COMPARATIVE ANALYSIS OF LAND COVER OF SOUTH ASIAN COUNTRIES OF BANGLADESH, BHUTAN, MYANMAR, NEPAL AND SRI LANKA (2020)

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ABSTRACT

Land is a primary natural resource and an asset on which all human activities take place. Land cover is the primary observation of land and can range into different categories. Due to multiple uses land is put to, there exist patterns of land use as well affected by the land cover. Land cover is currently very efficiently monitored by satellites these days. The current study is an examination of recent land use patterns of South Asian countries of Bangladesh, Bhutan, Myanmar, Nepal and Sri Lanka using Remote sensing and GIS. Land use information has been derived from ESA World Cover database. Such a study is useful in comparative analysis of geographies and is not readily available.

KEYWORDS: *Land, Land Cover, South Asian, ESA, Earth Engine*

INTRODUCTION

An asset and a resource, land is the base of all human life on earth. The Earth has approxminately 29.18% of its area as land and rest as water (Gregory, 2010) **[1].** In its definitional aspect, a combination of physical characteristics and functions comprise land resource (Vink , 1975) **[2].** One of the most significant aspects of land, besides being a resource, is that it can be delimited. A geographical area with location, geomorphology, soil, plants, and resources are components of the concept of land. In this regard, two aspects emerge as that of- land cover and land use (NOAA, 2021) **[3].** It is commonly mentioned that while the two are used frequently as terms; and many a times synonymously, they are different in meaning (Canada, 2015) **[4]** and that they should never be used interchangeably (Lambin et al. 2006; Coffey, 2013). **[5,6]**

Land cover is considered as the basics of studying land and includes the biological and physical aspects of the Earth. Land cover in this context broadly denotes defined as a cover in its physical manifestation with components such as vegetation, soil, urban built up, hydrology, agricultural land, and other varieties of infrastructure as well. It is taken as the observant and direct view of land as seeing it from above. Changes in land cover are very important to analyse and are a requirement of current scientific studies related to factors altering the Earth's surface (Turner II & Meyer, 1998; Ariti, van Vliet, and Verburg, 2015) **[7,8]**; particularly when these processes are observed to influence the process of climate change (Zhao, et al. 2006) **[9].** These changes involve simple to complex mechanisms at geographical scales over a period of time.

Land use is the human use of the landscape and its alteration by numerous human activities. The concept begins locally but is gaining significance at the world level in numerous studies (Srivastava et al. 2012) **[10].** Land use as well changes in land cover are constantly taking place (Ramankutty & Foley, 1998) **[11]** but recently this is at an unprecedented rate due to human activities (Giri, 2016) **[12].** Studies related to land cover in various forms at the world level acquires is more so significant due to constant international works and the need of a reliable database (Mora, Tsendbazar, Herold, & Arino, 2014) **[13].** Studies on land use and land cover are not limited to a discipline but are rather complementary amongst different subjects.

Remote sensing and GIS are highlighted as unmatched in providing a study of land use, management, and analysis (Al-Fares 2013; Obi Reddy, Singh, Patil, & Chaturvedi, 2017) **[14,15]** and these studies are more developed in the current context than ever before (Warner, Nellis, & Foody, 2009) **[16].** This is feasible at a various geographical scales (Rogan & Chen, 2004) **[17].** In this context, land cover has a comparative advantage of being mapped through remote sensing and with a greater detail (Sohl & Sleeter, 2011) **[18].** However, a disadvantage in this regard is that short term or rapid alterations in land use do not provide a proper indication of land cover (Green, Kempka, & Lackey, 1994) **[19].** This is particularly observed in the case of mixed vegetation surfaces and heterogenous land uses (Herold et al., 2008) **[20].**Currently as well, majority of the land on the Earth is utilised for agriculture (Ritchie & Roser, 2019) **[21].** This holds true for Asia as a continent as well, which has been observing unprecedented changes in land. Besides, Southeast Asian regions is also experiencing deforestation at unprecedented rates.

