ANALYZING OF VARIOUS INDICES OF BUILT-UP AND BARE LAND IN YANGON, MYANMAR

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Abstract

Land distribution guidelines and recognition of national trends are important in preparing and evaluating changes in the land description data. This paper focuses primarily on the basic extraction from the satellite images of LANDSAT 5,7,8 and Sentinel 2A from USGS within thirty years of the urbanization from 1990 to 2020 of modelling for the built-up area. GIS techniques for built-up area modeling are used in this research to calculate indices such as the Enhanced Built-up and Bareness Index (EBBI), the Normalized Difference Built-up Index (NDBI), the Urban Index (UI) and Normalized difference bareness index (NDBaI). Therefore, this research points out a variable approach to automatically mapping standard of enhanced built-up and bare land index (EBBI) changes with simple indices and according to index outputs. The number of outputs between the EBBI and NDBI and UI rate was to use the entire Landsat imagery spectral range, generating less spectral variability between modifications in the built-up area and higher precision compared to the other indices and NDBaI rate use to analyze the area of bare land. The percentage of Landsat's and Sentinel-2A's imaginary outputs was to use the entire spatial range of Landsat images that created less spectral complexity for higher accuracies between built-up area improvements compared to the other Landsat feature index, where the urban expansion area increased from 43.5% in 1990 to 92.5% in 2020. This research has an overall assessment accuracy of an average 78% in Landsat images and 93% in sentinel 2A with the value of coefficient of linear regression 0.97 is rated as substantial. The modelling method shows the correlation between the reliable built-up index of each, simple to implement quickly, which can be used to figure out the extraction of the built-up area in the focusing year.

Keywords: *Built-up area, EBBI, NDBAI, NDBI and UI.*

1. INTRODUCTION

Mapping the built-up areas is crucial because the existence of those varieties of land can be used as a landmark of city development and the rate of built-up area has huge and expansion in recent decades. The increasing populace has imposed the large demands for brand spanking new housing, colleges, transportation, and other primary areas. In current years, understanding the dynamics of sprawl, quantifying them, and sooner or later predicting the identical for a destiny length has attracted the massive interest of researchers and scientist [1]. Numerous problems have occurred in Yangon, the former capital and the most densely crowded city in Myanmar, including a major expansion of building expansion, highway interchanges, waste management, and flooding. Population growth leads to increases in water and energy consumption and causes land surface changes, which result in regional to global climate change and environmental degradation. The population densities and the expansion of urban areas, especially in metropolitan cities, have changed the shape of the surface of the earth throughout history [2]. Due to the fast urbanization and, the world's surface changes significantly on a local and worldwide scales as to the environmental and aesthetical impacts. In this way, land spread examination from the outside of the earth is essential for the entire world [3]. The objective of this study is to find the built-up area by modelling for the past thirty years by using the satellite images and checking the accuracy of the results of each built-up index between the images of the study area.

2. STUDY AREA

The study area, Yangon is a highest density of population and the main commercial capital city of

Myanmar and has a lot of industrial area, residential area and also commercial port. The area is 10276 km^2 and is located in lower Myanmar along with the Yangon River between latitude 17° 06′ to 16° 35′N and longitude 95° 58′ to 96° 24′E, east of the Ayeyarwady River delta. Yangon has a tropical monsoon climate with three distinct seasons. The rapid urbanization and accelerated development are occurring in Yangon. In this study, the built-up area is analyzed for the Yangon city (including 33 districts) which locates under the management of the Yangon city development committee. Yangon is the commercial city in Myanmar, and has recorded a rapid population growth over the past ten years (Regional EST forum, 2008). According to the huge expansion of urban area, the analysis of built-up area supports for the systematic approach to the town planning projects.

