Appendix C: India Indicators Testing Report

Report of the NCAVES Project

United Nations

System of Environmental Economic Accounting

Report on SEEA & SDGs

-by Monica Sharma

Contents

SEEA & SDGs

I. Introduction

The Sustainable Development Goals (SDGs) were born at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012[1]. The objective was to produce a set of universal goals that meet the urgent environmental, political and economic challenges threatening the world. SDGs also known as Global goals with an aim to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. In September 2015[2], the General Assembly adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs) (**Figure 1**). Building on the principle of "leaving no one behind", the new Agenda emphasizes an all-inclusive approach to achieving sustainable development for all.

Figure 1: Sustainable Development Goals

Source: United Nations Sustainable Development Goals Knowledge Platform

These 17 SDGs spans across 169 targets and 247 global indicators[3] (and 231 unique indicators) which indicate both the scale and ambition of SDGs. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental. These indicators help to access the condition of

[1] https://www.undp.org/content/undp/en/home/sustainable-development-goals/background/
[2] https://www.un.org/development/desa/disabilities/envision2030.html
[3] https://unstats.un.org/sdgs/indicators/indicators-list/

different aspects of the economy including the social, economic and environmental impacts.

II. Linkage between System of Environmental-Economic Accounting (SEEA) and Sustainable Development Goals (SDGs)

System of Environmental-Economic Accounting (SEEA)[4] is a framework that integrates economic and environmental data to provide a more comprehensive and multipurpose view of the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity. By providing internationally agreed concepts and definitions on environmental-economic accounting, SEEA proves to be an instrumental tool for compiling cohesive statistics, deriving coherent and comparable indicators and assessing progress towards sustainable development goals. Because of the strength of the underpinning accounting structure, particularly in terms of defining relationships between indicators and in providing a strong data compilation and confrontation framework, the SEEA Framework represents an important information base from which indicators can be chosen for use in populating different sets of indicators. SEEA supports the progress on range of global initiatives like Agenda 2030, post-2020 biodiversity agenda, and international climate policy.

Ecosystem accounts formed under the ambit of SEEA framework, whether it is extent account, condition account or ecosystem services account; provide an underpinning connection between the former and the Sustainable Development Goals. Amongst them, ecosystem extent account is an essential determinant for several SDG indicators, as it is comparatively easy to assess and provides a good indicator for broader sustainable development concerns. For example[5], extent of freshwater ecosystems is a good proxy for water provisioning services. Forest extent is a good proxy for conservation of forest biodiversity and the delivery of forest ecosystem services.

SDG indicators were reviewed and expert judgment was used to identify any indicators that could in part (e.g., ratio indicators) or completely, be generated by the SEEA framework (e.g., SDG Indicator 15.1.1 Forest area as a proportion of total land area), or that could provide input data to the SEEA framework (e.g., SDG Indicator 14.3.1 on marine acidity for ecosystem condition accounting). Each indicator was assigned a 'Full', 'Partial', or 'None'[6] possibility for alignment with the selected SEEA accounting modules where:

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[4] https://seea.un.org/

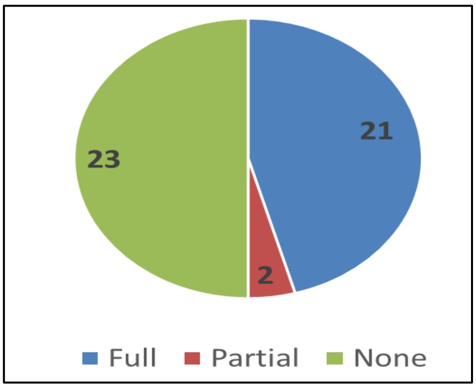
[5] Short notes on Testing Selected SDG Indicators Using SEEA EEA, UN, 2020 can be accessed at: https://seea.un.org/sites/seea.un.org/files/readme_first_-_testing_sdg_indicatorsv_8may2020.pdf

[6] Assessing the linkages between global indicator initiatives, SEEA Modules and the SDG Targets, Working Document (Version: 4th July, 2019) can be accessed at: https://seea.un.org/sites/seea.un.org/files/seea_global_indicator_review_methodological_note_post_workshop_0.pdf

- *Full:*
    - Where the SEEA has obvious potential to provide all, or most, of the information required to calculate the indicator or when the indicator clearly represents an input data for an accounting item of interest (e.g., an indicator of condition that could be directly integrated into an ecosystem condition account). This represents a conceptual alignment based on the structure of the SEEA framework.
- *Partial*:
    - Where the SEEA could organise some of the information for calculating the indicator but:
        1. there were more efficient /accepted means already in place;
        2. the indicator was derived from a statistical procedure to deal with missing data gaps (e.g., Living Planet Index); or,
        3. the SEEA provides information that is essential or highly suited for calculating the indicator, but substantial additional information from non-SEEA sources is also required.
- *None:*
    - where the identified accounts were not considered relevant to the issue the indicator is designed to inform on.

Out of the 46 SDG Indicator that were reviewed, 21 indicators are fully aligned with SEEA in comparison to 2 indicators which are partially aligned (**Figure 2**).

Figure 2: SEEA to SDG Indicators Matches



Source: Working Document: Assessing the linkages between global indicator initiatives, SEEA Modules and the SDG Targets.

Apart from the alignment of SDG indicators to SEEA framework, there are numerous advantages[7] in using the SEEA for calculating SDG target indicators, as well as other global and national indicators. The framework provides consistent use of definitions and concepts although its flexible and adapts easily to different contexts. Also, it

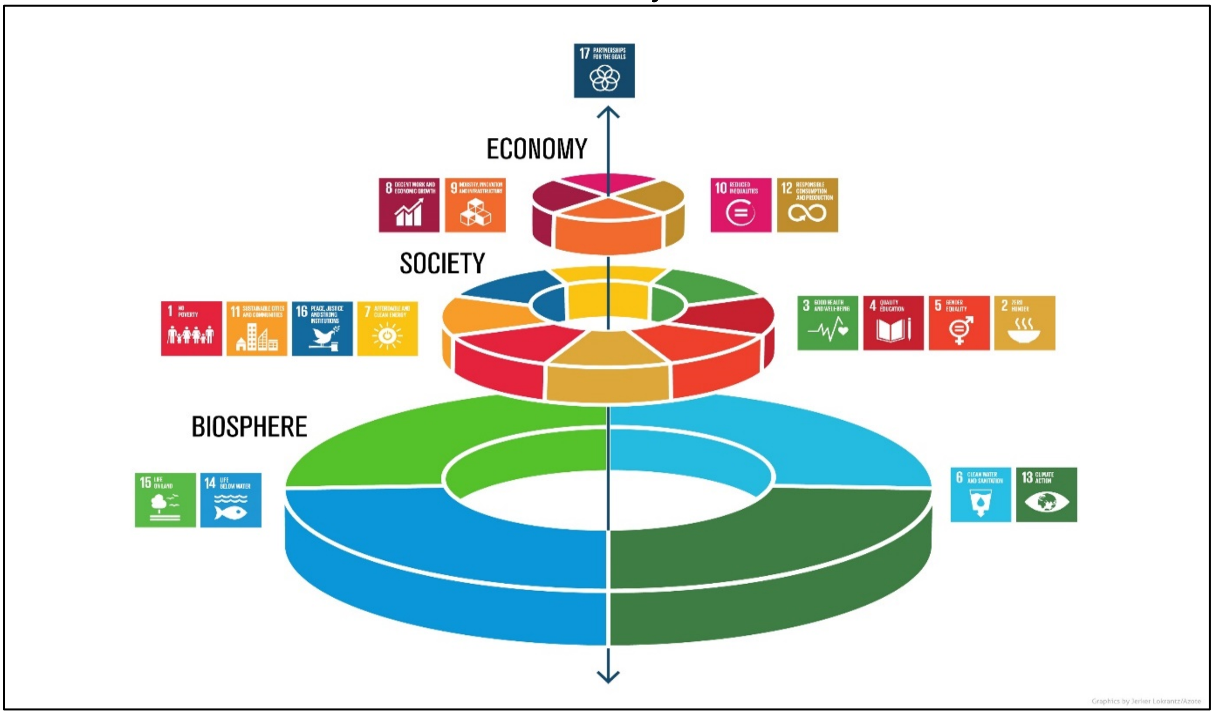
[7] Using the SEEA EEA for Calculating Selected SDG Indicators, Working Document (Draft Version: 31 October 2019), UN, 2019

acknowledges harmonization of environmental data from multiple sources and brings coherence and consistency across disparate statistics. It also establishes a centralized system for organizing information on the environment and the economy, thereby decreasing the likelihoods for repetition of data collecting activities across different government agencies and can help streamline reporting across multiple national reporting commitments. It also ensures that it initiates the discussions across different agencies and sectors and facilitates the trade-offs and synergies related to environmental management decisions to be more readily revealed.

According to Banerjee (2016)[8], SEEA EEA opens pathways to implement a range of integrated economic–environmental modelling approaches. The former is implied as SEEA EEA is grounded in the set of concepts and classifications that is coherent to System of National Accounts (SNA) and that can be aligned with the social statistics routinely compiled by national statistical offices. Also, it provides a mechanism to mainstream environmental information into economic and national development planning and is compatible with the Balance of Payments and International Investment Position framework, the International Standard Industrial Classification of All Economic Activities, the Central Product Classification system, and the Framework for the Development of Environment Statistics. The broad consistency that the SEEA brings to organizing environmental information is crucial for delivering a planning approach that considers all the social, economic and environmental dimensions to sustainable development in an integrated way (**Figure 3**).

[8] Banerjee, O., Cicowiez, M., Horridge, M., & Vargas, R. (2016). A Conceptual Framework for Integrated Economic–Environmental Modeling. Journal of Environment & Development, 25(3), 276–305.

Figure 3: Integration of the 17 SDGs across environment (biosphere), society and economy



Source: Stockholm Resilience Centre[9]

In other words, SEEA ensures that indicators are:

- *Consistent* - Internally and with supporting accounts and basic statistics
- *Coherent* – Allowing integration of environmental data with other statistics
- *Comprehensive* – Allowing a comprehensive assessment of environmental assets

All the above importance highlights the linkage existing between the SEEA and SDGs at different levels. Thus, use of SEEA framework in calculating/measuring the different SDG indicators is crucial.

III. Selection of indicators

As discussed above, several indicators are dependent upon the ecosystem account whether being ecosystem extent or condition or services account or thematic accounts. For most countries it is expected that ecosystem extent accounts will be a priority account, given its relevance to measure several SDG target indicators. Some of the SDG indicators have been identified for testing their calculation using the SEEA. These indicators draw complete (or substantial) information from the SEEA EEA ecosystem extent accounts, given their relevance. They comprise of the following indicators:

- *SDG Indicator 15.1.1* – Forest area as a proportion of total land area.
- *SDG Indicator 6.6.1* – Change in the extent of water-related ecosystems over time.

[9] https://www.stockholmresilience.org/research/research-news/2016-06-14-how-food-connects-all-the-sdgs.html

• *SDG Indicator 11.7.1* – Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.
• *SDG Indicator 15.3.1* - Proportion of land that is degraded over total land area.
• *SDG Indicator 11.3.1* - Ratio of land consumption rate to population growth rate.
Some of which are described in detail in the following sections.

IV. SDG Indicator 15.1.1: *Forest area as a percentage of total land area*

This indicator measures the proportion of the world's land area that is forested and is expressed as a percentage. Changes in forest area reflect changes in demand for land for other uses and may help in identifying unsustainable practices in the forest and agriculture sectors. The indicator will measure progress towards SDG Target 15.1. SDG 15.1.1 is a Tier I[10] SDG indicator, meaning it is conceptually clear, has an established methodology and standards are available, and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.

As per the SDG 15.1.1 Metadata Sheet[11] (UNSD, 2018b), for which the FAO is custodian, as outlined by the FAO (UNSD, 2018b), Forest is defined as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use". Total land area is the total surface area of a country less the area covered by inland waters, like major rivers and lakes. The indicator is expressed as percent and can be calculated using the following equation:

$$SDG\ 15.1.1 = \frac{\text{Forest area (reference year)}}{\text{Land area}} * 100$$

IV.1. SEEA Account for Forest Extent

SEEA EEA Accounts for forest extent that can support the generation of SDG 15.1.1 and can be used to combine information on forest extent into wider economic planning processes. It requires area within the country to be delineated into mutually exclusive and collectively exhaustive spatial units. Ecosystem extent accounting provides the basis, the composition of and the changes in, ecosystem types within the country and providing the time variant changes in the extent reveals the degree of change in the ecosystems. They are combined by ecosystem type within an ecosystem accounting area (EAA). IUCN Global Ecology Typology[12] (classification to distinguish between ecologically important land, water, and bioclimatic niches. It comprises of a nested hierarchy of units at each level, more detailed classified niches

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[10] https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/
[11] https://unstats.un.org/sdgs/metadata/files/Metadata-15-01-01.pdf
[12] https://iucnrle.org/static/media/uploads/references/research-development/keith_etal_iucnglobalecosystemtypology_v1.01.pdf

nested within broader units at higher levels) can be used as a globally consistent typology for ecosystem extent accounting using the SEEA EEA. Also, we can use a national classification instead of the IUCN GET for ecosystem extent accounting. Although, the former can be aggregated across countries to inform regional and global trends and consistent comparisons across countries whereas the latter provides a finer and more tailored representation of ecosystem assets in the landscape. If we use the latter, it is also important that the national typology should be crosswalked to the IUCN ETs for consistent international comparisons and aggregations.

In order to calculate SDG 15.1.1 using an ecosystem extent (**Table 1**) account it is necessary to identify the ecosystem types that are consistent with the FAO definition of forests. In contrast, in India, the term 'Forest Cover' refers to "All lands, more than one hectare in area, with a tree canopy density of more than 10% irrespective of ownership and legal status. Such lands may not necessarily be recorded forest area. It also includes orchards, bamboo and palm" (FSI, 2019)[13]. It is assessed through remote sensing. In addition, the term 'Recorded Forest Area' or 'Forest Area' refers to all the geographical areas recorded as 'Forests' in government records. Once the relevant ecosystem types for forest have been identified within the ecosystem extent account, the total forest extent can be readily calculated for the opening or closing year of the account.

Table 1: Ecosystem Extent Account Structure

	Ecosystem Types (ET)				Total Forest Area
	ET1	ET2	…	ETn	
Opening Stock (ha)					
Additions to stock					
Managed expansion					
Natural expansion					
Upward reappraisals					
Other additions					
Total additions to stock					
Reductions in stock					
Managed regression					
Natural Regression					
Downward reappraisals					
Other reductions					
Total reductions in stock					
Net change in stock					
Closing stock (ha)					

where ET are ecosystem types relevant to forest area of SDG Indicator 15.1.1

[13] India State of Forest Report (ISFR), 2019, Forest Survey of India (FSI)

As far as Total land area is concerned, the information under the ecosystem extent account on the extent of all different ecosystem types within an EEA, is aggregated across columns representing the measure that matches the total extent of the EEA. When the EEA is national, it will include all water bodies and the extent of a countries maritime area (i.e., its exclusive economic zone), which contradicts with the definition discussed above as per FAO. So, necessary precautions need to be taken while calculating the indicator 15.1.1 using the previously mentioned equation. These information in the Indian context can be obtained from Forest Survey of India. As seen from the above, SDG indicator 15.1.1 aligns with the SEEA extent account.

IV.2. Calculating SDG Indicator 15.1.1

Though this indicator has been compiled using the data from Ministry of Environment Forest and Climate Change at a periodicity of 2 years. But as mentioned in the previous section that SDG indicator 15.1.1 aligns with the SEEA extent account and can be calculated using the SEEA. Here, we have tried to calculate the same using data from India State of Forest Report (ISFR) by Forest Survey of India (FSI). The areas identified as forests are recorded in ISFR which we have used for calculation of SDG indicator 15.1.1. The indicator is expressed as percent and is calculated using the following equation using the extent account (given in **Table 2** and **Table 3**):

$$SDG\ 15.1.1 = \frac{\text{Forest area (reference year)}}{\text{Geographical area of the country}} * 100$$

Table 2: Forest Cover classified by canopy density classes

Forest Classes[14]	Area (sq. km)				
	Assessment Period (2008-09)	Assessment Period (2010-11)	Assessment Period (2013-14)	Assessment Period (2015-16)	Assessment Period (2017-18)
	ISFR 2011	ISFR 2013	ISFR 2015	ISFR 2017	ISFR 2019
Very Dense Forest	83,471	83,502	85,904	98,158	99,278
Moderately Dense Forest	3,20,736	3,18,745	3,15,374	3,08,318	3,08,472
Open Forest	2,87,820	2,95,651	3,00,395	3,01,797	3,04,499
Total	**6,92,027**	**6,97,898**	**7,01,673**	**7,08,273**	**7,12,249**
Scrub	42,176	41,383	41,362	45,979	46,297
Non-Forest	25,53,060	25,47,982	25,44,228	25,33,217	25,28,923

[14] Details of forest classes given in **Annexure I**

Forest Classes[14]	Area (sq. km)				
	Assessment Period (2008-09)	Assessment Period (2010-11)	Assessment Period (2013-14)	Assessment Period (2015-16)	Assessment Period (2017-18)
	ISFR 2011	ISFR 2013	ISFR 2015	ISFR 2017	ISFR 2019
Total Geographic Area	32,87,263	32,87,263	32,87,263	32,87,469	32,87,469
SDG 15.1.1	*21.05*	*21.23*	*21.35*	*21.54*	*21.67*

Table 3: Calculating SDG 15.1.1

	Very Dense Forest	Moderately Dense Forest	Open Forest	Total	Scrub	Non-Forest	Total Geographic Area	SDG 15.1.1
Opening Stock (2008-09, sq. km)	83,471	3,20,736	2,87,820	6,92,027	42,176	25,53,060	32,87,263	*21.05*
Net Change in the stock	15,807	-12,264	16,679	20,222	4,121	-24,137	206	
Closing stock (2017-18, sq. km)	99,278	3,08,472	3,04,499	7,12,249	46,297	25,28,923	32,87,469	*21.67*

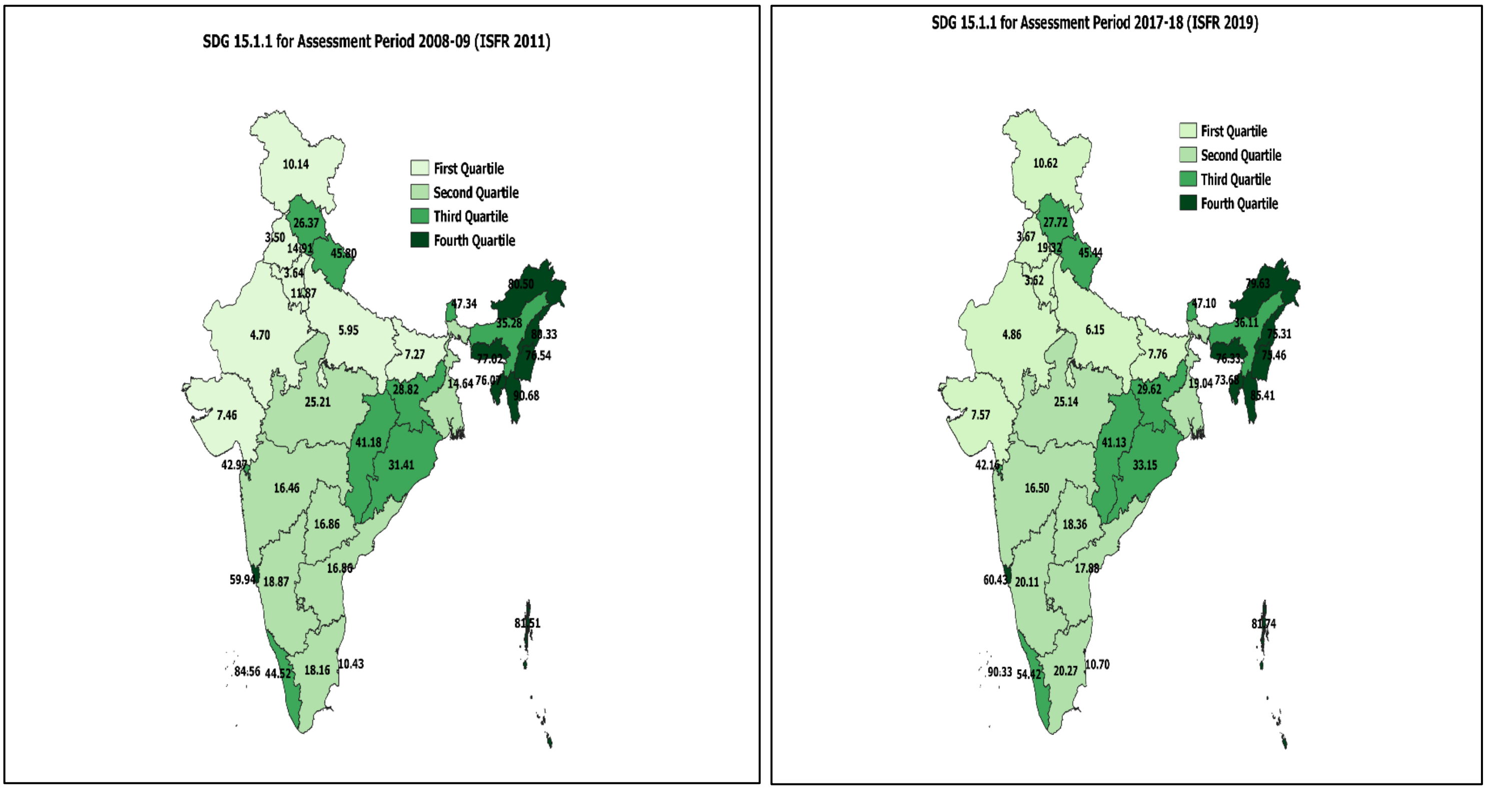
* Green Indicates data relevant to forest area of SDG indicator 15.1.1.
^ Orange indicated the type that do not contribute to SDG 15.1.1

$$SDG\ 15.1.1 = \frac{83471 + 320736 + 287820}{3287263} * 100 = \frac{692027}{3287263} * 100$$
$$= 21.05\% \ (for\ 2008 - 09)$$

Table 2 provides the SDG indicator for 15.1.1 from 2008-09 to 2017-18 biennially as FSI presents forest resource assessment at national level, biennially by publishing India State of Forest Report (ISFR). And **Table 3** tries to represent the data in the form similar to extent account to depict the alignment of SEEA extent account with the SDG indicator 15.1.1. The value of indicator has increased from 21.05% in 2008-09 to 21.67% in 2017-18 depicting increase in forest cover in India.

Annexure II show the state-wise SDG indicator 15.1.1 for 2008-09 and 2017-18, maps for the same are presented in below in **figure 4.**

Figure 4: State-wise SDG 15.1.1 for Assessment period 2008-09 and 2017-18



IV.3. Importance of SDG Indicator 15.1.1

Forest are critical for not just the survival of the humans, but for the survival of the planet. The services provided by forests cover a wide spectrum of ecological, economic, social and cultural considerations and processes providing a multitude of benefits at local, national and global levels which includes goods such as timber, food, fuel and bio-products; also play an important role in the ecosystem services such as carbon sequestration, habitat for biodiversity; further, they regulate the climate, hydrological and nutrient cycle, water flow regulation, water and air purification/ filtration, maintain soil quality, recreation and spirituality, affect health through disease regulation and provide jobs and local employment. Forest ecosystems conserve soil and stabilize the flows and runoff which in turn prevents land degradation and desertification, and diminishes the risks of natural disasters such as droughts, floods, and landslides, thus, it helps in maintaining and upgrading the environmental quality which is much beyond quantification. Therefore, highlighting the importance of forest, thus, knowing about the forest area (as a proportion of total land area) is an important indicator for sustainable forest management. Realizing the changes in the forest resources will help the policy makers to make informed policy and management actions and also help guide public and private investments. One of such policy is 'Green India Mission (GIM)'[15] with an objective of increased forest/tree cover on 5 m ha of forest/non-forest lands and improved quality of forest cover on

[15] http://naeb.nic.in/documents/GIM_Brochure_26March.pdf

another 5 m ha (a total of 10 m ha). It also aims to improve eco-system services like carbon sequestration, hydrological services and biodiversity and provisioning services like fuel, fodder, and timber and non-timber forest produces. It also has to increase forest-based livelihood income for about three million households. The indicator also can be used as a proxy for the extent to which forests are being conserved or restored and may help in identifying unsustainable practices in the forest. And this can be achieved through the strengths of SEEA extent account which helps us to get an estimate of the same.

