Roof Type Distribution and Roofing Trend Detection in an Urban Areas

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Abstract— Building roof is an essential component within the green city concept. Eco-friendly green roofs can make comfortable internal environment for dwellers. As the Kandy city is within the discussion of urbanization related problems arena in Sri Lanka, the city area within the extent from city clock tower to 1km buffer zone was selected to conduct current study. The objective of the study was identification of roof type distribution and roofing trend detection in an urban area. Landsat imageries, Google Earth Pro, and field survey data were utilized in the study and analysis process configured mainly with map analysis with the support of ERDAS IMAGINE and ArcGIS software. Accuracy assessment results could confirm that goodness of roof type classification with 94% of overall accuracy. Accordingly, the selected city limit is still predominant with clay tile roofs. Trend for newly constructed buildings is concreted roofs while renovated buildings have covered mostly with aluminum roofs. In this sense, there is no devastative issue at the moment. However, it is good to be ready for future. Thus, it would be better to go for clay tile roofs and concreted roofs while discouraging asbestos roofs.

Index Terms— Green city; Kandy; Roofing trend; Roof type

1 Introduction

THE concept of 'Green Cities' came to the platform with the complex devastative issues in the 21st century. The term 'Green' reflects sustainability and eco-friendliness of the cities [1]. Greening with natural environmental quality, green buildings, green infrastructure, green services, and green technologies are the major aspects pertaining to make green cities. The function of green buildings is a thriving aspect need to be concern as cities are growing fast and compact with buildings. The benefits of green buildings have been classified into three major categories as environmental, economic, and social [2]. Reduction of green house gas emissions, energy saving and efficiency, and make healthier, happier and productive social environment are the outstanding benefits of green buildings. Given that, building roof having major role in standing greener aspects. Sustainable roof is a causative factor for microclimate amelioration reducing cooling and heating loads and energy conservation in cities [3], [4]. Type of roof material used and rooftop gardening are the major aspects in shaping sustainable roof.

Protection from solar heat with applicability to tropical climatic conditions are impressive in making roofs within the Asian as well as Sri Lankan context. Cadjan (woven mats made from coconut palm leaves), straws, grasses were the widely used roof cover materials within the traditional historical contexts in Sri Lanka. Still some rural villagers as well as loges in hotels and restaurants use these roof cover materials with the purpose of tourist attraction. Then people were attracted to round tiles, calicut tiles, and mostly on metal profile roofing sheets (zinc alum) and asbestos. It is true, there were safety issues with the traditional roofing materials. In contrast, there were no troubles over natural environment. Many troubles with thermal performance hand in hand with social and natural environmental quality matters with newly invented roof materials such as zinc alum and asbestos. This is a considerable aspect in cities due to urban sprawl trend in the country. Urban population in Sri Lanka is around 18.4 % (3,945,488 people) in 2020 and it is expected that 65% of the population will live in urban areas by 2030 [5]. In this sense, 'Green Roof' is an essential aspect for provision of urban green space in compact city environments.

The current study formulated with the objective of identification of roof type distribution and roofing trend detection in an urban areas selecting Kandy city in Central Province Sri Lanka as a case study site. Because, detection of roofing trend is considerably important to propose sustainable roofing methods for urban cities in the country.

1.1 Study Area

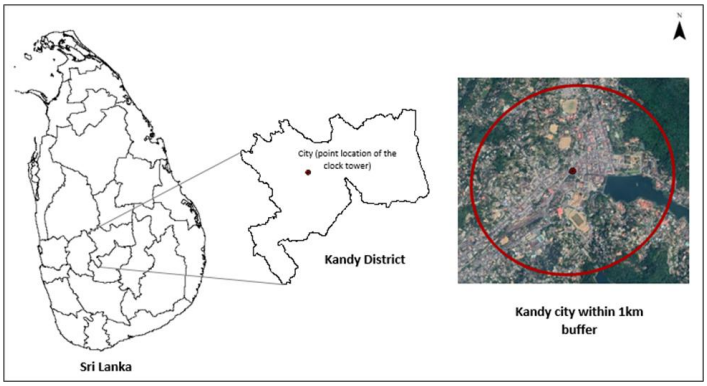

Fig. 01. Map of the Study Area

The study was conducted within 1km buffer area of the Kandy city (Fig. 01). Kandy is both an administrative and religious city and is also the capital of the Central Province [6]. The city

was the last capital of the ancient kings' era of Sri Lanka. Kandy city architecture is predominantly bearing influences from Kandyan Kingdom. Now the rapid urbanization and development appears instead to the city's traditional identities [7]. Therefore, the city was selected as an ideal place to identify roof type distribution and roofing trend detection in an urban areas in Sri Lanka.

3 Methodology

The objective of the study (i.e. identification of roof type distribution) was mainly conveyed with map analysis exercise. Landsat 8 OLI/TIRS C1 Level-1 data set average for the 24.03.2019 to 03.04.2019 time period was acquired through EarthExplorer. Layer Stack was built with the Geometric and Radiometric corrections in order to perform Supervised Image Classification in ERDAS IMAGINE. Normalized Difference Built-up Index also created in ERDAS to distinguish other landuse types from buildings and to clarify the Supervised Image Classification result.

