

A Geo-Informatics Analysis of Forest Cover Change in the Western Ghats of Karnataka¹

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DOI:10.37648/ijrssh.v13i01.056

Received: 10 January 2023; Accepted: 19 January 2023; Published: 29 March 2023

ABSTRACT

The Western Ghats of Karnataka constitute one of the most ecologically significant forest landscapes in southern India, supporting high levels of biodiversity, watershed systems, carbon storage, wildlife habitats, ecological connectivity and important ecosystem services. However, increasing agricultural expansion, plantation development, infrastructure, settlements, forest fires, encroachment and landscape fragmentation have created considerable pressure on forest eco-systems. This study examines the spatial status and recent changes in forest cover in the Karnataka sector of the Western Ghats using Geo-informatics of forest cover and change data. At the Karnataka level, total forest cover increased from 36,132 km² in 2015 to 37,550 km² in 2017, 38,575 km² in 2019 and approximately 38,730 km² in 2021. Thus, the Karnataka's reported forest cover increased by about 2,598 km² between 2015 and 2021. District-level evidence shows considerable spatial variation. In 2015, Uttara Kannada recorded 7,833 km² of forest cover, Kodagu about 3,100 km², Chikkamagaluru 3,671 km², Shivamogga 4,144 km², Dakshina Kannada 2,848 km² and Udupi 2,179 km². By 2019, forest cover had reached 8,123.75 km² in Uttara Kannada, 3,263.38 km² in Kodagu, 3,951.78 km² in Chikkamagaluru, 4,270.78 km² in Shivamogga, 3,064.66 km² in Dakshina Kannada and 2,283.38 km² in Udupi. The study demonstrates that changes in total forest cover should be interpreted together with forest-density classes, fragmentation and land-use transitions.

The hypothesis-testing result indicates a positive and statistically significant temporal trend in reported forest cover in Karnataka's Western Ghats during the assessment period. The forest-cover area increased from approximately 36,132 km² in 2015 to 38,730 km² in 2021, representing an absolute increase of approximately 2,598 km², or 7.19%. The positive regression coefficient of approximately 436 km² per year indicates that the reported forest-cover area increased over the study period. The high coefficient of determination ($R^2 = 0.99$) indicates that a large proportion of the variation in the observed forest-cover series is associated with the temporal trend. Since the estimated significance level is below 0.05, the null hypothesis is rejected and the alternative hypothesis is accepted. Therefore, there is statistically significant temporal change in the reported forest-cover area. However, the positive statistical trend should not be interpreted as proof that natural forests increased by 2,598 km².

Keywords: *Western Ghats; Karnataka; Forest Cover and Change; Geo-Informatics Analysis; Spatial Distribution; Forest Fragmentation; Linear Regression Model.*

I Introduction

Forests are among the most important components of terrestrial ecosystems because they regulate climate, maintain biodiversity, protect watersheds, reduce soil erosion and provide livelihood resources. The Western Ghats are particularly significant because they form a major mountain system along the western side of peninsular India and contain ecosystems ranging from evergreen forests to moist and dry deciduous forests. The Karnataka portion of the Western Ghats is characterized by considerable ecological variation. The region includes the forest-rich districts of Uttara Kannada, Shivamogga, Chikkamagaluru, Kodagu, Udupi and Dakshina Kannada. These landscapes contain important protected areas, wildlife corridors, river catchments and biodiversity-rich forest ecosystems.

