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The Dawn of Humane Leprosy Segregation: Transforming Leprosarium into Home

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ABSTRACT

Leprosarium or leprosy asylum has always been associated with cruel segregation of leprosy sufferers from the society. However, humane approach was suggested in the international arena in 1923 to reform the former unsympathetic compulsory segregation to make leprosy sufferers "human" again. Prior to this revelation that leprosarium should be attractive to persuade leprosy sufferers to admit themselves voluntarily, missionary organizations have been establishing humane leprosarium that mirrors a home rather than an institution. There are studies on the eminent Mission to Lepers, such as Kakar (1996), Buckingham (2002), Joseph (2003), and Robertson (2009). However, the architectural and planning idea of the missionary organizations, which is disparate from the conventional leprosy institutions established since the medieval time, has yet to be studied. The aim of this paper is to identify the idea and principles of humane segregation in leprosarium practiced by missionary organizations, especially the influential leprosarium model by Mission to Lepers. It is carried out through content analysis on missionary books, reports and biographies, leprosy journals, newspapers, drawings, and photographs. The analysis enables the identification of unique spatial planning and built form of missionary leprosarium model. The findings showed that missionary leprosarium model imitates the natural village to create a sense of home for leprosy sufferers, and self-sustainable in character. Missionary leprosaria are also community-driven and semi-autonomous. All this has accredited missionary leprosy organizations as the forerunner in humane leprosarium design that thrives in the 1920s to 1930s. This study would be able to help us to understand how architecture was utilized as a tool in disease prevention yet aspired to preserve the humanity among leprosy outcasts. Further research can be done to enhance the study such as human perception and psychology towards the architectural design of leprosarium and the socio-cultural impact on the residence as well as the society.

1. Introduction

'Leprosarium' or 'leprosaria' in plural form, is an exclusive institution that segregates leprosy sufferers from the society to prevent the spread of disease and as a medical treatment laboratory (Lim, 2013). Leprosy had impacted humankind for centuries and was no-stranger to ancient civilization such as China and Egypt. During the Middle Ages in England, leprosy sufferers were required to wear mask and hideous clothing to conceal disfigured face and body. They carried a bell along as a warning to others, announcing their unwanted presence (Haggard, 1929:131-134). In the past, leprosy has religious attachment, way before it became a public health issue. European medieval leprosaria were built annexed to the church building, such as the Kronoby Hospital in Finland shown in Figure 1. '*Li-Ren-Fang*', the first recorded leprosy asylum in China, was annexed to a Buddhist Monastery.

Leprosy then became a global phenomenon at the end of 19th century. The discovery of '*Mycobacterium leprae*', the leprosy germ, by Dr. Gerhard Armauer Hansen in 1873 contradicted with former hereditary theory and initiated the global urgency to device strict segregation policies. The first International Leprosy Conference in 1897 urged governments to apply compulsory segregation on leprosy patients as the best method against the disease and the Norwegian model was brought into limelight in the meeting to prove the feasibility of segregation method. Due to immense pressure from local and international parties, establishment of leprosaria around the world was unstoppable. There are still leprosaria that survived today, not as a place of segregation but a place where aged leprosy survivors spend the remaining day of their lives.

1.1 Background of the Study

Humane segregation approach was first proposed internationally at the third leprosy conference in Strasbourg in 1923. One of the resolutions passed in this conference, which was not present in the previous conference, is segregation of leprosy sufferers should be humane and

Figure 1: *Kronoby Hospital in Finland, accommodates leprosy patients in rooms (N), attached to church (M), where patients view into the church through tiny window (C) (Source: Richards, 1977:85)*

remain in the proximity of their family. This transformation in segregation policy has reform the previous institutional-like leprosarium and continues to evolve into the next decade by main advocator 'British Empire Leprosy Relief Association (BELRA). However, humane segregation approach was already in practice prior the international accord.

Since the first major evolution of leprosarium architecture occurred through the establishment and success of Culion Leper Colony, leprosaria has took lesser form of a hospital or asylum and more of a human settlement. The usual hospital type of leprosaria observed in Europe prior to the 18th century anteceded by cottage houses such as St Giles Leprosarium built in 1915.

Champa leprosy asylum in India was mentioned as a model leprosarium in a gathering of leprologists and asylum superintendents at Calcutta in 1920. Its architecture was shared in the conference as a fine example to be followed in the future direction of leprosarium construction in India – one of the most leprosy endemic regions. The leprosarium management discussed in this conference and in India has inspired some important leprologists such as Dr Ernest Muir, who was one of the key person at BELRA.

1.2 Definition of Humane Segregation of Leprosy Sufferers

The term 'humane' basically means compassion and relieving human sufferings. Thus, humane leprosy segregation can be defined as to approach leprosy sufferers as human rather than agent of disease. Previous leprosarium function as 'dumping site' to incarcerate leprosy sufferers away from the healthy public. Segregation of leprosy sufferer was nevertheless an inevitable part in leprosy prophylaxis. Therefore, leprosarium was reformed to provide them better living environment despite they have to be segregated from the outside world.

According to the conference in Strasbourg, humane segregation is led by segregation policy that is custom-made to native condition and feasibility. It means that one policy should not be applied in all regions and circumstances. The location of leprosarium should also be at the proximity of patients' family and efficacious treatment is available. The resolution only suggests compulsory segregation on pauper leprosy sufferers.

1.3 Significant of Study

Though many leprosy survivors contributed to the expansion of this history through oral testimonies, the recent demolition of leprosaria around the world had awaken us to look into this architectural product that bears cruel segregation practice in human history, which had affected millions of leprosy sufferers and their descendants. However, the humane leprosarium typology was scarcely discussed. Although it has ample contribution to the evolution of leprosarium, it did not receive much attention compared to its former typology.

The humane approach to segregation of leprosy patients has been long practice by missionaries. Missionary's leprosaria offers shelter and care to leprosy sufferers and ultimately to establish a Christian community. As this disease was perceived to be incurable, building a Christian community among leprosy patients was both practical and pious. Due to the strong missionary participation as well as disinterest of the colonial state in India, the Christian missionaries hold a significant role in disseminating modern western medicine for leprosy (Kakar, 1996). Even Gandhi pointed out the significant role missionary plays in leprosy prophylaxis work in India because there is no one else taking up this burden (Rogers, 1946).

Mission to Lepers was the first missionary group founded uniquely to serve leprosy sufferers (Joseph, 2003). Their contribution started in British India and then expanded to other regions such as China. This 'missionary model' inspires the forthcoming humane leprosarium evolution in the 1920s, including BELRA's leprosarium scheme. There are studies on the eminent Mission to Lepers, such as Kakar (1996), Buckingham (2002), Joseph (2003), and Robertson (2009). However, the architectural and planning idea of the missionary organizations, which is disparate from the conventional leprosy institutions established since the medieval time, has yet to be studied.

1.4 Objectives

The purpose of this paper is to identify the idea and principles of humane segregation practiced by missionary group, especially the significant leprosarium model by Mission to Lepers, and to demonstrate this new typology of leprosarium functioned more effectively as an architecture for disease prevention comparable to the former typology.

2. Methodology

This study employed content analysis method in order to understand the humane segregation principles in missionary leprosarium model. Content analysis is conducted on books written by Wellesley Bailey (founder of Mission to Lepers) especially three books recording his

travels and John Jackson's books on history of MTL, articles and reports written by leprologists and physicians, social historians, conference papers, drawings and photographs. The same method was also used to assess the strict and institutional-like leprosaria from widely read books on the topic on leprosy segregation such as 'Leprosy and Empire: A Medical and Cultural History' by Rod Edmond and 'Leprosy, Racism and Public Health' by Zachary Gussow, official reports, medical journals, drawings, and photographs of these leprosy institutions.

From the sources mentioned above, three types of data, which are (1) the building program, type, form, and spatial configuration of leprosaria constructed or funded by missionaries; (2) the principles and requirements established by Mission to Lepers in the construction of leprosaria and; (3) the segregation approach and the architectural characteristics of the former institutional-like leprosaria, were retrieved. The data collected from (1) and (2) on the missionary leprosarium model were analyzed in comparison with data (3) on the strict institutional-like leprosarium architecture.

The findings are categorized into three sections that discussed on the main design principles that attributed to the success of missionary model as humane leprosarium.

3. Findings and Discussions

3.1 Establishing a Home for Leprosy Patients

Generally, most of the buildings constructed for the purpose of medical treatment are in the form of institution, where it is hygienic, uniform, bland and furnished with modern equipment. Ever since the beginning, Mission to Lepers built leprosaria in simple form of houses in pleasant environment with no visible mark of confinement. The basic built form of their leprosarium is in the form of houses, where leprosy sufferers could re-establish a new community life in the leprosy colony. Mission to Lepers established their first leprosarium in Chamba, India in 1875. Chamba leprosarium has eight houses surrounded by scenic environment and fertile valleys. They build the first church for the leprosarium in 1877, which was used as school and venue for gathering. This is because Mission to Lepers believes that spiritual comfort is equally important in addition to physical and emotional relief. From the first observation on the approach employed by the missionary, leprosarium is defined as a place of refuge and comfort; it is not defined as an institution to segregate leprous people from the society.

Referring to Maslow's hierarchy of human needs, architecture that provides a sense of belonging and intimacy, which we usually found in our home, fulfills the third level of human need. Former harsher leprosaria generally only fulfilled the lowest level, which is food and shelter. Thus, the segregation method and leprosaria established by missionary demonstrates its humane design by being sympathetic to human basic needs.

In 1904, Mission to Lepers assisted in constructing a new home for the leprosy sufferers in Tarn Taran in Punjab, to replace mud houses of 200 to 300 patients (Jackson, 1910:36). Instead of hospital wards, Mission to Lepers builds co-shared houses for its patients made from local materials. The most apparent reason why missionary shelter leprosy sufferers in houses instead of wards is most of the sufferers were able-bodied, like any normal human being. It was just because of the hideous outward appearance that causes them to be ostracized. Thus, it was not necessary to place them on beds, in a ward building. They needed a

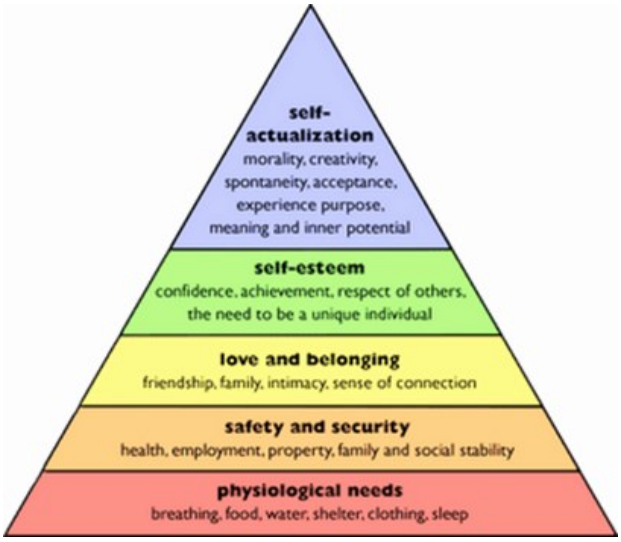

Figure 2: *Maslow's Hierarchy of Needs (Source: healtharchitecture.wikifoundry.com)*

home and not confined in an institution. How does the missionary built a home for these leprosy sufferers?

3.1.1 Leprosarium with a Natural and Pleasant Surrounding

Greenery landscape has always contributed to healing environment as it brings aesthetic values to the setting and improves human emotional health. Leprosarium located in such context reaped health benefits such as clean air produced to its environment. Bailey visited Almora leprosy asylum in 1881 shown in Figure 3. This asylum was one of the first four settlements aided by Mission to Lepers. Bailey described his journey through the little gate and a walk amongst fir trees leading to the settlement. The leprosarium appeared to him like a private dwelling (Jackson, 1910:24). Almora leprosy asylum was built on a hilly area and surrounded by trees and greenery. The patient's houses are constructed in terraces. The women's residences were located at the highest terrace while men's at the lowest. The married patients' houses were situated between the single men and women residence.

Such description on leprosarium seems to be analogous to the popular hill stations during British Raj. Hill stations were favored by many British officers due to the belief of its curative environment. The gardens around the hill stations offered peace and harmony to human

Figure 3: *Almora leprosarium built on terraces (Source: Bailey, 1888:iii)*

(Kennedy, 1996:47). This site planning strategy in missionary leprosaria model was reiterated in the later influential leprosarium model by the British Empire Leprosy Relief Association, BELRA. Prominent member of BELRA, Dr. Muir, included healthy site with good and fertile soil as essential requirement in his guidelines of establishing a good leprosarium. Besides offering a healing environment, healthy natural site has provided patients good cultivation grounds.

3.1.2 Human-scaled and Intimate

In his book 'Towards a Humane Architecture', Allsopp suggests a return to the village houses in the past, and rejects the monotonous housing design. He believes building should be human-scaled and intimate in order to be humane (Allsopp, 1974:80). A general layout and form of leprosy patient's house was presented by P.A. Penner at the 1920 Calcutta Conference. In his paper, "The Best Type of Wards", Penner described his quintessential house for leprosy patients based on Champa asylum in the region of Chhattisgarh (Penner, 1920). The house plan as shown in Figure 4 is 48ft long and 31ft wide, divided into three rooms of 12ft by 14ft. Each of this room can accommodate up to four patients and has a common 7ft wide open verandah space. This verandah area is designed as cooking space but can be used as sleeping area if needed. The house was also deliberately designed to allow abundant fresh air through windows, transoms and low-partition wall. According to Penner's house plan, it offers about 11.5 meters squared of space for each patients. The accommodation of living space is slightly larger compared to the typical barrack British built to house their workers in the colonies. Furthermore, leprosy patients did not have to share with a large number of people in one building.

Total of forty-nine leprosy workers from governments, mission, private organizations, Ernest Muir, and Issac Santra attended the Madras Leprosy Conference held in 1933 to discuss how the resolution of the

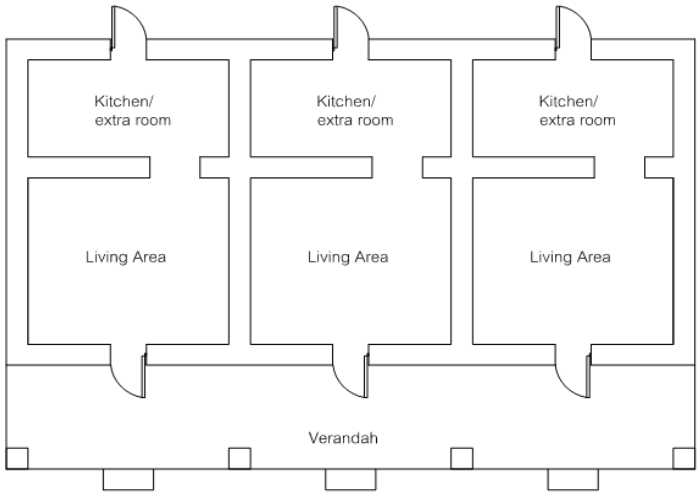

Figure 4: *A sketch of the patient's quarter according to Penner's proposal (Author)*

Calcutta Conference could be applied. Two leprosy institutions were suggested which were a large self-sustained colony and a voluntary colony just formed outside their own village ("Reports: Madras", 1930). This leprosarium scheme was important because it was later used as a fine model to follow in the construction of leprosaria in India and was also recommended by Ernest Muir in his book published in 1921 'Handbook on Leprosy: Its Diagnosis, Treatment and Prevention'. Muir's proposal became a guideline for planning and constructing leprosarium, especially on behalf on the influential humane advocator 'British Empire Leprosy Relief Association' (BELRA). This spatial planning of patient's house has certainly revolutionized the architecture of healing or disease prevention. Instead of ward pavilions, these human-scaled leprosarium co-shared houses gave patients sense of intimacy and community.

Figure 5: *Front view of the patient's house at Tampoi Leprosarium (Author, 2009)*

Figure 6: *Back view of the patient's house at Tampoi Leprosarium (Author, 2009)*

The patient's houses in Tampoi Leprosarium at Johor shown above in Figure 5 and Figure 6 has similar form and layout as Penner's proposal. Each room in the building, which can accommodate two patients, has one and a half storey of volume with windows and air vents. Tampoi leprosarium was built in 1928, thus suggested a legacy of missionary model.

Cochin leprosy asylum was one of the earliest leprosaria founded in India and it was established by Dutch missionary. It has two rows of houses and each row was assigned to each gender. One discernable planning strategy observed from the explanation above is gender segregation. Though leprosarium was designed to be intimate, the only contrast between leprosarium and a normal village is that male and female cannot reside together. Segregation according to gender is a common prevention measure in western medicine (Kakar, 1996). Yet, it was not for the same purpose. Leprosy asylums in India in the early

nineteenth century did not segregate patients according to their gender such as in Tarn Taran in 1886. Many children were born in the settlement due the absense of this restriction. The official proposal of segregation male and female patients in leprosarium was presented in a conference in Purulia in 1908. According to Mission to Lepers, male and female's living compound should be constructed apart as far as possible (Jackson, 1910:20). Instead for the reason of privacy and medical convenience, gender segregation was to avoid sexual intercourse among patients that leads to offspring, which might contract leprosy as well.

Segregation according to gender and discouraging marriage within the leprosarium received strong opposition from Indian sufferers. Most of the leprosaria in India separates male and female patients but there some exception such as Dharmsala in Bombay (Bailey, 1899:170). Bailey agreed on gender separation in leprosarium though the separation of married couple was against Christian teachings. Ultimately, gender segregation in leprosaria remained as one of principles in missionary model though the practice still varies in different location. Other than religious reason, gender separation within leprosarium was to avoid leprosy contagion from adult to children, who are more susceptible to leprosy disease. The untainted children born from patients must be separated from their parents and send to another institution outside the leprosarium.

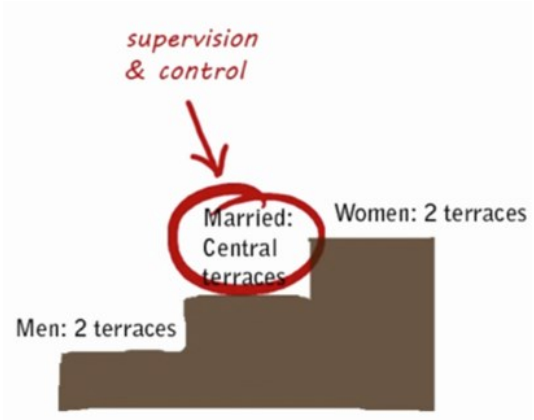

Figure 7: *Sex segregation in terrace arrangement at Almora asylum (Author)*

3.1.3 Organic Arrangement

The Mission to Lepers built a leprosarium two miles away from the city of Chumba. This leprosy colony has two compounds categorized by gender. Two rows of huts made from local materials were constructed for male patients. It is arranged in such a way it forms a common space in front of these houses. There was only one row of houses for female patients but it was constructed nearer to the river. The living environment that balances human and nature, such as the organic feature of a village and the communal atmosphere brings pleasure and enjoyment to the residents (Allsopp, 1974:91-92). Therefore, to establish a humane leprosarium, the arrangement of patient's houses should not be rigid or in massive scale. The whole leprosarium complex should be broken down into smaller form and distributed on pleasant landscape.

Mission to Leper's approach in building leprosarium alike to a village or human settlement is analogous to the social reformer William Booth. The founder of the Salvation Army, Booth proposed a solution in 1890 to reform urban poor by establishing a settlement for the hopeless. Booth did not adopt the workhouse typology, which was a widespread architectural solution for urban poor in Europe during the Victorian era. Booth suggested a farming colony instead. He repeatedly mentioned the first step to social reform was to create a decent, healthy and pleasant home, or assisting them to build one for themselves (Booth, 2008:212). The farm colony or settlement suggested by Booth was a self-sustained, self-governed and educative human settlement.

Figure 8: *A view of Hadleigh farm colony established by the Salvation Army (Source: hadleighhistory.org.uk)*

A rigid planning of patient's houses similarly to military barracks should be avoided. An example of a uniform, rigid and strict planning of leprosarium can be observed from the Kikuchi Keifuen Leprosarium in Japan shown in Figure 9. This institutional-like leprosarium was built in 1909, a result of Japan's Leprosy Prevention Act passed in 1907.

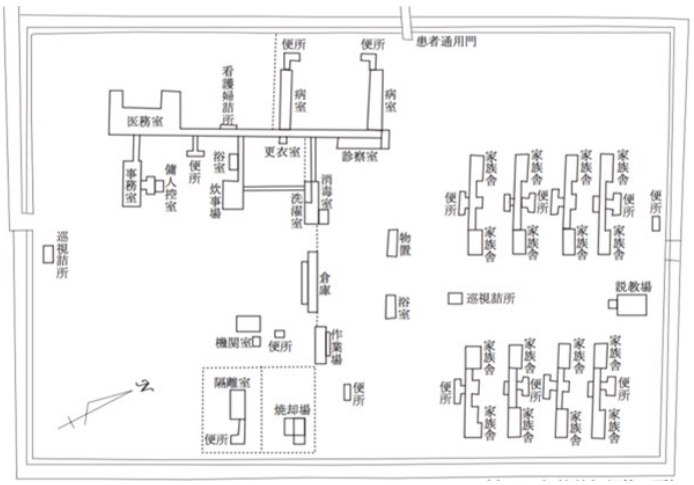

Figure 9: *Keifuen Leprosarium was built in 1909 (Sakaino, 2007:51)*

Most of the medical institution built during epidemic, such as leprosy, focuses on the functionality of the structure, not so much on the aesthetic. Nonetheless, some leprosaria are not built in haste and its appearance do matters to a certain extent. Carville leprosarium in the United States showed in Figure 10 was originally founded on a plantation ground and became an icon of modern medicine, with impressive white neo-Classical building complex in 1930. Leprosy patients lived in an institutional-like environment, rather than 'home', and lead a non-communal life (Fairchild, 2004). Even as referring to the seemingly comfortable and modern Carville leprosarium, editor from a major regional newspaper called it inhumane and senseless, when the officials mentioned inmates in the famous leprosarium was guarded from absconding the institution until they are paroled (Moran, 2012:166).

Figure 10: *The modern Carville leprosarium, patients lived in hospital wards and its architecture allows movement between wards only within an enclosed corridor (right) (HRSA)*

3.2 Leprosarium as Self-Sustainable Human Settlement

As idleness is not a virtue in mission leprosaria, all able-patients were either work, trained or educated to contribute to their new home. Most of the leprosarium under the management of Mission to Lepers has lands for farming or agriculture next to their settlement. The agricultural products will be divided among all the patients (Jackson, 1910:70).

Figure 11: *In Purulia Settlement, patients would work on fields to sustain their community (Source: Jackson, 1910:62)*

The principle of self-sustainable settlement in missionary model was just for economical purpose in the beginning, because growing food in the settlement done a great deal in reducing the cost for operating the leprosarium. During the early 20th century, research has proved that agricultural work does more than just providing food for the patients but also more speedy recovery and happier spirit, because working outside exposes them to sun and fresh air.

Leprosaria in Korea were built and managed by missionaries, such as Mission to Lepers, due to financial limitation (Fowler, 1930). Bailey visited Korea in 1913 and was impressed by the mission work among Korean leprosy sufferers and later raised funds to construct better buildings for them. As a result, more leprosy sufferers came voluntarily and form a self-support community within the leprosarium (Lewis and MacPherson, 2007:80). The two main leprosaria under Mission to Lepers are in Taiko and Yoshu. Robert Manton Wilson, a missionary from Southern Presbyterian Church in America, established leprosarium in Kwangju in 1909, which was later, moved to Yoshu. Wilson strongly encourages industrial work among leprosy patients. He stated that though the merchandises that the patients made were not for market, some colonies do sell to outsiders but only after it was sterilized. Wilson quoted a phrase "Faith, oil, work, but the greatest of this is work" to emphasize that work is indispensable in patient's life routine to fight the disease, apart from having faith and treatment oil (Wilson, 1930).

Mckean Leprosy Colony in Chiang Mai was established in 1908 on the southern part of Koh Klang (Middle Island). It was the first land granted by the government to leprosy sufferers. The ruler, Chao Inthwarorot Suriyawong donated the 164-acre of land to Dr. James McKean in 1907. The earliest houses were bamboo huts and their houses are grouped in villages. There were dormitories as well as small cottages for patients who can take care of themselves but male and female patients lived in separate villages. Many of the construction involved patients and with the hands-on effort, they took pride in their work and inspire other idle patients. The colony was built in the image of Siamese village, with houses on stilts and beautifully carved gable-end roof.

Figure 12: *Farm next to bamboo huts in McKean Leprosy Colony (McKean Rehabilitation Centre)*

Mission to Lepers was the main financial contributor to McKean Leprosy Colony from 1909 to 1917. Later during the Depression years, as McKean could barely support all the patients, the leprosy colony unintentionally becomes an educating and training centre because many trained patients resettled in different places to expand the work on leprosy treatment and religious faith.

3.3 Leprosarium as Semi-Autonomous Community

Unlike strict segregation in institutional-like leprosaria, leprosy sufferers in missionary leprosaria were not abandoned without care, even though medical provision was scarce. Leprosy patients were given power to manage their own community. Missionary leprosaria were built with very similar guidelines in building native churches. Missionaries were trained to establish Christian settlement that are self-governed and self-support. The self-supporting feature of missionary leprosarium model has been discussed above (Section 3.2). Leprosarium is still considered a semi-autonomous community because there is still a hierarchy of power between leprosy sufferers and the physicians. Nonetheless, leprosy patients were able to enjoy their freedom in managing their leprosy settlement. This approach also offered patients sense of dignity and control in their lives. A great example of such settlement under Mission to Lepers is Purulia Leper Colony.

3.3.1 Management and Maintenance Handled by Patients

Purulia leprosarium is the largest and perhaps the best example of Mission to Lepers's leprosarium model. The leprosarium is situated in a 'well-wooded' ground of fifty acres, housing almost seven hundred people including untainted children and health workers. Sir John Woodburn, the Lieutenant-Governor of Bengal then, commented Purulia as a model of compassionate approach in attracting leprosy sufferers without compulsion and walls (Jackson, 1910:79).

Figure 13: *Patient's houses in Purulia settlement has three rooms that accommodates four patients each (Source: Bailey, 1899:122)*

Muir commented that the self-governance approach practiced in Purulia settlement worked exceeding well (Muir, 1921:101). Purulia leprosy settlement was remarked as having 'well-devised' building scheme and that it has a symmetrical plan with houses built separately and ample spaces between each (Jackson, 1901:55). The housing compound was categorized into four main residential zones, which are reserved for male, female, boy and girl patients. The houses were uniform in size and have three rooms. Each room houses four leprosy patients, making twelve residents in one house. This human-scaled house has simple and clean facades.

Each of these houses has an appointed headman or headwoman. These leaders in each house took on the role of keeping peace, distributes food, as well as looking after the welfare of their members in the leprous community. This strategy in missionary model has lessened the burden of their caretakers. The strong and fit leprosy patients in Purulia settlement would help their other fellow sufferers who were too weak to take care of themselves (Jackson, 1901:60).

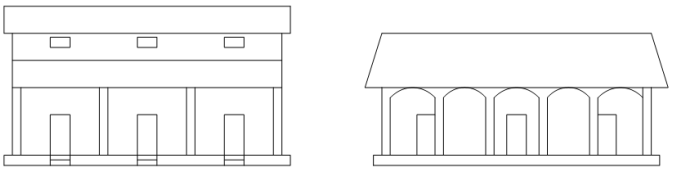

Figure 14: *A sketch illustrating the simple elevations of patient's house in Purulia colony (left) and Champa colony (right) (Author)*

From the sketch above, illustrating leprosy patient's houses in Purulia and Champa, shows similar guidelines in designing patient's residence. Both have three rooms per house and could accommodate up to twelve patients.

Leprosy patients in McKean leprosy colony selects their 'village elder', which what they commonly practiced too in normal native village. The security in the colony was not handle by outsiders but by the members of their own community. The leprosarium has their own police force to keep peace in the settlement (News, 1949:145).

3.3.2 Leprosarium as Educational Centre

Large leprosarium such as Purulia was functioning as teaching centre as well by training ex-leprosy patients and health workers to serve in the leprosarium ("This Spreading", 1974:31). Purulia colony was established in 1888 and the number of admissions grew rapidly and has about six hundred people at the turn of the century. Patient's previous dire living environment was transformed to be more airy and spacious (Jackson, 1910:131).

All able-bodied patients worked in the leprosarium. There is a large land for agricultural activities and also brick-making for building structure in the leprosy settlement (Jackson, 1901:55). Besides entertainment facilities, leprosarium also includes workshops. Not only that the life of attending school and work in the leprosaria helped the sufferers to forget their affliction, leprosy patients were equipped with skills that they might not obtained outside leprosarium. They do not only feel useful but they indeed becomes a productive community.

In the later humane leprosarium model, it continues to employ self-governed and educative characteristics. This practice has proven to be extremely valuable and essential during the discovery of effective cure for leprosy because many leprosy patients were able to support themselves after discharged from leprosarium. By 1929, the leprosarium has a unique building for leprosy patients with tuberculosis, a mortuary for post-mortem research, and dressing stations ("Mission to", 1931). Physicians and leprologists soon visited leprosaria around India and the world for research. Leprosarium was then transformed from an ailing community to a relevant center for medical breakthrough.