V. SDG Indicator 6.6.1 – *Change in the extent of water-related ecosystems over time.*

SDG Target 6.6 "By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes." focuses on the protection and restoration of water-related ecosystems in order to secure the delivery of essential ecosystem services. SDG Target Indicator 6.6.1, 'Change in the extent of water-related ecosystems over time', is aimed to inform on the trends in ecosystem assets that directly provide these services focusing exclusively on waterbodies/wetlands. UN Environment and the Ramsar International Convention on Wetlands (hereafter, Ramsar) are co-custodians for SDG Indicator 6.6.1. UN Environment maintain the metadata information for SDG 6.6.1a[16], which relates to measurement of changes in the extent of: vegetated wetlands; rivers and estuaries; lakes; and artificial waterbodies. It comprises of two levels. Level 1 comprises of Sub-indicator 1 – spatial extent of water-related ecosystems (excluding aquifers) which is classified as a Tier I SDG indicator, meaning it is conceptually clear, has an internationally established and available methodology and standards and data are regularly produced for at least 50 per cent of countries and of the population in every region where the indicator is relevant. Level 1, Sub-indicator 2 – water quality of lakes and artificial water bodies adds a condition component to the measurement of the spatial extent of water-related ecosystems. In Level 2, a further 3 sub-indicators are proposed (discharge in rivers and estuaries; water quality indicators from SDG Target Indicator 6.3.2; and groundwater quantity in aquifers). Ramsar maintain the metadata for SDG 6.6.1b[17] focusing on wetlands specifically, the internationally agreed Ramsar typology of wetlands is broad and includes all freshwater, saline, brackish, alkaline, and subterranean waters. These are aggregated and changes in extent are reported on under the following categories: marine/coastal; inland; and human-made.

Extent for SDG 6.6.1 is expanded beyond spatial extent to also include the quality, and the quantity of water-related ecosystems. This approach aligns well with the measurement of the 'stocks' of ecosystem assets in the SEEA-EEA, in terms of their extent and condition and Change is the shift from one condition of extent to another

[16] https://unstats.un.org/sdgs/metadata/files/Metadata-06-06-01a.pdf
[17] https://unstats.un.org/sdgs/metadata/files/Metadata-06-06-01b.pdf

over time, within a water-related ecosystem, measured against a point of reference. This is calculated as the sum of changes in the spatial extent of each water-related ecosystem type i (i=1 to n) over a period t_0 to t_1, divided by the total spatial extent of all wetland ecosystem types i (i=1 to n) at the start of that period (i.e., at t_0). This is set out in equation[7] below, where the result is multiplied by 100 to express the change as a percentage:

$$SDG\ 6.6.1 = \left(\frac{\sum_{i=1}^{n}(Spatial\ Extent_{it0} - Spatial\ Extent_{it1})}{\sum_{i=1}^{n} Spatial\ Extent_{it0}}\right) * 100$$

V.1. SEEA Account for Water-Related Ecosystems

The extent of water-related ecosystem extent account it is a priority account for calculating SDG Target Indicator 6.6.1. In order to calculate SDG 6.6.1 using an ecosystem extent (**Table 4**) account it is necessary to identify the ecosystem types that are consistent with the definition of water related ecosystems. Also, to calculate SDG Target Indicator 6.6.1, the aggregate extent of ecosystem types meeting the definition of water-related ecosystem types should be calculated for the open and closing periods and the change calculated and recorded in the 'total area of water-related ecosystems' column.

Table 4: Ecosystem Extent Account Structure

	Ecosystem Types (ET)				Total Area of Water related ecosystems
	ET1	ET2	…	ETn	
Opening Stock (ha)					
Additions to stock					
Managed expansion					
Natural expansion					
Upward reappraisals					
Other additions					
Total additions to stock					
Reductions in stock					
Managed regression					
Natural Regression					
Downward reappraisals					
Other reductions					
Total reductions in stock					
Net change in stock					
Closing stock (ha)					

where ET are ecosystem types relevant to water-related ecosystems and SDG Indicator 6.6.1

As described above, ecosystems considered as 'water-related ecosystems' are identified. Once all the number (n) of relevant ecosystem types for water-related ecosystems have been identified the net change in extent of each type (i), as shown in the ecosystem extent account (Table 4) over the accounting period should be determined. This is equivalent to $Spatial\ Extent_{it0} - Spatial\ Extent_{it1}$. These net changes should be summed to calculate the numerator. The extent of each type (i) for the opening period (t_0) should then be summed to calculate the denominator and hence indicator 6.6.1.

As part of a progressive monitoring approach to SDG 6.6.1, UN Environment propose a complementary indicator for the water quality of lakes and artificial waterbody ecosystems. SEEA EEA Ecosystem Condition Accounts provide a useful framework for organizing information on the quality of water-related ecosystems. Data on water quality parameters for these specific ecosystem types can be organized within the Ecosystem Condition Account **(Table 5)**. Aquifers are not considered as they are considered out of scope of the SEEA EEA (at least in current applications), they are still relevant to SDG 6.6.1. The accounts set out in the SEEA Water subsystem, would allow for organising information aquifers that could contribute to this more progressive reporting on SDG 6.6.1.

Table 5: Ecosystem Condition Account for Lakes and artificial water bodies

UNEP 6.6.1 Classifications >>		Lakes	Artificial
Suspended matter (TSS)*	Opening condition		
	Closing condition		
Chlorophyll A*	Opening condition		
	Closing condition		
pH^	Opening condition		
	Closing condition		
Nutrient concentrations (N)^	Opening condition		
	Closing condition		
Nutrient concentrations (P)^	Opening condition		
	Closing condition		
Dissolved oxygen^	Opening condition		
	Closing condition		
Electrical Conductivity^	Opening condition		

UNEP 6.6.1 Classifications >>		Lakes	Artificial
	Closing condition		
Temperature	Opening condition		
	Closing condition		
Ammonia	Opening condition		
	Closing condition		
Dissolved organic carbon (DOC)	Opening condition		
	Closing condition		
Salinity	Opening condition		
	Closing condition		
Biological Oxygen Demand (BOD)	Opening condition		
	Closing condition		
Bacterial coliforms	Opening condition		
	Closing condition		
Water-related species populations richness / abundance	Opening condition		
	Closing condition		
Alien invasive species abundance	Opening condition		
	Closing condition		
Endemic species abundance	Opening condition		
	Closing condition		

Note: *Identified as water quality indicators for sub-indicator 2 of SDG 6.6.1.
^ Identified as water quality indicators for sub-indicator 4 of SDG 6.6.1.

V.2. Calculating SDG Indicator 6.6.1

In India, land-use and land-cover (LULC) statistics are maintained by National Remote Sensing Centre (NRSC), Department of Space (DOS) through a component on National Land Use/ Land Cover (LULC) mapping of the Natural Resources Census (NRC) Project of National Natural Resources Repository (NRR) Program. Based on the change matrices by NRSC, the account for wetland has been provided in **Table 6.** State-wise details are given in **Annexure III** and **Figure 5.**

Table 6: Account for Wetlands/ Water bodies in India (Area in sq. km)

L1	L2	Opening Stock (2011-12)	Addition to Stock	Reduction in Stock	Closing Stock (2015-16)
Wetlands/ Water bodies[18]	Inland Wetland	8,175	458	1,027	7,606
	Coastal Wetland	10,719	189	121	10,787
	River/Stream/ Canals	61,032	2,130	2,333	60,829
	Water bodies	58,367	1,478	1,293	58,552
	Total	1,38,294	4,254	4,775	1,37,774

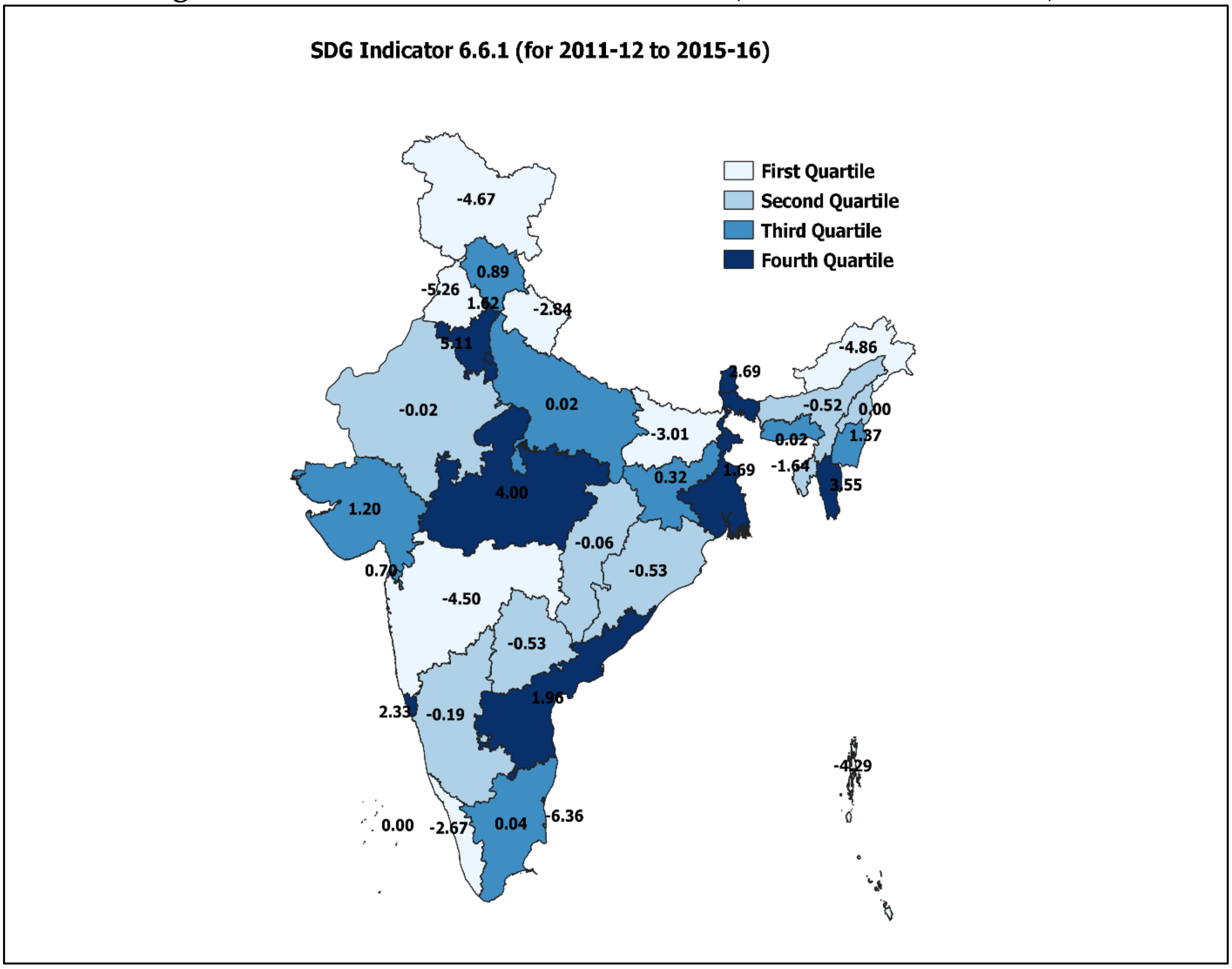
$$SDG\ 6.6.1 = \left(\frac{137774 - 138294}{138294}\right) * 100$$

SDG 6.6.1= -0.38% (for 2011-12 to 2015-16)

[18] **WETLAND / WATER BODIES:** All submerged or water-saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or dynamic, vegetated or non-vegetated, which necessarily have a land-water interface, are defined as wetlands. It consists of:

1. Inland Wetlands: These are the areas that include ox-bow lakes, cut-off meanders, playas, marsh, etc. which are seasonal as well as permanent in nature. It also includes manmade wetlands like waterlogged areas (seasonal and perennial).
2. Coastal Wetland: These include estuaries, lagoons, creek, backwater, bay, tidal flat/mud flat, sand/beach, rocky coast, mangrove, salt marsh/marsh vegetation and other hydrophytic vegetation and saltpans.
3. River /Stream / Canals: Rivers/streams are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or in to a lake or an inland basin in desert areas or a marsh or another river. Canals are artificial water course constructed for irrigation, navigation or to drain out excess water from agricultural lands.
4. Water Bodies: This category comprises areas with surface water in the form of ponds, lakes, tanks and reservoirs.

Figure 5: State-wise SDG Indicator 6.6.1 (for 2011-12 to 2015-16)



Wetlands are vital for our water and food security. As "kidneys of landscape", wetlands receive flows of water and waste from upstream sources. They help stabilize water supplies, cleanse polluted waters, protect shorelines, and recharge groundwater aquifers. The Convention on Wetlands, called the **Ramsar Convention**, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Convention was adopted in 1971 at the Iranian City of Ramsar. Contracting Parties to the Convention commit to designating wetlands into the List of Wetlands of International Importance, and wise use of all wetlands in their territory. India became a party to the Convention in 1982, and as on date has designated 37 wetlands as Ramsar Sites. State-wise details of 37 Ramsar Sites of India, which are being managed as per the Ramsar mandate, are given in **Table 7.**

Table 7: State-wise Details of Ramsar Sites (Wetlands) as on August 31, 2020

(Area in hectares)

No.	State/UT	Ramsar Wetland	Ramsar Area of State/UT	Wetland Area of State/UT	% Area of Ramsar Sites in State
1.	Andhra Pradesh	Kolleru Lake	90,100	14,47,133	6.23
2.	Assam	Deepor Beel	4,000	7,64,372	0.52
3.	Gujarat	Nalsarovar Bird Sanctuary	12,000	34,74,950	0.35
4.	Himachal Pradesh	Chandertal Wetland, Pong Dam Lake, Renuka Wetland	15,731	98,496	15.97
5.	Jammu and Kashmir	Hokera Wetland, Surinsar-Mansar Lakes, Wular Lake	20,625	1,77,926	11.59
6.	Kerala	Asthamudi Wetland, Sasthamkotta Lake, Vembanad Kol Wetland	1,57,763	1,60,590	98.24
7.	Ladakh	Tsomoriri Lake	12,000	2,13,575	5.62
8.	Madhya Pradesh	Bhoj Wetlands	3201	8,18,166	0.39
9.	Maharashtra	Nandur Madhameshwar	1437	10,14,522	0.14
10.	Manipur	Loktak Lake	26,600	63,616	41.81
11.	Odisha	Bhitarkanika Mangroves, Chilka Lake	1,81,500	6,90,904	26.27
12.	Punjab	Beas Conservation Reserve, Harike Lake, Kanjli Lake Keshopur - Mian Community Reserve, Nangal Wildlife Sanctuary, Ropar Lake	12,537	86,283	14.53
13.	Rajasthan	Keoladeo Ghana National Park, Sambhar Lake	26,873	7,82,314	3.44
14.	Tamil Nadu	Point Calimere	38,500	9,02,534	4.27
15.	Tripura	Rudrasagar Lake	240	17,542	1.37
16.	Uttar Pradesh	Nawabganj Bird Sanctuary, Parvati Arga Sanctuary, Saman Bird Sanctuary, Samaspur Bird Sanctuary, Sandi Bird Sanctuary, Sarsai	29,332	12,42,530	2.36

No.	State/UT	Ramsar Wetland	Ramsar Area of State/UT	Wetland Area of State/UT	% Area of Ramsar Sites in State
		Nawar Jheel, Upper Ganga River			
17.	West Bengal	East Calcutta Wetlands, Sunderbans Wetland	4,35,500	11,07,907	39.31
	Total		**10,67,939**		

Note: Area of wetlands in States derived from National Wetland Atlas 2011; For the UT of Jammu & Kashmir, area derived from state wetland area of Jammu & Kashmir minus the wetland are of Kargil and Leh districts which form the wetland area of the UT of Ladakh)]

V.3. Importance of SDG Indicator 6.6.1

Human pressures on water-related ecosystem, such as water abstraction and pollution, habitat alterations, flow modifications, fragmentation from dams and other infrastructure, over-exploitation of species and invasions of unfamiliar species (Juffe-Bignoli et al., 2016)[19] continue to grow, jeopardizing critical ecosystems services such as nutrient cycling, primary production, water provisioning, water purification and recreation (DOPA, 2017)[20]. The effects of these pressures are increasingly being felt by society. Water-related ecosystems provide important social and economic benefits to societies, such as provision of drinking water and sanitation, recreational opportunities, maintenance of aquatic habitats to support biodiversity and fishery industries, water for key sectors such as energy and agriculture, and regulation of water flows. To ensure these important services to society are sustained, water-related ecosystems must be both protected and restored which is why knowing the change in the extent of water related ecosystems over time is important. Indicator 6.6.1 enables countries to monitor progress towards achieving Target 6.6, in particular the protection and restoration of vegetated wetlands, open water, rivers and aquifers, all of which are known to play an important role in the delivery of water-related services. Indicator provides a comprehensive picture that enables informed decisions towards the protection and restoration of these ecosystems. It is therefore crucial to identify solutions that will contribute to conserving and preserving water-related ecosystems (Matthews, 2016)[21]. Effective regular global monitoring of water-related ecosystems

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[19] Juffe-Bignoli, D., Harrison, I, Butchart, S. H. M., Flitcroft, R., Hermoso, V., Jonas, H., Lukasiewicz, A., Thieme, M., Turak, E., Bingham, H., Dalton, J., Darwall, W., Deguignet, M., Dudley, N., Gardner, R., Higgins, J., Kumar, R., Linke, S., Milton, G. R., Pittock, J., Smith, K. G. and van Soesbergen, A. 2016. Achieving Aichi Biodiversity Target 11 to improve the performance of protected areas and conserve freshwater biodiversity. Aquatic Conservation: Marine and Freshwater Ecosystems, Vol. 26, No. S1, pp. 133–151. doi.org/10.1002/ aqc.2638

[20] DOPA (Digital Observatory for Protected Areas). 2017. Inland surface water and inland surface water change, DOPA Factsheet G.2. European Commission. http:// dopa.jrc.ec.europa.eu/sites/default/files/DOPA%20 Factsheet%20G2%20Inland%20Surface%20Water_0.pdf

[21] Matthews, N. 2016. People and fresh water ecosystems: pressures, responses and resilience. Aquatic Procedia, Vol. 6, pp. 99–105. doi.org/10.1016/j. aqpro.2016.06.012

to improve the relationship between human and freshwater ecosystems can help to identify and implement sustainable solutions.

VI. SDG Indicator 15.3.1 - *Proportion of land that is degraded over total land area*

SDG 15 promotes "Life on Land" and SDG target 15.3 states: 'By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation - neutral world.' In the case of SDG 15.3 the progress towards a land degradation neutral world will be assessed using indicator 15.3.1: "proportion of land that is degraded over total land area". The UN Convention to Combat Desertification (UNCCD) is the custodian agency for SDG indicator 15.3.1 ("Proportion of land that is degraded over total land area") to monitor progress towards achieving SDG target 15.3. Indicator SDG 15.3.1 has been upgraded to Tier 2[22] (indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries) in November 2017. Land degradation decreases crop cultivation. Water and other resources grow scarce. Food insecurity can be a consequence, ultimately forcing populations to migrate to survive. Thus, highlighting the importance of the indicator 15.3.1 which focuses predominantly on the use of three sub-indicators, including land cover and land cover change, land productivity, and carbon stocks above and below ground.

The term land degradation can be defined in several ways, we use the definition given by UNCCD since it is the custodian agency. Land degradation[23] is defined as "the reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from a combination of pressures, including land use and management practices". This definition was adopted by and is used by the 196 countries that are Party to the UNCCD. Land Degradation Neutrality (LDN) is defined as a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems. And Total land area is the total surface area of a country excluding the area covered by inland waters, like major rivers and lakes.

SDG Indicator 15.3.1 is a binary - degraded/not degraded - quantification based on the analysis of available data for three sub-indicators to be validated and reported by national authorities. The sub-indicators (Trends in Land Cover, Land Productivity and Carbon Stocks) were adopted by the UNCCD's governing body in 2013 as part of its monitoring and evaluation approach. Computation of this indicator follows "one out, all out" principle [considering changes in the sub-indicators which are depicted as (i) positive or improving, (ii) negative or declining, or (iii) stable or unchanging. If one of the sub-indicators is negative (or stable when degraded in the baseline or

[22] https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/
[23] https://knowledge.unccd.int/sites/default/files/inline-files/Metadata-15-03-01_20180123_1.pdf

previous monitoring year) for a particular land unit, then it would be considered as degraded subject to validation by national authorities.]

The assessment of areas of degraded land is made for each land cover class or ecosystem type and then aggregated for the entire area of analysis (or ecosystem accounting area). The total degraded area across all classes or types within a monitoring period t_n ($A(Degraded)_{tn}$), comprises the sum of land that has degraded within that monitoring period (t_n) and the land already assessed as degraded at the beginning of that monitoring period and also remains degraded at the end of the monitoring period. SDG 15.3.1 can be calculated by dividing this by the total area within the ecosystem accounting area ($A(Total)$)[7]. This is shown in equation below (which would represent the closing extent of degraded area for an accounting period)

$$\text{SDG } 15.3.1 = \left(\frac{A(Degraded)_{t_n}}{A(Total)}\right) * 100$$

VII.1. SEEA EEA Accounts for Land Degradation

The ecosystem extent account then provides data for inferring degradation via the land cover change sub-indicator of SDG 15.3.1. This is achieved using an ecosystem type change matrix and identifying the ecosystem changes that are indicative of degradation. The same could also be obtained from the Land Cover Account and concerned change matrix. The concept of land degradation is also clearly aligned to that of ecosystem condition. The Ecosystem Condition Accounts allow trends in the land productivity and carbon stock, sub-indicators for land degradation, and SDG 15.3.1 to be integrated with the extent of different ecosystem (or land cover) types. As such, they are also clearly relevant structures for organising information to calculate SDG 15.3.1. The information on the carbon stock sub-indicator could also be organised using the thematic carbon accounts. The approach to calculating SDG 15.3.1 is based on organising spatially explicit data on the three sub-indicators in an integrated manner. For this we need to assign information on each of the three sub-indicators to a pixel or grid cell derived from a georeferenced grid, ideally a resolution of 250m to 1ha grids. These grid cells are entirely consistent with the concept of Basic Spatial Units (BSUs) described in the SEEA EEA.

SEEA provides a centralised statistical process that can alleviate a significant portion of the data collation and processing burden for calculating this indicator. Moreover, it is possible to associate trends in land degradation with economic statistics, especially for agriculture sector by arranging land degradation statistics in a format that is compatible with national statistical systems. Representing this information in conjunction with key socio-economic statistics on unemployment, poverty and population, decision-makers will get a better picture of where livelihoods and well-being may be suffering most from the impacts of land degradation allowing for suitable responses to be prioritised for different areas, for example designing and implementing schemes to incentivise improved soil management. This in turn can help reduce the demand for land for economic activities, including for agricultural production.

