Shifting Land Use Patterns In India: A Comprehensive Analysis From 2004-05 To 2020-21

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Received: February 2022 **Accepted:** May 2022

Abstract
This study examines India's land use transformation from the 2005-06 to the 2020-21, driven by higher economic growth. Focusing on sector-specific trends, particularly the service sector versus agriculture, the research evaluates if the changing land use benefits more productive sectors and optimizes land resources. Employing satellite data and analysis, the paper aims to (a) study land use trends, (b) correlate sectoral land use with value-added growth, and (c) explore sector-wise land productivity variations due to economic, technological, and institutional shifts. Notably, non-agricultural land use has increased alongside industry and services growth, without diminishing agriculture. Instead, previously unused land is being economically utilized, a positive development. The fishing industry boasts the highest productivity growth (6.6%), while non-agricultural and agricultural sectors grow at 5.59% and 3.26%, respectively; however, forest production lags at 1.5% growth.

Key words: Land-use, Land-use patterns, Satellite imagery, agriculture.

1. Introduction:

As India gained independence in 1947, its economy was predominantly rooted in agriculture, which accounted for roughly half of the nation's Gross Domestic Product (GDP). However, this agricultural dominance has progressively waned over the years, dwindling to around 15% of the GDP today. Unlike the conventional trajectory of structural transformation observed in many economies, where manufacturing spearheads the shift away from agriculture before being reinforced by the services sector, India's experience has been distinct. The service sector's ascendancy took precedence over traditional industrialization, leading to India evolving into a service-driven economy. Consequently, agriculture's share has diminished, and manufacturing's contribution has plateaued.

Amidst this evolution, the consistent growth in the economy has raised questions about land productivity. Although the country's land area remains constant, one could infer that partial land productivity has increased in tandem with economic expansion. However, this growth has not been uniformly distributed across sectors. Agriculture, for instance, exhibited slower growth, resulting in its declining share of the GDP. Meanwhile, the service sector, among the non-agriculture segments, emerged as a key driver of overall economic growth.

In light of these divergent growth rates among sectors, our research endeavours to examine the transformations in land use patterns within India from 2004-05 to 2020-21. Of particular interest are two key questions: Firstly, whether the land use pattern has shifted towards more productive sectors of the economy; and secondly, whether the economy has efficiently harnessed its land resources to accommodate greater economic activity.

To address these questions, our study embarks on an extensive investigation of India's land use patterns during the specified time frame. The study's primary objectives encompass three dimensions:

a) To dissect the trends in land use patterns and delve into the allocation of land across various sectors.
b) To establish a nexus between the land use within specific sectors and the growth in their respective sectoral gross value added.
c) To scrutinize the patterns of sector-specific partial land productivity, and elucidate these patterns through the lens of economic, technological, and institutional changes.

The research methodology employs front-line techniques, leveraging satellite imagery-based land use data. By employing graphical and econometric tools, we aim to distil meaningful insights from the collected data. The implications of our findings extend beyond the immediate scope of our study. They bear relevance to broader, long-term concerns such as maintaining the growth trajectory of non-agricultural sectors while upholding the country's food security.

In the subsequent sections, we delve into the intricate details of our research methodology, data sources, and analytical framework. Through our rigorous examination of India's evolving land use patterns, we endeavour to shed light on the complex interplay between economic dynamics, land allocation, and sustainable growth.

The current paper is divided into seven sections. The second section describes the materials and methods employed in this study. Section three provides a quick review of the theoretical basis. In section four land-use/land-cover trends were investigated. Section five discusses the relationship between sector-specific gross value added and trends in land use patterns. Section six investigates inter-sectoral land productivity and growth rates. The broad findings of the whole exercise are summarised in the concluding section.