This is a description on Purulia Leprosy Colony in the early twentieth century:

"It is really a splendid place, wonderfully planned and executed. The houses are

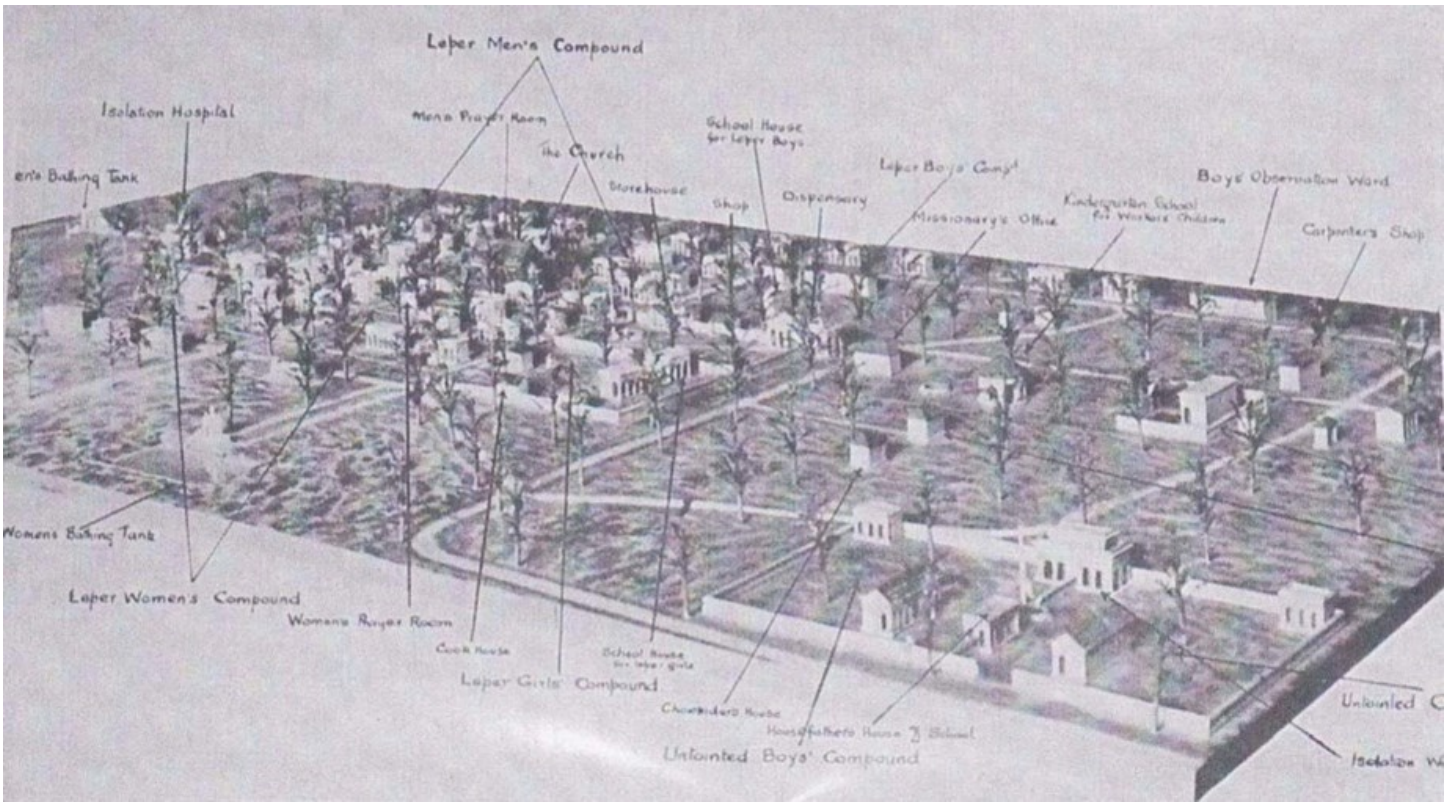

Figure 15: *A photograph of a model for Purulia Leper Settlement in India (MTL)*

strong and look very picturesque, being colour-washed in different hues. There are groves of trees all over the grounds, which are so spacious as to make a journey through them a good long walk."

The description above resonates curative environment that almost appear like a utopia for leprosy sufferers. The leprosarium offers more than mere shelter to its patients. The Purulia community was provided with a normal life routine where they enjoyed sports and music instruments (Jackson, 1910:164).

Figure 16: Native physicians and untainted boys were trained as health workers in the settlement or sent out to serve other leprosaria (Jackson, 1910:62)

4. Conclusion

Following the failure of compulsory segregation policy, harsh living environment and strict institutional-like buildings, leprologists came to acknowledge that to effectively stamp out the disease, leprosy sufferers have to come forward voluntarily. Segregation practices are both socially and financially challenging to many governments as leprosy issue gradually became a public health issue and an obstruction to national progress. In such timing, missionary method of segregation and leprosarium planning was perceived as an apt solution. The lack of attention and commitment from the government has aided missionary leprosarium model to flourish in many parts of the world. A long-term health institution such as leprosarium that replicated the external social environment akin to a normal human settlement has proven to be a more effective alternative in leprosy prophylaxis.

The missionary leprosarium avoided the orderly barrack planning and was broken down to smaller unit of houses and arranged in less intimidating configuration. Leprosarium as a human settlement also proved to be feasible during disease outbreak because of its self-sustainable ability. Leprosarium architecture and planning that imitates the natural village, self-sustainable, community-driven and semi-autonomous has brought missionary organizations as the forerunner of humane leprosarium builder, which later rise and thrive in the 1920s to 1930s. Missionary model of leprosarium has demonstrated that architecture built for plague did not have to be pathetic. It can be functional and humane at the same time.

In fact, missionary leprosarium model has produced a unique form of human settlement, a western legacy in tropical countries extended beyond disease prevention method. The missionaries were engineering an ideal, utopian, self-sustainable indigenous Christian community. The leprosy care and leprosarium construction contributed by missionaries, especially Mission to Lepers ultimately has a core purpose of evangelism. Missionaries acknowledged that by building a physical exclusionary world with 'homelike' environment has curative and moral reform effect. The physical environment in missionary leprosaria

was constructed in a way to reform its residents. Besides providing care and compassion, missionaries often view their responsibility in civilizing the seemingly 'backward' lifestyle of the leprosy sufferers. Leprosy sufferers were 'spiritually' civilized through religious teachings and were 'physically' civilized through hygienic practices, sexual abstinence, reject idleness through work, and contributing back to their community. It was proven to be a productive human settlement because patients were able to continue working, training, and learning, even within a segregated community. Relationship among patients and between health workers was also fostered in proximity amid facing a common struggle.

Even though missionary method was considered too 'soft' and inadequate in later 1930s, which legitimized the re-implementation of strict and authoritarian leprosaria in Nationalist model, this study has led us to understand how architecture was utilized as a tool in disease prevention yet aspired to preserve the humanity among leprosy outcasts. An architecture of human segregation can strived to be humane by providing a home environment to patients, be self-sustained through the hands of residents themselves, providing leisure and education as crucial for human development, and a productive self-govern community.

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The Need for Professionalism and Competencies in the Construction Industry

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ABSTRACT

The quantity surveyors, in the present day construction industry, analyze cost components of a construction project in a scientific way and applies the results of the analysis to a variety of financial and economic problems confronting the developer and the designer. However, competence, in any sphere of work, can be a difficult concept to pin down, especially, when it relates to professional occupations where such roles are complex and involved diverse professionals in the built environment sector. This paper aims to investigate the competencies of quantity surveyors in the discharge of its professional duties by evaluating the effects of professional competency on quantity surveying practices in Nigeria. The study population comprised professional quantity surveyors who are in the private construction/consulting firms in Lagos State, Nigeria. Data were obtained to investigate the professional views on the quantity surveying profession, the roles of quantity surveyors in the construction industry and the need for professionalism and competencies in the surveying industry. Questionnaires were administered to randomly select 200 practicing quantity surveyors in Lagos state. Findings revealed that the major role of quantity surveyors in the construction industry is the preparation of the bill of quantity as it ranked 1st with RII value of 1.00; it was also discovered that quantity surveyors were in agreement with client service delivery as the first ethical standard that construction professionals should consider when performing their professional obligations in order to avoid project failure and over-cost. It is therefore recommended that the professional bodies and the academia should organize proper and adequate service trainings, workshops and seminars which will enhance the possibility of acquiring more skills and experience so as to improve competence in the discharge of quantity surveyors professional duties.

1. Introduction

Quantity surveyors are one of the key professionals in the construction industry, as they are involved in cost planning, cost management, project procurement, contract administration, feasibility studies and asset financial management. Clients such as developers, government bodies and agencies, building proprietors, architects and contractors requires the services of the quantity surveying profession, especially, on cost estimation. The quantity surveyors, in the present day construction industry, through skills and ability, analyze cost components of a construction project in a scientific way and apply the results of the analysis to a variety of financial and economic problems confronting the developer and the designer (Ilias and Mohd 2010).

Badu and Amoah (2004) held that the changing roles of the quantity surveyors had been redefined by the quality of education received. The wide array of the quantity surveyors' responsibilities requires that they are educated, trained, and highly skilled in diverse subjects. Lenard (2000) argued that the changing nature of the construction and development industry as regards the adoption of innovative technological processes and development, emergence of highly focused professionals and the full range of advanced technologies necessitate a much stronger emphasis on job competencies than ever before. However, competence, in any sphere of work, can be a difficult concept to pin down especially when it relates to professional occupations where such roles can be complex, and the knowledge and skills involves many and varied professionals (Cheetham and Chivers, 1996).

According to Ilias and Mohammed (2010) quantity surveyors are construction economists who fulfill various comprehensive duties to support cost-effective construction and property development projects. The core competencies of quantity surveyors include determining project budgets, measuring project quantities, preparing contract documentation such as bills of quantities and cost control documents, administering contracts, and preparing final accounts. Despite being recognized as a professional discipline distinct from architecture and civil engineering since 1836, quantity surveyors are not immune to the threats and changes within the operating environment. While some parties in the construction industry have been critical about the quality of works and services rendered by quantity surveyors, some question the importance of appointing quantity surveyors as project consultants. Nonetheless, Nkado (1999) gives an overview of certain skills in quantity surveying profession which are pertinent to meeting clients' demands. Poon (2004) notes that some quantity surveying firms do not seem to understand how to handle clients finance and are culpable of certain actions that could severely damage the clients' interests which in turn affect the integrity and competencies of quantity surveyors. Pearl (2005) attributed this

ugly phenomenon that has robbed quantity surveying profession to the much expected pride of place among professionalism in the industry.

This paper aims to investigate the competencies of quantity surveyors in the process of discharging its professional duties by evaluating the effects of professional competency on quantity surveying practices in Nigeria. To achieve this, the followings questions are investigated (1) What are the roles and functions of quantity surveyor in Nigeria? (2) What are the areas of competences required of a quantity surveyor in the construction industry? (3) What are the effects of quantity surveyor's competence on the performance of quantity surveying firms?

2. Literature Review

2.1 Concept of Professional Competency

Stewart and Hamlin (1992) defined competency as something which a person who works in a given occupational area should be able to do. Holmes and Joyce (1993) also view competency as an action, behavior or outcome which a person should be able to demonstrate, or the ability to transfer skills and knowledge to new situations within the occupational area. Meyer and Semark (1996) described competence as the demonstration of an integration of knowledge, skill, personal attributes and value orientation. Wisher (1994) insisted that competencies provide a common cultural thread, a language for success, a framework for thinking about excellence and a way of communicating the future. Baker et al., (1997) observed that companies were starting to look into workers' competencies when they realized that providing a framework which brings greater clarity to the idea of competence in business in general, and operations and technology management in particular, would bring competitive advantage to their organizations.

Rankin (2000) reported that a significant number of companies in the UK are using competencies to improve individual and corporate performance. Roggema-van Heusden (2004) attempted to define competence from professional personnel point of view. They held that, competence is the ability to perform well in a professional situation that involves the accomplishment of a certain task or the dealing with a problem, in a manner that can be observed and be judged by others. That is to say: a competent professional is capable of applying the necessary expertise in confluence with effective behavior. Competent quantity surveyors must have a range of skills, knowledge and understanding that can be applied in a range of contexts and organizations (Hassall et al., 1996). Yet pressing issues which confront the quantity surveying profession today include increasing the relevance and level of awareness of the profession's services in the built environment and increasing the range of business opportunities for continued growth.

2.2 The Roles of Quantity Surveyors

A qualified quantity surveyor can gain employment in quantity surveying firms, construction companies, or with private property developers. Large organizations (public or private) that deal with a significant amount of building or construction procurement as part of their activities normally employ quantity surveyors among other construction professionals to become their project managers. Most quantity surveyors who work in consulting firms are retained by the construction clients to ensure that what is eventually built is in line with the client expectation and within budget (National Commercial Services UK, 2004). The responsibilities of the client's quantity surveyor include the preparation of Bills of Quantities and the giving of advice on what a project would cost. He also does cost planning during the design stage of a project, examine tenders, price quantities and report his findings. He also negotiates rates with contractors on negotiated contracts, prepares valuation on ongoing construction work.

Badu and Amoah (2004) noted that the distinctive skill of a quantity surveyor lies in his ability to analyze a project applying his skills and knowledge to the competence areas like progress payment and making recommendations as to payments to be made to the contractor including advising on the financial aspects of variations. The contractor's quantity surveyor on the other hand engages in matters relating to costs and estimates from the perspective of 'entrepreneurial' contractor, and agrees on measurements with the client's contractor for any specific project.

According to John Austen Associates (2004) the principal services that could be offered by any quantity surveying firm are: (1) Preliminary cost advice and feasibility estimates (2) Cost planning (3) Advising on contractual methods (4) Advising on selection of other consultants (5) Advising on contractor selection (6) Preparing tender documents (7) Obtaining or negotiating tenders (8) Reporting on tenders received or package deal/design and build offers (9) Evaluating construction work (10) Preparing and agreeing accounts for/with contractors (11) Preparing expenditure statements for tax accounting purposes (12) Periodic financial reporting (13) Technical auditing (14) Assessing replacement value for insurance (15) Project management related services (16) Giving expert evidence in arbitrations, adjudications and legal disputes, and (17) Preparing/defending against construction contract claims. Thus, the quantity surveying professionals must posses these skills and competencies to deliver their jobs successfully.

2.3 Quantity Surveying Professional Competencies

Royal Institution of Chartered Surveyors, RICS (1971) and Male (1990) opined that the competencies of the quantity surveyor are usually associated with the measurement and valuation that provides the basis for the proper cost management of the construction project in the context of forecasting, analyzing, planning, controlling and accounting. Hassal et al. (1996) noted that the process of professionalization demands that a profession should take responsibility for a prescribed body of knowledge by first defining the substantive field of knowledge that the professional should command and secondly the process of applying that knowledge. Thus, Leveson (1996) concludes that the area of quantity surveying competencies lies in the financial and contractual control of the building project and therefore the need for quantity surveyors to pay attention to developing soft skills.

Willis et al. (1994) described the body of knowledge of the quantity surveyor as one which incorporate the services of: preliminary cost advice; cost planning including investment appraisal, life-cycle costing and value analysis; procurement and tendering procedures; contract documentation; evaluation of tenders; cash-flow forecasting, financial reporting and interim payments; final accounting and the settlement of contractual disputes; cost advice during use by the client; project management; and specialist services. RICS (1998) therefore sets out the requirements and competencies for the assessment of professional competence by listing the competencies required of quantity surveyors in three categories which are: the basic competencies, the core competencies and the optional competencies. The basic competencies under the RICS structure are common to all construction professions such as land surveying, building surveying, etc. the core competencies are those uniquely required of quantity surveyors while the optional

Table 1 *Categories of Competencies of Quantity Surveyors*

Categories of Professional Competencies		
Mandatory/Basic	**Core**	**Optional**
Personal and Interpersonal skills	Construction Contract Practice	Arbitration and Other Dispute Resolution Procedures
Business skills	Construction Technology and Environmental Services	Development Appraisal
Data, Information and Information Technology	Economics of Construction	Facilities Management
Professional Practice	Procurement and Financial Management	Valuation
Law		Insurance
Measurement		Project Management
Mapping		Property Investment Funding
		Research Methodologies and Techniques
		Taxation Allowances and Grants

Source: RICS (1998)

competencies reflect areas of specialization or future career diversification. Moreover, Akosile, Ogunsemi and Owoeye (2007) identified and classified areas of competencies required of quantity surveyors into three categories viz. basic, core and optional. In 1998, The Royal Institution for Chartered Surveyors (RICS) put forward a model of competencies for quantity surveyors. The model was presented in three categories of mandatory/basic, core and optional competencies as shown in Table 1.

2.3.1 Mandatory Competencies

The basic competencies are widespread to all construction profession under the RICS structure and they are the personal and interpersonal skills, professional practice and business competencies common to all pathways and compulsory for all candidates. There are basic competencies required for all positions. A basic competency is defined as a knowledge, skill, or behavior essential for one to function as an effective member. The basic competencies include: (1) **Ethics and Integrity:** Consistently demonstrates the organizations values through behaviors; (2) **Customer Service:** Consistently meets the organization's expectations for customer service, striving constantly to achieve them; (3) **Communication:** Effectively communicates verbally and in writing; (4) **Problem Solving:** Develops effective approaches, addresses needs, and solves problems; (5) **Flexibility:** Demonstrates flexibility in one's job roles, and manages change in ways that result in productive performance; (6) **Technology:** Uses available equipment and technology safely, efficiently and effectively; (7) **Safety:** Complies with safety instructions, observes safe work practices, and provides input on safety issues; (8) **Self-Management:** Maximizes own time and talents to achieve organizational goals; (9) **Seizes Opportunities:** seeks opportunities to innovate and continually improve; (10) **Change Resilience:** develops effective approaches for managing self through organizational change; (11) **Teamwork:** Works effectively with team/work group or those outside the formal line of authority to accomplish organizational goals; and (12) **Cost effectiveness:** Prudently uses resources based on organizational priorities.

2.3.2 Core Competencies

The core competencies are exclusively vital to the profession of quantity surveying and it entails construction contract practice, construction technology and environmental services, economics of construction and procurement and financial management. In other words, core competencies are those capabilities that are critical to a business achieving competitive advantage. The starting point for analyzing core competencies is recognizing that competition between businesses is as much a race for competence mastery as it is for market position and market power. The main idea about Core Competencies was developed by C K Prahalad and G Hamel through a series of articles in the Harvard Business Review followed by a best-selling book – "Competing for the Future". The central idea was that over time companies may develop key areas of expertise which are distinctive to that company and critical to the company's long term growth. Prahalad and Hamel (1990) asserted that the managers will be judged on their ability to identify, cultivate, and exploit the core competencies that make growth possible. They will have to rethink the concept of the corporation itself. These areas of expertise may be in any area but are most likely to develop in the critical, central areas of the company where the most value is added to its products. For example, for a manufacturer of electronic equipment, key areas of expertise could be in the design of the electronic components and circuits. For a ceramics manufacturer, they could be the routines and processes at the heart of the production process. For a software company the key skills may be in the overall simplicity and utility of the program for users or alternatively in the high quality of software code writing they have achieved. Core Competencies are not seen as being fixed. Core Competencies should change in response to changes in the company's environment. They are flexible and evolve over time. As a business evolves and adapts to new circumstances and opportunities, so its Core Competencies will have to adapt and change.

2.3.3 Optional Competencies

A set of competencies selected by the candidate from a list defined for the particular pathway. In most cases there is an element of choice. These are mostly technical competencies, but certain mandatory competencies also appear on the optional competency list and candidates are permitted to select one of these at a higher level. The optional competencies reveal areas of specialty or future career diversification and these include arbitration and other dispute resolution procedures, development appraisal, facilities management, insolvency, insurance, project management, property investment funding, research methodology and techniques, taxation allowance and grants and valuation.

2.4 Other Models of Quantity Surveying Professional Competencies

The Australian Institute of Quantity Surveyors (AIQS) attempt to define and develop a model of competencies for the quantity surveyors (AIQS, 1998). The institute proposed 31 competency standards that need to be adhered to by the professional body in producing competent quantity surveyors. Apart from the competency standards, the Australian Institute of Quantity Surveyors also recommended 13 basic characteristics of abilities that lead to a competent quantity surveyor. These basic abilities in turn, form the platform from which a competent quantity surveyor can develop and are an integral part of the 31 units of

competency standards. The basic abilities include (1) Quantification/ measurement – the ability to quantify and enumerate (2) Analysis – the ability to observe, assess, identify problems and find innovative solutions (3) Appraisal/evaluation – the ability to assess value (4) Communication – the ability to impart knowledge, ideas and concepts through oral, written and visual means (5) Interpersonal skills – the ability to effectively work with others and to be part of a team (6) Leadership – the ability to lead and motivate (7) Self-development – the ability to set goals, display enthusiasm, self-motivate and undertake research (8) Management – the ability to organize, monitor, control and plan the effective use of resources (9) Documentation – the ability to prepare written information in a format which clearly conveys meaning (10) Synthesis – the ability to combine fact or ideas into a complex whole (11) Computer literacy – the ability to understand and apply basic computer skills (12) Construction technology – the ability to understand basic construction technology (12) Construction law and regulation – the basic knowledge of national laws and regulations related to construction.

In 1999, The Pacific Association of Quantity Surveyors (PAQS) analyzed a full range of competencies required by a modern quantity surveyor. In principle they agreed to accept 10 competency standards for the quantity surveyors. Those are: strategic planning, budgetary process, cost estimating, cost planning, procurement advice, documentation, tendering process, construction account management, construction change management, feasibility studies. The most recent competency of a quantity surveyor which is beginning to gain popularity among professionals in the construction profession is the use of Building Information Modeling (BIM). It is currently in use by a number of engineers and architects during practice and also has the potential to improve the Quantity Surveyor profession. BIM is the process of creating an information data base for a project in which the life cycle information is expressed in an inter-operable manner to create, estimate, illustrate and construct a project (Schwegler, 2001). Succar (2008) claims that BIM is presenting an organized set of data to construct, analyze, manage, maintain and calculate the construction cost of a building project. Lee et al., (2005) sees BIM as a three or four dimensional drafting application that generates data intensive plans.

According to Aouard et al., (2007) BIM has the potential to automate measurement and facilitate the preparation of accurate estimates. According to the study there have been successful attempt to produce Bills of Quantity automatically with the use of Industry Foundation Class (IFC) data by the Cooperative Research Centre for construction Innovation. Lee et al., (2003) observe that the hallmark of BIM allow contractor to receive design document which have specified materials and accurate quantities in electronic format. According to Thomas (2010), BIM is adopted in the quantity surveying profession for the following reasons (1) The designers drawing are not sufficient for construction which was agreed by 92% of client (2) Project that did not meet the original budget were above 30% (3) 38% of carbon emission are from buildings and not cars (4) 10% of the cost of a project is due to change other (5) Material waste in the construction site is estimated to about 37%.

Therefore BIM can help in improving the overall reliability of a project cost (Eastman et al., 2008). Azhar and Brown (2009) states that BIM is highly significant for the future development of the construction industry. BIM can also help to improve project and improve cooperation among the project team which would lead to reduce cost, proper time management and improve profit (Azhar et al., 2010). It is therefore necessary for quantity surveyors to get used to BIM to enhance the quality of project delivery.

3. Methodology

The study population comprised the quantity surveyors who are professionals in the private organization in the Nigerian construction industry. Data obtained involved assessing professional views on the profession, examining the roles of quantity surveyors in the construction industry and assessing the need for professionalism and competencies in the industry. Questionnaires were administered to the practicing quantity surveyors in Lagos state. The respondents were randomly selected among the various firms in Lagos state. Two hundred (200) questionnaires were distributed with the aim of eliciting response from the private organizations toward determining the need for professionalism in carrying out construction project.

4. Results and Discussion

The various roles of quantity surveyors in the construction industry were identified in Table 2 and ranked using its Relative Importance Index (RII). The roles of quantity surveyors in the construction industry revealed that preparation of the bill of quantity ranked 1st with RII value of 1.00; cost estimation relating to construction materials, time and labor and cost advise ranked 2nd with RII value of 0.94; work in progress variation and materials on site for interim payment ranked 3rd with RII value of 0.87; materials schedule for building project ranked 4th with RII value of 0.79, while cash flow payment ranked 5th with RII value of 0.76. The findings from the table revealed that all the roles are significant with the least role having 76 (0.76) percent significance.

Table 2 *Assessment of the roles of Quantity Surveyors in the Construction Industry*

Roles	S.A	A	U	D	S.D	RII	Rank
Preparing bill of quantity	195	0	0	5	0	1.00	1
Materials schedule for building project	5	30	15	75	75	0.79	4
Cost estimation relating to construction materials, time and labor and cost	0	5	0	45	150	0.94	2
Work in progress variation and materials on site for interim payment	0	5	30	60	105	0.87	3
Cash flow payment	15	45	20	50	70	0.76	5

Source: Field Survey (2014)

*S.A = Strongly Agreed; A = Agreed; U = Undecided; D= Disagree; S.D = Strongly Disagree; RII = Relative Importance Index

Table 3 shows the mean item score (MIS) for the level of compliance of ethical practices as perceived and ranked by the quantity surveyors. From the result of the analysis, generally all the fifteen (15) ethical practices identified by the study were highly ranked with MIS ranged 3.29 > 3.0 above averages. Three ethical standards which are client's service delivery, educational training and professional qualification and standards of practice respectively indicating client service delivery as the most significant ethical standard were ranked 1st, 2nd, and 3rd by the quantity surveyors. However, we found that public welfare and fair compensation factors are two least importance aspects that the quantity surveyors professionals must have. The respondents considered that these two things are loosely correlated with the profession of quantity surveyors. One surprise found in the survey was that the sustainability aspect was not considered as important factor in

quantity surveying profession. The case will be different if the survey were conducted in more advance country, where the sustainability becomes a very important aspect in construction industry.

Table 3 *Ethical standard and competence requirements of a Quantity Surveyor*

Ethical Standard and Competence	Mean Value	Rank
Standards of practice	3.17	3
Education and professional qualification	3.24	2
Fair competition	3.10	8
Confidentiality	3.14	6
Integrity	3.15	4
Public welfare	2.98	14
Conflict of interest	3.01	11
Safety	3.04	9
Environmental friendliness	3.02	10
Maintenance culture	3.01	11
Client's service delivery	3.29	1
Cost effectiveness	3.12	7
Fair compensation	2.96	15
Professional development	3.15	4
Sustainability	3.00	13

Source: Field Survey (2014)

*The scale used: (1) Highly unimportant (2) unimportant (3) either unimportant or important (4) important (5) highly important.

The quantity surveyors were in agreement to client service delivery as the first ethical standard that construction professionals should consider when performing their professional obligations. Quantity surveyors in some cases can also be contractors or consultant quantity surveyor, either working for an organization or for the contractor as they are saddled with the responsibilities of preparing the cost estimate of any proposed project, preparation of interim valuation and physical measurement of works among others to enable payment to the contractor among others. They also monitor the clients' resources to ensure services are delivered with the best standards and at minimum cost which is the major service delivered by quantity surveyors.

Educational training and professional qualification is also of great importance, because this is where professionals gain academic training, technical competence and skills about a particular profession. It is therefore important for professionals to have sound educational background to be able to cope with the projects challenges. This finding conforms to Chan and Chan (2002) that; professionals need to be placed in appropriate educational framework to ensure their continuous relevance. Quantity surveyors should only accept to offer services for which they are qualified by education, training and professional experience.

Quantity surveyors deals basically with financial management of the contracts and this is the area where the integrity of most professionals are put into the mud especially if there is a conflict between personal and professional values. The moral standing and upbringing of each individual professional appears on how they protect their own integrity in dealing with clients rather than being mindful of their personal gain. The findings corroborated Cardammone (2011) that established that professionals are linked with notion of services they provide, hence the need to focus more on personal professional development so as to provide services that are of high quality for all that needed their services.

The characteristics/knowledge and abilities required of a competent quantity surveyor are ranked in Table 4 according to its significant to quantity surveying profession. The table clearly indicated the areas of competence characteristics that are significant to the performance of quantity surveying firms in Nigeria. The area of quantification and measurement is been selected as the most important/significant competence required in the performance quantity surveying firms in Nigeria, with a mean score of 4.66, while synthesis is considered less important to the performance of quantity surveying firms in Nigeria, with a mean score of 3.47.

This indicated that the most important characteristics, abilities and knowledge for quantity surveyors to possess are quantification/ measurement analysis, documentation, communication, construction technology and interpersonal skills which are also regarded as highly important for quantity surveyors to achieve an accepted level of competency. Other less important characteristics, abilities and knowledge to acquire are management, appraisal/evaluation, construction law and regulation, self-development, leadership, synthesis, and computer and information technology literacy.

Table 4 *Characteristics/Knowledge/Abilities required of a competent Quantity Surveyor*

Characteristics	Mean Value	Ranking
Computer and Information Technology Literacy	4.38	6
Leadership	3.87	11
Construction Law and Regulation	4.36	7
Self-development	4.03	10
Appraisal/Evaluation	4.34	8
Management	4.26	9
Synthesis	3.74	12
Documentation	4.56	2
Communication	4.53	3
Construction Technology	4.49	4
Interpersonal Skills	4.41	5
Quantification/Measurement Analysis	4.66	1

Source: Field Survey (2014)

*The scale used: (1) Highly unimportant (2) unimportant (3) either unimportant or important (4) important (5) highly important.

5. Conclusion and Recommendations

Quantity Surveying is one profession that has attracted unprecedented ubiquitous demand in the construction industry in the recent times with increasing opportunity for service diversification and adaptive applicability. Client's satisfaction is also a function of professional ethics in relation to respecting public interest with respect to the willingness to serve the public, good sense of responsibility and practice technical competencies. Therefore, as challenges and ubiquitous demands expand with new entrants of quantity surveying practice professing with different goals, it may be difficult to hold them under serious legal obligation to uphold ethical practices. This is because they may not be recognized as members of professional bodies until they are duly examined and registered, which may not be a mandatory requisition to operate within their delimited scope. Also, except in exceptional cases, academic establishments are not so keen in monitoring the ethical conducts of their products out of school. Thus the need to reposition the profession and ensure strict monitoring to ensure that quacks and non-professionals do not bastardize the profession especially in the face of the growing economy.

Professionalism and competency is the bedrock and soul of the success in handling construction works. Thus, in achieving the need for professional competence in the industry, the following are hereby recommended:

i. Organizing proper and adequate service training, workshop and seminars by the professional bodies and the academia which will enhance the possibility of acquiring more skills and experience so as to improve competence in the discharge of duties. Frequent training and retraining is inevitable to season members of the profession with current trends in ethical development and uncertainties, not only to equip members' competencies but to give the much needed rebirth to nurture and protect the goal of the professionals serving the public interest to exist.

ii. Quantity surveyor should not settle down with just the roles and function of the profession but should also acquaint themselves with the roles and function of other professionals in the field which can also be referred to as self-development to improve on their competence.

iii. Quantity Surveyors should ensure that they possess skills that are inclusive of personal qualities, core skills and process skills. The personal qualities should include independence, adaptability, initiative taking, willingness to learn and ability to reflect on what has and what has not been achieved. The core skills of a quantity Surveyor should include the ability to present clear information within a group, self-management, critical analysis and the ability to listen to others while computer literacy, commercial awareness, prioritizing, negotiating, acting morally and ethically, coping with ambiguity and complexity are the process skills required of a quantity Surveyor.

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Assessment of Viability Appraisal Practice by Estate Surveyors and Valuers in Lagos Metropolis, Nigeria

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ABSTRACT

A capital investment appraisal is a means of ensuring value for money. It is not meant to provide an indication of profit or loss, but rather a comparison of costs in relation to those areas where there is an opportunity or an inclination for change. The decision to invest in a project is based on the expectation of future returns since a rational investor does not expect to incur loss on his capital outlay. This decision making is usually hinged on advice obtained during pre-investment appraisal. This study is aimed at evaluating the mode of practicing investment viability appraisal by Estate Surveyors and Valuers in Lagos metropolis. The data for the study was obtained by randomly administering structured questionnaires on eighty-seven (87) practicing Estate Surveyors and Valuers in the study area and the findings were analyzed through descriptive statistical tools such as the Likert scale to present the result. Findings revealed that the payback period is the most adopted appraisal technique in practice as evidenced with a mean score of 3.57. The objective (s) of the investor is also the most significant factor being considered while selecting appraisal technique with a mean score of 3.83 while the problems of actual return varying from the expected return and also difficulty in the repayment of loans always result when a wrong viability technique is employed. The success of any viability study goes beyond knowing the objective (s) of the investor; therefore, it was recommended that appraisers should ensure that they are equipped with adequate knowledge required for the execution of feasibility and on viability studies because knowing the right viability criteria for a particular objective will help in advising an investor on a course of action that will best achieve the developer's objective.

