions as well as small and medium-scale construction companies in developing countries often slow to adopt e-procurement processes. However, its advanced applications are less prevalent even in developed countries. Hence, the study attempted to analyze the factors influencing the adoption of e-procurement for the public sector Works in Sri Lanka within the limitation of Works procurement practices of the XYZ public sector educational institute. A mixed method was used to carry out the research. At the outset, a detailed literature review was conducted and identified people, technology, internal organization, and external environment as key e-procurement adaptation variables. Moreover, three structured interviews accompanied to demystify the literature review findings concerning the Srilankan context. Finally, a detailed questionnaire survey was conducted among a population consist of 70 respondents by following the census procedure and 72.9% of them were responded. Descriptive statistics were used to analyze the data with the support of SPSS software. According to the overall result of the analysis, 'Technology' was realized as the most significant factor which considerably influenced e-procurement implementation for XYZ public sector institute in Sri Lanka.

Keywords: E-Procurement, External environment, Internal organization, People, Public sector, Technology

Introduction

Public procurement can be considered as an important tool that provides social and economic goods to the common public and its efficiency enables careful utilization of public funds (Varité Research, 2017). According to the views of Amarapathy, et al. (2013), traditional manual procurement practices are predominant in Sri Lankan public sector constructions. Conventional work practices in line with traditional procurement processes related to Works contracts often experiencing information asymmetries (Pozin and Nawi, 2016), high administrative and transaction cost, anti-competitive practices (Varité Research, 2017), risks in scams, and corruptions (National Procurement Commission, 2018), too much documentation and paper works (Singh, 2008), disintegrate institutional processes (Kong and Gray, 2006) and extra time consumption (Liyanage, 2005). As stated by Varité Research (2017), public sector procurement also suffers from similar nature drawbacks though the government of

Sri Lanka spent approximately 5.3% of Gross Domestic Product through public procurements.

Moreover, the 2016 Auditor-General Report of XYZ institute, a regional level public sector educational institute in Sri Lanka, also exaggerates the similar issues of procurement practices followed by them. As per the report concerns, nearly 60% of the procurement actions made detrimental results to the financial and administrative functions of the institute. Therefore, the National Procurement Commission (NPC) of Sri Lanka deployed e-procurement guidelines to their recently drafted National Procurement Manual by considering the drawbacks of traditional paper-based procurement practices of Sri Lankan public sector institutions (NPC, 2018).

E-procurement, as a subsection of e-commerce (Whiteley, 2001), can be considered as a prime feature of e-government processes which produce an automation for a company's procurement of goods and services directing for attaining transparency, efficiency, effectiveness, dematerialization and improve competition through the procurement process activities (Gardenal, 2013). Despite such positive results, e-procurement is not yet common even among developed nations and often experience very low-level adoption among developing countries in the South Asian region during the past decade (United Nations, 2013). Sri Lankan public sector institutions also dragging behind in the adoption of e-procurement applications (Rajasooriyar and Perera, 2016). Also, e-procurement applications are comparatively low in the construction industry compared to other industries (Shukla et al., 2016). Therefore, public construction organizations may require a detailed assessment of these key adoption factors before any e-project initiation, since e-government projects may largely impact developing countries and often result in failures (Choi et al., 2016).

However, there is a substantial gap in identifying the factors influencing the adoption of e-procurement strategies for public sector institutions that handle construction Works. Therefore, the objective of this paper is to identify and analyze the factors influencing the adoption of e-procurement for public sector Works in Sri Lanka subjected to the limitations of XYZ public sector educational institutes & the minor construction Works handled by them.

Public sector Works procurements in Sri Lanka

According to the National Procurement Commission (2018), Works can be denoted as construction allied activities such as the construction of buildings, highway, bridges, harbor, etc. Hence, the public sector Works procurement process is the process used by government entities to acquire Works from external sources for their construction activities (National Procurement Commission, 2018).

As observed by Testa et al. (2012), there are distinct features between regional level and state level procurement handling. One such difference is the limits of authority assigned for different procurement committees. If a public procurement entity follows the National Competitive Bidding procedure in Sri Lanka, the limit of the authority vested on the Regional Procurement Committee is well within the scope of 10 Million rupees (National Procurement Commission, 2018). Hence, Rs. 10 Million is the conferred financial limit assigned for XYZ institute to handle the procurement of Works.

The government of Sri Lanka upholds a legislative framework through the updated procurement manual aiming to establish proper e-government procurement

mechanisms for public sector institutions with the support of information technology. (National Procurement Commission, 2018).

Key concerns on e-procurement adoption factors

The complex nature of the construction procurement due to excess stakeholder engagements and variance in project location influence the categorization of public sector e-procurement adoption factors (Eadie et al., 2010, cited in Laryea et al., 2014). Despite the fact of identifying key categorization factors, Amarapathy et al. (2013) denote the causes: uncertainty to the legal position, poor Information Technology (IT) infrastructure, costly IT system applications, lack of e-procurement knowledge of staff and their technical skills, indistinct supplier integration, cultural issues such as resistance to change and poor leadership and security issues as key areas to be a concern on e-procurement implementation. Moreover, obstacles concerning cultural, IT Infrastructure, security, legal, compatibility, personnel, and economic dimensions are predominantly influenced for e-procurement implementations (Laryea and Ibem, 2014 and Al-Yahya and Panuwatwanich, 2017). Despite the different classification of web-based technology applications in construction procurements into usage risk, cultural leakages, and tool leakages, Afolabi et al. (2018) also held similar views. Unlike other authors, Nawi et al. (2017) exaggerate the impact of changes in a political, economic, and technological context, inadequacy in government policies and legislations, inter-organizational barriers, and lack of standards as external environment challenges for e-procurement adoption in the Malaysian public sector constructions. However, Gunawardhana and Karunasena (2016) prevail on the same issues to identify the gaps in public procurement practices in Sri Lanka. Moreover, high initial cost, lack of required finance, poor integration with stakeholders, difficulties for technological adaptation with existing IT infrastructure, Inadequate business processes to support e-procurement implementation, poor management support, and cultural issues can be considered as organization related obstacles which affect the slowness of e-tendering adaptation in addition to the people-centered barriers such as resistance to change, lack of electronic application knowledge and training, negative attitudes of top managers (Addison, 2016). These findings have been extended with the external environment barriers such as inadequate e-procurement solutions in the market, lack of standards, and poor supplier relations (Mukhongo and Aila, 2018). However, strong economic and political commitment is required to overcome the e-procurement implementation barriers in the Sri Lankan context (Amarapathy et al., 2013).

Tran et al. (2011) attempt to evaluate the role of the government, organization, and individuals for improving the e-procurement implementation readiness level of the construction organizations of developing countries and conclusively develop a readiness model in terms of Government, Organization, and Technology factors. Choi et al. (2016) also exaggerate the similar views and proposed Strategy, Technology, Organization, People, and Environment (STOPE) e-procurement adoption framework supported by case analysis in Indonesia. Though Tran et al. (2011) omit people-related factors at the conclusion; Arunga and Paul (2017) considerably appreciate the requirement of effective human service delivery other than their technical skills and ethical practices of public sector individuals towards e-procurement adaptation. However, the ultimate result has shown that the technological infrastructure including software, hardware, networking, and interoperability significantly influences

e-procurement implementation of the public sector (Arunga and Paul, 2017).

E-procurement adoption factors and indicators

The number of e-procurement adoption factors addressed by various authors can be suppressed into technology, external environment, organization, and people related categories. Overall literature review outcomes of factors and indicators related to each adoption factor can be summarized as in Table 1.

Table 1. E-procurement adoption factors and indicators

Key Factors and Indicators	Citation
1. People	(Choi et al., 2016 and Alyahya, 2017)
1.1 Nature of staff adaptation to change	(Amarapathy et al., 2013; Laryea and Ibem, 2014; Addison, 2016; Al-Yahya and Panuwatwanich, 2017 and Mukhongo and Aila, 2018)
1.2 E-procurement knowledge of the staff	(Amarapathy et al., 2013; Laryea and Ibem, 2014; Addison, 2016; Al-Yahya and Panuwatwanich, 2017 and Mukhongo and Aila, 2018)
1.3 Technical expertness of staff	(Amarapathy et al., 2013; Laryea and Ibem, 2014; Addison, 2016; Al-Yahya and Panuwatwanich, 2017; Arunga and Paul, 2017 and Mukhongo and Aila, 2018)
1.4 Accountable service deliveries	(Addison, 2016; Arunga and Paul, 2017 and Mukhongo and Aila, 2018)
1.5 Ethical practices	(Arunga and Paul, 2017)
2. Technology	(Addison, 2016; Choi et al., 2016; Alyahya, 2017; Arunga and Paul, 2017 and Mukhongo and Aila, 2018)
2.1 Software applications	(Afolabi et al., 2017; Alyahya, 2017 and Arunga and Paul, 2017)
2.2 Hardware applications	(Afolabi et al., 2017 and Arunga and Paul, 2017)
2.3 Network applications	(Afolabi et al., 2017; Alyahya, 2017 and Arunga and Paul, 2017)
2.4 Interoperability capacity of existing IT infrastructure	(Addison, 2016; Afolabi et al., 2017; Alyahya, 2017; Arunga and Paul, 2017 and Mukhongo and Aila, 2018)
2.5 Assurance for digital security & authentication	(Amarapathy et al., 2013; Laryea and Ibem, 2014; Addison, 2016, Al-Yahya and Panuwatwanich, 2017 and Mukhongo and Aila, 2018)
3. Internal Organization	(Tran et al., 2011; Choi et al., 2016 and Alyahya, 2017)
3.1 Institutional structure	(Alyahya, 2017)
3.2 Institutional culture	(Addison, 2016; Afolabi et al., 2017; Alyahya, 2017 and Mukhongo and Aila, 2018)
3.3 Policies and procedures of the institute	(Alyahya, 2017)
3.4 Organizational readiness for capacity development	(Alyahya, 2017)
3.5 Financial ability of the institute	(Addison, 2016 and Mukhongo and Aila, 2018)
4. External Environment	(Tran et al., 2011; Choi et al., 2016; Alyahya, 2017 and Nawi et al., 2017)
4.1 Government leadership	(Tran et al., 2011; Amarapathy et al., 2013; Laryea and Ibem, 2014; Al-Yahya and Panuwatwanich, 2017 and Nawi et al., 2017)
4.2 Current IT management strategy	(Alyahya, 2017 and Nawi et al., 2017)
4.3 Status of the legal and regulatory framework	(Amarapathy et al., 2013; Laryea and Ibem, 2014; Al-Yahya and Panuwatwanich, 2017; Nawi et al., 2017 and Varité Research, 2017)
4.4 Financial support	(Amarapathy et al., 2013; Addison, 2016; Nawi et al., 2017 and Mukhongo and Aila, 2018)
4.5 Stakeholders readiness level to work with e-procurement	(Amarapathy et al., 2013; Laryea and Ibem, 2014; Addison, 2016; Al-Yahya and Panuwatwanich, 2017; Nawi et al., 2017 and Mukhongo and Aila, 2018)

Research Methodology

The research methodology consists of research design and research methods that utilize principles and techniques required to achieve the research objectives. To support XYZ case study based research data analysis, a mixed method was used to obtain data. By improving the validity of variables, a preliminary interview can be considered as

an applicable way to discover the user behaviors and expert opinions for a particular subject area (Creswell, 2013). Therefore at the outset, three preliminary structured interviews were carried out among three specialists who have more than 10 years of experience and awareness in the procurement, construction, and IT sectors. Preliminary interviews aimed to demystify the literature review findings in line with the Srilankan context. Interviewees were desperately in line with the literature findings with special considerations on accountable services and ethical practices as people related indicators.

When researchers make aware of what precisely requires measuring the variables and what type of information is essential, questionnaires are the most effective data collection instruments (Sekaran and Bougie, 2010). Hence, a self-administrative questionnaire was also developed and piloted among three public sector procurement specialists. As a result of their responses, some questionnaire statements were amended before the detailed survey. The main research instrument for the study, the paper-based questionnaire, entailed with two main sections. The first section was confined to extract general demographic aspects and procurement awareness of the respondents. The second section was made-up with 20 items related to 4 different e-procurement adaptation factors, namely; People, Technology, Internal Organization, and External Environment. A five-point Likert scale was adopted to articulate a scale for the questionnaire statements in the second section. The degree of influence was obtained through the Likert scale ranged from Not at all influential = 1, to Extremely influential = 5. For analytical justifications, the mean value of the degree of influence below 2.50 was considered as a value of 'least influential'. Correspondingly, the mean value between 2.50 to 3.50 was considered as 'somewhat influential', and the mean value above 3.50 was occupied as 'high influential' value by following a similar strategy occupied by Ibem et al. (2017).

'Census' is an attempt to collect data from the total population when the target population is limited in the selected study region (Jupp, 2006). The total population for this study encompassed with a census population of 70 numbers of respondents who representing top management (management board level), middle management (executive level), bottom management (management supportive level), and other supporting staff levels who were predominantly aware of various procurement activities of XYZ public sector institute. 72.9% of the total population was responded as shown in Table 2.

Table 2. Response rates in line with occupational levels of XYZ public sector institute

Occupation Level	Target Population	Responded Population	Response Rate
Top Management (Board) level	14	11	78.6%
Middle Management (Executive) level	27	23	85.2%
Bottom Management (Assistant) level	19	14	73.7%
Other supportive staff level	10	03	30%
Total	70	51	72.9%

Findings of the empirical study were compared with the literature outcomes and overlay factors were considered as critical influential factors for e-procurement adoption.

Results and Discussion

People as an adoption factor of e-procurement

In the first instant, respondents were requested to select the level of influence for

people related indicators. As per the tabularized results in Table 3, the majority of the respondents indicated 'Accountable service deliveries' with 3.88 mean (> 3.50) highly influence the effectiveness of e-procurement implementation and it was 60.8% of proportionate responses. Besides, 52.9% of respondents deliberately chose that 'staff adaptation to change' (mean > 3.50) as an e-procurement implementation factor with high influence whereas the results showed 39.2% agreed responses for the moderate influence of 'e-procurement knowledge of the staff'. Moreover, 37.3% of the responded population agreed with the moderately influential nature of 'technical expertness of the staff' (mean = 3.08) while 39.2% settled with 'ethical practices' (mean = 2.92) as a moderately influencing indicator for successful e-procurement implementation.

Table 3. Indicators of people factor

No	Indicator	Mean value
1	Accountability	3.88
2	Staff adoption to change	3.65
3	E-procurement knowledge	3.10
4	Technical expertness	3.08
5	Ethical practices	2.92
Average		3.33

Technology as an adoption factor of e-procurement

Secondly, respondents were requested to indicate to what extent did technology influences e-procurement implementation regarding the selected case study. Results stated in Table 4 responsively showed that the majority of respondents (78.4%) settled with the statement that 'software application' (mean > 3.50) highly influences e-procurement adaptation in the studied institute. Moreover, 76.5% and 74.5% of respondents highly agreed with the significant influence of 'hardware applications' and 'network applications' (mean > 3.50) for e-procurement applications respectively. Similarly, the results indicated a higher influence of 'interoperability capacity of existing IT infrastructure' (mean > 3.50) on effective e-procurement adaptation with a high respondent percentage of 62.7%. However, 41.1% majority believed that 'assurance for digital security and authentication' (2.5 ≤ mean ≤ 3.5) was just a moderately influencing e-procurement application indicator belong to the technology factor.

Table 4. Indicators of the technology factor

No	Indicator	Mean value
1	Network application	4.06
2	Hardware application	4.04
3	Software application	4.02
4	Interoperability capacity of current IT infrastructure	3.51
5	Assurance for digital security	2.86
Average		3.70

Internal environment as an adoption factor of e-procurement

Thirdly, there was a need to identify the influence of internal organization factors on e-procurement adaptation. Hence, a frequency chart was generated and the mean value results can be revealed as in Table 5.

Findings indicated that the majority of respondents (68.7%) forecasted high influence for the 'financial ability of the organization to apply new technologies on successful e-procurement implementation' (mean > 3.50). However, there was a moderate response rate (52.9%) for the influence of 'organizational policies and procedures associated with the public institute' on e-procurement applications.

However, 56% of respondents believed that 'organization structure' will not necessarily influence e-procurement implementation with the received mean value between 2.5 and 3.5. Correspondingly, the 'cultural influence of the organization' for its e-procurement implementation was not reaching a higher margin since the 35.5% of respondents only affirmed its moderate influence over e-procurement application by attaining a moderate mean value. Furthermore, 47.1% of respondents somewhat believed that e-procurement implementation was influenced by the 'organization's readiness for capacity development' to a certain extent.

Table 5. Indicators of internal environment factor

No	Indicator	Mean value
1	Finance management ability within the institute for new applications	3.92
2	Internal policies & procedures	3.27
3	Organizational readiness for capacity development	3.06
4	Institutional culture	2.86
5	Institutional structure	2.53
Average		3.13

External environment as an adoption factor of e-procurement

The fourth and the last e-procurement adaptation factor identified by the researcher was the external environmental factor. The study specified the extent of external environmental indicators' influence on e-procurement implementation as demonstrated in Table 6.

According to the findings, 74.5% response on 'financial support afforded by the government', 64.7% response on 'IT management strategy of the government', and 58.8% response on the 'legal and regulatory framework', respectively epitomized each factor as a highly influential factor which considerably influences e-procurement adoption in the selected public institute. Although, 41.2% proportion of respondents conceived that 'external stakeholders' readiness level to work with e-procurement' may not substantially influence e-procurement adaptation, 54.9% of respondents believed 'government leadership' ($2.5 \leq \text{mean} \leq 3.5$) was somewhat influential for successful e-procurement adoption.

Table 6. Indicators of the external environment factor

No	Indicator	Mean value
1	Financial support afforded by the government	4.16
2	Government's legal & regulatory framework system applications	3.59
3	Government's IT management strategy	3.57
4	Government leadership (Ministry level) for new system applications	3.39
5	External stakeholder readiness to work with e-procurement	2.67
Average		3.48

As a measure of central tendency, 3.33 mean value was obtained from the responses made by the participants on 'people factors'. This mean value positioned between 2.5 and 3.5 revealed that people somewhat influential for effective e-procurement adaptation.

The 'technology factor' was the central variable that could perhaps be explained with the reviewed observation consists of a high average mean value (> 3.50). Acquired average mean value (3.70) proved the highly influential nature of technology as an effective e-procurement implementation factor.

The study further demonstrated an 'internal organization' as a factor of comparatively low influential nature than other revealed factors that affect successful e-procurement

implementation. Since the average mean value was 3.13, the internal organization was somewhat influential for effective e-procurement applications.

The external environment factor was the second largest factor demonstrates a high average mean value (3.48). Though that mean value, as a measure of central tendency, was closure to the high mean value range, it can only be considered as somewhat influential for effective e-procurement adaptation. However, the external environment influenced e-procurement adaptation more than the people and the nature of the internal organization of the XYZ public sector institute.

Conclusions

The study identified four adaptation factors; people, technology, internal organization, and external environment, which possibly influence e-procurement implementation. Concerning the limits of the XYZ public sector institute, technology was the only factor that made a significant influence on the e-procurement adoption in public sector Works procurement processes in Sri Lanka. Hence, the expansions in software, hardware, and network application and their secured interoperable capacities possibly generate value addition to public sector Works procurement processes in Sri Lanka.

The young population engaged with the institute may induce this positive response for technology in response to their level of interest towards technological enhancements. Therefore, further researches need to be carried out by diversifying the research context with more public sector institutes having different financial authorities and by adding new factors and indicators (constructs) to generalize the findings.

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Robust Street edges as an Extension of Shop Fronts; a study with special reference to area of Negombo

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Abstract: Streets are providing a media for the moving elements such as pedestrians and vehicles, but it serves a place for myriad purposes and forming a major part of the cities. While streets offering multiple activities for multiple purposes of different type of people, this quality called robustness. According to Lynch, the contribution of elements on either side of the path, are highly Impact on the human behavioral pattern. Buildings where on eitherside of the streets effect on the robustness of the street edges. Some activities within the building used to extend towards outside and making connections with outdoor activities. As a result of this street edges being taken place for spectrum of activities and functions.

To determine that how extended shop fonts contribute to street edges to become robust and As result of that, Robust street edges become not only limited to single fixed use, but taking place for multiple uses and activities. Market Street, Main Street and the Station road are the three streets selected from Negombo for the study where one of commercial city since the past. All three streets are Commercial corridors in three different locations of the city and each has unique characters. An attempt to figure out from Plan view, elevations along the street and sections through the site revels how shop used to articulate their fronts with the help of other six factors such as; Legibility, Permeability,Variety,VisualAppropriateness,Personalization and Richness and how effects on outdoor activities on the street edge.

Keywords: Streets, Robustness, Responsiveness

Introduction

Multiple uses and activities are more important than buildings structures to the life of public realm. Number of human activities in the urban context cannot be limited into a single fixed use. They spread along streets, nodes, landmarks, edges and district. But specially, streets are involving for human activities by providing the media to move them. According to Lynch, "People observe the city, while moving through it & along these paths the other environmental elements are arranged." That means the contribution of elements on either side of the path, are highly Impact on the human behavioral pattern. Most of Shop fronts on either side of the streets, tend to extend their inner volumes, towards outside. As well as they used to articulate those frontages for many different purposes rather using only an entrance.

Offering Many Different purposes from a one space, can be define as Robustness. The Concept of Robustness starts from master scale and its scale down into smaller particles and it offer benefits to the particular aspects of user's life. Negombo is a one of city, which has given more potential to Commercial activities. Therefore shop streets spreading throughout the city. Mostly Street sellers on either side of the streets, living in a smaller plot, used to overflow their interior volumes to the outer facades to steps, steps to street edge or pavement. Robustness is not a single phenomenon that happens individually. It works with many of factors. Legibility, Permeability, variety, Visual Appropriateness, personalization , richness and Robustness are key factors of responsive Environment, where weaving together.

Research Question

Why Certain streets are more attractive?

i. Is Robustness Being factor to make street habitable?

ii. (Reasons for this occurrence were explored via a study on collective data from three streets in Negombo)

iii. What are the parameters affect on Robustness?

iv. How extended shop front use parameters (Legibility, Permeability, variety, Visual Appropriateness, Personalization, Richness) to overcome Robustness?

Research Aim

The research aim will be, to identify how factors impact on street edges to become robust and how shops on either side of the street, physically and functionally articulate their shop fronts for giving contribution to the street robustness and further more how street robustness conduses healthy interaction between people and places.

Objectives

i. To understand that Robustness is not only a single phenomena where interrelated with Legibility, Permeability, Variety, Visual Appropriateness, Personalization and Richness

ii. To identify that how shops on either side of the street, tend to articulate their shop fronts

iii. To determine while extending their shop fronts to the outside how it effects on immediate street edge and activities happened at the street edge

iv. To determine that how extended shop fonts contribute to street edges to become robust.

v. Identifying Robust street edges are not only limited to single fixed use, but taking place for multiple uses and activities

Research Methodology

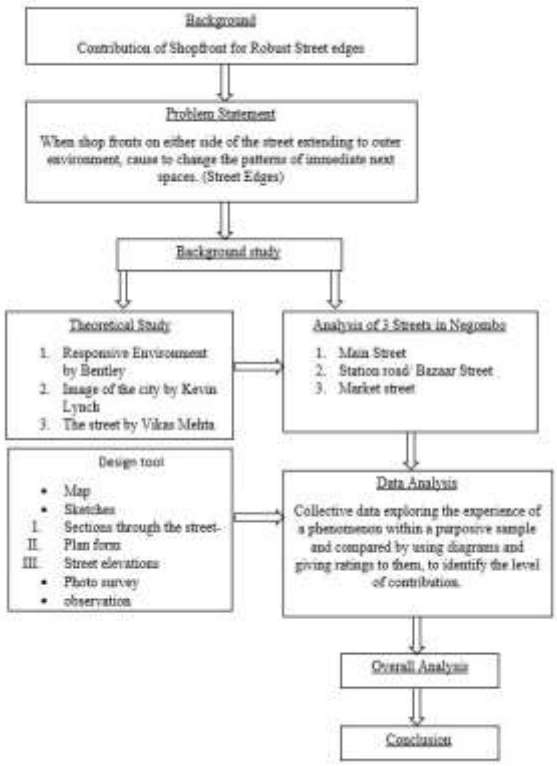

Figure 1- Research Methodology
Source: by Author

Introduction to Location of the Study

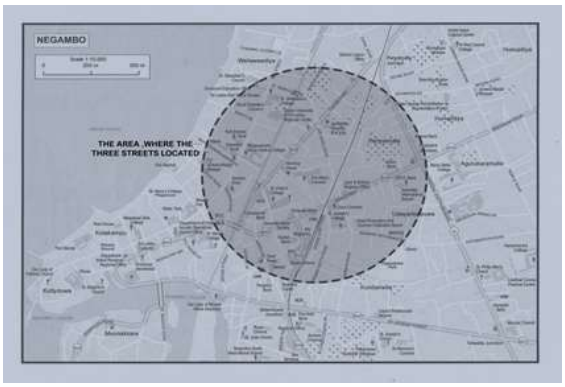

Figure 2- Negombo map
Source: Department of surveying

Well-ordered urban fabrication of Negombo has been led well organized road network and establishments to the city. Small Scale and Large Scale Robustness of the cityscape promotes the sociability index which built since past. As a result of that, Three commercial corridors; Market Street, Main Street and the Station road have taken as the case study, where elaborating unique characters to them with the quality of robustness in different scale. All three street are

crossing over city and selected from three different locations.