3. DATA PROCESSING

In this research, the analysis of the built-up area is performed dependent on the processing information extricated utilizing of the index modelling. The study approach is to identify the difference in the built-up area utilizing time arrangement satellite images order from 1990 to 2020 is explored. Landsat and Sentinel2A images are accessible for research reasons for the examination region, and there is no ground- truth perception during those years. In this manner, Landsat TM, ETM+, OLI and MSI and imagines are utilized for the land use of the built-up area for as far back as thirty years. The preparing of imagines is performed on index modelling in raster calculator to accomplish an improved result for include reclassification. The use of built-up area extraction is done dependent on the EBBI, NDBI and UI estimations and NDBaI is the index extraction for bare land. The index esteems in the study area are isolated according to the boundary of the management of Yangon city development committee for the images and preparing information are extricated for every five years. The selection of satellite images is selected on the basis of some data acquired in different months in order to improve the data interpretation from the website of united states geological survey (USGS) with the time range imaginary for the study area. The shape file of the boundary of the study area is downloaded from the Myanmar information management unit which are legally data (published on February 11, 2020) and is reliable to use. There have two types of data collection that are the required imaginary and the shaped files of the boundary for the location of the study area. The time detection for the study area were for the previous thirty years and therefore the collected Landsat imaginary were for 1990, 1995, 2000, 2005, 2010, 2015 and 2020. Satellites images with zero cloud cover in the study area were selected to minimize the negative impact of weather on the analysis, factors such as acquisition time, coverage, cloudiness, and also the resolution were considered. The Multispectral Imager (MSI) of Sentinel-2A delivers 13 spectral bands ranging from 10 to 60-meter pixel size and the Landsat **Operational Land Imager (OLI)** includes 9 spectral bands from band 1 to 9 with 15, 30 and 60 m resolution and the other 2 bands with a spatial resolution of 100 meters are **Thermal Infrared Sensor (TIRS)**.

4. METHODOLOGY

The four models of analyzing built-up index are used for the current spatial resolution of Landsat 5 and Landsat 7 channels (30 m resolution), Landsat 8 channels (15 m resolution), Sentinel-2A channels (10 m resolution) with the multispectral satellite data merging procedures have been implemented to improve the precision of the classifications for the built-up area according to each decade for previous thirty years. The accuracy levels of the analyzed data performed using several remote sensing indices were compared to the distribution of built-up and bare land areas of each index.

Table 1 The spatial resolution of bands of each satellite images imaginary in this study area

Band	R/G/B	NIR	SWIR-1	SWIR-2	TIR
Landsat-5TM	3/2/1	4	5	7	6
Landsat-7 ETM	3/2/1	4	5	7	6
Landsat-8 OLI	4/3/2	5	6	7	11
Sentinel-2 MSI	4/3/2	8	11	12	-

A random sampling technique was used to collect sample pixels to compare the accuracy of the built-up extraction and bare land from different indices and to evaluate the difference between the outputs of them. The spectral modellings for the built-up indexes and the spatial resolution bands of the data are classified steps by step according to the flow of methodology as showed in figure 1.

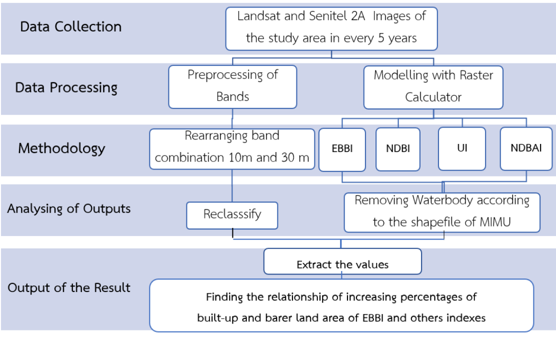

Figure 1 Flow Chart of the Methodology

The remotely sensed indices were used for quickly mapping of EBBI analysis were compared to the results of other remote sensing indices: NDBI, UI, and NDBal. The equation of each indices are as follows:

$$EBBI = \frac{SWIR-Red}{\sqrt[10]{(SWIR+TIR)}} \quad (1)$$

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \quad (2)$$

$$UI = \frac{SWIR2 - NIR}{SWIR\,2 + NIR} \quad (3)$$

$$NDBaI = \frac{Red - TIR}{Red + TIR} \quad (4)$$

The method was consummate by associating built-up areas dogged by indices of EBBI [1], NDBI [5], UI [5] and NDBal [6] with the outcome from Landsat images.