1. Introduction

A capital investment appraisal is a means of ensuring value for money in relation to developing an estate strategy and capital project. It is not meant to provide an indication of profit or loss, but rather a comparison of costs in relation to those areas of the estate where there is an opportunity or an inclination for change (Baum and Mudambi 1999). The inputs should therefore only consider situations where the option may increase or decrease cost or value. It is usual to generate a range of options covering the extreme solution (e.g. total relocation) to a 'do minimum' approach (Layard and Glaister 1994). The decision to invest in a project is based on the expectation of future returns because rational investors usually aim at minimizing risk as well as maximizing returns. This therefore calls for a thorough investment appraisal through the application of a technique that will guide the investors in order not to incur loss on his capital outlay. Investment appraisal involves the weighting of benefits against costs by the application of one or more decision rules because it is a way of ascertaining the worthwhileness of such investment (Okoh 2008).

The search for a reliable method of project appraisal dates back to decades. Before the advent of modern technology, people employ the traditional appraisal method to assist in decision making of their capital to be invested. Despite the usefulness of the traditional appraisal, these methods have been criticised on several grounds such as its inability to project or forecast effectively thereby making an investor to incur loss on his capital outlay. Capital investment decisions are of high importance to any business because they involve the commitment of key resources which has an impact on the long-term performance and the shareholders' wealth; therefore finding reliable methods for measuring the potential value of capital investment proposals is a matter of concern for not only managers but also shareholders of a firm (Akalu, 2001).

The study of performance of investment is very important at this time when emphasis is on investment performance analysis in many parts of the world (Oyewole, 2013). Nigerian economy has witnessed a significant change; the buoyancy experienced in early 70's and 80's cannot be compared to today's economy (Ajayi 1998). The viability indicators upon which decision making in property development is based are fast becoming more difficult to predict in a dynamic and unstable economic system like Nigeria. Investment viability studies are required as "conditions" for meeting either statutory approvals or securing development finance. It is equally important when a bank is considering an open-end loan because repayment of the loan may depend upon the project's sales or leasing program. Overall, the investor or financial institutions must determine whether or not a thorough feasibility study justified the project before the bank issued a

loan commitment. It must also ensure that an unsound appraisal or analysis that does not reflects current and reasonably anticipated market conditions must be rejected (Beaman, 2012).

The prospective investor would have made a decision to execute the project before carrying out a feasibility and viability study. The decision taken often has its impact on the overall performance and the final outcome of some projects. Bello (2013) stated that feasibility and viability appraisals are basically carried out primarily for the purposes of assessing the need for and the market prospects of the investment proposal; estimating the costs of the project as well as its expected revenue; preparing a suitable schedule of programme of activities for the implementation of the proposal; evaluating the proposed funding arrangement for the project given the promoters current financial position; and the determination of the level of profitability expected from the investment proposal.

There have been criticisms on the development appraisal techniques used by professionals on the basis of their simple assumptions about incidence of cost and finance charges (Darlow, 1990). It is assumed that costs and values will not change through time. In view of the sensitive nature of the variables considered in development appraisal there is need for some sort of sensitivity analysis. The traditional practice of using current estimate of rental value, investment yield; building cost and finance rate is susceptible to error taking into consideration the dynamic nature of the variables involved in the development appraisal. Higher than anticipated interest rate, upward variation in construction cost estimate, lower than expected yield and longer void periods now pose new challenges to development appraisal methodology.

However, this problem is not peculiar to Nigeria. As observed by Thai (1983), Born (1988) and Pagliari (1995), there is no development appraisal that is hundred percent accurate. The quality of advice provided to clients by development surveyors is fast becoming inadequate in a dynamic economy. There is the need for preparation of appraisal reports that can match what operates in a complex property development market. The current practice of implicit treatment of risk elements in property development appraisal makes the profession lag behind in the field of general finance. The outcome of commercial development appraisal can no longer be left to intuition and past experience of surveyors. The risk characteristics and tolerance of investors differs considerably, and where this fact is dismissed, appraisers result will produce perception of risks that deviate from that of their client (Ogunba, Ojo and Boyd, 2005).

Viability study involves highly critical analysis of viability criteria (physical indicator, financial, economic, legal, sociopolitical and cultural indicators) in order to properly advise prospective investors (Ogbuefi, 2002). Categories of decision required different viability criteria, and the criteria suitable for any decision can only be those which are in consonance with the objectives of the decision-maker. The objectives or set of objectives of a client should serve as yardsticks for the valuer. Odeyomi (2007) stated that there are two main methods for determining the profitability of or otherwise of real estate project and they are the traditional and modern methods. Appraisal techniques can either be deterministic or probabilistic. Deterministic approach relies solely on the best estimate of all variable inputs for the viability computation perceived from a single-point view, and the result is run once, while the probabilistic approach, on the other hand, incorporates risk, which the deterministic approach does not recognize. It hinges on the premise that the expected returns which is the best estimate might not actually be achieved, thus uncertainty comes in (Ojo, 2006). The deterministic approach such as residual valuation method, developmental method, break-even valuation, cost benefit technique, cash flow technique, payback period, Net Present Value (NPV), the Internal Rate of Return (IRR), Annuity method, profitability index, debt coverage ratio among others has been criticized on the ground that it does not incorporate risk in its computation, especially in an economy that is very susceptible to inflationary changes and uncertainty. Therefore, they cannot be relied upon in a situation where the economy is unstable, inflation is high, and there is high interest and exchange rate as is the case in Nigeria.

Ojo (2006) observed that the decision making techniques used in real property development appraisals, are greatly influenced by the dynamic and complex socio-economic environment in which property development operates. The reliability of development appraisal greatly depends on the ability of the appraiser to accurately estimate the variable inputs used in the appraisal. Appraisers do base their judgment only on the objective(s) of the decision-maker, which is always to maximize profit. The implication of the adoption (by the appraiser) of a more optimistic risk attitude than that considered appropriate by their clients is that development appraisals might not be adequately addressing the client's lower risk tolerance. Modern methods of appraisal that incorporate measurement of risk and uncertainty such as Monte Carlo Simulation, Risk Adjustment Discounted Rate technique, Certainty Equivalent technique and Sliced Income technique are not yet embraced in practice despite experts' view that these are the best methods that are more applicable under conditions of risk and uncertainty. The modern appraisal techniques have been developed to deal with the problems inherent in the traditional method of appraisal; these modern methods has been tested in the developed countries and found to be more effective and efficient to deal with the persistent problems encountered in the process of adopting the traditional methods of appraisal.

Ogunba *et al.* (2005) noted that most development appraisers that include an analysis of risk in their development appraisal simply employed the risk analysis approach that suited them (appraisers). It argued that the choice of viability criteria and consequently the appropriate appraisal technique should be based on the perception and tolerance of risk of the investor. The valuer's role is to discover those criteria before selecting the appropriate technique to be used because the main trust of investment appraisal is the examination of costs and benefits that result from an investment. The decisions to invest are of vital importance to all companies, and effective appraisal techniques are most valuable tools to support the decision-making process. However, even in the face of economic instability, the common probabilistic approaches such as sensitivity analysis, the risk-adjusted discount rate, risk adjusted cash flows (the certainty equivalent technique and the weighted average approach), and Monte Carlo simulation are rarely used. Most development appraisals focus more on returns and less on risk analysis, which is why the techniques being used are deterministic in nature and is fast becoming inadequate to take care of today's dynamic socio economic investment environment (Ratcliff and Stubbs, 1996).

The methodology of determinism makes these techniques unsuitable in such a volatile economy as that of Nigeria. The first attempts at jettisoning determinism in project appraisal come in the form of sensitivity analysis. Sensitivity analysis is based on the premise that change in the values of the key economic variables can bring about an effect on profitability. A particular case of sensitivity analysis is to take high, low and medium values of the key economic parameters and

compute the profitability for various combinations of these pessimistic, average and optimistic estimates, thus providing ranges of possible alternative results. Baum and Crosby (1988) undertook a comprehensive review of deterministic and probabilistic techniques employing a methodology of numerical examples. Their critique of the techniques is similar to those of Sykes and Patrick (1983). Their contribution was the recommendation of new techniques - the "Sliced Income" technique as a preferred alternative to the Risk Adjusted Discount Rate and Certainty Equivalent techniques in guiding UK investors when selecting between alternative investments. In essence, this method is a hybrid of the Risk Adjusted Discount Rate and Certainty Equivalent techniques. The adoption of this approach in Nigeria with the absence of data banks and computer proficiency could result in practical difficulties. Ajayi (1987) was able to compliment Umeh (1977) work on development appraisal.

In view of the foregoing, this study is aimed at appraising investment viability practice by Estate Surveyors and Valuers in Lagos State, Nigeria with a view to pave way for best practice that will allow consistency in evaluation approach across a wide range of projects. The focus of the study is to examine the investment appraisal techniques adopted by Estate Surveyors and Valuers in arriving at opinion of judgment that guides investors in decision making, the factor (s) that guides their selection these appraisal techniques, the viability criteria considered Estate Surveyors and Valuers when carrying out viability study and assessment of the problem (s) that may arise from the use of appraisal tools that cannot adequately measure the investor's objective.

2. Methodology

Lagos State is the former federal capital of Nigeria and also known to be the commercial nerve of the country. Aside from Cairo, Lagos is the hub where both national and international events are executed and remains the fastest growing urban area in Africa (Oladokun, Gbadegesin and Ogunba, 2010). As at 2006, the population stands at above 14 million people due to the presence of most forms of land use related activities (Omoogun, 2006). Lagos State harbours "60% of the nation's industrial and economic establishment and 80% of the nations of the total value added of manufacturing activities in the country" (Omoogun, 2006). Lagos metropolis, one of the most important commercial cities in Nigeria, forms the base of our study area. Lagos metropolis is located in the South-Western Coast of Nigeria along the Bight of Benin approximately between latitude 6^0 40' North and 4^0 30' South of Equator and between longitude 2^0 05' West and 4^0 20' East of Greenwich Meridian. Lagos State covers an area of about 3,577sq.km representing 0.4 percent of Nigerian territorial land mass (Esubiyi, 1994). Lagos state, with its capital at Ikeja, was created on the 17th of May, 1967 by virtue of the State Creation and Transitional Provision Decree (No 14) of 1967, which restructured Nigeria into twelve states. Lagos had a population of 5,685,781 people out of a national population of 88,515,501 based on the 1991 provisional census figures. In the economic sense, the metropolis has grown from a small fishing settlement to become the most important center of commerce, finance and maritime activities in Nigeria, housing headquarters of several banks, industries and commercial enterprises. It also contains the nation's largest seaport and international airport. The main commercial districts of the metropolis as identified by Ogunba (1997) are Victoria Island, Ikoyi, Lagos Island, Yaba/Surulere and Ikeja. Ogunba pointed out that firm of Estate Surveyors and Valuers aggregate at these commercial districts where the property market is most active. This study adopted Ogunba's (1997) classification of Lagos metropolis into economic nuclei and this form the basis for this research work.

The target population for this study consists of Registered Estate Surveyors and Valuers in Lagos State. By virtue of Decree 24 of 1975, Estate Surveyors and Valuers are the only professional statutorily empowered to undertake valuation of proprietary interests in property and related assets in Nigeria. The data for this study will be obtained from the Estate Surveyors and Valuers who are duly registered with Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON), and have practicing firms in Lagos. Eighty-seven (87) structured questionnaires were randomly administered on the target population questionnaires and the response was used for the data analysis towards achieving the goal of the research. The survey approach was used for this study and the findings analyzed using descriptive statistics. The questionnaire was structured to examine the types of viability criteria mostly considered by Valuers, the method of appraisal often employed, assessment of the problems emanating from employing appraisal technique that does not match its intended purpose, and factors that are considered before selecting the choice of appraisal technique. The result from the analyses of these data forms the basis for inference. The descriptive statistics computed on the sampled data provides the basis on which inferences was made about the population. The Weighted Mean Score (W.M.S) was used for the presentation of the result. This was achieved by assigning numerical values to respondent's rating on factors identified. The W.M.S method was used due to its simplicity and ease of communicating result.

3. Discussion of results

Table 1 reveals that 18.39% of the respondents were principal/ managing partners of the firms, 35.63% were branch managers, 39.08% were resident Estate Surveyors and Valuers, while 7.1% represents other designations such as admin staff, confidential secretary and official designations. From the Table, it can also be observed that 39.08% of the respondents had working experience ranging between 1 – 5 years, 32.18% of the respondents have been in practice between 6 – 10 years, while 10.34% have been in practice between 11 – 15 years and 18.40% were in practice for over 15 years. This shows that the most of the respondents had the required working experience that could make the information reliable.

Table 1 *Characteristics of the Respondents*

Status	Response	Percentage
Principal/Managing partner	16	18.39
Branch Manager	31	35.63
Resident Estate Surveyor and Valuers	34	39.08
Others	6	6.90
Total	**87**	**100.00**
Years of Experience		
1-5	34	39.08
6 - 10	28	32.18
11 - 15	9	10.34
Above 15	16	18.40
Total	**87**	**100.00**

Table 2 showed the responses of Estate Surveyors and Valuers in relation to how frequent do they receive instructions to carry out feasibility and viability appraisal in their organization. From the Table, it was revealed that 35.63% of the respondents do fairly frequent secure instructions to carry out such task, 25.29% frequently receive such instructions, while 28.74% and 10.34% of the respondents are of the opinion that they do receive such instructions most frequently and least frequently respectively. The Table also revealed that none of the respondents opined that they had never received instruction for carry-

Table 3 *Use of Appraisals Techniques*

Appraisal Techniques	Most Often Used (4)	Often Used (3)	Seldom Used (2)	Not Used (1)	Mean Score	Rank
Payback Period	62.43	33.30	4.27	0.00	3.57	1
Net Present Value	40.50	59.50	0.00	0.00	3.40	2
Internal Rate of Return	45.20	28.57	26.23	0.00	3.18	3
Sensitivity Analysis	28.60	48.20	16.60	6.60	2.99	4
Accounting Rate of Return	14.20	42.40	21.50	21.50	2.49	5
Residual Method	9.40	30.20	30.20	30.20	2.21	6
Risk Adjusted NPV	18.20	18.20	21.50	42.10	2.14	7
Monte Carlo Simulation	0.00	21.50	48.20	30.30	1.92	8
Weighted Average Rate of Return	0.00	21.50	48.20	30.30	1.92	8
Certainty Equivalent Method	0.00	21.50	48.20	30.30	1.92	8

ing out investment appraisal. This implied that most the respondents consent to the fact that sizeable numbers of investors do seek the advice of professionals before embarking on capital development projects.

Table 3 showed the frequency of usage of viability appraisals techniques in development appraisal by Estate Surveyors and Valuers. From the table, it was revealed that the Payback Period, which is one of the traditional methods of appraisal, is the most adopted appraisal technique in practice. This is evidenced with the mean score of 3.57 in Table 3. This is followed by the NPV and IRR methods with mean scores of 3.40 and 3.18 respectively, while the techniques that incorporate risk were not often employed by the appraisers. Though, the studies of Baum and Crosby (1988), Baum *et al*. (1997) and Ojo (2006) revealed that the traditional methods might not be in tune with the present day economic reality. The findings of this study showed that the practice of viability appraisal is still centered on the traditional methods of development appraisal. Modern methods of appraisal that incorporate measurement of risk and uncertainty such as Monte Carlo Simulation, Risk Adjustment Discounted Rate technique, Certainty Equivalent technique and Sliced Income technique are yet to be fully embraced in practice despite experts' view that these are the best methods that are more applicable under conditions of risk and uncertainty as is experienced in Nigeria today. Ogunba *et al*. (2005) noted that in the assessment of risk in development appraisal, the probability weighted cash flows (based on the net present cost technique) is the most appropriate method for the public developer client, Monte Carlo simulation for the private developer client, and certainty equivalent cash flows for clients that are development lenders. These are all modern appraisal techniques, which are not or rarely used by valuers.

Table 4 *Factors considered before selecting the choice of appraisal tools*

Factors	Very Sig (4)	Sig. (3)	Undecided (2)	Not Sig (1)	Mean Score	Rank
Investor's objective (s)	82.40	17.60	0.00	0.00	3.83	1
Economic inflationary trend	76.80	23.20	0.00	0.00	3.77	2
Suitable viability standards	63.90	36.10	0.00	0.00	3.64	3
Changes in rate of interest	42.90	38.60	0.00	18.50	3.06	4
Investor's level of risk tolerance	42.90	28.80	0.00	28.30	2.85	5

Table 4 showed the factors considered by Estate Surveyors and Valuers while selecting appraisal technique. Findings revealed that the objective (s) of the investor is the most significant factor being considered while selecting appraisal technique to be adopted. This is shown with a mean score of 3.83, closely followed by economy inflationary trend and suitable viability standards as they ranked 2nd and 3rd with mean scores of 3.77 and 3.64 respectively. Changes in interest rate ranked 4th with a mean score of 3.06, while the level of risk tolerance by investors ranked least with a mean score of 2.85. This implied that appraisers don't always consider how far the investors are ready to take risk in embarking on such investment. This corroborates with the findings of Ogunba *et al*. (2005) which examined the assessment of development appraisal risk with reference to client specific risk tolerance and find out that valuers do employ their own risk tolerance level while choosing the appraisal technique considered appropriate for an appraisal instead of that of the client. The study by Ojo (2006) also revealed that some appraisers do not even consider risk factors when selecting appraisal techniques instead they just choose that which are simple and easy to compute. The role played by Valuers in choosing the right appraisal technique is seen in the way they incorporate the functions in the table into their appraisals. Failure to critically look into these functions has led to wrong use of viability appraisal technique.

Table 5 *Viability Criteria Considered when Carrying out Viability Study*

Viability Criteria	Always (3)	Sometimes (2)	Not Considered (1)	Mean Score	Rank
Economic	100.00	0.00	0.00	3.00	1
Financial	100.00	0.00	0.00	3.00	1
Physical	73.56	26.44	0.00	2.74	3
Technological	43.68	56.32	0.00	2.44	4
Socio-cultural	50.58	32.18	17.24	2.33	5
Political	32.18	50.58	17.24	2.15	6

Table 5 revealed that both economic and financial viability criteria were majorly considered by appraisers when carrying out viability studies. This is shown with the mean scores of 3.00 each for both criteria respectively. This is followed by physical viability criteria with a mean score of 2.74; technological viability criteria with 2.44 mean score; socio-cultural viability criteria and political viability criteria have 2.33 and 2.51 mean scores respectively. This result shows that viability appraisal is mostly an issue of 'cost and benefit' implications of any proposed investment. This implied that investments that will thrive are usually hinged on economic and financial criteria.

Table 6 showed the responses to problems resulting from choosing a viability appraisal technique that cannot adequately measure investor's objective. 65.40% of the respondents agreed with the fact that the problems of actual return varying from the expected return and that of difficulty in the repayment of loans always result from usage of such viability technique, 28.20% were of the opinion that the use of such appraisal technique can lead to investment performance deviating from the investors objective while 38.20% and 29.50% opined that the problem can be as a result of the client not being able to manage the investment well thus exposing it to risk and foreclosure. The findings

also revealed that due to the choice of such appraisal technique, the actual return from the investment can varied with the expected returns. This finding corroborates that of Ezeokoli, Adebisi and Olukolajo (2014) which suggest that the use of wrong choice of viability criteria will bring about variance between the expected and actual return.

Table 6 *Problems that may arise from using an appraisal tool that cannot adequately measure investor's objective*

Problems	Agreed (3)	Neutral (2)	Dis-agreed (1)	Mean Score	Rank
Actual returns varied with its expected returns	65.40	34.60	0.00	2.66	1
Loan repayment difficulty	65.40	26.80	7.80	2.57	2
Developed properties has longer void periods	40.00	18.60	41.40	1.99	3
Performance deviating from investor's objectives	28.20	24.60	47.20	1.81	4
Exposure of clients to more risk	38.20	0.00	61.80	1.76	5
Foreclosure of mortgage properties by lenders	29.50	8.20	62.30	1.68	6

4. Conclusion and Recommendations

Investors do require and seek professional advice before embarking on project investments. The reliability of development appraisal greatly depends on the ability of the appraiser to accurately estimate the variable inputs used in the appraisal. These variable inputs include land price, landholding period, planning/building size, building cost and period, ancillary cost, professional fees, finance cost, lettable space, anticipated void period, rental value, investment yield, and required profit/return on investment. The susceptibility of these variable inputs to change makes the role of a valuer more pronounced. Viability investments are being practiced by Estate Surveyors and Valuers and must be done in order to cope with the global trend of the economy. Most appraisers execute an appraisal exercise in a way that is open and more suitable to them. Different appraisal tools are available for use in the determination of this exercise to aid decision making of an investment. This study established that the application of appropriate modern appraisal techniques is a difficult task for Estate Surveyors and Valuers in practice as it requires critical analysis of tools which are too cumbersome or requires rigorous mathematical application in which most appraisers are not too vast in. It is one thing for an appraiser to understand the variety of alternative techniques in development risk analysis and quite another to assess and employ the technique that is most appropriate for each occasion. The success of any viability study goes beyond knowing the objective(s) of the investor, but also the knowledge of the criteria upon which those objectives are based, the level of risk tolerance of the investor, change in interest rates as well as the trend of inflation in the economy. This will help to determine the nature of data to look out for and the appropriate appraisal technique to be employed in order to arrive at a good investment decision.

As a result of the findings, the following are recommended:

i. Estate Surveyors and Valuers whose opinion of value serves as a benchmark for investor's decision making should try as much as possible improve their learning culture on the use and adaptation of different appraisal tools. This is because the tool to be employed for investment analysis must be adequate and effective enough to cope with the global trend of improvement in the economy while also achieving an investor's objective.
ii. Appraisers should put into consideration other factors that can aid the attractiveness of an investment and not only concentrate on the investor's objective (s), economic inflationary trend, suitable viability standards, changes in rate of interest and investor's level of risk tolerance. This is necessary because most investors are ready to take the risk to embark on an investment.
iii. Since viability appraisal is mostly an issue of 'cost and benefit' implications of any proposed investment, appraisers should pay adequate attention to carefully consider the appropriate viability criteria for the proposed investment when carrying out viability study because it has been established that investments will thrive in economically and financially friendly environment.
iv. Problems can arise in an investment portfolio which may be as a result of an appraiser adopting an investment tool that cannot adequately measure the intended goal of the investment while advising the investor on the profitability and attractiveness of his investment portfolio. Therefore an appraiser should as much as possible endeavor to adopt tool that will not jeopardize the investor objective but one which can successfully guide a rational investor on investment viability.

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Impact of Contractors' Bidding Strategies on Bid Success in the Nigeria Construction Industry

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ABSTRACT

Several types of researches have been carried out prior to the new millennium on the subject of bidding strategies in the construction industry. Today, organizations are faced with a very complex decision of bid/no-bid because it requires the assessment of large number of highly inter-related variables. The study aims at examining different types of Contractors' Bidding Strategies (CBS) with a view to determining their impact on bid success. In line with the aim, the study objectives include; evaluation of different types of CBS and; assessment of the success rate of contractors' bid. The method of approach elicits information on the number of projects bided and successes recorded over a period of time. A total of one hundred and seventy-one useable responses were retrieved from questionnaire administration. Descriptive statistics, tables and percentages as well as mean item score (MIS) were used for data analysis. The study showed that lowest bid, public relations and joint venture bidding strategies have great impact on contractors' bid success especially on residential, educational and administrative projects in the Nigeria Construction Industry (NCI). Therefore, the study concluded that relationship exists between contractors' bidding strategies and equivalent successes recorded over a period of time. It is important to also know that lowest bid strategy still remains the most effective bidding strategy for public works contracting in the NCI.

1. Introduction

Contracts are usually awarded through the process of bidding in the construction industry and contractor's goal in developing a bidding strategy is to win a bid award. Bagies and Fortune (2006) stated that smart contractors realize the importance of doing initial research and project evaluation before committing themselves to a construction project. Undergoing initial research before bidding proper help contractors' maintain fee schedules at a level that will support and ultimately assist in running a profitable and high quality business that best serves the need of clients who rely on their products and services.

Contract bidding is a well-established mechanism for achieving distribution of work to willing contractors and is concerned with contractors making strategic decisions. The decision-making at this stage according to Bagies and Fortune (2006) is accomplished by two related decisions i.e., bid/no bid decisions that consider factors that would help contractors to determine the appropriate bidding strategy and the benefit expected from a particular project and secondly, mark-up decision, which is one of the consequences of the bidding strategy.

Bidding generally involves a very complex decision requiring simultaneous assessment of large number of highly inter-related variables to arrive at a decision (Chua et al., 2001). General construction contractors develop bidding strategies to guide them in determining what jobs to bid and how to bid for those jobs. Oo et al. (2010) stated that bidding strategies varies from contractor to contractor, each of which will have different degrees of sensitivity towards the factors affecting their bidding decisions. Competitive bidding is widely applied in many sectors of the economy beside the construction industry, and as a form of strategy, it can be reflected in two ways; open or sealed bidding and a combination of the two according to McCaffer and Harris (2001).

Tan et al. (2008) noted that the development of the construction industry has led to an increase in the number of criteria imposed by project clients for selecting contractors. The trend has attracted research interest in devising various methods for helping project clients to assess contractors' bids. For example, clients often request tenderers to satisfy various conditions such as a tight program, financial strength, management ability, relevant work experiences, technical strength, high workmanship standards and safety requirements (Flanagan et al., 2007; Lu, 2006). Contractors must be able to show competence in different types of bidding strategies (such as lowest bid strategy, joint venture, public relations, selective bidding, negotiated work etc.), in order to meet with various criteria imposed on them by the clients.

Hence, this study aims at identifying and assessing different types of contractors' bidding strategies with a view to determining their impact on bid success. To achieve the aim, the study objectives evaluated different types of contractors' bidding strategies adopted in the NCI and also assessed the success rate of contractors' bid. To win a bid award, contractors need to strategize, hence the need for a bidding

strategy. While developing bidding strategies that would compete favourably for a bid award, contractors need to authenticate the feasibility and viability of construction works before channeling all resources into it. This in essence would help contractors perform better since they are well informed on the bidding processes.

2 Contractors' Bidding Strategies

Bidding strategy is one of the important strategies in the early stages of project life cycle to determine project success. It is a management skill that makes use of all available resources in order to offer a comprehensive and competitive bidding while considering various aspects, including internal, external and environment, with aim to win the bidding competition, and provide maximum project performance. In effect a bidding strategy is the decision by a company on which work to price for and the level of profit to incorporate in order to successfully secure the project and maintain the businesses financial security.

Bidding strategy in construction comprises a number of decisions to be made including whether to bid or not bid; the level of mark-up to be adopted. If the decision is to bid and be successful on the bidding strategy, it is necessary to bid high enough to ensure getting profit on each job and low enough to get job (Chua and Li, 2000). Various research works have been carried out on the subject of competition strategies in the construction market. Friedman (1956) cited in Tan et al. (2008) argued several possible objectives a bidder may wish to achieve and for which different competition strategies are developed. The objectives include; maximizing total expected profit, gaining at least a certain percentage of investment, minimizing expected losses, minimizing the profits of competitors, keeping production going.

Cooke and Williams (2015) highlighted some benefits of a bidding strategy which includes; determining the chances of getting a job by bidding with any given markup; identifying the markup that will result in the greatest possible profit on a specific job in view of the prevailing competitive situation surrounding that job; select from a number of different projects, the jobs offering the greatest profit potential and; decide whether a particular job offers sufficient profit potential to justify submitting a bid at all. Furthermore, Cooke and Williams (2004) evaluated some key factors influencing contractor's decision to bid and these include; current workload, sufficient working capital, availability of resources, location of project, size and type of project etc.

Boughton (1987) cited in Barr (1990) found in his survey (with useable responses from 126 general construction contractors from around the United States) that the factors in developing a bidding strategy are clearness and detail of specifications, past experience with similar work, confidence in subcontractor bid and location of project. Furthermore in a descending order are number of competitors, duration of project, workload, market condition and size of bid. Others are opportunity for follow-on work, relationship with the owner; competitors bid history and confidence in external events (interest rates, inflation etc). Boughton concluded from this survey that the general construction contractor's number one concern about a prospective job is how well he will be able to control the construction process. However, the market conditions play a substantial role in the development of a contractor's bidding strategy.

2.1 Types of Contractors' Bidding Strategies

The Hong Kong study on an examination of the factors affecting contractor's competition strategy by Tan et al. (2008) identified five types of competition strategies particular to the area of study. They include lower bid strategy, joint venture, public relations, risk control and claim strategy. Also, in the study of Emily (2013) on construction bidding strategies, three types of bidding strategies identified are quantity bidding, selective bidding and negotiated work. They are discussed as follows.

Lowest Bid Strategy: By adopting a lower bid strategy, the contractor will offer a much lower bidding price than other competitors in order to increase the chance of winning the contract. On the other hand, it should be noted that the adoption of this strategy is in sacrifice of the contractor's profit margin.

Joint Venture Strategy: Adopting a joint venture strategy to compete in the construction market means that several contractors form a joint organization to tender for a contract. Since the construction projects are becoming more complex and risky, there is increasing demand for contractors with diverse strengths and weaknesses to form joint ventures to collectively bid for projects (Kumaraswamy et al., 2000).

Public Relations Strategy: Public relations are the practice of managing the communication between an organization and other stakeholders in the construction market. The public relations strategy is used to help contractors in communicating effectively and positively to the public, clients and consultants. The communication can be in different ways, such as attending conferences, winning industry awards or establishing long-term cooperation with clients. The strategy will help improve the contractor's image, thus increasing the chances of winning in competitions in the market.

Risk Control Strategy: Risk control means to assess and manage risks related to a project. Contractors can demonstrate that they have the best skill in risk control if they adopt the proper strategy. Thus they can gain better credits from clients. The risk control strategy includes avoiding the risk, reducing the effect of the risk, transferring the risk to other parties, or accepting the consequences of a particular risk.

Claims Strategy: The claim strategy is used when the expectation is that there are potential changes in the design of a project, or there are uncertainties existing in the project which may lead to claims in the future. The adoption of this strategy depends on the characteristics of the project. For example, a small project with a detailed design is not appropriate for selecting this strategy, but a large complex project without a detailed design may be a good choice for implementing this strategy.

Quantity Bidding Strategy: The most widely used bidding strategy for many contractors is to simply bid on every job that comes along. This high-volume approach is based on the belief that putting out a large quantity of bids means that you will usually win at least a certain percentage of them. This strategy is very time consuming and usually results in low profit margins. The bidding-by-volume approach is most effective for newer companies with little name recognition in the industry that has trouble landing work. It may also be a good strategy for companies struggling to find work, or those that have a large number of employees who are not busy with current projects.