VII.2. Calculating SDG Indicator 15.3.1

This indicator has been calculated using data from NRSC at national level at a periodicity of 5 years as per Progress Report[24] on SDG, but we have tried to calculate the same using mapping techniques which can be aligned with SEEA. As seen above calculating SDG Indicator 15.3.1 requires estimating the three sub-indicators, including land cover and land cover change, land productivity, and carbon stocks above and below ground. To estimate these, the QGIS plugin, Trends.Earth[25] was used. Trends.Earth (formerly the Land Degradation Monitoring Toolbox) is a platform for monitoring the changes in land using Google Earth Engine. It allows the user to compute each of these sub-indicators in a spatially explicit way generating raster maps which are then integrated into a final SDG 15.3.1 indicator map and produces a table result reporting areas potentially improved and degraded for the area of analysis by using Google Earth Engine by using land cover maps from ESA CCI. The integration of the three SDG 15.3.1 sub-indicators is done following the one-out all-out rule, this means that if an area was identified as potentially degraded by any of the sub-indicators, then that area will be considered potentially degraded for reporting purposes. Though the tool provides the option to use the custom data for each of the sub-indicators but for our analysis we have used the default dataset or the UNCCD default data. The time period under consideration is 2001 and 2015. **Table 11** presents the results of the estimation. No data in the SDG 15.3.1 is an indication of no data in some of the input datasets used in the analysis. Further details are given in **Annexure IV**. The estimate using the mapping technique/trends.earth represents the value of the indicator over the period unlike the ones given by NRSC[26] which measures the total degraded data and not the change.

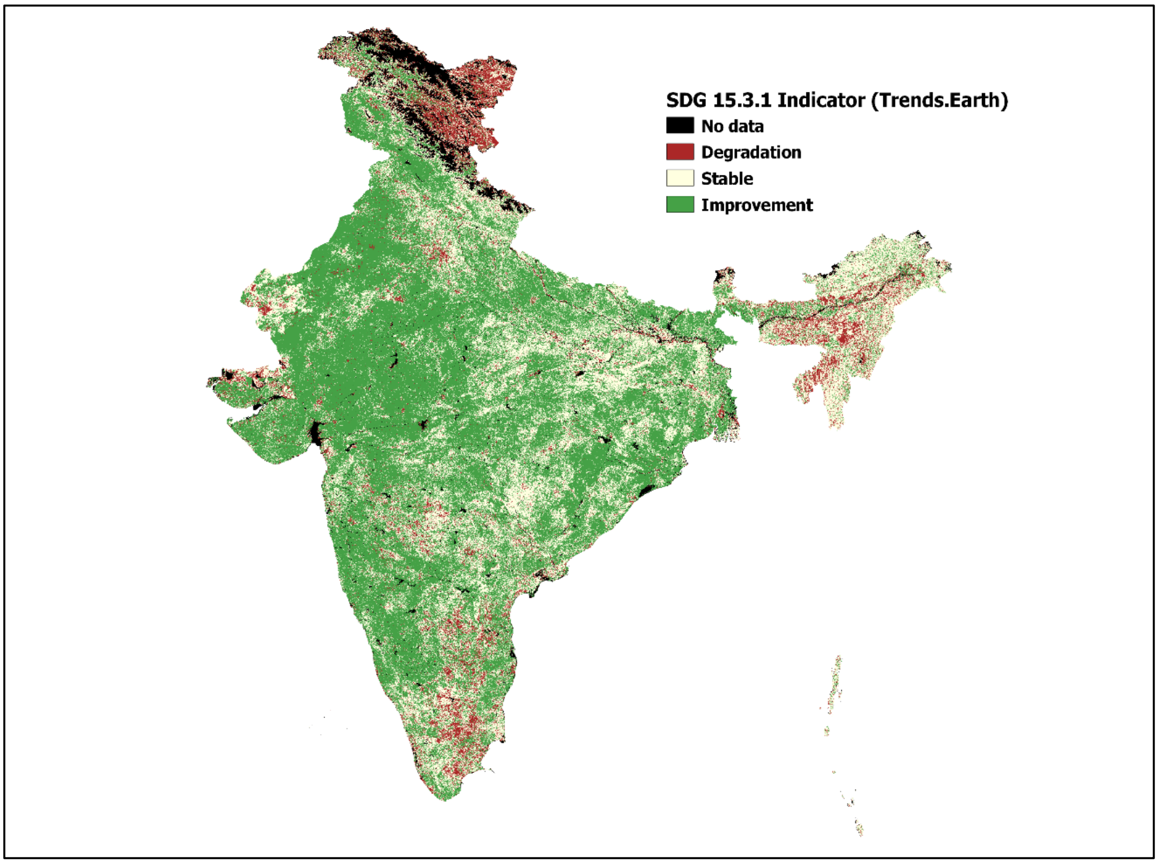
Table 8: Summary of SDG 15.3.1 Indicator

	Area (sq km)	Percent of total land area
Total land area:	32,15,129.6	100.00%
Land area improved:	17,89,096.3	55.65%
Land area stable:	10,77,146.2	33.50%
Land area degraded:	2,61,197.6	8.12%
Land area with no data:	87,689.5	2.73%

[24] Sustainable Development Goals, National Indicator Framework, Progress Report 2020 (Version 2.0), Ministry of Statistics and Programme Implementation Can be accessed at http://www.mospi.gov.in/sites/default/files/publication_reports/SDGProgressReport2020.pdf
[25] http://trends.earth/docs/en/training/tutorial_compute_sdg_indicator.html
[26] https://www.sac.gov.in/SACSITE/Desertification_Atlas_2016_SAC_ISRO.pdf

The **Table 11** and **Figure 7** shows that 8.12% area has degraded over the span of 15 years from 2001 to 2015. These are the estimates using the global datasets and can be refined further using the national and local level datasets for calculating each of the sub-indicators and indicator itself.

Figure 6: Map showing SDG Indicator 15.3.1 for 2001-2015



VII.3. Importance of SDG Indicator 15.3.1

Ever increasing human requirements, economic activities etc are creating a growing pressure on the land resources, which creates competition and conflicts leading to sub-optimal use of the resource. Resultant being that the land resources are degrading at an alarming pace affecting livelihoods and food security of the global population (UNCCD 2015b)[27]. Human activities are the principal drivers of the processes of land degradation, desertification and climate change which can be witnesses as pressures from food producer and demands from industries are stressing arable lands, pastures, and other essential areas, land degradation decreases crop cultivation, water and other

[27] UNCCD (2015b). Transforming Land Management Globally. Q&A about land in the 6th GEF Replenishment Phase (GEF-6). In. https://sustainabledevelopment.un.org/content/documents/19242015_Transforming%20Land%20 Management.pdf.

resources grow scarce, food insecurity can be a consequence, ultimately forcing populations to migrate to survive. Thus, a measure of Proportion of land that is degraded over total land area gives an estimate to the decision makers for better management practices and helps in combating the issue.

VII. SDG Indicator 11.3.1- *Ratio of land consumption rate to population growth rate*

Within the United Nations Sustainable Development Goals (SDGs), Goal 11 aims to "Make cities and human settlements inclusive, safe, resilient and sustainable". Under this goal are several targets and indicators. SDG Indicator 11.3.1 is defined as the ratio of land consumption rate to population growth rate. Thus, requires the definition of land consumption rate and population growth rate. As per the metadata[28], in estimating the **land consumption rate**, one needs to define what constitutes **"consumption" of land** since this may cover aspects of "consumed" or "preserved" or available for "development." Secondly, there is not one unequivocal measure of whether land that is being developed is truly "newly-developed" land, or if it is partially "redeveloped." As a result, the **percentage of current total urban land** that was newly developed (consumed) will be used as a measure of the land consumption rate. Fully developed areas are sometimes referred to as built up areas. This indicator is categorized under Tier II, meaning the indicator is conceptually clear and an established methodology exists but data on many countries is not yet available. UN-Habitat and other partners such as the Global Human Settlement Layer (GHSL) team and ESRI will support various components for reporting on this indicator. Indicator 11.3.1 is computed as follows:

Population growth rate (PGR):

$$PGR = \frac{\ln(\frac{Pop_{t+n}}{Pop_t})}{y}$$

Where:
Pop_t: Total population within the city in the past/initial year
Pop_{t+n}: Total population within the city in the current/final year
y: The number of years between the two measurement periods

Land consumption rate (LCR): This rate gives us a measure of compactness which indicates a progressive spatial expansion of a city.

$$LCR = \frac{\ln(\frac{Urb_{t+n}}{Urb_t})}{y}$$

[28] https://unstats.un.org/sdgs/metadata/files/Metadata-11-03-01.pdf

Where:
$Urban_t$: Total areal extent of the urban agglomeration in km^2 for past/initial year
$Urban_{t+n}$: Total areal extent of the urban agglomeration in km^2 for current/final year
y: The number of years between the two measurement periods

Ratio of land consumption rate to population growth rate (LCRPGR):

$$LCRPGR = \frac{LCR}{PGR}$$

VIII.1. SEEA EEA Accounts for Ecosystem Extent

SEEA EEA Accounts for Ecosystem extent especially urban extent accounts can support generation of SDG 11.3.1 and can be used to combine information on the same into wider economic planning processes. Implementation of urban ecosystem accounting requires establishing the urban ecosystem accounting area. Once this is determined, with a suitable urban ecosystem typology and associated maps for these urban ecosystem assets, information can thus, be organized for an urban ecosystem extent account as done in case of SDG indicator 11.7.1. Also, the concept of population especially population density can be an indicator of urban condition account as discussed in earlier sections. SDG indicator 11.3.1 could also be obtained from the Land Cover Account. Land use and land cover (LULC) changes are broadly studied as a proxy for human development. These along with LULC change matrix would help in estimating the urban extent or the extent of built-up area as they are useful to explore the changes of a multitude of land cover typologies (e.g., forest areas) and to propose estimates of land conversion to urban area. Land accounts[29] as per SEEA Central Framework is shown in **Table 12**. Here, these ET's can be based on the national classification or international classification. In case of India, these may correspond to National Remote Sensing Centre (NRSC's) Land Use Land Cover Classes. Based on the following table we get the extent of urban area and using the corresponding population parameters, we can calculate SDG 11.3.1 based on the earlier mentioned methodology, thus, highlighting the alignment of SEEA with SDG indicator.

Table 9: Physical Account for Land Cover (hectares)

	Category of Land				Total
	ET1	ET2	…	ETn	
Opening Stock (ha)					
Additions to stock					
Reductions in stock					
Closing stock (ha)					

[29] https://seea.un.org/sites/seea.un.org/files/seea_technical_note_-_land_jan_2017_draft.pdf

This information can be used for inclusive and sustainable urbanisation, planning and management.

VIII.2. Calculating SDG Indicator 11.3.1

The Global Human Settlement Layer (GHSL)[30] is a freely available global dataset showing the spatial extent of urban/built-up areas and of population. These gridded raster datasets are available at four epochs: 1975, 1990, 2000, and 2014. Aside from the available datasets, the GHSL project has a suite of tools available to assist with this type of research. The tool discussed is the LUE – Land Use Efficiency tool which is available as QGIS plugin which is used in our analysis to estimate SDG indicator 11.3.1 and it also estimates LUE Indicator[31]. Applying this tool on the global urban and population datasets using GHSL, we obtain the following estimates of 11.3.1 for the year 2000 and 2015 along with the foundational data as per the GHSL given in **Table 13.** This tool calculates the urban area for the area or city in question along with the corresponding population of the city and thus calculates indicator 11.3.1 using the former parameters. We have done the analysis for 52 million plus cities in India for the years 2000 and 2015.

[30] https://ghsl.jrc.ec.europa.eu/

[31] The LUE tool allows to calculate the LUE indicator as defined below in Equation 1 and the SDG indicator 11.3.1. With the proposed global indicator computation, it may be difficult to capture the dynamics of cities with negative or zero population growth; or cities that due to severe disaster have lost part of their territories. To face this challenge, JRC has developed a tool to calculate the indicator 11.3.1 based on a proxy of Land Use Efficiency (LUE). JRC tool proposes to adapt the formulation of the Land Use Efficiency indicator in order to measure the change rate of the built-up area per capita (Corbane et al. 2016[31]):

$$Idx_t = \frac{Y_t - Y_{t+n}}{Y_t} \tag{1}$$

Where:
$Y_t = BU_t / POP_t$;
BU_t = built-up surface at t and
POP_t = population at t.

The indicator can be estimated at different time intervals upon the availability of observations. In order to ensure the comparability of the results at different times, it is recommended to normalise the values to obtain the variation a 10-year average change which divides the indicator by n (the number of years that separate the observations) and then multiply by 10. The formula of the normalised indicator is:

$$Idx_t = \frac{Y_t - Y_{t+n}}{Y_t} * \frac{10}{n}$$

Table 10: Summary of SDG 11.3.1 Indicator

S.No.	Million Plus Cities	Built-up Area (sq. km)		Population		Population growth rate (PGR)*	Land consumption rate (LCR)*	SDG_11.3
		2000	2015	2000	2015			
1	Delhi	535.95	574.37	1,19,35,312	1,55,31,798	0.02	0.00	0.26
2	Greater Mumbai	317.59	327.95	1,69,99,844	2,04,70,412	0.01	0.00	0.17
3	Kolkata	1669.63	1801.05	2,78,34,202	3,17,78,530	0.01	0.01	0.57
4	Chennai	376.26	450.97	1,04,17,138	1,39,96,528	0.02	0.01	0.61
5	Bangalore	281.08	398.79	67,05,881	1,16,44,489	0.04	0.02	0.63
6	Hyderabad	383.65	477.89	99,90,576	1,30,99,904	0.02	0.01	0.81
7	Ahmedabad	195.71	260.95	64,81,823	83,70,143	0.02	0.02	1.13
8	Pune	191.33	300.29	69,27,953	1,00,29,066	0.02	0.03	1.22
9	Surat	72.39	94.11	39,81,396	65,99,944	0.03	0.02	0.52
10	Jaipur	165.19	215.58	46,43,163	64,37,605	0.02	0.02	0.81
11	Kanpur	81.13	98.40	35,46,565	40,28,626	0.01	0.01	1.51
12	Lucknow	75.49	98.98	33,00,038	45,76,152	0.02	0.02	0.83
13	Nagpur	125.54	148.07	37,92,530	45,36,954	0.01	0.01	0.92
14	Ghaziabad (NCR)	122.90	140.91	21,06,180	33,91,502	0.03	0.01	0.29
15	Indore	94.40	138.72	22,36,351	33,25,779	0.03	0.03	0.97
16	Coimbatore	114.35	142.58	28,35,523	35,59,949	0.02	0.01	0.97
17	Kochi	211.78	269.15	34,51,226	36,92,139	0.00	0.02	3.55
18	Patna	61.50	66.54	43,07,235	57,48,874	0.02	0.01	0.27
19	Kozhikode	88.98	103.53	30,62,793	33,48,708	0.01	0.01	1.70
20	Bhopal	65.56	85.28	16,70,302	23,80,512	0.02	0.02	0.74
21	Thrissur	125.32	165.91	33,19,210	34,79,151	0.00	0.02	5.96
22	Vadodara	88.35	103.72	24,83,906	29,63,535	0.01	0.01	0.91
23	Agra	65.19	90.96	32,20,018	42,12,359	0.02	0.02	1.24

24	Vishakhapatnam	85.32	102.44	37,59,262	44,36,787	0.01	0.01	1.10
25	Malappuram	107.99	127.86	38,44,444	45,03,356	0.01	0.01	1.07
26	Thiruvananthapuram	131.96	144.06	35,71,934	35,96,108	0.00	0.01	13.01
27	Ludhiana	201.75	233.30	26,30,305	31,66,283	0.01	0.01	0.78
28	Kannur	100.81	122.66	25,64,482	26,95,536	0.00	0.01	3.93
29	Nashik	72.92	107.59	46,88,253	61,73,266	0.02	0.03	1.41
30	Vijayawada	216.59	251.74	86,83,135	95,96,213	0.01	0.01	1.50
31	Madurai	33.06	41.91	28,24,343	35,43,186	0.02	0.02	1.05
32	Varanasi	70.84	85.52	29,87,367	36,97,858	0.01	0.01	0.88
33	Meerut	58.37	90.06	26,05,820	31,55,884	0.01	0.03	2.27
34	Faridabad (NCR)	95.04	108.24	11,98,953	17,77,085	0.03	0.01	0.33
35	Rajkot	89.95	114.90	23,15,919	29,68,480	0.02	0.02	0.99
36	Jamshedpur	44.86	46.41	20,05,747	24,74,249	0.01	0.00	0.16
37	Jabalpur	25.43	30.75	19,74,701	23,70,078	0.01	0.01	1.04
38	Asansol	336.76	401.19	65,27,659	75,24,842	0.01	0.01	1.23
39	Vasai - Virar (MMR)	129.80	139.47	52,82,612	81,52,592	0.03	0.00	0.17
40	Allahabad	31.96	39.66	43,79,362	57,00,824	0.02	0.01	0.82
41	Dhanbad	92.86	96.51	22,62,857	26,05,968	0.01	0.00	0.27
42	Aurangabad	60.37	79.58	27,14,577	37,79,537	0.02	0.02	0.83
43	Amritsar	78.79	103.76	18,42,904	22,22,663	0.01	0.02	1.47
44	Jodhpur	74.40	93.57	25,48,764	36,01,689	0.02	0.02	0.66
45	Ranchi	39.02	45.49	21,67,559	29,07,543	0.02	0.01	0.52
46	Raipur	59.00	73.60	15,05,410	22,78,593	0.03	0.01	0.53
47	Kollam	102.94	110.47	27,16,713	27,08,840	0.00	0.00	-24.35
48	Gwalior	34.67	44.28	14,67,464	19,95,485	0.02	0.02	0.80
49	Durg-Bhilainagar	67.22	82.10	13,34,223	16,91,684	0.02	0.01	0.84
50	Chandigarh	13.39	16.47	4,43,392	5,40,450	0.01	0.01	1.05

51	Tiruchirapalli	29.67	59.24	25,67,477	30,10,417	0.01	0.05	4.34
52	Kota	66.50	80.99	13,77,661	18,56,173	0.02	0.01	0.66

* Note: the growth rate is for the period 2000-2015.

Along with the above, the tool provides us with the map for LUE for each of the cities, shown in **Annexure V.** The map shows the negative, zero and positive values of LUE. According to Melchiorri et al. (2019)[32], the LUE can be understood has follows:

LUE class	Information about the urban centre (Melchiorri et al., 2019)
LUE ≤ -1	Demographic decline is simultaneous to substantial spatial expansion
-1 < LUE ≤ 0	Demographic decline is simultaneous to spatial expansion
0 < LUE ≤ 1	Population densification takes place
1 < LUE ≤ 2	Rate of spatial expansion is greater than the demographic growth
LUE > 2	Spatial expansion takes place at a place that is at least double the one of demographic growth

Ideally, the LCR should be synchronized with the PGR, indicating that the development of the two is coordinated. Efficient land use, moving toward efficiency, and moving toward sufficient land per person in Table below indicate that the relationship between land use and population growth is coordinated, and the remaining three in Table below indicate that it is uncoordinated. The indicator as per UN-Habitat can be interpreted as follows:

City Urban extent density	Indicator Value: LCRPGR Value	
	<1	>1
10-150 persons/hectare	Efficient land use	Inefficient land use
151 -250 persons/hectare	Moving toward efficiency	Moving away from efficiency
Greater than 250 persons/ hectare	Insufficient land per person	Moving toward sufficient land per person

Though this tool has a limitation which is its inability to capture the vertical development of constructions, which is primarily since the available input data represents 2D information of built surface and population.

VIII.3. Importance of SDG Indicator 11.3.1

Urban expansion and demographic changes are inevitable process of population increase. Worldwide urban area has increased by 58,000 km^2 from 1970 to 2000, with an estimated increase of an additional 1,527,000 km^2 expected by 2030 (Seto et al., 2011)[33]. However, unplanned urban growth tends to create concerns such as

[32] Melchiorri, M., Pesaresi, M., Florczyk, A. J., Corbane, C., & Kemper, T. (2019). Principles and applications of the global human settlement layer as baseline for the land use efficiency indicator—SDG 11.3.1. *ISPRS International Journal of Geo-Information*, 8(2). https://doi.org/10.3390/ijgi8020096

[33] Seto, K.C.; Fragkias, M.; Gu, B.; Reilly, M.K. A Meta-Analysis of Global Urban Land Expansion. PLoS ONE 2011, 6, e23777.

environmental pollution, traffic congestion, and water stress. Many cities around the world have highly consuming urban expansion plans. Urban sprawl can increase CO_2 emissions and pose a threat to people and the planet. Also, excessive increase in population will intensify traffic pressure, poor living conditions, high unemployment rates, hunger, poverty, and resource shortages. Thus, highlighting the fact that urban expansion needs to be done efficiently and inclusively to ensure sustainable land use and management. In this context, this indicator which is used to describe the relationship between urban expansion and demographic change can give insight into efficiency of land use and sustainability, and how much area is being consumed compared to population. This indicator allows decision makers to track and manage urban growth and therefore allows them to promote land use efficiency. Moreover, it ensures that the SDGs adequately address the broader dimensions of space and land and provides a foundation for achieving other sustainable development goals, including those pertaining to health, food security, energy, and climate change[34]. It provides policy makers and stakeholders the necessary information to project demand for public goods and services and identify new areas of growth. Also, 11.3.1 indicator is connected to many other indicators of the SDGs[35]: 11.7.1 (Public space), 11.a.1 (Regional Development Plans); 15.1.2 (Forest area), 8.1.1 (City Product per Capita); 8.2.1 (Growth rate per employment); 8.5.2 (Unemployment Rate) and 11.6.1 (Solid Waste Collection).

VIII. Conclusion

UN Statistical Commission recognized the SEEA as a useful framework for measuring the SDG related to environment-economy. The SEEA can be the basis for:

1. The development of coherent environmental-economic SDG indicators
2. The disaggregation of SDG indicators to inform national policy (spatial, sectoral, etc.)

The systems approach of the SEEA enables countries to develop sets of statistics and indicators on both natural resources (e.g. timber, water) and ecosystems and how they relate to the economy. The SEEA framework can be used to directly measure several SDG indicators (**Annexure VI**) and provide supplemental information for numerous others. It increases efficiency and provides policy makers with relevant information to measure and monitor progress towards achieving SDGs.