1) Street 1- Market Street: This street composition can be considered as most bustling commercial and entertainment stretch in Negombo. This two dimensional ribbon is tied with 3 main points. They are Main Street - Kamachchode junction and end with Sea. Kamachode junction is the intersection point of the sea street and the Market Street. The main street and the Sea Street provide accessibility to the street and the area comprises as a commercial and some other parts of the street settle as residential. For Wednesdays, and Sundays the Pola comes alive. So the street perspective is tending to frame the Kamachode weekly fair. Suburb village vendors already have their permanent structures long the market street and while the Pola Functions; Many of sellers come from outside city. This Neighborhood Commercial Corridor Fulfils Day to day needs, vital goods, fresh vegetable, textiles, grocery for the people.

There are small scale of shops bearing grams, grinding millers and textiles and from the other side pottery outlets and Dutch buildings and structures with Dutch influenced details. The massive gate way or the pandole tracing through the layers of commercial activities. In between Toddy turbans, cinema hall and some gipsy settlements have suddenly change the pattern of flow.

2) Street 2- Main Street: Main street is congested with vehicles, people and shops. Beyond the St. Mary's church and Koppara Junction are the two nodule edges of the main street. When Passes through the street Historically mansion buildings such as Dutch influenced colonial buildings, series of Jewelers shops, Fancy Shops, Branches of shopping centers and Ample of Parking Facilities makes visual clusters in the streetscape. As well as overflowing commercial Activities of shops corporate towards to the street, as a result, explode activities on either side of extended part of the shop fronts. Especially for the Christmas and other important occasions of the St Mary's church the street formed to festive character. Rather than other three streets this consists of large scale shopping malls and jewelry shops and the edge spaces of those kinds of buildings are being a part of vendor sellers, Cut piece sellers and some are selling newspapers, dry fish and antiques on their temporary structures. Or else it's act as space for displaying their own selling items.

For the weekends Street gets Really Busy with Suburb commuters because of the Formal Commercial establishments such as Branches of shopping malls like Nolimit, Glitz, Sriyani Dress point, Molly, Rare, Muthukaruppanchettiyar, vogue Jewells.

3) Street 3- Bazaar Street(Station Road): Bazaar street is completely different from the main street. This also a shop street consists with, retails, variety of textiles, kitchen items, cosmetics and toys. Usually the street known as Bazaar Street, because it is functioning while the Bazaar functioning. The Bazaar take place once a week and for other days its function as a normal access road. When this street function as a bazaar, the activity pattern has been totally changed than other days. The perspective view of the street has compact with vibrant textiles and retail shops and narrow paths facilitating to peeing to flow of people.

The Location of the street highly involves attracting people while the Bazaar Functions. The bazaar street has bank with Samanla Book shop, Buddhist Mandhir , Bank of Ceylon and on the other side railway track and some settlements merge with the city. The entry point -node which facing to the city center, act as welcoming place for many of activities. This street is being a kind of transition point because the railway track and the bus station creates a transport hub and Pedestrians, couples and stokers used to transfer through this street. People tend to use this street because of the quietness and cozy quality of the space. The activities of the street has hardly linked with the immediate spaces with Saturday Vegetable Market, weekly Fair.

Method of Data Collection

From each street, 3 blocks have selected as the samples and observe how the profile of the

shops on either side of the street and street elevation along each street involve to determine how shop fronts achieve Legibility, Permeability, variety, Visual Appropriateness, personalization and richness. As well as the Section through each block useful to determine, while shop fronts extending towards the street edge, How social behavioral pattern has been changed. The final analysis elaborates the contribution level of each block to make the street edge as Robust space.

1) Street 1- Market Street

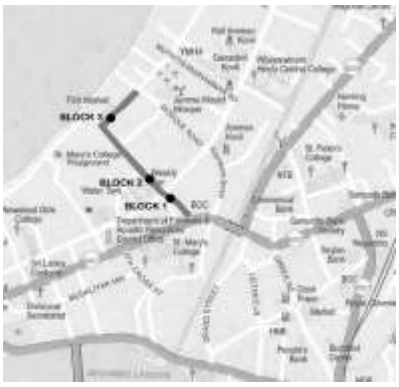

Figure 3- Market Street
Source: by author

2) Street 2 - Main Street

Figure 4- Main Street
Source: by Author

3) Street 3- Bazaar Street

Figure 5- Station Rd(Bazaar Street)
Source: by Author

Analysis

A. Analysis of Three streets

All three streets have closer proximity to immidiate main neighborhood commercial corridors, where fulfils day to day vital needs. The location of these streets promotes its legibility. Because they are closer proximity to city core area and walkable distance from city center to each street. Usually people from nearest suburbs visit to Bazaar Street and Main Street for shopping. Mostly, neighborhood community is the user group of the Market Street. Overflowing activities and extended shop fronts are common characters of those shop streets, and create active building edges and offering range of outdoor activities.

B. Zone of activities of three street

This studying area comprises as a commercial and some parts settle as residential. Small shop street where filled with horizontally and vertically extended spaces and the central stripy space has allocated for the pedestrian movement. Shop front, edge and the street are offering multiple activities for pedestrians as well as merchants.

1) Zone of Activities of Market Street

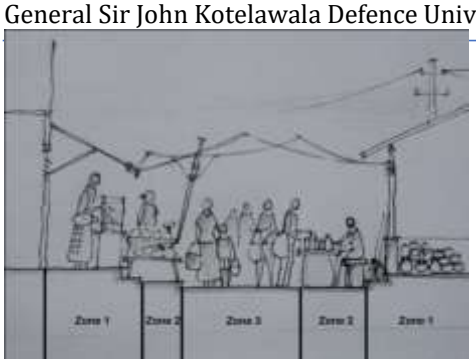

Figure 6- Market Street- block 1
Source: by author

Figure 7- Market Street
Source: by author

Figure 8- Market Street
Source: by author

Block 1 has been an extended part of the Market Street. Basically I have identified 3 zones. Though the Pola is held or not, The Building edge is always being active. As I mentioned earlier, Zone 1 is always used as an entry point to the shop. But sellers are displaying their selling items along the edge space and canopies and long eaves protect them from weather conditions. Zone 2, immediate next space to the building edge, where serves as a rentable area for other sellers who are coming from outside. They used to arrange them goods under temporary huts. Mostly Zone 3 is the narrow strip where allocated for pedestrian movements and rarely bicyclist uses this zone.

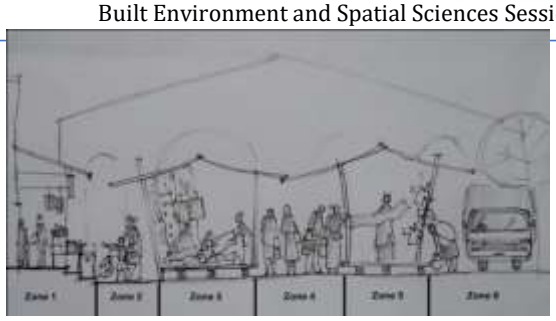

Figure 9- Market Street- block2
Source: by author

Figure 10- façade created by own selling
Source: by author

Figure 11- Orderly stacked selling on extended shop fronts
Source: by author

Same as Block 1, permently settle Shops are locate in zone 1and mostly they sell grocery items, oil and eggs. The building edge has been articulate with orderly stacked grocery items. People who are coming to these shops and the fair, parking their vehicles such as threewheelers and BicycleS in Zone 2. When the Pola is held, market street is filled with temporary Shops and creating shopping lanes within the street. therefore Zone 3, 4 and 5 are availble on Wendsdays and Sundays. Zone 6 is use to park lorries, vans which borrows vegitables, fruits and clothes to the fair.

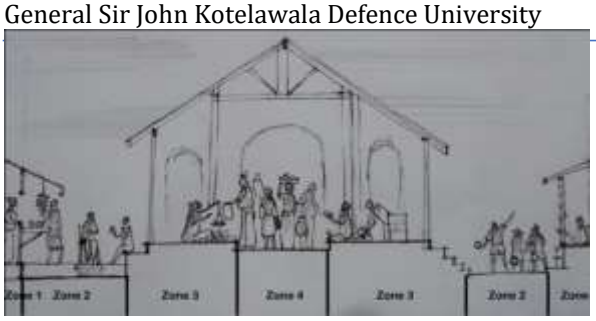

Figure 11- Market Street- Block 3
Source: by author

Figure 12- Market Street- Block 3
Source: by author

Figure 13- window selling along street
Source: by author

The new market and the residential area are belongs to the block 3. Specially these residential building haven't varenda spaces. Therefore they really engaging to activities which happened in the fish market.As a result of this, zone 1 is articulte as window shops or shop houses. They selles tea,and sweets for the sellers who work at the market. Sellers come to zone 2, when they need a relax and some time its being a place for children to play.When the fair dosent held, they attact the market for gathering and lingerings. zone 4 is compact with people when the pola held.

2) Zone of Activities of Main Street

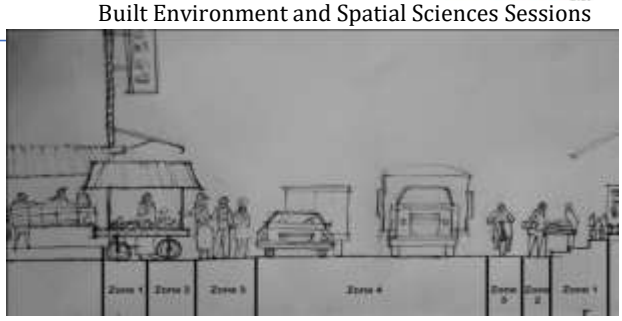

Figure 14- Main Street- Block 1
Source: by author

Zone 1 is usually used by vendor sellers, or people who are selling fruits and newspapers. But sometimes, we can identify activities in zone 1 become active ,while the pola function. If not most of people who visit to the St. Marys church, are hanging around this zone and most they visit to buy statues of gods, to buy some fruits or the daily newspaper as well. Therefore, daily we can see the fruit cart and statues, Newspaper seller and statues which keep in front of the shop. Same as Zone 2 is allocated for parking purpose. Zone 3 has been used by the pedestrian and zone 4 is used by vehicles. Mostly the days when the weekly fair held and the special occasion of the church (Good Friday, Christmas) the Zone 2, 3 and 4 become congested with people.

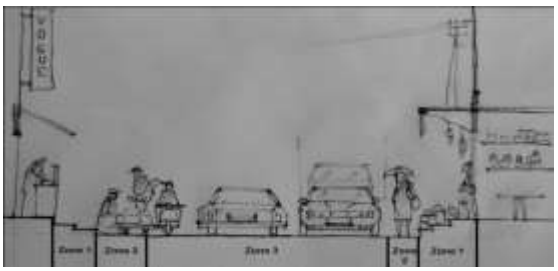

Figure 15- Main Street- Block 2
Source: by author

Figure 16- Main Street- Block 2
Source: by author

Figure 17- Main Street- Block 2
Source: by author

As mentioned earlier in block 1, same scenario is happening in the street. Though Zone 2 is allocated for the parking, sometimes it becomes a place of sellers who are selling clothes and retails in a reasonable price. The other Specialty is that, not like other blocks most of the building are belongs to gold shops, and fancy shops. Shop owners keep dummies with new arrivals, fashionable dresses in front of the building and pedestrians waiting at the building edge to watch the new arrivals.

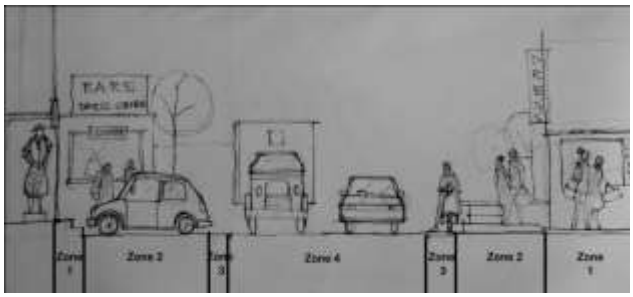

Figure 18- Main Street- Block 3
Source: by author

Most of buildings are shopping centers like Nolimit, Rare, Molly, Sriyani Dresspoint. They didn't tend to extend their interiors to outside and glass facades are making visual connection with outer environment. Therefore zone 1 is usually use for entry and exit point to the building. Zone 2 has allocated for ample parking spaces with tree shades, small benches. Therefore people used to spend there for relaxing, and chatting with others while their relatives shopping.

3) Zone of Activities of Bazzar Street

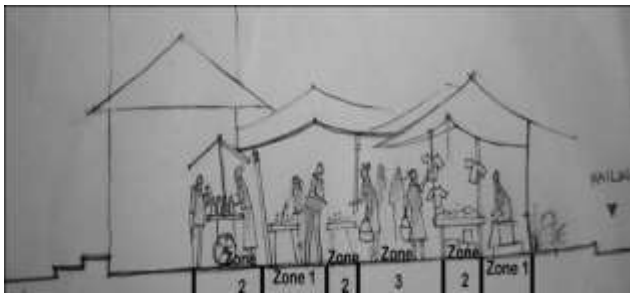

Figure 19- Bazaar Street- Block 1
Source: by author

Figure 20- Bazaar Street- Block 1
Source: by author

Figure 21- Bazaar Street- Block 1
Source: by author

Zone 3 has allocated for the pedestrians. Zone 1 is used by the sellers to keep their selling items and sometimes their shop space extending towards zone 2 as well. People who comes to the shop, usually staying at zone 2 and they spent their while choosing, buying.

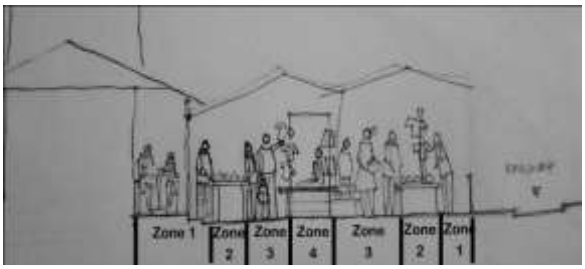

Figure 22- Bazaar Street- Block 2
Source: by author

Figure 23- Bazaar Street- Block 2
Source: by author

Same situation on block 2, but the difference is that, zone 3 become narrower, beacause another

strip of space grabbed by the selling purposes. The compact environment occurs a hustle and bustle situation within the street.

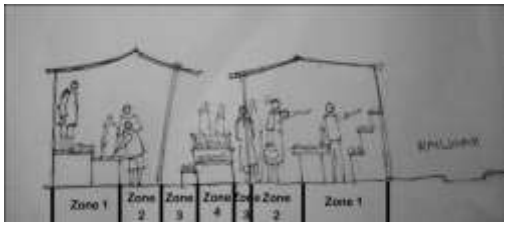

Figure 22- Bazaar Street- Block 3
Source: by author

Figure 23- Bazaar Street- Block 3
Source: by author

Same as block 2 Activities happening on each zone but the open end of the street limit the compact situation

4) Overall Analysis of Physical Arrangement of Three Streets: This studying area comprises as a commercial and some parts settle as residential. Small shop street where filled with horizontally and vertically extended spaces and the central stripy space has allocated for the pedestrian movement. Shop front, edge and the street are offering multiple activities for pedestrians as well as merchants.

Market Street and the bazaar streets are highly actively contributed to active the street edges rather than Main Street. Therefore the edge spaces can be considered as soft Areas, because time to time the space can use for many of function. Edge is not only for entry point to the building, it offers opportunity to people staying, waiting for someone, buying or choosing thing of the shop and to shop owners its being a place for displaying new arrivals. Sometimes Building Edges covered with extended roof where provided small sheltering for the pedestrians to protect from rain.Finally we can identified that, active building edges making background to become robust as well as it supports to urban life to come alive.

C. Physical Arrangement of three streets

Table 1. Ratings for Successive Contribution for the Robustness

Rating for Successive contribution for the robustness	**Representing Color**
High	
Medium	
Low	

Table 2. Overall Analysis of Physical Arrangement of Three Streets
Source: by Author

D. Physical Composition of three street

Overall Analysis of Physical Arrangement of Three Streets			
Character	**Market Street**	**Main Street**	**Station Road (Bazaar Street)**
Legibility	Kamachchode weekly fair and the Market is the main character which emphasis the street as Robust. But bit away from the city.	Prominent landmarks, Nodes and branches of the street where leading City, combined with the street.	Being located closer to the city center and the active node anyone can easily identify the location
Permeability	Lack of alternatives to the Market Street.	Branches of the Main street making connection to other places of the city	Limited alternative routes cause the lack of permeability of the layout.
Variety	has mix diversity of built use layout	Variety of shops establishments where represents social, cultural and entertaining.	Mixed uses and many of business increases the variety of the street.

Table 3. Ratings for Successive Contribution for the Robustness
Source: By Author

Rating for Successive contribution for the robustness	Representing Color
High	
Medium	
Low	

Table 3. Overall Analysis of Physical Composition of Three Streets
Source by Author

Overall Analysis of Physical Composition of Three Streets			
Character	**Market Street**	**Main Street**	**Station Road (Bazaar Street)**
Legibility	Usually people recognized as a place for Vegetables and fruits. But retails and bakery equipments also available.	People from other cities come to by gold, jewels and clothes. Because famous gold shops and dressing malls took place in this street.	Cheap available and choices cause to attract people.
Permeability	Permeable shop fronts helps to revel inside and people deal with the shops while staying outside of the shop.	Permeable glass facades displaying new arrivals of jewelries, dress on dummies.	Hanging, stacking their selling items on façade or the shop fronts, people get the idea what selling in this shop
Variety	variety of vegetables and fruits are the common availabilities, in fact colorful curtains, clothes where making varieties on the façade	Variety of displaying patterns, textures and orders of the façade	Variety of sellings articulate the façade itself
Visual Appropriateness	When people gather around some shops, other also attract to them to find what selling there.	While displaying new fashionable clothes or any other arrival, people may attract to them	People attracting by articulating their façade by own selling.
Richness	Making a favorable enclosure for the pedestrians by the temporary structures on either side of the street	Axially composed elevations along the street provide many things to watch on the shop fronts	Lack of richness of the street. Because the space itself doesn't provide a livable environment or a microclimate
Personalization	Some sellers are unique to sell one thing and some have unique collections.	Dressing the building façade with many different unique collections. from season to season	Everyone have variety of goods offering multiple possibilities to the customers

Conclusion

While people walking down the street, they are engaging activities on either side of the shop fronts. As a result of this, street edges become robust. The contribution of the shop front may present on different ways. Robustness is not only a phenomenon which happens individually. Legibility, Permeability, Visual Appropriateness, Richness and Personalization are the factors also help to fulfil the requirement of Robustness.

The location of the street where how much closer to active landmark, nodes, paths, edges or the district is important when considering about the legibility of the street because layout should provide a clear image of the street to the pedestrians. Bazaar street and the Main Street are more benefitted than Market street because there closer to the city centers and actively function nodes. On the other hand, the legibility has differed relating user aspects. Compared to bigger shops, small business consumed smaller plot of space to fulfill their requirement. As a result of this Rather than Main Street, small vendor sellers in Bazaar Street and the Market Street making their robust environment within small plot of land. As well as they achieve permeability by articulating their façade as well. Decorating their shop windows with their own selling or stacking them into order in front of the shop, by providing chairs, benches for the

people who come to their place are the simple method that they use to engage with the Street. The contribution of Variety of uses, good and services are more important than the variety of the built use of the street. Main Street has consisted with commercial, Socio and entertaining establishments such as Saree shops, Gold shops, Dressing malls, saloons, pharmacy, Book shops and hardware. Shops in Market Street and Bazaar Street uses to articulate their façade by Variety of selling items and they create variety of colors, textures, orders and patterns as well. People walking by these shops and some are used to stay at street edge while observing, buying and choosing them. Though these streets are not much rich with aesthetical pleasant appear, people willing to watch eye catching elements where displaying in front of the shop. Therefore the quality of visually appropriateness has fulfilled by the three streets. Lack of ventilation, the uncomfortable, unsafe atmosphere and visual barriers, endless view of the street has destroying the sensory richness of the Bazaar Street. But axially composed shop arrangements on either side of the street, enhance the directional quality and the sense of environmental comfort of the Market Street and Main Street. Personalization is the other thing that contributes the robustness from large scale to small scale. Large shopping centers at the main streets use to display their unique collection on glass façade as well as they articulate their façade from season to season to attract and provide multiple experiences to the people. Even sellers who are selling vendors, fancy items also have a unique character to engage and encourage people's activities who are walking by them.

Finally, in such way extended shop fronts helps to create Active Building edges and get benefits from the outdoor public realm. Therefore, it creates robust street edges and offers number of choices. Building edge with benches, balconies, Shaded canopies steps, windows are making alive the street and they encourage activities on edges. It encourages both indoor and outdoor activities; people encourage walking along, walking through it and giving the experience of sense of volume. So that lively building edges are part of social fabric, street, city as well as people life. Finally, the robustness can be apply for the cities, cities to street, streets to building edges, to make an environment friendly setting.

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GIS Mechanism For Terrain Trafficability

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Abstract: Geographic Information Systems(GIS) could be identified as a leading application mechanism that grows beyond in each and every aspect of the world. The GIS applications in decision making in the military field was gradually increasing in nowadays.This study oriented to compare the application of GIS in foreign armies and find a suitable GIS application for Sri Lanka Army. The design of this research was accomplished in three stages as reviewing the existing GIS application of foreign armies, and developing the terrain trafficability model using model builder application of GIS. Therefore by reviewing existing applications of other armies in foreign countries clearly identified some of the applicable GIS applications for Sri Lanka. And then by using questionnaire survey including Sri Lankan army officers figure out the appropriate application for the country. As the results of the questionnaire survey, it has found terrain trafficabiliy analysis method is the most suitable method for the country. Then Kalutara district was selected as the study area and land use, soil, elevation, used as raw data. In present, the Sri Lankan army doing terrain analysis using the Intelligence Preparation of the Battlefield(IPB). Terrain overlay is the part of IPB which identify go, no go, slow go areas of the terrain. This research focused on the identification of GIS mechanism for this manual process using GIS accurately compared to the manual process. Therefore suggest utilizing this analysis in the future for the terrain analysis in Sri Lanka Army.

Keywords: GIS, Trafficability, IPB

Introduction

The ability to negotiate varied kinds of terrain is crucial for army land-based operations.During offensive ground operations, the commander and staff has to identify which routes to take as part of the advance and attack. While the commanders at the respective stages consider the strategic, operational and tactical situations the engineer officer has to determine the trafficability/negotiability of the terrain throughout the theatre of operations. The Sri Lankan military is far behind in using digital technology in comparison to defense forces of other countries. Sri Lankan army doing the terrain analysis using the Intelligence Preparation of the Battlefield (IPB). Terrain overlay is the part of IPB which identify go, no go, slow go areas of the terrain. This research focused on the identification of GIS mechanism for this manual process.

The aim is to identify an appropriate mechanism for Sri Lanka army through the examination of the use of GIS in foreign armies. The researches are limited in Sri Lanka focusing the military terrain traficability. Modern military operations are highly dependent on mechanized vehicles and these vehicles are in turn only efficient on terrain which able to move with less obstacles.