Selective Bidding Strategy: A more effective strategy is to carefully evaluate bid opportunities based on quality, and to pass on bids that are not a good match for the company. This allows estimators to take their time on each bid and refine their price, which usually results in more

successful bids. To utilize this strategy, a contractor considers the type of work the company is most successful at. This may be a specific project type, like hospitals or schools, or a certain size range of jobs. Once an appropriate bid opportunity has been found, time is therefore taken to produce an accurate estimate and obtain material prices from suppliers. Evaluate the plans and schedule to see how you could perform the job efficiently. This will allow you to keep your bid low and improve your chances of landing the job.

Negotiated Work Strategy: Most bids for government work or municipal agencies are sealed bids. This means that prices are submitted and the lowest qualified bidder gets the job. There is no room for negotiation or bid modification. In open bid, prices are submitted to the owner who can base his selection on a wide range of criteria. There is no legal obligation to give the contract to the lowest bidder. In negotiated job type, relying on networking and personal relationships helps contractor land a work. This involves carefully preparing bids and staying in contact with the owner/client as much as possible throughout the process. Performing to the highest standards is therefore very important once a contractor lands a work. This will often lead the owner to awarding additional work through a negotiation process, rather than a bid. Negotiated work often comes with higher profit margins and fewer communication problems.

3 Research Methodology

Three states were selected base on convenience for the purpose of this study; i.e., Ondo – oil producing state and Lagos and Osun – non-oil producing states in the Southwest Geo-political zone of Nigeria. The total number of registered contractors domiciled in each state was physically sought for and obtained from the office of the supervising authority on public procurement, the Bureau of Public Procurement (BPP). Base on contractors' due registration with Corporate Affairs Commission (CAC), current tax payment and value of work to bid for, two hundred and thirty-seven were randomly selected and provided questionnaire but one hundred and seventy-one useable responses were retrieved indicating 72% response rate. Ling and Liu (2005), Oo et al. (2008) and Tan et al. (2008) are of the opinion that contractors are often secretive about their bidding activities. However, Tan et al further stated that the normal research survey rate in the local construction industry is between 10% and 20%. Therefore, 72% response rate was adjudged reasonable, high and representative. A pilot survey carried out on the subject under discussion initially revealed contractors have the knowledge of different types of bidding strategies thereby giving rise to the responses as discussed.

The study objectives evaluated different types of contractors' bidding strategies adopted in the NCI and also assessed the success rate of contractors' bid. To this end, the questionnaire obtained information from the contractors' on their experience on bidding processes, understanding of different types of bidding strategies, number of projects bided for and successes recorded over ten year period 2005-2014 were requested for. Five-point Likert scale, which are (1) Extremely Not Important (2) Not Important (3) Either not important nor important (4) Important and (5) Extremely important, were adopted to prepare a closed-ended questionnaire. This was preferred most as opined by Akintoye and Main (2007) in order to reduce the level of bias and to facilitate coding. Descriptive statistics, tables and percentages as well as mean item score (MIS) were used for data analysis.

4 Findings and Discussion

4.1 Awareness on the types of contractors' bidding strategies

Table 1 presents responses from the survey carried out among contractors in three different states (Lagos, Ondo and Osun). The contractors showed awareness on the types of bidding strategies. On the overall, 28.7% of the contractors showed they are aware of lowest bid strategy while 21.6% and 15.8% are aware of public relations and joint venture bidding strategies respectively. The analysis revealed that lowest bid strategy top the awareness list among all the strategies in the three states while some level of awareness was also revealed on other types. Offering low bids according to Tan et al. (2010) will reduce contractors' profits and potentially make development less attractive. Contractors need to understand their specific resources that generate competitive advantage and accordingly develop strategies to win contracts.

4.2 Frequency of Use of Contractors' Bidding Strategies

Presented in Table 2 is the MIS of the frequency of use of contractors' bidding strategies. The result shows that public relations strategy (MIS=4.45) is the most frequently used bidding strategy. A pilot survey revealed the situation of the construction market in Nigeria

Table 1 *Awareness on the types of Contractor's Bidding Strategies*

Bidding Strategies	Overall		Lagos State		Ondo State		Osun State	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Lowest Bid Strategy	49	28.7	21	30.9	12	28.6	16	26.2
Public Relations Strategy	37	21.6	16	23.5	9	21.4	12	19.7
Joint Venture (Consortium) Strategy	27	15.8	12	17.6	6	14.3	9	14.8
Quantity (Mass) Bidding Strategy	20	11.7	5	7.4	6	14.3	9	14.8
Negotiated (Bargained) Works Strategy	18	10.5	5	7.4	5	11.9	8	13.1
Selective (Choosy) Bid Strategy	9	5.3	4	5.9	2	4.8	3	4.9
Risk (Loss & Hazard) Control Strategy	5	2.9	3	4.4	0	0	2	3.3
Claims Strategy	6	3.5	2	2.9	2	4.8	2	3.3
Total	171	100	68	100	42	100	61	100

Table 2 *Mean Item Score (MIS) of frequency of use of Contractor's Bidding Strategies*

Contractors' Bidding Strategies	Overall		Lagos State		Ondo State		Osun State	
	MIS	Rank	MIS	Rank	MIS	Rank	MIS	Rank
Public Relations Strategy	4.45	1	4.44	2	4.39	1	4.53	2
Lowest Bid Strategy	4.41	2	4.50	1	3.72	5	5.00	1
Joint Venture (Consortium) Strategy	4.18	3	3.98	4	4.28	2	4.27	4
Risk (Loss & Hazard) Control Strategy	4.02	4	4.20	3	3.90	3	3.95	5
Quantity Bidding Strategy	3.55	5	3.50	5	3.86	4	3.29	6
Claims Strategy	3.36	6	3.33	6	2.47	7	4.29	3
Negotiated Works Strategy	3.28	7	3.29	7	3.63	6	2.91	8
Selective (Choosy) Bid Strategy	2.91	8	3.23	8	2.29	8	3.22	7

construction industry to which this finding agrees with. Contractors bidding for public works always look forward to securing bid awards by creating external relationship with clients outside the normal relationship brought about by the contract. This was found to frustrate the purpose of public procurement meant for transparency. On the contrary, Tan *et al.* (2008) emphasized the intention of public relations strategy which was meant to help contractors communicate effectively and positively to the public, clients and to consultants and this could be in different ways; attending conferences, winning industry awards and establishing long-term cooperation with clients.

4.3 Effectiveness of Contractors' Bidding Strategies

Table 3 presents the MIS values and rankings of the effectiveness of contractors' bidding strategies. Findings revealed public relations strategy with MIS values of 4.54 and 4.59 as the most effective bidding strategy in Lagos and Osun state – non-oil producing states. However, lowest bid strategy with MIS value of 4.41 is the most effective in Ondo state. Average Mean Item Score (MIS) of the three states further indicated lowest bid strategy as the most effective in the Nigerian construction industry with average MIS value of 4.46. This is followed by public relations strategy with average MIS value of 4.42 and selective (choosy) bid strategy with an average MIS value of 4.09. There is no doubt that lowest bidder gets an award for contracts bided for in the construction industry and this explains why it is still the most effectively adopted strategy. According to Shen et al. (2006) and Tan et al. (2008), evaluation of contractors has continued to emphasize on tender price with less attention on contractor's performance attributes.

4.4 Contractors' Bid Success

In order to determine the success rate of construction firms', different types of construction works were considered. Table 4 shows the responses of the contractors' on different types of construction works. The contractors provided the number of projects bided for and number of projects won for a period of ten years. Thereafter, bid success rate for the projects were determined according to the responses provided by the contractors'. The results indicated that majority of the contractors have recorded more than 70% success on residential type of project over this period. Also, contractors in Ondo and Osun states respectively have recorded minimum of 80% success on educational facilities than contractors in Lagos state. However, about 80% of successes recorded on administrative facilities are from contractors in Lagos state. This result is therefore indicative of a mature organization with established strategy and tactics as stated by Wolstencroft (2014) that, success rates of a minimum of 50% is decent and success rates of 70% or more are indicative of a mature organization with an established strategy and tactics used when bidding for construction works. A low win rate should therefore lead a contractor to examine strategic alignment and timing of bids. Base on the pilot survey, the findings indicate that lowest bid strategy had an impact on the success of bids for construction works.

5 Conclusions and Recommendations

Results have shown that contractors in the Nigeria construction industry are aware of the different types of bidding strategies across the

Table 3 *Mean Item Score (MIS) of the effectiveness of Contractor's Bidding Strategies*

Contractors' bidding strategies	Overall		Lagos State		Ondo State		Osun State	
	MIS	Rank	MIS	Rank	MIS	Rank	MIS	Rank
Lowest Bid Strategy	4.46	1	4.48	2	4.41	1	4.48	2
Public Relations Strategy	4.42	2	4.54	1	4.14	4	4.59	1
Joint Venture (Consortium) Strategy	4.09	3	4.36	3	4.20	3	3.70	6
Selective (Choosy) Bid Strategy	4.03	4	3.91	5	4.14	4	4.03	4
Negotiated Works Strategy	4.02	5	3.92	4	3.75	5	4.38	3
Quantity Bidding Strategy	3.85	6	3.23	7	4.33	2	4.00	5
Claims Strategy	3.75	7	3.83	6	3.75	5	3.67	7
Risk (Loss & Hazard) Control Strategy	3.01	8	2.67	8	2.86	6	3.50	8

Table 4 *Bid success rate of construction firms*

Construction Works	Lagos State	Ondo State	Osun State
Residential facilities (housing, hostels)	97%	85%	78%
Administrative facilities (offices, law courts)	79%	71%	53%
Educational facilities (laboratory, classrooms, library)	64%	83%	88%
Religious facilities (temples, churches, mosques)	53%	56%	20%
Health facilities (hospitals, clinics)	47%	6%	17%
Industrial facilities (factories)	40%	-	-
Common facilities (toilets, storages)	20%	49%	83%
Recreational facilities (stadium, parks)	17%	-	-

states selected for the purpose of this research. Public relations strategy has been adopted more frequently by contractors in Ondo state as against its adoption in Lagos and Osun state. This result from Ondo was expected being an oil-producing state where contractors want to land project award and execution. It was also concluded that lowest bid strategy was adjudged the most effective when bidding for construction projects in the public sector.

However, to be successful in bids, contractors are encouraged to be project specific and not bid base on quantity as this would lead to poor output and wasted effort. This was revealed from the percentage of successes recorded residential, administrative and educational facilities in the selected states respectively.

Considering the impact of these bidding strategies on bid success, construction industry in its competitiveness require contractors' to be smart with their bidding activities. The adoption of public relations strategy should function in advertising the construction firm in order to foster a long lasting relationship with the client. The decision on a particular strategy lies mostly on the top management and the technical department of an organization, and in order to be successful, contractors' must device means to out-run other competitors. Hence, the need for contractor's bidding strategy in the construction industry.

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Shelter planning based on self-saving concepts in urban residential districts

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ABSTRACT

With increasing population density in Asia, the potential higher risk was resulted from the residential districts with the higher plot ratio, especially in some megapolis (eg. Beijing and Shanghai). Presently it is more difficult for the rescue operation during the disasters because of the decreasing safe space among the buildings as a result of higher buildings and denser the district. Thus, an immediate self-saving action is more important than before during the disaster in the residential districts, and its realization depends on the reasonable shelter planning and its management system. In this study, the factors related to the self-saving were analyzed and concluded by the related the literatures retrieval and case study, and the case study was done by the in-depth interview and questionnaires in three different residential districts in Shanghai. It was found that the following factors related to the self-saving should be considered in the shelters planning: the distribution of the shelters including their space accessibility and area, evacuation passageways, the facilities of the disaster prevention (such as fire hydrant and guide signs) and subsidiary facilities (such as vegetation for the disaster prevention), the social cohesion, awareness of the self-saving and disaster prevention. Simultaneously, the shelters planning countermeasures based on the self-saving were proposed, which provided some theoretical bases for the study and plan of the security residential districts in future.

1. Introduction

Disasters occurrences are mostly unpredictable. Even though it is predictable the warning lead time that allows people to prepare is too short (Johar and Permana, 2015). When disasters strike the unprepared community, the loss and damage will be incredible (DeBreo, 2015). The well-prepared community with self-saving capability is therefore crucial. Around the whole world the frequency of the various casualties is increasing because of the climate change and increasing population density, and this seriously hinders the social stability and developments of the cities. To reduce the losses resulted from the casualties, the urban refuges, which are the important parts of the urban public spaces, were planned as the important locations for the citizens. However, the shelters which were based on the urban master planning were always paid more attention than that in the residential districts.

As the vital components of the cities, the majority of population are daily accommodated in urban residential districts during some specific time (such as sack time), and there amounts of the public infrastructures (such as facilities used for electricity and *Natgas* supplies) are intensively contained, but the residential districts were always mistaken for the relatively safer locations. Simultaneously, the larger potential risks have arisen in modern urban residential districts during the disasters because there the high density of population resulted from the increasing density and height of the buildings. So during the paroxysmal disasters these are prone to result in more casualties and the serious losses of properties compared with other urban areas, and even it may causes serious secondary disasters. Therefore, the shelters planning in urban residential districts have become more important for the modern city, especially in China, compared with that in the last century. Actually the second world conference on disaster reduction (2005), held in Kobe, Hyogo, Japan, 1have suggested that the urban residential districts should be as the elementary unit for disaster mitigation.

Generally the various relatively open areas, which include the green land, entrance halls, the top of the buildings and so on, can be planned as the shelters in the residential districts, and the residents can arrive there by some distinct guiding signs if necessary. For the high-rise buildings in residential districts, the areas divided regularly in floors are also planned as the shelters. Simultaneously, some infrastructures (such as fire hydrant and drinking water supply) and the special evacuation passageways for the disable are set in the shelters. In addition, with the synthetic consideration for the economics and necessity, the different shelters planning was implemented according to the density and height of the buildings and number of people in the resident district. So far many theories and methods of the shelters planning like above mentions have been proposed and studied, but few researches for the shelters planning based on the self-saving have been conducted.

The shelters in residential districts are generally planned as the preferred emergency refuge for the residents during the disasters, and the losses and casualties may be greatly mitigated during the paroxysmal disasters if these can be effectively utilized by the residents to realize stir-and mutual-rescue before the rescue teams' arrival, simultaneously which is also conductive to the rescues and reconstruction after the disasters. This relays on the following aspects: residents' needs, residents' familiarity with the shelters, maintenances

and improvements of their functions after the constructions. In addition, the shelter planning is a pattern of the resource allocation, and it is involved with the security interest of the residents. So it is necessary for the residents to participate in the planning, routine maintenances and use training of the shelters, which the social cohesion among the residents plays an important role in. Therefore, the social cohesion should be one of the main considerations for the shelters planning based on the self-saving.

In this study, the factors which were related to the self-saving and should be considered in the shelters planning were analyzed, and the shelters planning countermeasures based on the self-saving were proposed, which provided some theory basis for the studies and planning of the security residential districts in future.

2. Definition of Concepts

There are some working definitions in this study. These definitions are given below.

Self-saving, in the context of disaster rescue operation, is an individual effort to avoid the injuries, casualties or deaths by his/her present own capability at the time of disasters or present dangers. This concept was based on the fact that the event of some kind of disasters is unpredictable and unforeseeable, for instance earthquake. Earthquake is unpredictable. Some other disasters are predictable but the time to respond is too short. The shortness of warning lead time makes the number of casualties or even loss of life can be higher. Thus, the self-saving practice becomes important to minimize the casualties or loss of life.

The residential districts are the areas with certain scale, which is divided by the roads or natural boundaries (such as rivers) in city and no main road is throughout, and there are the public greenbelts and the completed infrastructures which can meet the residents' daily life. A residential district comprised of several housing clusters is a unit of the resident area. According to Code of Urban Residential Areas Planning & Design (GB50180-93, 2002) in China, the scale of a residential district should range from 2,000 to 4,000 households (approximately 7,000-15,000 residents), and land-use area range from 10,000 to 36,000 square meters.

In the event of disasters, self-saving practices by the citizens within the urban residential districts play an important role in minimizing the number of casualties or loss of life. The self-saving practice becomes essential when the rescue team response was hampered by many factors such as disturbed connection i.e. cut roads/bridges, the equipment of the rescue team or even the team member itself struck by disasters. By this situation, the creativity to avoid the threats or injuries by the citizens through self-saving efforts would be indispensable.

The shelters mentioned in this study, which solely referred to the emergency and temporary refuges rather than the municipal or provincial refuges, are the transitional places before the refugees can be transferred to the larger public shelters together in the disasters (Design code for urban disasters emergency shelter- exposure draft, 2012, GB xxxxx-2012). Simultaneously, in this paper the shelters in which the infrastructures can be set are limited to the open area with a certain scale in the residential districts, and the residents can conveniently utilize them in daily life or disasters for the different purposes.

Other definition given is refugee behavior. This refers to all the behaviors or actions which could be taken when people is in danger.

The psychology of refugee behavior refers to all the psychological activities which arise and directly result in producing the refuge behaviors when people are in danger. The physiology of refuge behavior significantly affect the refugees' choices of the evacuation passage ways and shelters, so that should be as important one of the considerations for the disaster prevention planning, which is helpful to improve the urban disaster prevention system and reduce the losses in the disasters.

The disasters mentioned in this study, which belongs to the urban disasters, likely occur in the residential districts and threaten the security of the residents' life and properties. These are composed of natural and man-made disaster and mainly include earthquakes, floods, severe colds, typhoons, tsunamis, fires, epidemics and the secondary disasters potentially resulted in by them (Liu, 2006).

The infrastructure to prevent the disasters refers to the supporting facilities which can meet the necessary needs of the refugees' living in the disasters. The facilities include tents, barrack-like temporary housing, emergency water supply, emergency power supply system and lighting facilities, emergency medical service and so on.

The emergency evacuation passageway refers to the preferred passageway to the shelters, which the residents can immediately utilize as soon as the disaster occurs. Most of them are the roads in the shelters and these also include a few urban minor roads.

The vegetation for disaster prevention refers to the plants which can, in subsidiary manner, prevent the refugees from harms in the disasters, and this includes mitigating the harms resulted from the falling objects, slowing the spread of flames and so on.

The term "social cohesion" was first coined by Emile Durkheim in 1983 (Regina, 2000) and defined that it was a characteristic of the social order, which was expressed by the interdependence, mutual loyalty and solidarity among members of society. Subsequently, it has various definition narrated by many scholars, and some governments and organizations have made many efforts for improving its level among their citizens or members. The Social cohesion is a tie among the members of society, and its level can be assessed by the following factors: social relationship, task relation, perceived unity and emotion (Forsyth, 2010). Actually except the expression of social cohesion mentioned above, there also include belongingness, inclusiveness, the participatory, recognition, legality, shared values, shared challenges, equal opportunities and so on.

3. Research Objectives

The objectives of this study were to (i) explore the roles of the influencing factors related to the self-saving in the shelters planning; (ii) Highlight the importance of the shelters planning based on the self-saving; (iii) propose some shelters planning countermeasures based on the self-saving.

4. Research Methods

A mixed method was designed and applied in this study. Firstly, we identified the related literatures by searching the electronic databases of SCI, EI and CNKI, and the following keywords were used in various

combinations: "self-saving", "residential districts", or "shelters planning". Secondly, to obtain the real needs of the residents, we respectively made the in-depth interviews with 15 persons from the different residential districts, who are the residents, members of the neighborhood committees, or staffs from the property management companies. Every interview was randomly carried out for approximately half an hour, and the contents of the conversation were not limited before. Finally, the factors selected form the related studies were combined with the topics frequently mentioned in the interviews to design a questionnaire and a total of 100 questionnaires were distributed in three different residential districts located in Shanghai.

5. Results and Discussion

The serious losses of life and property were always caused because the calamities unpredictably and rapidly happened. The comprehensive measure for the disaster protection is one of effective methods to minimize the losses. A shelter in the residential districts is one of the important locations used for the disaster protection, so it is necessary for the immediate and efficient utilization of the shelters during the residents' self-saving in the unexpected disasters, which is directly related to its planning. In this study, the factors related to the self-saving were investigated and highlighted in the shelters planning, and some shelters planning countermeasures based on the self-saving was suggested, which may be helpful to the related researches and planning.

5.1 Baseline of Case Study

A total of 100 questionnaires were distributed, and 92 valid questionnaires were identified for the subsequent analysis. The information mentioned in the questionnaires was obtained from three different residential districts located in Shanghai (Fig. 1).

5.2 Importance of the Shelters in Resident Districts

The various disasters can happen anywhere at any time. More than 64% of the respondents in this survey indicated that they or their friends suffered the disasters (Fig.2). The residential districts are the important one of the functional units in city and are the areas with the dense population. The population mobility in the residential districts always focuses on the special time in daily life. In our surveys, it was found that 28% of the respondents stayed in their home only at night and 45% for all day (Fig.3). Simultaneously, the plot ratio is gradually increasing with the increase of population density, which resulted in the reduction of their safe distances. The secondary disasters (such as Stampede) are more easily resulted from the above factors when many panic residents with simultaneously escape for the refuge in the crowed spaces during the disaster. The shelters in resident districts are generally planned as the preferred emergency refuge for the residents during the disasters, and its reasonable planning can partly mitigate the losses and above risks, which is also conductive to the rescues and reconstruction after the disasters.

The shelters in the resident districts are the important parts of the urban public spaces, but actually the other urban public spaces were always paid more attention than them. This may resulted form that the resident areas especially residential districts were mistaken for the relatively safe locations. So far, the follow-up of many existing shelters, including the construction, rationality of their utilities, maintenances, improvements of their functions and so on, was infrequently concerned by their planners after accomplishments of their planning.

Figure1: *The Location of Three Residential Districts in Shanghai*

Table 1 *The Baseline Characteristics of Three Residential Districts*

		Tang Chen Hao Ting	Pu Fa Bo Yuan	Chi Feng Xiao Qu
No of Respondents		30	32	30
Gender (Male:Female)		16:14	16:16	15:15
Age	Under18	2	3	6
	19-30	3	5	9
	31-50	21	19	9
	51-70	3	5	4
	Above70	1	0	2
Residence type		High-rise residential building and small high residential building	High-rise residential building and low-rise residential building	Multi-story residential building and low-rise dwelling
Housing ownership (Rent:Own)		1:5	1:7	7:8
Gross area		132,000 m2 (Large residential district)	8,700 m2 (Medium-sized residential district)	8,541 m2 (Medium-sized residential district)
Total number of households		466	590	1,200
Time Period of construction		2002-04	2009-09	1983-06
Plot ratio		1.2	1.3	1.8
Occupancy rate		44%	42%	72%
Parking space		Ground parking spaces 200, Underground parking 300	413	200
Greening rate		52%	36.10%	30%

5.3 Importance and Awareness of the Self-saving in Urban Residential Districts

The disasters are usually unanticipated and unpredictable for their rapid occurrence. It causes the losses of life and casualties before the rescue teams' arrival. For instance, the earthquakes only last for tens of seconds. If the self-saving can be felicitously taken in time, the rescue teams can learn the more detail information of disaster area from more survivors and take more pertinent measures, which can raise the efficiency of the rescues. Reversely, the following rescue work may be more difficult. So it is important for the reduction of the losses and casualties that self-saving is immediately adopted with the shelters and facilities of the disaster prevention.

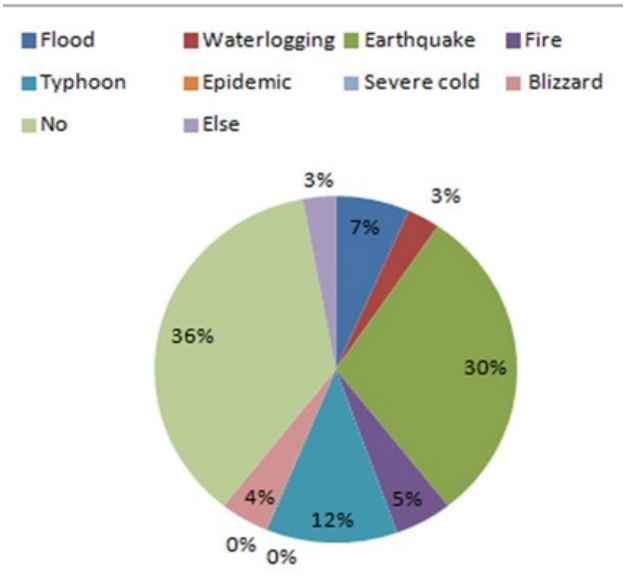

Figure 2 *Disasters Experienced by Respondents*

5.4 Analysis for the factors related to the self-saving in urban residential districts

The factors which affect the self-saving are complex, and these can be roughly divided to the objective factors and human factors. The objective factors were paid more attentions in the previous studies or existing related planning (Ran;Jenks,M., Burton,E. and Williams,K., 1996; Meng,X.H. and Song,L., 2012; Han,R. and Liu,J.Y., 2009), and these included the facilities of the disaster prevention, the shelters, the roads and so on. In this survey, 80%-90% respondents in Tang Chen Hao Ting and Pu Fa Bo Yuan indicated that there are the fire hydrants and evacuation passageways in their residential districts, and the ratio was significantly higher than that in Chi Feng Xiao Qu(Fig.4 and Fig.5), suggesting that the facilities of the disaster prevention in the residential districts were gradually paid more attentions than before.

The shelters are also the important one of the objective factors related to the self-saving. The nearby and open areas (such as green lands) are

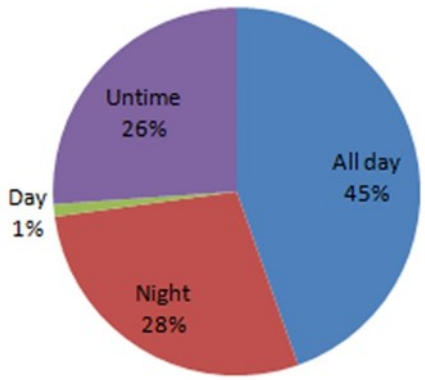

Figure 3 *During Disaster Events hen do You Stay in Your Home?*

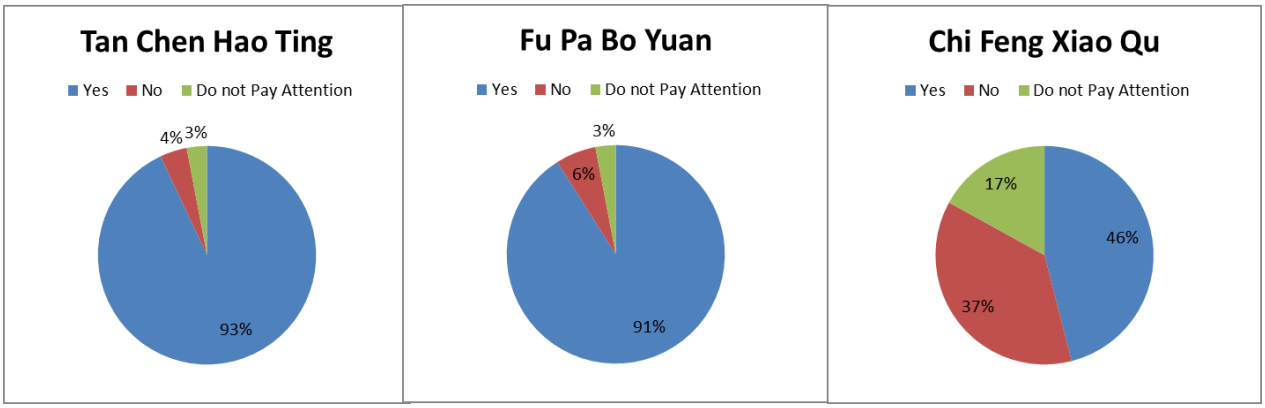

Figure 4 *On the availability of the Hydrants of Fire Extinguishers*

generally chosen or planned as the emergency shelters in the residential districts, which are relatively safer and convenient for the arrival, and the effective area of the shelters in the residential districts is the residual area except for water area and area potentially covered by the collapse of the buildings. In China it is generally thought that the area in a residential districts should be more than 500 square meters, and the average area per capita should range from 1 to 2 square meters (li,X.J. and Li,J.W.,2013; Ormsb,S.J.,1978; Emergency shelter for earthquake disasters-site and its facilities (GB21734-2008), 2008; Scientific Survey Team of National Earthquake Response Support Service (NERSS) 2008; Department of health of Qinghai province, 2010; Earthquake resistant design codes in Japan, 2000, Program on improved seismic safety provisions,1987). In this survey, for the convenience of this research, the average area per capita was artificially defined as 1square meter. It was better in Tang Chen Hao Ting and Pu Fa Bo Yuan that the existing effective area of the shelters in the residential districts can meet the above criteria, suggesting that the shelters in the residential districts were gradually improved.

In addition, the roads and the parking spaces are important to the self-saving. For instance, it is stipulated in China that the width of the roads in the residential districts should be not below 4 meters, and at least one of them should be linked with an urban road. This is not only convenient for residents but also enables the fire trucks or ambulance to smoothly enter the residential districts in time. Simultaneously, the enough parking spaces in the residential districts can avoid the jam by the disordered parking cars. In this survey, the parking spaces in Chi Feng Xiao Qu were seriously not enough for the real needs, and this resulted in the half of the roads was occupied by the parking cars. The phenomenon in two other residential districts was significantly improved (Table 2), suggesting that the fluency of the roads in the residential districts were gradually paid more attentions than before.