2. Data and Methodology:

2.1 Preparing the Data:

The study is based on secondary data gathered from various sources.Satellite imagery Land use data have been collected from the National Remote Sensing Centre (NRSC), ISRO, Hyderabad. There are two sets of data are available under land use land cover change (LULCC) categoriesin India with two different scaling: (a) National Land Use/ Land Cover Mapping on 1:50,000 scale using temporal Resourcesat-1 Linear Imaging Self Scanning Sensor (LISS) -III data. Data available under this category for the years 1985, 1995, 2005, 2011 and 2011; and (b) National Land Use and Land Cover Mapping using Multi-temporal AWiFS Data (1:250,000 scale) — LULC-AWiFS. Continuous data are available under this category from the year 2005-06 to 2018-19 and for 2020-21.From the Directorate of Economics and Statistics, Government of India, sector-wise composition of gross value added (GVA) at 2011-12 constant price was collected for the year 2005-06 to 2020-21.

2.2 Area Covered and Analytical Framework:

The study covered analysis at all India levels. Using LULC-AWiFS data, we have drawn continuous graph to show the trend of land use pattern. The correspondence between structural change and land-use patterns were examined by juxtaposing the sector-wise composition of GVA and land-use pattern with graphical presentation. For correspondence we reclassified both the sector-wise GVA and land use/land cover into agriculture, non-agriculture, forestry and fishing sectors. Table-1 shows the reclassification of land use/land cover and GVA:

Table-1: Reclassification of Land and Sector-wise GVA

SL No.	Sector	Land-use Types	GVA
1	Agriculture	Kharif crop only, Rabi crop only, Zaid crop only, Double/Triple/Annual Crop, Plantation/Orchard, Current Fallow, Grassland, and Shifting Cultivation	GVA from Crops and Livestock
2	Non-agriculture	Built-up (area of human habitation developed due to non-agricultural use and that has a cover of buildings, transport and communication, utilities in association with water, vegetation and vacant lands). [Mining area not included]	GVA fromManufacturing, Construction, Electricity, gas, water supply, other utility services, Transport, storage, communication, services related to broadcasting, Trade, repair, hotels and restaurants, financial services, Real estate, ownership of dwellings, professional services, public administration and defence and other services. [GVA from Mining and quarrying not included]
3	Forestry	Evergreen/ Semi-evergreen Forest, Moist/Dry Deciduous Forest, Shrub/degraded forest, and Littoral / Swamp / Mangrove	GVA from Forestry and Logging
4	Fishing	Waterbodies maxspread, and Waterbodies min spread (Which include Aquaculture, Wetlands, River / Stream / canals etc.)	GVA from fishing and aquaculture

Partial productivity indices of sector-wise land were carried out to understand the correspondence. Land productivity is defined as the sector's GVA per hectare of land. Inter-sectoral land productivity is calculated as:

$LP_i = \frac{SGVAi}{LUi}$---------(2)

Where, LP_i is land productivity of ith sector,$SGVAi$ is the sectoral GVA of ith sector and LUi is the land-used by ith sector.
Where, i-takes value 1, 2, 3 and 4 for Agriculture, Non-agriculture, Forestry and Fishing, respectively.

Given that the levels of productivity are highly disparate in absolute terms, we created productivity indices for each sector using the base years 2005-06 to compare the productivity of agricultural, non–agricultural, forestry, and fishery land.
To formally analyze the overall growth rate of land productivity a linear trend equation was fitted to partial productivity of each sector. The equation was specified as:
$lnY_{it} = a + bt + u_t$-----------(3)
Where, t= 1, 2, 3………., 16, starting with 2005-06 as 1 for the sectors agriculture, non-agriculture, forestry and fishing sector.
$Y_i$is the partial land productivity (i.e., GVA/ Land) of sector i,
i= Agriculture (A), Non-agriculture (N), Forestry (F) and Fishing (S),
and u is the random disturbance term.

3. Some of the Theoretical Backgrounds:

3.1 Land:

Land refers to the solid surface of the earth, which includes all natural resources such as soil, water, air, minerals, and vegetation. It is an important natural resource that supports human and non-human life and provides a range of ecosystem services such as food and water supply, climate regulation, and biodiversity conservation.