The present study is a recent, one-time analysis of land cover as observed through the satellite data from ESA World Cover 10m 2020 land cover map through the Earth Engine Code Editor. Derived at 10m resolution for 2020, the ESA worldwide land cover mapping is defined as a new and baseline product for global land cover with unparalleled detail and unprecedented gathering of land cover information (Agency, 2022) **[22].** It aims to provide information related to 'bio diversity, food security, carbon assessment and climate modelling'. It uses data from Sentinel 1 and Sentinel 2 satellites and forwards an output of an unmatched resolution since through these satellites information can be generated even if cloud cover is there. This land cover map has 11 land cover classes and the output is generated as 3*3 degree tile as Cloud Optimised GeoTiffs with a minimum overall accuracy of 75%. All these points provide an edge to ESA over other land cover information databases. With these specialities of the data, the current study aims to observe the recent land cover record for the above mentioned South Asian countries which have distinct locations and other specific geographical characteristics. It holds significance in terms of its data source and analysis of updated and recent information which can provide a further base to subsequent such studies.

Study Area- The study area comprises of the South Asian countries of Bangladesh, Bhutan, Nepal, Myanmar and Sri Lanka. As is discussed above regarding their specific characteristics as countries, their location lends them a distinct geography as can be seen in Figure 1. While Bhutan and Nepal lie along the might Himalayan range in proximity to each other, Bangladesh is a largely plain landscape dominated country surrounded by the Bay of Bengal on one side. Mynamar has a mix of topography with the mighty Himalayan range reaching culmination in its extreme eastern part and a vast plain area in the middle and Bay of Bengal in its west. Both

countries share borders. Sri Lanka has a distinct location as it is surrounded by mighty water body of the Indian Ocean and the equator passing through the country.

Following specific characteristics can be observed for the study area:

a. Bangladesh- Sharing its international borders with India and Myanmar and the Bay of Bengal in the south, Bangladesh covers an area of approximately 147,630 sq. km. (Worlddata.info, 2022**) [23].** It is mainly a flat land with average elevation reaching just 85 m above sea level. About two-thirds of the eastern Ganga- Brahmaputra Plain lies in the country and the ridges of alluvial plain run north and south separating the border of Bangladesh from its neighbours (Tinker & Hussain, 2021) **[24].** The rivers of the country have played a major role in modifying its topography and numerous rivers and streams flow throughout the country. As of 2021, the estimated population of the country is 170,371,000. Agriculture is the main occupation, besides fishing and manufacturing and majority of the country is rural. Monsoonal climate, high humidity and warmer temperatures mark the country.

Figure 1. Location of Bangladesh, Bhutan, Myanmar, Nepal, and Sri Lanka
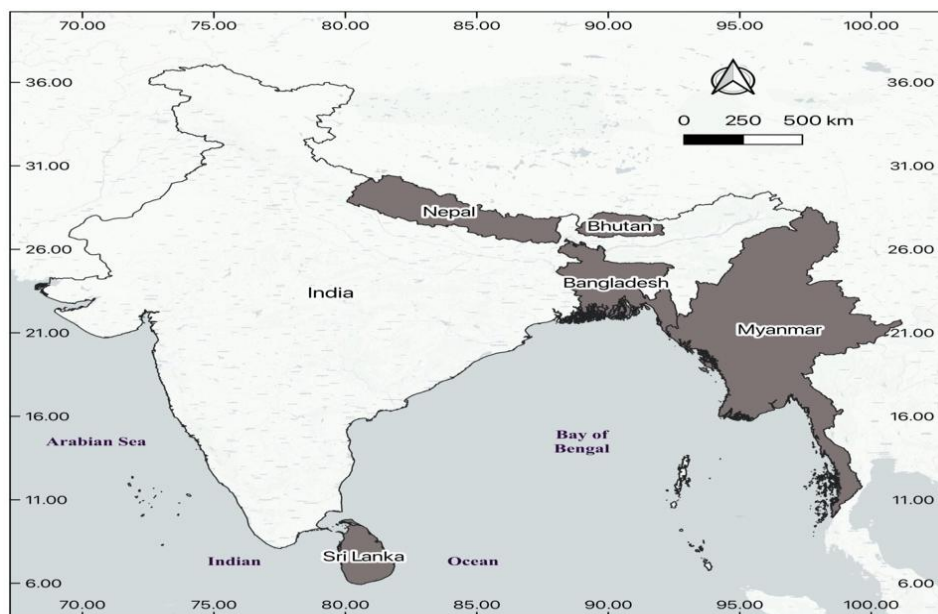
Source- Author, 2022