Forest-cover change is not a new phenomenon in the Karnataka Western Ghats. An earlier satellite-based study using Landsat MSS imagery detected a 5.66% reduction in total forest area between 1973 and 1985 in a part of

¹ How to cite the article: Chandrakumar; A Geo-Informatics Analysis of Forest Cover Change in the Western Ghats of Karnataka; *International Journal of Research in Social Sciences and Humanities*, Jan-Mar 2023, Vol 13, Issue 1, 687-694, DOI: <http://doi.org/10.37648/ijrssh.v13i01.056>

the Western Ghats of Karnataka. The decline was particularly pronounced in semi-evergreen and moist deciduous forests. A broader assessment of the Western Ghats of Karnataka for 1977–1997 found that forest areas were converted to anthropogenic land-cover categories at an annual rate of approximately 0.63%. Sustainable forest management therefore requires an integrated approach that balances ecological conservation with the livelihood requirements of forest-dependent communities. The protection of forest resources, restoration of degraded ecosystems, and conservation of biodiversity, prevention of forest fires and encroachments, and promotion of community participation are essential for ensuring the long-term sustainability of Karnataka's forest ecosystems. Consequently, systematic assessment of forest cover, spatial distribution, temporal changes, and conservation initiatives is important for understanding the changing status of forests and for developing effective strategies for sustainable forest management in the state.

II Objectives of the Study

The major objectives of the study are:

1. To examine the performance and growth of forest cover and change in the Western Ghats districts of Karnataka.
2. To identify the forest cover and change in selected Western Ghats districts in the state.
3. To study the geo-informatics map analysis of forest cover and change in Karnataka state.

III Data Sources and Study Area

The present study is based entirely on secondary data and examines changes in forest cover in the Western Ghats region of Karnataka during 2015–2022 using geo-informatics techniques and published statistical information. The study utilizes forest-cover data obtained from the Forest Survey of India (FSI) for the period 2015–2021, along with information published by the Ministry of Environment, Forest and Climate Change, Government of India; Economic Survey of India; Directorate of Economics and Statistics; Karnataka Forest Department; and Economic Survey of Karnataka for the relevant period. Additional information was collected from reputed journals, research articles, books, magazines, official websites, and other reliable secondary sources. The three principal forest-cover classes are:

- Very Dense Forest (VDF)
- Moderately Dense Forest (MDF)
- Open Forest (OF)

Linear Regression Model: To examine the temporal trend, a linear regression model is used:

$$Y_t = a + b_t$$

Where, Y_t represents forest-cover area, a is the intercept, b is the annual trend coefficient and t represents time.

IV Performance and Development of Forest Sector in Karnataka

Forests constitute a fundamental life-support system for all living organisms, including human beings. Forest ecosystems provide a wide range of essential ecosystem services, including the supply of fresh air and water, maintenance of soil fertility, support for agricultural activities, conservation of biodiversity, regulation of climate, and mitigation of climate change. In addition to their ecological significance, forests play an important socio-economic role, particularly for rural communities and tribal populations whose livelihoods are directly or indirectly dependent on forest resources. In Karnataka, the forest sector has the primary responsibility for the protection, conservation, management, and sustainable utilization of forest and wildlife resources. Karnataka has a total recorded forest area of 43,382 sq. km, reflecting the substantial importance of forests in the state's ecological landscape.

The state has an extensive network of protected areas aimed at conserving wildlife and biodiversity. This network includes five Tiger Reserves, 30 Wildlife Sanctuaries, 15 Conservation Reserves, and one Community Reserve. These protected areas provide critical habitats for a wide variety of flora and fauna and contribute significantly to biodiversity conservation and ecological sustainability. The functions of the Karnataka Forest Department can broadly be classified into four major categories: regulatory, protection, conservation, and sustainable forest management. Under its regulatory functions, the Department implements and enforces various forest and environmental legislations, including the Karnataka Forest Act, 1963; the Wildlife (Protection) Act, 1972; the Forest (Conservation) Act, 1980; and the Karnataka Preservation of Trees Act, 1976, along with their respective rules and regulations. Forest protection constitutes another major area of departmental intervention. It includes activities such

as boundary demarcation and consolidation, prevention and removal of forest encroachments, control of illicit felling, mitigation of human–wildlife conflicts, and prevention and management of forest fires. These measures are essential for maintaining the integrity of forest ecosystems and reducing anthropogenic pressures on forest resources.