Scope of this study is to identify an appropriate GIS mechanism for the terrain trafficability of the battlefield for the Sri Lanka Army. Although there are various kind of applications of GIS in the military field, this research was only focus to the analysis of the terrain traficability. Military means combination of tri forces, but in this research it has been limited only for Army. This study will helpful in future for the commanders when taking decisions on geospatial data with new technology.

Experimental Design

When designing the research, three stages were identified and the existing GIS applications of foreign armies were examined as the first stage. I accustomed review research papers, journals

and websites that is that the secondary knowledge supply to urge the specified information. The journels, reseach papers and specific web sites were used as sources to find the current mechnisms in foring armies. Secondary knowledge has been taken on existing researches, therefore information terribly correct.

As the second step of my research design, identification of suitability of GIS mechanism for Sri Lanka army was carried out. Because it cannot be notice as higher than secondary knowledge. Questionaire survey has been done among officers in Sri Lanka Army. Actually it has been distributed form by taking a minimum of one officer from every of the regiment to cover the entire army. Further it has used GIS specialists to gather knowledge of this survey.

GIS Applications Identified In Foreign Armies

USA is the most powerful country within the military sector. They used the highest standard of technological equipment and technology for their operations. According to Warren and Bagley(1992), US Army has adopted a standardized land condition and trend analysis approach to the land management that comes with the use of a geographic information system and satellite imagery. In Esri.com(2020), describe that the USA army use the GIS technology in their military decision-making processes.

According to Fleming, Steven & Jordan, Thomas & Madden, Marguerite & Usery, E. & Welch, R.. (2009) business geographic system (GIS) software system for the military-specific applications is presently being developed and utilized with digital databases to produce custom-made digital maps of variable scale, content and symbolization personal to distinctive demands of military force. Department of Défence, model GIS models for military tasks in ocean, land associate degreed air conditions were made of many informational collections of an investigation territory at United States United States Marines Base Camp Lejeune, North geographical area.

According to Roy A. Welch, (2004) unclassified, commercial remote sensing data in the form of images assimilated from airplanes, unmanned aerial vehicles (UAVs) and satellites are regularly being employed to populate coastal zone databases. GIS are also being worked to integrate and analyse geographic information for military operational purposes.

UK military has high asset of man power, air power, land forces, naval forces, natural resources and so on. According to the website Ieeexplore.ieee.org (2020) over the past few years, the Naval Oceanographic Office (NAVOCEANO) has led the way. in the development of this pioneering technology. According to Dykes, James & Hancock, T.E.. (2002) GIS methodology is principally well suitable for collecting, organizing, storing, analysing, and distributing geological, oceanographic, meteorological, and even space data. As users at NAVOCEANO have come to know how GIS tools could vastly improve operations, certain capabilities for giving out and distributing relevant METOC (meteorological and oceanographic)information have evolved.

According to Petrovski and Toshesvki (2016) capabilities that use in UK for GIS are following: Command and management, Defence mapping organizations, Base operations and facility management, Force protection and security, Military engineering, Mine clearance and drawing, Mission coming up with, Terrain analysis etc.

Thailand is a south Asian country which faced for many wars within the history. According to Anon (2020), Khotcharit (2004) applied GIS tools to make a CCM (Country College of Morris) map in Kanchanaburi Province in western Thailand, using the weight-linear-combination technique. The considered data were surface slope, soil, vegetation, transport, obstacle, rainfall, and built-up area.

According to the Geospatial World (2020), Specific GIS functionalities which are of importance from the point of view of battlefield surveillance are Data fusion, Demonstration of

spatial data, Spatial analysis, Database management, Visualization of ground and 3D Analysis, Image processing,Database management, Visualization of ground and 3D Analysis, Image processing

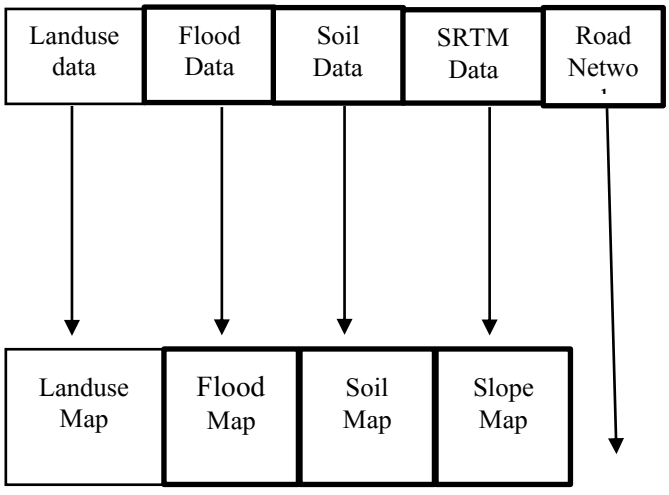
Considering about the African countries Nigeria has the biggest armed force. According Francis Fajemirokun, O. Adewale& Timothy Idowu et.al (2006) GIS as a tool is used by police personnel to line up effectively for emergency response, make sure mitigation urgencies, analyse past events, and predict future events. GIS can likewise be applied to induce basic data to crisis responders upon report or whereas foe course to an event to help strategic composing and response.

Questionnaire Survey

Applicability of GIS mechanism for military and required variables for terrain traficability model were identified through the questionnaire survey among the selected military officers. The study sample consisted 45 officers including 2 officers from Engineering Service Corp and Corps of Engineers, one officer from each an every regiment of Sri Lanka Army, 5 KDU Lectures, 5 Officers from Centre of Research and Development, 5 officers from Defence Ministry of Intelligence and 2 Other GIS expertise. From this 45 sample 41 had been respond to the Questionnaire.

C.Terrain Trafficability Model

Beginning from the research problem number of steps were followed according to the research methodology. The methodology flow chart of the research is given as Figure



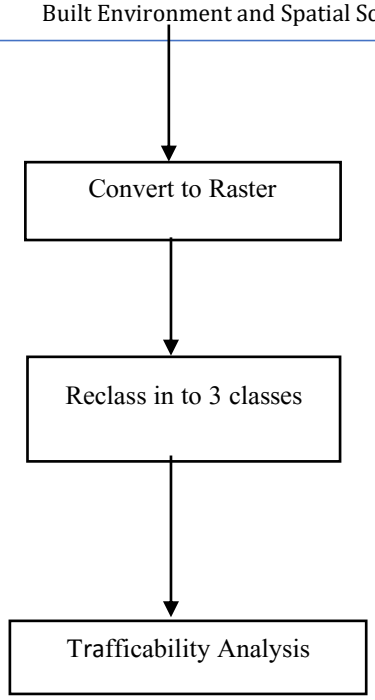


Figure 1 : Methodology flow chart of terrain trafficability model

Source : Created by researcher(2020)

Question	Answers	Percentages
1. Are you familiar with GIS?	Yes	80%
	No	20%
2. Software related to GIS use at present	Arc GIS	45.7%
	QGIS	37.1%
	Arc GIS & QGIS both	5.8%
	Arc GIS & GRASS GIS	2.9%
	No	2.9%
3. Extent of the GIS use in their applications	Highly	12.8%
	Moderately	56.4%
	Never use	30.8%
4. Qualification regarding GIS	By the experience	45%
	BSc.	17.5%
	Masters	12.5%
	Post graduate courses	5%
5. Applications currently use in GIS technology	Nothing	17.9%
	Map digitizing and Overlay	7.1%
	Intelligence planning in Battlefield	7.1%
	QGIS mapping	5.6%
	Environment Related Analysis	5.6%
	Teaching	5.6%
	Analysis tools	5.6%
	QGIS	5.6%
	Plan works in Land Surveying	5.6%
	Nothing	5.6%
	Currently not using	5.6%
	Arc GIS , WebGIS	5.6%

D.Data Collection

From the given institutes below used to collect the data for the model.

a. Surveyor Department:

1:50 000 land use map

Hydrological data of Kalutara District

Road Network of Kalutara District

b. Agricultural Department

Soil data

c. Disaster Management Centre:

Flood data

d. USGS :

1)SRTM data

Collected data from the various kinds of institution have to categorized according to the given below considering their basic characteristics.

Data	Tafficability		
	Go	Slow go	No go
Slope	Low elevation	Moderate elevation	High elevation
Flood data	No risk flood	Moderate risk flood	Vulnerable flood
Soil data	Dry	Moist	Wet
Land use type	Sparse vegetation Grass land	Moderate dense vegetation, cultivated land and marshy land	Built up area, dense vegetation and thick jungle
Obstacle layer	Military locations	Culvert points	Minefields and Streamlines
Road Network	Main, minor road	Track road	

Figure 2 : Terrain Trafficability criteria table

Source: Aticle " Intelligence Preparation in Battlefield"

RESULT

By the literature review, it was identified the foreign applications of GIS in their armed forces. The results of the questionnaire survey as the given below. As per in the questionnaire survey able to find the applications of GIS in the Sri Lanka Army can be apply in future.

	Question is not clear, but I used GIS	3.6%
	To make direction, access	3.6%
	Not having technical items	3.6%
	Software applications	3.6%
6. Barriers going to face applying GIS technology for their applications	Lack of GIS expertise	30.8%
	Lack of availability Of data	15.4%
	Lack of Licensed software	10.8%
	Lack of resources	10.8%
	All mentioned reasons	10.3%
	Lack of skillful workers	7.7%
	Less practical knowledge	2.6%
7. Applications of Sri Lanka Army that GIS technology can be apply	Terrain Trafficability Analysis	45.3%
	Intelligence and Operations Systems	30.8%
	All mentioned applications	5%
	Logistic Information System	2.5%
	Proximity analysis	2.5%
	Multiple, Terrain, Wire house Management	2.5%
	Any Application	2.5%
	No application	2.5%

Figure 3 : Percentages of Responses

Source : Results of the Questionaire survey

As per the results it was found that terrain trafficability is the most suitable application in GIS

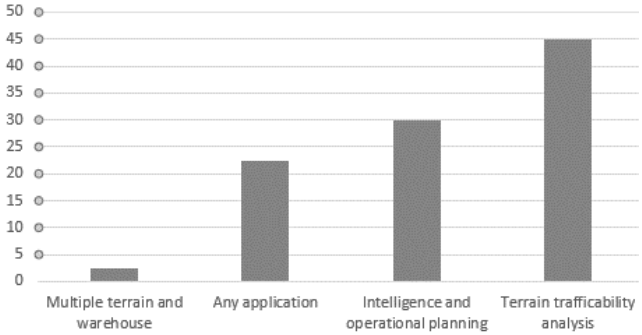


Figure 4 : Suitable application in GIS for Army

Source : Results of the Questionaire survey

Classified Maps

Above collected data has been classified as per the criteras of the above table.

Land Use Map

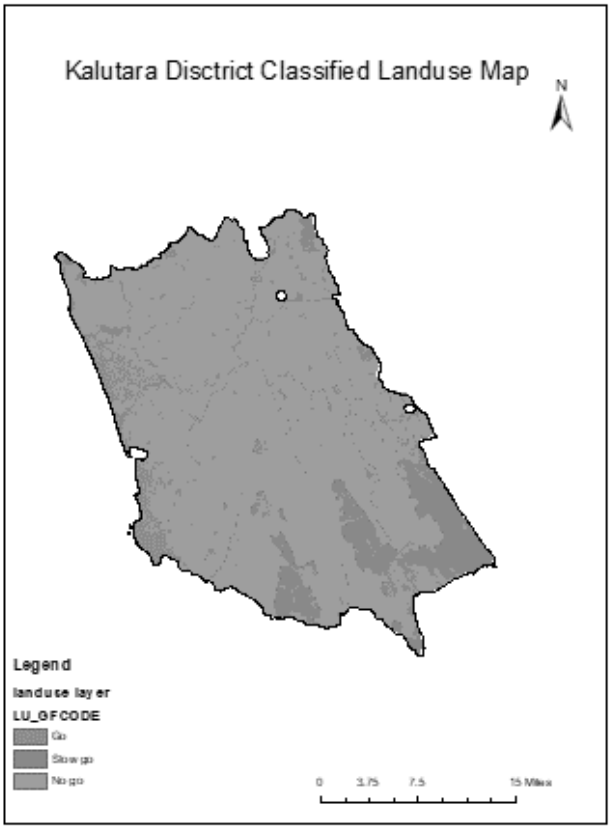


Figure 5 : Classified landuse map of Kalutara Disctrict

Source: Constructed by Researcher (2020) in ArcGIS

Flood Map

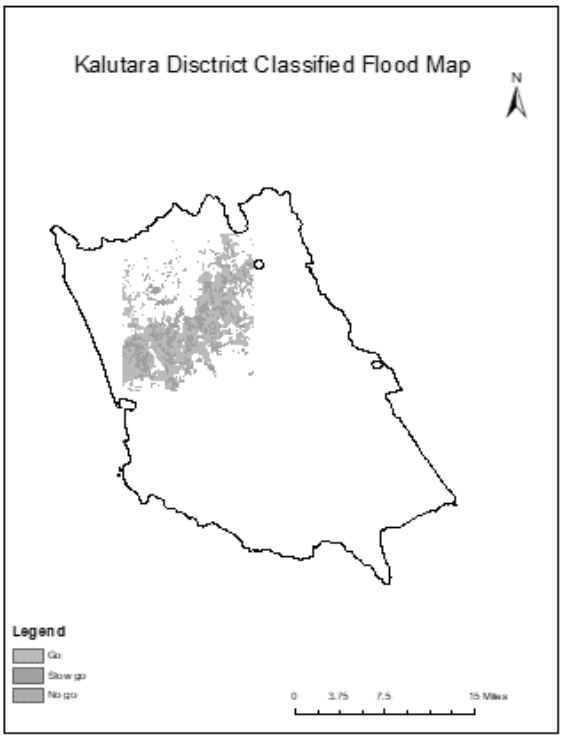


Figure 6 : Classified flood map of Kalutara district

Source : Constructed by Researcher (2020) in ArcGIS

Slope Map

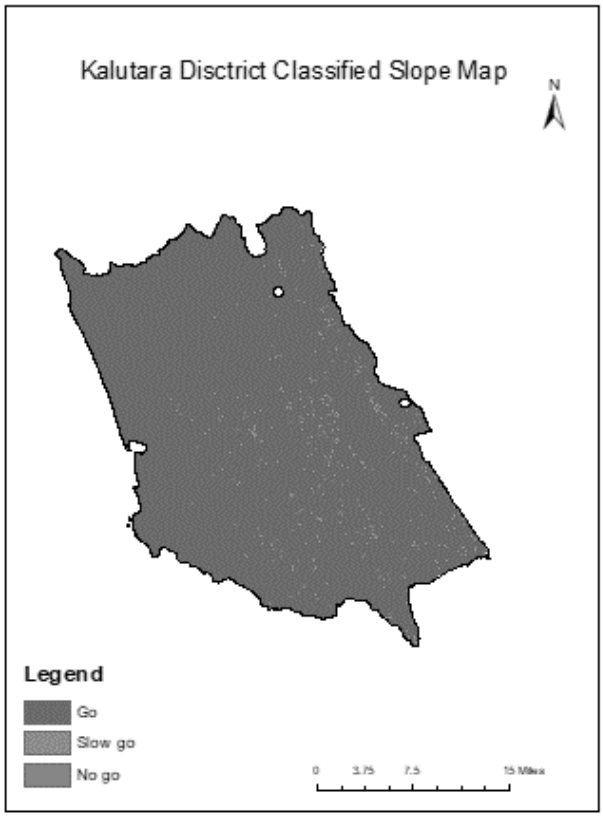


Figure 7 : Slope map of Kalutara Disctrict

Source : Constructed by Researcher (2020) in ArcGIS

According to above classified raster maps I have completed the final output of this study. It is the map shown the areas of GO, SLOW GO and NO GO areas of the teerain in Kalutara district

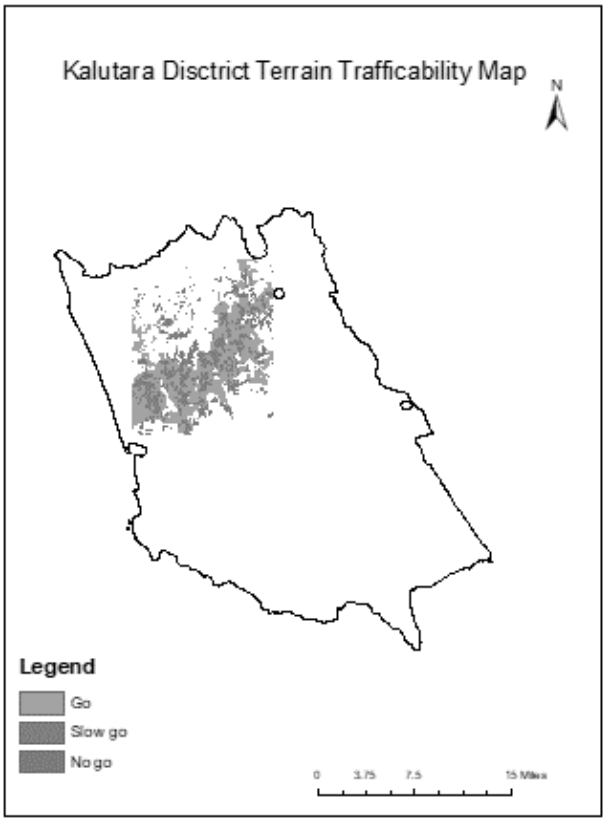


Figure 8: Terrain Trafficability map

Source : Constructed by Researcher (2020) in ArcGIS

Discussion and conclusion

GIS is a worldwide spatial technology use in most of the applications deal with terrain. Army is the ground force of military who fights in land against to the enemies. So, informations abaout the terrain is much important for the armed forces.

In this research first find out what are the applications of foreign armies on GIS. It has been found that GIS applications of foreign armies by refering the research paper articles in many other countries.

Questionaire survey through google forms has been conducted to identify what are the present applications of GIS in Sri Lanka army and for what kind of applications we can apply GIS in future. It has been find out terrain trafficability

is the most essential application for Sri lanka army that can be done using GIS.

According to the above requirement terrain trafficability map has been created in ArcGIS software. It can be clearly show areas which can be identify to the solider as go, no go and slow go. Eventhough it has been done through the IPB process manually this method is more efficient and very accurate.

But when we going to implement this kind of model to the military purposes, officers who involve with decision making procedures based on geospatial data should have sufficient knowledge on GIS.

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Sustaining 'Walkability' in the Future City : with Special Reference to Central Business District of Colombo, Sri Lanka

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Abstract: Colombo was founded as an outpost by Portuguese in 1505. Later it fell in the hands of Dutch and British. This non-organically produced city later became the capital of the independent Ceylon. Throughout the history this colonial structure was in a constant negotiation with the indigenous community. Despite the historical prominence present city existence is at a risk. Streets congested with vehicles affecting the environment, economy, well-being of the community is the most prominent issue of modern Colombo. This situation was once common to most of the developed cities, and they termed this issue as an 'urban crisis'. Main reason behind this urban crisis was cities being oriented on auto mobiles. To overcome this crisis 'Walkability' was the best alternative. This study was basically aimed to find the compatibility of the Walkability concept with the socio-spatial structure of Colombo.

Location specific indicators of walkability identified through a questionnaire survey and universal indicators identified through the literature were used to assess the four selected case studies within the limits of Central Business District (CBD) of Colombo, to list out the prospective and retro-prospective lies in the social-spatial structure of the city. As the number of prospective are greater than the retro-prospective and as most of the retro-prospective are potential to be amended into prospective Walkability can be sustained in the CBD of Colombo. A change in planning conception, innovation to mix the land use and improvement in the physical attributes are the few needs to sustain walkability in the Colombo CBD.

Keywords: Walkability, Colombo CBD, Sustaining

Introduction

The city of Colombo which is the commercial capital of Sri Lanka once was the power hold of Indian ocean, inheriting a rich and sophisticated history. Owing to the emphasis of the ancient port city and due to the economic and defence powers, it reached the point that Ceylon was made what it is in the world because of Colombo (Perera M.C.N, 1994). Colombo is rather a distinguish urbanity in Sri Lanka, as it was the capital which was not an organic production of the local community. The city was elevated up to the city level only by the colonialists (Munasinghe.H), R.L. Brohier (1984/2000; 2) asserts that "Colombo is a city forced on the peoples of Ceylon in spite of themselves. It was never a creation of their own choice or making". Starting as an outpost of Portuguese in 1505, colonial Colombo was ruled by Portuguese, Dutch and British for decades. Modern Colombo after 1948 is a foreign implant with neither a hinterland that produced it nor a history of organic development related to Lankans (Perera, 2002). Therefore, the existence of the city and even its meaning was intimately depended on European metropolises. Yet Colombo was this city which became the capital of independent Ceylon and the commercial capital of present Sri Lanka. Adaptation of this colonial city by the locals was a complicated process, which is a continuous negotiation between the colonial city structure and indigenous Ceylonese. This have ultimately resulted a city into a contested, hybrid and liminal space which led

the modern city planning intervention to transform this ancient city of diversified social ethics into misanthropic community.

Urbanization is a process which takes place in majority of countries in all corners of the world from the beginning of the 21st century (Pacione.M, 2001:67). But the present urbanization process has resulted in an urban crisis.While carrying out researches and studies to control this urban crisis, the urban planning professionals understood that the main factor affecting urban sustainability is urban transportation (Pacione.M, 2001:251). As a solution to this issue of urban transportation, professional came up with the 'walkable city model' as an alternative to sustainable urban mobility, (Turon.K et al., 2017) which led to the urban planning concept, "walkability". Walking is the simplest and the most primary form of transportation and benefits of walking will have a positive effect on all individuals and the public community (Rafiemanzelat et al., 1999). Walkable cities will be the answer to make problems which the urbanized cities are presently facing including automobile orientation, pollutant emission, reduction of greenery, lack of social encounters, people getting diseased and the deflating economy of the country.

Rapid urbanization in the city of Colombo is at a high rate. Since its origin majority of the city users live in dormitory suburbs and travel to the city for work. In migration to Colombo daily and in excess of 250000 vehicles enter the city limits of Colombo. According to Professor Amal Kumarage these vehicles get jammed due to the limited streets and parking slots in the city. Gradually the maximum speed permitted within city are decreasing. Engines of vehicles run for a long time resulting in high air pollution. According to statistics, 70% of CO_2 emission in Colombo is emitted from these vehicles. The only way for these pollutants to be filtered is by the greeneries. Presently the green cover in Colombo is decreasing at an alarming rate of 0.4 km^2/year. The general public are not taking any remedial action to minimize this situation but continues urban expansion. It will result in increment of activities. More people will come to Colombo, the number of vehicles coming into Colombo will increase and will worsen the present non-sustainable situation. All around in Colombo, walking has been limited to recreational activities and pedestrian facilities are concerned only on creating perfectly walkable jogging track. Most devastated fact is that the people of dormitory suburbs, wake up early and jog early to save time to spent on traffic whilemoving to city for work. If these two things could become one,even for a certain extent,Colombo may able to sustain its urban transportation while sustaining the city as a whole. Therefore, the research problem identified is the negative causes of urban transportation at Colombo that lead for unwanted time spent in transportation daily, which inversely cause a higher daily cost while reducing the quality of both physical environment and peoples' psychology and health.

The study was done based on the hypothesis, that sustaining walkability in the city limits of Colombo will reduce the prevailing crisis situation. The study is done to figure the compatibility of social – spatial structure of Colombo when considered with the identified hypothesis. "Walkability" is the independent variable of the study, while the 'User Experience', 'Physical atributes' and 'Land use mix' be the three dependent variables according to literature. The initial part of the study will figure the relationship between the variables in the context of Colombo then the latter part of the study will analyse the compatibility of the city to these variables, as 'walkability' is a complex whole which is not able to asses directly on an urban context. Therefore, the main of the study is to figure wether the future city of Colombo is able to sustain through making it walkable. The

objectives used to achieve the aim are as below, - to understand the urbanisation process and urban crisis - to study the sustaining process of urban mobility - to identify the vitality of the concept: 'Walkability' - to identify the influential criteria of Walkability - to asses the criteria of walkability on four case studies

The study have been spanned over, urbanisation process in concern to third world countries and Colombo, urban crisis of modern urbanities, sustaining the urban mobility, sustainable alternative: walkable city model, concept of walkability, assessing criterions of walkability and Colombo city morphology.

Study may not provide any master proposal or design suggestions, but will conclude with the prospective and retro-prospectives of Colombo city to sustain in the future by making it walkable.