b. **Bhutan-** The landlocked country is located in the eastern Himalayas with the fertile valleys of the lesser Himalayas separated by continuous high and intricate ridges from north to south (Norbu, Karan, & Pradyumna, 2021) **[25].** It is surrounded by China in the north and India on all other three sides. Its northern part lies in the Great Himalayas, followed by Lesser Himalayas and narrow plains further south with numerous rivers and streams dissecting the landscape. A sparsely populated country, the main occupation is agriculture in limited parts of the country where conditions are favourable along with livestock rearing and mining activities. As of 2022, Bhutan's population is 7,85,717 people (Worldometer, 2022) **[26].** The climate is, mixed ranging from hot, humid and subtropical.

c. **Mynamar-** Observed as the northern most country of South east Asia, Myanmar is bounded by China in the north and north east, Laos in the east, Thailand in the south east, India in

the north west and Bangladesh in the west (Thwin, Aung, & Steinberg, 2021) **[27].** The Himalayan range extends from north to south in the western part of the country, followed by a central basin and the Shan Plateau in the further east with the Irrawaddy, Chindwin and Sittang rivers flowing through it. The Irrawady occupies the maximum drainage of the country. The population of the country as of 2022 is 55,0001,577. The climate is largely tropical and dependent upon elevation. A country of diverse ethnicity, agriculture is the main occupation along with forestry and fishing.

d. **Nepal-** Located along the mighty Himalayan range and bounded by Tibet in the north and India on all other sides, Nepal is a land locked country (Rose, Karan, Proud, & Zuberi, 2022) [28]. It has a rugged terrain and the topography ranges from mountains to plains from the north to south with numerous rivers. The climate ranges depends on the altitude and a large forest area exists. As of present, the population of the country is 29,986,474 persons. Agriculture is the main occupation along with tourism and manufacturing.

e. **Sri Lanka-** A densely populated country, the relief of Sri Lanka is occupied by a mountainous area in its south central region which is surrounded by a dissected plain. This mountains are rugged and very dissected. Besides, numerous rivers run across the country. The climate is tropical with immense amounts of rainfall due to location in the equatorial region. Natural vegetation of variety covers a large part of the country. Majority of the country is rural and agriculture and trade of agricultural goods are the main occupations (Peiris & Arasaratnam, 2022) [29].

Within this broad background, the following database and methodology have been attempted.

Database and Methodology- The current study requires the location of the countries, their administrative maps and the maps of respective land cover to draw interpretations and make comparisons. The administrative map has been depicted in Figure 1. The land use maps have been derived from Google Earth Engine Code Editor from the European Space Agency (ESA) World Cover 10 m 2020 database. This database provides the world cover map for 2020 at 10 m resolution and as mentioned earlier, is a recent, updated and unprecedented database on land cover mapping. It uses data from Sentinel 1 and Sentinel 2 satellites with a maximum accuracy of 81%. There are eleven land cover classes generated by the database. The information has been mapped for the study area and interpretive analysis has been attempted. It is a single time point study covering the South Asian countries which are predominantly agricultural. The eleven classes identified by the database are:

Trees, Shrubland, Grassland, Cropland, Built-up, Barren/ sparse vegetation, Snow and ice, Open water, Herbaceous wetland, Mangroves, and Moss and lichen. The information derived has been further analysed for area under each class of land cover. For this purpose, area under each class is corresponded with the pixel count and pixel resolution of individual land cover classes of the study area. All analysis has been performed in QGIS 3.16 software.

So, such a study would be insightful in observing what pattern land cover generates in these nations when agriculture is the dominant activity in the background of the existing landscape. A collective analysis such as this is not readily observed in literature. The limitation of the study is that the maps for land cover depict the yearly observation while during different seasons some variations can take place particularly in the vegetation category.