5. MODELLING OF THE INDEXES

The bands of TIR channels are very operative for diagramming built-up areas reliant on a low spectrum which eradicates the influence of vegetation and water, while a high spectrum determines built-up areas evidently. The temperature of a built-up area is 10-12 degrees higher than that of vegetation [4]. Consequently, the amalgamation of NIR, SWIR and TIR wavelengths create it conceivable to mend the plotting method for built-up areas relation to earlier existing remote sensing indices. In a time-series ranging 1990-2020, the improvements were derived from seven satellite images. There were advantages and limitations to each index mentioned above.

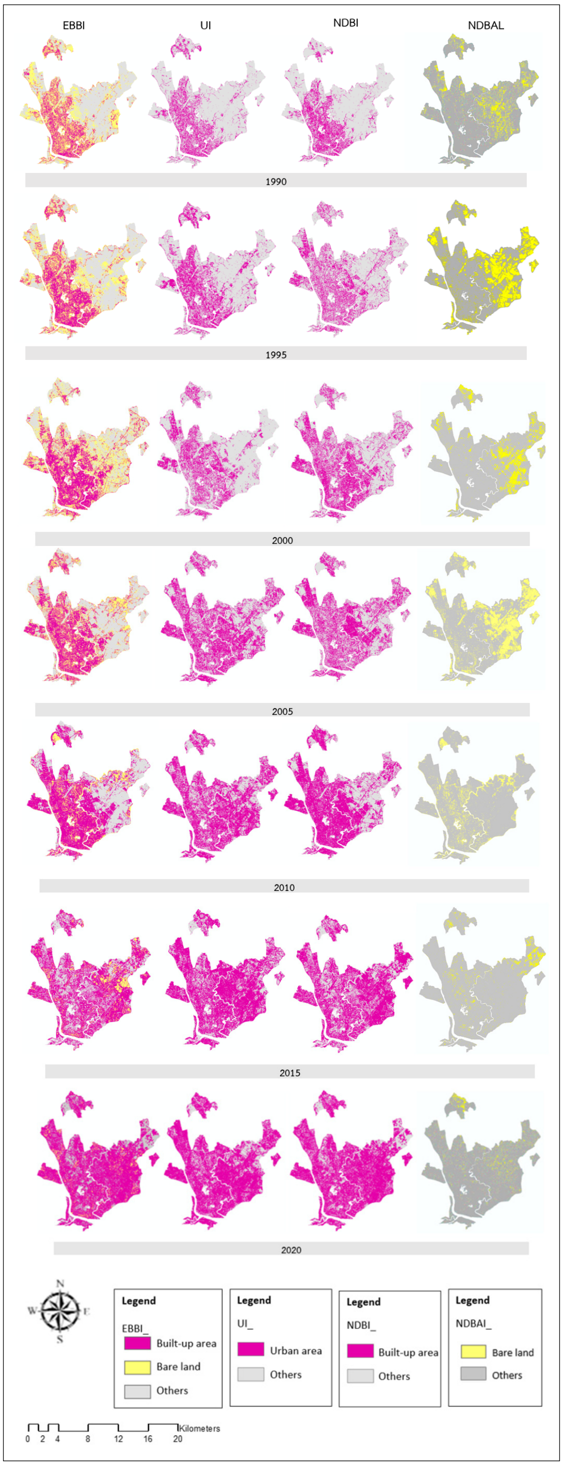

Figure 2 Enhanced Built-up and Bare land index (EBBI) in the study area from 1990 to 2020 (Descriptions; 0.1 to 0.3 is built-up areas, <0.1 is bare land and >0.3 is the other areas)

Normalized Difference Built-up index (NDBI) of the study area from 1990 to 2020 (Descriptions;

All positive value shows built-up area)

Built-up index (BU) of the study area from 1990 to 2020 (Descriptions; the value of -1 shows urban area and 0 shows the others area)

That was the reason why some indexes were integrated in order to increase the accuracy of the classification of certain classes of land cover, especially EBBI. EBBI was described as an area for this analysis, which was not only growth as land, built-up area, but also included bare land that could still be filled with grass.