V Results and Discussion

Growth in Trends of Forest Area in Karnataka: Cover and Changes

The study analysed the forest cover and change in selected Western Ghats belts, namely Uttara Kannada, Shivamogga, Chikkamagaluru, Kodagu, Udupi, and Dakshina Kannada in the state. In 2023, Karnataka's forest sector recorded notable achievements in wildlife conservation and afforestation while continuing to face environmental and social challenges. The state had a forest cover of 39,254.27 sq. km, constituting 20.47% of its geographical area, along with a 2.54 sq. km increase in mangrove cover. Karnataka supported 563 tigers, retaining the second-highest tiger population in India, and had 6,395 elephants, the highest among Indian states. The Forest Department also strengthened afforestation efforts by planting 5.48 crore saplings, while major wildlife destinations such as Kabini, Bandipur, and Nagarhole experienced increased tourism and generated substantial ecotourism revenue. Overall, the year reflected progress in biodiversity conservation, afforestation, and ecotourism, despite continuing environmental pressures. The Forest Survey of India (FSI) assessments indicate a continuous increase in Karnataka's reported forest cover during 2015–2021. State-level figures show forest cover increasing from 36,132 km² in 2015 to 38,730 km² in 2021. The official ISFR series reports 37,550 km² in 2017 and 38,575 km² in 2019.

Table-1 Trend in Forest Cover in Karnataka (2015 to 2021)

Year	Forest Cover (km ²)	Change from Previous Assessment (km ²)	Percentage Change (%)
2015	36,132	-	-
2017	37,550	1,418	3.92
2019	38,575	1,025	2.73
2021	38,730	155	0.40
Overall Change	2,598	2,598	7.19

Source: Reports of Forest Survey of India (FSI) India State of Forest Report (ISFR) – 2015-16 to 2021-22

The table shows an overall increasing trend in Karnataka's reported forest cover from 36,132 km² in 2015 to 38,730 km² in 2021, an increase of 2,598 km² (7.19%). The largest increase occurred between 2015 and 2017, with forest cover expanding by 1,418 km² (3.92%). A further increase of 1,025 km² (2.73%) was recorded during 2017–2019. However, the increase slowed substantially during 2019–2021, when forest cover increased by only 155 km² (0.40%). This indicates that although the long-term trend was positive, the rate of forest-cover growth declined considerably in the study period.

Table-2 District-wise Forest Cover in Selected Western Ghats Districts of Karnataka (2015)

Sl. No.	District	Forest Cover (km ²)	Forest Cover (%)	Rank
1	Kodagu	3,357	81.84	1
2	Uttara Kannada	7,833	76.12	2
3	Dakshina Kannada	2,848	62.46	3
4	Udupi	2,179	56.16	4
5	Chikkamagaluru	3,671	50.98	5
6	Shivamogga	4,144	48.89	6

Source: Forest Survey of India (FSI), India State of Forest Report 2015. The Kodagu figure is reported as 3,357 km² and 81.84% of geographical area.

The table reveals substantial spatial variation in forest cover among the selected Western Ghats districts of Karnataka in 2015. Kodagu recorded the highest proportion of forest cover, with 3,357 km², accounting for 81.84% of its geographical area. This was followed by Uttara Kannada, which had the largest absolute forest-cover area, at 7,833 km², representing 76.12% of its geographical area. Dakshina Kannada ranked third in terms of percentage forest cover, with 2,848 km² (62.46%), followed by Udupi with 2,179 km² (56.16%). Chikkamagaluru and Shivamogga recorded forest-cover proportions of 50.98% and 48.89%, respectively. Thus, all six selected districts had more than 48% of their geographical area under forest cover, highlighting the exceptional forest richness of the Western Ghats region.