Although the above objective factors related to the self-saving have been respectively improved at the various degrees, it was found in the survey that the related human factors were still not paid enough attentions, especially the social cohesion, awareness of the self-saving and disaster prevention. The formation of the social cohesion is affected by the complex and diverse factors, which include kinship, traditional or national concepts, class status, social mentality based on the consistency of the realistic interests and so on. For instance, it was founded from this survey that 92% of the respondents indicated that they prefer to stay with their family members when the disasters happen (Fig. 6). In this study, for the concretely reflecting the levels of the social cohesion in the resident districts, it was artificially and

Table 2 *The Parking Space of Three Residential Districts*

	Chi Feng Xiao Qu	Pu Fa Bo Yuan	Tang Chen HaoTing
Households	1200	590	466
Should have parking space	720	590	466
Existent parking space	200	413	400

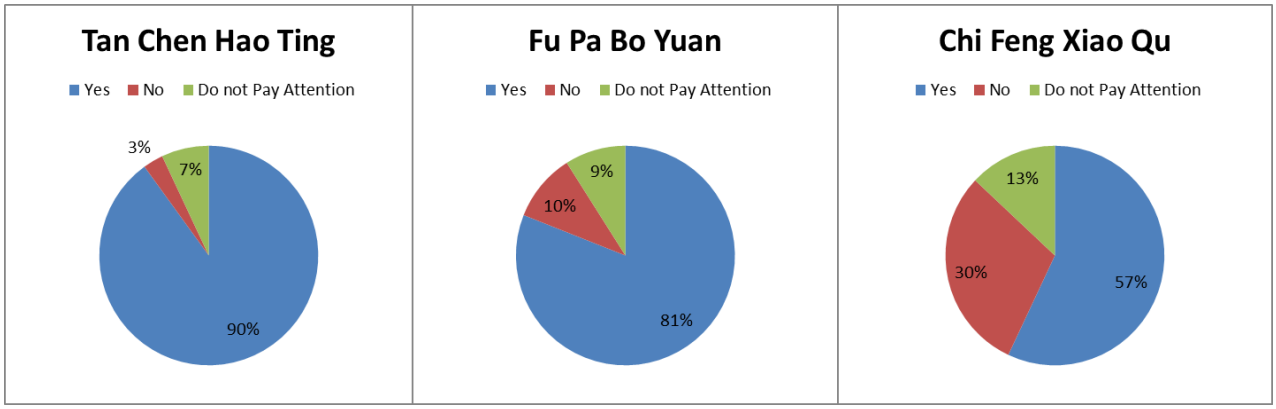

Figure 4 *On the availability of the Evacuation Passageways in Buildings*

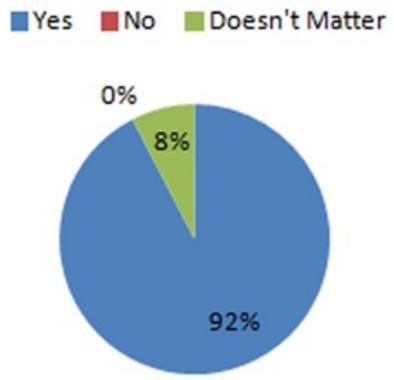

Figure 6 *Preference to Stay with Your Family Members When the Disasters Happen*

simplistically defined and assessed with the following factors in the resident district: the degree of familiarity among the residents, the frequencies and effects of the collective activities, the degree of residents' satisfaction for the public spaces, the utilization rate of the public spaces and so on.

It was proved above that the objective factors (such as facilities of the disaster prevention and the shelters) were important to the self-saving, and actually their effective utilization relay on residents' familiarity with them, their maintenances and improvements, which the social cohesion plays an important roles in. The shelters in the resident districts are planned for and will be mainly utilized by the residents, so it is rational to consider their needs in the shelters planning. The function conservation of the shelters can successfully be realized between daily life and disasters when the planning meets the needs of the residents, which is impossible without the residents' opinions. Simultaneously, actually the shelters planning is also a pattern of the resource allocation, and it is involved with the security interest of the residents. Marx (1956) said that people are fighting for everything to do with their interests. So it is necessary for the residents to participate in the planning, routine maintenances and use training of the shelters, which the social cohesion among the residents plays an important role in. In this survey, if the resident districts were dissatisfied, 50%, 28% and 3% of the respondents respectively chose to suggest property management companies, neighborhood committees or governments for it, and 5% chose to move and 14% did not know who should be in charge of it (Fig.7). This indicated that there was not a very definite way for the residents' participation in the affairs (such as the affaires related to the safety) of the resident districts.

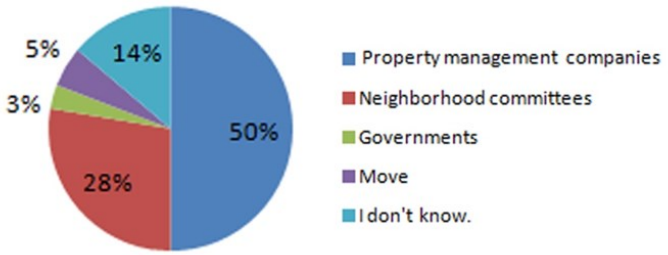

Figure 7 *On the Agency in Charge in Residential District during Disasters*

The success of the self-saving is also primarily actuated by the awareness of the self-saving, for which it is necessary that the residents should have the awareness and knowledge of the disaster prevention. In this survey, approximately 40%-50% of the respondents did not know where the shelters were in their residential districts (Fig.8), and more than half of the respondents indicated that they would need others' helps during the disasters (Fig.9), suggesting that the awareness of the self-saving and disaster prevention was not enough in the residential districts. Simultaneously, compared with two other resident districts, more respondents in Chi Feng Xiao Qu were not clear the location of the evacuation passageways or fire hydrant (Fig.4 and Fig.5), suggesting that the awareness was gradually improved with the construction of the new residential districts. In addition, the proportions of the respondents trained in the disaster prevention decreased with age (Fig.10), suggesting that the training had been increasingly paid more attentions. This suggested that the effect of the training was yielded and the psychological fore-warning system on residents trained had been gradually constructed.

5.5 How to realize the shelters planning based on the self-saving

With the above analysis for the factors related to the self-saving, three kinds of the distribution of the shelters in the residential districts were proposed as the following. For the new large or medium-size resident districts with the relatively dense buildings, it was suggested that the centre squares should be planned as the shelters during the disasters (Fig.11: A). This is conductive to the space accessibility and intensively establishing the infrastructures because the wider and integrated areas located in the central can be used, which is also more

Figure.8 *On the Satisfaction level with the residential area shelter*

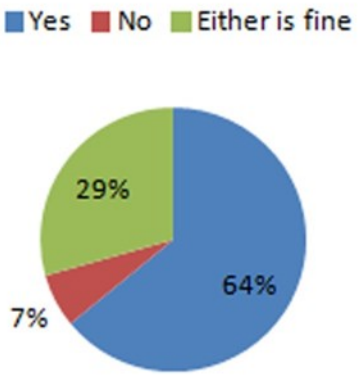

Figure 9 *On Help needed from others During the Disasters*

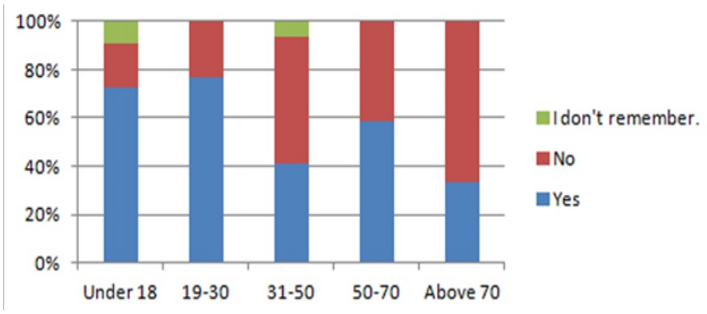

Figure 10 *The Proportions of the Respondents Trained on Disaster Prevention*

economical, and the shelter can simultaneously accommodate more people; For the old and small-size resident districts with the dense buildings, the joint areas of the resident districts and the outside can be utilized as the shelters during the disasters because there none large and integrated area located in the central is generally available (Fig.11: B). However, this may block the roads when the evacuation or rescues would be implemented; For the resident districts with the low plot ratio, the shelters can be planned with the scattered distribution (Fig.11: C). Although this can make the shelter nearer to the dwellings, but simultaneously more and similar infrastructures will be needed, which results in the increasing of the budget for the shelters construction. So which distribution of the shelters can be chosen should be referred to the land use and plot ratio of the resident districts.

Simultaneously in this survey, nearly 20% of the respondents did not know where the shelters were in their residential districts (Fig.8), suggestion the guide signs for the shelters were not marked. So the distinct and comprehensible guide signs should be used for the shelters. The vegetation for the disaster prevention can be also used in the self-saving and should be considered in the shelters planning.

In addition, the human factors should be also considered in the shelters planning based on the self-saving (or improvement) except for the above objective factors. In this survey, it was found that the social cohesion plays an important role in the self-saving. For instance, the respondents trained in the disaster prevention intended to choose the correct escape routs and shelters; some shelters (such as schools and open areas in the enterprise) in or near to the resident districts may not be available during the disasters because of their management mechanisms. Simultaneously, more than 90% of the respondents would like to participated in the rescues or reconstructions and the group activities held in the residential districts if possible (Fig.12, Fig13 and Fig.14), although many respondents indicated that there the group activities were never held. So it should be considered how to utilize the enthusiasm to let them be familiar with the shelters for the self-saving in the disasters.

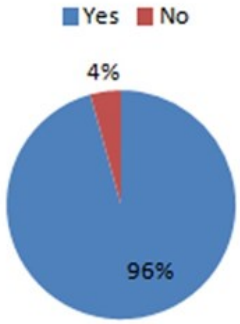

Figure 12 *Willingness to Participate in the Rescue Operations*

Figure13 *Willingness to Participate in the Reconstructions*

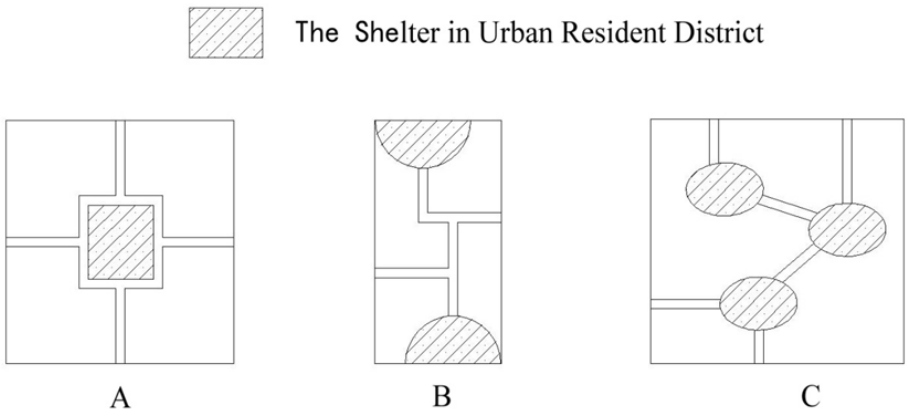

Figure 11 *Three Types of the Shelter distributions in the residential districts*

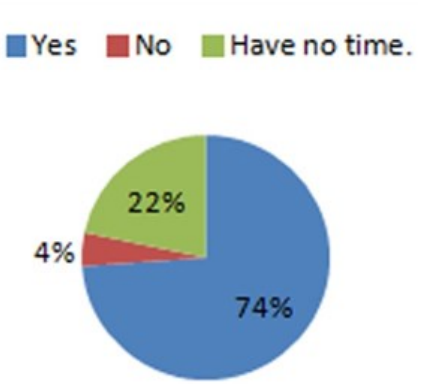

Figure 14 *Willingness to Participate in group activities held in the residential districts*

The guidance for improving the awareness of the self-saving is also one of the conditions of the shelters planning based on the self-saving, which can be partly realized by the disaster prevention trainings. The mechanisms that the residents participate in the maintenances and improvements of the shelters should be also considered, which can include the collection and feedback of the residents' advices, managements of the neighborhood committees, emergency plans of surrounding environment or infrastructures and so on.

6. Limitation

Due to limited number of respondents, there were certainly several limitations in this study. Firstly, there were the biases of the amount of the different classified respondents, which was resulted from the limited total number of the respondents, and this may resulted in the deviations in the analysis results; Secondly, the refuge behaviors and the corresponding physiology could be only forecasted by some of the respondents who had never suffer the disasters. It may be bias since the respondents have never really experienced with disasters. Thirdly, the questionnaires were only distributed in Shanghai, and the results of this survey were not compared with that in other places for the further confirmation; Therefore, a detailed and well-designed study by univariate analysis and the multivariate analysis should be performed to further confirm our results.

Even though the study may not statistically reflect the real situation of the whole citizens in the study area, the most important point of this study is that the messages of the potential victims must be taken into account seriously. The stakeholders of disasters, particularly authority must provide the disaster preparedness efforts to reduce the number of death tolls and casualties. The citizens must be equipped with sufficient knowledge and practices on how to do self-saving procedures. From the urban planning viewpoint, the built environment must be planned and designed to minimize the damages by any disasters. Buildings codes and development control must be followed accordingly.

7. Conclusion and Recommendations

In conclusion, the shelters in residential districts are the important parts of the urban public spaces, which are closely related to residents' daily life and self-saving in the disasters. Our study does support that the self-saving should be important one of the considerations in the shelters in urban residential districts. The recommendations for the shelters planning based on the self-saving were summarized as follows: the distribution of the shelters can be planned according to the land use and plot ratio of the resident districts; the facilities of the disaster prevention (such as guide signs for the shelters or evacuations passageways) should be planned for the more effective utilization, and the subsidiary facilities (such as vegetation for the disaster prevention) can also be appropriately planted in the shelters; simultaneously, the social cohesion and aware of the self-saving, which is contributed to arouse the enthusiasm of the residents' participation in the planning, maintenances and improvements of the shelters in daily life, should be also paid more attentions in the shelters planning, and the group activities in the resident districts (such as disaster prevention trainings) should be frequently held, which can make the residents be familiar with the shelters in order to raise their effective utilization rate in the self-saving. Consequently, the more effective self-saving was taken, the smaller losses would be during the disasters.

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Forecasting Temporal and Spatial Climatological Influence for Land Suitability Evaluation in Bentota Sri Lanka

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ABSTRACT

Climate change has raised much concern regarding its impacts on future land use planning, varying by region, time, and socio-economic development path. The principle purpose of land suitability evaluation is to predict the potential and limitation of the land for crop production and other land uses. This study was carried out to predict the temperature and rainfall trends as one of the major factor for evaluating land suitability. Climatic data such as monthly mean temperature, total monthly rainfall, maximum daily rainfall and total annual rainfall during last 30 years of all weather stations located in Bentota River basin was collected and analyzed applying time series analysis, correlation analysis and Manna Kendall trend test methods. Spatial distribution of forecast rainfall values was illustrated applying Arc GIS software. The findings revealed that monthly mean temperature and maximum daily rainfall had a general increasing trend whereas, total monthly rainfall and total annual rainfall showed a general decreasing trend in Bentota area. It was indicated relatively high rainfall situations during May and October while low rainfall situations during January and February by occurring flood situation in once per five year. During Yala season the area will be received comparatively more rainfall (331mm) than Maha season (300mm) in future. Community and the farmers in this area can be aware about the anticipated spatial distribution of total monthly rainfall during two major seasons and flood occurrence periods. Decision makers should evaluate land suitability of Bentota area by considering above climatological influences and its spatial distribution pattern that identified as major outcome of this research. The approach and the methodology adopted in this study will be useful for other researchers, agriculturalist and planners to identify the future climatological influences and its spatial distribution pattern for land suitability evaluations and other decision making purposes for other areas.

1. Introduction

Appropriate land use decisions are vital to achieve optimum productivity of the land and to ensure environmental sustainability. Land should be used based on its capacity to meet human needs and ensure the sustainability of ecosystems (Amiri and Shariff, 2012). The amount of land is fixed and the kinds of use that the land can support and the competition among these uses vary over time. The intensity of the competition is often proportion to the density of the population and in the demands of the population on the land (Jafarzadeh et al, 2005). Relatively scarcity of land resources for agriculture and insufficient food security of the world's population require that the land be used in an optimum way in the context of climate change (Liambila, Kibret, 2016). Thus, land evaluation is a vital link in the chain leading to sustainable management of land resources (FAO, 2007). Land evaluation is only part of the process of land use planning. Land evaluation is the selection of suitable land, and suitable cropping, irrigation and management alternatives that are physically and financially practicable and economically viable (FAO, 1984) and it is also the process of making predictions of land performance over the time based on specific types of uses considering soil, climatic, land form and socio economic conditions of an area (Al-Mashreki et al., 2011). These predictions are then used as a guide in strategic land use decision making. With the increase of demand for land, land suitability evaluation has become more important as people strive to make better use of the limited land resources. The principle purpose of land suitability evaluation is to predict the potential and limitation of the land for crop production and other land uses (Pan and Pan, 2012). Therefore, suitability is a function of crop requirements and land characteristics. Land suitability analysis is a prerequisite to achieve optimum utilization of available land resource in a sustainable manner (Mustafa,et al, 2011). In this manner, land suitability evaluation plays very important role in order to help developers and agriculturists to match the land optimum use and optimizing the use of a land piece for a specified use (Sys, Van and Debaveye, 1991).

Identification of the factors and related measures on land qualities and characteristics that use to evaluate the land suitability is the first step in the process of land suitability analysis. Ritung et al,(2007) show that land quality has the complex attributes of lands and contains more land characteristics. The land quality could either be directly observed in the field or estimated based on land characteristics and land evaluation requirements involve not only soil but also climatic, land form and socio economic conditions (FAO, 1976). Important land characteristics in any land evaluation include topography, soil, and climate (Ritung et al., 2007). Kamkar, Dorri and Silva (2014) identify that the climatic conditions and soil quality of an area are the most important factors of land suitability evaluations. Forecasting temporal and spatial rainfall and temperature trends is necessary for examining the climatological factor in land suitability evaluations. The climate and meteorological conditions in the world have been changed considerably by their intensity, term and duration due to the changing pattern of the human lifestyles and environment pollution.

Therefore identification of future climatic conditions of an area is one of the major factors of land suitability evaluations. Many studies on land suitability evaluations have been considered prevailing climate condition of an area along with its spatial distribution but not based on future climate change scenario. In this background, this study intends to forecast temporal and spatial rainfall and temperature trends in Bentota River basin for examining future climatic conditions in the area as one of the major factor that should be taken in to account in studies on land suitability evaluations. For land evaluation, the required climate data are monthly mean temperature, total monthly rainfall, maximum daily rainfall value for each month, total annual rainfall and number of dry and wet months which are generated either from weather stations or from climatic maps (Liambila and Kibret, 2016).

2. Methodology

Weather forecasting is a scientific appraisal of the weather conditions in a particular area during a specified time period (Buckle, 1996). Various methods are used to forecast weather such as Time series analysis (Box and Jenkins, 1976), Autoregressive (Hurrell, 1995) and Moving Average Model (Kaushik and Singh, 2008), Autoregressive-Moving-Average Modeling (Walker, 1933), Seasonal ARIMA Model (Aziz et al, 2013), etc. Box & Jenkins (1970) defined as a time series is a collection of quantitative observations that are evenly spaced in time and measured successively. Kim and Jaun (2003) show that time series are analyzed in order to understand the underlying structure and function that produce the observations. Aziz et al (2013) shows that time series analysis can be applied by assuming that a time series data set has at least one systematic pattern. Box & Jenkins (1970) show that time series analysis has two most common patterns as trends and seasonality. Trends are generally linear or quadratic and moving averages or regression analysis is often used to derive trend line. Seasonality is a trend that repeats itself systematically over the time. Understanding the mechanisms of a time series allows a mathematical model to be developed that explains the data in such a way that prediction or monitoring can occur. Hence, to describe a trend of time series, Mann–Kendall trend test was used to see whether there is a decreasing or increasing trend. Mann–Kendall statistics (S) is one of the non-parametric statistical tests used for detecting trends of climatic elements. Mann–Kendall trend test is also the most widely used methods since it is less sensitive to outliers (extraordinary high values within time series data) and it is the most robust as well as suitable for detecting trends in rainfall (Keradin et al. 2013). Mann–Kendall nonparametric trend test has first been proposed by Mann (1945) then further studied by Kendall (1975) and improved by Hirsch and James (1984) who allowed taking into account seasonality. The null hypothesis H0 for these tests is that there is no trend in the series. The three alternative hypotheses that there is a negative, non-null, or positive trend can be chosen. The Mann-Kendall tests are based on the calculation of Kendall's tau measure of association between two samples, which is itself based on the ranks with the samples. In Mann-Kendall trend test, the first series is an increasing time indicator generated automatically for which ranks are obvious, which simplifies the calculations. To calculate the p-value of this test, XLSTAT can calculate as in the case of the Kendall tau test, an exact p-value if there are no ties in the series and if the sample size is less than 50.

The S statistic used for the test and its variance is given by:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} Sgn(x_j - x_i)$$

$$Var(S) = \frac{n(n-1)(2n+5)}{18}$$

Where n is the number of observations and xi (i=1…n) are the independent observations.

In the case of seasonal Mann-Kendall test, the seasonality of the series is taken into account. This means that for monthly data with seasonality of 12 months, one will not try to find out if there is a trend in the overall series, but if from one month of January to another, and from one month February and another, and so on, there is a trend. For this test, first all Kendall's tau for each season is calculated then calculate an average Kendall's tau. The variance of the statistic can be calculated assuming that the series are independent (eg values of January and February are independent) or dependent, which requires the calculation of a covariance. To calculate the p-value of this test, XLSTAT uses a normal approximation to the distribution of the average Kendall tau. Finally, the Inverse Distance Weighted interpolation method in Arc GIS 10.3 was used to estimates cell values by averaging the values of forecasted rainfall of all whether stations in the neighborhood of each processing cell. The closer a point is to the center of the cell being estimated, the more influence or weight and it has in the averaging process.

For this study, Bentota river basin located in the southwest region of Sri Lanka is considered since Bentota river valley is facing the natural phenomena of flooding in the rainy season and saltwater intrusion in the dry season annually and at present more than 80% of paddy lands in of Bentota river basin have been abandon and converted for other uses which are not productive due to contrasting degrees of saltwater intrusion. Weather data on monthly mean temperature, total monthly rainfall, and maximum daily rainfall value for each month and total annual rainfall from year 1986 to 2015 that recorded at three weather stations located in Bentota River basin was obtained from the Metrological Department of Sri Lanka. According to Aziz (2013) weather station data provide accurate information on weather condition around the vicinity of the instrument. Therefore, it is assumed that the data recorded from available all three weather stations in Bentota River basin are perfectly very similar to the weather conditions of the area.

3. Data Analysis and Results

The temporal distribution of average total monthly rainfall and average maximum daily rainfall value during each month of all three whether stations located in Bentota River basin as Agalawatte, Bentotawatta and Pallegoda can be illustrated by Figure 1. Table 1 shows the descriptive statistics of the temporal distribution of whether data on monthly mean temperature, total monthly rainfall and maximum daily rainfall value from year 1986 to 2015. Accordingly highest temperature in Bentota area is about 29.2 oC during months of March and April and lowest temperature is about 25.6 oC during months of July and August in every year being the mean temperature as 27.3 ^{O}C. There are no more variations among the temperature of that each particular month during last 30 years since the values of coefficient of variation for each month varies from 0.01 to 0.02 for all months. Mean total monthly rainfall in Bentota River basin is 328mm. Bentota River basin has been received relatively high total monthly rainfall (600mm) with effect of southwest monsoon during the month of May and with effect of second inter monsoon during the month of October. The area is not receiving much rainfall from Northeast monsoon. Hare (2003), coefficient of variation (CV) is used to classify the degree of variability of rainfall events as less ($CV < 0.20$), moderate ($0.20 < CV < 0.40$), and high ($CV > 0.40$). Total monthly rainfall values with respect to months of January, February and July show the values of coefficient of variation as 0.65, 0.82 and 0.68 respectively by emphasizing the high degree of variation in total monthly rainfall values during these months from 1986 to 2015. Oldeman (1975) has defined that the wet months are the months which total monthly rainfall is greater than 200 mm and the dry months are the months which total monthly rainfall is lower than 100 mm. This criterion is more applicable for annual crops, especially rain fed rice. Schmidt and Ferguson (1951) used a different criteria, in which the wet months are those with >100 mm total monthly rainfall and the dry months are those with <60 mm total monthly rainfall. This latter criterion is usually used for, but not limited to perennial crops. Since Bentota River basin is located in wet zone of Sri Lanka and area is predominantly based on rain fed agriculture, the first definition was considered. Accordingly months of January and February can be considered as the dry months since the average total monthly rainfall of these two months during last 30 years is approximately less than 100mm and remaining months can be considered as wet month since the average total monthly rainfall during those months during last 30 years is more than 200mm.

Table 1 *Descriptive statistics of the temporal distribution of whether data from 1986-2015*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature in Bentota River basin from 1986-2015												
Mean	27.1	27.6	28	28.1	27.8	27.3	27	26.9	27	27	27.2	27.1
Median	27.1	27.6	28	28.1	28	27.5	27.1	26.9	27.1	27.1	27.3	27.1
Sd	0.4	0.5	0.5	0.4	0.6	0.5	0.5	0.3	0.4	0.5	0.4	0.5
Minimum	26.2	26.7	27.1	27.2	26.1	26.3	25.6	25.8	25.9	26.2	26.4	26
Maximum	28.1	28.5	29.2	29.2	28.7	27.8	27.7	27.5	27.5	27.8	27.7	28
CV	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.02
Total Monthly Rainfall in Bentota River basin from 1986-2015												
Mean	161.7	122.4	222.3	421.8	562.9	424.4	303.5	296.0	433.1	557.9	391.4	276.7
Median	139.9	114.4	208.1	378.8	562.7	393.4	261.2	277.4	407.6	581.2	383.2	242.4
Sd	91.3	94.2	117.6	151.6	212.3	167.5	178.0	145.1	183.2	195.8	113.4	125.0
Minimum	45.8	0.0	2.6	173.4	88.4	173.6	24.9	46.7	109.2	192.1	170.2	60.7
Maximum	404.1	358.6	458.9	703.1	1069.6	931.9	887.0	729.7	762.5	1069.8	612.0	517.0
CV	0.65	0.82	0.56	0.40	0.38	0.43	0.68	0.52	0.45	0.34	0.30	0.52
Maximum Daily Rainfall in Bentota River basin from 1986-2015												
Mean	57.0	38.8	60.5	92.3	116.7	95.6	75.6	68.2	92.2	98.0	75.1	73.1
Median	51.0	35.5	56.0	89.0	112.0	79.0	54.1	67.8	89.0	94.8	64.0	67.5
Sd	25.2	25.9	30.4	41.0	56.8	82.3	59.2	30.3	46.3	35.8	30.5	31.4
Minimum	19.1	0.0	2.2	41.9	23.2	28.6	8.2	18.7	23.1	39.8	35.8	32.8
Maximum	127.0	107.4	165.5	243.4	308.0	443.8	266.5	145.0	201.6	219.1	164.0	145.0
CV	0.44	0.67	0.50	0.44	0.49	0.86	0.78	0.44	0.50	0.36	0.41	0.43

Mean annual rainfall in the area is 3933mm with a range from 3096mm to 4699mm showing less degree of variations (CV=0.12) and the stable climate conditions during last 30 years. Total Annual Rainfall is greater than 4400mm (mean+SD) in years of 1988, 1993, 1995, 1998, 1999 and 2008. Mean maximum daily rainfall value in the area is 420mm. Coefficient of variation

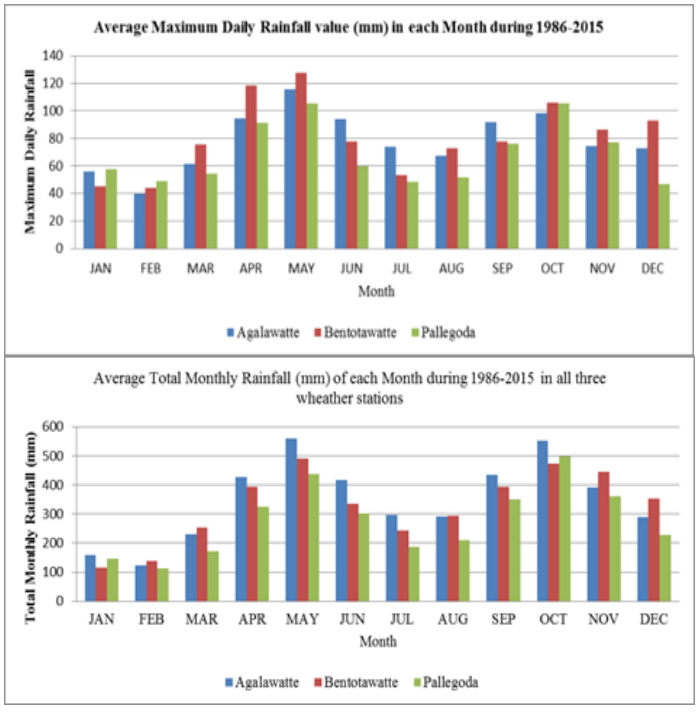

Figure 1 *The temporal distribution of average total monthly rainfall and average maximum daily rainfall value*

values of maximum daily rainfall values with respect to months of February, June and July show as 0.67, 0.86 and 0.78 respectively by emphasizing the high degree of variations in maximum daily rainfall values during these months from year 1986 to 2015. Since the coefficient of variation of maximum daily rainfall with respect to months of May and October show moderate degree of variations, comparatively highest maximum daily rainfall is received in the area during these two months in every year.

The dates which maximum daily rainfall value is more than 200mm in all three whether stations and overall Bentota River Basin from year 1986 to 2015 is shown by Table 2. Here maximum daily rainfall values for Bentota river basin is calculated considering average value of maximum daily rainfall values of all three weather stations. These dates were further more evidenced by the past flood records of the area and comparatively minor flood situations could be observed in year 1993, 1998, 2003, 2008 by indicating flood occurrence period as once in five years and major flood situations could be observed in year 2010 and 2014. According to the past flood records of the area, comparatively minor flood situation can be defined as when maximum daily rainfall of each whether station is in between 200mm to 300mm and major flood situation would be when maximum daily rainfall of each whether station is in between 350-450mm.

The general time series plot of collected weather data indicated a cyclical pattern due to the effect of seasonality component and an irregular way with indicating an increasing or decreasing trend. Weather data was subjected to time series tests were analyzed applying decomposition method which include trend, cycle, seasonal and irregular components using Microsoft Excel 2013. First, Moving Average (MA12) and Centered Moving Average (CMA12) methods were applied sequentially to make the time series in to smooth curve reducing the impacts on seasonality and irregularity. This CMA series can be named as 'base line' which shows the amount of fluctuation to up and down from the base line. Decomposition Method {Yt= f (St, It, Tt)} was applied with multiplicative model to identify trend cycle and seasonal analysis. When applying decomposition method, the patterns of seasonal and irregular

Table 2 *The Dates which Maximum daily rainfall value is more than 200mm in each Month from 1986-2015*

Agalawatte				Bentotawatte				Pallegoda				Overall Bentota River Basin			
Year	Month	Date	MDR	Year	Month	Date	MDR	Year	Month	Date	MDR	Year	Month	Date	MDR
1993	MAY	27	256									1993	MAY	27	256
1998	MAY	17	266									1998	MAY	17	266
2003	MAY	6	308					2003	MAY	6	232	2003	MAY	6	270
2008	MAY	1	259	2008	MAY	1	203	2008	MAY	1	205	2008	MAY	1	222
2010	MAY	23	440	2010	MAY	23	400	2010	MAY	23	420	2010	MAY	23	420
2014	JUN	1	444	2014	JUN	1	364	2014	JUN	1	392	2014	JUN	1	400
MDRV- Maximum Daily Rainfall															

component (St, It) were identified by dividing the original observation by the CMA values. The average seasonal data (St) for each month were calculated later on. Then the seasonally adjusted data are computed by dividing the original observation by the seasonal component which can be known as 'de- seasonal data' (Yt/St =Tt × It). The trend line equation was derived applying simple liner regression (SLR) analysis and trend values (Tt) were calculated considering original observation of weather data as dependent variable and time (t) as independent variable. Multiplicative Model (Yt= St × It × Tt) was applied for forecasting weather data. Pearson correlation coefficient value was calculated in order to identify the reliability and the accuracy of the forecasted values comparing them with original observation of weather data. Table 3 illustrates the analysis of total monthly rainfall data for year 1986 only. Same analysis was applied for total monthly rainfall values for other years up to year 2015 and other whether data of all three whether stations and overall values for Bentota river basin. These developed Multiplicative models were used to forecast the rainfall and temperature values from year 2016 to 2025.