Land is a limited resource that is affected by natural processes and human activities, including land-use changes, deforestation, soil erosion, pollution, agriculture, mining, and urbanization. Some of these activities have negative impacts on the environment such as greenhouse gas emissions, soil degradation, and habitat loss, which can lead to a decline in ecosystem services.

3.2 Land Use/Land Cover (LULC):

Land use and land cover refer to the ways in which humans use the land and the natural vegetation and other features that cover the land. Land use relates to how people use the land, while land cover refers to the physical and biological coverage of the land's surface.

Land use and land cover can vary greatly depending on the location and human activities in that region. Common forms of land use include agricultural land, urban areas, forests, wetlands, and water sources. Land cover includes trees, shrubs, grasses, crops, water bodies, and natural habitats.

Land use and land cover changes are closely linked to human activities and have significant environmental impacts. Deforestation and desertification lead to significant soil erosion, reduced water availability, impacts on local biodiversity, and ultimately threaten the livelihoods of people who depend on these resources.

3.3 Land Use/Land Cover Patterns:

Land use/land cover patterns refer to the spatial arrangements of different types of land use and land cover on the earth's surface. These patterns can be determined using remote sensing techniques such as satellite imagery, and are influenced by environmental, cultural, social and political factors.

Some common land use land cover patterns include urban areas, agricultural landscapes, forested areas, wetlands, and water bodies. In urban areas, land use patterns often show a high concentration of residential, commercial, and industrial areas with low vegetation cover. In contrast, agricultural landscapes typically exhibit a patchwork of crop types or field boundaries, while forested areas tend to be dominated by a single forest type. Wetlands and water bodies may vary in size and shape depending on the geography of the area.

3.4 Satellite Imagery:

Satellite imagery is an important tool for mapping and monitoring land use land cover. Satellite sensors capture images of the earth's surface from space, which can be used to identify and classify different types of land use land cover. There are many different types of satellite imagery that can be used for land use land cover analysis, including optical, radar, and thermal sensors.

Optical sensors, such as those found on the Landsat and Sentinel satellites, detect visible and near-infrared light, allowing for the identification of different types of vegetation, water bodies, and urban areas. Radar sensors are particularly useful for mapping land cover in areas with heavy cloud cover, vegetation, or topographic barriers. They use microwave radiation to penetrate through vegetation and detect the shape and structure of the earth's surface.

Thermal sensors measure the temperature of the earth's surface, which can be used to map areas with different types of land use, such as urban areas, forests, and agriculture.

By analyzing different types of satellite imagery, land use land cover can be identified and classified at various spatial and temporal scales. This information can then be used to build models predicting future land use changes or to evaluate the impacts of different land use scenarios on the environment.

3.5 Land Use/Land Cover using Satellite Imagery:
There are numerous methods for monitoring or detecting changes in ground cover over time. Previously, scientists used field data and aerial photos to map Land Use Land Cover Change (LULCC) over smaller areas. As the scope of the research expands, these methods become prohibitively expensive and time consuming. Remote sensing via satellite imagery is an excellent tool for studying LULCC because images can cover vast geographic areas and have a high temporal resolution. Remote sensing is also used to examine historical LULCC and to provide data (e.g., ground truth) in inaccessible areas. The main drawbacks of remote sensing stated as the inability of many sensors to collect data and information through cloud cover, the possibility of mistaking different phenomena if they appear the same to the sensor, the possibility that the resolution of satellite imagery is too low for fine-scale mapping and for separating minute contrasts, and the high cost of very high-resolution satellite imagery (Fonji and Taff 2014).