'Walkability' as a remedy to modern urban crisis

The historical studies have identified three main transformation which have altered the course of human life. First among them had been the development of Agriculture and Neolithic settlements in 7000BC(Pacione M, 2001). The second one had been the pre-industrial revolution prior to 18th century as in which cities came to be acording to Kevin Lynch in 'A Theory of Good City Form. Third and the most influential had been the industrial revolution in the 18th century. Cities are believed to be originated in pre-industrial era and evolved into modern cities in industrial revolution. Italian philosopher Giovanni Botero, in the 16th century (Kostof S, 1992) refers to the city as, "……. An assembly of people, a congregation drawn together to the end they may thereby the better live at their ease in wealth and plenty. And the greatness of the city is said to be, not the largeness of the site or the circuit of the walls, but the multitude and number of the inhabitants and their power". Later in the era of renaissance, the cities were studied as an art and lead the scholars to identify the urban process underlying the city development which gave rise to jargons such as urbanisation, urbanism and urban growth. The whole evolution of primitive cities in pre-indutrial era to initial form of modern cities have been explained well by Wheatley as, With reference to the pre-industrial city, Wheatley described the word, 'Urbanisation' as, "… that particular set of functionally integrated institutions which were first devised some 5000 years ago to mediate the transformation of relatively egalitarian, ascriptive, kin-structured groups into socially stratified, politically organized, territorially based societies". The institutional change that he was referring in the definition is the key element of civilization of modern urbanity which contributed for a major socio-political restructuring of the society. This process is common for both the developed countries and third world countries, yet the degree of visibility may vary with the geographical location and its continent.

Urbanisation is always a result of both natural increase of the urban population and net immigration to urban areas. The utter product of urbanisation is the urbanism[1](Pacione M, 2001). The net effect of this socio-spatial process in changing the city is clearly visible in the change occurred in land use mix. Based on this identification, Conzen (1960), divides the urban landscape into three main factors including land-use, buildings and town plan (or the street layout) to study the urban morphogenesis. Central Business District (CBD)[2] or the commonly known downtown is the principal element of major urban land use.

This urban development from pre-industrial to postmodernism in Europe is not common to

[1]Urbanism is the spread of changed social and behavioral characteristic due to urbanisation

[2] Key characteristic of CBD is accessibility. High density and land values are the characteristics

the whole world. The process differs based on the specific geographical locations. The high rate of urbanisation seen in every corner of the world now is a relatively recent phenomenon[3]. For most of these cities, urbanisation is a contemporary and ongoing process (Pacione M, 2001).Urbanisation in the third world countries was almost a direct influence of Britain and other European regions. The most obvious influence of European world in third world countries is the development of new cities, based on their ease of transportation, exporting trades and defence requirements. Most of the times these cities were not only a forceful city implication but a whole new form of complex content, turning their own urban forms and urbanisation patterns. These newly built cities are still the metropolitans in most of the regions[4] (Pacione M, 2001).

Table 1. Phases of Urbanisation

Chronological phases	*Major features of urbanisation*
Pre contact	Small organically patterned towns predominate
1500, Mercantile colonialism	Limited colonial presence in existing ports. Trade usually in natural products of local region
1800, Transitional phase	Reduced European interest in investments in overseas. Great profits to be made in industrial revolution
1850, Industrial colonialism	European need for cheap raw materials and food. Colonialism takes territorial form, new settlement patterns and morphology created
1920, Late colonialism	Intensification of European morphological influence. Extension to smaller towns in hierarchy. Increased ethnic segregation
1950, Early independence	Rapid growth of indigenous populations through migration in search of jobs. Expansion of slums and squatter settlements.
1970, New international division of labour	Appearance of multinational corporation factories. Further migrational growth of cities. Increasing social polarization.

Source – D.Drakakis- Smith (1987) The Third World City London: Methuen

As in other regions of the Asia, South Asian cities also reveals the imprint of both colonial and indigenous forces. Michael Pacione in Urban Geometry, present two models depicting this hybrid form of urban models which can be identifies in South Asian cities, as colonial-based city and the bazaar-based city.

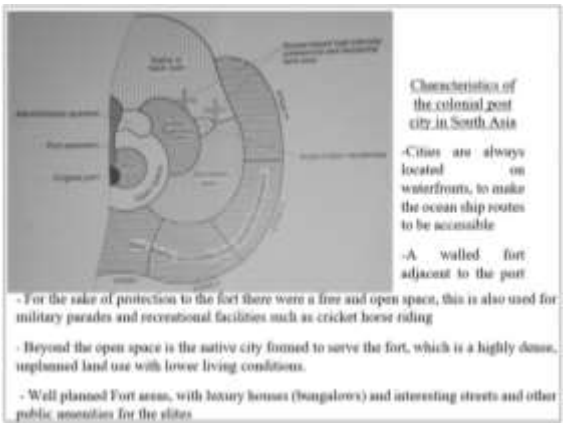


Figure 2. The model of the Colonial based city

Source: M. Pacione (2001) Urban Geometry

Still the fort or the colonial city is a well-planned urban settlement with specious urban quarters, tree lined avenues, and other service facilities. Later when the colonial city expands the local elites got residential spaces at the periphery of the colonial city, leading to a gradual process of reorganizing the whole, physical, social and political structures of the ancient administration systems.

Urbanisation in the means of Colonialism: Urbanisation of Sri Lanka with reference to Colombo.

Later in 1420s, realization of the seas as one entity by the Europeanists along with the transformation of world from infinite space[5] to a finite place that is knowable and controllable. These findings made the Europe to concern on long-distance trading, over the seas and gradually connect the world together (Pacione M, 2001). Early as in the 16th century, Sri Lanka faced these invasions of Europe, commencing with the Portuguese followed by Dutch and British (Perera.M.C.N,1994)

Sri Lanka as a naturally rich country, with a self-sufficient, sophisticated history of about 2000 years had its own urban planning, centralized to the agriculturally rich North

[3]In mid 1980s only a 3% of world population was urban and except for Europe, urbanisation level is insignificant in the other regions of the world

[4]Examples - Lima, Buenos Aires, Rio de Janeiro in Latin America, Johannesburg, Cape town in sub-Saharan Africa and Calcutta and Bombay in Asia

[5]*infinite space*- in which social, political and trading activities took place

central province. Development of the new colonial city at Colombo made a clear turning in these ancient town planning patterns.

However, at present Sri Lanka stands at an Urban paradox. In the United Nations World Urbanization Prospect, 2018, Sri Lanka raked at the 11th least urbanized country on earth with 18.2% urban population Yet there are considerable evidences proving that the real urban population is greater than what is stated in the above document. As an example, agglomeration index, which uses multiple indicators, Sri Lanka's real Urban population is calculated to be around 35% to 45% (Uchida &Nelson, 2010) Sri Lanka's urban paradox is most clearly apparent in the capital, Colombo, and it is the largest urban conurbation of the island (SoSLC, 2018). Colombo being a small trading post of merchants came from, Arabia, Morocco, and Persia evolved to be the capital city afterwards (Dayaratne.R, 2010). In 1505 Portuguese over took Colombo, followed by Dutch and British in the 18th and 19thcenturies (Perera.M.C.N, 1994). Due to the strategic location on maritime routes, Colombo developed and established as a node in the international trade network in the colonial ruling (Dayaratne.R, 2010). With the destruction of the Sinhalese power-hold Kandy by British to succeed their colonizing attempt (Perera.M.C.N, 1994;97), Colombo became the both commercial and administrative center of the island (Dayaratne.R, 2010). In fact, the attention given to Colombo by colonialists made it centralize in the process of urbanizing the island ever since. This is address by Nihal Perera in 'Decolonizing Ceylon' as, 'Colombo made Ceylon but not vice versa' (Perera.M.C.N, 1994;95). Introduction of Ceylon to capitalist economy in the 19th century, formation of the Colombo municipal council in 1865 (Perera.M.C.N, 1994;144) and legislating the House and Town improvement ordinance in 1915 (Weerakoon.K.G.P.K, 2013) were the most influential milestones of urbanisation process of Ceylon.

Centralized emphasis given to colonial Colombo made it way to become the capital of independent Ceylon from 1948. The interest of relocating the seat of government in 1980s, government declared Kotte as the administrative capital (Perera.M.C.N, 1994;449). This made Colombo into the commercial capital and the fort was developed into the Central Business District (CBD) (Perera.M.C.N, 1994;450). In the present Sri Lankan cities are accounted to be expanding in a rate of 6.2%, which is greater than those observed in European countries (SoSLC, 2018). Urban sprawl[6] is the typical form of urban expansion in Sri Lankan cities which have led its provincial capitals plagued with overcrowding, ad hoc development and failing infrastructure, which is apparent in the commercial capital, Colombo.At the time of independence Ceylon with Colombo as it capital, was an aspiring third world country, yet uni-directional urbanisation for decades have resulted an urban crisis in Colombo followed by other provincial capitals of the country (Dayaratne.R, 2010).

Sustaining the urban built environment

As discussed by many scholors such as M. Graces, Jonathan Glancey, Malgorzata Dymnicka, Joanna Badach, John McArthur and Patrick Sisson the modern urban world is at a crisis, financially, socially, and environmentaly. In number of collective efforts sustaining cities have brought into sustaining urban transportation and breaking the sole dependednt of automobiles. In this scenario, leading scholor Jeff speck along with many urban designers have identified the 'walkable city form' as an alternative or as a remedial action to sustain cities as a whole. Jeff Speck in Walkable city; how downtown can

[6] Urban sprawl is defined as unplanned or uncoordinated low-density expansion, & involves rapid land consumption (Bhatt,2010)

save America (2012) writes clearly about the vital role of Walkability in urban sustainability as, " after several decades spent redesigning pieces of cities, trying to make them more livable and more successful, I have watched my focus narrow to this topic as the one issue that seems to both influence and embody most of the other.. GET WALKABILITY RIGHT AND SO MUCH THE REST WILL FOLLOW." (Speck.J., 2012;06).

Walking is generally recognized as a movement which is the simplest form of transportation (Rafiemanzelat et al., 2016) and also has been the oldest form of urban transportation and cities were compacted to support walking till the industrial revolution in the 19th century (Newman et al., 1999)[ ]. Generally, in the urban contexts walking is defined as a short distance movement from one point to another (Razali et al., 2017)[ ]. With the major transformation of transport after the industrial revolution, private individual transportation widespread in the 20th century (Bilyamin.S., 2014) and made public transport as well as walking became less prioritize in the urban planning agendas (Rizali et al., 2017). The recognition of walking have led planners around the world to promote walkability (Su et al., 2017) and recently it has become the focus of sustainable development of cities (Rizali et al., 2017). This centralized concept of urban sustainability has made many scholars to study walkability based on many issues. to identify the indicators to measure walkability of urban environments. Land use mix, land use patterns, street layout, public transport supply, attractiveness, connectivity, proximity and urban design are the indicators to measure walkability (Rizali et al., 2017 &Mustafiz et al., 2018).

Walkability and Physical Environement: street layout, street bloacks and land use

None of the element of the built environment is important to walkability as the "Streets' are (Ewing et al., 2006). The street 'is a mere traffic channel, ensconced within the city's solid mesh, the street is a complex civic institution, culture-specific and capable of dazzling formal variation and calculated nuance" (Kostof.S, 1992;220)[ ]. The streets is both an urban form and also an institution, and the traditional purpose of the street were the traffic, exchange of goods and communication. In urban planning we are only concerned with the urban streets, only when they are in a settlement, defined by buildings (Kostof.S, 1992;189).

Except for the streets the other two main walkability connections of physical environments are the Street block design and land use mix.It is even believed that the traditional urban setting of residential and office work arranged over the ground floor facing shopping street (shop-houses), as it reduces the need for mobility. This evidence the need to reduce the mobility in contemporary cities, street block and land use mix are the two prominent features which determines the mobility in modern cities (Moughtin.C, 1996). It is the size, function and the structure of the street block which gives form to the public spaces and contributes to the vitality of those spaces (Moughtin.C, 1996).

Walkability and User perception:

Man cannot separate himself from the space, from his inner psyche to the physical body he embeds in space. From existential space man creates 'space' shaping it to suite his needs and problems, this lead the human in creating a dwelling out of a cave back in the Neolithic era. Starting from that spontaneously evolved place to the sophisticated architectural space of they built today, (Bambaradeniya.R.R.M.C, 2006). Though built or un-built every space have an ability to evoke a sixth sense in human as an emotion or a feeling. The process of man's emotion change based on the space is

broadly termed as 'Perception'. In urban environments, perception is not one's psychological reaction to space but rather a common image in many dwellers mind, this majorities' perception of urban space is the phenomenon known as, 'The Image'. The 'common way'of perceiving is simply known as the image of the urban space (Bambaradeniya.R.R.M.C, 2006) the city can be perceived in diverse aspects such social, political or economic or physical, but in this chapter it is only discussed the literature on physical perception. Kevin Lynch have done many researches on this user perception and image to identify these perceptible elements. Path, Edges, Districts, Nodes and Landmarks are the five main elements of the city image according to Kevin Lynch in, 'The image of the city' (1982).

Table 2. Elements of the Image

Path	Paths are the channels in through which observers, customarily, occasionally or potentially move. The streets, railway tracks, pathways, transit lines and canals can be a path in an image and for most of the observers, this is the most crucial element
Edges	These are too linear elements as paths, but which are not identified as the walking paths by the observer which is rather a physical boundary between two districts
Districts	These are the sections of the cities, or specific areas which the observer mentally enters 'inside of', these are always identifiable from the inside yet used for external referencing.
Nodes	Are the strategic spots in a city into which an observer can get into, which are the focal point to and from which he is traveling. Nodes can be simply a junction, a place of break in transport etc.
Landmarks	Are the identifiable spots, which basically act as a symbol or a sign. Landmarks mostly act as reference point in the cognitive image of the city

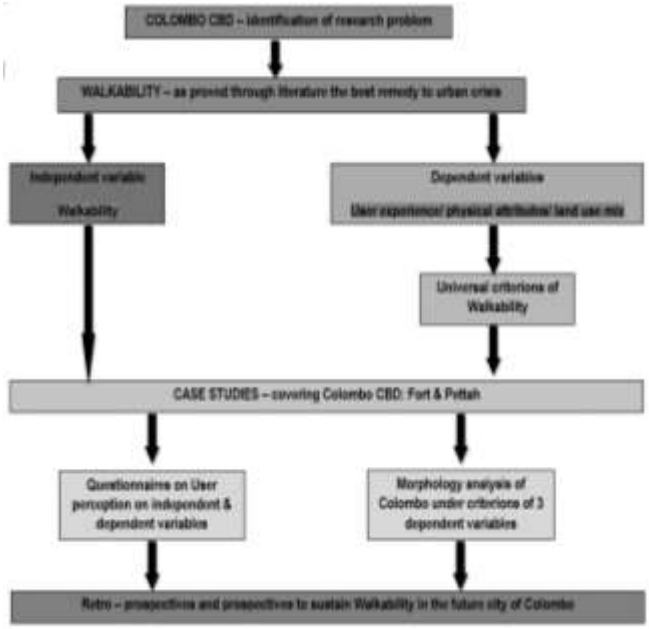
Source: Kevin Lynch, Image of the City(1982)

Case Study

The study involves a mixed method as the independent variable: Walkability contains both qunatitive and qualitative aspects. The basic aim of the study is to cross check the relationship between dependent variables and independent variable specifically in the context of Colombo. The study will analyse the universal criterions of walkability on Colombo and will conclude with a lsit of prospective and retroprospectives to sustain Walkability in the Colombo city.

Figure 2. The framework of the study

The study is limited to the Central Business District of Colombo. The CBD comprise two



parts as, Fort and Pettah. As these two parts are different from its nature, origin and function, four case studies are selected for the overall study, including 2 from Fort and 2 from Pettah. All the case studies are selected considering few common criterions. The questionnaire survey is conducted for 40 persons from each case accounting for a total of 160. This population was limited visitors but not shop owners or hawkers as they tend to give positive reactions due to their longer engagements with the city. The questionnaire will be structured with two main segments including positive and negative criterions under three dependent variables for the participants who perceive the area as walkable or not respectively. The two types are shown as below.

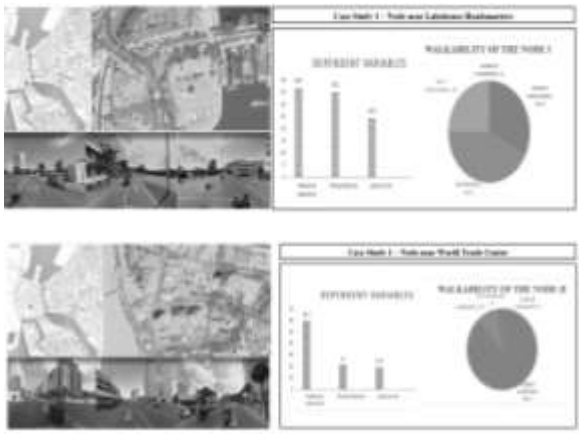
Table 3. Factors postitively influencing walkability

GROUPS	FACTORS	INDICATORS (FACTORS POSITIVELY INFLUENCING WALKABILITY)
1	Experiences of pedestrian activities	Trade and other activities
		Storage of window shopping
		Safe walking beside road
		Quick and easy transit access
		Interesting and adequate food stalls
		No obstacles from construction/construction materials
		Clean pedestrian ways
		Non-disturbing hawkers' activities
2	Configuration or physical features of pedestrian way	Adequate pedestrian width
		Manageable road width and vehicular movements
		Continues pedestrian circulation
		Even level changes
		Roadside barriers for safety
		Maintained surfaces
		Clearness of the pedestrian paths & roads
		Proper locating of electric posts and billboards
		Quality of paving material
3	Walking for land use mix patterns	Public amenities (shopping, hospitals, restaurants)
		Recreational activities
		Commercial activities (business, banks, office)
		Public transport connectivity

Table 4. Factors postitively influencing walkability

GROUPS	FACTORS	INDICATORS (FACTORS NEGATIVELY INFLUENCING WALKABILITY)
1	Experiences of pedestrian activities	Lack/ disturbing trade and other activities
		Lack of storage of window shopping
		Unsafe walking beside road
		Crowded for quick and easy transit access
		Insufficient and small food stalls/ lack of food stalls
		Obstacles from construction/construction materials
		Unclean pedestrian ways
		Disturbing hawkers' activities
2	Configuration or physical features of pedestrian way	Inadequate pedestrian width
		Non-manageable road width and vehicular movement
		Discontinues pedestrian circulation
		Uneven level changes
		No roadside barriers for safety
		Broken surfaces
		Unclean pedestrian paths & roads
		Disturbing locating of electric posts and billboards
		Substandard of paving material
3	Walking for land use mix patterns	Public amenities (shopping, hospitals, restaurants)
		Recreational activities
		Commercial activities (business, banks, office)
		Public transport connectivity

Questiionaire study will get the overall perception of the participants on walkability and then rating on above criterions to identify the particular relationship between dependent and independent variable in the physical and socio-cultural context of Colombo.



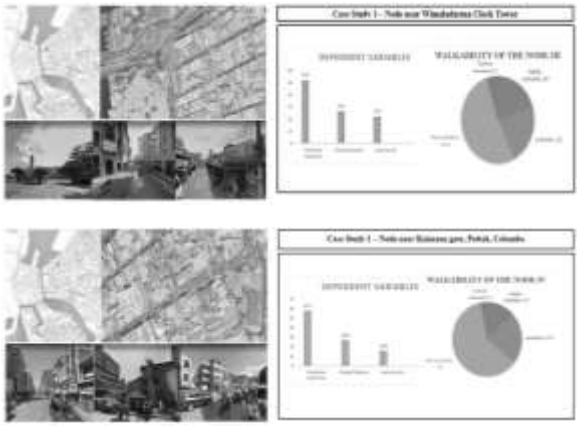


Figure 3. Detailing of the case studies and primary data input

Table 5. Independent variable as perceived in case studies

	Highly walkable (1)	Walkable (2)	Not Walkable (3)	Cannot comment (4)	Total Perceived as walkable (Total= 1+2) (5)	Perceived as not walkable (Total= 3) (6)	Least perception (5 or 6) = 4 (7)
CASE STUDY I	32.5	42.5	25	0	75	25	25+0=25
CASE STUDY II	85.7	9.5	0	2	95.2	0	0+2=2
CASE STUDY III	20	22.5	52.5	5	42.5	52.5	42.5+5=47.5
CASE STUDY IV	13	22.5	61	3	35.5	61	32.5+3=35.5

Table 6. Contribution of dependent variables

	CASE STUDY I	CASE STUDY II	CASE STUDY III	CASE STUDY IV	TOTAL (out of 400)	PRECENTAGE
Dependent variable I- User experience	36.7	59.7	51.9	57.4	205.7	51.42 - 51%
Dependent variable II – Physical attributes	24.3	19.3	21.8	15.8	81.2	20.3 - 20%
Dependent variable III – Land use mix	35.1	21	26.3	26.8	109.2	27.3 - 27%

Based on the location specific criterions affecting user perception on walkability, and the universal criterions taken from literature sources, 16 criterions were listed to check on Colombo urban morphology, through which the prospectives and retro-prospectives are identified.

1. Safe walk besides roads for pedestrians
2. Mixed land use patterns
3.Residential uses mixed with commercial, trade & recreational activities
4.Intergration of the streets
5.Smaller street blocks with appropriate connections
6.Streets with mangeable width and vehicular movement to match human scale
7.No private vehicles parked on the streets or in any other pedestrian spaces
8. Parking for automobiles
9. Improved public transport/ transit connectivity
10. Promote biking facilities
11. Law & Policy addressing walkability
12. Friendly & Unique streetscapes
13. Identity and character
14. Interesting open spaces
15. Trees shading the streets
16. Lifestyle & culture

Table 7. Results summery of assessing criterions

PROSPECTIVE	RETRO PROSPECTIVE
1. Existing pavements and roadside barriers in the physical essence of Fort and some part of pettah	1. activity patterns at pettah, which does not allow to demarcate pedestrian spaces - can make them fully walkable without vehicles
2. Existing land use mix	2. larger street blocks in the present - occurred pedestrian paths within the street blocks can be developed
3. Existed street block sizes are more walkable than the present expanded ones	3. wide streets and heavy vehicular movement defeating the human scale
- the existing pedestrian paths at pettah within one street blocks are a prospective which can be developed in future	4. Absence of proper parking slots and vehicles parked on streets - these parking can be designed and can mark the vehicle slots to park more
4. integration of existing street layout	5. Lack of public transport services penetrating to Fort and pettah inlands - implementing shuttle services into Fort and pettah streets
5. Friendly and unique streetscape in both Fort and Pettah areas	6. No provision for biking
6. Strong identity and noticeable character	7. Lack of law and policy addressing walkability
7. Vegetation cover shading most of the streets of the Fort	8. Lack of open interesting spaces affordable to all the people - can dedicate few spaces in fort and pettah for this function such as parking

5. Friendly and unique streetscape in both Fort and Pettah areas
6. Strong identity and noticeable character
7. Vegetation cover shading most of the streets of the Fort
6. No provision for biking
7. Lack of law and policy addressing walkability
8. Lack of open interesting spaces affordable to all the people
- can dedicate few spaces in fort and pettah for this function such as parking

Conclusion

Colombo as solely possesses many potentials that can help to sustain walkability, yet these potentials are not composited to one another due to the lack of appropriate conceptions in planning. Ancient Lankan culture and their urban settlements non doubly influenced the walking and all the settlements were walkable before the colonial invasions and globalization. Yet in modernization of urbanities walkability was withdrawn little by little over a considerable period. None of the planning intervention of Colombo, did use the concept of walkability as appropriate, while the vitality of the concept is proven in many case examples of the world such as, Poland, Neither land, Barcelona, Singapore and Rome. Historical values, rich and strong identity, tropical weather, colonial structures were influential factors for most of these successful cities, which Colombo do inherit.

This critical analysis on the comparison of four case studies can be concluded as, users of Colombo perceive any given environment of it Walkable only if they are provided with a safe pedestrian path/space accompanied by variety of activities mixed together creating diverse options in one entity. The results of the analysis have shown that it is unambiguous that the potential to sustain walkability in Colombo is greater than the negativities lies against it. When considering the need of Colombo based on its users' perception, the city requires its activities to be mixed in land use strengthening the street activities while the physical attributes of the built environment supports those. This needfulness of Colombo can be supported from the theory by David Canter in his book, 'The psychology of Place' referring to three basic elements of space as shown in below diagram.