Results and Discussions- In the following figures (2.1.-2.5.), the land cover of respective countries is mapped. For Bangladesh, the land cover is in direct consonance with the topography. Cropland dominates the country which is clearly indicative of favourable topography for this activity. Besides, the presence of numerous water sources make this more feasible. Mangroves of the Sunderban delta can be observed as occupying the southern part of the country. Besides, dense built- up is observed along the capital city of Dhaka. Besides, other smaller areas of built-up can be seen as scattered in the country. A dominant land cover in the form of trees is covering the landscape in the eastern most part of the country where it shares its border with Mynamar. Natural vegetation is also scattered in other parts of the country as well.

Figure 2. Observations on Land Cover in the Study Area (Map not to scale)

Figure 2.1. Land Cover- Bangladesh
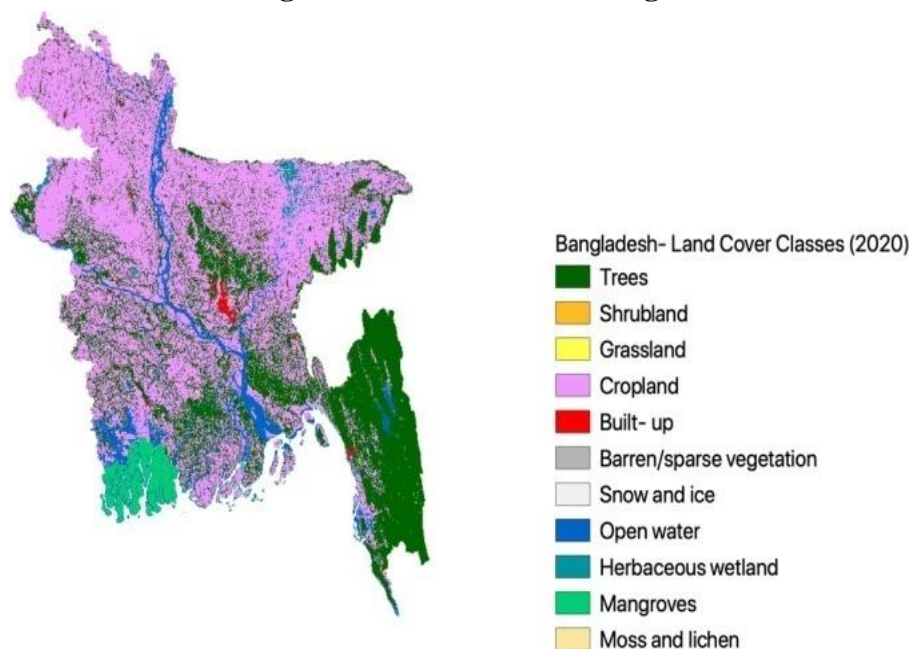
For Bhutan, the land cover is highly dominated by natural vegetation and in the higher altitudes as discussed above, grassland dominates. In the further higher altitudes, snow and ice category is visible as a land cover. Myanmar's land cover indicates a dominance of natural vegetation, particularly in the physiographic region of the mountains as discussed. The Central Basin is depicting cropland area in dominance, running from north to south and central region of the country. Some cropland is also observed in the western part of the country and in the intermittent regions of the natural vegetation. Open water and herbaceous wetland are also a significant land cover. Grassland is also an important land cover category in the west central and east central part of the country.
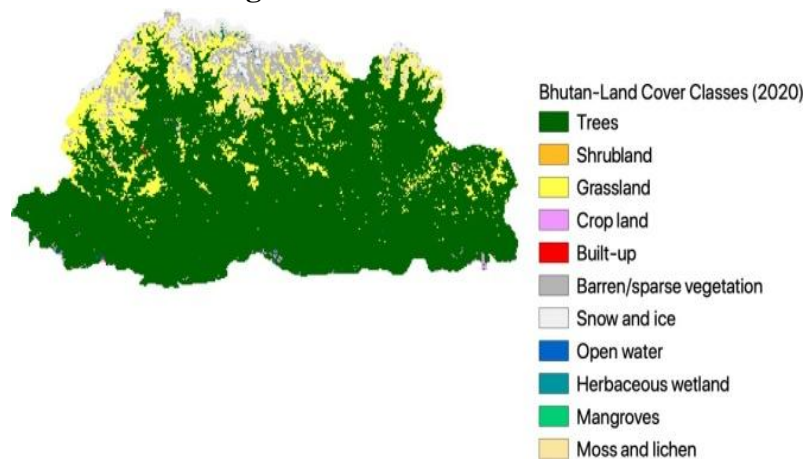
Figure 2.2. Land Cover- Bhutan