Identification of roof types were predetermined to categorize corresponding to four types (i.e. clay, concrete, aluminum, asbestos); which are common roof types in Sri Lanka. Training data to classify roof types into these four particular classes were marked using Google Earth Pro. Boundary layer which demarcate 1km buffer from the location of the city clock tower was put over the Google Earth Pro and placemarks were put recognizing four roof types. After verification of placemark points corresponding to their coordinates in the ground survey, it was considered 10 training samples to recognize each specified roof type (Fig. 02).

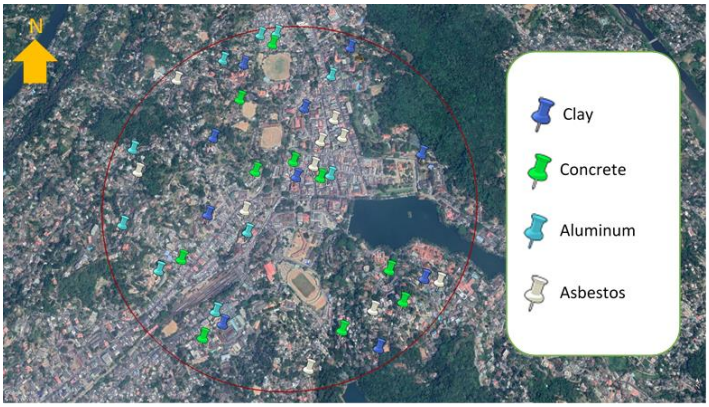

Fig. 02. Verified Sample Roof Types within the Study Area

Then the extracted build-up area layer from ERDAS was converted to the vector format in ArcMap. Google Earth Pro KML files which were converted to the layer files in ArcMap were used to create Signature File by creating training samples on build-up area layer. Signature File was used to perform Supervised Classification to distinguish roof types. Finally, the accuracy assessment was conducted by using Google Earth Pro images and ground survey data as reference. Accordingly, producer accuracy and user accuracy and Kappa coefficient were computed to further clarify the results.

Roof material of newly constructed or renovated buildings were considered to envisage trend of roofing pattern; whether it is towards greening or away. Altogether 50 newly constructed and 50 renovated buildings during 2015 to 2020 period within the selected study site were considered in the survey.

4 Results and Discussion

According to the map analysis, altogether there are 40960 buildings within the 1km buffer zone of the Kandy city limit. Accuracy assessment results confirm that goodness of roof type classification with 94% of overall accuracy (Table 01).

TABLE 1
Accuracy Assessment Results for Roof Type Classification

Producer accuracy (%)	93.71
User accuracy (%)	96.04
Overall classification accuracy (%)	94
Overall Kappa statistics	0.9217

Highest number of buildings with 57% represent clay roof tops (Table 02). The lowest is concrete roof tops. Though concrete slabs have constructed, top of the roof have remained for further construction. Therefore, most of the building roof tops have temporarily covered with aluminum or asbestos. It was observed during the field surveys.

TABLE 2
Roof Type Distribution within the Selected City Limit of Kandy City

Roof type	Number of buildings	Percentage represent (%)
Clay	23347	57
Concrete	2458	6
Aluminum	6963	17
Asbestos	8192	20

Generated roof type classification map illustrate distribution of four specified roof types within the preferred city limit (Fig. 03).

Still clay tile roofs are predominantly visible within the Kandy Grid City (KGC) area. Asbestos and Aluminum roofs also have spread-out over the city. Concrete roof tops are few within the KGC area. However, there is limited space to horizontal expansion of KGC and most possible way of city expansion is vertical expansion. In this context, concrete roof tops are strategically important.

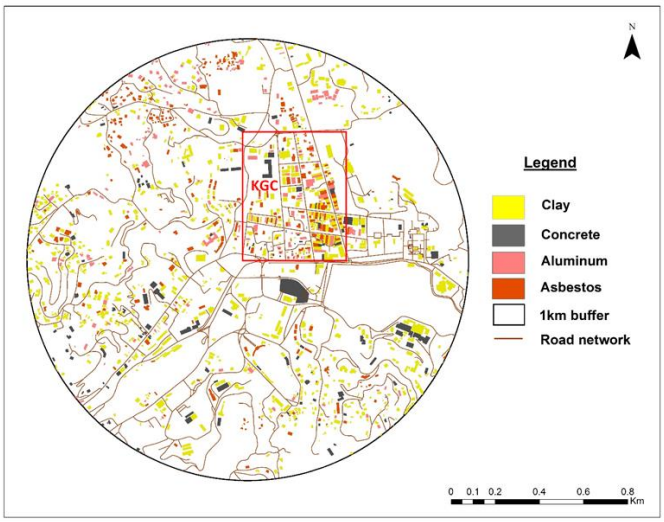

Fig. 03. Roof Type Classification Map

Results of roofing trend detection showed that, roof material of newly constructed buildings within the selected study site is oriented towards concrete roofs (Fig. 04). Possibility of future vertical extension, possibility for roof top gardening [8], durability, and wind resistance may be the possible reasons for this trend. Interest towards clay and aluminum roofs are moderate. Less percentage of asbestos roofs for new constructions is good and further it is need to go away from asbestos materials. Asbestos material is highly carcinogenic and have been banned in most of the countries around the World. According to WHO records, 107,000 people die because of Asbestos related illnesses. Though the blue asbestos has been banned in Sri Lanka since 1997, white asbestos is still use as roofing sheets in Sri Lanka [9].