[34] https://data.landportal.info/book/sdgs/1131/sdgs-indicator-1131
[35] http://www.geoessential.eu/wp-content/uploads/2020/01/AUTH_SDG-11.3.1-Built-Up-Area.pdf

ANNEXURES

Annexure I

Forest cover classified in terms of tree canopy density

In India, forest cover has been classified in terms of the following tree canopy density as follows:

Very Dense Forest(VDF)

All lands with tree canopy density of 70% and above

Moderately Dense Forest(MDF)

All lands with tree canopy density of 40% and more but less than 70%

Open Forest (OF)

All lands with tree canopy density of 10% and more but less than 40%

Scrub

Forest lands with canopy density less than 10%

Non-forest

Lands not included in any of the above classes. (includes water)

Source: ISFR 2019

Annexure II

State-wise SDG indicator 15.1.1 for 2008-09 (ISFR 2011)

States/UTs	Very Dense Forest	Moderately Dense Forest	Open Forest	Total Forest Cover	Total Geographic Area	SDG 15.1.1
Andhra Pradesh	850	26,242	19,297	46,389	2,75,069	*16.86*
Arunachal Pradesh	20,868	31,519	15,023	67,410	83,743	*80.50*
Assam	1,444	11,404	14,825	27,673	78,438	*35.28*
Bihar	231	3,280	3,334	6,845	94,163	*7.27*
Chhattisgarh	4,163	34,911	16,600	55,674	1,35,191	*41.18*
Delhi	7	49	120	176	1,483	*11.87*
Goa	543	585	1,091	2,219	3,702	*59.94*
Gujarat	376	5,231	9,012	14,619	1,96,022	*7.46*
Haryana	27	457	1,124	1,608	44,212	*3.64*
Himachal Pradesh	3,224	6,381	5,074	14,679	55,673	*26.37*
Jammu & Kashmir	4,140	8,760	9,639	22,539	2,22,236	*10.14*
Jharkhand	2,590	9,917	10,470	22,977	79,714	*28.82*
Karnataka	1,777	20,179	14,238	36,194	1,91,791	*18.87*
Kerala	1,442	9,394	6,464	17,300	38,863	*44.52*
Madhya Pradesh	6,640	34,986	36,074	77,700	3,08,245	*25.21*
Maharashtra	8,736	20,815	21,095	50,646	3,07,713	*16.46*
Manipur	730	6,151	10,209	17,090	22,327	*76.54*
Meghalaya	433	9,775	7,067	17,275	22,429	*77.02*
Mizoram	134	6,086	12,897	19,117	21,081	*90.68*
Nagaland	1,293	4,931	7,094	13,318	16,579	*80.33*
Odisha	7,060	21,366	20,477	48,903	1,55,707	*31.41*
Punjab	0	736	1,028	1,764	50,362	*3.50*
Rajasthan	72	4,448	11,567	16,087	3,42,239	*4.70*
Sikkim	500	2,161	698	3,359	7,096	*47.34*
Tamil Nadu	2,948	10,321	10,356	23,625	1,30,058	*18.16*
Telangana	-	-	-	-	-	-
Tripura	109	4,686	3,182	7,977	10,486	*76.07*
Uttar Pradesh	1,626	4,559	8,153	14,338	2,40,928	*5.95*
Uttarakhand	4,762	14,167	5,567	24,496	53,483	*45.80*
West Bengal	2,984	4,646	5,365	12,995	88,752	*14.64*
Andaman and Nicobar Islands	3,761	2,416	547	6,724	8,249	*81.51*
Chandigarh	1	10	6	17	114	*14.91*

States/UTs	Very Dense Forest	Moderately Dense Forest	Open Forest	Total Forest Cover	Total Geographic Area	SDG 15.1.1
Dadra and Nagar Haveli	0	114	97	211	491	*42.97*
Daman and Diu	0	0.62	5.53	6	112	*5.49*
Lakshadweep	0	17.18	9.88	27	32	*84.56*
Puducherry	0	35.37	14.69	50	480	*10.43*
Total	83,471	3,20,736	2,87,820	6,92,027	32,87,263	*21.05*

State-wise SDG indicator 15.1.1 for 2017-18 (ISFR 2019)

States/UTs	Very Dense Forest	Moderately Dense Forest	Open Forest	Total Forest Cover	Scrub	Non-Forest **	Total Geographic Area	SDG 15.1.1
Andhra Pradesh	1,994	13,938	13,205	29,137	8,255	1,25,576	1,62,968	17.88
Arunachal Pradesh	21,095	30,557	15,036	66,688	229	16,826	83,743	79.63
Assam	2,795	10,279	15,253	28,327	173	49,938	78,438	36.11
Bihar	333	3,280	3,693	7,306	250	86,607	94,163	7.76
Chhattisgarh	7,068	32,198	16,345	55,611	610	78,971	1,35,192	41.13
Delhi	6.72	56.42	132.3	195.44	0.3	1,287	1,483	13.18
Goa	538	576	1,123	2,237	0	1,465	3,702	60.43
Gujarat	378	5,092	9,387	14,857	2,994	1,78,393	1,96,244	7.57
Haryana	28	451	1,123	1,602	154	42,456	44,212	3.62
Himachal Pradesh	3,113	7,126	5,195	15,434	315	39,924	55,673	27.72
Jammu & Kashmir # — UT of Jammu & Kashmir	4,203	7,952	8,967	21,122	250	31,886	53,258*	39.66
Jammu & Kashmir # — UT of Ladakh	78	660	1,752	2,490	298	1,66,633	1,69,421*	1.47
Jammu & Kashmir # — Total	4,281	8,612	10,719	23,612	548	1,98,076	2,22,236	10.62
Jharkhand	2,603	9,687	11,321	23,611	688	55,417	79,716	29.62
Karnataka	4,501	21,048	13,026	38,575	4,484	1,48,732	1,91,791	20.11
Kerala	1,935	9,508	9,701	21,144	13	17,695	38,852	54.42
Madhya Pradesh	6,676	34,341	36,465	77,482	6,002	2,24,768	3,08,252	25.14
Maharashtra	8,721	20,572	21,485	50,778	4,256	2,52,679	3,07,713	16.50
Manipur	905	6,386	9,556	16,847	1,181	4,299	22,327	75.46
Meghalaya	489	9,267	7,363	17,119	600	4,710	22,429	76.33
Mizoram	157	5,801	12,048	18,006	1	3,074	21,081	85.41
Nagaland	1,273	4,534	6,679	12,486	635	3,458	16,579	75.31
Odisha	6,970	21,552	23,097	51,619	4,327	99,761	1,55,707	33.15
Punjab	8	801	1,040	1,849	33	48,480	50,362	3.67
Rajasthan	78	4,342	12,210	16,630	4,760	3,20,849	3,42,239	4.86
Sikkim	1,102	1,552	688	3,342	307	3,447	7,096	47.10
Tamil Nadu	3,605	11,030	11,729	26,364	715	1,02,981	1,30,060	20.27
Telangana	1,608	8,787	10,187	20,582	3,615	87,880	1,12,077	18.36
Tripura	654	5,236	1,836	7,726	29	2,731	10,486	73.68
Uttar Pradesh	2,617	4,080	8,109	14,806	587	2,25,535	2,40,928	6.15
Uttarakhand	5,047	12,805	6,451	24,303	383	28,797	53,483	45.44
West Bengal	3,019	4,160	9,723	16,902	146	71,704	88,752	19.04

States/UTs	Very Dense Forest	Moderately Dense Forest	Open Forest	Total Forest Cover	Scrub	Non-Forest **	Total Geographic Area	SDG 15.1.1
Andaman and Nicobar Islands	5,678	684	381	6,743	1	1,505	8,249	*81.74*
Chandigarh	1.36	14.24	6.43	22.03	0.1	92	114	*19.32*
Dadra and Nagar Haveli	0	80	127	207	5	279	491	*42.16*
Daman and Diu	1.4	5.69	13.4	20.49	0.19	90	111	*18.46*
Lakshadweep	0	16.09	11.01	27.1	0	3	30	*90.33*
Puducherry	0	17.66	34.75	52.41	0	438	490	*10.70*
Total	99,278	3,08,472	3,04,499	7,12,249	46,297	25,28,923	32,87,469	*21.67*

Note: # Includes Jammu & Kashmir area outside LoC that is under illegal occupation of Pakistan and China.
* Area of shape file provided by Survey of India (December, 2019). Notified geographical area from SOI awaited.
** Non-Forest= Total Geographical Area- (Total Forest cover +Scrubs)

Annexure III

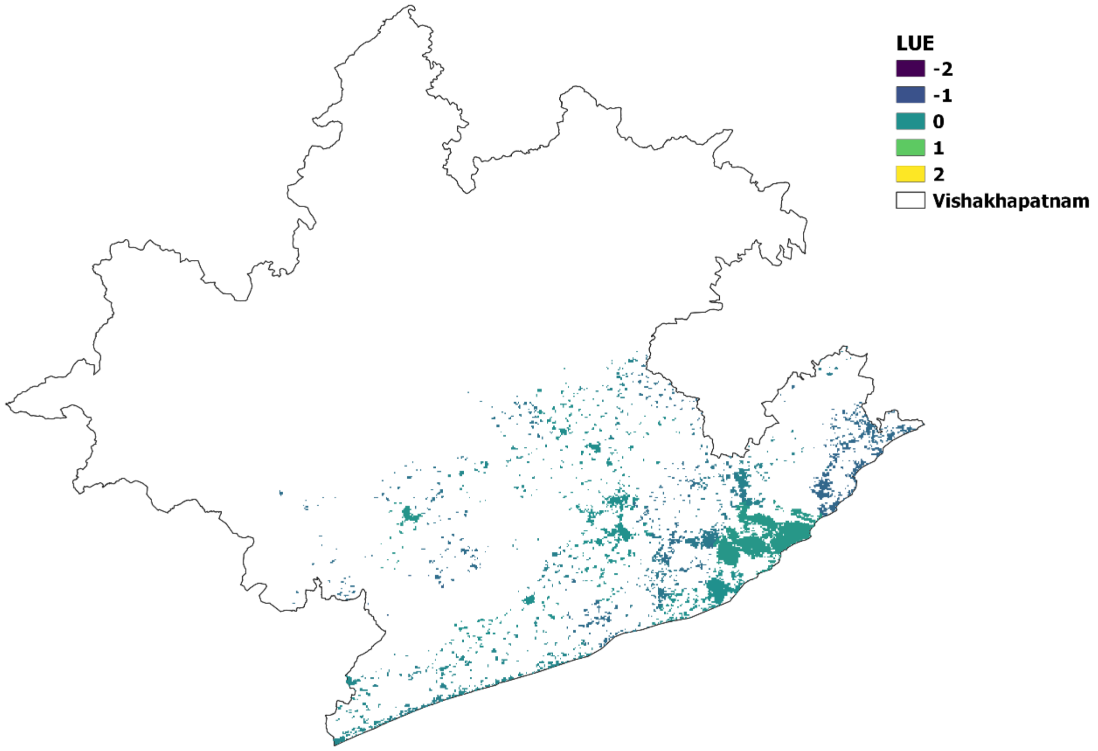
Annexure III_SDG 6.6.1.xlsx

Annexure IV

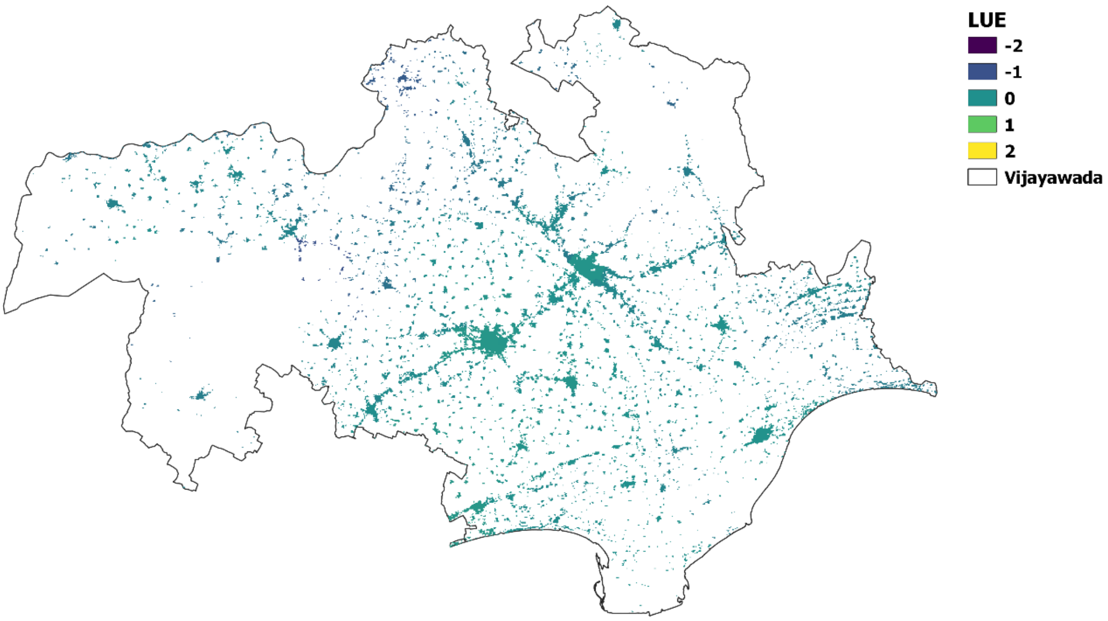
Annexure IV-SDG 15.3.1 India.xlsx

Annexure V

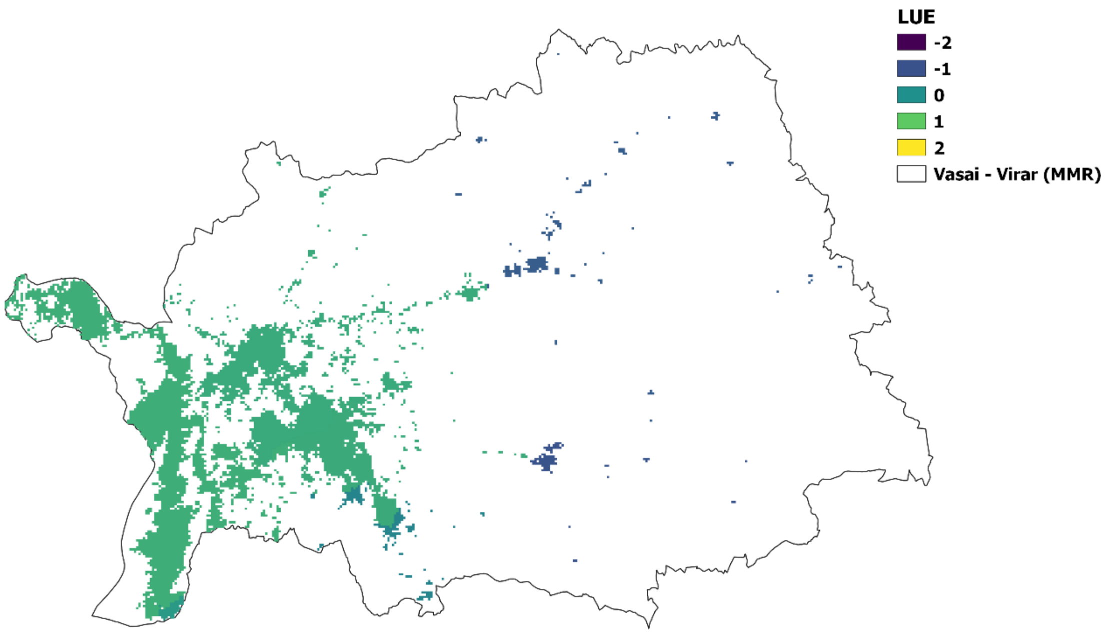
Vishakhapatnam



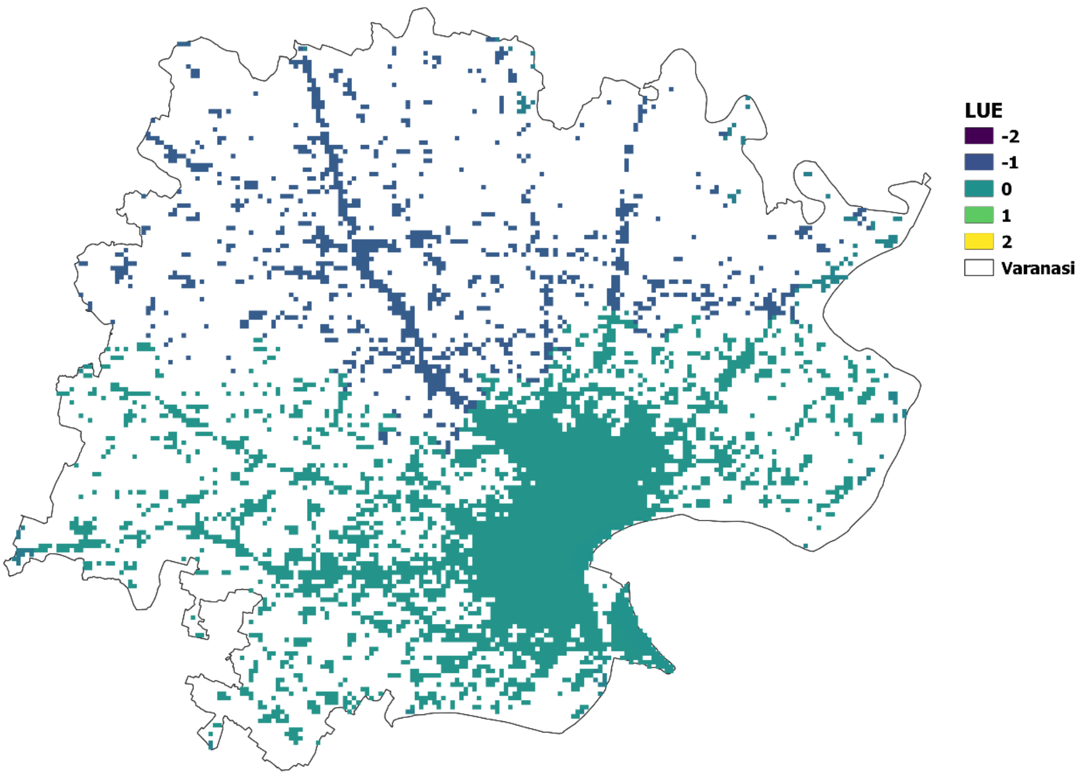
Vijayawada



Vasai-Virar (MMR)



Varanasi



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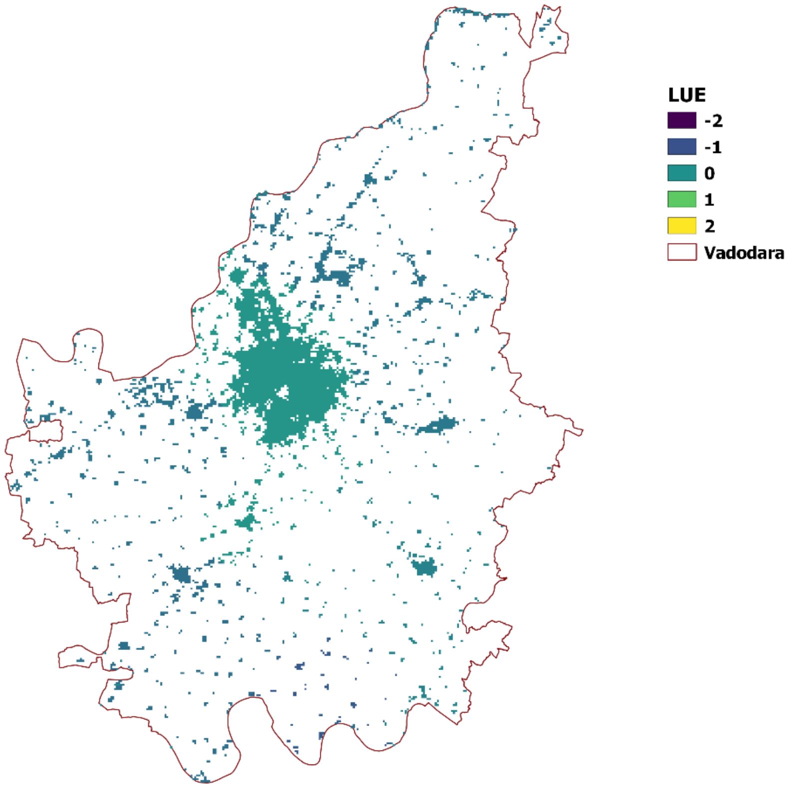

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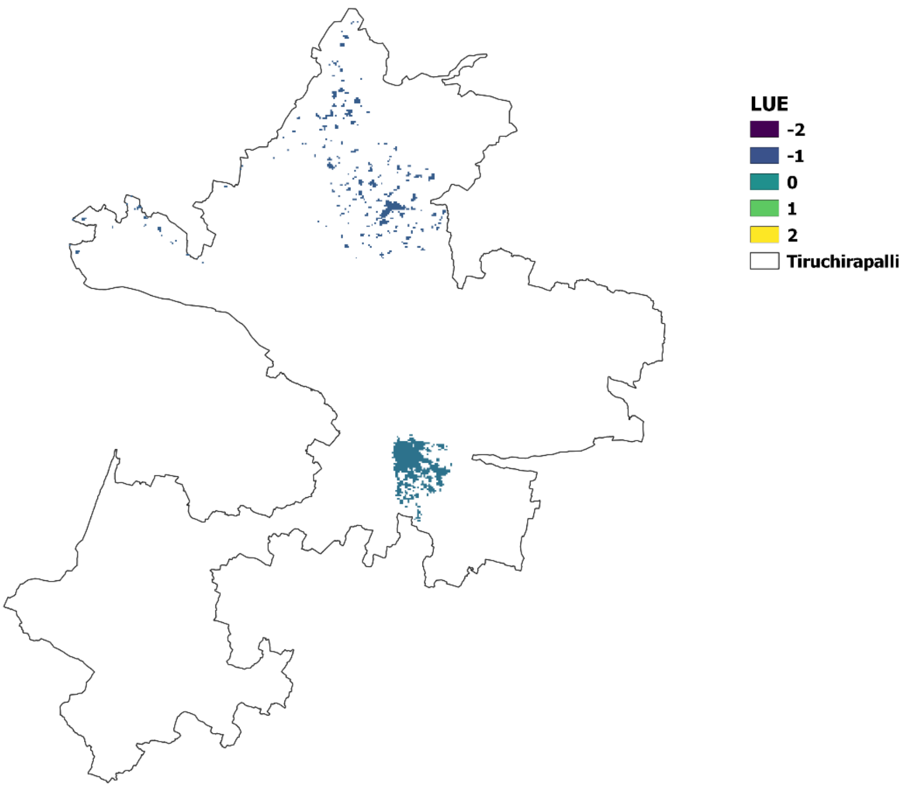

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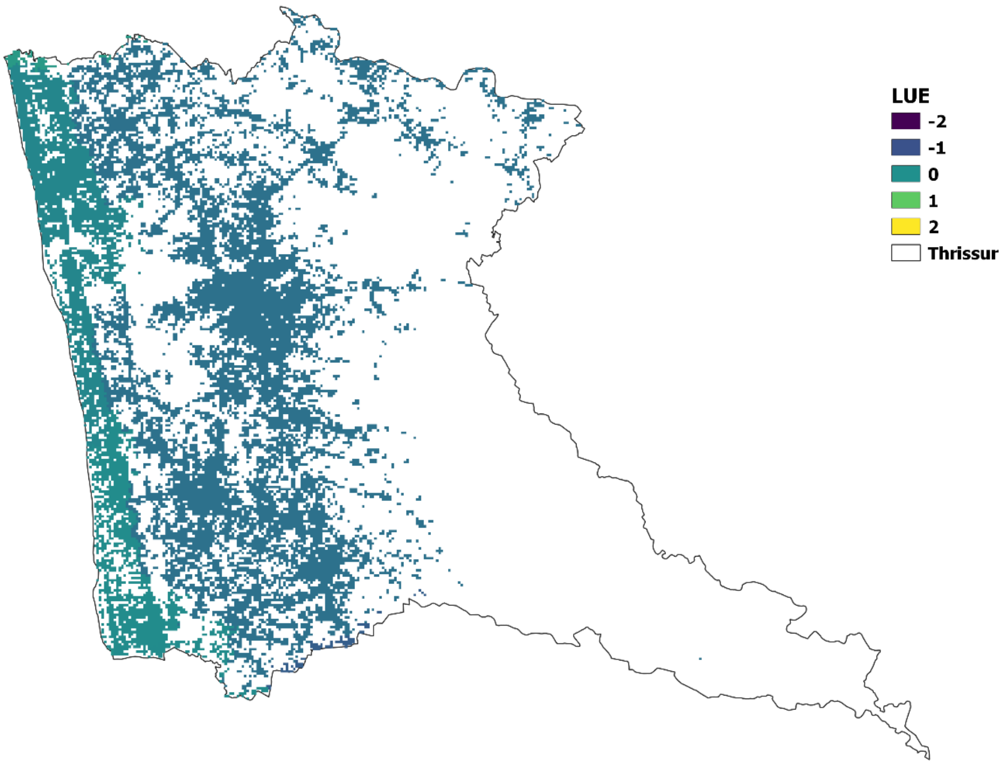