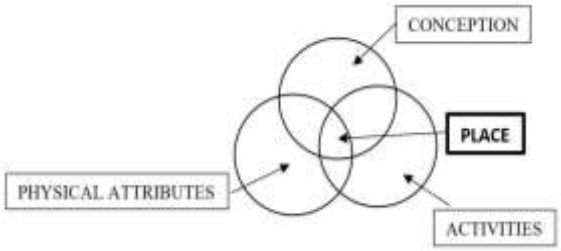


Figure 4. Basic elements of the space

As above if the Colombo streetscapes needed to be reorganized considering the concept of walkability as the strategy of sustaining the city providing mix variety of activities, along with safe and adequate pedestrian paths/spaces. Irrespective to the mean through which walkability can be achieved, the study is intended to prove the higher compatibility that city of Colombo posses with the concept of walkability. 'Sustainability' is a complicated multi-disciplinary whole which is out of the capacity of this study, yet understanding the prospective and retro prospective of Colombo to make it walkable

will lead the way towards a sustainable future city. Historical and strategic values may be reestablished to what it was and people of it will no longer ignore and bypass the city but will inclined to visit this beautiful city of their own. Walkable city will lead the lifestyle of the new generation and will result in a social development too. This society will be strongly bonded with natural and built environments due to this concept of Walkability which will in return strengthen the economy of the country. If all these social, historical, geopolitical and economical values that Colombo possess in the present reshaped in to a walkable future city, Colombo will lack nothing to be the Wonder of Asia.

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Factors affecting contractor's risk on cost overburden in Sri Lankan Construction Industry

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***Abstract*—** Cost overrun is one of the major issue faced by the construction industry at present. The contractor's cost overrun directly affects with the contractor's profit margin which has become a major burden within the contractor's scope of work. This study attempts to identify the severity of the factors affecting contractor's risk on cost overburden in Sri Lankan construction industry under the factors affecting cost estimate, factors affecting final cost and contract specific factors. Data collection was done by a questionnaire survey which a questionnaire was distributed among experienced quantity surveying professionals in Sri Lanka. Collected data was subjected to a quantitative analysis using the Relative Index technique and ranking of questionnaire was done. The findings elaborated that the factors affecting the finl cost have the highest impact on contractor's cost overburden in Sri Lankan context. Proper consultation of clients on variations and on time payments and proper management of stability of the country's economy by the government will improve the contractor's cost performance and the project performace as a whole. Focusing on mitigation approaches to avoid the risk factors causing cost overbureden will improve the efficiency of the construction industry in Sri Lanka.

Keywords: Contractor, Cost overburden, Sri LankanConstruction Industry

Introduction

The primary aim of an industry is to achieve the completion of the project within the given time and specified budget. This has become as same for the Construction Industry which the final expectation is to complete the project on time, within budget and with the expected quality. But with the complexity and uncertainty, the Construction Industry frequently face by problems like reduction of efficiency, quality lapses, issues with completing within allocated time, overruns in cost, etc. (Memon et al., 2011). At present, construction cost overrun has become a major issue faced by the industry in all around the world and the impact is basically distributing in between Clients, Contractors and Project Managers (Creedy et al., 2010).

The burden of cost overrun in Construction is basically hold by the Client and the Contractor. The Contractor's cost overrun will directly influence the Contractor's profit margin which will cause a massive burden to the Contractor. This impact on profit margin becomes high because of the inadequate identification of the cost overruns and lack of a methodical approach in managing such situations by mitigating or avoiding such cost overruns.

The main intention of the research is to identify and analyse the factors affecting Contractor's risk on cost overburden in orderly with basis of the severity. The basic limitation of the research is limiting for the traditional procurement. In order to narrowing down the research the framework has been built focusing the traditional procurement which has become the most practical procurement method in use in the present construction industry in Sri Lanka.

The findings of this research will improve the standards of the construction industry and will help to develop the contractor's provision in an outstanding manner. Also, this will be a guidance for the development of the construction industry of other developing countries also.

Literature Review

It has been clearly identified that the cases on cost overruns within the Construction are higher than the time overruns (Subramani T. et al, 2014), which has become a major issue to be considered significantly (Kasimu, 2012). Moreover, it has become a significant challenge faced by the stakeholders in construction industry. Cost overrun in construction has emerged as a fact of increasing the cost in Construction and additional pressure in investments. This matter influences the investment decision making and moreover extend up to the wastage of national finance. Therefore, proper identification of cost overrun issues with a considerable burden in order to avoid or mitigate such issues as possible has emerged utmost important (Ali & Kamaruzzaman, 2010).

Abdulaziz M. et al, (2015) identified that the cost overburden problems faced by the contractors have become a major cause of Construction risk factor which affect for the overall Construction. Risk on cost have been directly influenced with the Contractor's profit obtained from the project (Akintoye and MacLeod, 1997) and are left low with the efficiency of decision-making actions within the Construction organizations (Zavadskas et al., 2010). Loosemore et al. revealed that there is a lack in maintaining a procedural system of risk management in Construction projects which enhances better interaction within the stakeholders specially with the Contractor which would help to avoid the possible risks by improving the project predictions and demands throughout a solid, straight and practical approach.

Akinci B. & Flsher M. (1998) has clearly elaborated that there is a major impact from the uncontrollable risk factors on the Contractor's cost which will massively impact for the Contractor's profit margin. Moreover their finding elaborated that the implementation of a scientific approach by analyzing the risk factors properly will be more beneficial in reducing the critical situations that may occur within the project.

It has been significant that there is a lack of the studies and findings which identify risks related with the Contractors cost in developing countries (Iqbal et al., 2016). Further, findings of the studies related with such issues in construction projects in developed countries were identified as incompatible with the state of construction industry in developing countries (Hosseini et al., 2016). The main reason was because of such matters related with construction projects were directly linked with the state of political, economic, environmental, and sociocultural sectors of a particular country which could be observed as unique features differ from one country to another (Perera et al. 2014).

Through this research the main intention is to identify the factors affect the Contractor's risk on cost overburden by prioritizing them in order to identify the most severe risk factors which enables the construction professionals to undergo the management of the projects, specially the management of Contractor related factors in a successful manner. The findings will safeguard the Contractor's side as well as the project.

Methodology

The data collection was done under a questionnaire survey which was distributed in between Quantity Surveyors who are currently working in Sri Lankan Constrcution Industry. Under the above mentioned population, a randomly selected sample of 40 quantity surveyors with minimum 5 years of experience was selected.

30 questions were prepared for the questionnaire focusing the objective of the research by mainly considering the factors affecting cost estimate, factors affecting final cost and contract specific factors under the

base of the literature review of Akinci B. & Flsher M. (1998)

For the analysis of collected data, a five point scale method was used and the questions were prepared as scale type questions which were scaled under five weights as follows:

Strongly Agree	=05
Agree	=04
Neutral	=03
Disagree	=02
Strongly disagree	=01

Relative Index Analysis technique which would provide the ranking of the factors from the highest severity to the lowest was used for the analysis of the collected data.

The formula used under the Relative Index analysis is as follows:

$$\text{Relative index} = \frac{\sum 5R_1+4\ R_2+3\ R_3+2R_4+R_5}{5\sum R_1+R_2+R_3+R_4+R_5}$$

R_1= number of response for Strongly Agree

R_2= number of response for Agree

R_3= number of response for Neutral

R_4 = number of response for Disagree

R_5 = number of response for Strongly Disagree.

Analysis and discussion

With the data collected through the questionnaire, a quantitative analysis was done under the relative index method. Out of 40 questionnaires distributed, 32 were responded and 08 were not responded. A category based rank was produced by taking the average of each sector to identify the most affecting sector for the contractor's cost overburden. The outcomes of the analysis are shown under the following table.

Table 1. Relative index and ranking of challenges

SN		Frequency					RELI IND	CA
	Problem Statement	**SA**	**A**	**NC**	**D**	**SD**		
FACTORS AFFECTING COST ESTIMATE								
Estimator specific								
1	Clerical errors	7	19	5		1	0.7938	0.8175 - 03
2	Wrong production rates	8	20	3	1		0.8188	
3	Improper identification and assessment of risk	11	18	2	1		0.8438	
4	Lower consideration on market, quantity and location	7	23	2			0.8313	
5	Less experience	7	21	2	1	1	0.8000	
Design and project specific								
6	Excluding risk beyond the project team	6	20	2	4		0.7750	0.7984 - 07
7	Initial stage material pricing	10	16	5		1	0.8125	
8	Improper scheduling of time for completion	9	19	3	1		0.8250	
9	Advanced technology	5	20	6	1		0.7813	
FACTORS AFFECTING FINAL COST								
Construction related								

10	Unforeseen geological conditions	8	21	3			0.8313	0.8125 - 04
11	Unexpected weather conditions	7	19	5		1	0.7938	
Client generated risk factors								
12	Changing needs	15	16	1			0.8875	0.8250 - 01
13	Claims record of client	6	21	5			0.8063	
14	Past experience with client	4	19	8		1	0.7625	
15	Payment delays	4	18	9	1		0.8438	
Subcontractor related risk factors								
16	Weak financial stability	6	19	6	1		0.7875	0.8063 - 06
17	Uncertainty in reliability and timeliness	9	18	5			0.8250	
Economic factors								
18	Price escalation	8	22	2			0.8375	0.8250 - 01
19	Inflation	10	16	6			0.8250	
20	Economic instability of country	8	20	3		1	0.8125	
Political factors								
21	Political instability	5	18	8	1		0.7688	0.8104 - 05
22	Change in regulations	6	22	4			0.8125	
23	Labour shortage	10	20	2			0.8500	
CONTRACT SPECIFIC FACTORS								
Type of contract								
24	Lump sum	8	15	3	6		0.7563	0.7763 - 09
25	Measure and pay	9	21		2		0.8313	
26	Cost plus fixed fee	8	16	5	2	1	0.7750	
27	Cost plus percentage	4	20	5	2	1	0.7500	
28	Cost plus fluctuation	7	18	3	3	1	0.7688	
Context of contract								
29	Improper risk allocation	8	19	4		1	0.8063	0.7906 - 08
30	Ambiguous contract clauses	6	21	2	1	2	0.7750	

Source: Questionnaire survey

The outcomes of the quantitative analysis are as follows:

With the obtained relative indexes, it was identified that the most severe factor which cause the highest risk on cost overburden of the contractor was the changing needs of the client which is affecting to the final cost of the project. The second priority was obtained by the labour shortage under the political factors which cause the exceed in final cost due to the inefficient execution of project. The third priority was obtained by the factor of payment delays which is caused by the client which will affect the effective continuity of the project.

Usage of cost plus percentage contract was identified as the least affective factor on contractor's risk on cost overburden. The burden to the contractor is low because of providing a percentage of profit with relation to the cost of the project.

Considering the major three sectors, the most severe factor which affect the cost estimate was identified as the factor of improper identification and assessment of the risk by the estimator. Negligence of the obligation as an estimator to have a proper assessment of risk in every aspect with the preparation of cost estimate has become a fact which generate a considerable cost overburden to the contractor.

The first priority among the facors affecting the final cost was obtained by the factor changing needs of client under the client

generated risk factors. It clearly depicts that the complexity and construction sophistication caused by the changing needs of client has been a severe burden with the contractor's cost performance.

Undergoing a measure and pay contract by the contractor was the highest factor of causing the cost overburden to the contractor under the contract specific factors. Receiving the amount after the completion of work segments will cause an improper cashflow of the contractor.

When considering the obtained category based rank, client generated risk factors and economic factors have obtained equally the highest priority of all categories. This clearly elaborates that the client and the state of country's economy are the major sources affecting the contractor's risk on cost overburden in Sri Lankan context. The minimum consideration was given to the type of contract which depicts that the state of contract agreement and conditions of contract are merely affecting the cost performance of the contractor.

By summarizing the analysis the final outcome can be obtained as contractor is having the highest risk of causing cost overburden due to the factors affecting final cost and the lowest threat on cost overburden generated by the contract specific factors. With the factors affecting the final cost, the contract amount will exceed the estimated budget which will cause a considerable impact on contractor's profit margin.

Conclusion and Recommendations

Construction industry manipulates in a complex environment which focusses on completion of the project fulfilling the achievement of main three constrains; time, cost and quality. The contractor is having the main responsibility on the project execution as agreed with the client party. Having cost overburden issues to the contractor will directly impact with the project performance which will obstruct the completion of the work as expected. Among the factors affecting the contractor's risk on cost overburden, factors affecting final cost were taken the priority among other factors. Identification and proper management of the factors will avoid the exceeding of the final cost than the estimated cost. Proper consultation of client to move on with effective implementations with minimum variations and to provide continuous flow of payment as agreed without delaying will improve the efficiency of the contractor as well. The contractor is also bearing a considerable responsibility in managing the site works effectively even at a conflict situation such as a labour shortage where the contractor could improve the efficiency and fulfill the requirements avoiding cost overruns. The project management party should be well qualified enough in understanding the cost overrunning situations and act accordingly by advicing the client and the contractor party appropriately which will be beneficial in safeguarding the contractor as well as the client by cost overburden issues. Further, the government should be well aware on maintaining the economic stability of the country which will safeguard the performance of not only the construction industry but also all other industries in country as well.

This research was undergone a quantitative analysis on identifying the factors affecting contractors risk on cost overburden by prioritizing them from highest severity to the lowest. With the outcomes of this research, further research can be continued on identifying the most appropriate mitigation approaches to mitigate the impacts of the affected factors. Also the research was limited to the traditional procurement system only. Future researches can be directed under other procurement systems such as design and build, management and partnering. Moreover, this research was limited under the views of quantity surveying professionals only.

Extending the research finding by considering the views of other stakeholders in construction industry, specially from the contractor and the client will improve the quality of the findings up to a considerable extend. With the finding reveled the objective was achieved and the aim was successfully completed.

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Contribution of Built Environment on Inclusive Urban Design: with Special Reference to Selected Transport Related Public Spaces in Galle, Sri Lanka

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Abstract: Designing architectural spaces is thought to contribute to social inclusion, eventually satisfying all components of the society. The building and space characteristics have a powerful impact on the quality on peoples 'lives. It's all about the choices the planners, developers or architects make. And those choices can either encourage or restrict people's well-being. With parallel technological innovations to these built environment and sociological research, many characteristics have been added to the built environment that empowers availability, security and feeling of belonging. This scenario is also apparent in developing nations as the bulk of the population belongs to the poor and low-income groups. Furthermore, the suggestions for growth are always subject to other factors such as policy, financial factors and profit. With regard to all these problems, there have been numerous summits and conferences on maintaining social inclusion, achieving general sustainability. Among them, the Sustainable Development Goals 11 is one of the most prominent in the process of transforming towns into more livable urban buildings and also highlights social inclusiveness as a major need. The whole research aims to promote social inclusion and defeat the present exclusivity. Social exclusivity leads to arise in social inequity, which is today's primary social problem. In overcrowded government areas such as the Galle bus stand and the Galle railway station, these problems are very evident. The objectives of this study are to, identifying the probability of exclusive design to create social inequality, understanding and defining the Social Inclusion as a concept, and then identify the potentials of inclusive design on overcoming social issues.

Keywords: Social Inclusion, Architectural design, Exclusive design

Introduction

Once the society is analyzed well, many social problems can be identified. Social unrest, social conflicts, accidents, alienation of victim groups are few of them. And sociological studies point out that they all rise as a result of exclusive urban designs. Many different sociological studies have pointed out these issues and their relation to built environment. Recognition of built environment in causing these numerous social issues varying in diverse social and cultural contexts, the professions and scholars of the built environment started on studying the issue.

Many of these social issues are caused due to the exclusiveness of the city or built environment structure. This exclusiveness leads to social inequity and cause number of social issues such as, social unrest in low income groups, social conflicts between lower social groups and upper social groups, occurrence of protests and other violence activities against the ruling systems, law agendas and authority decisions. In contributing reducing these issues the built environment professionals came up with a new concept in their professional study area to overcome these causes of built environment in order to sustain the globe as a whole.

The concept "Inclusive Urban Design" emerged as a solution for this in the field of

built environment. Social Inclusion can be defined as, is the process of improving the term in which individuals and groups take part in society- improving the ability, opportunity and dignity of those disadvantaged on the basis of their identity (World Bank official website). It is believed that designing of architectural spaces can contribute on achieving social inclusion, ultimately satisfying all the parts of the community.

The qualities of buildings and spaces have a strong influence on the quality of people's lives. It all lies on the decisions that are made by the planners, designers or Architects. And those decisions can either promote or limit the well-being of the people. With technological developments parallel to these built environment and sociological studies, many features were added to built environment empowering accessibility, safety and sense of belonging.

But still some of the issues remain still due to the lack of concern of the planners and their decisions on the proposing redevelopment plans. In developing countries this situation is further noticeable as a majority of the population belongs to the poor and low income groups. And moreover public spaces common for these low income people is always under limitation of services. Further the development proposals are always under other influences such as, politics, economic considerations and profit. Concerning all these issues there were many summits and conferences on sustaining social inclusion, achieving overall sustainability and built environment in achieving sustainable and inclusive city structures. Among them, the Sustainable Development Goals 11, is one of the prominent in the process of transforming the cities into more livable urban structures and also mentions the social inclusiveness as a prime concern.

Sustainable Development Goals commonly known as SDG 11 establishes goals for urban areas around the world to be both sustainable and inclusive. As three out of ten goals of SDG 11 relates to ensure accessibility equity, it can be considered as the prominent and foremost important document in regards to social inclusion. These three goals feature provisions to 'ensure' or 'provide' access to environmental goods and services, including basic housing, sustainable transport, and urban green spaces, in particular for the commonly known victim groups of exclusive cities, namely, women, adults, children, disabled. (John Brandit, T Chakraborty, Glenn Sherif, 2018) Social inclusions achieved by Built environment always promote social sustainability. This contributes to overall sustainability and well-being of both living component and physical component of a city. Galle is a city on the Southwest coast of Sri Lanka. It is city founded by Portuguese colonists in the 16th century.

City is known for the Old Dutch fort, Light house, Dutch reformed church and many more. Due to all these notable architectural pieces and beautiful coastal line, Galle is one of the cities in Sri Lanka with the highest tourist attraction. Because of this most of the re-development plans led by the local authorities are always focused on tourism, while the needs of local community are set aside to a larger extent. This is one of the major reasons for built environment to be exclusive to many vulnerable groups.

Galle being a city accommodating a dense population, and being a transit city use by a large population, transport related public spaces (bus stand and railway station) depict the features of exclusive built environment.

The whole study is aimed at promoting social inclusion, defeating current exclusivity of the city structure. As social inclusiveness is a wide and complicated concept, covering many areas such as, housing, green spaces,

transportation and other numerous services provided by a city, the dissertation is only limited to the inclusivity of transport related public spaces.

Study will include three main parts, first it will state the social inclusion as a concept in professional studies and its relation to physical built environment through the existing literature sources, and then a field study will be conducted, in the framework compromising stated indicators of social inclusion, to measure inclusivity and identify the issues in the existing context.

Galle being the capital of the Southern province is a very prominent and a densely populated city. This bustling city is very popular transit cities which provide access to many other suburban areas. And Galle is one of the best tourist destinations in the Island too. Due to this reason large number of tourists is accommodated in the city limits. This has resulted in leaving the local community aside and giving the priority for the tourism. And this is further influenced by the development proposals aiming tourism developments. And once a public space is designed aiming a one or few social groups of people or in other words if many social groups are abandoned when these public spaces are designed; they give rise to many social conflicts and social exclusiveness. Social exclusiveness results in the increase of social inequity which is a prime social concern of the present day.

These issues are very much clear in overcrowded transport related public spaces such as Galle bus stand and Galle railway station. This particular problem is discussed in detail in this research study.

The aim of the study is to understand the contribution of built environment, architectural practice on inclusive design. The aim will be achieved through few objectives such as, identifying the probability of exclusive design to create social inequality, understanding and defining the Social Inclusion as a concept, and then identify the potentials of inclusive design on overcoming social issues. Then the level of inclusivity of two selected public spaces of Gale will be measured and evaluated. Research will adapt a mixed method compromising both quantitative and qualitative methods. The primary data will be collected through surveys and interviews. Through purpose sampling the participants will be selected for the questionnaire assessment. And secondary data will be collected through books, research papers and other existing sources of literature, covering the areas of Inclusion, social sustainability and urban planning.

The primary data will be used to measure and evaluate the degree of inclusivity of two selected spaces of Galle city and secondary data will be used to make suggestions to overcome the identified issues. Parallel to that a field study will be conducted to document the physical parameters of the built environment.

In measuring the degree of inclusivity of the existing city context, a framework is developed, based on the SDG 11. The framework includes three main indictors and based on the framework the questionnaires and interviews will be structured. Proportion of urban population that has convenient access to public transport, by sex, age and person with disabilities, proportion of population with direct participation in transport spaces and access to regarding services, and average share of the built up area of the city that is open space for public use for all by sex, age and persons with disabilities.

Literature Review

“Meeting the needs of the present without compromising the ability of future generations to meet their own needs” A process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and

institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations" (Bruntland, 1987)Sustainable development is an inter balance of environmental resource protection, social progress, economic growth and stability for the present and future generations to come.At the Rio de Jeneiro earth summit of 1992, economic growth, social inclusion and environmental balance were identified as the paradigm of sustainable development. (UCLG, 2010) Above named dimensions alone cannot possibly cover the complicated current society therefore agencies and institutions such as UNESCO introduced culture as the fourth pillar of sustainable development that provide a means of connections between the three other pillars of sustainability. (Fathian, Powell, 2009)

Social sustainability is an often-overlooked aspect of sustainability as overall sustainability cannot be approached by only looking into the other two pillars of sustainability.

"Social sustainability occurs when the formal and informal processors system, structures and relationships actively support the capacity of current and future generations to create healthy and livable communities. Socially sustainable communities are equitable, diverse, connected and democratic and provide a good quality of life." (WACOSS, 2002)

The UN global compact cities state human rights as the cornerstones of social sustainability. This extends to special community groups such labor force, women, children, indigenous people, poor, uneducated and minority ethnic groups. Social sustainability is a worthy investment in urban design projects as city residents and users are safe, satisfied, healthier and more productive.Furthermore, socially sustainable built environments enjoy greater production, consumer patronage as city users tend to support their living environment. Aiming for social sustainability can help a city to attract more investments, work force, tourists which can positively influence the economy of the city.

This present situation give rise too many issues related to environment, society and economy of the world. As this uncontrolled and unorganized built environment get wide spread day by day giving raise to many issues, it is now identified as a highly contributing factor in sustainable development. Many research studies have now identified and urge of a new definition of the relationship between built and natural environment in order to achieve a more sustainable society.

The concept, Sustainability can be defined as development that meets the needs of the present generation without compromising the ability of future generation to meet their needs. Sustainability is based upon three pillars: economic growth, social progress and environmental protection. And in order to achieve sustainability in built environment it includes designing, building and operating structures to extend it meets or exceeds the expectation of the clients and wider stakeholders.Amidst many expectations and demands of the clients and stake holders from the companies related and operating built environment, expecting the company to behave ethically, treat people fairly, increase the wellbeing of people, protecting and enhancing the natural environment, minimize the consumption of energy and natural resources and conveying social value through operations can be high lightened as the major and foremost expectations of clients and stakeholders.Built environment is one of the most highly contributing factor of sustainable development which influence all the three aspects of sustainability, environmental, economic and social .This is clearly seen in OECD countries (Organization for Economic Co-operation and development). In these

countries built environment is responsible for 25-40% of total energy use, 30% of raw material use, 30-40% of global greenhouse gas emissions (45% in UK), for 30-40% of solid waste generation. Apart from that people spend almost 90% of their life inside buildings; therefore it is very clear that built environment is a highly contributing factor of sustainable development. Buildings and construction works are identified as largest single share in global resource use and pollution emission. (William, 2012)

At present social sustainability is identified as the main concerns of today's world. And built environment has an effect on social sustainability too. Though it is hard to see the connection of objective physical world with the society at once, it is recognized that this objective physical built environment is cable of making subjective reactions that effect social sustainability. There are many issues related to social sustainability. Human rights, equity, safety, wellness, empowerment, fare labor, living conditions, health, community engagement and many more are included in the issues related to social sustainability.