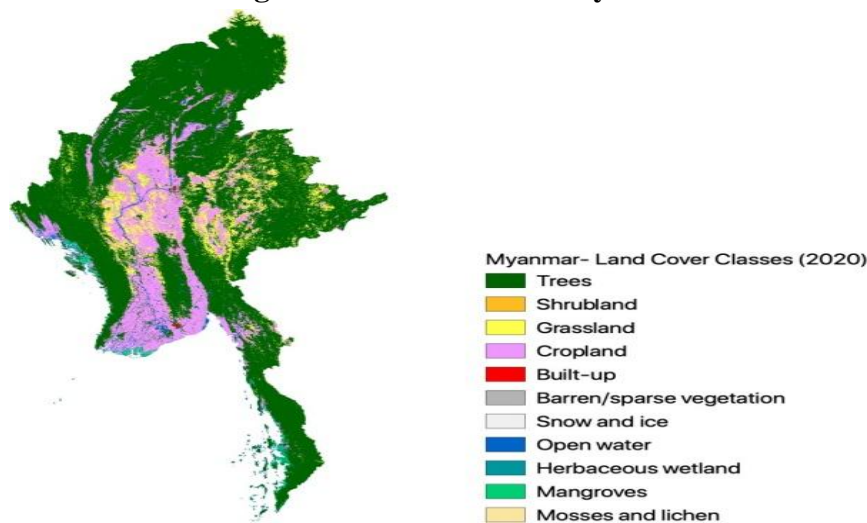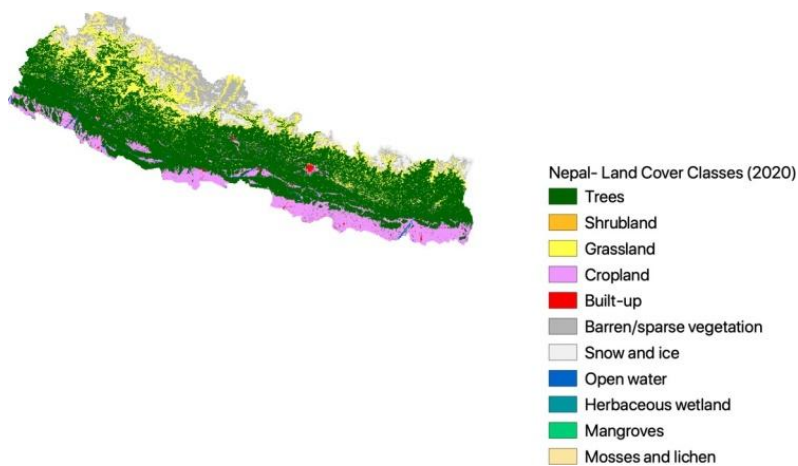**Figure 2.3. Land Cover- Myanmar**

Figure 2.4. Land Cover- Nepal

In Nepal, land cover can be observed as directly following the topography. It is parallel to the mountain ranges. The lofty Himalayan mountains provide a rugged topography and are followed by the Middle Himalayan Range of the Mahabharat Hills and then the low lying marshy Terai region. The rugged range in its higher elevation is marked by Snow and Ice Cover in its higher altitudes and is also covered with Grassland region particularly in the west due to climatic conditions. It is followed by a broad belt of Trees which cover the country from east to west; showing maximum coverage of land cover. A clearly visible built-up area is observed along the capital of Kathmandu and in the Terai belt. The southernmost belt marks the Terai and is covered with cropland.