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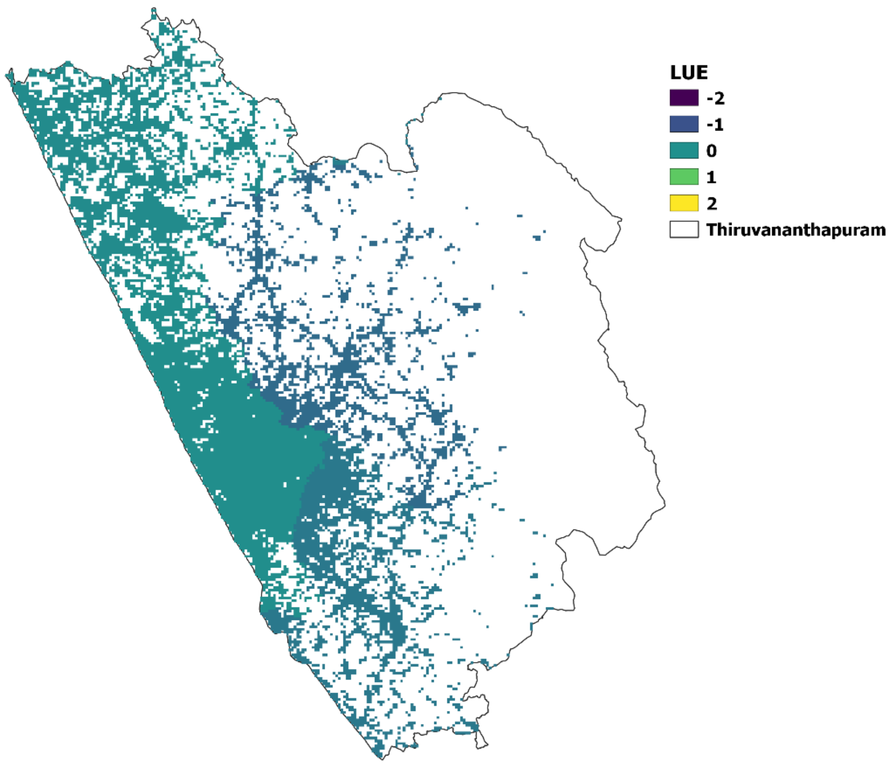

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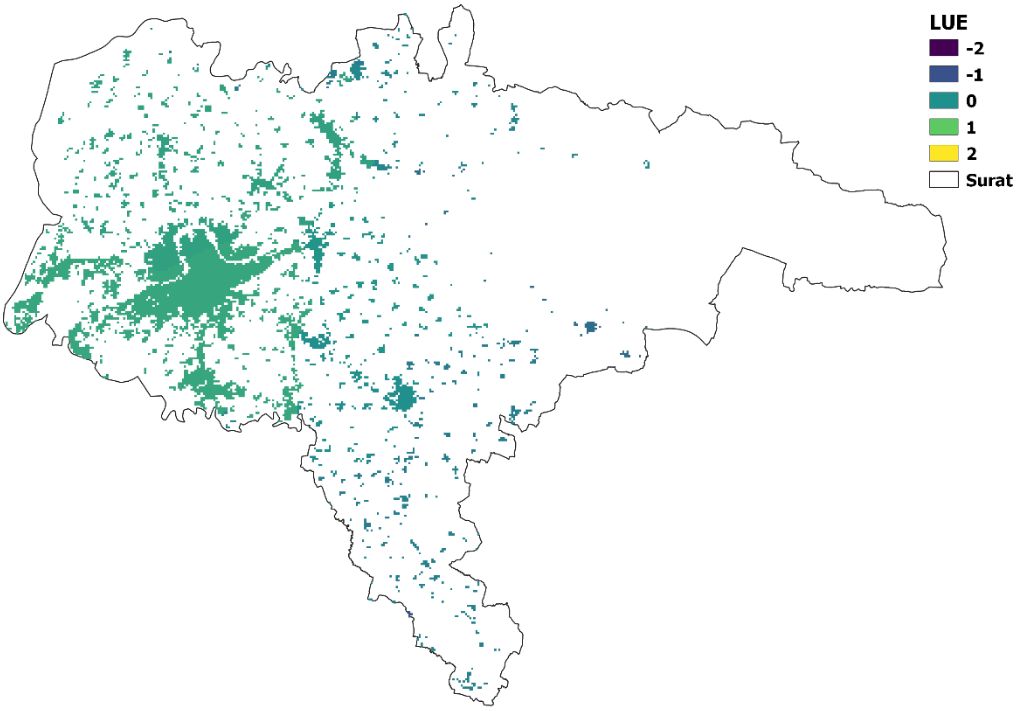

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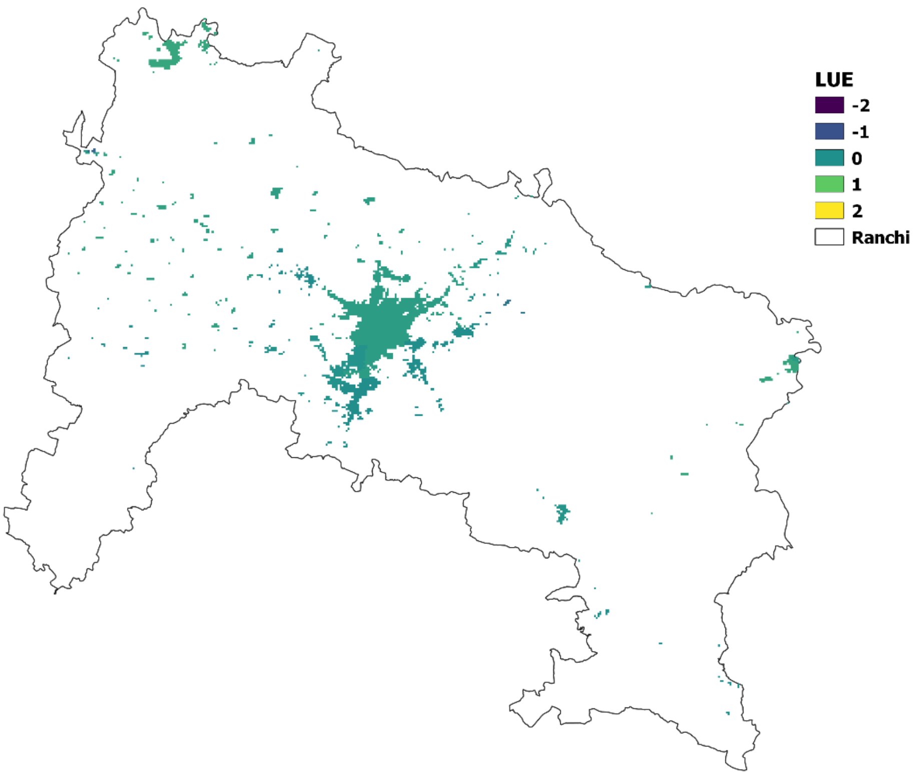

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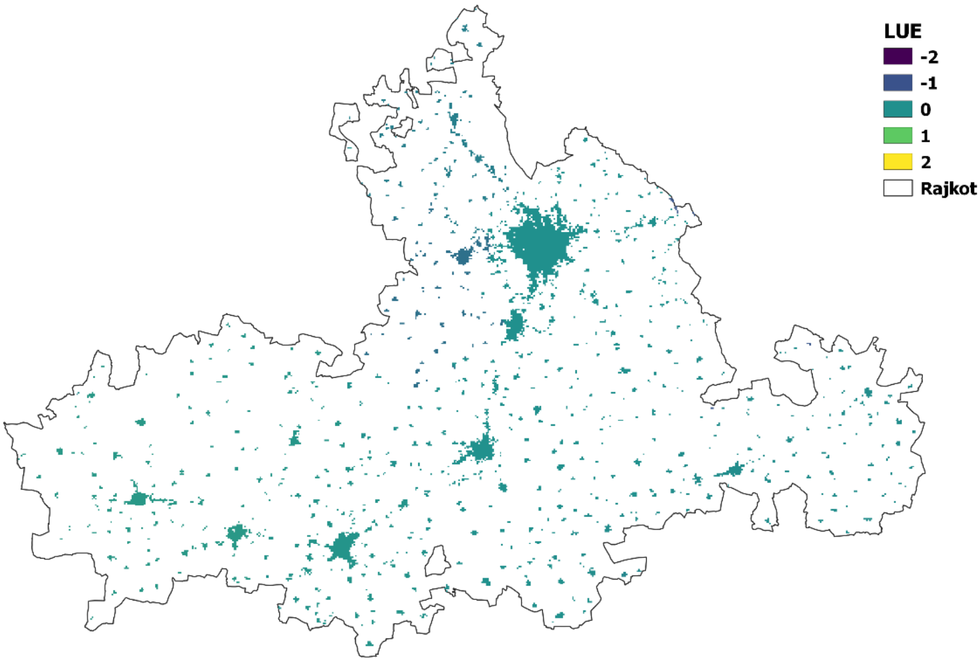

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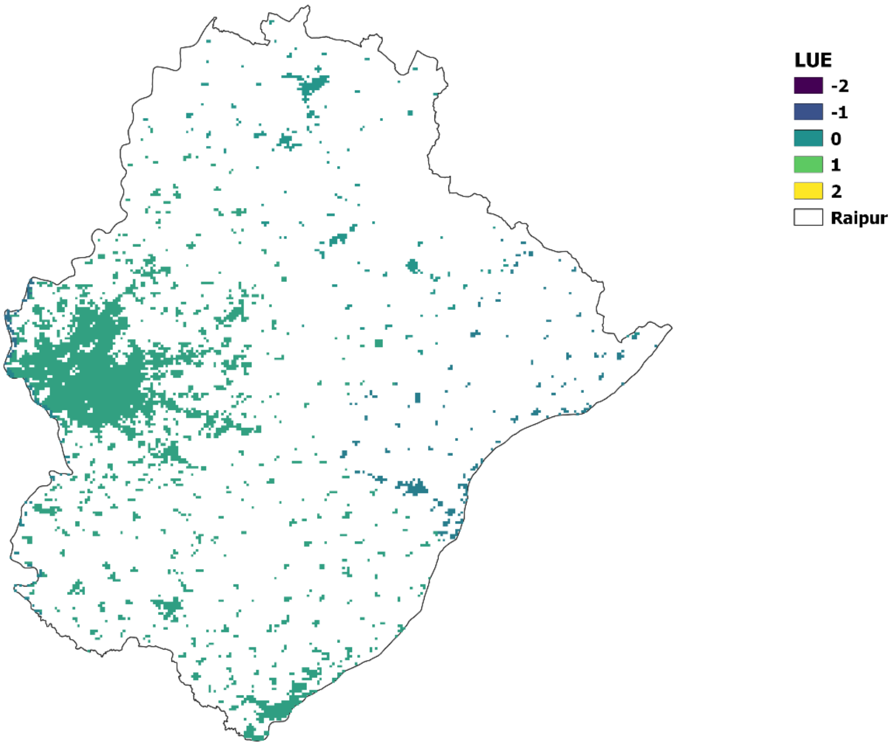

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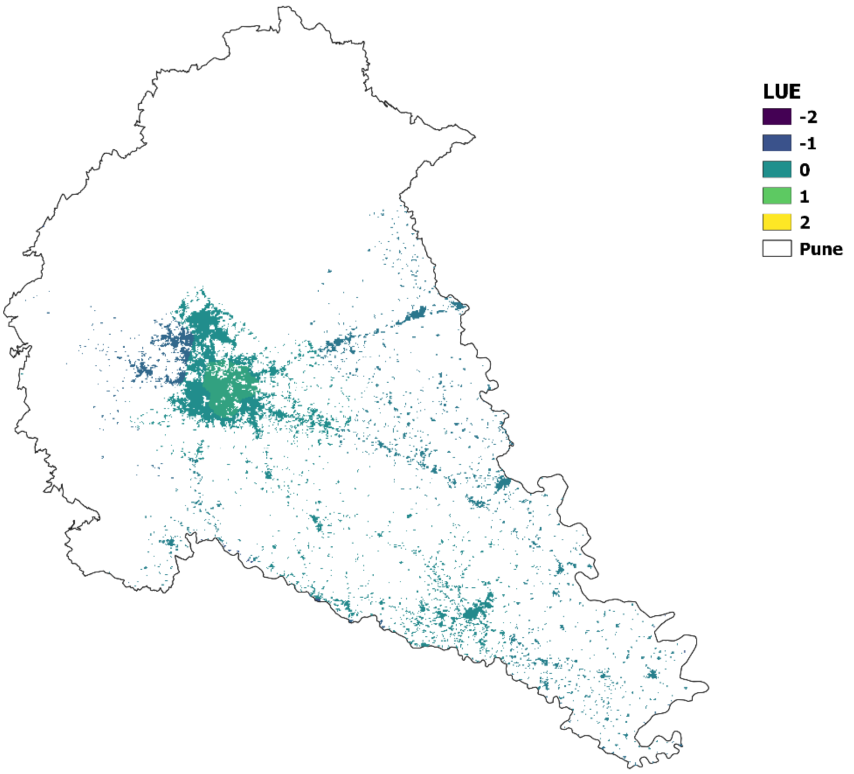

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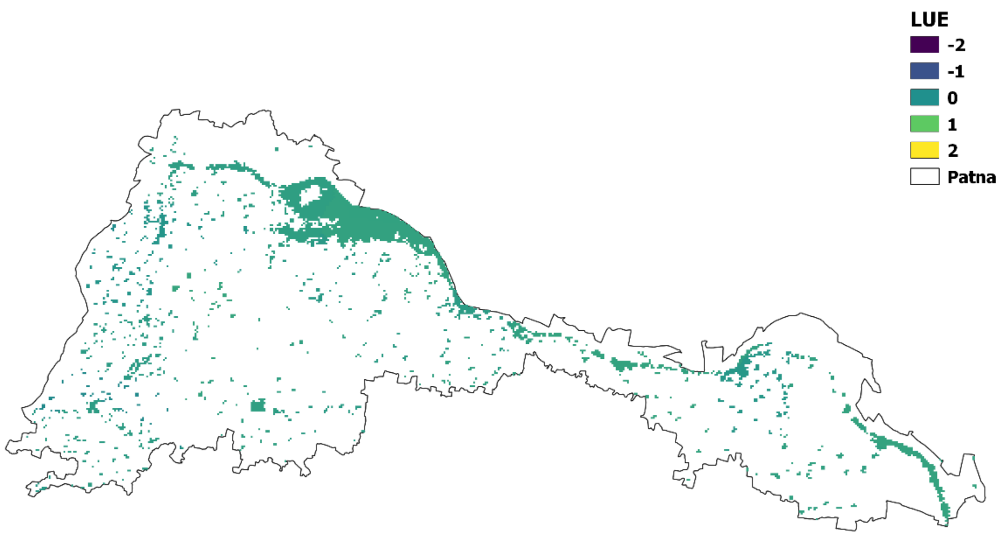

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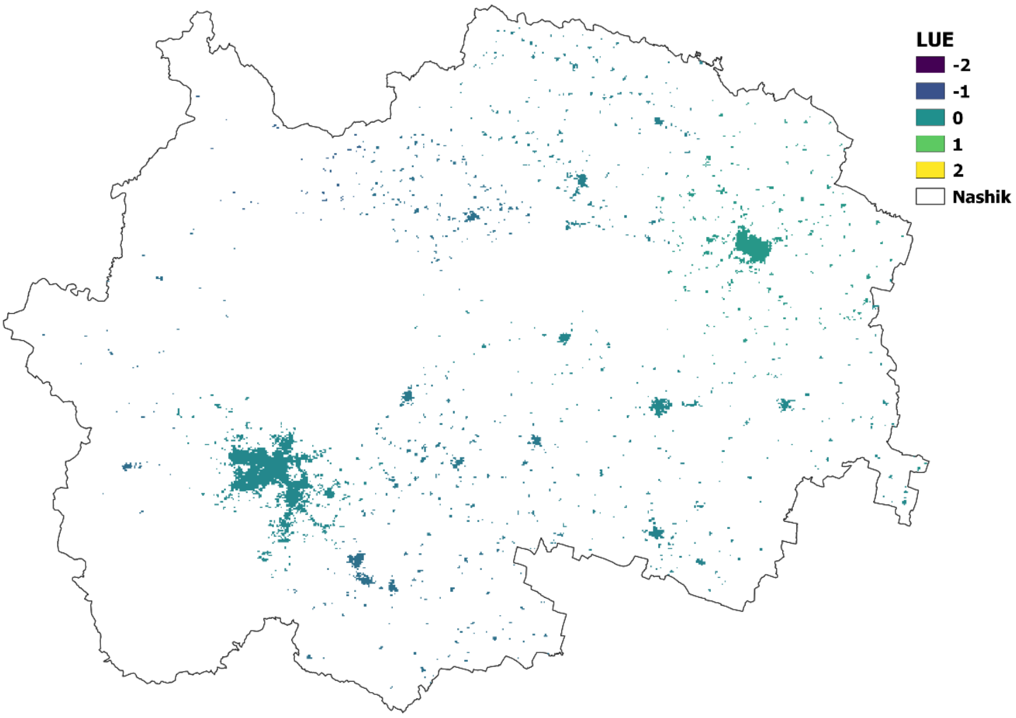

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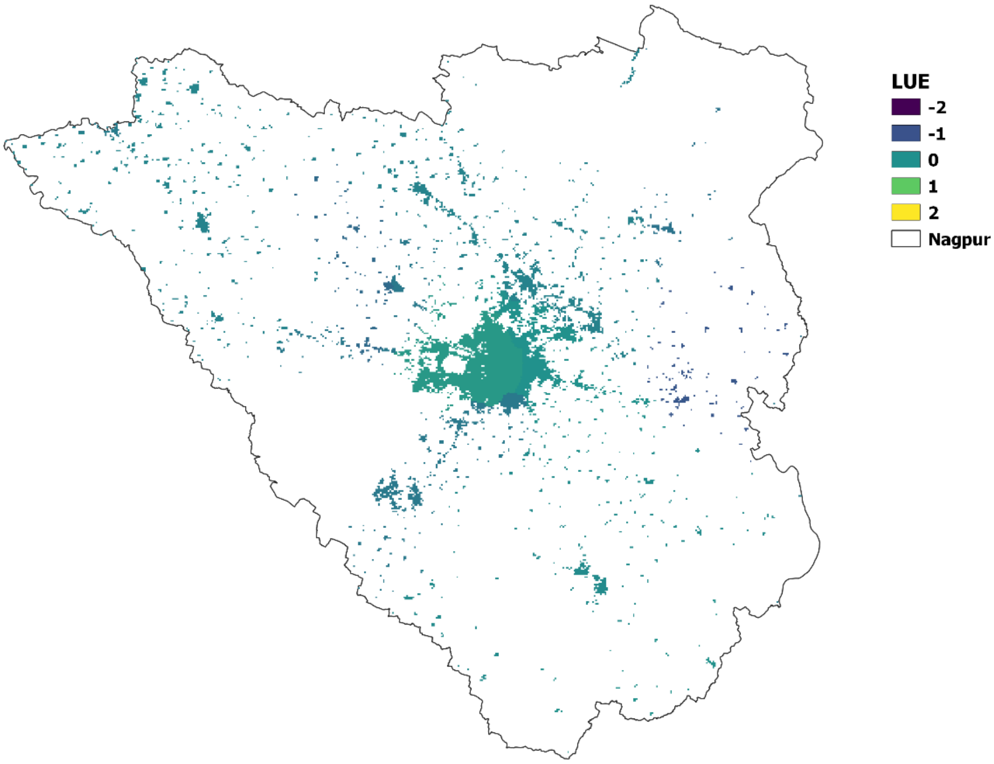

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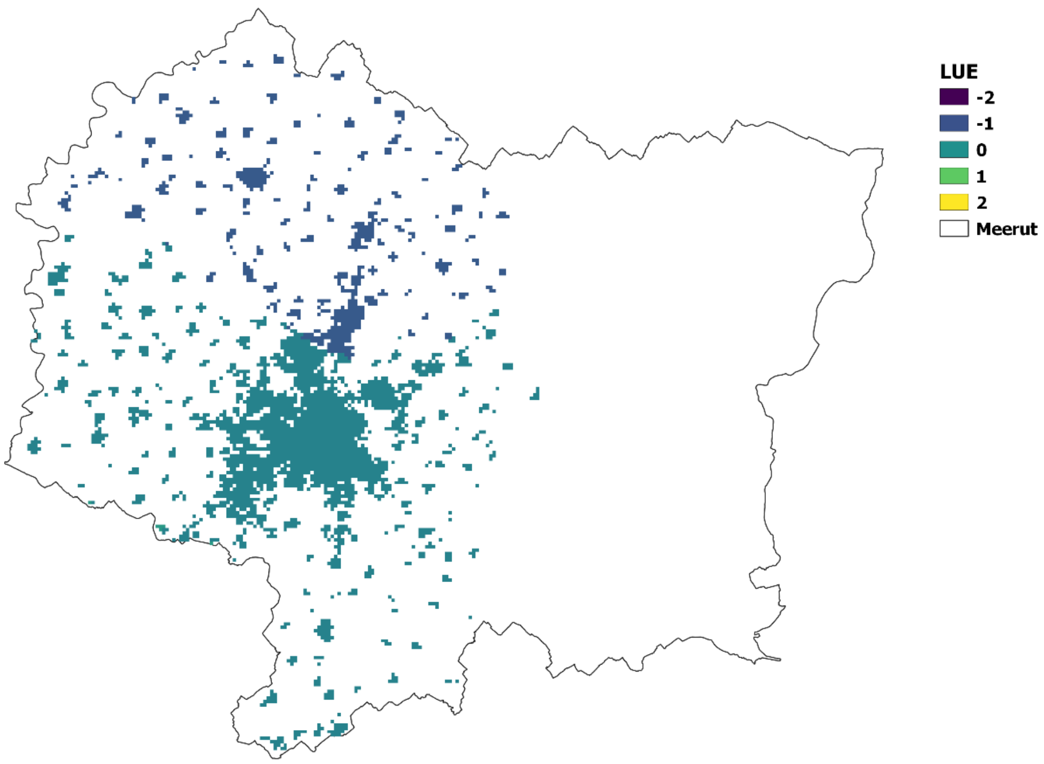

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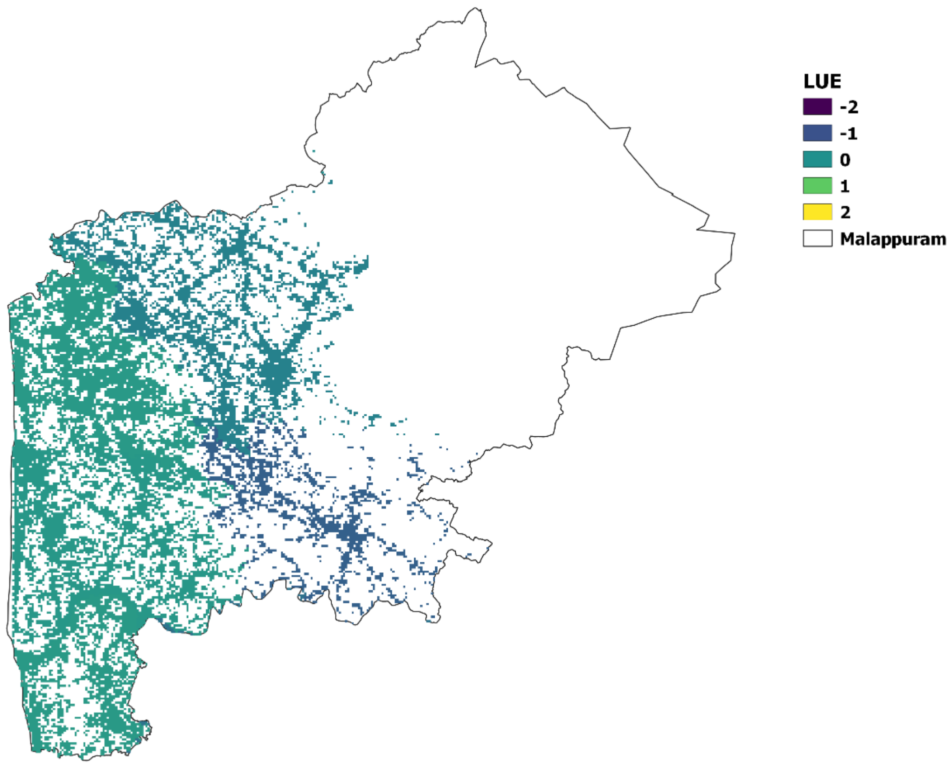