These issues are not easily quantifiable or measurable. But they can be easily identified. Especially in transport related public spaces these social issues are clearly seen. Few examples lack of accessibility, safety issues, lack of infrastructure facilities and overall spatial quality of the spaces. These are the primal causes of socially exclusive urban built environments.

Research studies carried out in the field of sociology have clearly pointed out the relationship of subjective social exclusion and objective built environment. This recognition has given the rise for an architectural consideration on built environment as socially inclusive public built spaces.

Social Inclusion as a goal in Sustainable Development

In 1972, governments met in Stockholm, Sweden for United Nations Conference on the Human Environment to consider the rights of the family to a healthy and a productive environment. In 1983, the United Nations created the World Commission on Environment and Development. Later it was named as the Brudtland Commission, which defined the sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" Negotiation on the post – 2015 began in January and ended it August. This was carried in parallel to the negotiations on financing development by United Nations. A final document was presented at the UN Sustainable Development Summit in September 2015 in New York.

UN General Assembly took place with the presence of 193 countries on 25 September 2015. Assembly adopted the 2030 Development Agenda which was titled as "Transforming our world: the 2030 Agenda for Sustainable Development". This agenda is comprised of 92 paragraphs and 17 Sustainable Development Goals (SDGs) are included in the paragraph 51. Apart from the 17 sustainable development goals 169 targets and 232 indicators are included the agenda. There are 196 targets to be accomplished to achieve the 17 goals and each target has between 1 and three indicators that are used to measure the progress towards each target. There are 232 approved indicators in total. (John Brandit, T Chakraborty, Glenn Sherif, 2018) Eleventh goal of 17 SDGs is named as sustainable cities and communities. In detail this goal is stated as "make cities and human settlements inclusive, safe, resilient and sustainable".

Indicators of social inclusivity

When the attention is focused on environmental sustainability in cities, the 11th goal of SDGs proposes that cities must be both

sustainable and inclusive. Three indicators out of ten indicators for 11th SDG state that "ensure" or "provide" access to environmental goods and services such as housing, sustainable transport and urban green spaces. And the access to these spaces must be ensured for all the parties of a community such as women, children, adults, disable people, priests and etc.

Out of the main indicators related to social inclusion SDGs (11.1, 11.2, 11.6, 11.7) 11.2 is related with transport related public spaces. The indicators 11.2 and 11.2.1 is stated as the proportion of population that has convenient access to public transport, by sex, age and personals with disabilities.

Furthermore 11.2 states that by 2030 access should be granted for every individual including with the individuals those are in vulnerable situations such as women, children, disable people and old age people to safe, affordable and sustainable transport systems. It is stated that special attention to be paid for those in vulnerable situations. (John Brandit, T Chakraborty, Glenn Sherif, 2018)

Defining Social Inclusion

According to SoSLC report of 2018 it clearly states the importance of a spatial development for a better urban future for all the Sri Lankan cities. SoSLC report further explains the five main attributes of spatial development. They are competitiveness, resilience, safety, sustainability and inclusivity. (SoSLC, 2018)

It also suggests rapid expansion and sprawl as factor to reduce inclusivity. Urban sprawl means the unrestricted growth of housing, commercial development, and roads over expanses of land in urban areas without a proper planning. Urban sprawl causes difficulties for residents in the urban periphery to access urban services. In order to achieve urban development redrawing urban boundaries in a way that residents are included in peri-urban fringe is very necessary.

Social inclusion is the process of improving the terms of which individuals and groups take part in the society – improving the ability, opportunity and dignity of those disadvantaged on the basis of their identity. In every country certain groups such as indigenous, migrants or other minorities confront barriers that prevent them from equally participating in their nation's political, economic and social life.

These groups are excluded through numerous factors ranging from gender, race, ethnics, religion, disabilities, and stereotypes, superstations based on gender, sexual orientation and gender identity. These kinds of practices can negatively impact on any of these social group's dignity, security and living a better life.

Social inclusion and built environment

Once the place we live, facilities and services we use and our neighborhoods and meeting places are designed inclusively and, in a manner, which is easy to access them, then the built environment can contribute to a more inclusive and a cohesive society. The term inclusion has a very wide meaning, it is not just access- this starts from what is an inhospitable built environment looks and feel like and extends up to unintended social, cultural and economic inequalities.

The way how people experience the built environment is different from one individual to another. It differs according to who they are. One's social, cultural and economic background effects on how a particular person experiences the built environment. In order to make every single individual comfortable in a particular space or to make them feel that the place belongs to them, a wide diversity of experiences is needed to be considered. The following perspectives of few individuals vividly illustrate clearly how they experience the built environment differently."Being able to live well in my home environment is essential to my mental and physical wellbeing.

Yet those of us most at risk of breakdown in our mental health and well-being are much more likely to live in squalid housing amid constant noise and in an environment where we are subjected to harassment and abuse. Quiet, books, natural beauty, green, open spaces – these are all essential for me.

As this study is specifically focused on transport related public spaces and their inclusivity, it is important to consider the inclusivity and urban built public spaces separately to identify the relations between inclusivity and urban built spaces.Once we consider the transport services, we just simply don't use them. When we say we use transport services it also means that people are getting around and using the space too. Getting around means much more than accessing buses, trains or any other public transport. This includes the presence of well-designed and well managed streets and roads with less traffic that does not affect free movement. Inclusive transport related public spaces refer to dignified, accessible, affordable, safe and easy spaces to use. Or in other words an inclusive transport design can be easily used by everyone to get around.

Therefore, such spaces must possess chill proof shelters with security, seating, talking countdown systems, emergency phones, a safe and a comfortable place to wait, security at night for all the parties and many more. And also buses with ramps and etc. must be there for people. And when it comes to social inclusion in built environment, location is also one of the most important factors. And when designing the spaces, they are built in a way it specifically related to the location. The location and the design of place have a major effect on how people benefit from them.

When selecting locations, design, equipment for public spaces, often they are fail to take minority cultural and religious groups, women, disable people, old people and many more other groups in vulnerable situations into account.

Most of the time these vulnerable parties are isolated and left aside. The designers and constructors are often unable to pay attention to the special requirements of these groups.

For an example when the public spaces are built issues such as the absence of spaces for prayers and washing facilities and etc. can be seen in common. Impacts of a bad or a poor design are more likely to be felt by groups such as disables, old people, kids women, priests and people from minority religions and etc.

Location is one of the deciding factors in inclusive built environment. For an example decentralization of healthcare services is now a very commonly accepted concept. This is now very welcome as it is good for patients as they have fewer disturbances from noises and etc. But there are practical issues linked with them such as how easy are they to be used by people without a car. The physical and technical access to a particular space is discussed as a vital design issue. And also, despite the very advanced technologies, anti-discrimination legislations and policies and etc.

There are many buildings that are still difficult for disable people to enter with dignity and ease. Managing a space is important in a way that every individual who visits the space feels that they belong in here.

Inclusive design is a process of designing, building, managing and populating places and spaces that ensure that they work for as many people as possible, not just some groups. It encompasses where people live and the public buildings they use, such as health centers, education facilities and libraries; and how they get around – neighborhoods, streets, parks and green spaces and transport.

An inclusive design is basically about 3 main factors. Which are namely, access with dignity, treatment with respect and relevant services

and there are six main characteristics of an inclusive built space. An inclusive space be responsive to people's needs, be flexible in use, offer choice when a single design solution cannot meet all users' needs, be convenient so they can be used without undue effort or 'special separation', be welcoming to a wide variety of people, making them feel they belong, accommodate without fuss or exception those who have specific requirements.

Inclusive design takes into account people with specific mobility, dexterity, sensory, and communication impairments; learning disabilities; continence needs; and people whose mental well-being should be supported by a thoughtfully crafted and managed environment.

Consultation is a key to inclusive design. Right from the outset of any project, particular attention should be paid to those likely to be overlooked or whose views are less likely to be accommodated. This includes women and transgender people, elderly and younger people and children, religious minorities, poorer and socially excluded communities, lesbians and gay men, black and minority ethnic people. This does not happen enough; for instance, people who are victims of racist and homophobic hate crime are unlikely to be consulted about the design of public spaces.

Benefits of social inclusion

Inclusivity and built environment are two components which are interrelated and are influencing each other. Sustaining inclusivity provides numerous benefits to the community as a whole despising the varieties of it. As the main character inclusive designed spaces will be welcoming to all, it will enrich the sense of equity in the community and diversely impact the social well-being. Further inclusive urban built environments will provide easy access to all the social groups providing specific needs of them, without hurting their dignity or occurring anxiety. All these can strengthen the mental health of the users and sustain the well-being of the whole community.

Further more inclusive built environment provides equal access to economic and natural resources and other services in the city, which can affect the economy of the country.

III. methodology and data analysis

The aim of the study is to understand the contribution of built environment, architectural practice on inclusive design. To achieve this goal, the survey used structured questionnaires in personal interviews. Structured questionnaires may be the most widely used technique for collecting survey data and are widely used in descriptive and analytical research to identify facts and opinions.

Research approach

Research methods are mainly divided into quantitative and qualitative. Quantitative methods are often associated with positivism, collecting factual data, studying the relationship between facts and these facts, and methods corresponding to previous theories and findings. The survey method chosen for this study is the most appropriate. There is an important difference between research and investigation. The studies "gather information about the characteristics, behaviors, or opinions of many people (so-called populations)." Research that encourages scientific knowledge" (Kraemer, 2002). The design and methodology of the study should also be matched when selecting a particular research method. Research design refers to the overall strategy of those who choose an attack problem, and for the effective resolution of the problem, it is necessary to consistently and logically integrate other components of the research (Grover, 2015).

Research technique

Researchers need a lot of tools and skills to gather information. Testing is a measurement tool that guides researchers through data

collection and evaluation. Equipment complexity, analysis and research design vary. Each tool is suitable for collecting specific information. This study is used to collect information about various research data. But their strategies, issues, interviews, timelines, monitoring and evaluation scale.

This study requires data views and opinions on skilled structures. Therefore, data collection surveys and interviews are collected from the top of selected research strategies.

Data Collection Technique

The aim of the study is to understand the contribution of built environment, architectural practice on inclusive design. To achieve this objective 130 people 0f bus stand and 130 people of railway station were randomly selected. This study selected 7 categories of people which Schooling children, disabled person, office workers, tourists, middle age women, old age persons and clergy. The questionnaire collected preliminary data and selected secondary data from the Government Statistics Office in Sri Lanka and previous literature reviews, articles, books and surveys.

Questionnaire design

The purpose of the questionnaire is to obtain further information to support the research objectives and identify the probability of exclusive design to create social inequality, understanding and defining the Social Inclusion as a concept, and then identify the potentials of inclusive design on overcoming social issues. This questionnaire includes 17 questions regarding the study. It mainly focuses about the scale type questions.

Methodology for the research

Research will adapt a mixed method compromising both quantitative and qualitative methods. The primary data will be collected through surveys and interviews. Through purpose sampling the participants will be selected for the questionnaire assessment. And secondary data will be collected through books, research papers and other existing sources of literature, covering the areas of Inclusion, social sustainability and urban planning.

The primary data will be used to measure and evaluate the degree of inclusivity of two selected spaces of Galle city and secondary data will be used to make suggestions to overcome the identified issues. Parallel to that a field study will be conducted to document the physical parameters of the built environment. The framework includes three main indictors and based on the framework the questionnaires and interviews will be structured. Proportion of urban population that has convenient access to public transport, by sex, age and person with disabilities, proportion of population with direct participation in transport spaces and access to regarding services, and average share of the built up area of the city that is open space for public use for all by sex, age and persons with disabilities.

Method of data analysis

To choose the right analytical method, you need to understand the level of measurement. There is a suitable method for each measurement method, but no other method is available. In this study, a hierarchy was used. Numbers assigned to significant digits (1, 2, 3, and 4) have the same spacing between scales and do not represent absolute numbers.

Table 1: Structure of ratings

Item	High satisfy	Satisfy	Not satisfy	Cannot comment
Scale	1	2	3	4

In measuring the degree of inclusivity of the existing city context, a framework is developed, based on the 11 Sustainable Development Goals.

Data analysis

This chapter discussed the analyzed data and

results of the study. 130 people of bus stand and 130 people of railway station were randomly selected. This study selected 7 categories of people which Schooling children, disabled person, office workers, tourists, middle age women, old age persons and clergy for give clear idea about the social exclusiveness. This chapter mainly provides the overall information of contribution of built environment on inclusive urban design.

Galle is the capital of the southern state and is a very important and densely populated city. This bustling city is a very popular transportation city that leads to many other suburbs. Galle is also one of the best tourist destinations on the island. For this reason, many tourists are hosting this city. This leads to putting the community aside and prioritizing tourism.

The main objective of this study is to understand the contribution of built environment, architectural practice on inclusive design. This main objective will be achieved through few sub objectives such as, identifying the probability of exclusive design to create social inequality, understanding and defining the Social Inclusion as a concept, and then identify the potentials of inclusive design on overcoming social issues.

This research conducted 7 different categories of people with Galle bus stand and Galle rail way station and identified variations among these people. When considering total sample of the study, this study found out following results.

Case Studies

There are two main case studies taken to study in this research study. The first one is the Galle Railway station and the next one is the Galle bus stand. As mentioned above the questionnaire study will be conducted to check the indicators found in literature review. The two indicators for the case study I (Railway station) are as below,

"Proportion of urban population that has convenient access to public transport by sex, age and person with disabilities."

"Proportion of population with direct participation in transport spaces and access to regarding services." The two indicators for the case study II (Bus stand) are equal as above.

Iv. concluding remarks

Chapter 4 includes the conclusion, recommendations and limitation of the study. This chapter discusses the aim of this study and the objectives and the hoe far achieve those aim and objectives. To explain those achievements this chapter uses the data which collected and previous related literatures. Moreover, this study mainly discusses the 7 categories of people which Schooling children, disabled person, office workers, tourists, middle age women, old age persons and clergy for give clear idea about the social exclusiveness. Finally, gives conclusion regarding to the aim and research objectives.

The study was intended to understand the contribution of built environment, on inclusive design. The aim will be achieved through few objectives such as, identifying the probability of exclusive design to create social inequality, understanding and defining the Social Inclusion as a concept, and then identify the potentials of inclusive design on overcoming social issues. The main case study done on Galle, Sri Lanka is played with numerous negativities, and exclusive to its local users. The prevailing exclusivity can be concluded as; the two main transportation hubs (railway station and bus stand) are not accessible to disabled users, lack of transition available, hard to access at peak time of usage, lack of opportunities, safety, and supportive service.This makes nothing lack of Galle to be exclusive in all the aspects. Yet Galle as the main transit city of the southern region of the

island a huge population daily engages with this exclusive city structure.

According to the collected data there is an exclusive urban design in the Galle city. This design mainly based on the tourism. That's why the satisfaction of inclusiveness of the railway station and bus stand, only tourists are satisfied with this indicator and other six category of domestic passengers are not satisfied with this indication. And also this results show that the probability of exclusive design to create social inequality. Especially, people who disabled, old and middle age; they should have fair services in the public transportation services. But, chapter 4 showed that those particular respondents are not satisfied with the services of Galle railway station and bus stand. It is also a reason for social exclusiveness. There services also focused on tourists. But the problem is local passengers are using public transportation services than tourists in Galle city.Through the analysis it is identified that, the planning concepts on mainly focusing on tourism as the most influential cause of exclusivity of the city. Focusing on tourism has been demarcating the provisions of the local communities.City is a composition of social component interacting with physical environment. Losing its local society may not lately support the focused tourism.Therefore the analysis was done to figure whether the Galle prevailing city structure is compatible with the concept of "inclusive planning". The results confirm that city is still potential enough to make it inclusive for its local users as well as foreigners. Planning for urban planning measures to enhance inclusiveness can take several forms. First, removing exclusivity can have an important impact in current urban planning regimes and procedures. Improving the accessibility of transport for marginalized groups can be facilitated or free transport for the poor in the city, or for people who travel from a greater distance, or set up new transit routes to serve previously uninhabited settlements, making investments in transport without transit time reduced. A proper planning intervention may therefore make Galle an inclusive urbanity for the generation to come. This will enrich and celebrate the local livelihood promoting the tourist a livelihood to enjoy. A city of tomorrow, inclusive will sustain the society, improving tourism positively affecting the economy, and will ultimately sustain the Galle city both heritage city and outer city. Preserving the greatness and historical values which are experienced by the present generation to the future generations.

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Impact of Colour on Worker Performance and Satisfaction in Sri Lankan Office Buildings with Reference to Bank Buildings in Gampaha District

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Abstract: Colours helps to generate spatial qualities in architecture and affect the psychological and physiological condition of the user. Colours can influence on wellbeing and provide impact on human behaviour. Careful use of colours can create harmonious spaces and change the behaviour of the users positively. colour schemes play important role in office working environments.

Office is a place where, employees spend their majority of time. Banks are a specific office type which deals with money. office environment affects directly, in shaping the day of a person, his moods, performance and satisfaction.

Main objective of this study is to enhance the awareness of designers and facility managers in the banks on the importance of colour schemes to improve bank employee's performance and satisfaction.

Three Sri Lankan office buildings with reference to banks in Gampaha district selected and see how colours have been supportive or less conducive towards, performance and satisfaction and to find out most important colour scheme for the increase performance and satisfaction. Three different bank environments in Gampaha District were selected for this study.45, were employed as participants.

Sample size was selected considering the People who facing directly to the selected colours while working.

Primary data were collected using researcher made questionnaire regarding the factors related to respondent's (A) basic information, (B)comfortability regarding applied colour scheme and its effect on the performance (C) comfortability regarding existing physical environmental factors, (D)colour scheme preferences for the working environment. (E) job satisfaction. Data were analysed descriptively.

Keywords: Gampaha District, Performance, Satisfaction

Introduction

Colours can play an important role in satisfying people. According to the Jalil et al (2011) colours provide important impact for the human lives through psychologically, physiologically, sociologically and physically. Colour affects feel of space, function of the space, activity and colour promotes satisfying human relationship and makes the built environment more comfortable. According to the UK essays (2016) Colours are identified as a powerful force which can be used for motivate, stimulate and control actions of the people. Colours can create environment whether it is joyful one or misery one. Colours play a major role in achieving the required spatial quality. As cited by Dardeer (2017) Bleicher (2005) implies that, in a space, colours affect the occupant's state of mind or mood. Thus, colours can be negatively or positively affected for the comfortability of the users.

colour schemes play important role in office working environments. Office is a place where, employees actively spend their majority of time. different offices that perform different functions and Banks are a specific office type which deals with money. office environment affects directly, in shaping the day of a person, his moods, performance as well as satisfaction. According to the Pacific interiors (2018) colours provide considerable effect for the comfortability inside the space. Comfortability inside the space is a major factor for the workspace satisfaction.

Kamarulzaman (2011) implies that employee satisfaction can be identified as an important factor in the success of an organization and it considered as a key indicator of performance. WBDG Productive Committee (2018) explains Uncomfortable conditions inside the workspaces can decrease the workspace satisfaction, so it can be a reason to decrease the performance in a workspace.

In office environments selection of interior colour is mostly done according to organizational preferences, concept or in relation to logo. User preferences and satisfaction are unconsidered while choosing colours. If inappropriate colours are chosen, for the office interiors occupants might be subject to negative psychological impacts such as tension, depression, anxiety, stress, grief, loneliness, frustration, inefficiency and indolence. Inappropriate usage of colours can contribute to decrease performance and satisfaction in the office environments. So, to overcome this issue facility managers should therefore be advised to improve the surroundings of the office to facilitate psychological needs and comfort of the employees.

In Sri Lankan context, most of banks use their interior colours based on logo colours or organization defined colours for the office interiors without considering comfort of the users. So, it can negatively affect the workers and resulting unhealthy, lethargic and restless office environments. Therefore, the study intends to explore whether we can improve the performance and satisfaction of the bank employees, by providing their perceived colour scheme.

Main objective of this study is to enhance the awareness of designers and facility managers in the banks on the importance of colour schemes to improve bank employee's performance and satisfaction. My secondary objective is to find out whether colour scheme inside the bank building, affects employee's performance and satisfaction in Gampaha district, Sri Lanka. As tertiary objective, my attempt would be to look at Sri Lankan office buildings with special reference to banks in Gampaha district and see how the colours have been supportive or less conducive towards their performance and satisfaction and to find out most important colour scheme for the increase performance and satisfaction inside a bank.

Colours can generate emotional impacts, health impacts, physical impacts, psychological impacts etc on user. This Study focuses only colours and its impact on performance and satisfaction of bank workers. The study is limited to contemporary architect designed bank interiors in Sri Lankan context, Gampaha district. Study conducted in three sub branches and it was unable to find out same working caliber large sample within the bank. Study conducted giving special reference to environmental factors which are affecting for the performance and satisfaction. Study carried out selecting only three case studies. Questionnaire helps to find out bank worker's perceive level of performances and satisfaction

Three different bank environments located in Gampaha District were selected for this study. A total of 45 individuals (15 from each bank) from different age groups were employed as participants among the people who work in

the three banks. Sample size was selected considering the People who facing directly to the selected colours while working. (Sampath bank -orange, union bank – blue, National Savings Bank (NSB) bank – grey).

Primary data were collected using researcher made questionnaire regarding the factors affecting for the performance and satisfaction in a workspace as mentioned below.

01. Ambient conditions (quality of lighting, temperature, noise level, air quality),

02.Physical characteristics of the workstation (colour, amount of floor space, quality of equipment and furniture),

03.Workspaces (differentiation between different organizational spaces and the place

which is occupied by each person),

04.Office layout (disposition of space and equipment-telephone, fax, email)

05.Building layout (separation and differentiation of work units, localization of organizations different departments)."

These are number of factors that affect for performance and satisfaction of users in office environment. Out of them the study focuses on one factor which is colour of particular working environment.

questionnaire consist with 5 main parts and, (A) respondent's basic information, (B) respondent's comfortability regarding applied colour scheme and its effect on the performance (C) respondent's comfortability regarding existing physical environmental factors, (D) respondent's colour scheme preferences for the working environment. (E) respondent's job satisfaction. Data were analysed descriptively.

Methodology/ Experimental Design

Two private banks and one state bank in Gampaha District were used as case studies namely Sampath bank, Union bank and NSB bank. A total of 45 individuals (15 from each bank) from different age groups were employed as participants among the people who work in the three banks. Sample size was selected considering the People who facing directly to the selected colours while working. (Sampath bank -orange, union bank – blue, NSB bank – grey).Collected data were analysed descriptively.

Results and Discussion

The data which were collected through researcher made questionnaires were summarized using graphs.

Satisfaction With The Applied Colour Scheme

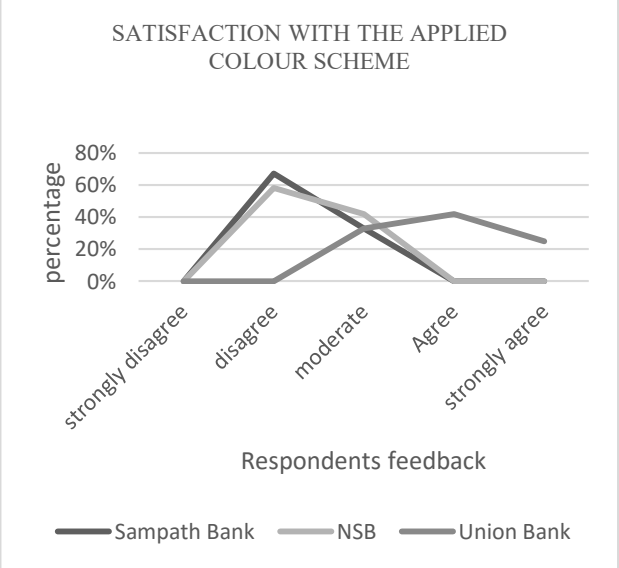

Figure 1. Satisfaction with the applied colour scheme

Analysing the results, most of the employees in Sampath bank and NSB are unsatisfied with the available colour scheme. Most of the union bank employees are satisfied with the colour scheme applied. So, Employees perceived satisfaction for blue is higher than orange and grey colours.