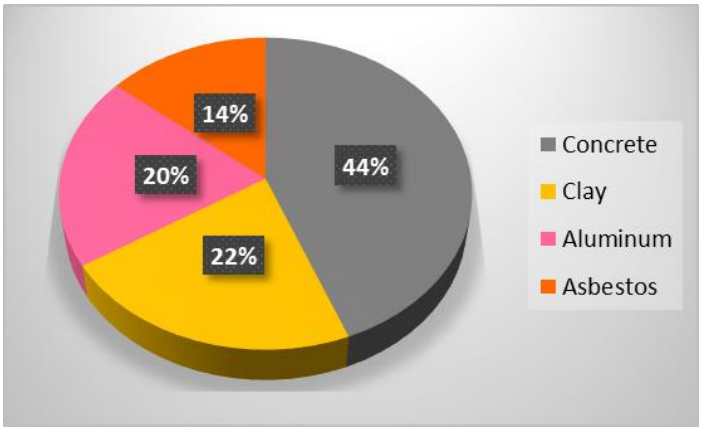

Fig. 04. Roof Material of Newly Constructed Buildings during 2015-2020 (among the 50 selected sample)

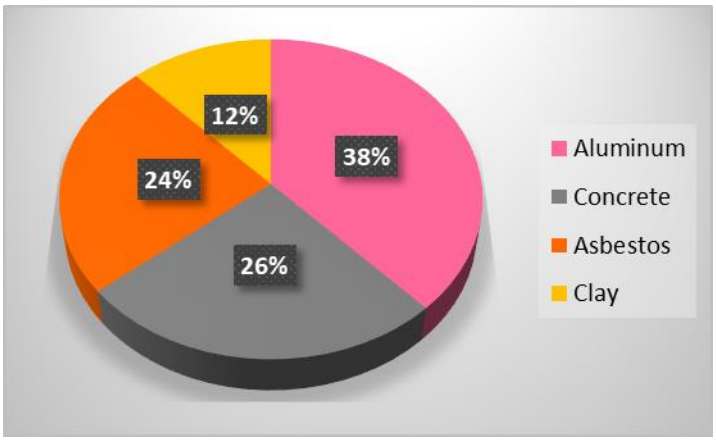

Fig. 05. Roof Material of Renovated Buildings during 2015-2020 (among the 50 selected sample)

Aluminum roofs are the mostly used roofing material for renovated buildings within the selected sample. Compared to the asbestos, aluminum is not non-toxic and thus it is safe than asbestos [10]. More or less similar proportions have obtained concreted and asbestos roofs. Clay type roofs used for the renovated buildings obtained the lowest proportion. However, this is a considerable aspect. When it looks back to the 18th century, building roofs of the Kandy city are predominant with clay roofs (Figure 06 (a)). Now the situation is completely different (Figure 06 (b)).

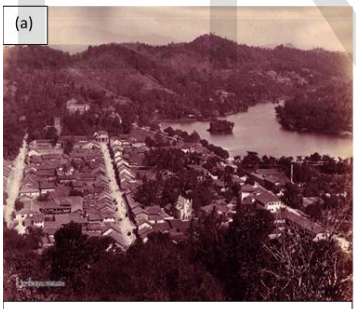

Fig. 06 (a). Image of Building Roofs of Kandy City in Late 1800s

Source: Lankapura.com, 2009

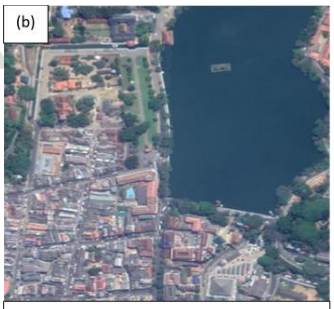

Fig. 6 (b). Image of Building Roofs of Kandy City in 2020

Source: Google Earth Pro, 2020

6 Conclusion and Recommendation

Building roofs within the Kandy city limit is still predominant with clay tile roofs. Compared to the historical context, now the city area consists different roof types. Together the asbestos and aluminum roofs have been spread-out within the selected study site obtaining second proportion of the distribution. When it seeks roofing trend, highest proportion of newly constructed buildings have covered with concreted roofs while highest proportion of innovated buildings have covered with aluminum roofs. It is good to go away from asbestos roofs in order to avoid its side effects. Concreted roofs can suggest for newly

constructed buildings especially with the purpose of vertical expansion. This would be a solution for urban sprawl of Kandy city as well. Especially for commercial building structures. Clay tile roofs would be applicable for houses, if there is no idea for vertical expansion in anyway. Especially for low- and middle-income families who have no affordability for internal air conditioning. Otherwise, it is good to have concreted roof top as it can make sense of greening with roof top gardens instead to the more other benefits.

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