Despite these drawbacks, remotely sensed satellite data have been employed to detect changes in a range of land and aquatic habitats, including coastal, agricultural, forested, and urban settings(Berlanga and Ruiz 2002). This is especially true for remote areas, which are frequently inhospitable and difficult to reach, making it difficult to gather the necessary data using conventional techniques. (Roberts et al. 2003; Cingolani et al. 2004). Remote sensing data is frequently used by LULCC researchers to provide details on resource inventories and land use, as well as to recognize, track, and measure changing patterns in the landscape. In many parts of the globe, population shifts and distribution play a significant role in LULCC. Census data and biophysical data have been combined to better comprehend the local, regional, and global drivers of LULCC since the development of GIS over the past two decades (Mladenoff et al. 1995; Lo and Faber 1997; Cardille and Foley 2003; Codjoe 2004; Mena et al. 2006; Kamusoko et al. 2009; Radeloff et al. 2000). Using satellite images and socioeconomic data, Dewan et al. (2009) examined shifts in land use and land cover as well as urban growth in Greater Dhaka, Bangladesh, between 1975 and 2003.

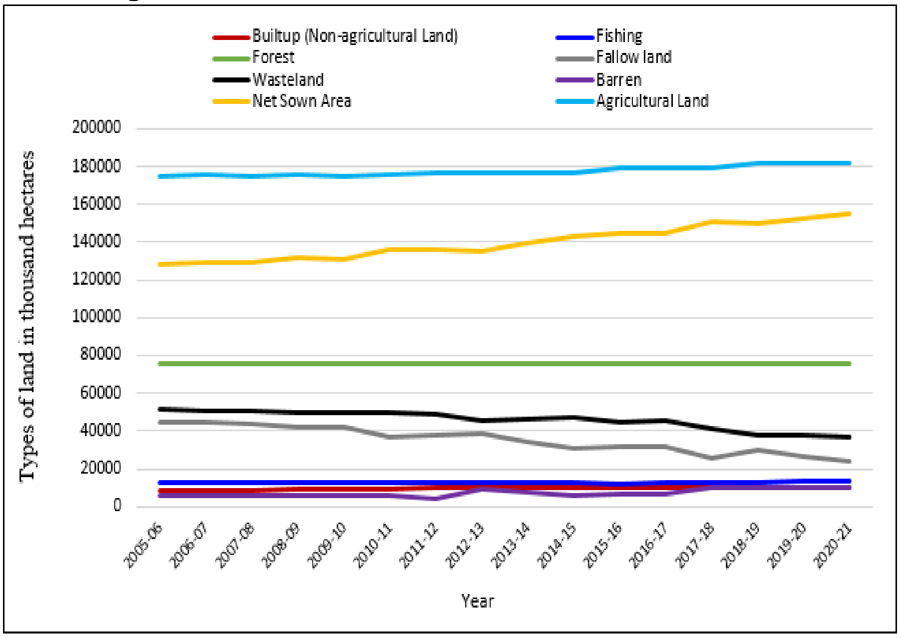
The Indian experience on use of satellite data for LULC analysis mainly comes from studies conducted at National Remote Sensing Agency (NRSA) in collaboration with various central and state government organisations.

There are two sources of data available under land use land cover change categories in India:
(I) National Land Use/ Land Cover Mapping on 1:50,000 scale using temporalResourcesat-1 Linear Imaging SelfScanning Sensor (LISS) -III data:It has been taken up by the Department of Space (DOS) as part of the National Natural Resources Repository (NRR) Programme's Natural Resources Census (NRC) Project. The project was conducted in collaboration with numerous state, central, and private universities, as well as other partner institutes. The land-use/Land-cover classification scheme of1:50,000scaleconsists of Level-I: 9 classes, LevelII: 29 classes and Level-III: 79 classes(NRSA, 2007).

(II) National Land Use and Land Cover Mapping using Multi-temporal AWiFS Data: Recognising the significance of LULC across time, regional-level mapping was done in India using IRS AWiFS data with a spatial resolution of 56 metres to identify causes, rates, magnitudes, patterns, and trends in land use and land cover changes. Using multi-temporal satellite data, a composite land use and land cover data collection was created for this study. The analysis is being done on a 1:250,000 scale with Level-I and certain Level-II land use classifications (Roy et al. 2006).