Trend component of monthly mean temperature, total monthly rainfall, maximum daily rainfall value for each month and total annual rainfall from year 1986 to 2015 that recorded at three weather stations located in Bentota River basin can be illustrated by Figure 2,3,4 and 5. The relevant equation of each trend line is indicated by respective color on each figure with reference to all three whether stations and overall Bentota river basin. Overall rainfall values for Bentota river basin is calculated considering average value of rainfall values of all three weather stations. Independent variable (x) for total annual rainfall analysis is time (t) which considered as the number of years from year 1986. Independent variable (x) for total monthly rainfall, maximum daily rainfall and temperature analyses is time (t) which considered as number of months from the month of start year for each weather station.

Trend component of time series analysis of monthly mean temperature shows an increasing trend with 0.0011 ^{O}C increment per month (Figure 2). Pearson correlation coefficient value between actual and forecasted monthly mean temperature values for each month indicates a positive strong linear relationship with 0.677 correlation coefficient value and it emphasizes the forecasted values are more or less similar to actual values (Table 3). In Mann–Kendall's Test, the computed p-value (0.0001) is lower than the significance level (alpha=0.0) and the null hypothesis H0 can be rejected and accept the alternative hypothesis Ha says that there is a trend in the series of monthly mean temperature. Seasonal Mann-Kendall test shows that there is a trend from one month to another in each year since p value (0.0001) is lower than the significance level (Table 7 and 8). Deviation of monthly mean temperature values from CMA called as average seasonal component values and average actual temperature values for each month during 1986-2015 was calculated (Table 4). Considering the seasonal component and trend component of time series analysis of monthly mean temperature, average actual temperature for each month during 1986-2015 and average forecasted temperature for each month from year 2016-2025 was calculated (Table 4) and Pearson correlation coefficient value between them is 0.999. It highlights that Area may have high temperature during Month of April and May in future too under the prevailing climate change scenario.

Trend component of time series analysis of total monthly rainfall of overall Bentota River basin shows a decreasing trend with -0.0507 mm decline per

Table 3 *Time series Analysis for Total Monthly Rainfall (mm) of Agalawatta weather station in Bentota River Basin 1986-2015*

t (x)	Year	Month	Total Monthly Rainfall (mm) (Yt)	MA(12)	Centered moving Average - CMA(12)	Yt/CMA (12) St,It	St	Deseasonalised data = (Yt/St)	SLR Trend Component of Total Monthly Rainfall (mm) - Tt	Multiplication Forecasted Total Monthly Rainfall (mm) = Stx Tt
1	1986	JAN	94.7				0.47	202.4	329.42	154.12
2		FEB	167.4	339.6	345.4	0.48	0.35	477.7	329.50	115.46
3		MAR	512.2	351.3	344.8	1.49	0.68	755.4	329.59	223.47
4		APR	576.4	338.4	320.2	1.80	1.24	466.5	329.67	407.37
5		MAY	498.1	302.1	297.6	1.67	1.61	309.0	329.75	531.48
6		JUN	192.9	293.2	291.5	0.66	1.19	161.9	329.84	393.02
7		JUL	136.6	289.9	294.8	0.46	0.86	159.4	329.92	282.77
8		AUG	201.2	299.7	295.0	0.68	0.84	240.4	330.00	276.15
9		SEP	482.3	290.4	312.4	1.54	1.24	388.0	330.09	410.30
10		OCT	425.4	334.4	331.3	1.28	1.59	268.3	330.17	523.44
11		NOV	427.8	328.2	339.9	1.26	1.12	382.4	330.26	369.46
12		DEC	359.9	351.7	349.2	1.03	0.83	433.7	330.34	274.11
	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
360	2015	DEC	347.5				0.83	418.8	359.46	

***Table 4**: Regression and Descriptive statistics of Temperature and Rainfall Data*

Climatological Variable	Regression Statistics							Descriptive Statistics				
	r^2	Intercept	Slope	F	Sig	R1	R2	Mean	SD	Min	Max	CV
Temperature	0.065	27.130	0.0011	24.6	0.000	0.677	0.999	27.3	0.61	25.6	29.2	0.02
Agalawatte TMR	0.004	329.33	0.1032	1.6	0.062	0.665	0.999	346.6	198	0.0	1069	0.57
Bentotawate TMR	0.003	350	-0.2378	0.27	0.076	0.698	0.993	330	167	8.0	825	0.51
Pallegoda TMR	0.005	271.59	0.058	0.12	0.080	0.657	0.999	277	176	0	854	0.64
Overall Bentota River Basin TMR	0.001	335.85	-0.0507	0.42	0.057	0.683	0.999	328	190	0	1069	0.58
Agalawatte MDR	0.012	69.77	0.0454	4.5	0.034	0.434	0.997	78.5	48	0	444	0.61
Bentotawate MDR	0.003	85.39	-0.0836	0.33	0.015	0.517	0.996	81	49	5.2	317	0.60
Pallegoda MDR	0.004	69.76	-0.0165	0.15	0.009	0.510	0.998	69	41.5	6	253	0.60
Overall Bentota River Basin MDR	0.002	71.55	0.0166	0.79	0.003	0.479	0.998	75	41	0	420	0.55
Total annual rainfall of Bentota River Basin	0.057	28701.24	-12.38	1.69	0.202	-	-	3933	455.64	3096	4699	0.12

R1- Pearson correlation coefficient value between Actual and Forecasted Values for Each Month from 1986-2015
R2- Pearson correlation coefficient value between Average Actual and Forecasted Values for Each Month
TMR-Total Monthly Rainfall
MDRV Maximum Daily Rainfall value in each Month
SD- Standard Deviation
CV- Coefficient of Variance (=SD/Mean)
Note: independent variable (x) is time (t) which considered as the year from year1986 for total annual rainfall and independent variable (x) is time (t) which considered as number of months from the month of start year of each whether station for other climatological variables

month (Figure 3). Pearson correlation coefficient value between actual and forecasted total monthly rainfall values of overall Bentota River basin for each month indicates a positive strong linear relationship with 0.683 correlation coefficient value and it emphasizes the forecasted values are more or less similar to actual values (Table 4). In MK Test, the computed p-value (0.723) is greater than the significance level (0.05) and one cannot reject the null hypothesis H0 says that there is no trend in the series of total monthly rainfall. In Seasonal Mann-Kendall Test, the computed p-value (0.849) is greater than the significance level (0.05) and one cannot reject the null hypothesis H0 says that there is no trend from one month to another in the series of total monthly rainfall (Table 7 and 8). The computed p-values of two MK tests are greater than the significance level 0.05 for total monthly rainfall of all three whether stations that implying no trend in the series even from one month to another. Considering the seasonal component and trend component of time series analysis of total monthly rainfall; average actual total monthly rainfall for each month during 1986-2015 and average forecasted total monthly rainfall for each month from year 2016- 2025 for all three whether stations and overall Bentota River basin was calculated (Table 5) and Pearson correlation coefficient values between average actual total monthly rainfall and average forecasted total monthly rainfall values for each month of all three whether station and overall Bentota River Basin are near to 0.9 and it highlights the accuracy of the prediction of total monthly rainfall up to year 2025. Bentota area may have high total monthly rainfall during Month of May and October in future under

***Table 5** Average Monthly Mean temperature (oC) of each Month during 1986-2025*

Month	Seasonal component (Deviation of monthly mean temperature values from CMA)	Average actual monthly mean temperature for each month during 1986-2015	Average forecast-ed monthly mean tempera-ture for each month during 2016-2025
JAN	0.991	27.08	27.36
FEB	1.010	27.57	27.88
MAR	1.024	27.97	28.27
APR	1.028	28.07	28.37
MAY	1.016	27.77	28.05
JUN	0.996	27.22	27.49
JUL	0.986	26.98	27.24
AUG	0.984	26.92	27.18
SEP	0.985	26.94	27.21
OCT	0.987	27.01	27.26
NOV	0.994	27.17	27.44
DEC	0.991	27.13	27.38

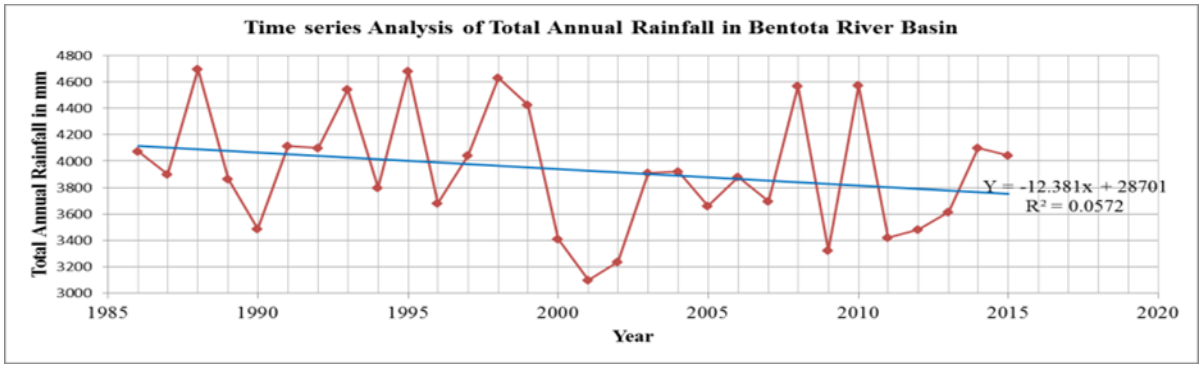

***Figure 5** Time series Analysis for Annual Rainfall Value in Bentota River Basin from 1986 to 2015*

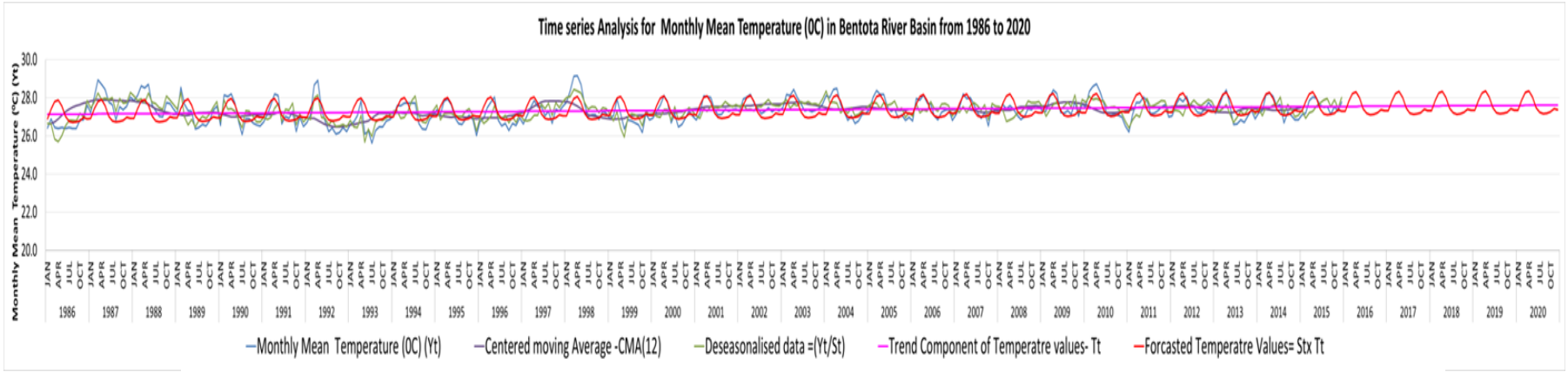

Figure 2 *Time series Analysis for Monthly Mean Temperature (0C) in Bentota River Basin from 1986 to 2020*

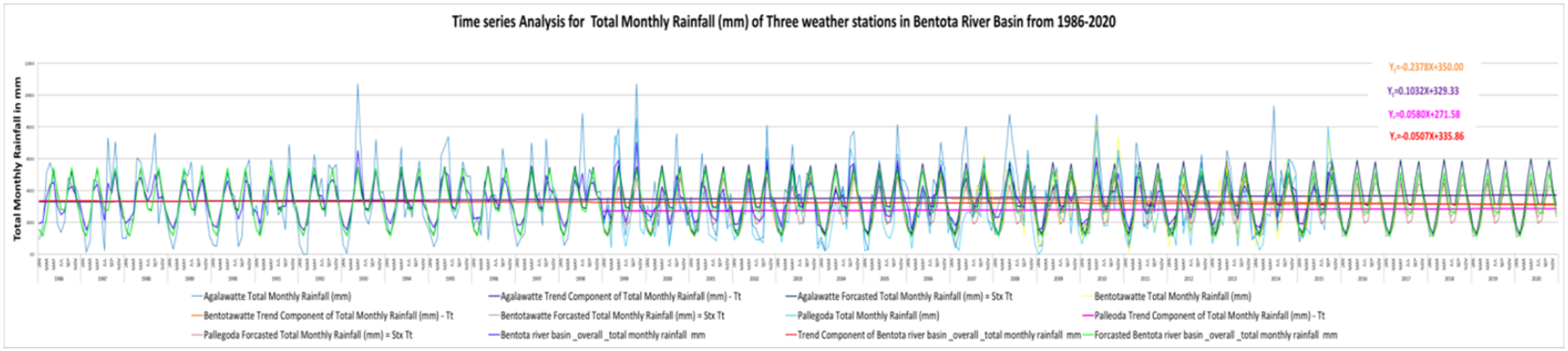

Figure 3 *Time series Analysis for Total Monthly Rainfall (mm) in Bentota River Basin from 1986 to 2020*

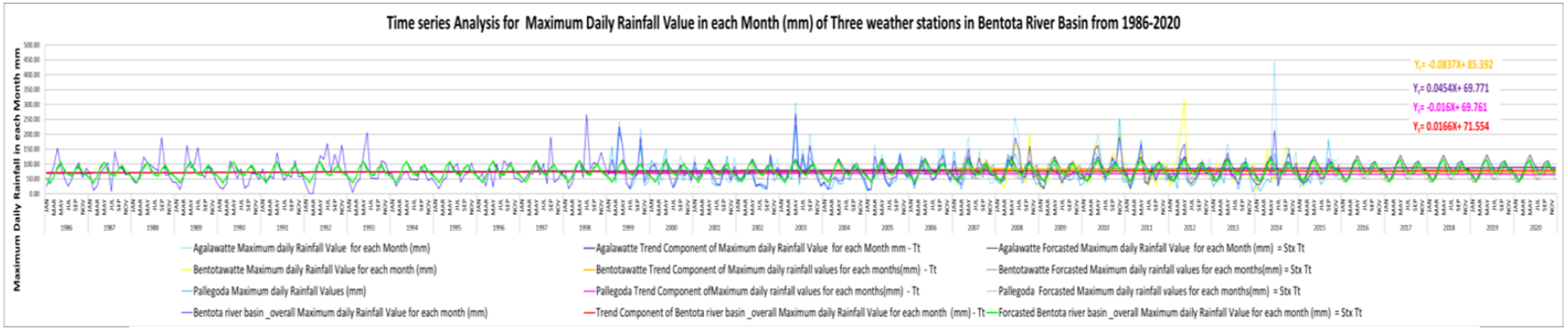

Figure 4 *Time series Analysis for Maximum Daily Rainfall Value in each Month (mm) in Bentota River Basin from 1986 to 2020*

Table 6 *Average Total Monthly Rainfall (mm) of each Month during 1986-2025*

Month	Agalawatte			Bentotawatte			Pallegoda			Bentota River Basin		
	SC	ATMR	FTMR	SC	ATMR	FTMR	SC	ATMR	FTMR	SC	ATMR	FTMR
JAN	0.468	159.45	174.12	0.350	115.29	108.98	0.529	145.14	151.60	0.470	149.81	147.94
FEB	0.350	123.91	130.45	0.413	138.67	128.59	0.411	112.36	117.91	0.350	113.58	110.14
MAR	0.678	231.95	252.47	0.775	253.16	240.74	0.636	173.13	182.33	0.648	208.46	204.06
APR	1.236	426.94	460.26	1.208	394.35	375.03	1.168	324.29	334.97	1.225	396.26	385.56
MAY	1.612	560.70	600.50	1.505	490.84	466.94	1.575	437.22	451.76	1.625	529.21	511.32
JUN	1.192	416.70	444.07	1.021	334.26	316.63	1.076	301.15	308.76	1.138	373.21	357.88
JUL	0.857	297.95	319.50	0.748	242.97	231.59	0.682	186.22	195.74	0.851	281.08	267.62
AUG	0.837	292.82	312.03	0.869	293.44	268.93	0.752	211.01	215.93	0.815	268.77	256.32
SEP	1.243	434.76	463.62	1.107	393.56	342.54	1.224	350.57	351.42	1.243	415.78	390.86
OCT	1.585	553.53	591.48	1.391	472.74	430.02	1.774	498.75	509.41	1.624	530.89	510.50
NOV	1.119	392.60	417.49	1.312	446.74	405.32	1.310	361.62	376.13	1.188	390.63	373.27
DEC	0.830	289.19	309.75	0.967	352.96	298.56	0.821	228.34	235.70	0.838	275.16	263.39

SC- Seasonal component (Deviation of Total Monthly Rainfall (mm) values from CMA)
ATMR- Average (Mean) Actual Total Monthly Rainfall (mm) of each Month during 1986-2015
FTMR- Average (Mean) Forecasted Total Monthly Rainfall (mm) of each month during 2016-2025

Table 7 *Average Maximum Daily Rainfall value (mm) in each Month during 1986-2025*

Month	Agalawatte			Bentotawatte			Pallegoda			Bentota River Basin		
	SC	AMDR	FMDR	SC	AMDR	FMDR	SC	AMDR	FMDR	SC	AMDR	FMDR
JAN	0.743	55.93	65.87	0.566	44.81	40.63	0.835	57.54	54.64	0.747	54.42	58.65
FEB	0.496	39.50	43.99	0.536	44.10	38.45	0.690	48.79	45.17	0.529	39.71	41.51
MAR	0.819	61.43	72.66	0.951	75.71	68.09	0.800	54.27	52.32	0.781	56.49	61.27
APR	1.214	94.37	107.75	1.404	118.15	100.37	1.316	91.44	86.09	1.269	94.41	99.62
MAY	1.488	115.77	132.15	1.519	127.85	108.51	1.526	105.51	99.82	1.488	110.37	116.82
JUN	1.176	94.19	104.50	0.965	77.89	68.85	0.872	59.89	57.00	1.075	80.74	84.45
JUL	0.920	73.89	81.82	0.654	53.22	46.63	0.746	48.31	48.76	0.919	70.17	72.23
AUG	0.871	67.53	77.51	0.900	72.78	64.07	0.754	51.81	49.28	0.842	63.31	66.14
SEP	1.183	91.97	105.26	0.947	77.86	67.29	1.124	76.14	73.42	1.161	87.93	91.21
OCT	1.269	98.27	113.00	1.363	106.08	96.74	1.579	105.31	103.14	1.338	98.42	105.22
NOV	0.946	74.40	84.27	1.048	86.56	74.28	1.142	77.31	74.60	1.029	76.83	80.90
DEC	0.929	72.91	82.77	1.157	92.79	81.95	0.708	46.96	46.24	0.883	66.47	69.48

SC- Seasonal component (Deviation of Maximum daily Rainfall (mm) value in each month from CMA)
AMDR- Average Actual Maximum Daily Rainfall value (mm) in each Month during 1986-2015
FMDR- Average Forecasted Maximum Daily Rainfall value (mm) in each Month during 2016-2025

the prevailing climate change scenario (Figure 5). There is comparatively high degree of variations of total monthly rainfall of all three whether stations and there is no difference among them since CV are around 0.6.

Trend component of time series analysis of maximum daily rainfall of overall Bentota River basin shows an increasing trend with 0.0166mm increment per month (Figure 4). Pearson correlation coefficient value between actual and forecasted maximum daily rainfall of overall Bentota River basin for each month indicates a positive moderate linear relationship with 0.479 correlation coefficient value and it emphasizes most of the forecasted values are more or less similar to actual values (Table 4). In Mann–Kendall's Test for maximum daily rainfall of overall Bentota River basin, the computed p-value (0.035) is lower than the significance level 0.05, the null hypothesis H0 should be rejected, and accept the alternative hypothesis Ha says that there is a trend in the series of maximum daily rainfall of overall Bentota River basin. Seasonal Mann-Kendall Test of maximum daily rainfall of overall Bentota River basin shows that there is a trend from one month to another in each year since p value (0.043) is lower than the significance level (Table 8 and 9). The computed p-values of two MK tests are greater than the significance level 0.05 for maximum daily rainfall of Pallegoda and Bentotawatte whether stations that implying no trend in the series even from one month to another. But p value (0.025) of MK test and p value (0.023) of seasonal MK test for maximum daily rainfall of Agalawatte station is lower than the significance level; there is trend in the maximum daily rainfall of Agalawatte station and from one month to another in each year as well. Considering the seasonal component and trend component of time series analysis of maximum daily rainfall, average actual maximum daily rainfall for each month during 1986-2015 and average forecasted maximum daily rainfall for each month during 2016-2025 for all three whether stations and overall Bentota River basin was calculated (Table 6). Pearson correlation coefficient values between average actual maximum daily rainfall and average forecasted maximum daily rainfall values for each month of all three whether station and overall Bentota River Basin are near to 0.9 and it highlights that Bentota area may have high maximum daily rainfall during Month of May and October in future under the prevailing climate change scenario (Figure 5). The degree of variations of maximum daily rainfall of all three whether stations is relatively high and making difference being the highest is at Pallegoda and lowest is at Bentota Watte.

Trend component of time series analysis of annual rainfall of overall Bentota River basin shows a decreasing trend with -12.38 mm per year (Figure 5). In Mann–Kendall's Test for annual rainfall of overall Bentota River basin, the computed p-value (0.201) is greater than the significance level 0.05, one

Table 6 *Average Total Monthly Rainfall (mm) of each Month during 1986-2025*

Month	Agalawatte			Bentotawatte			Pallegoda			Bentota River Basin		
	SC	ATMR	FTMR	SC	ATMR	FTMR	SC	ATMR	FTMR	SC	ATMR	FTMR
JAN	0.468	159.45	174.12	0.350	115.29	108.98	0.529	145.14	151.60	0.470	149.81	147.94
FEB	0.350	123.91	130.45	0.413	138.67	128.59	0.411	112.36	117.91	0.350	113.58	110.14
MAR	0.678	231.95	252.47	0.775	253.16	240.74	0.636	173.13	182.33	0.648	208.46	204.06
APR	1.236	426.94	460.26	1.208	394.35	375.03	1.168	324.29	334.97	1.225	396.26	385.56
MAY	1.612	560.70	600.50	1.505	490.84	466.94	1.575	437.22	451.76	1.625	529.21	511.32
JUN	1.192	416.70	444.07	1.021	334.26	316.63	1.076	301.15	308.76	1.138	373.21	357.88
JUL	0.857	297.95	319.50	0.748	242.97	231.59	0.682	186.22	195.74	0.851	281.08	267.62
AUG	0.837	292.82	312.03	0.869	293.44	268.93	0.752	211.01	215.93	0.815	268.77	256.32
SEP	1.243	434.76	463.62	1.107	393.56	342.54	1.224	350.57	351.42	1.243	415.78	390.86
OCT	1.585	553.53	591.48	1.391	472.74	430.02	1.774	498.75	509.41	1.624	530.89	510.50
NOV	1.119	392.60	417.49	1.312	446.74	405.32	1.310	361.62	376.13	1.188	390.63	373.27
DEC	0.830	289.19	309.75	0.967	352.96	298.56	0.821	228.34	235.70	0.838	275.16	263.39

SC- Seasonal component (Deviation of Total Monthly Rainfall (mm) values from CMA)
ATMR- Average (Mean) Actual Total Monthly Rainfall (mm) of each Month during 1986-2015
FTMR- Average (Mean) Forecasted Total Monthly Rainfall (mm) of each month during 2016-2025

Table 7 *Average Maximum Daily Rainfall value (mm) in each Month during 1986-2025*

Month	Agalawatte			Bentotawatte			Pallegoda			Bentota River Basin		
	SC	AMDR	FMDR	SC	AMDR	FMDR	SC	AMDR	FMDR	SC	AMDR	FMDR
JAN	0.743	55.93	65.87	0.566	44.81	40.63	0.835	57.54	54.64	0.747	54.42	58.65
FEB	0.496	39.50	43.99	0.536	44.10	38.45	0.690	48.79	45.17	0.529	39.71	41.51
MAR	0.819	61.43	72.66	0.951	75.71	68.09	0.800	54.27	52.32	0.781	56.49	61.27
APR	1.214	94.37	107.75	1.404	118.15	100.37	1.316	91.44	86.09	1.269	94.41	99.62
MAY	1.488	115.77	132.15	1.519	127.85	108.51	1.526	105.51	99.82	1.488	110.37	116.82
JUN	1.176	94.19	104.50	0.965	77.89	68.85	0.872	59.89	57.00	1.075	80.74	84.45
JUL	0.920	73.89	81.82	0.654	53.22	46.63	0.746	48.31	48.76	0.919	70.17	72.23
AUG	0.871	67.53	77.51	0.900	72.78	64.07	0.754	51.81	49.28	0.842	63.31	66.14
SEP	1.183	91.97	105.26	0.947	77.86	67.29	1.124	76.14	73.42	1.161	87.93	91.21
OCT	1.269	98.27	113.00	1.363	106.08	96.74	1.579	105.31	103.14	1.338	98.42	105.22
NOV	0.946	74.40	84.27	1.048	86.56	74.28	1.142	77.31	74.60	1.029	76.83	80.90
DEC	0.929	72.91	82.77	1.157	92.79	81.95	0.708	46.96	46.24	0.883	66.47	69.48

SC- Seasonal component (Deviation of Maximum daily Rainfall (mm) value in each month from CMA)
AMDR- Average Actual Maximum Daily Rainfall value (mm) in each Month during 1986-2015
FMDR- Average Forecasted Maximum Daily Rainfall value (mm) in each Month during 2016-2025

cannot reject the null hypothesis H0 says that there is no trend in the series of annual rainfall (Table 8). Inverse Distance Weighted tool in Arc GIS 10.3 was used to estimate cell values by averaging the values of forecasted total monthly rainfall value during Yala and Maha season of all weather stations for year 2016-2025 period. The spatial distribution of forecasted total monthly rainfall during Yala season from March to August and during Maha season from month of September to February during the period of year 2016- 2025 for Bentota Divisional Secretariat division Area can be shown by Figure 6 and Figure 7.

In past, during the Yala season from March to August, the area has been

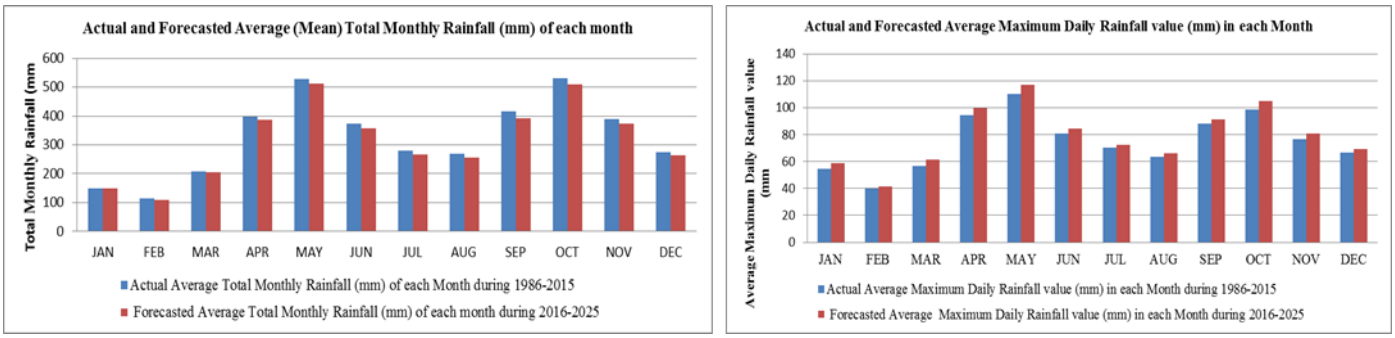

Figure 6 *Actual and Forecasted total monthly rainfall and maximum daily rainfall from year 1986 to 2015*

Table 8 *Mann–Kendall's Test*

Weather Station and data type	No. years	Mann–Kendall's Test H0: there is no trend in the series Ha: There is a trend in the series					
		Mann–Kendall stat (S)	Var. (S)	Kendall's tau	P-value	Sen's slope	Test interpretation
Temperature BRB	30	9604.0	5205482	0.148	0.0001*	0.001	Reject H0, Accept Ha.
Agalawatte TMR	30	1904	5205496	0.029	0.404	0.080	Accept H0.
Bentotawatte TMR	9	50	116145	0.010	0.886	0.073	Accept H0.
Pallegoda TMR	17	838	950173	0.04	0.391	0.168	Accept H0.
BRB: TMR	30	-810	5205500	-0.013	0.723	-0.036	Accept H0.
Agalawatte MDR	30	3492	5205426	0.054	0.025*	0.028	Accept H0.
Bentotawatte MDR	9	-82	119574	-0.016	0.815	-0.024	Accept H0.
Pallegoda MDR	17	105	950085	0.005	0.915	0.004	Accept H0.
BRB: MDR	30	1982	5205466	0.031	0.035*	0.015	Reject H0, accept Ha.
Total annual rainfall BRB	30	-73	0	-0.168	0.201	-12.53	Cannot reject H0.

Table 9 *Seasonal Mann-Kendall Test*

Weather Station and data type	No. years	Seasonal Mann-Kendall Test / Period = 12 / Serial independence H0: there is no trend in the series Ha: There is a trend in the series				
		Mann–Kendall stat (S)	Ken-dall's tau	P-value	Sen's slope	Test interpretation
Temperature BRB	30	1012	0.194	0.0001*	0.016	Reject H0, and accept Ha.
Agalawatte TMR	30	267	0.051	0.171	0.977	Accept H0.
Bentotawatte TMR	9	-11	-0.033	0.721	-6.09	Accept H0.
Pallegoda TMR	17	60	0.037	0.483	1.967	Accept H0.
Overall BRB:TMR	30	-38	-0.007	0.849	-0.543	Accept H0.
Agalawatte MDR	30	443	0.085	0.023*	0.537	Reject H0, and accept Ha.
Bentotawatte MDR	9	-19	-0.057	0.520	-0.65	Accept H0.
Pallegoda MDR	17	43	0.026	0.617	0.146	Accept H0.
Overall BRB:MDR	30	393	0.075	0.043*	0.5	Reject H0, and accept Ha.