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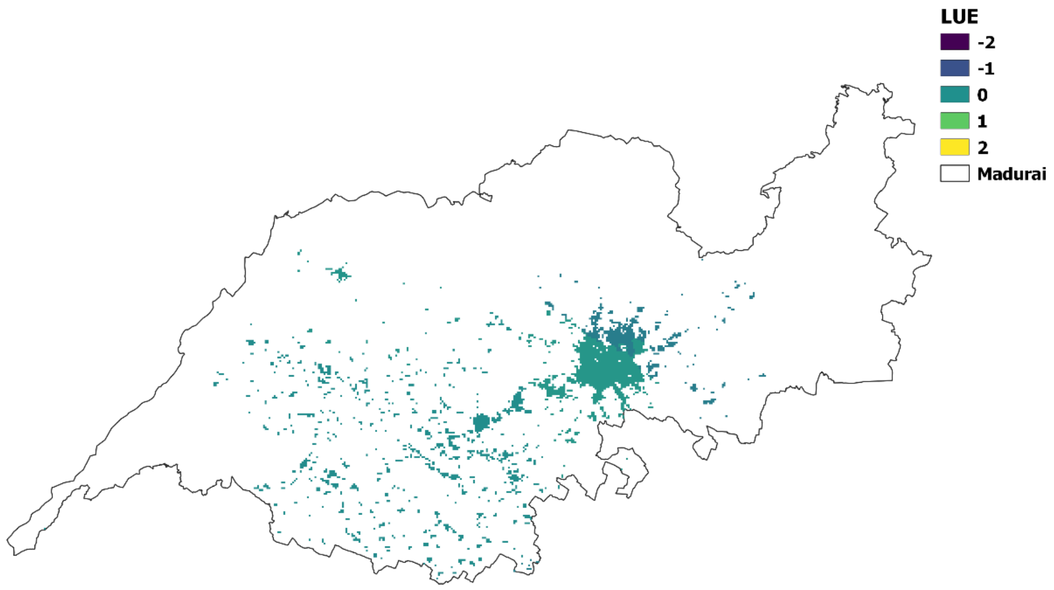

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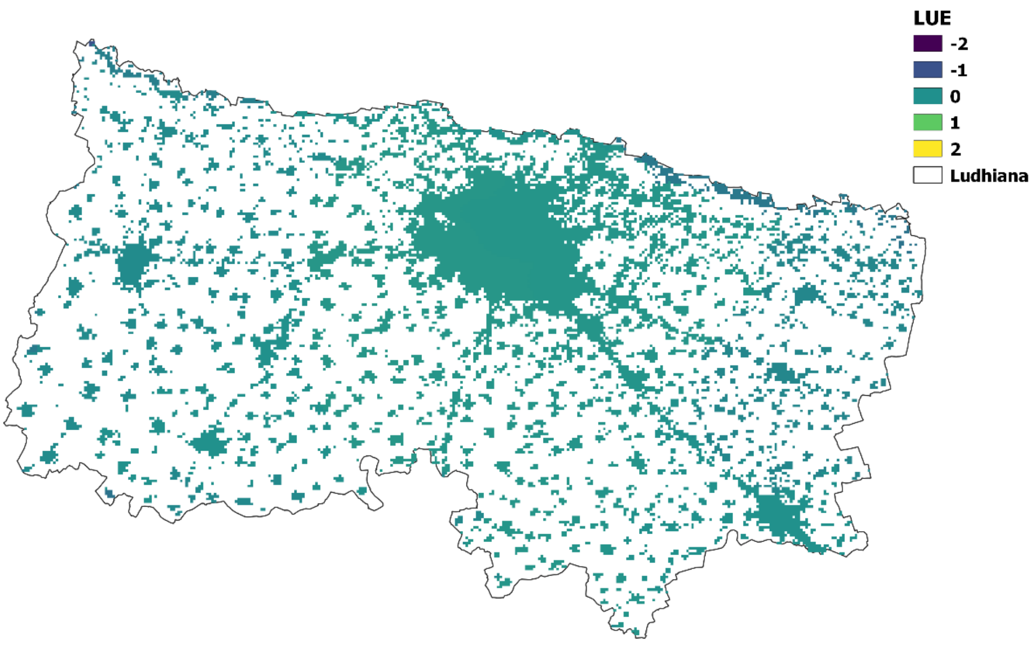

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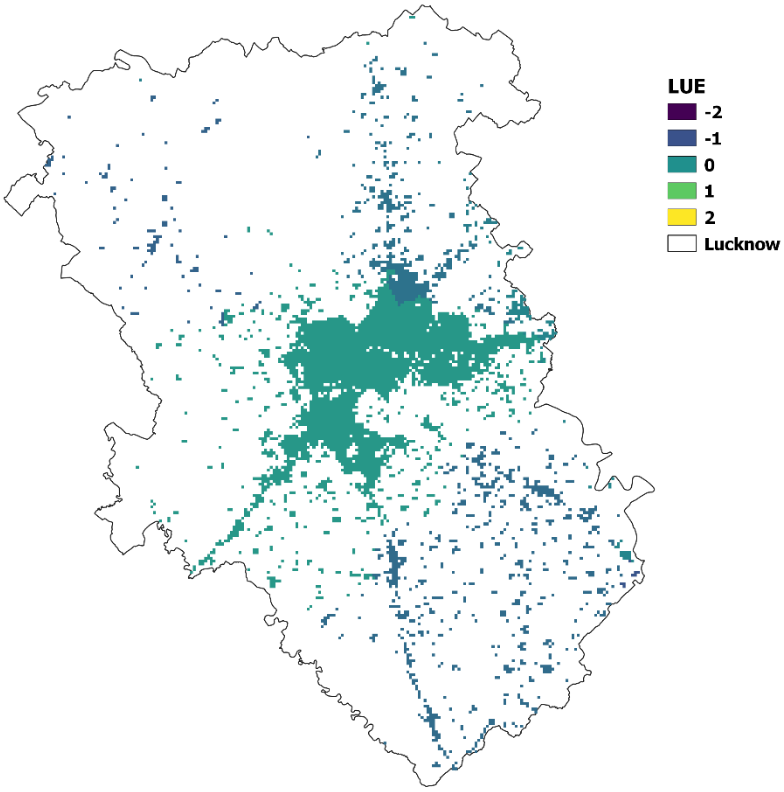

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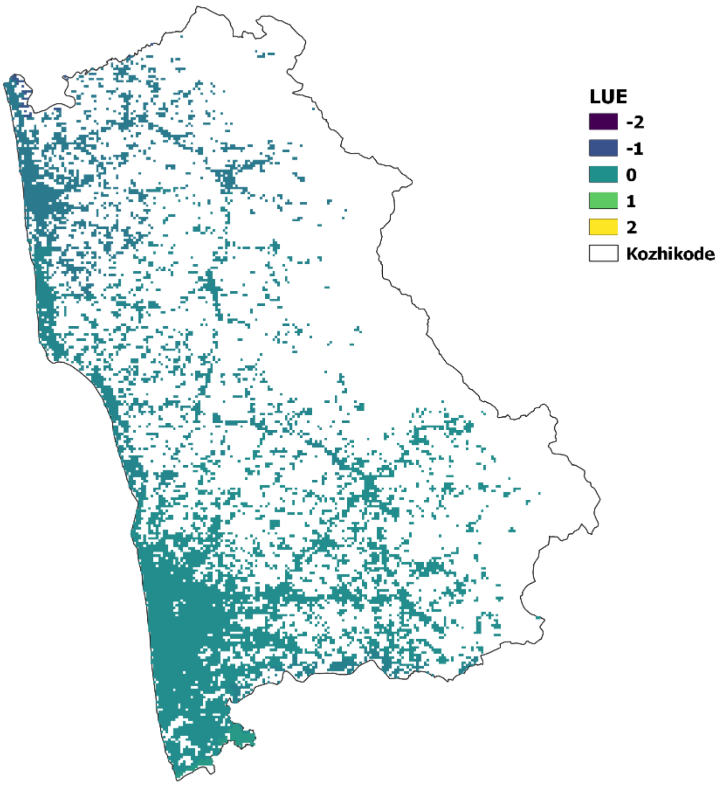

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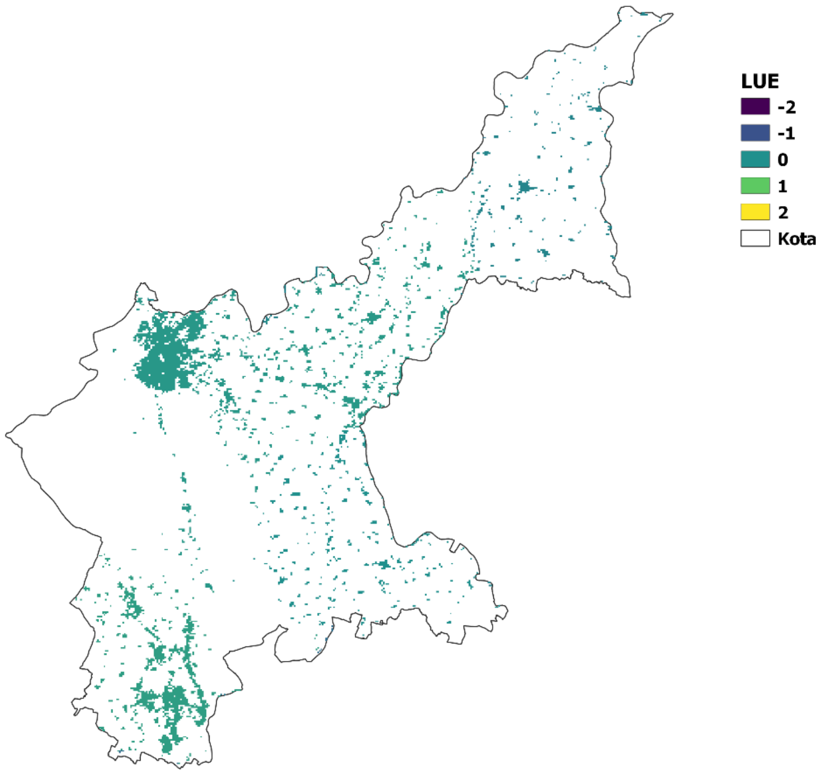

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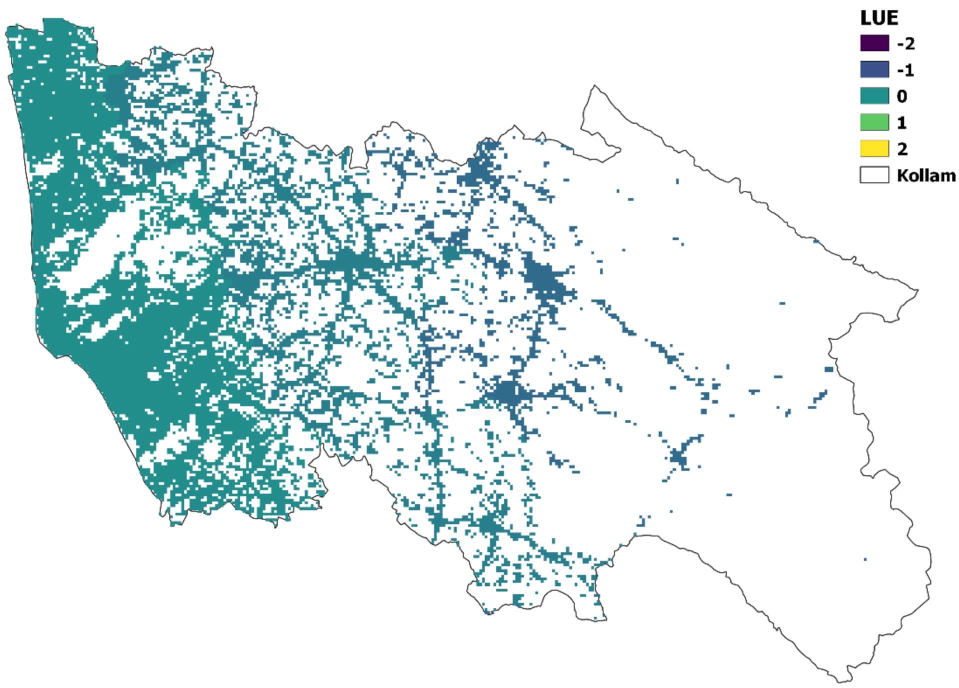

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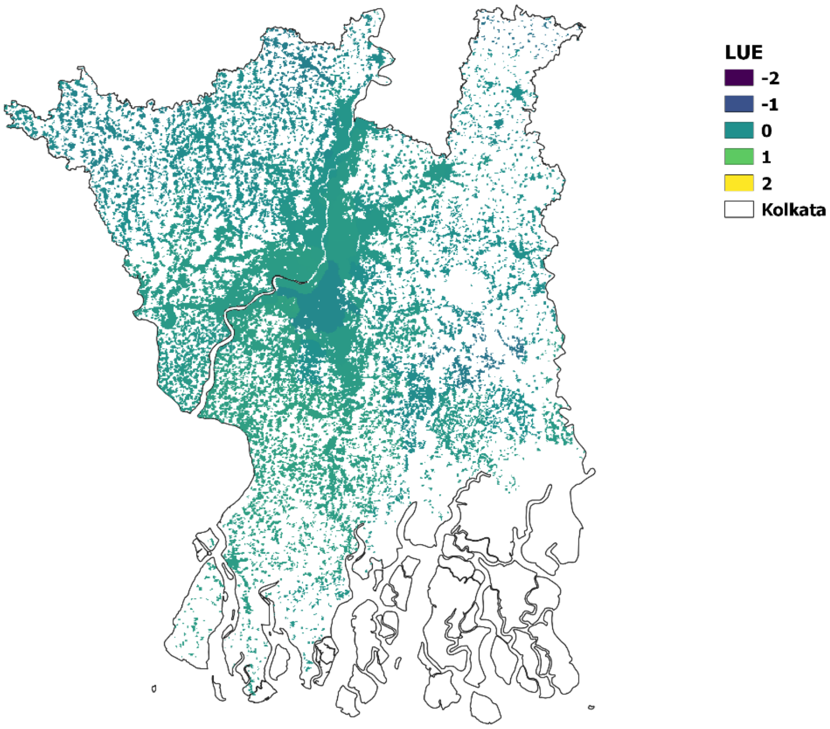

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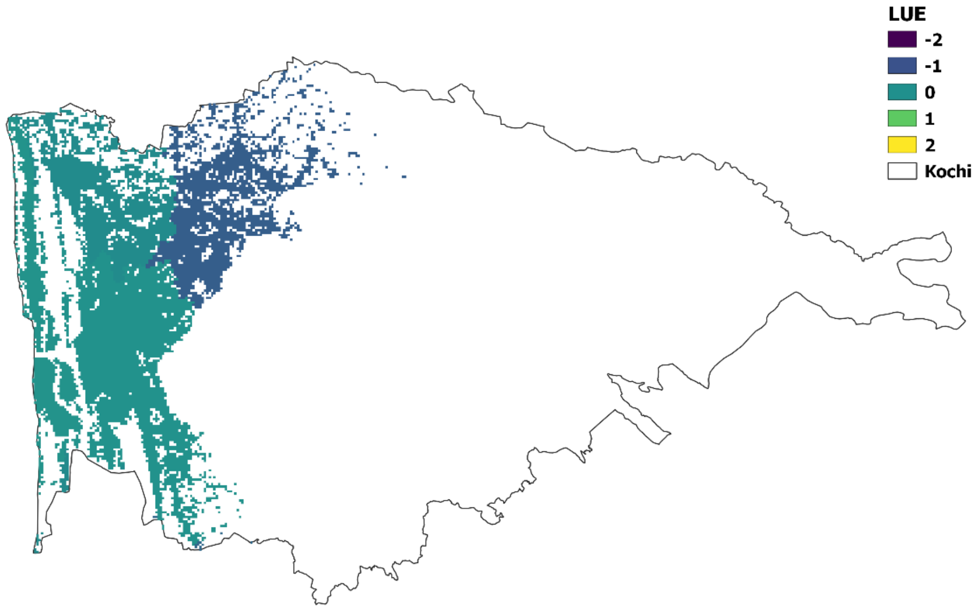

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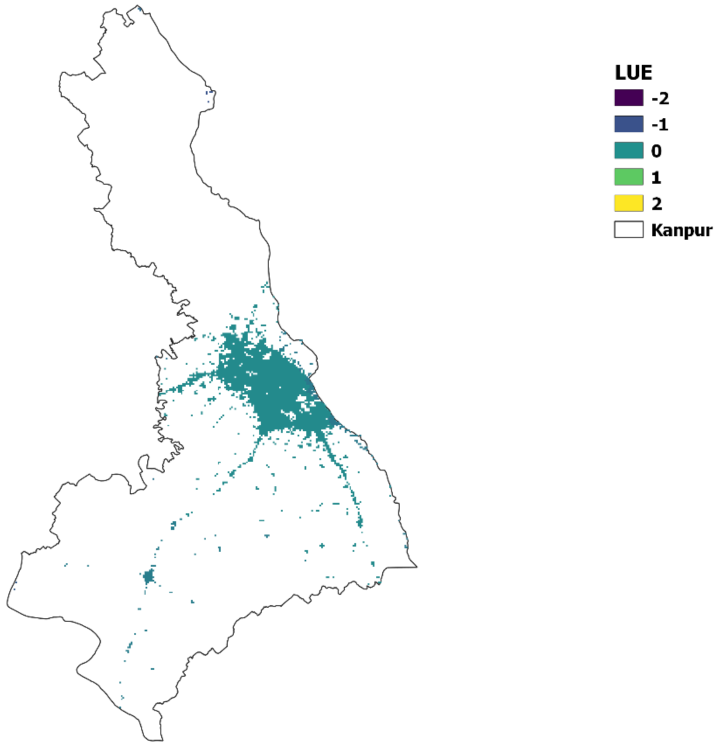

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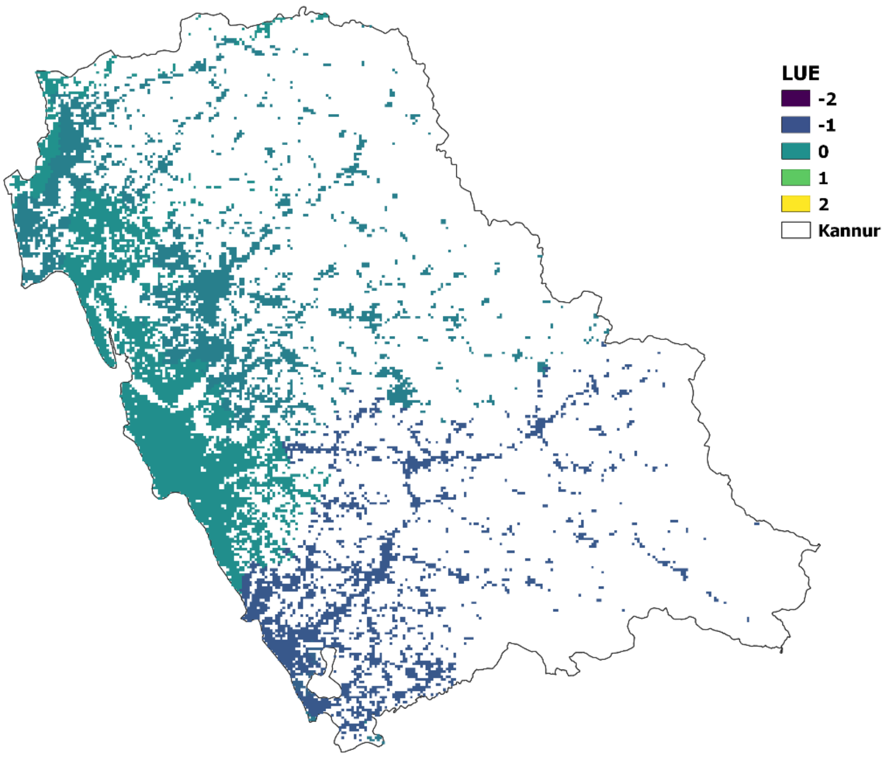

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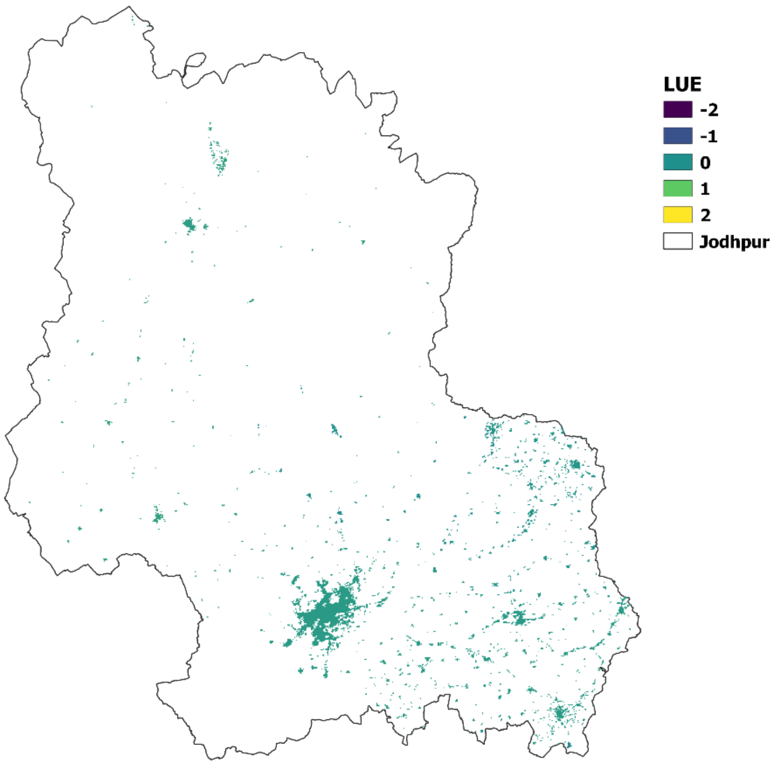

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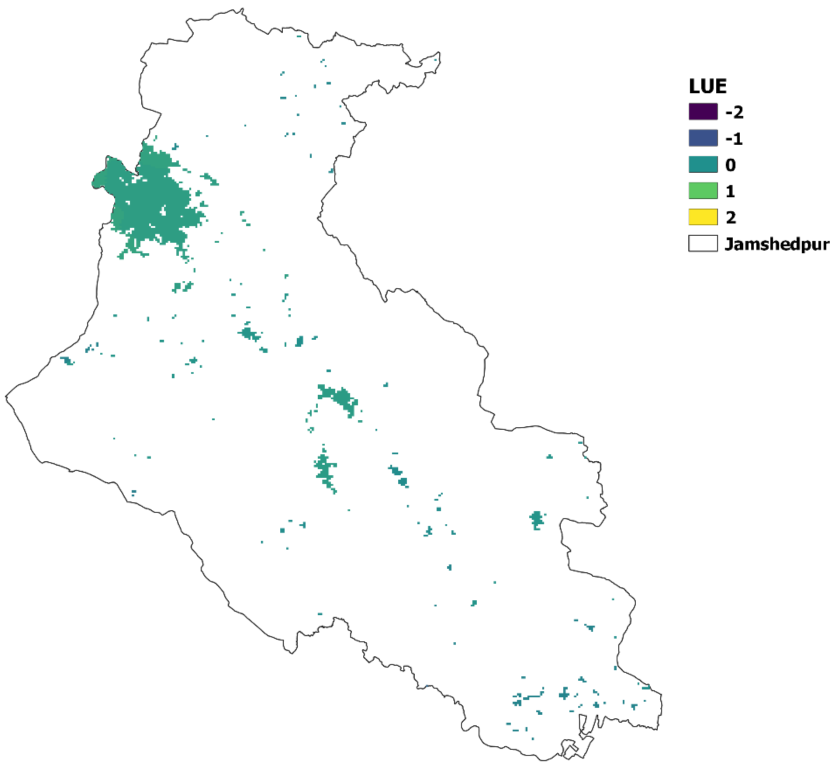