Effect of Applied Colour Scheme For The Performance

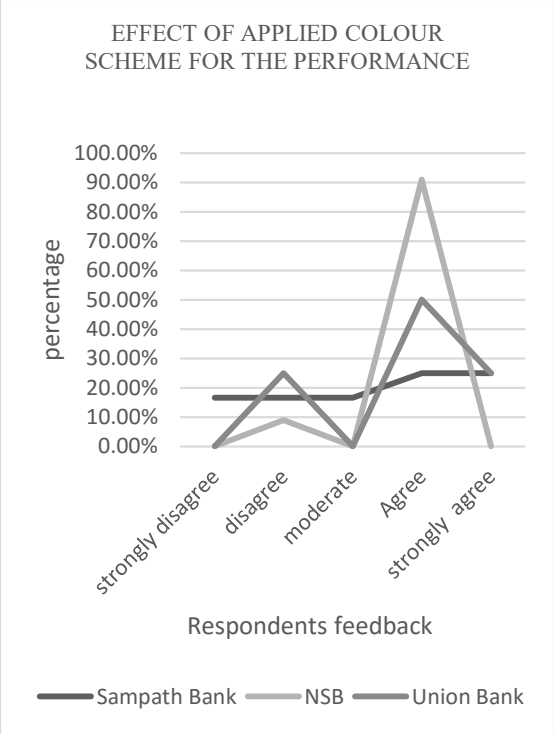

Figure 2. Effect of applied colour scheme for the performance

According to the results, most of the employees in all three banks provided agreement or strongly agreement for the given statement. This means that the workers are aware of the importance of the colour scheme towards their work performance. This results tally with the previous studies conducted by fisher (1997), which reveals applied colours in the workspace affect the worker performance.

Feeling About Applied Colour

Range Between Very Sad To Very Happy

Figure 3 shows that most of the employees in Union bank happy with the colour scheme (blue) inside. Followed by Sampath bank(orange) and NSB (grey).

Range Between Very Boring To Very Exciting

Analysing the results in figure 3, it is clear to see NSB respondents perceive, they feel boring and very boring compared to other two bank employees. NSB employees work with grey based environment and this result is matched with the TMD studio (2017) findings which explains grey provide boring feelings to occupants.

Range Between Very Deactivating To Very Energizing

According to the figure 3 results, it is clear to see NSB respondents perceive, they are less energized compared to other two bank employees. Also, NSB employees are more deactivated compared to other two banks. NSB employees work with grey based environment and this result matched with Adams (1973) in literature review which explains grey as a deactivating colour.

Range Between Very Distracting To Very Concentrating

Considering the figure 3 results most of the employees in NSB bank feel their colour scheme is distracting compared to other two banks. These results match with Kuller et.al (2007) in literature review, which says grey colour happens to decrease the concentration of the occupants. Most of the employees in Sampath bank feel distracting compared to other bank employees. This results match with the findings of Wexner (1954) which identified orange as disturbing colour.

Ability To Finish Work Within Given Time

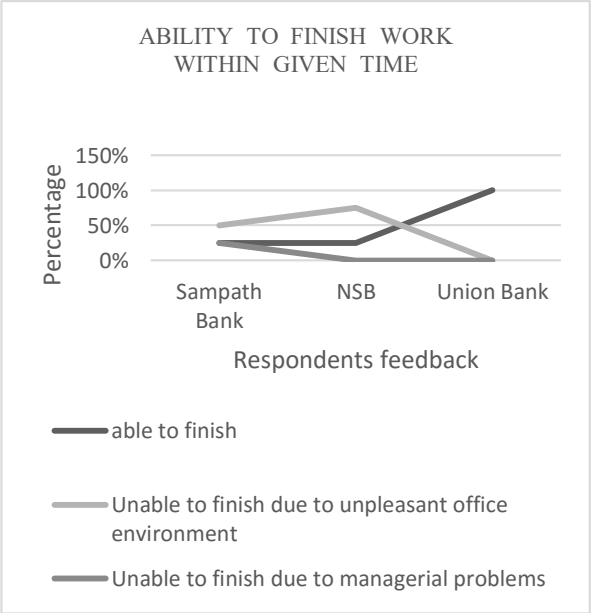

Figure 4. Ability to finish work within given time

(75%) of Sampath bank workers are unable to finish the work within given time due to

unpleasant work environment and managerial problems respectively. (75%) employees in the NSB bank are unable to finish the work during the given time due to unpleasant office environment. 100% of the employees inside Union bank are able to finish their work during the given time. According to the results it is clear that union bank employees perform well compared to NSB and Union bank.

Satisfaction With The Ambient Conditions

According to the figure 5 most of the employees are satisfied about ambient conditions inside their banks.

Satisfaction With The Physical Characteristics Of The Workstation

Figure 6 shows that most of the employees are satisfied about physical characteristics of the workstations inside their banks. Satisfaction With The Workspaces

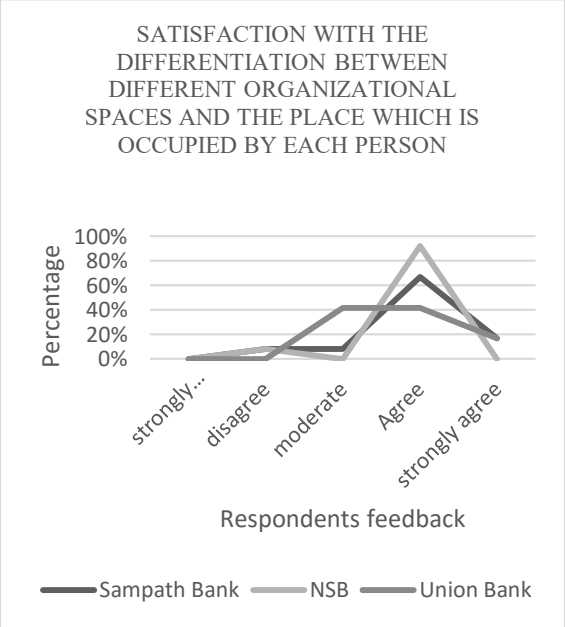

Figure 7. Satisfaction with the workspaces

According to the figure 7 most of the employees are satisfied about workspaces inside their banks.

Satisfaction With The Office Layout

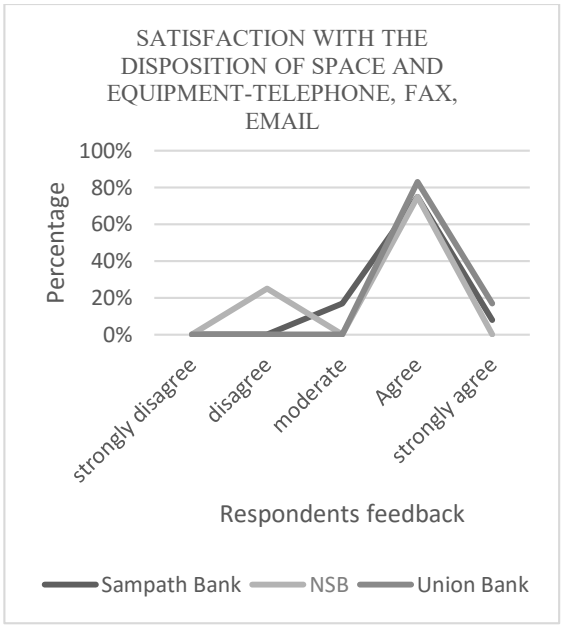

Figure 8. Satisfaction with the office layout

Figure 8 shows that, most of the employees are satisfied about the office layout inside their banks.

Satisfaction With The Building Layout

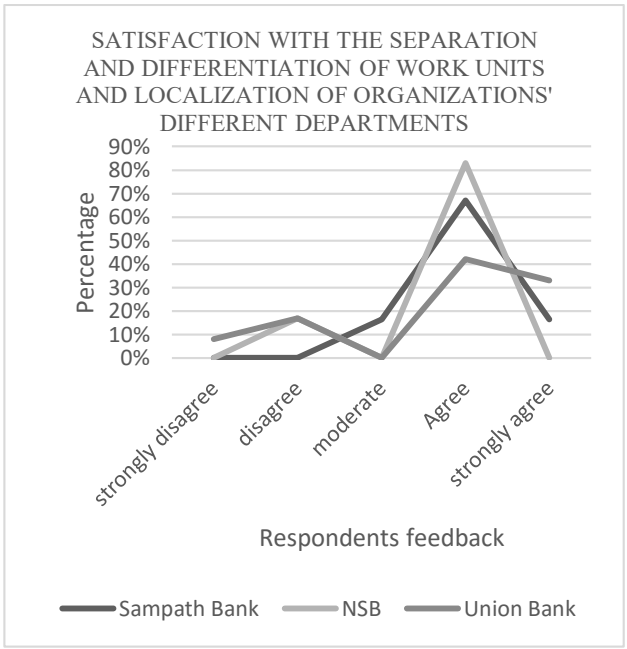

Figure 9. Satisfaction with the building layout

Figure 9 shows that most of the employees are satisfied about the building layout inside their banks.

Favourite Colour Scheme For Office Environment

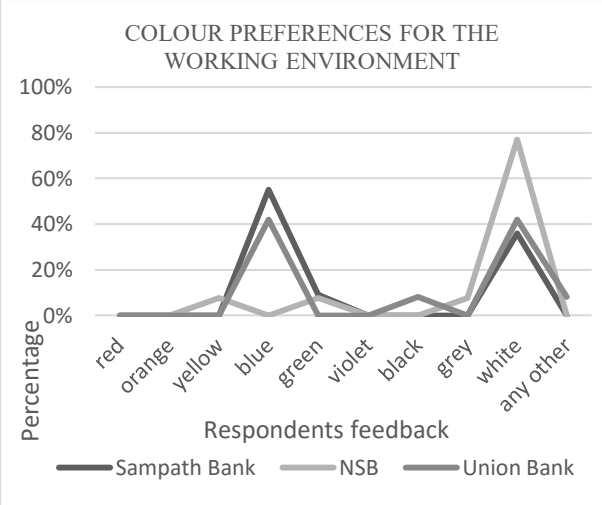

Figure 10. Favourite colour scheme for office environment

Union bank employees equally prefer blue and white for their working environment. They are currently working with their preferred colours for work. Results clearly show that the favourite colour preference for the working environment for most of the respondents is White; this finding is not tallying with brill.et al (1985) findings from the literature review, which stated that blue is the most preferred colour for the working environment. This finding completely deviates from the findings which are established in the western countries. These findings match with satio (1996) findings as the literature review says most of the Asians prefer white colour for their working environment

Respondent's Job Satisfaction

According to the figure 11 results most of the employees are happy and very happy about level of work fairness, enjoying their jobs, having good relations among each other and they think every employee in the bank is treated equally. Considering the results of the Job satisfaction questions, it seems that most of the employees in all three banks are satisfied with their jobs.

Conclusion

According to the results it is clear that most of the employees' performance of the Sampath bank and NSB is less, compared to the employee's performance in Union bank. As perceived by the employees it is mostly because of the unpleasant environmental condition.

Managers responses for the given questionnaire also proved the same order of performance. (Highest performance is recorded for union bank, secondly Sampath bank and least in NSB respectively.)

When considering the section C results, it is proved most of the employees in all three banks are satisfied with the environmental factors inside their offices including lighting level, temperature, noise level, air quality, floor space, quality of equipment and furniture, differentiation between different organizational spaces and place which is occupied by each person, disposition of space and equipment-telephone, fax, email, separation and differentiation of work units, localization of organizations' different departments.

So, according to the section B results NSB and Sampath bank employees said they are unable to finish their work due to unpleasant environmental condition and when considering section C, most of them are satisfied with the working environment conditions.

According to the results of the satisfaction with applied colour scheme, Union bank

most of employees are satisfied with it and other two banks are not. So, employees

perceived satisfaction for blue is higher than orange and grey. This finding again is

proved by managers' answers for the given questions. Union bank manager is

satisfied about the colour scheme inside and other two managers are little unsatisfied.

According to the analysis, most of the employees prefer white as their favourite colour for working environment. This finding deviates from the previous studies which are

conducted in western countries. In the western countries most of them prefer blue colour as their first choice for the working environment. Thus, results match with Satio (1996) findings which says most of the people in Asian countries prefer white for their working environment

The analysis revealed the following findings.

Union bank employees equally prefer blue and white as their highest favourite colours for the working environment and union bank employees are working under their preferred colours.

Perceived performance is high in Union bank

Perceived Satisfaction is high in Union bank

So, the research question was Can we improve the performance and satisfaction of

the bank employees, by providing their perceived colour scheme?

It is proven that organization can improve the employee performance and satisfaction

by providing them, their perceived colour scheme.

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Impact of Workforce Diversity on Employee Performance in Sri Lankan Construction Industry

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Abstract: Workforce diversity provides heterogeneity to a workforce thereby making it a strategic capability to provide competitive advantage to organizations. Effective management of diverse human resource in the right manner can attract profitability to organizations as human diversity enhances the flow of novelty, creativity and innovation. This research study aims to investigate employee performance in construction industry in Southern and Western provinces of Sri Lanka. Out of numerous workforce diversity factors, age, educational background, work experience and attitudes were selected as the independent variables for the study. When conducting the research,120 questionnaires were distributed among employees engaged in the construction industry to collect data through simple random sampling technique. The results indicated that there's a positive impact of diversity in terms of age, educational background, attitudes and work experiences on employee performance. The outcome of this study would benefit organizations in providing potential considerations to the management and workforce from different perspectives which would enable the distinguishing of dimensions of workforce diversity variables to further improve employee work performance.

Keywords: Workforce diversity, Employee performance, Construction Industry

Introduction

Work diversity is defined as similarities and differences among employees in terms of age, race, religion and cultural background, gender, physical abilities and disabilities and sexual orientation.

The success of an organization is determined by its' driving force which is the workforce as it is them who are responsible in carrying out operations. The diversity among workforce could be a challenging factor as well as a strategic capability to the organization. Thus,work diversity could be considered a competitive necessity which should be managed well in order to achieve success and to be effective in performances for an organization.

Srivastava & Agarwal (2012) claimed that people with multiple talents who come from diverse backgrounds, are more capable in acknowledging and grasping business opportunities creatively and rapidly. Christian, Porter & Moffitt (2016) stated that interpersonal conflicts, miscommunication, destructive interpersonal relations and employee turnover would rise if the organizational environment hinders employee diversity thereby not supporting it.

Kurtulus & Amber (2011) postulated that a borderless viewpoint should be adhered by organizations to ensure workforce diversity be a part of everyday operations if they are planning to be more dynamic, profitable in the future sustainance of the organization. Inefficient management of diversity could ultimately enhance discrimination in terms of social, religious, ethnic and educational backgrounds which could result high dissatisfaction and turnover rate among employees.

Moreover, Erasmus (2007) revealed that workforce diversity can bring out negative as well as positive outcomes to an organization based on the approaches adopted by its

management to manage the diversification of the employees.

Overall, the management requires to understand the ways of diversities in order to effectively deal with and to manage problems pertained to diversity. Individual differences should be recognized, addressed and respected thereby appreciating the individual uniqueness, as a means of encompassing variety to the organization.

Thus, this study is an attempt to bridge the impact of diversity variables and employee performance by developing a framework and to assess the degree of the impact of those variables on the dependent variable, employee performance. In order to conduct the study, executive and operational level employees from the construction industry were considered since the industry itself is endowed of a workforce which seem to have come from various social, economical, cultural and educational backgrounds. Construction industry has a workforce with diverse backgrounds such that it would also bring out various attitudes they have inculcated in them through experiences and learning. All such factors which represent workforce diversity could have a direct impact on their performance as well as the overall success of the organization. Hence, this study strives to analyse the nature of the impact of four workforce diversity elements with employee performance.

The general objective of this study was to identify the impact of the workforce diversity on employee performance in the field of construction in southern and western Provinces of Sri Lanka.The study attempted to achieve the following specific objectives.

To identify the impact of age diversity on employee performance.

To identify the impact of educational background diversity on employee performance.

To identify the impact of work experience diversity on employee performance.

To identify the impact of employees'attitude diversity on employee performance.

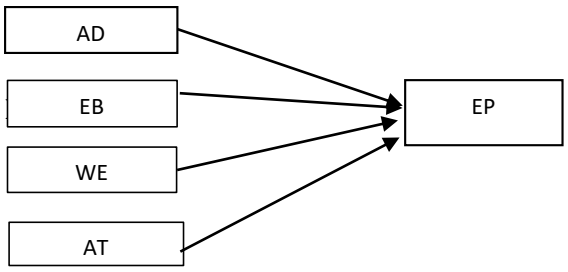
Methodology And Experimental Design

Statistical analysis tools were used to examine the impact of workforce diversity on employee performance. The researcher adopted a quantitative approach and self administered questionnaires were used for data collection.

Under the category of 'descriptive research design' the population considered was executive and operational level employees of the construction industry in Sri Lanka. The study population endowed of two construction related organizations and 120 employees were taken as the sample derived from the population through simple random sampling technique. Under the probability sampling method, simple random sampling research technique was used. 5 point likert scale was used as a measurement of survey for the questionnaire and SPSS version 20 was used as the statistical tool for analysis of the responses.

Through an extended review of literature, four hypotheses were derived based on the results of the previously done researches. Age diversity is the calibre of a company to concede all different types of ages within an organization (Kumar & Singh, 2017) . Workforce stereotyping is prevalent in workstations involving a varied age group. According to researches, younger employees are viewed as highly qualified and having high potential (Darwin Joseph, 2014) . Alghazo et al. (2016) revealed that increasing age exerts positive impacts on employee performance. Hence, the first hypothesis was derived from the previous findings as follows. H1: There is a positive impact of age diversity on employee performance. Most of the researchers including Elsaid (2012) postulated that educational diversity has a positive relation on employee performance. Pitts, Hicklin, Hawes and Melton (2010) found that employees who have come from diverse levels of educational backgrounds of the same workplace can create constructive associations and more interactive involvement. They further stated that it could also transcend levels of creativity and

innovation. Furthermore, Dainel (2017) claimed that level of productivity of an employee is reflected through his level of education and that education would also be discernible on his personality and cognitive capacities. Accordingly, the following hypothesis was thus formulated as H2: There is a positive impact of educational background diversity on employee performance. Most of the researchers including Lotur & Anbazhagan (2015) have further postulated that there is a positive relationship between diversity in employees' prior work experiences with their job performance. Consequently, a hypothesis was developed as follows based on the findings. H3: There is a positive impact of work experience diversity on employee performance. Findings of Millar and Tesser (2011) ,concerned with the moderating role of affective cognitive consistency in the relationship between attitude and behaviour. Allport (1935) defines job attitude as a physiological or a neutral state for willingness, formulated through practice. Velnampy (2010) found that attitudes namely satisfaction involvement and performance are significantly correlated. Saeed et al. (2013) has proved that diversity in attitudes of employees have posititively impacted their performance. Based on the existing literature, the fouth hypothesis was derived accordingly .H4: There is a positive impact of attitude diversity on the employee performance.



AD= Age Diversity, EB= Educational Background diversity, WE= Work Experience diversity, AT= Attitude diversity, EP= Employee Performance.

Figure 1: Conceptual Framework

Source: researcher's construct, 2020

Results

When considering the demographic analysis,one hundred and twenty executive level employees were considered as the selected respondents in order to study the effects of workforce diversity on employee performance. Out of 120 responses, 62.3%were male employees while 37.7% were female employees. When considering the Sri Lankan construction industry, it was observable that the construction industry has highly attracted male employees more than female employees. Based on the results of the descriptive statistics of this study, it was also observed that the sample was a representative portrayal of the composition of quintessential Sri Lankan construction industry which confines of more male employees than female employees.

Reliability Analysis is defined as gaining of proportion of systematic variation in a scale which will measure the degree of being free from error thereby yielding consistent results.George and Mallery (2003) have defined the following rules for alpha values. If alpha value exceeds 0.9 it is considered an excellent value. Alpha values that exceed 0.8 is considered a good value. An Alpha value that exceeds 0.7 is considered an acceptable value. Alpha values which exceed 0.6 are questionable, An alpha value that exceeds 0.5 are considered a poor value, alpha values below 0.5 are considered to be unacceptable. Thus, a reliability test was done to measure the internal constancy of the variables used in this study. Since the reliability coefficient attained by all the constructs were above 0.06, it could be proved that the reliability of the measurements used in this research study were high as depicted by the table 1 below.

Table 1: Reliability analysis

Variable	Cronbach's alpha	No.of items
Age diversity	0.720	6
Educational background diversity	0.735	5
Work experience diversity	0.810	6
Attitude diversity	0.705	6
Employee performance	0.740	10

Source: Survey Data (2020)

Under bivariate analysis, correlation is used to determine the relationship between the independent variables and the dependent variable including the direction of the relationship. For this study, Pearson's correlation coefficient was used to show the direction and the significance of the relationship. Based on the findings, it was evident that there was a positive association of the independent variables in terms of age diversity, education background diversity, work experience diversity and attitude diversity on the dependent variable,employee job performance.

Table 2: Correlation analysis
Source: Survey Data (2020)

	Standardized Coefficients Beta	t	Sig.
(Constant)		.186	.852
AD	0.378	3.105	.004
EB	0.369	3.068	.003
WE	0.143	2.348	.022
AT	0.231	2.364	.036

AD= Age Diversity, EB= Educational Background diversity, WE= Work Experience diversity, AT= Attitude diversity, EP= Employee Performance.

Furthermore, under predictive modelling, standardized regression coefficients were also considered to test the variance in employee performance which is explained by age,educational background, work experiences and attitudes.When considering the standardized beta value of the four independent variables, the significance values need to be less than 0.05 in order to be accepted as significant. Further, the result value of beta was found positive which depicts that the impact exerted is positive. The value derived for the impact of age diversity on employee performance was 0.378. A significant value of 0.004 was obtained. When considering the results of the second independent variable, it was evident that increase in educational background diversity would affect employee performance by 0.369. This impact was found to be significant with a significant value of 0.003. Moreover, the value derived for the impact of work experience diversity on employee performance was 0.143 with a significant value of 0.022. The value obtained for the impact of attitude diversity on employee performance was 0.231 and was also found to be significant with a value of 0.036. When further explained, it could be identified that variation in one unit of attitude diversity would result 0.378 variations in employee performance, variation in one unit of education background would result 0.369 variations in employee performance,variation in one unit of work experience would result 0.143 variations in employee performance and variation in one unit of attitudes would result 0.231 variations in employee performance. Thereby it was manifested that these four variables exerted a positive and a significant impact on employee performance. Hence all four hypotheses were accepted. The obtained results are displayed in the following table.

Table 3: Coefficients of variables
Source: Survey Data (2020)

	AD	EB	WE	AT	EP
AD	1				
EB	-307*	1			
WE	.210	-.230	1		
AT	.406**	-.067	.075	1	
EP	.543	.086	.268	.512**	1

Since the model is derived to analyse the level of assurance for employee performance, it was also required to investigate the overall predictive fit of the model. The predictive fit capacity is derived from the R 2 value, which obtained the value 0.443 for the model. In order to obtain the R2 value, the R value or the correlation coefficient was considered.The result for the correlation coefficient R for this model was 0 .688 a. This value speculates the degree of the association between the employee performance with the four independent variables of age diversity, educational background diversity, work experience diversity and attitude diversity.

Furthermore, the adjusted R 2 is taken in to consideration in order to reduce the inflation of the R 2 when more independent variables are added to the model. Based on the results as per depicted by Table 4 it was evident that the Adjusted R square value was 0.409. Hence it reflected that 40.9% of employee performance

is explained by the four independent variables and that there is a variance of 40.9% in the dependent variable due to the effects of the four independent variables used in the study.

Table 4: Model Summary

Source: Survey Data (2020)

Model	R	R square	Adjusted R square	Std. error of the estimate
1	0.688a	.443	.409	.18752

Analysis of variance (ANOVA) is a statistical technique performed to test whether the means of two or more groups are significantly different from each other. It also measures if the regression model used was good in predicting variables that influence the dependent variable. The results of the findings of this study indicated the significant value to be 0.000 which was less than 0.05. Thus, the model is overall fit of data and was good in predicting how the effects of four independent variables impact on employee performance. The results are shown in the table 5 below.