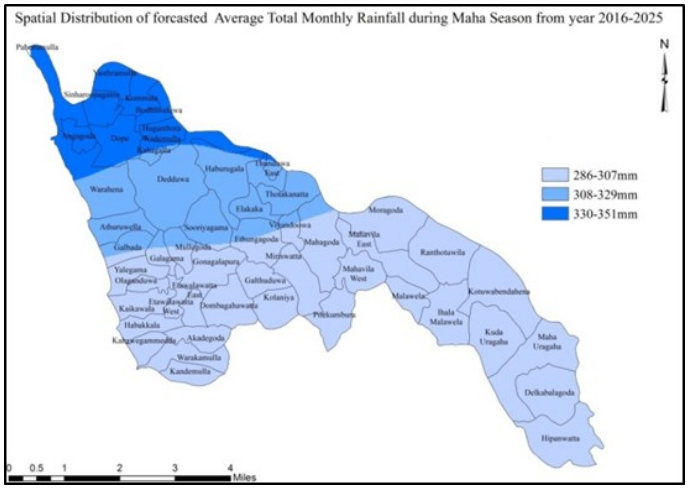

Figure 7 *The spatial distribution of forecasted total monthly rainfall during Yala season from March to August*

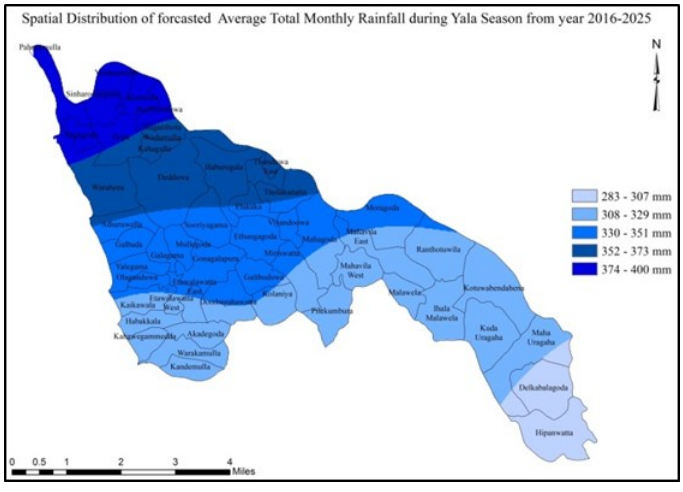

Figure 8 *The spatial distribution of forecasted total monthly rainfall during Maha season from September to February*

received averagely 343mm rainfall and during Maha season from September to February, the area has been received averagely 313mm rainfall. According to time series analysis, during Yala season the area will be received comparatively more rainfall (331mm) than Maha season (300mm) in future. Since the Trend component of time series analysis of total monthly rainfall of overall Bentota River basin shows a

decreasing trend, the amount of total monthly rainfall to be received in future will be decreased. Community and the farmers who live in this area can be aware about the anticipated spatial distribution of total monthly rainfall during two major paddy cultivating season of the area and major and minor flood occurrence periods.

4. Conclusions

Identification of the factors and related measures on land qualities and characteristics that use to evaluate the land suitability is the first step in the process of land suitability classification. Forecasting temporal and spatial rainfall and temperature trends is necessary for examining the climatological factor in land suitability evaluations. This study forecasted the temporal and spatial rainfall and temperature trends in Bentota River basin by examining future climatic conditions in the area as one of the major factor that should be taken in to account in studies on land suitability evaluations. Highest temperature in Bentota area is recorded during months of March and April and lowest temperature is recorded during months of June, July and August in every year. Period of rainfall in a year in Sri Lanka has been divided into 4 categories as first inter monsoon period is from March to April, South west monsoon period is from May to September, Second inter monsoon period is from October to November and North east monsoon is from December to February. Bentota River basin receives the highest total monthly rainfall with effect of southwest monsoon during the month of May and with effect of second inter monsoon during the month of October. During the Yala season from March to August, the area is receiving comparatively high rainfall than Maha season from September to February. January and February can be considered as the dry months in the area. Minor flood occurrence period in the area is once in five years. Trend component of time series analysis of monthly mean temperature shows an increasing trend with $0.0011^{O}C$ increment per month. Maximum daily rainfall of overall Bentota River basin shows an increasing trend with 0.0166mm increment per month. Trend component of time series analysis of total monthly rainfall of overall Bentota River basin shows a decreasing trend with -0.0507 mm of decline per month while annual rainfall of overall Bentota River basin also shows a decreasing trend with -12.38 mm per year. The degree of variations of maximum daily rainfall and total monthly rainfall of all three whether stations are comparatively high and have similar variations of whether changes throughout the year. In future the area may have comparatively high temperature and less rainfall and can be expected extremes daily rainfall during month of May and October occurring minor flood situations. Land use planner, agriculturalists would evaluate the land suitability of the area for selecting specific lands for different types of land use by paying attention to this temporal and spatial climatological influence to the area under the context of future climate change on rainfall and temperature trend as one of the major factor that should be considered in land suitability evaluations. The approach and the methodology adopted in this study will be applied by other researchers, agriculturalist and planners to identify the future climatological influences and its spatial distribution pattern for land suitability evaluations and other decision making purposes for other areas.

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Courtyard as a Passive Cooling Strategy in Buildings

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ABSTRACT

One of the most significant current discussions in the built environment, architectural practice, theory, and procedures is "Passive Design". It is becoming very difficult to ignore the issues of passive architectural design strategies in buildings. Recent studies emphasized the need for passive architectural design strategies and the application of the courtyard as a passive design strategy for cooling in buildings. Also, that the courtyard is very suitable in almost all building typologies in all the climatic zones due to its passive tendencies for cooling. Its cooling potentials can be achieved only when design requirements are not ignored. The courtyard has social, cultural, religious, and environmental benefits. Despite its abundant advantages, research effort towards courtyard design requirements is very scarce. Therefore, the main objective of this study is to investigate the design of central courtyard as a passive cooling strategy for improving indoor thermal comfort in Universiti Teknologi Malaysia (UTM) Buildings. Courtyard design requirement such as the courtyard configurations, orientation, and natural features in courtyard buildings in UTM were investigated. Besides the design variants, courtyard usage in such buildings was also examined. The methodology of this study involved the developing of a checklist based on literature for the field survey. Forty-six (46) courtyards in thirty-two (32) buildings in UTM were surveyed, and the statistical description method was used to interpret and analyzed the data. The Results of this quantitative study shows that UTM central courtyards buildings were designed based on a cautious consideration to orientation and configurations to enhance their effective passive cooling potentials, however, only two courtyards had water pools. The study concluded that courtyards in UTM buildings are creatively designed but future experimental studies to appraise their thermal performances is required, and future simulation studies can predict a better design requirement for optimum performance. Therefore, further simulation studies are recommended.

1. Introduction

One of the most significant current discussions in the built environment, architectural practice, theory, and procedures is "Passive Design". It is becoming increasingly difficult to ignore the issues of passive architectural design strategies in buildings. According to the Intergovernmental Panel on Climate Change (IPCC) (2015), atmospheric temperature is anticipated to move up over the 21st century under all assessed emission situations. But the concern is that if the temperature will continue to rise, what then can the architect do in his architectural scheme? Should he continue in his design of buildings that depends on active means of reducing the effect of rise in temperature and continue to add to the lingering challenge of greenhouse gas emissions as use of electric generators remain the only sure source of power in most of the underdeveloped countries in the world, most especially in African nations such as Nigeria, or, should a shift to passive strategy for architectural design of buildings be considered as an alternative?

Recent studies in passive architectural design have emphasized the need for passive architectural design strategies as the best option for mitigating temperature-rise in buildings. Therefore, the application of courtyard as a passive design strategy in architectural vocabulary may be one among the most suitable approaches to the attainment of passive buildings. Tablada *et al.*, (2005) asserted that passive design is a major strategy for mitigating cooling effects in buildings and recommended the application of the courtyard. Akande (2010), also concurred in his studies on Passive Design Strategies. He concludes that the use of certain passive design strategies such as; good courtyard and building orientation can improve cooling naturally and bring to a minimum the energy required for cooling in buildings.

The application of the courtyard as an architectural design element in buildings is not uncommon to architects. The courtyard is a universal design element which has been put into practice long ago. In particular, contemporary buildings in UTM have this concept and it has become an area of interest in recent times to scholars. This is perhaps due to the numerous benefits of the courtyard. According to Edwards *et al.* (2006), the use of the courtyard in buildings was originally initiated in the hot and dry climatic regions of the world. Thus, its application is most suitable in the tropical regions. However, it is also applicable to all climatic regions. Abass *et al*. (2016) defined courtyard as a covered

outside space but open to the element at its apex. Mishra & Ramgopal (2013) also defined the courtyard as a room that is open to the heavens, a square or rectangular in form and bordered by a group of buildings or the most important rooms. The definitions can go on and on.

The courtyard configuration is a very vital requirement for the courtyard optimum performance and the appropriate form supposed to vary from one climatic region to the other, even its location in the building. For instance, having a courtyard in the middle of the architectural design may not do better in all climatic situations (Ghaffarianhoseini *et al.*, 2015). Thus, adopting the courtyard form from the western states into the tropical region; the hot-dry climatic region or the hot humid climatic region in particular, rather than the using the original indigenous concept which is adaptable to the cultural, climatic and religious requirement of the people may lead to a more thermal distress in buildings. More so, many primordial courtyards in the Arab nations have elucidated a clear picture of a courtyard designed based on the social, cultural and climatic requirements. The courtyard design parameters for instance; aspect ratio, height, orientation, exposure to the sky, nature of the courtyard wall components and much other physical factors were evolved in other to obtained an effective courtyard that responds to the human requirement for comfort in buildings (Berkovic *et al.,* 2012).

The use of the courtyard as an architectural design element is adaptable to almost all building typologies in all the climatic zones due to its passive tendencies for low energy consumption in buildings. It has social, cultural, religious, and environmental usage. Despite its abundant advantages, research effort towards courtyard design requirements is very scarce. Therefore, the main objective of this study is to investigate the design of central courtyard as a passive cooling strategy for improving indoor thermal comfort in Universiti Teknologi Malaysia Buildings (UTM). Courtyard design requirement such as; the courtyard configurations, orientation, and natural features in courtyard buildings in UTM were investigated. Besides the design variants, courtyard usage in such buildings was also examined. The methodology of this study involved the developing of a checklist based on literature on courtyard studies for the field survey. Forty-six (46) courtyard in thirty-two (32) buildings in UTM were surveyed, and the statistical description method was used to interpret and analyzed the data. This paper is divided into five (5) parts; the introduction, study background, methodology, findings and discussion, and the conclusion. This study is important not only to architects but even to scholars as it has provided a background for future allied studies.

1.1. Courtyard Functions

In architectural design, the courtyard has been put into use for many years particularly in housing design. Its application is justified due to its numerous benefits. In recent times, scholars have opined the benefits of the courtyard in order to elucidate its relevance in a building. These benefits include; architectural benefits, social benefits, climatic benefits, cultural benefits, economic benefits, and the religious benefits (Almhafdy *et al.*, 2013a).

The courtyards were frequently used as meeting area for specific functions such as gardening, cooking, working, playing, sleeping, or even in some cases as places to keep animals (Edwards *et al.*, 2006). The courtyard suitability for diverse functions may not be far from its location in the house layout (which varies from one group of culture to another). According to Antonio & Carvalho (2015), the importance of such a space was by their being located in central sites within the urban fabric or building. Surrounded by arcades and colonnades, paved, landscaped with water bodies, various plants, shade, and light, they all played an important role in our social and working life. In terms of its contribution to good health, Antonio & Carvalho (2015) continued that the courtyard can be used as a place for facilitating the healing process due to its natural healing environment. The courtyard also contributes in a major way by modifying the climatic setting and thereby inducing mental and physiological sensation of its end users.

1.2 Courtyard Configuration

The rectangular and square forms are the most commonly adopted for courtyard in buildings even though, there is no any particular form that is considered as the most suitable (Almhafdy et al., 2013b). In residential design, the courtyard is in rectangular or square form, but circular, curvilinear and other forms may evolve. The courtyard form can be adapted to by using the numerous eco-friendly aspects such as scenery, site limitations, and building orientation, to generate new shapes such as; U, L, T or Y (Das, 2006; Reynolds, 2002). Also, the courtyard form can be fully enclosed, semi-enclosed or in some cases even two sided (Berkovic *et al.*, 2012). Again, the application of these forms is not limited to residential buildings alone but even in non-residential and multi-purpose buildings.

Scholars have conducted studies on courtyard design concepts. The studies made it clear that the form can be manipulated to act as a microclimate modifier to the built environment. For instance, the courtyard form was found to be a key design requirement in a study on the archetypal rectangular courtyard form and its impact on the eco-friendly performance in the tropical region by (Aldawoud, 2008). Tablada *et al.* (2005) studied and suggested that the courtyard form and its entire envelope needed to be protected against extreme solar radiant heat and the penetration of dusty air as well as air movement which has a severe consequence on thermal stress. Also, Ganem *et al.* (2014) conducted a study on "the effect of three-sided courtyard on the microclimate behavior in a building". The result revealed that the courtyard generated improved microclimatic condition; mostly when some design requirements for instance orientation, depth of courtyard and ventilation strategies are not ignored. Again, Muhaisen (2006) researched on 'The Effect of a Rectangular Courtyard Proportions at Four Different Climatic Locations' using the simulation method, the impact of courtyard form and orientation on shading effect was investigated. The appropriate courtyard elevation to obtain a good shading effect in summertime and wintertime was discovered to be at least nine (9) meters in hot-humid region, six (6) meters in hot-dry region and three (3) meters in cold and temperate region. This suggests that higher elevations should be used for courtyards in warmer climatic regions while low elevation should be applicable for courtyards in the cooler climatic region. Furthermore, Huang *et al.* (2014) revealed that the deeper form generates more shadow within the courtyard in summertime whereas narrow courtyard form behaves well in wintertime. They suggested an annual calculating ratio. But, for the daylight, this recommendation is not applicable. The courtyard potential to act as a passive cooling element can be compared with a building composition in terms of airflow rate and pattern.

Enes and Ok (2014), studied the effect of courtyard geometry in terms of energy effectiveness or thermal comfort. The main objective of the study was to propose a model for optimum courtyard form and comfort based on the variety of climatic and meteorological conditions for three different climatic regions such as the hot dry, hot humid and the cold region. In the study, all thermal factors were kept constant except temperature. The building energy simulation tool used was the

Computational Fluid Dynamics (CFD). The study revealed that the more the courtyard is exposed to solar radiation, the more cooling is needed during summer and equitably less heating is needed during winter. The best courtyard ratio was defined as that which permits least radiant heat gain during summer and high radiant heat gain during winter. The study concludes with "H" (6000mm x 9000mm x 6000mm) option as the best courtyard form for all the three regions in terms of thermal gain and the criteria of comfort in Turkey.

Mohsen (1979) in his study on "Solar Radiation and Courtyard House Form -A Mathematical Model" proposed a mathematical model that simulates the relation between the courtyard geometry and the thermal performance. The study concludes that solar radiation is the main determinant of discomfort in the hot dry climate region and the optimum courtyard form should be calculated at the pre-design stage. Olgyay (1963) in a study on courtyard optimum ratio recommended an inverse relationship between the thermal impact and the form. In a separate document prepared by The United Nations Department of Economics and Social Affairs titled "Design of Low-Cost Housing Communities Facilities, Climate and Housing Design 1" the concept of the courtyard is recommended based on the fact that the courtyard shape factor that is, its plan should not exceed its height. Also, in another similar document on climatic design in Islamadad (1966), four typologies of courtyards were studied, it was revealed that the courtyard height is the most significant factor that influences solar radiation and shading: increase in a story height resulted in two to three hours of reduction of radiant heat penetration. The conclusion was the recommendation of overhead shading devices for a courtyard with an area greater than $18m^2$.

Muhaisen and Gadi (2006a) in a study entitled "Shading Performance of Polygonal Courtyard forms", study the shading behavior of five-sided courtyard, six-sided courtyard, seven sided courtyard and eight-sided courtyard forms. They produced a computer package that could calculate the shaded and unshaded areas produced by all the studied courtyard geometries. The study revealed that the courtyard geometry has a substantial impact on the shading behavior of courtyard forms. For a reasonable performance throughout the whole year courtyards with R1 equal to or greater than 5 are recommended. They ensure a significant amount of internal shadows in summer, as well as a considerable sunlit area in winter.

In another study on "Shading Simulation of The Courtyard Form in Different Climatic Regions," Muhaisen (2006b) aimed at the effect of quadrilateral courtyard sizes on the shading and degree of exposure created the form in four different sites. The sites include Kuala Lumpur, Cairo, Rome, and Stockholm. They represent the climatic zones of hot humid, hot dry, temperate and cold climates, respectively. The study reveals that it is difficult to achieve the optimum courtyard ratio, as the optimum ratio for effective performance in summer was found to be the opposite in winter. However, the optimum courtyard height for a sensible performance in summer and winter was revealed to be nine meters (9m) in hot humid climates, six meters (6m) in hot dry and temperate climates, and three meters (3m) in a cold climate.

In a computational analysis study on "A Ventilated Courtyard as a Passive Cooling Strategy in the Warm Humid Tropics" conducted by Rajapaksha *et al.,* (2003), examined the possibility of a courtyard for passive cooling in a building of three meters (3m) height in Colombo, Sri Lanka a warm humid climate. The objective is to propose some design principle for courtyard in buildings. A better performance in terms of air temperature reduction is observed when heat exchange between the courtyard indoor air and ambient air temperature is allowed. But, this performance is influenced by the courtyard dimensions and proportion. With the used of k-e two equation turbulence model for simulation, a good thermal adjustment is observed when the courtyard acts as an air funnel discharging indoor air into the sky, then the courtyard form is configured to acts as a suction zone encouraging air movement from its sky opening into the courtyard and back to the atmosphere.

1.3. Orientation

Courtyard orientation is also another design variant that seems to record very few literature. However, scholars that have contributed in this regards include Antonio & Carvalho (2015), he studied the impact of courtyard orientation on its environmental performance by using both experimental and simulation methods. He discovered that increased height of courtyard walls will cause reduction in the degree of air temperature in the courtyard as well as the rooms in a nearby location to the courtyard. On orientation, the study reveals less significance on air temperature but affects ventilation significantly as the enclose walls tend to block air free passage. (Berkovic *et al.*, 2012), continued that elongated east-west rectangular courtyard has the smallest portion of shade and consequently, not recommended for effective shading strategy for cooling. Almhafdy *et al*. (2013a), asserted that there is no evident record on verification of the most suitable courtyard orientation for its optimum environmental performance, although, there is a general assumption that courtyard orientation with the elongated side facing the north to south direction is the best option.

According to Meir, *et al.* (1995), accurate orientation of courtyard can increase their thermal well-being, but orienting it irrespective of solar angles and wind course may create thermal distress. But the setting of a building is considered in most cases by the orientation. The factors with direct impact on courtyard microclimatic behavior include; location of the sun, direction of the wind, shading effect and radiant heat (Bagneid, 2006). All these factors are key to Courtyard orientation. Finally, these copious discoveries only seem to establish the fact that building orientation and courtyard relationship is a key strategy for mitigating the courtyard cooling effects, and by and large, the building. However, due to the difference in geographical location two different latitudinal and longitudinal locations are bound to have different orientation requirement. Thus, according to Almhafdy *et al*., (2013b), there is no evident record on verification of the most suitable courtyard and building orientation for optimum cooling performance for two different locations, although, there is a general assumption that orientation of buildings with the elongated side facing the north/south direction is the best option. Therefore, understanding the most suitable orientation for a single story residential courtyard building in Nigerian hot-dry climate will be a very important objective of this study.

1.4. Wall Enclosure

Courtyards enclosing walls varied from one region to the other. The variations are caused by the social, cultural, economic and eco-friendly conditions. Even though the design remains analogous, the requirements of the design are determined by usage and location (Meir *et al.,* 2000). Wall enclosure can be defined as the summation of the courtyard components within the building. These components include walls, doors and windows. They play a significant role in the microclimate performance of the courtyard through natural ventilation strategies. They can also be influenced by opening or closing of the openings and by altering the wall to window ratio. According to Al-hemiddi & Al-saud (2001), insignificant cooling is observed when all

windows are closed. But, opened windows and doors improve natural ventilation in the courtyard. Other scholars such as: (Muhaisen, A. 2006; Bagnied, A. 2006) agreed that other preferences to look into when optimizing courtyard are the choice of the component material, color and specifications.

Application of natural elements in a courtyard would yield eco-friendly benefits. Muhaisen (2006), revealed that vegetation (as garden elements) in a courtyard can meaningfully impact the thermal performance of a courtyard as they provide shade and increase humidity level in hot-dry regions. Al-Hemiddi & Megren (2001) revealed in a study on the impact of applying a water pond in a courtyard that the interior courtyard with a pool during sunny hours delivered substantial cooling impact within the internal courtyard envelope.

2. Methodology

Information were derived from literatures on courtyard functions, courtyard design variants and their effect on environmental behavior and used to generate a checklist. This methodology was adopted from Almhafdy et al., (2013), a study on "Analysis of the Courtyard Functions and its Design Variants in the Malaysian Hospitals", even though few modifications were effected. The checklist was used in examining all the surveyed courtyards.

2.1. The Checklist

Table 1 illustrates the checklist that was used for the site survey. The checklist was derived according to the study background as presented in the literature of this study. Furthermore, roof shading device was added.

2.2. Sites Visit and Observation

A total of forty-six (46) courtyards in thirty-two (32) buildings in UTM were surveyed. Figure 2 is a sample of some of the courtyards. The specification list was used for data collection as mentioned. Due to the favorable response from the Physical Unit of Universiti Teknologi Malaysia, the whole exercise lasted for two (2) weeks only as there were not major issues encountered. A comprehensive observation was carried out for each of the courtyards. On the courtyard usage, the observation was based on people activity inside the courtyards. The nature of the courtyard design conditions was investigated

3. Results and Discussions

The survey documented true data such as the courtyard functions, form and shape, aspect ratio, height, orientation, vegetation, water body and roof/shading devices inside the courtyard. It was revealed that the use of courtyard is conversant in Kaduna-Nigeria commercial centers (shopping complex).

3.1. Courtyard Function

In architectural design, the courtyard has been put into use for many years particularly in housing design. Its application is justified due to its numerous benefits. In recent times, scholars have opined the benefits of the courtyard in order to elucidate its relevance in a building. These benefits include architectural benefits, social benefits, climatic benefits, cultural benefits, economic benefits, and the religious benefits. However, in UTM courtyards buildings satisfy four (4) important function. As shown in figure 3, its functions include playing ground,

Table 1 *Specification List of Courtyard Design Variants*

				YES	NO
Courtyard Configuration	Form	Square			
		Rectangular			
		Triangular			
		Irregular			
	Shape	Fully enclose	**O**-Shape		
		3 Sided enclose	**U**-Shape		
		2 Sided enclose	**L**-Shape		
		Others	**I**-Shape		
Orientation	North/South				
	East/West				
	North-east/South-west				
	North-west/South-east				
Shading Device	Cantilever Roof				
	Overhangs				
Natural Features	Vegetation				
	Water body				
Usage	Lighting				
	Playing				
	Ventilation				
	Car parking				
	Recreational				

Figure 2 *Samples of some of the courtyards surveyed in UTM*

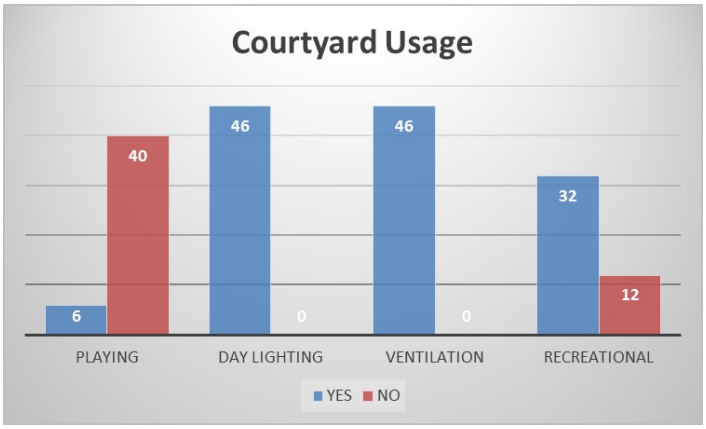

Figure 3 *Distribution of Courtyards Usage in UTM Buildings*

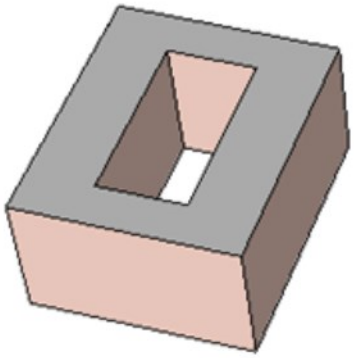

Figure 4 *Showing a fully enclosed courtyard*

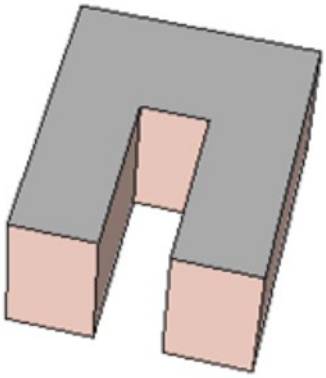

Figure 5 *Showing a semi-enclosed courtyard*

ventilation, lighting, and recreational activities. The study shows that out of the forty-six (46) courtyard surveyed, only six (6) are used for playing, thirty two (32) for recreational functions. All the surveyed courtyards fulfil the architectural requirement for lighting and ventilation. This suggests that Almhafdy et al., (2013a) assertion that the courtyard has numerous functions; such as; architectural, social and climatic benefits is true. However, 12 courtyards did not fulfil the recreational function.

3.2. Courtyard Shape in UTM Buildings

In residential design, the courtyards are in rectangular or square form, but circular, curvilinear and other forms may evolve. The courtyard form can be adapted to by using the numerous eco-friendly aspects such as scenery, site limitations, and building orientation, to generate new shapes such as U, L, T or Y (Das, 2006; Reynolds, 2002). Also, the courtyard form can be fully enclosed, semi-enclosed or in some cases even two sided (Berkovic *et al*., 2012). Again, the application of these forms is not limited to residential buildings alone but even in non-residential and multi-purpose buildings. This study has revealed that the application of courtyard in UTM is comparable to other Asian countries, for instance in Iran, where the courtyard has been designed and shaped to modify the courtyard microclimate (Almhafdy et al. 2013a). As illustrated in figures 4 and 5, the courtyard shape can be categorized as fully enclosed, and semi-enclosed. The fully enclosed courtyards typology are bounded on all the sides (4 sides), while the

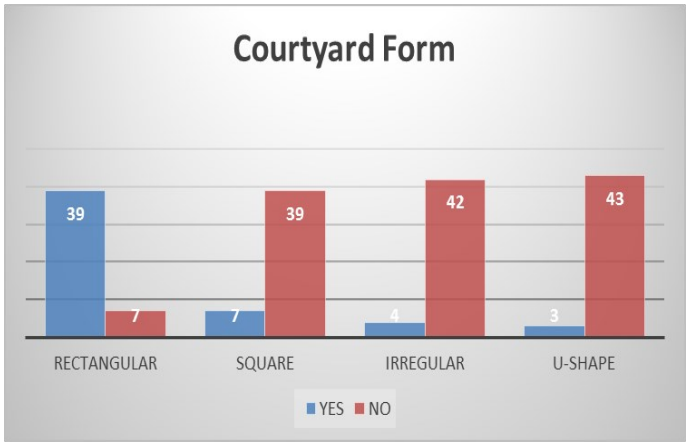

Figure 6 *Distribution of Courtyard Form in UTM Buildings*

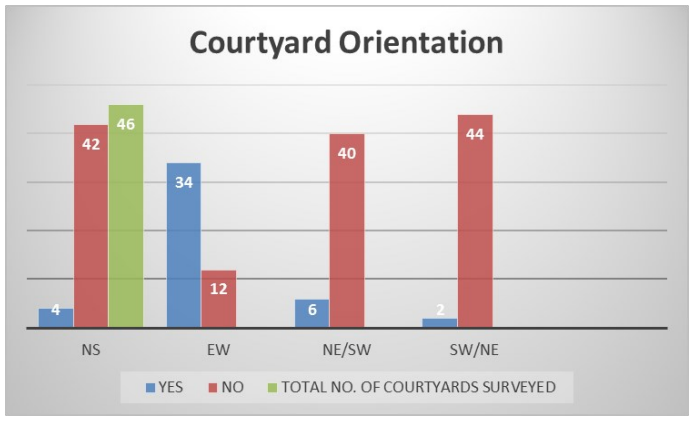

Figure 7 *Orientation of Courtyards in UTM Buildings*

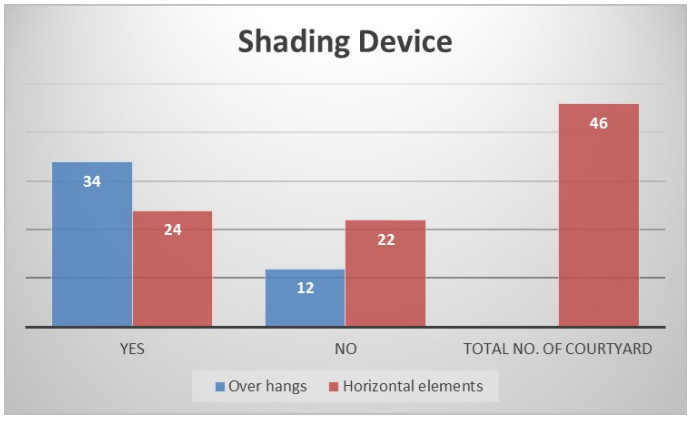

Figure 8 *Shading Devices in UTM Courtyard Buildings*

semi-enclosed typology are defined by courtyard exposure to the atmosphere through its walling components.

Among the surveyed courtyards, 38 are fully enclosed, while 8 are semi-enclosed. It signifies that about 82% of the surveyed courtyards are fully enclosed. This has agreed with Meir (1995) assertion that fully enclosed courtyard have better microclimatic modifying capability than

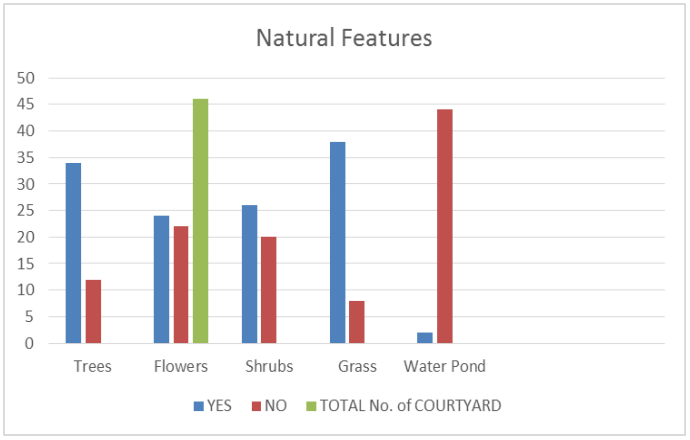

Figure 9: Natural Features of Building Courtyards in UTM

the semi-enclose typology, hence, it can be deduced that the good number of courtyards in UTM buildings have the most preferred courtyard shape for optimum climatic performances.