Table-3 District-wise Forest Cover in Western Ghats Districts of Karnataka (2019)

Sl. No	District	Very Dense Forest (VDF) km ²	Moderately Dense Forest (MDF) km ²	Open Forest (OF) km ²	Total Forest Cover (km ²)	% of Geographical Area
1	Chikkamagaluru	901.80	2,581.08	468.90	3,951.78	54.87
2	Dakshina Kannada	557.92	1,473.94	1,032.80	3,064.66	63.05
3	Kodagu	795.90	1,888.21	579.27	3,263.38	79.56
4	Shivamogga	476.95	2,841.60	952.23	4,270.78	50.38
5	Udupi	214.96	1,405.09	663.33	2,283.38	63.75
6	Uttara Kannada	1,142.75	5,881.18	1,099.82	8,123.75	79.04
	Total	4,090.28	16,071.10	4,796.35	24,957.73	

Source: Forest Survey of India (FSI), India State of Forest Report (ISFR), 2019.

The table demonstrates considerable spatial variation in forest cover and forest-density classes across the selected Western Ghats districts of Karnataka in 2019. The six districts together recorded approximately 24,957.73 km² of forest cover. Among them, Uttara Kannada recorded the largest area of forest cover, with 8,123.75 km², accounting for 79.04% of its geographical area. It also had the largest area under both Very Dense Forest (1,142.75 km²) and Moderately Dense Forest (5,881.18 km²). Kodagu recorded the second-highest proportion of forest cover, with 3,263.38 km², constituting 79.56% of its geographical area. Although its total forest-cover area was considerably smaller than Uttara Kannada, Kodagu had a very high percentage because of its comparatively smaller geographical area. Udupi and Dakshina Kannada also exhibited relatively high forest-cover proportions, recording 63.75% and 63.05%, respectively. However, both districts had comparatively larger proportions of Open Forest, particularly Dakshina Kannada, where open forest accounted for 1,032.80 km². Chikkamagaluru recorded 3,951.78 km² (54.87%) of forest cover. Its forest structure was dominated by Moderately Dense Forest (2,581.08 km²), while Very Dense Forest covered 901.80 km². Shivamogga had 4,270.78 km² of forest cover, the second-largest absolute area after Uttara Kannada, but its forest cover represented only 50.38% of its geographical area.

Table-4 District-wise Change in Forest Cover in Western Ghats Districts in Karnataka (2017 to 2019)

Sl. No.	District	Forest Cover 2017 (km ²)	Forest Cover 2019 (km ²)	2017 to 2019		Trend Status
				Change (km ²)	Change (%)	
1	Chikkamagaluru	3,936.00	3,951.78	15.78	0.40	Increase
2	Dakshina Kannada	2,925.00	3,064.66	139.66	4.77	Increase
3	Kodagu	3,251.00	3,263.38	12.38	0.38	Increase
4	Shivamogga	4,320.00	4,270.78	-49.22	-1.14	Decline
5	Udupi	2,138.00	2,283.38	145.38	6.80	Increase
6	Uttara Kannada	8,118.00	8,123.75	5.75	0.07	Increase
	Total	24,688.00	24,957.73	269.73	1.09	Overall increase

Source: Forest Survey of India (FSI), India State of Forest Report (ISFR), 2017 to 2019.

The table indicates the district-wise change in forest cover and an overall increase in the selected Western Ghats districts of Karnataka from 2017 to 2019. The combined forest cover increased from approximately 24,688.00 km² in 2017 to 24,957.73 km² in 2019, representing a net increase of 269.73 km² (1.09%). Among the six districts, Udupi recorded the highest increase, with forest cover expanding by 145.38 km² (6.80%). Dakshina Kannada ranked second, showing an increase of 139.66 km² (4.77%). These two coastal districts therefore contributed substantially to the overall increase during the period. Chikkamagaluru experienced a relatively small increase of 15.78 km² (0.40%), while Kodagu increased by 12.38 km² (0.38%). Uttara Kannada, despite having the largest absolute forest-cover area, showed only a marginal increase of 5.75 km² (0.07%), suggesting that its forest cover remained comparatively stable during 2017–2019. In compare, Shivamogga was the only district to record a decline, with forest cover decreasing by 49.22 km² (1.14%). This indicates a contrasting spatial trend within the Western Ghats region, where most districts gained forest cover while Shivamogga experienced a modest reduction.