Table 5: ANOVA test

Source: Survey Data (2020)

Model	Sum of Squares	df	Mean Square	F	.Sig
1. Regression Residual Total	2.387 4.275 6.486	8 91 99	.458 .029	22.11 2	.000b

a. Dependent Variable: Employee Performance

b. Predictors: (constant), Age diversity, Educational background, Work experiences, Attitudes

DISCUSSION

Effective management of a diversified workforce is a challenge and a persistent need for any organization. In a dynamic globalized market diversity is recognized as an element of strength and uniqueness for organizations to stand out from the rival companies. Despite the complexity of the context, workforce diversity is paramount for any form of industry in determimg overall success and performance. Taking this importance in to consideration, this study was conducted to investigate the effects of workforce diversity on the work performance of employees with special reference to construction industry in Sri Lanka.

After studying previous literature, out of many independent variables of work diversity which have proven to have effects on employee performance, four variables were selected. Workforce diversity in terms of age, educational background, prior work experiences and attitudes were the indepedent variables used to measure their impact on employee job performance. According to the results obtained from the regression analysis of this study, it was revealed that there was a positive as well as a significant impact of workforce diversity on employee performance. When considering the results derived, the findings revealed that there was a positive and significant relationship between age diversity and employee performance. The results of prior research work also proved how the increase in age diversity positively impacted on employee performance. Age diversity if managed properly would bring positive outcomes to the organizations since different aged employees would stimulate and share diverse perceptions and understanings among each other. This feature could be positively employed in assigning and managing team work.

The results of this research study indicated that there was a significant and a positive relationship between educational background diversity and employee performance. Prior research work depicted by Odhiambo (2014) arrived at the same conclusions stating that there is a positive and a significant relation between educational diversity and employee performance. Hence the hypothesis made based on the prior research findings were further proved and established through the results of this study. An employee's level of education is determined through knowledge, skills and attitudes acquired through learning. Hence, an educated employee is an asset and a human capital. Similarly, a workforce with diverse knowledge on various fields of education would bring multiple rewards to an organization. Human resource managers should contemplate

on enhancing diverse levels of education in employees by providing continuous training and development to enhance multiple knowledge in them.

Moreover, the findings also revealed a positive and a significant relation of work experience diversity on employee performance. Previous research work conducted by Dokko, Wilk, and Rothbard (2009) also proved the positive relationship between the independent and dependent variables mentioned above. The management of the organizations can employ the diversity of work experience of employees through mutual learning by allowing the employees to share their expertise and experience with each other to improve themselves.

The results of the analysis further indicated that there was a significant and positive impact of attitude diversity on employee performance. The results obtained through regression supported this implication. In addition, it further established the findings of previous research work, postulating that there was a positive impact of attitude diversity on the job in terms of employee performance. Attitude is one of the hardest features to be managed and one of the most diverse factors that could be identified in an individual. Effective use of this feature can be successfully employed in creating a positive work culture, employee motivation and enhancing team work in an organization.

Finally , the results stipulated from this research could be utilized in providing recommendations to the senior management of the organization regarding the need to focus more on diversity management to improve the employee performance within the organization. It is also suggested that organizational leaders should formulate policies, laws and procedures on equal employment, regardless of employees' socio cultural background, ethnic group, sexual orientation and gender in order to reinforce mutual respect, creative thinking and innovation within the organization. The deployment of gender heterogenous groups instead of gender homogenous groups would also add creativity and smooth functioning to an organization. Moreover, it should also be ensured that the most qualified employees are recruited.The diversity among employees should be taken into consideration to improve the variety thereby improving an ingenious organizational culture and an environment. This could be adopted by relevant authorities inorder to make employees feel valued by the organization whilst enhancing their performance.

Conclusion

This research study aimed to identify the impact of workforce diversity on employee performance in executive level employees of the construction industry. In order to prepare the framework of the research, prior research findings and literature were used as the theoretical basement. The conceptual framework was developed accordingly selecting four independent variables with the dependent variable. the final results, the independent variables in terms of age diversity, educational background diversity, work experience diversity, attitude diversity on the job were proved to have a positive and a significant impact on employee performance. This research provided strong evidence to manifest the impacts of the aforementioned four variables on the dependant factor employee performance. The results of existing literature were further verified and supported through this study. However, this research was conducted limiting to two organizations thus the sample size could have beejn increaded otherwise. More studies should be conducted focusing on the impact exerted on other industries too, apart from construction industry. Also, this study recommends future researchers to deploy different other variables to explore their impact on the variance of the dependent variable. The findings of this research could be referred and applied by the management of organizations in effectively managing workforce diversity to derive optimum levels of employee performance.

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Abbreviations and specific symbols

AD= Age Diversity

EB= Educational Background diversity

WE= Work Experience diversity

AT= Attitude diversity

EP= Employee Performance

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Auto-generate Landmine Path, Digitize and Visualize the Data for the Sri Lankan Context

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Abstract: Landmines could be identified as affordable and effective defensive weapon, but it has many complexities. Human deaths and injuries, agricultural land degradation, destruction to infrastructure, environmental destruction, economic cost for demining humanitarian aid and etc. Those complexities cause due to the unconventional landmine fields which could be find it difficult to demine. To avoid that, landmines had to be laid according to universally accepted methods in a standard pattern. As per the International agreements, Sri Lankan security forces also follow the standards in warfare. But their data recording mechanism is manual and not efficient.The objective of this study is to introduce a new system to record positions of landmine data in digital format. The design of this research was accomplished in three stages, identification of current practice of data recording, develop the computer program to generate locations of landmines and data visualization and analysis using the result of the computer program. Therefore, through reviewing existing mechanism, lapses of existing system could be identified. By developing a computer program we could be able to auto-generate locations of each landmine on a landmine pattern by two initial inputs. Matlab has been used to develop the program which is a very powerful platform. Qgis is a highly demanded spatial data manipulating system, which is utilized in the visualization and analysis of data. The proposed system will be more convenient, efficient, effective, and accurate system that will avoid the malpractices of recording landmines.

Keywords: Landmine, Location, MATLAB, Minefield, QGIS

Introduction

Sri Lanka is one of the most strategically prominent states in the Indian Ocean region. From the past, Sri Lanka has been under many invasions. Sri Lankan Civil War could be taken as the latest example (1983 to 2009).

Sri Lankan security forces used many strategies to face and overcome this civil war. One of that is laying landmines. Sri Lankan Security Forces have not used them as an offensive weapon, but purely as a defensive measure. According to the UN, Sri Lankan Security Forces have laid protective minefields to prevent the terrorists from reoccupying rescued areas. These minefields are laid in keeping with universally accepted standards of laying to a specific pattern, following proper marking and recording procedures (Strategy For Mine Action Sri Lanka, 2006).

According to International Mine Action Standards (IMAS), a landmine is a 'munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or a vehicle'(Zucchetti et al., 2017). Fundamentaly, these Landmines can be categorized as Anti-personal landmines (AP) and Anti-tank (AT) landmines which are intended to defeat people and armoured tanks or vehicles respectively.

Since landmines are cheap and effective weapon there are many complexities of landmines. Human deaths and injuries, agricultural land degradation, destruction to infrastructure, environmental destruction, Medical and rehabilitation services exhaustion, economic cost for demining

humanitarian aid, etc. (Strategy For Mine Action Sri Lanka, 2006).

Furthermore, many countries are suffering because of unexploded and unconventional landmines laid in past wars since the World Wars. There are more, approximately 60 countries no longer involved in wars, but suffering due to over 60 million unexploded landmines which cause up to 25000 deaths/injuries per year (Kraenzle, 2000). Also, according to UNICEF there are exploded landmines more than 1 million by damging people since 1975, and are currently thought to be killing nearly 800 people per month around 64 countries. There are estimated 110 million landmines still lodged in the ground. They remain active for many decades since 1975. (The legacy of land-mines, 2020).

That is a considerable fact that effects human life, their activities, and the development of the countries. Many of these cases become complicated because of unconventional data, loss of data, less accurate data as well as failures of proper marking when landmines are being laid. Sri Lanka also faced this case and there were 593 civilian injuries reported due to landmines within four years of time after the war. Those were happened because of landmine fields laid by LTTE which were unconventional. So, it has been taken a long time to clear landmines in Sri Lanka. (Strategy For Mine Action Sri Lanka, 2006).

Sri Lankan Security Forces are laying landmines according to the universally accepted standards. Yet, all the data manipulation and recording of laying landmines are being conducted manually. Thus, the data about laid landmines are recorded in a record sheet (a paper) and a sketch of graphs in papers manually. Also, the practice is to measure the location coordinates of some important points (Starting point, turning points, and end point) of the minefield by using handheld GPS. Those coordinates might not be accurate. This manual procedure would be lead to unnecessary time consumption, recording less accurate data, and less afford. This recording procedure should be computerized and get use them efficiently by using positioning and mapping techniques in the surveying profession.

By developing a new system it would be able to record data accurately. The system consists of a computer program that could be able to extract the locations (coordinates) of landmines. The computer program has been developed by using 'Matlab' software and the results (coordinates of each landmine of the landmine path) can be store as digital version of documents as 'Ms Excel' sheets which are easier to manage, more efficiently, and more secured. Those coordinates can be used to develop mine maps. It is very efficient and accurate to develop maps by using those coordinates with a geospatial data management platform as Qgis.

Those maps could be very useful within the military operations as well as more efficient when performing the demining process. Also, those maps could be developed as conventional maps that show the areas with landmines by conventional signs, mine danger maps, and any other map according to a relevant operational purpose. Further the damage of each landmine in the minefield can be analyzed and visualized by using the Qgis software framework. Those data also could be visualized and analyzed by the backgrounds of web based maps.

Background Details

In this research, we consider one method which has been universally accepted by the UN. That is the strip method which is one of the most common and accurate universally accepted patterns used by Sri Lankan security forces. In strip method, there are relevant distances to maintain with each landmine and landmines are laying in two parallel lines separated by the baseline. There are four types of strip patterns are existing as Anti-

personal, Anti-tank, fragmentation, and mixed. This system is developed for Anti-personal, Anti-tank, and fragmentation patterns.

In the current process the GPS coordinates of the starting point, ending point and turning points of a mine field is recorded by using the handheld GPS with the other details such as the number of landmines, their type, special landmarks etc. Thus their accuracy is not as efficient as the survey-grade GPS.

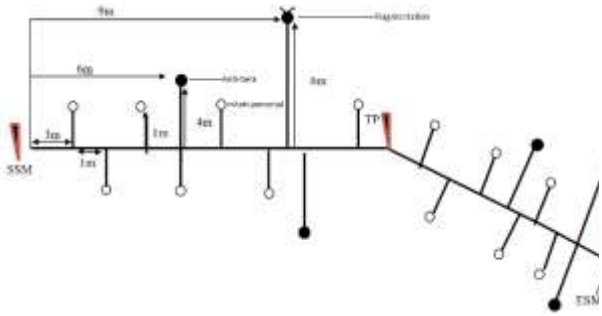


Figure 1. Strip pattern mixed landmine path

Source: Constructed by Researcher (2020)

As per Figure 1, there are standard relevant distances for each type of landmine and relevant gaps. Figure 1 shows the strip method with mixed landmine pattern. When it comes to the individual type of landmine pattern as Anti-personal, Anti-tank, and fragmentation the same distances are being maintained as per Figure 2. Figure 2 shows an example for Anti -personal type in strip pattern.

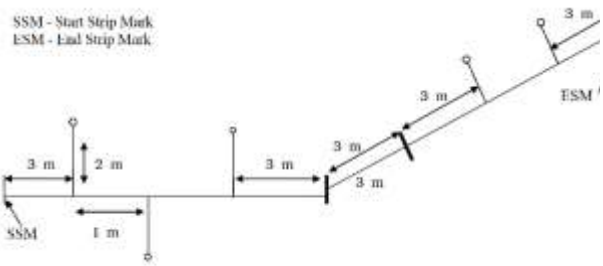


Figure 2. Strip pattern Anti-personal landmine path

Source: Constructed by Researcher (2020)

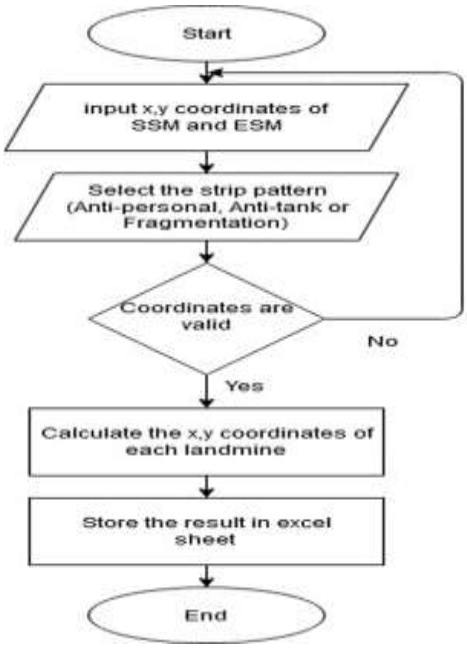
Experimental Design

When designing the research, three stages were identified, the identification of current practice of data recording, develop the computer program to generate locations of landmines, and data visualization and analysis by using the result of the computer program.

Developing of the computer programme

The computer program has been developed by using Matlab software which is flexible for mathematical and logical operations. Matlab is a programming platform that has been designed precisely for engineers and scientists and the most important part of this platform is the MATLAB language, which is a matrix-based language consenting the most natural expression of computational mathematics. (www.dw.com, 2020).

The computer program would return the result, the location (x,y coordinates) of each landmine in the landmine strip according to the initial inputs of the coordinates of the Starting point and the ending point known as 'Start Strip mark' and 'End Strip Mark' of the landmine strip. Those coordinates are being measured also in the manual method by using handheld GPS. Here it is recommended to measure the relevant coordinates by using a



survey-grade GPS which should be in SLD 99 or Kandawala system coordinates.

Figure 3. Flowchart of the program

Source: Constructed by Researcher (2020)

The program has been coded by using mathematical formulas. With the initial inputs, it could be able to calculate the gradient of the landmine strip. Each coordinate of landmines can be calculated by using the gradient and relevant standard distances to landmines in the landmine strip. There could be identified 'Mine raw', a single row of landmines. When there are two parallel mine rows laid simultaneously with the standard distances it is called 'Mine strip'.

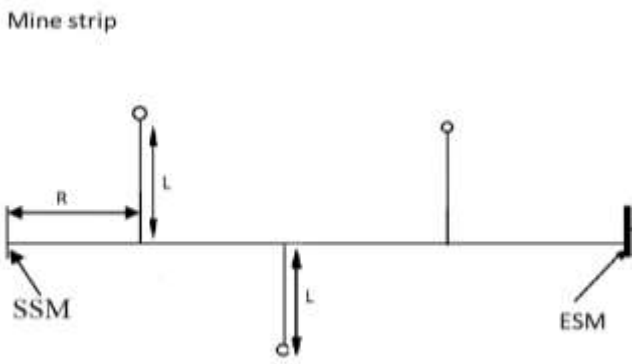


Figure 4. Mine strip

Source: Constructed by Researcher (2020)

Considering the gradient of landmine strip as 'q', and x, y coordinates of starting point and ending point as (xs, ys) and (xe, ye) respectively, the gradient of the baseline is calculated as follows.

$$tan\,(q) = (ys - ye)/(xs - xs)$$

A basic mine strip has been shown with Figure 4. 'R' is assumed as the distance to each landmine from the SSM along the baseline of the landmine strip. 'L' is the constant perpendicular distance to any landmine from the baseline of the mine strip. Also, assume that the x,y coordinates of any landmine included in two mine-rows is $(x1, y1)$ and $(x2, y2)$, then;

$$x1 = xs + R.cos(q) - L.sin(q)$$
$$y1 = ys + R.sin(q) + L.cos(q)$$
$$x2 = xs + R.cos(q) + L.sin(q)$$
$$y2 = ys + R.sin(q) - L.cos(q)$$

Those equations have been compound according to the gradient of 'mine strip' to get the result.

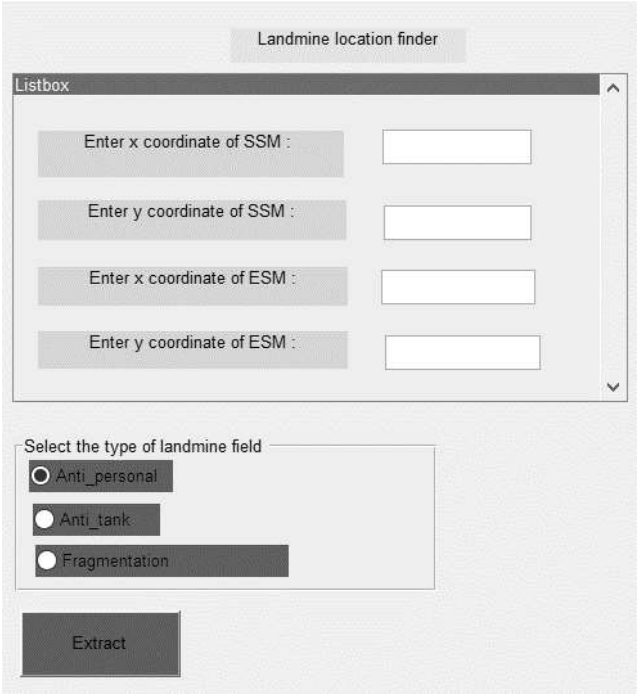


Figure 5. Interface of the computer program

Source: Constructed by Researcher (2020) in Matlab program

The interface of the computer program has been developed to enter x,y coordinates of 'SSM' and 'ESM'. Then to select the type of landmine field and to hit the push button named 'Extract' to get the result as per the Figure 5.

Result data visualization and analysis

The program will return the (x, y) coordinates of each landmine of the landmine strip, which is imported to the Qgis software for visualization. Qgis is free and open-source software that is highly convenient for spatial data manipulation. The result data could be visualized as points in Qgis software and then by using the software it could be able to develop maps, analyze danger buffer zones, open with web-based maps, add conventions, etc.

RESULT

Figure 6. Result visualization with background OSM standard map

Source: Constructed by Researcher (2020) in Qgis

Figure 7. Result visualization with background OSM standard map zoomed

Source: Constructed by Researcher (2020) in Qgis

Since the input coordinates are in SLD 99 coordinates, the result are also in the same. Those coordinates could be able to import to the 'Qgis' software and there can be visualized the landmine locations as a point layer. There it could be easy to visualize the locations of landmines as well as their places. Also, it could be able to analyze access to the area, the terrain, etc by observing the background map.

By using an "OSM standard" map or else "Google Labels" map to the background with the landmine points layer it could be possible to analyze the place or the relevant area landmines have been included. Also, it could be possible to identify land features near to the landmine field. The roads or paths near to the landmine field and could be analyzed the accesses through the landmine field.

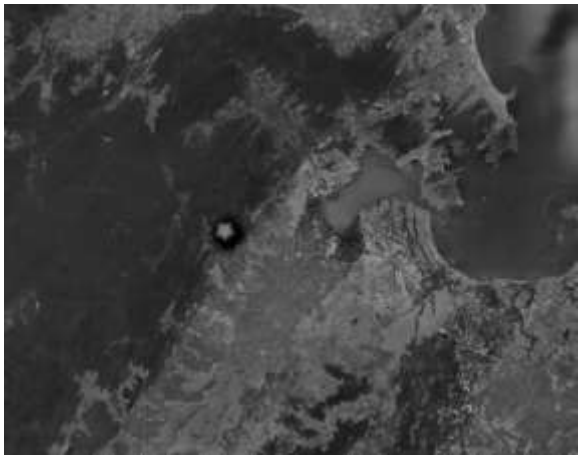


Figure 8. Result visualization with Google satellite map zoomed

Source: Constructed by Researcher (2020) in Qgis

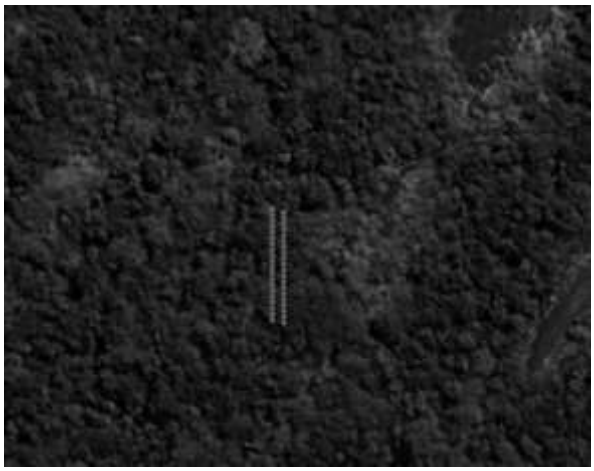


Figure 9. Result visualization with Google satellite map zoomed

Source: Constructed by Researcher (2020) in Qgis

Then by using the satellite based map such as "Google satellite" as background with the landmine points layer there could be able to analyze actual situation of land features near to the landmine field. Also, the terrain as well as the possibility of existing a landmine in a relevant location.

Also, the hazard zone could be able to generate by using the tools in Qgis. The buffer tool has been used there to show a convenient example.

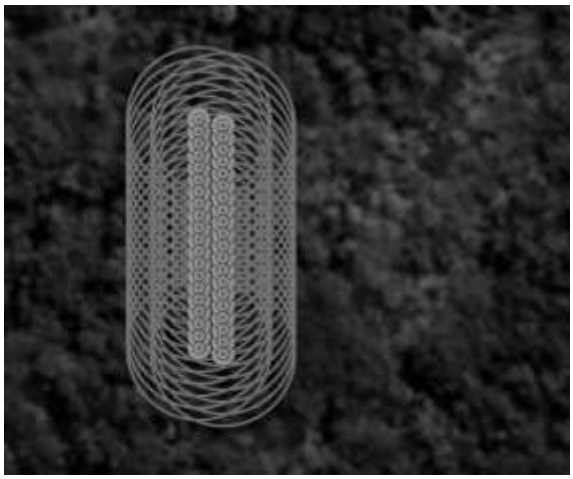


Figure 10. Buffer zones on hazardous areas by landmines

Source: Constructed by Researcher (2020) in Qgis

As per Figure 10, the yellow area having 1 m of radius of a circle could be highly dangerous and can cause deadly injuries or loss of life. A person could be injured, within the area of purple coloured, which is having 1.5 m radius of a circle. Within the blue circles there is posibility to have any damage. The outter side of the blue cirle is safe. Likewise, with accurate and precise data, the damage analysis, hazardous area analysis, or accessibility analysis can be done.

Further there could be able to develop conventional or any other maps for the use of military or security purposes. According to the requirements, the details could be used to find safe accessibilities for the demining process, for any military operation, resettlements, etc.

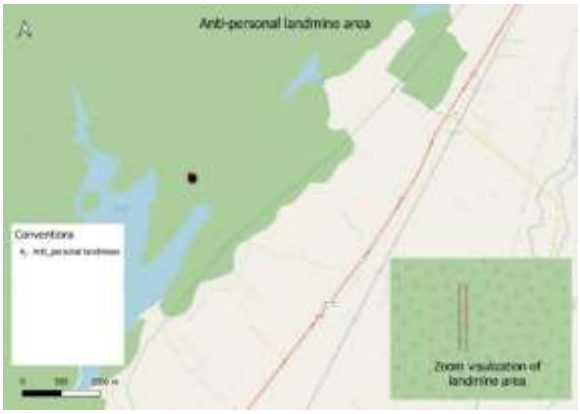


Figure 11. Conventional map on landmines

Source: Constructed by Researcher (2020) in Qgis

By using the result of the computer program it could be very easy, efficient as well as effective to visualize and analyze the landmine fields.

Discussion and Conclusion

Landmines are such an effective defensive weapon but that causes many complexities. There have been introduced standards follow when laying landmines and standard security forces accept those conditions and do accordingly.

Within the Sri Lankan context, the current practice is to record and store the data on laying landmines manually which is not accurate as well as efficient.

There have been introduced a new system to record the data as well as analyze the data on landmines which are being laid according to the universally accepted methods to a standard pattern. A program has been developed which records the coordinates of each and individual landmines and store them in a digitized file. This is very effective, efficient, accurate as well as safe. The program has been developed by using Matlab software which is highly demanded on logical programming operations and very accurate.

Then the location of landmines has been visualized and also have developed some of the analysis applications by using Qgis software an affordable spatial data

manipulation software. With that, there could be able to develop many applications and these results could be able to avoid the complexities of landmine fields. For the military operations, demining processes, go areas and no-go areas analysis and more advantages could be carried out by using this introduced new system.

There in this research, it has been introduced the system only for one standard pattern and that can be able to develop to get used for many standard patterns and that would be applicable to other countries also. Hence, data visualization and analysis can be also further developed by using high-resolution background maps and other spatial tools.

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