Figure 2.5. Land Cover- Sri Lanka
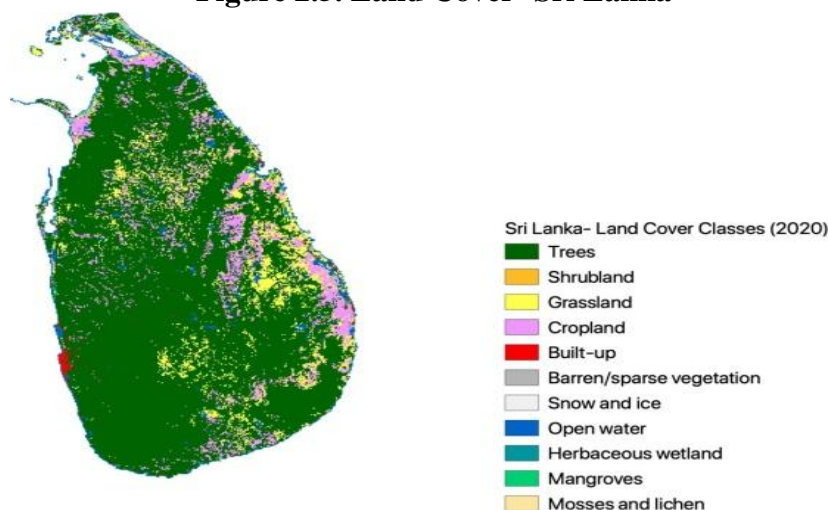
Source- Author, 2022

Sri Lanka has a distinctly tree cover in majority of its land. It is interspersed with grassland, open water and built up area. Grassland cover is observed wherever the tree cover ends to the plain region. Open water is clearly visible across the landscape. The built up area in the western part is the capital of the country- Colombo. In the northern most tip, a variety of land cover is visible in the small region.

Thus, it can be concluded that the land cover classes in all these countries follow the geography. This information is further detailed land cover class wise in Table 1. to find the actual area under each land cover for respective countries.

TABLE 1. AREA UNDER LAND COVER CLASS

Land Cover Class/Country	Bhutan	Bangladesh	Myanmar	Nepal	Sri Lanka
	Land cover area in each class (Sq.mt.)				
1. Trees	3303200	5239200	49491300	9535900	5198500
2. Shrubland	-	700	229200	2800	6300
3. Grassland	545000	20500	6307500	2240600	600000
4. Cropland	14100	8548100	13756400	2074200	635600
5. Built-up	1400	100100	159600	57100	28100
6.Barren/sparse	188700	114800	630600	1532900	67900

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vegetation					
7. Snow and ice	119600	-	19800	784100	-
8. Open water	9900	1113900	1563100	82600	273000
9. Herbaceous wetland	-	148400	35000	200	13000
10. Mangroves	-	469100	700400	-	19700
11. Mosses and lichen	144000	-	154300	670500	-

Source- Derived by Author from ESA World Cover 10m 2020, (2022) through QGIS 3.16 software

The distributional share of land cover in the study area can be observed from the above table and Table 2. below

TABLE 2. PERCENTAGE OF AREA UNDER LAND COVER

Land Cover Class/Country	Bhutan	Bangladesh	Myanmar	Nepal	Sri Lanka
	Land cover area in each class (%)				
1. Trees	76.35	33.25	67.75	56.15	75.97
2. Shrub land	-	0.00	0.31	0.01	0.09
3. Grassland	12.59	0.13	8.63	13.19	8.76
4. Cropland	0.32	54.25	18.83	12.21	9.28
5. Built-up	0.03	0.63	0.21	0.33	0.41
6.Barren/sparse vegetation	4.36	0.72	0.86	9.02	0.99
7. Snow and ice	2.76	-	0.02	4.61	-
8. Open water	0.22	7.07	2.13	0.48	3.99
9. Herbaceous wetland	-	0.94	0.04	0	0.19
10. Mangroves	-	2.97	0.95	-	0.28
11. Mosses and lichen	3.32	-	0.21	3.94	-

Source- Derived by Author from Table 1.

It can be observed that the land cover classes calculated correspond to the visual interpretation. For the study area, with the exception of the South Asian nation of Bangladesh, all other countries exhibit a dominance of trees as the land cover class. It is only in Bangladesh that the cropland occupies the maximum share of land cover. Sri Lanka has the highest share of trees as the land cover class. This can also include the plantation agriculture. It can be concluded that trees and cropland emerge as the dominant land cover in the South Asian countries observed for the study.

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