4. Trends in the Land Use/Land Cover Change in India
Figure-1 depicts the trend of land use in India from 2005-06 to 2020-21 on the basis of AWiFS data. As shown in the figure it is seen that the trend of net sown area increases on the other hand the trend of fallow land has been declining. However, the overall agricultural land has been increasing over the years and thetrend gets more intense after 2014-15 [figure-2 clearly reflects the trends of agricultural land]. Built-up land and fishing land have been increasing. On the other hand, waste land has been declining over the years.

Figure-1: Land-use Pattern in India from 2005-06 to 2020-21



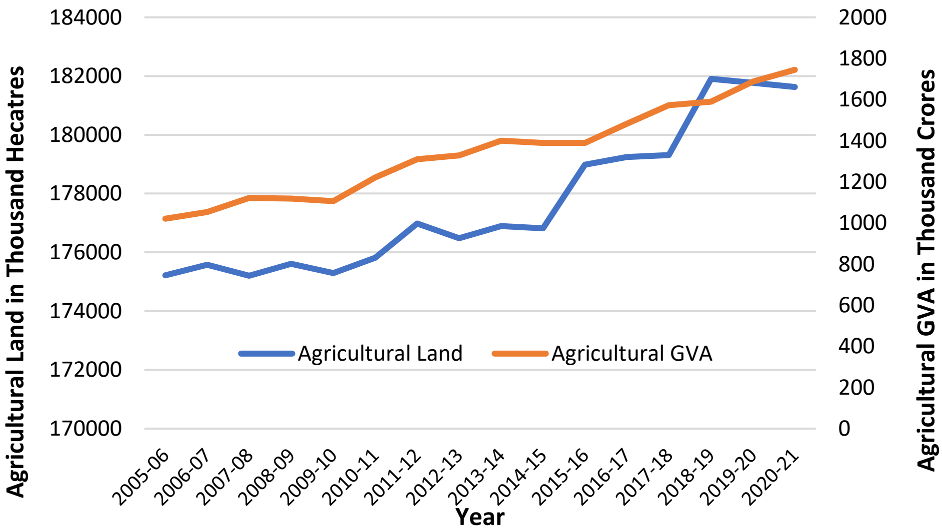
Source: Authors construction using data from Government of India
Note: Missing values for the year 2019-20 have been incorporated using linear interpolation technique

Thus, from the aboveanalysis it is found that the net sown area has been increasing since 2005-06 as well as the overall agricultural land also increases. Non-agricultural land as well as fishing land have been increasing. On the other hand, waste land and fallow land have been declining during the time period. Forest land has remained almost constant over the years. However, the barren land has been increasing during the time frame. Thus, increase in the land use under agriculture, non-agriculture and fishing have been possible because of reclaiming of waste land, activation of fallow land.

Thus, what we found from the above analysis is that land in India has been utilizing from the unproductive use to productive use. To understand whether more productive sectors are getting more land or not we studied the correspondence of sectoral GVA and land use and the partial land productivity in the following section.

5. Sector-Wise Land Use and Correspondence with Share in GVA:
Figure-2 illustrates the relationship between agricultural land and agricultural GVA in India from 2005-06 to 2020-21. The figure shows that the GVA from agriculture has been increasing in absolute terms, and the land use under this category has also been increasing during the same period.

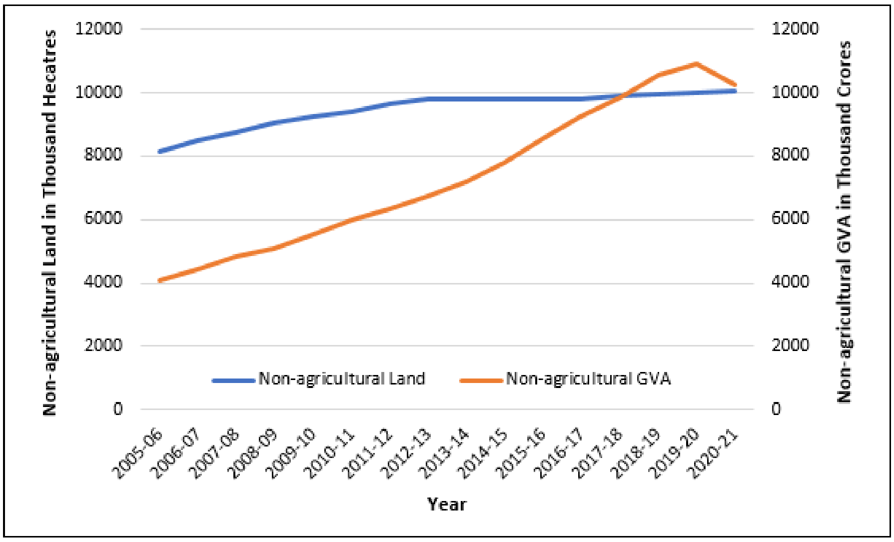
Figure-2: Correspondence between Agricultural Land and Agricultural GVA in India from 2005-06 to 2020-21