5.1. TABLES AND OUTPUT OF THE RESULTS

5.1.1. TABLES

After the evaluation was achieved, the classification that had been between constructed by combining each band's spectral index and pattern by classifying the one produced only by the index frame. Accordance with the provisions to the range counted and the difference of average value of each index for each class, such as EBBI, UI, NDBI, and NDBaI are the following table 1.

Table 1 The difference increasing rate percentage of built-up area of each index in this study area

Year/ Index	EBBI	UI	NDBI	NDBaI
	Built-up area			Bare land
1990	-	-	-	-
1995	1.244	6.884	1.063	2.648
2000	7.564	10.08	18.29	2.932
2005	10.130	3.791	3.930	13.353
2010	1.213	3.691	2.791	28.231
2015	9.060	13.640	5.659	24.144
2020	13.919	10.941	3.351	18.035

Table 2 The increasing percentage of built-up area of each index in this study area

Years	1990	1995	2000	2005	2010	2015	2020
EBBI	35.55	36.75	44.31	54.24	55.44	64.5	78.42
UI	43.56	50.45	60.53	64.32	67.9	81.54	92.48
NDBI	32.85	43.48	61.77	64.47	66.59	72.14	75.46

5.1.2. OUTPUTS OF THE RESULTS

According to the figure 3, the built-up area extracted from EBBI (proposed method) and the two commonly used built-up indices, normalized difference built-up index (NDBI) and the urban index (UI) for the year 1990 to 2020. The patterns of built-up area extraction were found similar in the three indexes thought the built-up area was more in case of NDBI and UI compared to EBBI. Due to the NDBI and UI cannot be distinguished between built-up and bare land and much of bare land area near with the built-up area has been mixed with the area being developed. And hence we analyzed between the increasing of enhanced built-up and population growth rate by correlation of the linear regression as final of the data analysis in the thirty years of the study area.

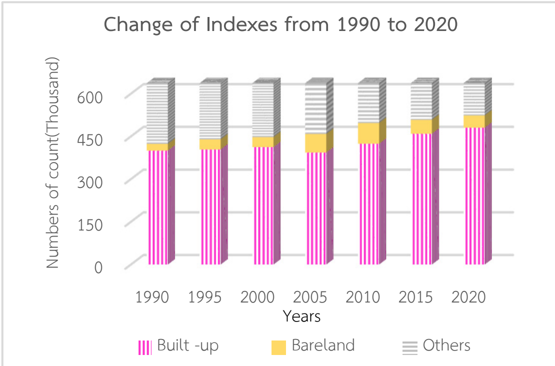

Figure 3 The changing of numbers of built-up and bare land from 1990 to 2020

So, it will be done in this analysis to identify the indexes that this included a landscaped area and bare land that could be developed.

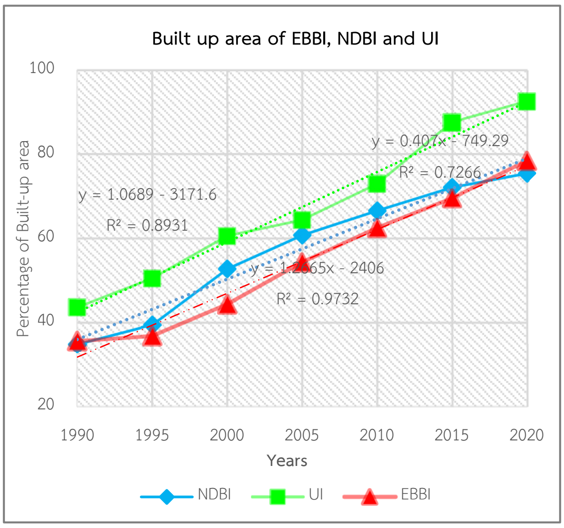

Figure 4 The percentages of the expansion of built-up and bare land from 1990 to 2020

After doing verification of land cover images from 1990 to 2020 used index data and then applied the linear regression, but it was still needed further verifications to data. The built-up index on 1990 to 2000 could be seen slightly increasing and the most increasing is after 2005 as shown in the figure (4). According to calculation of the built-up area in Yangon from 1990 to 2020, it could be seen clearly the significant changes on decreasing bare land and increasing build land (Table 2). On EBBI index (built-up and bare land), there was impairments, where on 2015 the difference percentage was about 24.144% and on 2020 it was about 18% of all total area of Yangon city.