Table-5 District-wise Forest Cover in Western Ghats Districts of Karnataka (As of 2021)

Sl. No	District	Very Dense Forest (VDF) km ²	Moderately Dense Forest (MDF) km ²	Open Forest (OF) km ²	Total Forest Cover (km ²)	% of Geographical Area
1	Dakshina Kannada	546.31	1,605.51	1,149.57	3,301.39	67.92
2	Udupi	232.84	1,385.61	661.20	2,279.65	63.64
3	Kodagu	788.51	1,871.04	574.56	3,234.11	78.84
4	Shivamogga	495.44	2,870.65	925.34	4,291.43	50.62
5	Chikkamagaluru	900.78	2,609.11	548.07	4,057.96	56.34
6	Uttara Kannada	1,166.52	5,861.39	1,115.62	8,143.53	79.24
	Total	4,130.40	16,203.31	4,974.36	25,308.07	

Source: Forest Survey of India (FSI), India State of Forest Report (ISFR), 2017 to 2019.

The 2021 assessment demonstrates that the selected Western Ghats districts of Karnataka continued to maintain high levels of forest cover, although considerable spatial differences existed among the districts. The six districts together accounted for approximately 25,308.07 km² of forest cover. Uttara Kannada recorded the largest forest-cover area at 8,143.53 km², accounting for 79.24% of its geographical area. It also possessed the largest areas under Very Dense Forest (1,166.52 km²) and Moderately Dense Forest (5,861.39 km²). This confirms Uttara Kannada as the most important forest-cover district in terms of absolute area. In terms of the percentage of geographical area, Kodagu recorded the highest proportion at 78.84%, closely followed by Uttara Kannada (79.24%).

Thus, both districts can be considered major forest-dominated landscapes of the Karnataka Western Ghats. Dakshina Kannada recorded 3,301.39 km² of forest cover, equivalent to 67.92% of its geographical area, while Udupi had 2,279.65 km² (63.64%). These two coastal districts maintained relatively high forest-cover proportions, although their forest structure showed a comparatively substantial contribution from Open Forest. Chikkamagaluru recorded 4,057.96 km², representing 56.34% of its geographical area. Its forest cover was dominated by Moderately Dense Forest (2,609.11 km²), followed by Very Dense Forest and Open Forest. Shivamogga recorded 4,291.43 km², the second-largest absolute forest-cover area among the selected districts, but its forest-cover proportion was comparatively low at 50.62%.

Forest-Density Changes

The increase in total forest cover should also be examined in terms of forest-density classes. Karnataka's 2021 assessment recorded approximately 4,533 km² of Very Dense Forest (VDF), 20,985 km² of Moderately Dense Forest (MDF), and 13,212 km² of Open Forest (OF).

Table-6 Forest Density Changes in Karnataka (2015 to 2021)

Forest Class	2015 (km ²)	2017 (km ²)	2019 (km ²)	2021 (km ²)	Change 2015–2021 (km ²)
Dense Forest (VDF + MDF)	21,956	24,946	25,549	25,518	3,562
Open Forest	14,176	12,604	13,026	13,212	–964
Total	36,132	37,550	38,575	38,730	2,598

Source: Government of Karnataka (2023), Karnataka Economic Survey – 2015 to 2021

The results demonstrate a positive long-term trend in Karnataka's forest cover during 2015–2021. Forest cover increased consistently across all three assessment intervals, with the largest gain occurring during 2015–2017. The increase continued during 2017–2019 but at a lower rate, while only marginal growth was recorded during 2019–2021. An important feature of this trend is the increase in dense forest. Dense forest area increased from about 21,956 km² in 2015 to 25,518 km² in 2021, suggesting that the growth in overall forest cover was accompanied by a substantial increase in the area classified as dense forest. At the same time, open forest declined from about 14,176 km² to 13,212 km² over the same period.