Source: Authors construction using data from Government of India
Agricultural GVA was calculated using constant prices in 2011-12

Figure-3 demonstrates the correlation between non-agricultural land (excluding mining and quarrying) and non-agricultural GVA (excluding mining and quarrying) in India from 2005-06 to 2020-21. The figure shows that the GVA under the non-agricultural sector has been increasing until 2019-20 but declined in the following year due to the COVID-19 pandemic. Correspondingly, the land use under the non-agricultural sector has also been increasing over time.

Figure-3: Correspondence between Non-agricultural Land and Non-agricultural GVA in India from 2005-06 to 2020-21

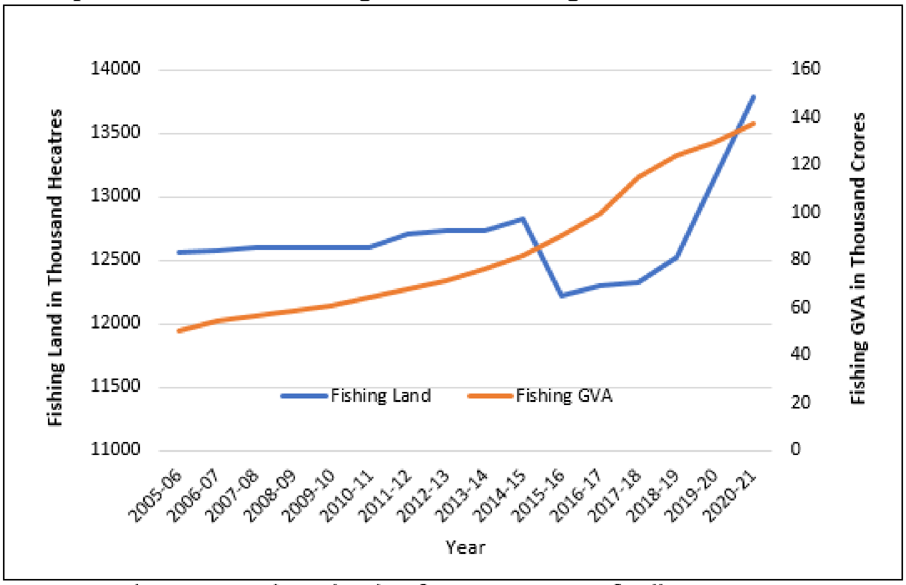


Source: Authors construction using data from Government of India
Note: Non-agricultural Land included only Built-up (Rural and Urban) and not included Mining and quarrying land and fishing land. Correspondingly Non-agricultural GVA not included Mining GVA and Fishing GVA.

Non-agricultural GVA was calculated using constant prices in 2011-12

Figure-4 displays the correlation between fishing GVA and fishing land in India from 2005-06 to 2020-21. The figure shows that the GVA from fishing has been increasing over time, and the land use under this sector has also been increasing. However, the growth rate of fishing land was nominal until 2015, and since then, it has increased at a higher rate after a sudden fall in 2015-16.