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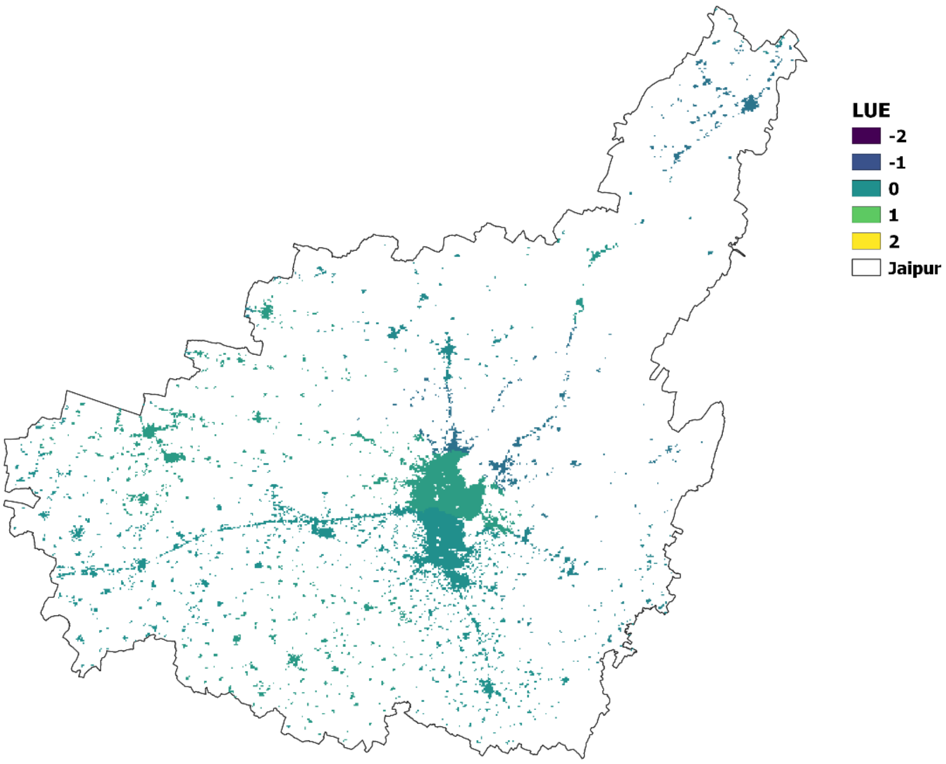

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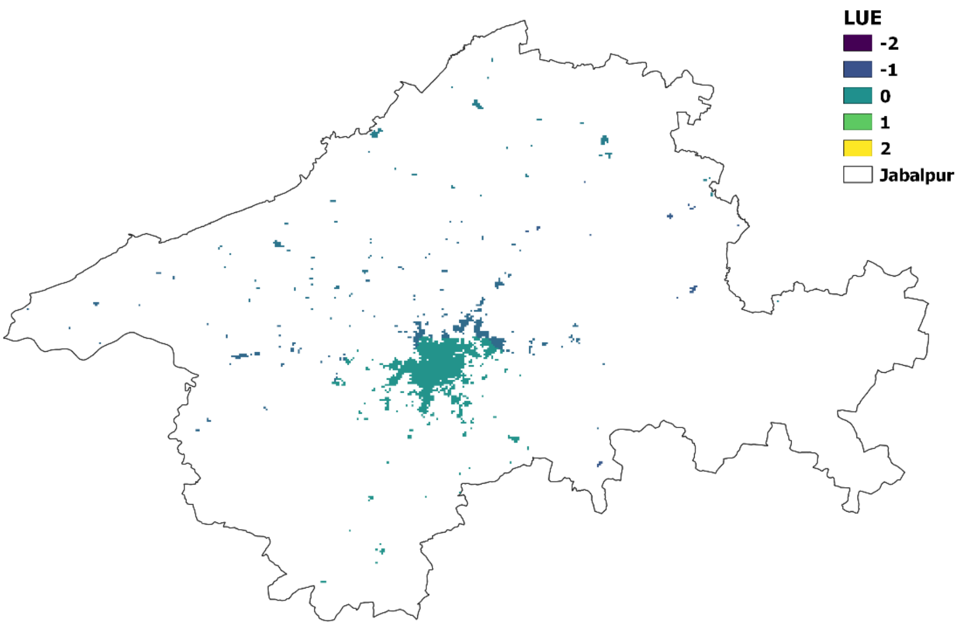

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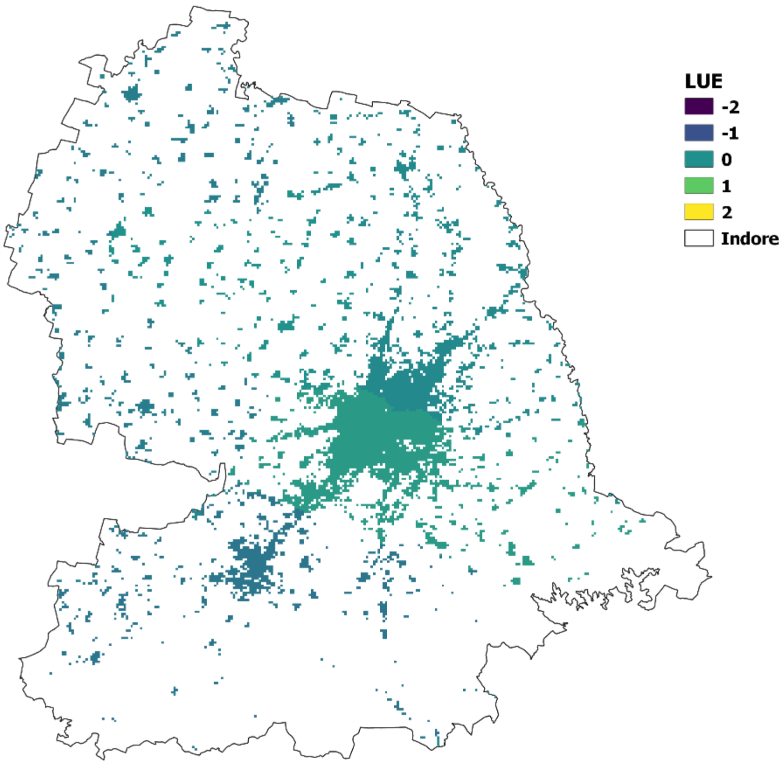

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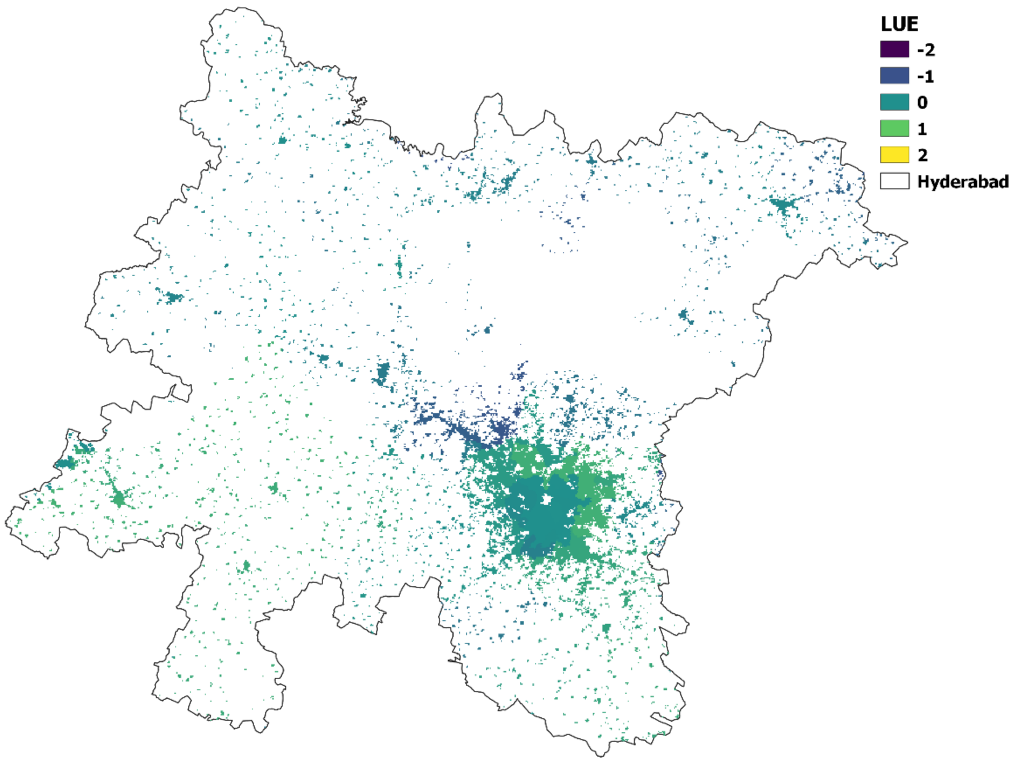

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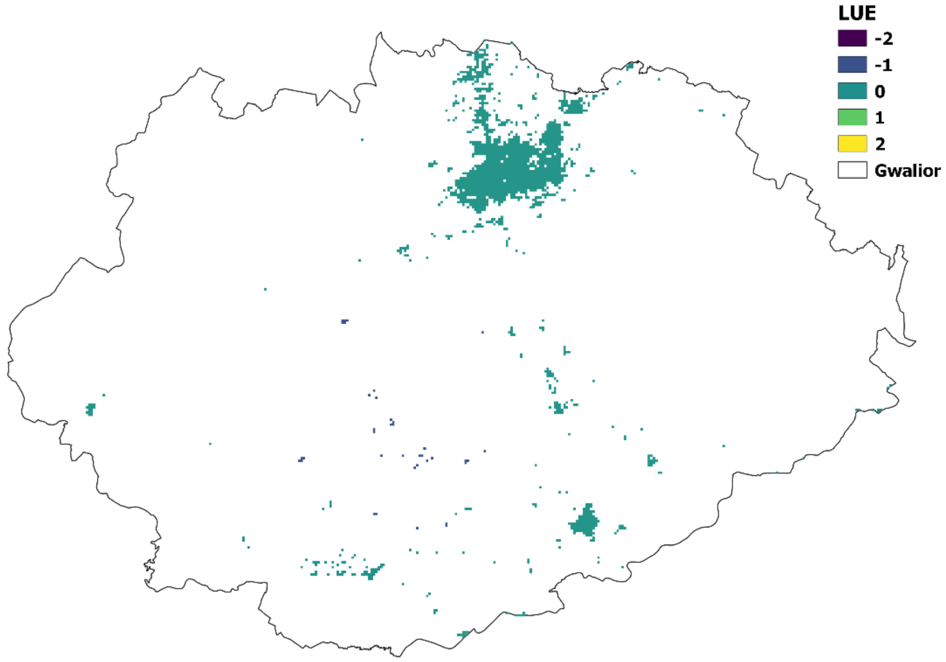

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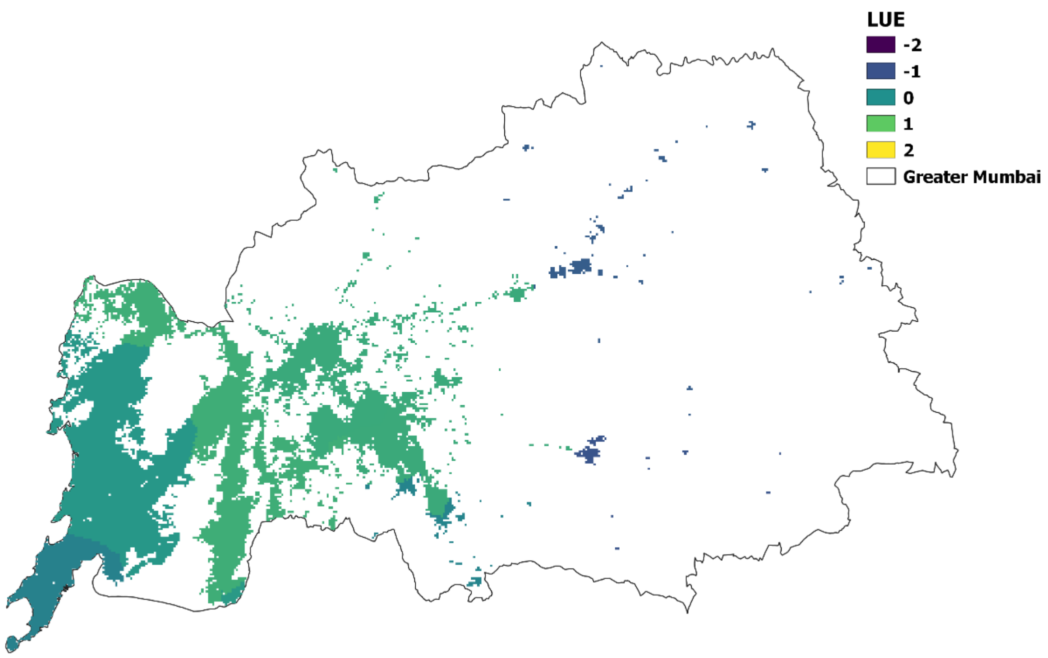

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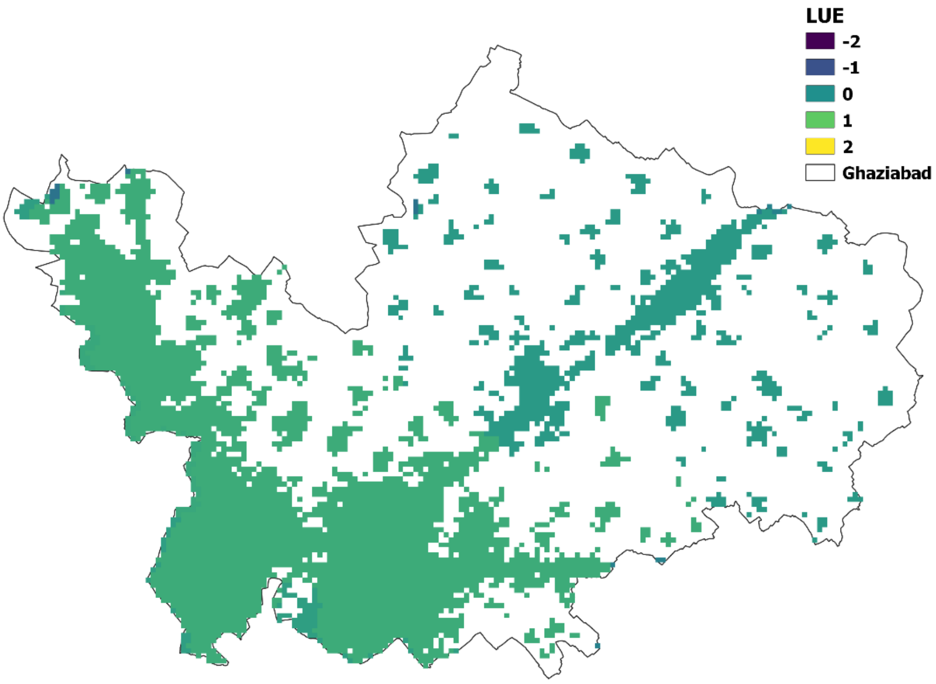

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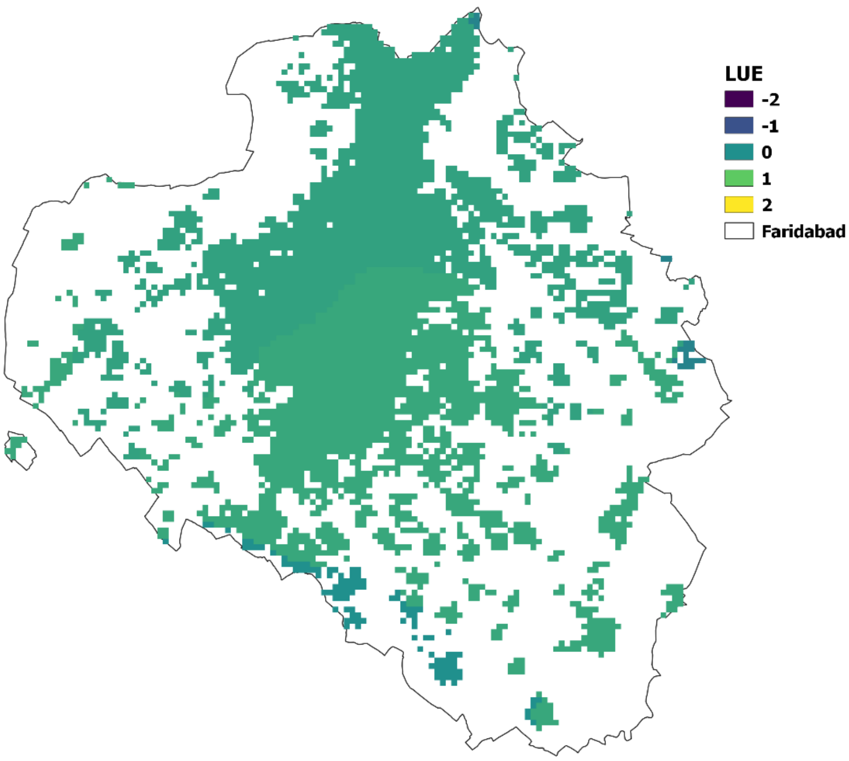

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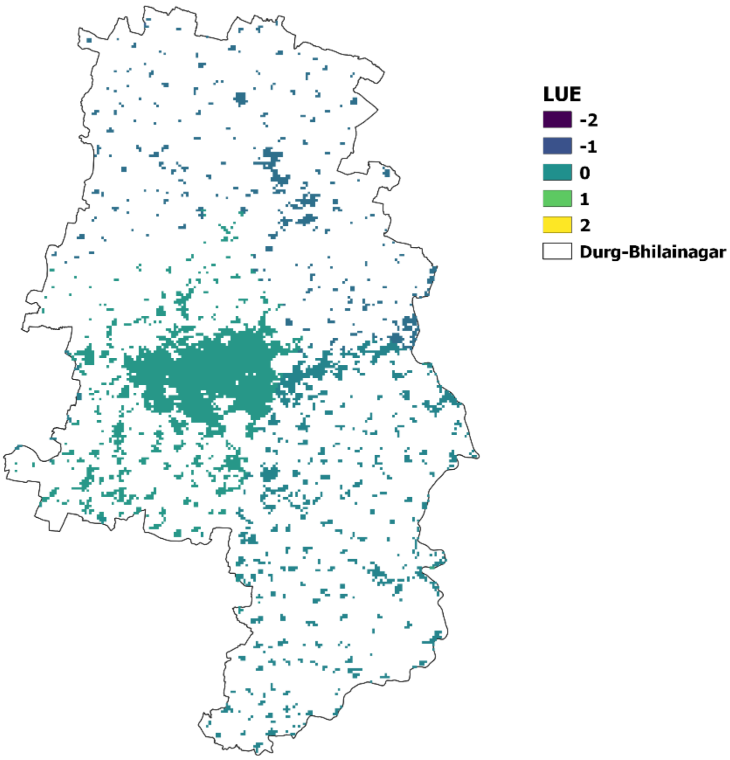

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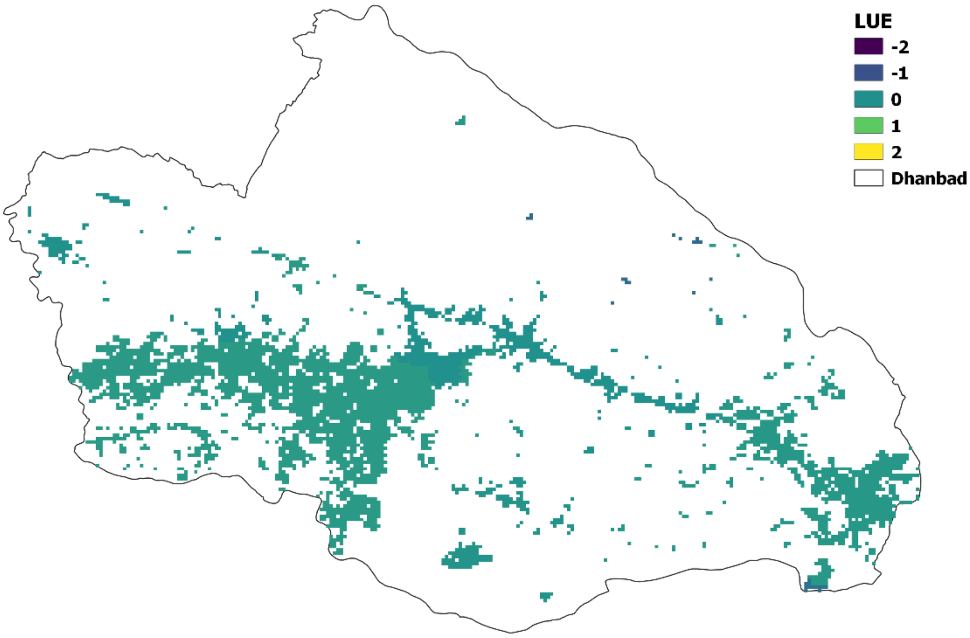

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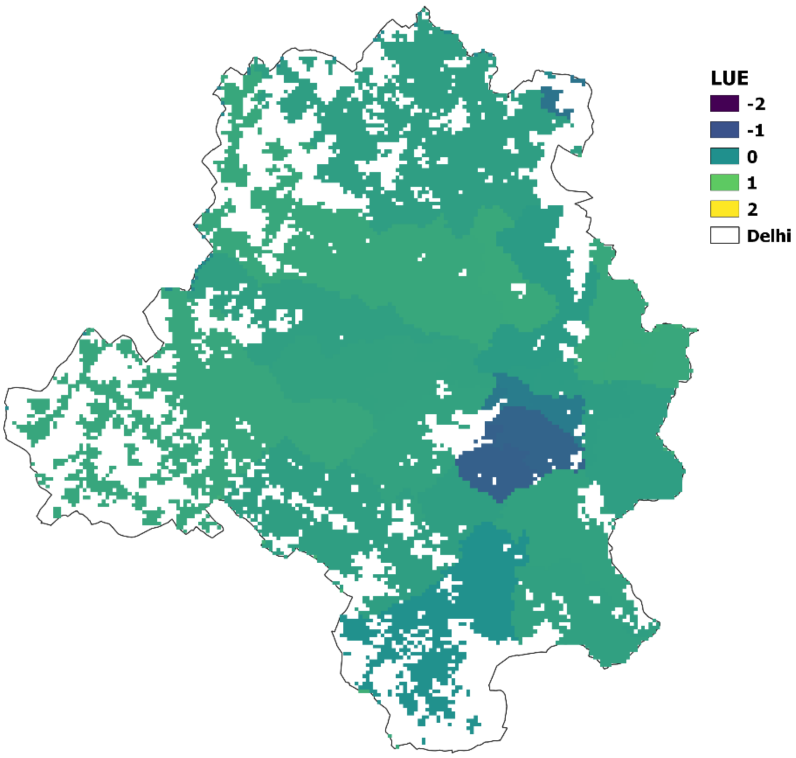