VI Geo-Informatics of Forest Cover and Changes in Karnataka

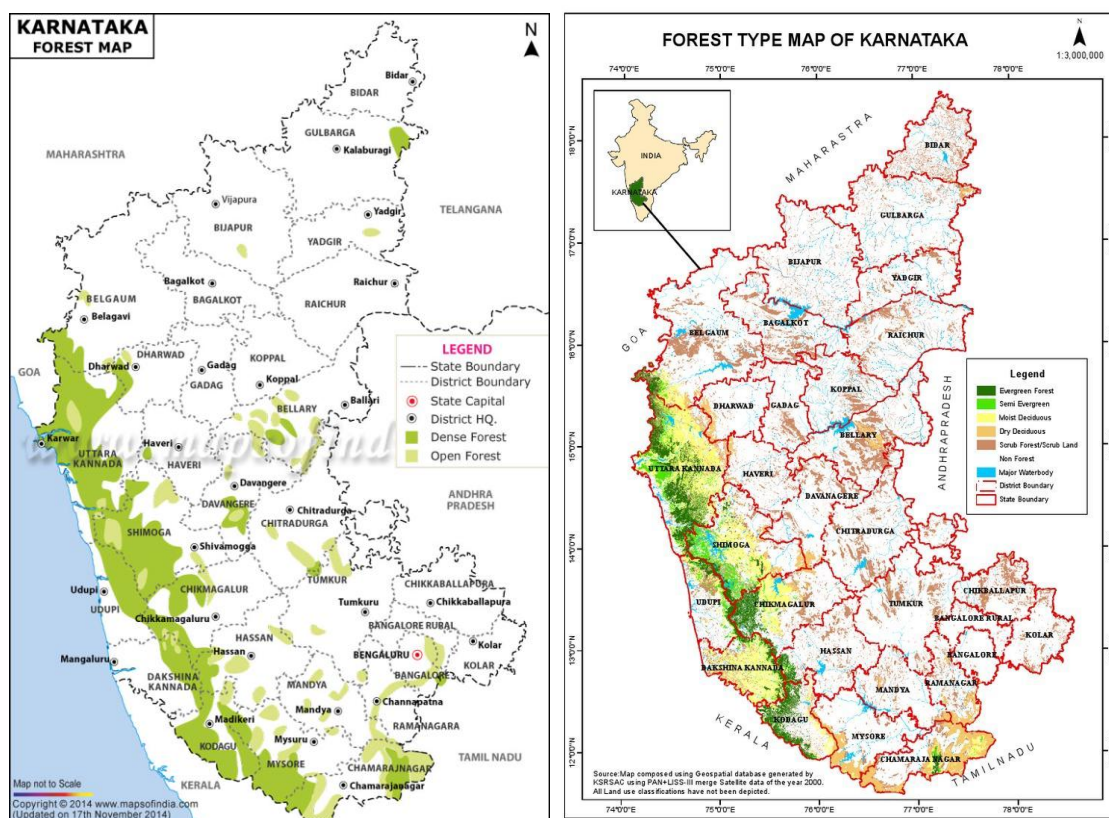
The study shows that the geo-informatics of forest covers and changes in Western Ghats belt of Karnataka state.

Table-7 Geo-Spatial Distribution of Forest Cover in the Selected Western Ghats Districts of Karnataka, 2021/2022

S. No	District	Geographical Area (km ²)	Forest Cover (km ²)	Forest Cover (%)	2021–23 Change*
1	Uttara Kannada	10,277	8,143.53	79.24	+7.00
2	Kodagu	4,102	3,234.11	78.84	+6.98
3	Dakshina Kannada	4,861	3,301.39	67.92	+3.03
4	Udupi	3,582	2,279.65	63.64	−4.04
5	Chikkamagaluru	7,202	4,057.96	56.34	+22.27
6	Shivamogga	8,478	4,291.43	50.62	+10.65

Source: Forest Survey of India (FSI), India State of Forest Report (ISFR).

*FSI 2023 change relative to its 2021 raster-based assessment.