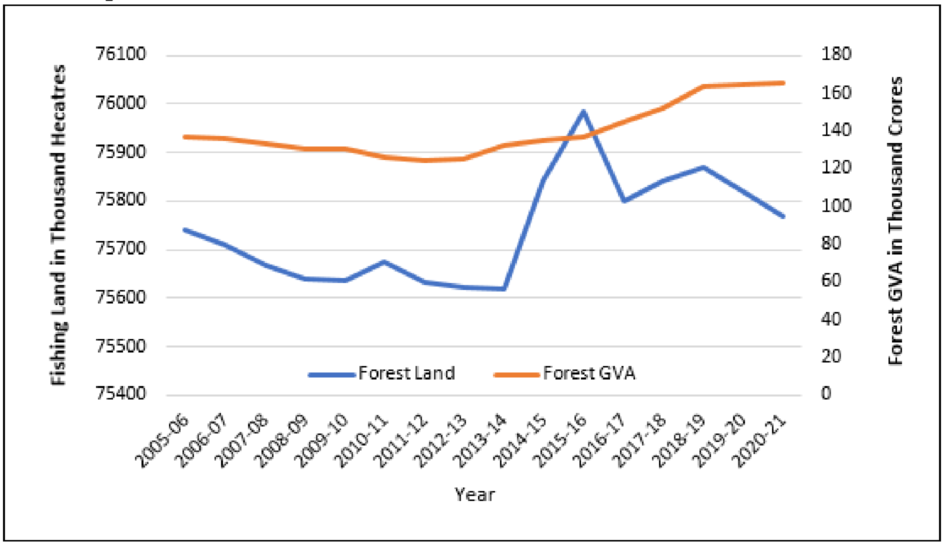
Figure-4: Correspondence between Fishing Land and Fishing GVA in India from 2005-06 to 2020-21



Source: Authors construction using data from Government of India
Fishing GVA was calculated using constant prices in 2011-12

Figure-5 presents the correlation between forest land and forest GVA in India from 2005-06 to 2020-21. The figure shows that the GVA from forestry has been increasing marginally over time, and the land use under forestry has remained almost constant during the period.

Figure-5: Correspondence between Forest Land and Forest GVA in India from 2005-06 to 2020-21



Source: Authors construction using data from Government of India
Forest GVA was calculated using constant prices in 2011-12

6. Sector-wise Partial Land Productivity in India:

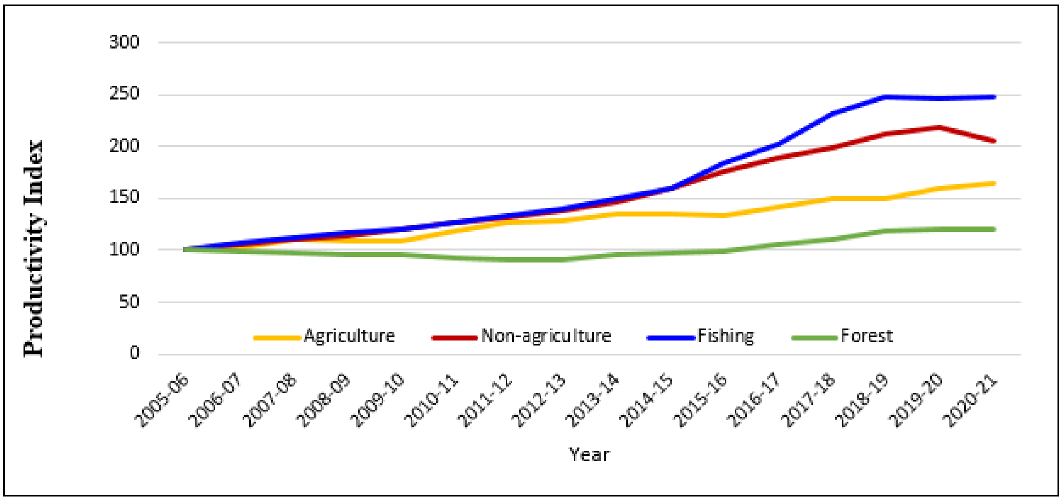
Table-2 displays the partial land productivity of the agricultural, non-agricultural, forestry, and fishing sectors. Agricultural sector productivity is comparatively low because agriculture is a land-intensive activity, while non-agricultural sector productivity is the highest among the other sectors. Forest sector productivity is the lowest and has remained almost constant over the years. Fishing sector productivity is also low compared to agriculture and non-agriculture.