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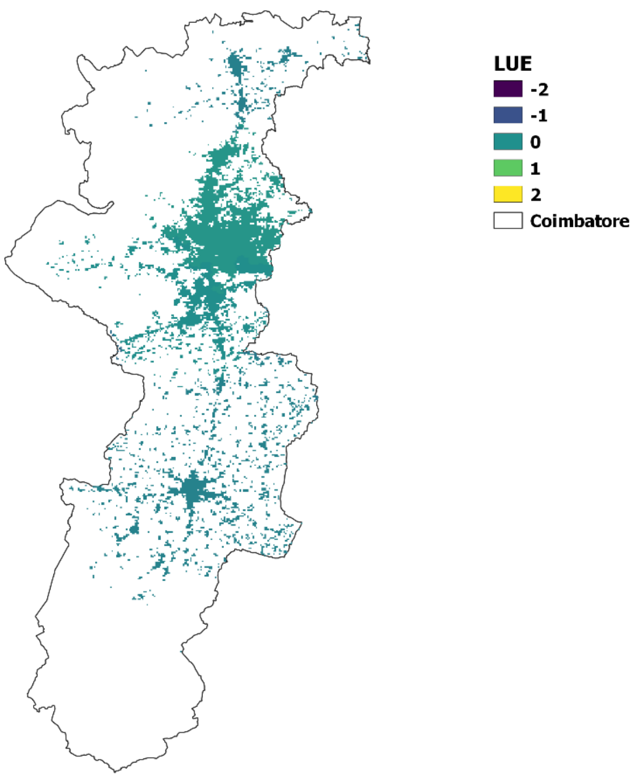

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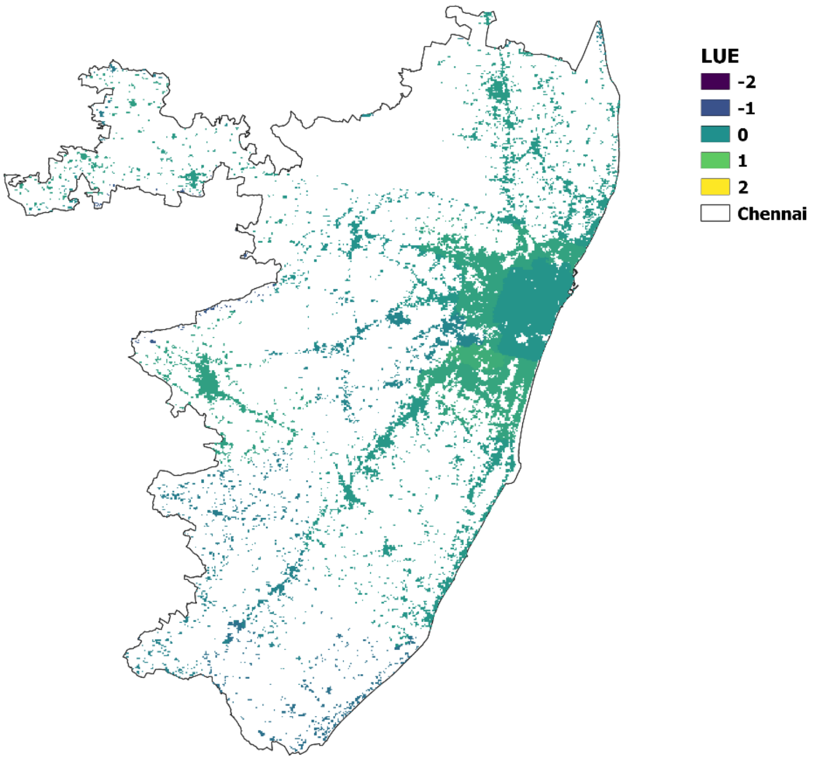

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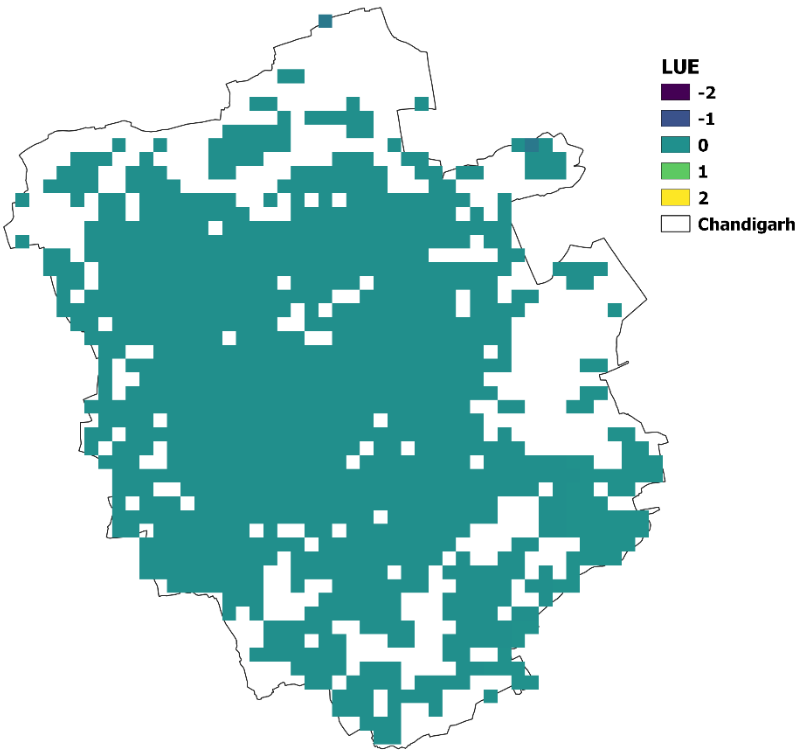

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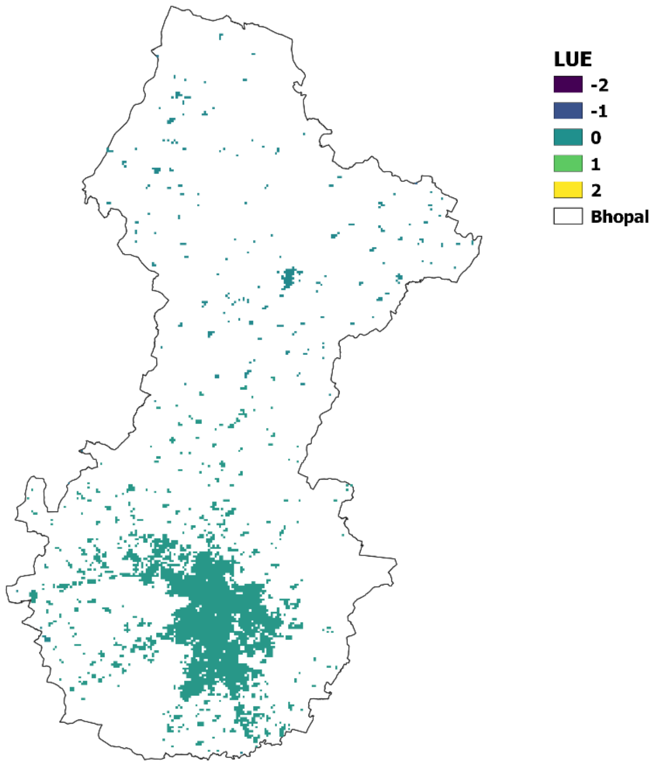

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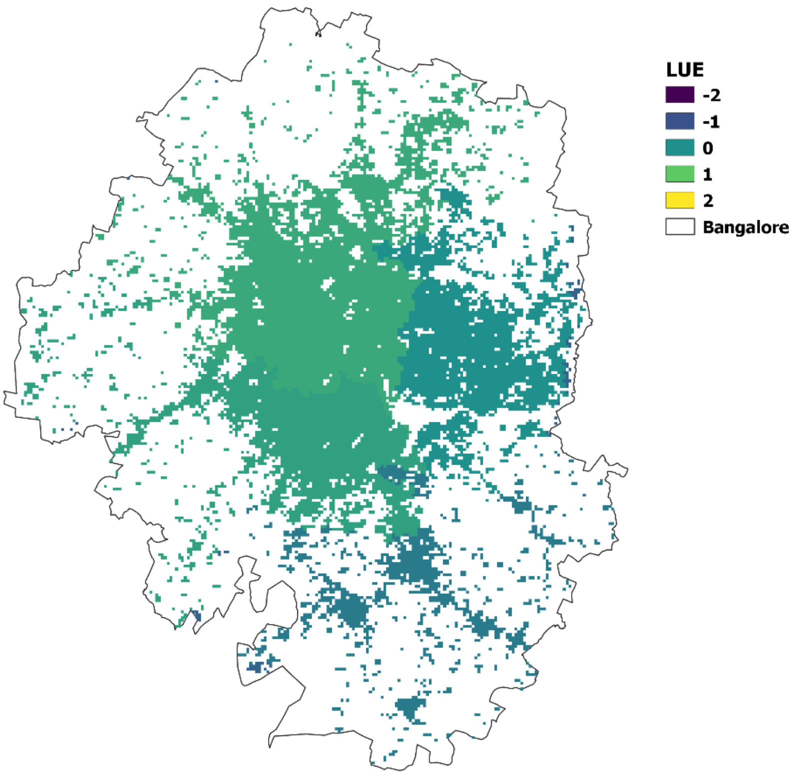

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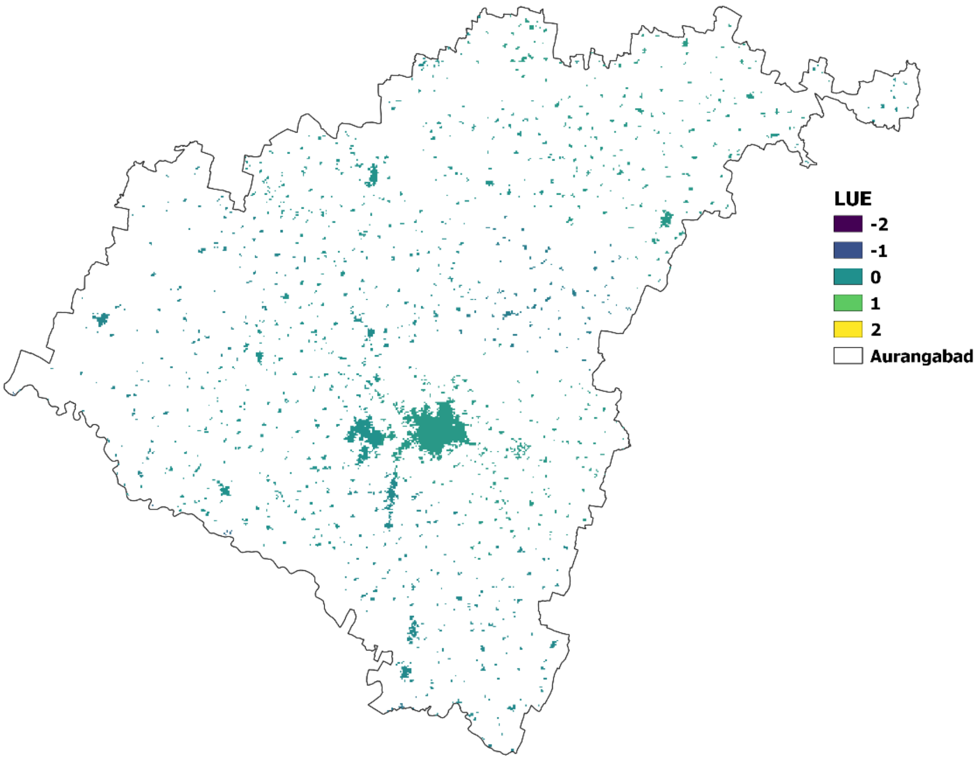

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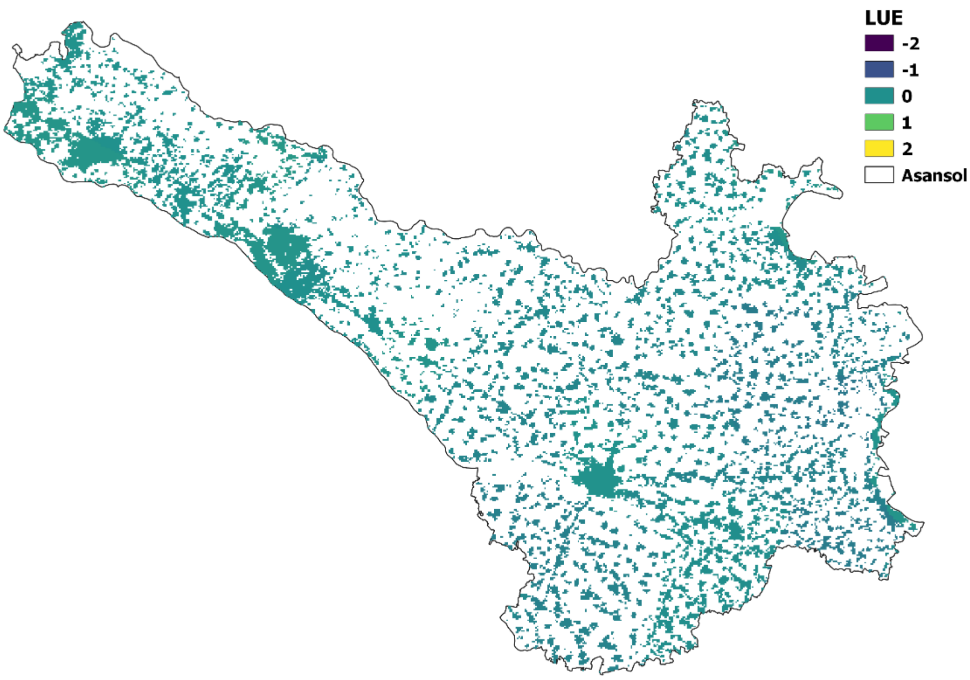

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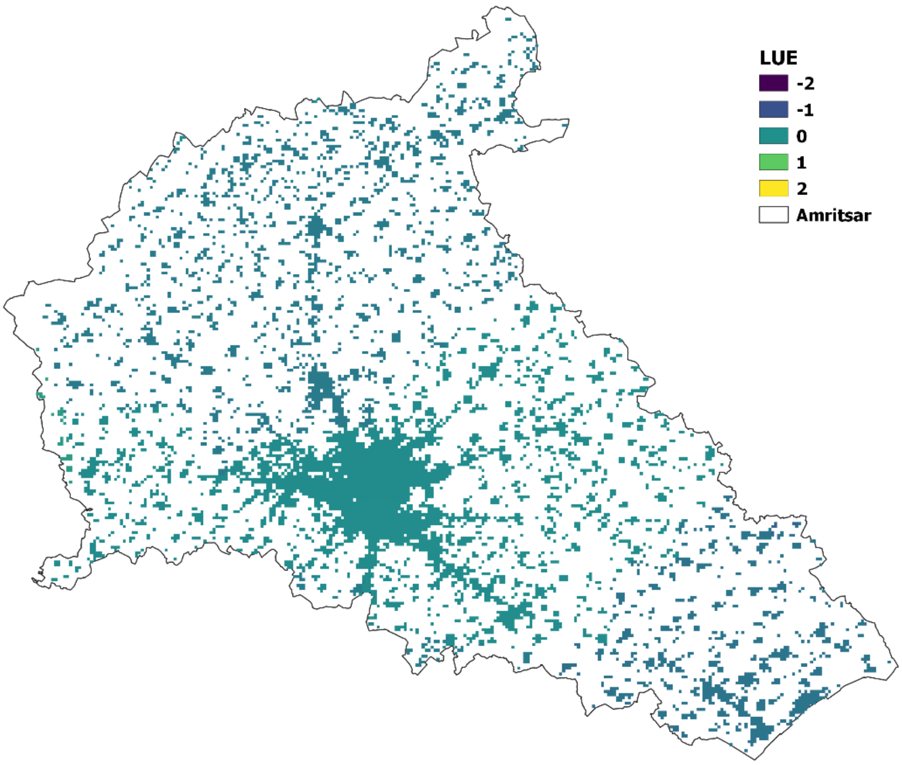

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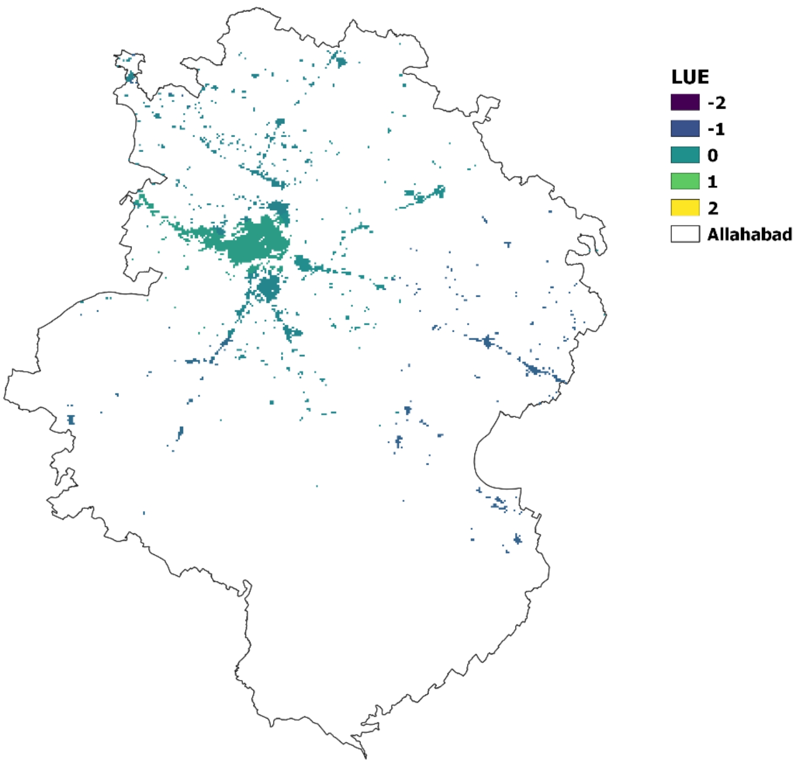

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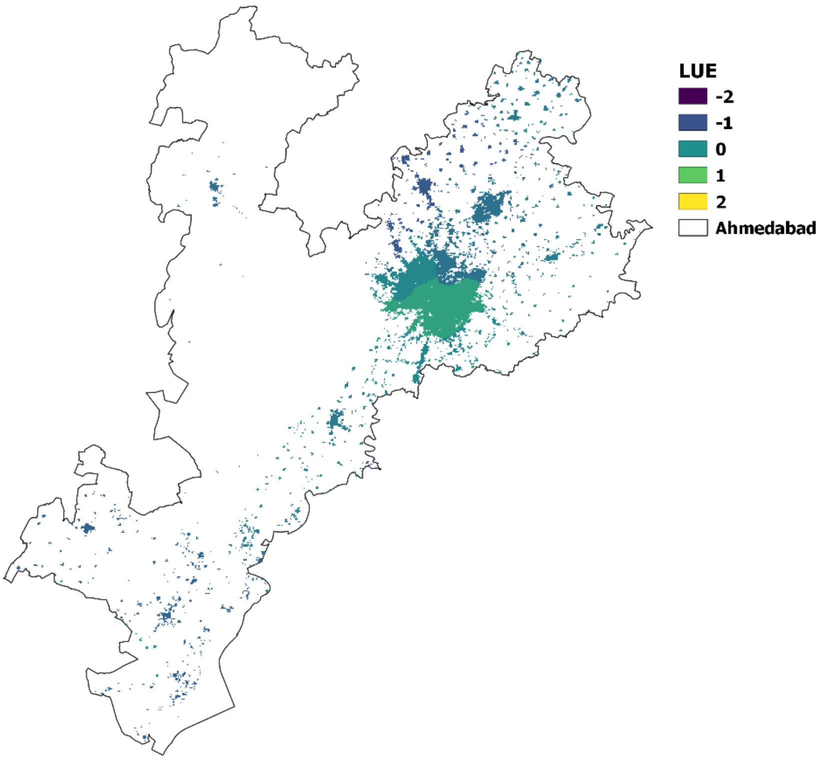

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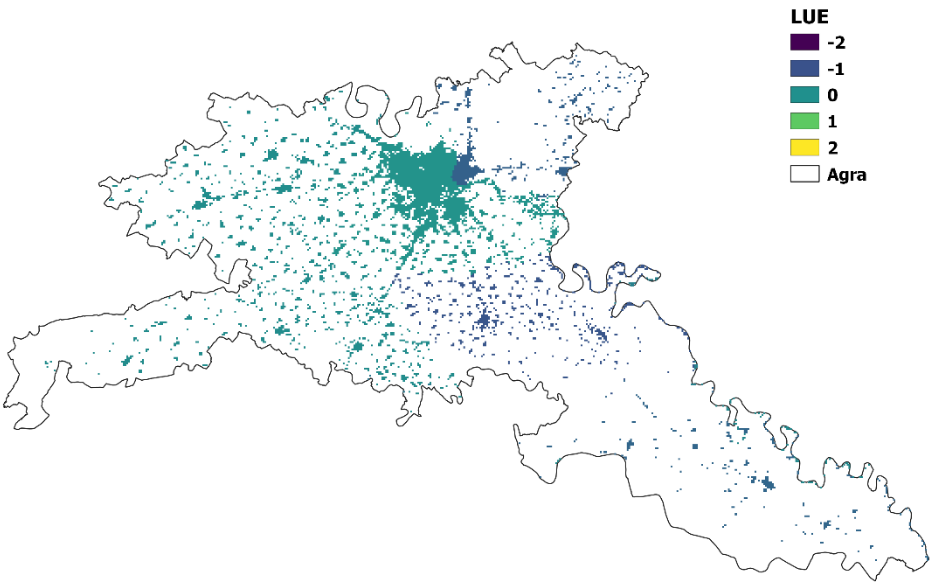

Annexure VI

SDG Target Indicators for testing calculation via SEEA[36]

SDG Indicator ID	SDG Indicator	Relevant Accounts
15.3.1	Proportion of land that is degraded over total land area	Ecosystem Condition Account & Ecosystem Extent / Land Cover Account
6.6.1	Change in the extent of water-related ecosystems over time	Ecosystem Extent / Land Cover Account & SEEA Water Accounts
15.1.1	Forest area as a proportion of total land area	Ecosystem Extent / Land Cover Account
15.9.1	Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020	All
6.3.1	Proportion of wastewater safely treated	SEEA Water Accounts
6.4.1	Change in water-use efficiency over time	SEEA Water Accounts
15.2.1	Progress towards sustainable forest management	Ecosystem Extent / Land Cover Account & Ecosystem Condition Account
15.4.1	Coverage by protected areas of important sites for mountain biodiversity	Biodiversity Account & Ecosystem Condition Account
11.3.1	Ratio of land consumption rate to population growth	Ecosystem Extent / Land Cover Account
14.5.1	Coverage of protected areas in relation to marine areas	Ecosystem Condition Account and Biodiversity Account
15.4.2	Mountain Green Cover Index	Ecosystem Extent / Land Cover Account & Ecosystem Condition Account
6.3.2	Proportion of bodies of water with good ambient water quality	SEEA Water Accounts & Ecosystem Condition Account

[36] https://seea.un.org/sites/seea.un.org/files/seea_for_sdgs_working_document_311019.pdf

SDG Indicator ID	SDG Indicator	Relevant Accounts
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	SEEA Water Accounts
8.9.1	Tourism direct GDP as a proportion of total GDP and in growth rate	Ecosystem Extent / Land Cover Account & Ecosystem Services Account
11.7.1	Average share of built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities	Ecosystem Extent / Land Cover Account & Ecosystem Services Account
14.4.1	Proportion of fish stocks within biologically sustainable levels	SEEA Central Framework Asset Accounts (Fisheries)
14.7.1	Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries	SEEA Central Framework Asset Accounts (Fisheries)