3.3 Courtyard Form in UTM Buildings

The studies made it clear that the form can be manipulated to act as a microclimate modifier to the built environment. For instance, the courtyard form was found to be a key design requirement in a study on the archetypal rectangular courtyard form and its impact on the eco-friendly performance in the tropical region by (Aldawoud, 2008).

As shown in figures 4 and 5, the courtyard shapes as revealed are: fully enclosed and semi-enclosed courtyards. However, they are in the square, rectangle, irregular and U-shape forms. Figure 6 revealed that out of the 46 surveyed courtyards, 39 are in a rectangular form, 7 square, 4 has an irregular form, and 3 U-shape. The Most popular form is the rectangular, followed by the square, irregular and the u-shape. This revelation has concurred with Almhafdy et al. (2013b) assertion that rectangular and square courtyard form are the most used in buildings. Thus it means that about eighty (80%) of the surveyed courtyard buildings in UTM are rectangular in form, and constitute an excellent grade.

3.4. Orientation

Courtyard orientation is also another design variant that seems to record very few literature. However, scholars that have contributed in this regards include Antonio & Carvalho (2015), he studied the impact of courtyard orientation on its environmental performance by using both experimental and simulation methods. He discovered that increased height of courtyard walls will cause a reduction in the degree of air temperature in the courtyard as well as the rooms in a nearby location to the courtyard. On orientation, the study reveals less significance on air temperature but affects ventilation significantly as the enclose walls tend to block air free passage. Courtyard orientation is another significant design variant. Although past studies have not shown the best courtyard orientation, the common assumption is that courtyard orientation with its longest axis facing north-south will improve thermal performance (Almhafdy et al. 2013a). In figure 7, the study revealed that four (4) courtyards are oriented in the North-South direction, six (6) in the North-East/South-West direction, thirty-four (34) in the East-West and two (2) in the South-West/North-East

direction respectively. It is obvious that about ninety-four (94%) percent of the courtyards has large portions under shade, as these courtyard are oriented in the East-West direction and are rectangular in form configuration as illustrated in figure 5.

3.5. Shading Devices

The literature has shown that shading strategies is a key factor for cooling in the courtyard (Berkovic et al., 2012). Figure 8 reveals that thirty-eight (38) courtyards have overhangs while twenty -four (24) has horizontal shading elements. This connotes that about 72% and 60% of the surveyed courtyard has overhangs and horizontal shading elements respectively. This result suggests that a very good percentage of the courtyard buildings in UTM are well shaded.

3.6. Natural Features

Natural features such as vegetation; trees, flowers, shrubs, grass and water ponds has been revealed as very effective in courtyard thermal performance (Edward *et al.* 2006). Figure 9 reveals thirty-four (34) courtyards had trees, twenty-four (24) had flowers, twenty-six (26) had shrubs, thirty-eight (38) had grasses and only two had water pool. This result signifies that about 75% of the courtyard studied has a satisfactory percentage of natural features, hence, their thermal performances is expected to be excellent (Muhaisen 2006). Also, the fact that only two courtyards had water pools is a very good result due to the fact that humid regions like Malaysia will not require a water pool because it lead to increase in humidity level, but rather recommended in a hot dry climatic region as a water pond can improve courtyard humidity level and thereby influencing positively the hot-dry atmospheric conditions (Meir 2000).

4. Conclusions

Courtyard design requirement such as the courtyard configurations, orientation, and natural features in courtyard buildings in UTM were investigated. Besides the design variants, courtyard usage in such buildings was also examined. The methodology of this study involved the developing of a checklist based on literature for the field survey. Forty-six (46) central courtyards in thirty-two (32) buildings in UTM were surveyed, and the statistical description method was used to interpret and analyzed the data. The results of this quantitative study show that UTM central courtyards buildings were designed based on a cautious consideration to orientation and configurations to enhance their effective passive cooling potentials, however, only two courtyards had water pools. Also, this study explains a research work that adds in the direction of understanding the characteristics of courtyards in UTM buildings. The finding reveals that courtyards are common architectural elements used in UTM buildings. They are categorized into fully enclosed and semi-enclosed shapes. The most regular courtyard form is the fully-enclosed rectangular courtyard. About 72% and 60% of the surveyed courtyard has overhangs and horizontal shading elements respectively; 75% of the courtyard studied has a satisfactory percentage of natural features, hence, their thermal performance is expected to be excellent. On orientation, thirty-four (34) courtyard buildings are in the East-West direction. All the courtyards contributed to ventilation, lighting, and recreational functions while only six were suitable for playing. The study concludes that courtyards in UTM buildings are creatively designed but future experimental studies to appraise their thermal performances is required, and future simulation studies can predict a better design requirement for optimum performance. Therefore, simulation studies are recommended.

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Stakeholders Assessment of Constraints to Project Delivery in the Nigerian Construction Industry

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ABSTRACT

The central goal of construction stakeholders is to successfully deliver projects to stated objective (s). However, for decades, construction projects have been plagued by perennial constraints of cost and time overruns, poor quality, and lack of sustainability. The objective of this paper is to identify and assess the constraints to construction project delivery, and to recommend solutions to enhance project performance. This paper adopted both quantitative and qualitative methods to establish the constraints in the Nigerian construction industry. A pilot survey and literature reviewed revealed a total of fifty (50) construction constraints, which were further classified into eight (8) major groups. Well-structured questionnaires were administered to construction stakeholders (client, consultant and contractor) in Abuja, the federal capital city of Nigeria. Relative Importance Index (RII) was used to analyze the data using Likert scale. The results suggest that cost/time overrun related factors (inability to reduce project cost), Stakeholders interactive-related factors (inability to establish client value system), Client-related factors (Delay in interim payment and finance problem), and Labor/ material-related factors (escalation of material prices and materials quality variability) are the most prevalent constraints in the Nigerian construction environment. To mitigate the effects of these challenges, it is suggested that a formal innovative approach should be used by stakeholders to address the problems of poor communication, high project cost, and delay. Clients should also take measures to provide adequate funding and should promptly honor interim certificates.

1. Introduction

The construction industry is all-important and indispensable to the economic development of most nations in the world. It is one of the largest single industries that greatly subscribe to the development of a nation (Helen et al., 2015). The industry is large because it provides investment products and Government is usually its major client. The industry has been described by Ali and Rahmat (2010) as an engine of growth and a growth-stimulating catalyst of a nation's economy. The duty for the physical development of any country rests on the construction sector.

From a wider viewpoint, the construction industry is a complex system of construction stakeholders (clients, consultants, contractors, manufacturers and distributors, suppliers and sub-contractors, end-users etc.), building works (residential, commercial, industrial etc.), civil and heavy engineering works (roads, railways, bridges, sewers, dams, airports, jetties, cofferdams, caissons, tunnels, refineries, power stations etc), and construction training establishments (research institutes, polytechnics and universities). The industry globally generates employment and contributes between 2%-10% to the GDP of most developing and developed countries. Therefore, the construction industry has the proficiency of either to sustain a floating economy or recuperates an economy that is already depressed. Presently its new role includes the call for low carbon ideologies by using eco-friendly and energy-saving construction materials.

Global Construction (2010) forecasted that Nigeria's construction growth would be one of the fastest of all markets by 2018, as a result of an increase in wealth and urbanisation emanating from the production of its oil. In 2015, Nigeria Gross Domestic Product (GDP) was 2.79% (NBS, 2016) and the construction industry accounted for 4.18% of the GDP (NBS, 2015a). Tanko and Azi (2011) submitted that the industry in Nigeria is an essential contributor to the process of development which includes the construction of schools, houses, hospitals, factories and several infrastructures. Consequently, the demand for infrastructure and buildings in Nigeria has led to the growth of the country's construction industry over the recent years. However, the industry is faced with many multi-faced problems. The successful operation of construction industry in any economy has a huge influence on various sectors of the economy. Therefore, the problem of unsuccessful delivery of products and services by the construction industry becomes a critical challenge.

2. Background

The Nigerian construction industry is characterized by lack of planning, control and organization. Any individual could build any structure without the knowledge of government and against building codes and standards. Therefore, there are no restrictions to entry into the construction industry. As a result, a number of contractors are unprofessional and lack probity. In the same vein, Akanni (2014) submitted that the construction industry in Nigeria is a wide range of loosely integrated organizations that collectively construct, alter and repair a wide range of different buildings and civil engineering projects. Awodele et al. (2009) stated that the Nigerian construction industry is poor as it is characterized with frequent setbacks, cost overruns and abandonment of projects. According to Omoregie and Radford (2006), one of the critical concerns in the construction industry of most developing countries is the high rate of project delay and cost escalations. The project environment in many developing countries like Nigeria present special challenges for project managers that almost presupposes extensive cost and time overruns even before the commencement of a project (Akanni, 2014). Aibinu and Jagboro (2002) found out that an average of 92.64% and 59.23% time overruns on housing projects of less than 10million and above 10million respectively.

A construction project is a complex process that involves many stakeholders, long project durations, and complex contractual relationships (Oyegoke et al., 2013). One of the most significant expectations of every construction industry is the ability to meet the client's need of quality, cost, time, satisfaction, business performance, and safety. However, the Nigerian construction industry is characterized with many problems due to the fact that the problems of quality, cost and time are evident in every stage of the project from design to completion. These challenges need to be controlled early or face the certainty of poor quality, cost overruns and time delays which will eventually lead to displeasure to clients. As clearly emphasized by Helen et al. (2015), relationship and continuous coordination between stakeholders is paramount throughout the life cycle of projects to enhance the performance of projects. Stakeholders can overcome the construction problems by identifying and assessing the most prevalent problems in the industry.

According to Helen et al. (2015), poor construction performance has affected the Nigerian construction industry and its stakeholders do not have documented construction problems for future references. Although Akanni (2014) classified the problems into six (6) groups which include: economic and financial; political; legal; political; social and cultural; physical factors and construction technology and resources. The first five (5) groups were considered in this study and are captured under external factors. Consequently, Helen et al. (2015) had eight (8) classifications (project characteristics, labour and material, contractual relationship, project procedures, consultants, clients, and contractors' related factors). All these groupings were taken into consideration in this study. However, several researchers have advanced the problems facing the industry, but lack appropriate classification that would have included cost/time overrun and stakeholders interactive related groups. Therefore, the paper through the review of literature, interaction with construction stakeholders, and a pilot survey, seeks to identify and assess the critical problems in the Nigerian construction industry as perceived by major stakeholders, and to proffer solutions to enhance the performance of projects. Accordingly, the findings of this study will assist in recommending necessary measures that will tackle the constraints of project delivery and improve the performance of the construction industry. In this paper, the term 'stakeholders' refers to the client, consultant and contractor.

3. Constraints to Project Delivery in the Nigerian Construction Industry

Previous related studies by Helen et al. (2015), identified 46 factors affecting the performance of construction projects in Akure, Nigeria. Their findings however indicated that 10 leading factors were identified. These include material price escalation, motivating skills of the project team leader, quality control of materials, consultant's commitment, delay of progress payment, project team leaders experience, technical skill of the project team leader, overall management actions, and the economic environment. Atomen et al. (2015) found out that the engagement of non-professionals and shortages of materials on construction sites affect the productivity of the construction and advocated for a better trained and skilled manpower. Another common problem in the industry is the lack of construction skills certification scheme which would have addressed the challenge of construction skilled workforce. The challenge of skills certification, and other problems which include: slow decision making; unskilled workers; lack of skills certification scheme; delay in site handing over; client interference during construction; inadequate design/specifications; no adherence to specifications; lack of cultural changes to new innovations; and inadequate budget allocation by government/government policy, were identified at the preliminary stage (pilot survey) of this study.

Akanni (2014) identified 29 environmental factors that affect construction project performance and found 'civil conflicts and disturbance' as the leading environmental factor influencing the performance of construction projects. According to Balogun (2005), cost escalation is the most common problem facing the industry. Daniel et al. (2014) advanced that the prevalence of non-value adding activities and poor performance of the construction industry result in economic loss to the country. Conversely, the slow adoption of new innovative construction management methods (e.g. lean construction, six sigma and value management) has been a major challenge facing the industry. Wahab and Alake (2007) further identified inappropriate contract documents and procurement preparations, old-fashioned methods of dispute resolution, and delay in paying public projects' contractors as various constraints in the construction industry. According to Odeyinka and Yusif (1997), seven (7) out of every ten (10) projects experience delay in the Nigerian housing industry.

Generally, there are a lot of scholarly works on constraints in the Nigerian construction sector. These challenges range from poor communication and management(Ojoko et al. 2016; Helen et al. 2015; Omoreige & Radford 2006; Kunya et al. 2005), inability of construction professionals to define clients' objectives (Dim and Ezeabasili, 2015; Odediran and Windapo, 2014), poor contract management (Ameh et al., 2010; Otunola, 2008; Eshofonie, 2008; Omoreige and Radford, 2006; Kunya et al., 2005; Mansfield et al., 1994; Okpala and Aniekwu, 1988), finance problems (Odediran & Windapo 2014; Akanni et al. 2014; Eshofonie 2008; Otunola 2008; Omoreige & Radford 2006; Atomen et al. 2015), inappropriate contingency allowance (Aibinu and Jagboro, 2002), unrealistic schedules (Otunola, 2008; Eshofonie, 2008; Omoreige and Radford, 2006; Kunya et al., 2005; Nwosu, 2003; Mansfield et al., 1994), escalation of material prices (Ojoko et al. 2016; Helen et al. 2015; Dim and Ezeabasili 2015; Odediran & Windapo 2014; Akanni et al. 2014), to the inability to reduce project cost (Aibinu and Jagboro, 2002).

Table 1 *Previous research on project delivery constraints in the Nigerian construction industry*

N/S	Constraints / Authors	Ojoko et al. (2016)	Pilot Survey (2015)	Helen et al. (2015)	Atomen et al. (2015)	Dim and Ezeabasili (2015)	Odediran & Windapo (2014)	Akanni et al. (2014)	Ameh et al. (2010)	Eshofonie (2008)	Otunola (2008)	Omoregie & Radford (2006)	Kunya et al. (2005)	Nwosu (2003)	Aibinu & Jagboro (2002)	Mansfield et al. (1994)	Okpala & Aniekwu (1988)
C1	Nature of project			√													
C2	Complexity of project			√													
C3	Size of project			√													
C4	Inadequate Completion period		√														
C5	Inaccurate estimates								√	√	√	√	√	√		√	
C6	Inappropriate contingency allowance								√						√		
C7	Delay	√															
C8	Inability to reduce project cost					√							√		√		
C9	Unrealistic schedule					√					√	√		√			
C10	Poor planning/monitoring/feedback mech.	√									√		√				
C11	Inability to establish client value system (objectives)					√	√										
C12	Poor communication, management, and teamwork.	√		√								√	√			√	√
C13	Delay in conflict resolution		√														
C14	Slow decision making		√														
C15	Inadequate planning and control	√							√	√							
C16	Lack of progress meetings		√														
C17	Inability to identify cost and time overrun items at the design stage					√											
C18	Materials quality variability	√		√													
C19	Escalation of material Prices	√		√			√	√	√		√	√				√	√
C20	Unskilled workers		√		√												
C21	Lack of skills certification scheme		√														
C22	Delay in material availability									√		√				√	√
C23	Unavailability of requisite equipment							√									
C24	Proximity to needed resources							√				√					
C25	Imported materials							√	√			√					
C26	Delay in interim payment	√		√													
C27	Finance problems				√		√	√		√	√	√				√	√
C28	Variation change orders	√					√				√	√					
C29	Delay in site handing over		√														
C30	Lack of maintenance culture		√														
C31	Client Interference during construct.		√														
C32	Inability to define project objectives					√											
C33	Inadequate design/specifications		√														
C34	No adherence to specifications		√														
C35	Variances in contract documents	√															
C36	Delay in inspection and approval		√														
C37	Inadequate safety/accidents on site		√														
C38	Rework due to errors	√															

Table 1 *Previous research on project delivery constraints in the Nigerian construction industry (Cont'd)*

N/S	Constraints / Authors	Ojoko et al. (2016)	Pilot Survey (2015)	Helen et al. (2015)	Atomen et al. (2015)	Dim and Ezeabasili (2015)	Odediran & Windapo (2014)	Akanni et al. (2014)	Ameh et al. (2010)	Eshofonie (2008)	Otunola (2008)	Omoregie & Radford (2006)	Kunya et al. (2005)	Nwosu (2003)	Aibinu & Jagboro (2002)	Mansfield et al. (1994)	Okpala & Aniekwu (1988)
C39	Low labor output		√														
C40	Poor construction method	√															
C41	Conflict with other stakeholders				√				√								
C42	Civil unrest/lack of political stability	√						√									
C43	Lack of economic stability			√					√	√							
C44	Adherence to codes and standards	√															
C45	Unethical/unprofessional practices					√				√							
C46	Delay in construct. permit approval		√														
C47	Bye laws and regulation changes	√							√								
C48	Inclement weather	√			√			√	√								
C49	Lack of cultural changes		√						√								
C50	Inadequate budget allocation by government/government policy		√								√						

Table 1 shows a summary of previous related studies on the constraints to project delivery in the Nigerian construction environment.

4. Methodology

The study adopted a mixed qualitative-exploratory and quantitative survey. Non-probability purposive sampling technique was used for this study, and well-structured questionnaires were administered to construction stakeholders (client, consultant and contractor) in Abuja, the federal capital city of Nigeria, which has a significant level of construction output. Fifty (50) construction delivery constraints were identified through literature review, pilot survey, and interaction with some stakeholders in the construction industry. The questionnaire was designed to evaluate the frequency of the identified problems, and administered to 90 construction professionals undertaking public projects in Abuja. The Quantity Surveyors, Architects, Builders, Structural/Civil Engineers, and Electrical/Mechanical Engineers were the target construction professionals selected for this study. A good number of professionals were registered with either the Quantity Surveyors Registration Board of Nigeria (QSRBN), Architects Registration Council of Nigeria (ARCON), Registered Builders of Nigeria (CORBON) or the Council of Registered Engineers of Nigeria (COREN).

The professionals were chosen from client organization, contracting, and consulting firms. The respondents were asked to express their level of assessment on a 5-point Likert. Out of 90 administered questionnaires, 62 questionnaires were returned which represents 68.89% of returned questionnaires. This was considered appropriate for the analysis of the research. The sampling technique provided us with the opportunity to meet the target groups which informed a high rate of response.

The frequency of occurrence was established on a Likert scale (1= never; 2= rarely; 3= sometimes; 4= often; 5= very often) by using the Relative Importance Index (RII). This approach was adopted by Aibinu and Jagboro (2002), Muhwezi et al. (2014) and Desai & Bhatt (2013). The respondents provided numerical scores in order to express their assessment level with 5 as the highest value. The data collected were analyzed using RII calculated by equation 1.

$$RII = \sum ni.pi/N.Rv. \quad \text{(Eq.1)}$$

Where,

ni = number of respondents that chose pi.
pi = 1 to 5 on a Likert scale
N = total number of questionnaire returned.
Rv.= highest value in Likert scale.

5. Results and Discussion

Table 2 shows respondents characteristics within the various organizations. A total of 62 questionnaires were returned, 18 were returned by the clients' organization, 24 and 20 were returned by the consulting and contracting organizations respectively. From the table, it can be deduced that 27% of the total respondents are Quantity surveyors, 34% Architects, 24% Builders, 11% Engineers and 3% are others. It can also be inferred from the table that 66% of the total respondents were registered professionals, and only 5% and 3% of the respondents had Ordinary National Diploma (OND) and no qualification (Others) respectively. That is to say 92% of respondents had at least a degree.

Table 3 depicts the respondent's working experience and specialization. It can be deduced from the table that, the respondents have the required experience to undertake this survey because only 19% of the

Table 2 *Respondent's designation, registration body and qualification*

Demographic Characteristics		Client (N= 18)		Consultant (N= 24)		Contractor (N=20)		Summary (∑N=62)	
		f	%	f	%	f		∑f	%
Profession	QS	5	27.78	7	29.17	5	25.00	17	27.42
	Architects	7	38.89	11	45.83	3	15.00	21	33.87
	Builders	3	16.67	4	16.67	8	40.00	15	24.19
	Engineers	3	16.67	2	8.33	2	10.00	7	11.29
	Others	-	-	-	-	2	10.00	2	3.23
Registration Body	QSRBN	3	16.67	4	16.67	3	15.00	10	16.13
	ARCON	6	33.33	8	33.33	3	15.00	17	27.42
	CORBON	3	16.67	2	8.33	5	25.00	10	16.13
	COREN	1	5.56	2	8.33	1	5.00	4	6.45
	None	5	27.78	8	33.33	8	40.00	21	33.87
Qualification	OND	3	16.67	-	-	-	-	3	4.84
	HND/BSc	11	61.11	14	58.33	14	70.00	39	62.90
	PGD/MSc	3	16.67	8	33.33	4	15.00	15	24.19
	PhD	1	5.56	2	8.33	-	-	3	4.84
	Others	-	-	-	-	2	15.00	2	3.23

Table 3 *Respondent's working experiences and field of specialization*

Demographic Characteristics		Client (N=18)		Consultant (N= 24)		Contractor (N=20)		Summary (∑N=62)	
		f	%	f	%	f	%	∑f	%
Working Experience	≤5yrs	1	5.56	2	8.33	3	15.00	6	9.68
	6-10yrs	2	11.11	2	8.33	2	10.00	6	9.68
	11-15yrs	9	50.00	10	41.67	5	25.00	24	38.71
	16-20yrs	4	22.22	6	25.00	7	35.00	17	27.41
	≥21yrs	2	11.11	4	16.67	3	15.00	9	14.52
Specialization	Building works	11	61.11	14	58.33	13	65.00	38	61.29
	Civil works	3	16.67	4	16.67	5	25.00	12	19.36
	Both	4	22.22	6	25.00	2	10.00	12	19.36

respondents had less than 10 years working experience. 61% and 19% of the respondents engage in building and civil works respectively. While 19% engage in both building and civil works.

Tables 4 and 5 show stakeholders' ranking of the constraints in the Nigerian construction industry. The most severe constraints are the inability to reduce project cost (Av.RII=0.97) under cost/time related factors and the inability to establish client value system (Av.RII=0.97) which falls under stakeholders interactive related group. Delay in interim payment and finance constraints which are both client related factors ranked 3rd and 4th leading constraints in the industry. Stakeholders interactive related factors: poor communication and teamwork (Av.RII=0.91) and poor monitoring/feedback mechanism (Av.RII=0.89); ranked 5th and 6th leading constraints in the Nigerian construction industry. Thereafter, unrealistic schedule (Av.RII=0.88), which is cost/time overrun related group and variation change order (0.83) under client related group, ranked 7th and 9th respectively. While labour and materials related factors: escalation of material prices (Av.RII=0.84) and materials quality variability (Av.RII=0.80); ranked 8th and 10th leading constraints.

Table 4 *RII and Rank (Rk) of construction problems as perceived by stakeholders*

Project Delivery Constraints		Clients (N=18)		Consultants (N=24)		Contractors (N=20)		Overall; ∑N =62) Average	
		RII	Rk	RII	Rk	RII	Rk	RII	Rk
Project characteristics related factors	C_1.Nature of project	0.50	32	0.33	40	0.44	33	0.397	38
	C_2.Complexity of project	0.31	44	0.24	48	0.28	43	0.277	46
	C_3.Size of project	0.32	42	0.28	44	0.23	48	0.313	43
	C_4.Inadequate Completion period	0.74	12	0.68	17	0.81	10	0.739	15
Cost/time Overrun related factors	C_5.Inaccurate estimates	0.71	15	0.63	19	0.75	13	0.697	18
	C_6.Inappropriate contingency allowance	0.32	42	0.31	41	0.29	42	0.332	42
	C_7.Delay	0.77	11	0.72	14	0.78	12	0.777	12
	C_8.Inability to reduce project cost	0.91	1	0.91	2	0.92	1	0.968	1
	C_9.Unrealistic schedule	0.82	6	0.83	7	0.88	5	0.877	7
Stakeholders Interactive related factors	C_{10}.Poor monitoring/feedback mech.	0.81	7	0.85	6	0.86	6	0.894	6
	C_{11}.Inability to establish client value sys.	0.89	2	0.92	1	0.89	3	0.968	1
	C_{12}.Poor communication and teamwork.	0.84	5	0.86	5	0.84	8	0.910	5
	C_{13}.Delay in conflict resolution	0.39	40	0.37	38	0.31	40	0.397	38
	C_{14}.Slow decision making	0.69	17	0.69	15	0.67	17	0.736	16
	C_{15}.Inadequate planning and control	0.80	8	0.79	8	0.86	6	0.777	12
	C_{16}.Lack of progress meetings	0.40	39	0.38	37	0.33	39	0.413	37
	C_{17}.Inability to identify cost and time overrun items at the design stage	0.70	16	0.74	13	0.73	15	0.777	12

Table 4 *RII and Rank (Rk) of construction problems as perceived by stakeholders (Cont'd)*

Project Delivery Constraints		Clients (N=18)		Consultants (N=24)		Contractors (N=20)		Overall; ∑N =62) Average	
		RII	Rk	RII	Rk	RII	Rk	RII	Rk
Labour and Materials related factors	C_{18}.Materials quality variability	0.72	13	0.77	11	0.68	16	0.803	10
	C_{19}.Escalation of material Prices	0.80	8	0.78	9	0.82	9	0.839	8
	C_{20}.Unskilled workers	0.58	27	0.63	19	0.55	24	0.658	20
	C_{21}.Lack of skills certification scheme	0.59	26	0.56	24	0.60	20	0.603	25
	C_{22}.Delay in material availability	0.49	33	0.43	33	0.42	34	0.477	32
	C_{23}.Unavailability of requisite equipt	0.30	45	0.29	43	0.27	44	0.313	43
	C_{24}.Proximity to needed resources	0.34	41	0.35	39	0.31	40	0.371	40
	C_{25}.Imported materials	0.47	34	0.43	33	0.37	37	0.471	33
Client related factors	C_{26}.Delay in interim payment	0.89	2	0.88	4	0.90	2	0.942	4
	C_{27}.Finance problems	0.86	4	0.91	2	0.89	3	0.952	3
	C_{28}.Variation change orders	0.78	10	0.78	9	0.81	10	0.832	9
	C_{29}.Delay in site handing over	0.42	37	0.44	32	0.45	32	0.465	34
	C_{30}.Lack of maintenance culture	0.46	35	0.39	36	0.41	35	0.436	36
	C_{31}.Client Interference during construct.	0.69	17	0.64	18	0.65	18	0.697	18
	C_{32}.Inability to brief project objectives	0.68	19	0.69	15	0.62	19	0.732	17
Consultant related factors	C_{33}.Inadequate design/specifications	0.63	21	0.58	22	0.59	22	0.636	22
	C_{34}.No adherence to specifications	0.61	23	0.54	27	0.55	24	0.597	27
	C_{35}.Variances in contract documents	0.63	21	0.61	21	0.57	23	0.655	21
	C_{36}.Delay in inspection and approval	0.56	29	0.48	30	0.52	28	0.536	30
Contractor related factors	C_{37}.Inadequate safety/accidents on site	0.60	24	0.58	22	0.54	26	0.626	23
	C_{38}.Rework due to errors	0.43	36	0.42	35	0.40	36	0.448	35
	C_{39}.Low labour output	0.60	24	0.55	25	0.53	27	0.600	26
	C_{40}.Poor construction method	0.42	37	0.31	41	0.34	38	0.361	41
	C_{41}.Conflict with other stakeholders	0.57	28	0.53	28	0.49	30	0.571	28
External related factors	C_{42}.Civil unrest/lack of political stability	0.28	46	0.23	49	0.24	47	0.261	49
	C_{43}.Lack of economic stability	0.28	46	0.26	45	0.24	47	0.281	45
	C_{44}.Adherence to codes and standards	0.26	49	0.25	46	0.25	45	0.268	48
	C_{45}.Unethical/unprofessional practices	0.72	13	0.75	12	0.74	14	0.790	11
	C_{46}.Delay in construct. permit approval	0.27	48	0.25	46	0.25	45	0.271	47
	C_{47}.Bye laws and regulation changes	0.52	31	0.46	31	0.50	29	0.507	31
	C_{48}.Inclement weather	0.24	50	0.23	49	0.23	48	0.252	50
	C_{49}. Lack of cultural changes	0.54	30	0.50	29	0.48	31	0.545	29
	C_{50}.Inadequate budget allocation by government	0.64	20	0.55	25	0.60	20	0.613	24

Table 5 *Top ten (10) project delivery constraints in the Nigerian construction industry*

S/N	Constraints	Group	RII	Ranking
C8	Inability to reduce project cost	Cost/time Overrun related	0.968	1
C11	Inability to establish client value system	Stakeholders Interactive related	0.968	1
C27	Finance problems	Client related	0.952	3
C26	Delay in interim payment	Client related	0.942	4
C12	Poor communication and teamwork.	Stakeholders Interactive related	0.910	5
C10	Poor monitoring/ feedback mechanism	Stakeholders Interactive related	0.894	6
C9	Unrealistic schedule	Cost/time Overrun related	0.877	7
C19	Escalation of material Prices	Labor and Materials related	0.839	8
C28	Variation change orders	Client related	0.832	9
C18	Materials quality variability	Labor and Materials related	0.803	10

It can be deduced from this study that four (4) groups which include: project characteristics related; consultant related; contractor related; and external related categorizations, out of eight (8) classifications of the constructions constraints did not fall under the ten (10) most prevalent constraints in the construction industry.

6. Conclusion and Recommendations

Critical construction constraints are stumbling block or drawbacks to successful project delivery. These have affected the construction industry and as a result impacted negatively on the economic development of the country. However, these challenges can be mitigated when the weighty or critical constraints are identified. The stakeholders (Client, Consultant and Contractor) examined and assessed fifty (50) constraints in the Nigerian construction industry. The results of this paper revealed ten (10) most frequent constraints to project delivery in the industry. These include: Inability to reduce project cost; Inability to establish client value system; Finance problems; Delay in interim payment; Poor communication and teamwork; Poor monitoring/feedback mechanism; Unrealistic schedule; Escalation of material Prices; Variation change orders; and Materials quality variability. The findings of this study should create a path for the construction industry to add value to the country's physical products and services. Therefore:

1. A formal innovative approach should be used by construction stakeholders to tackle the stakeholders' interactive-related constraints of establishing the client value system, poor communication, and poor monitoring/feedback mechanism. This creative management system which should involve all decision makers and other stakeholders, could address the challenge of unnecessary and high project cost, unrealistic schedule, variation change order and materials quality variability.

2. Government being the major clients of public projects should also take measures to provide adequate funding and should promptly honor interim certificates.

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