Table-2: Sector-wise Partial Land Productivity in India (GVAin Lakh/land in hectares)

Year	Agriculture	Non-agriculture	Fishing	Forest
2005-06	0.58	49.84	0.40	0.18
2006-07	0.60	52.51	0.43	0.18
2007-08	0.64	55.03	0.45	0.18
2008-09	0.64	56.47	0.47	0.17
2009-10	0.63	59.92	0.49	0.17
2010-11	0.69	63.45	0.51	0.17
2011-12	0.74	65.63	0.54	0.16
2012-13	0.75	69.09	0.56	0.16
2013-14	0.79	73.49	0.60	0.17
2014-15	0.79	79.89	0.64	0.18
2015-16	0.78	87.43	0.74	0.18
2016-17	0.83	94.25	0.81	0.19
2017-18	0.88	99.50	0.93	0.20
2018-19	0.87	105.75	0.99	0.22
2019-20	0.93	109.22	0.99	0.22
2020-21	0.96	102.10	1.00	0.22

As productivity value stated above are highly disparate, to compare the trends of productivity over time, we calculated the productivity index and its trend. The trends of agriculture, non-agriculture, and fishing sectors have been increasing over the years, with the fishing sector growing at the highest rate, followed by non-agriculture and agriculture. Figure-6 shows the trend of sector-wise partial land productivity index in India:

Figure-6: Trend of Sector-wise Land Productivity Index in India



Source: Authors construction using data from Government of India

To formally analyse the growth rate of productivity, we used a trend equation, the regression results of which are shown in Table-3. Table-4 then displays the growth rate of productivity accordingly.

Table 3: Regression Results of Growth Rate of Productivity(GVA in lakh per hectare of Land)

Variables	**Estimated Coefficient/Values**			
	Ln_Agriculture	Ln_Nonagri	Ln_fishing	Ln_forest
Time	0.0325987*** (21.85)	0.0558615*** (25.10)	0.0664608*** (20.12)	0.015029*** (4.10)
Constant	-.5681838*** (-39.38)	3.828249*** (177.88)	-1.030593*** (-32.26)	-1.82155*** (-51.42)
R Square	0.9715	0.9783	0.9666	0.5459
F	477.24*** [1, 14]	629.91*** [1, 14]	404.71*** [1, 14]	16.83*** [1, 14]

Source: Author's calculation using STATA 15
Figures within () are respective t-value and figures within [] are the degrees of freedom for F-statistics
*** Indicates significant at 1 percent.

Table 4: Sector-wise Exponential Growth Rate of Productivityin India

Period	**Agriculture**	**Non-agricultural**	**Fishing**	**Forest**
2005-06 to 2020-21	3.26%	5.59%	6.65%	1.5%

Source: Author's calculation.

The fishing sector has the highest productivity growth rate, which is expanding at a rate of 6.6 percent. Productivity in the non-agricultural sector has been increasing at a pace of 5.59%. Productivity in the agriculture sector is increasing at a pace of 3.26%. The growth rate of forest productivity, on the other hand, is the slowest, increasing at a rate of 1.5%.

7. Conclusion:

The net sown area has been increasing since 2005-06 as well as the overall agricultural land also increases. Non-agricultural land usage has increased in tandem with the increasing importance of industry and services in the economy. However, it is vital to emphasise that the land-share of non-agriculture has been increasing, not at the expense of agriculture, but by gradually bringing to use land that was previously uneconomically used. This is a positive step forward in the economic use of the country's scarce land resources. With a growth rate of 6.6 percent, the fishing industry has the highest rate of productivity growth. The non-agricultural sector has experienced productivity growth at a rate of 5.59%. Agriculture productivity is rising at a 3.26% annual rate. On the other hand, the growth rate of forest production is the slowest, rising at a rate of 1.5%.

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