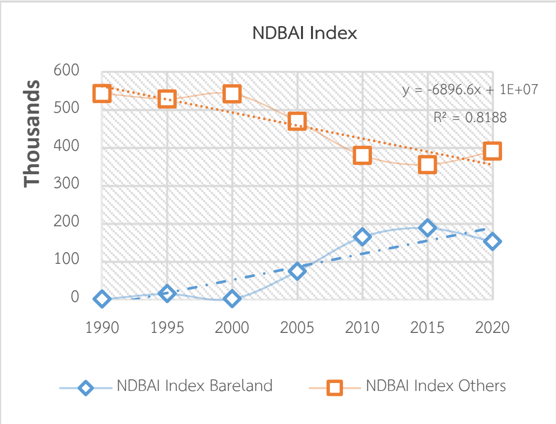

Figure 5 The difference of the percentages of built-up and bare land from 1990 to 2020

6. CONCLUSIONS

This research found that detection and identification of built-up area used EBBI, UI, NDBI and NDBaI indexes and the spectral band together with Landsat 5,7,8 and sentinel-2A are used with the analyzing difference rate of built-up and bare land area. The results show the index of EBBI is the significantly increasing nearly twice of built-up area expansion from 1990 to 2020 in the study area. The EBBI index for built-up area was increased from 35.5% to the 78.4% expanse with the high related correlation coefficient of linear regression (0.97). Further research needed to test and evaluate combination of those indexes to get the best method for detection of built-up area. Therefore, the modeling method of the indexes are usefully to figure out the extraction and improvement of the built-up area in the city.

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8. REFERENCES

[1] As-syakur, A. R., I. Adnyana, I. Arthana and I. W. Nuarsa. “Enhanced Built-Up and Bareness Index (EBBI) for Mapping Built-Up and Bare Land in an Urban Area.” Remote. Sens. 4, 2012, 2957-2970

[2] Cao, Hui & Liu, Jian & Chen, Jianglong & Gao, Jinlong & Wang, Guizhou & Zhang, Wanfeng. ”Spatio temporal Patterns of Urban Land Use Change in Typical Cities in the Greater Mekong Subregion (GMS)” Remote Sensing. 11. 2019, 801. 10.3390/rs11070801.

[3] Juan C. Valdiviezo-N, Alejandro Téllez-Quiñones, Adan SalazarGaribay, and Alejandra A. López-Caloca, "Built-up index methods and their applications for urban extraction from Sentinel 2A satellite data: discussion," J. Opt. Soc. Am. A 35, 35-44. 2018

[4] Wenk, Gary & McGann-Gramling, Kristin & Hauss-Wegrzyniak, Beatrice & Ronchetti, Daniela & Maucci, Raffaella & Rosi, Wenk et al, 2004 2004 International Society for Neurochemistry, J. Neurochem. (2004) 89, 484–493.

[5] Wu, Jing & Yang, Shen & Zhang, Xu. “Interaction Analysis of Urban Blue-Green Space and Built-Up Area Based on Coupling Model—A Case Study of Wuhan Central City”, 2020. Water. 12. 2185. 10.3390/w12082185.

[6] Zhao, Hong-Mei & Chen, Xiaoling. “Use of normalized difference bareness index in quickly mapping bare areas from TM/ETM+”. International Geoscience and Remote Sensing Symposium (IGARSS) in 2005, 3. 1666 - 1668. 10.1109/IGARSS. 2005. 1526319.