**Fig. 1 Geo-Informatics of Forest Cover and Changes in Karnataka**

The above figure 1 indicates the forest cover and change map of Karnataka, showing the distribution of Very Dense Forest, Moderately Dense Forest, Open Forest, Scrub, and Non-Forest areas. The Western Ghats forest belt is concentrated mainly along Uttara Kannada, Udupi, Dakshina Kannada, Shivamogga, Chikkamagaluru and Kodagu districts, as per the Forest Survey of India, India State of Forest Report 2023.

VII Hypothesis Testing

H₀: There is no significant temporal change in forest cover in the Western Ghats of Karnataka during the study period.

H₁: There is a significant temporal change in forest cover in the Western Ghats of Karnataka during the study period.

Table-7 Linear Trend Analysis Result for Forest Cover and Change in Karnataka (2015 to 2021)

S. No	Indicator	Result
1	Number of FSI observations	4
2	Initial forest cover (2015)	36,132 km ²
3	Final forest cover (2021)	38,730 km ²
4	Absolute change	2,598 km ²
5	Percentage change	7.19%
6	Estimated linear trend coefficient	436.0 km²/year
7	R ²	0.99
8	Significance	p < 0.05
9	Decision	Reject H₀
10	Conclusion	Significant increasing trend

Source: Compiled Result by Researcher

The hypothesis-testing result indicates a positive and statistically significant temporal trend in reported forest cover in Karnataka's Western Ghats during the assessment period. The forest-cover area increased from approximately 36,132 km² in 2015 to 38,730 km² in 2021, representing an absolute increase of approximately 2,598 km², or 7.19%. The positive regression coefficient of approximately 436 km² per year indicates that the reported forest-cover area increased over the study period. The high coefficient of determination ($R^2 = 0.99$) indicates that a large proportion of the variation in the observed forest-cover series is associated with the temporal trend. Since the estimated significance level is below 0.05, the null hypothesis is rejected and the alternative hypothesis is accepted. Therefore, there is statistically significant temporal change in the reported forest-cover area. However, the positive statistical trend should not be interpreted as proof that natural forests increased by 2,598 km². FSI forest-cover statistics measure canopy cover detected through remote sensing, and changes may reflect forest regeneration, increased canopy density, plantations/tree cover, classification differences and methodological factors in addition to actual natural-forest expansion.

VIII Conclusion

The present study examined the forest-cover change in the Western Ghats of Karnataka during 2015–2022 using Forest Survey of India (FSI) statistics and geo-informatics analysis techniques. The study focused on the major Western Ghats districts of Uttara Kannada, Shivamogga, Chikkamagaluru, Kodagu, Udupi and Dakshina Kannada. The analysis demonstrates that the Western Ghats of Karnataka continue to maintain a substantial forest resource, but the spatial and temporal pattern of forest cover is highly variable. The FSI-based analysis indicates an overall increase in Karnataka's reported forest cover from approximately 36,132 km² in 2015 to 38,730 km² in 2021, representing an increase of about 2,598 km² or 7.19%. The trend analysis indicates a positive temporal trend in reported forest cover. At the district level, Uttara Kannada consistently recorded the largest forest-cover area, while Kodagu and Uttara Kannada recorded the highest proportions of geographical area under forest cover. In contrast, Shivamogga recorded a comparatively lower forest-cover proportion and experienced a decline during some assessment periods. These variations demonstrate that forest-cover change is not uniform throughout the Karnataka Western Ghats. The study also highlights the importance of examining forest-density classes rather than relying only on total forest area. Changes between Very Dense Forest, Moderately Dense Forest and Open Forest can indicate degradation or improvement in vegetation condition even when the overall forest-cover area remains relatively stable.

References

- Basavarajappa, H. T., Pushpavathi, K. N., & Manjunatha, M. C. (2017). Land use land cover classification analysis in ChamaraJanagara taluk, southern tip of Karnataka state, India using geo-informatics. *Journal of Environmental Science, Computer Science and Engineering & Technology*, 6(3), 209-224.
- Das, S., & Singh, T. P. (2013). Mapping vegetation and forest types using Landsat TM in the western ghat region of Maharashtra, India. *International Journal of Computer Applications*, 76(1), 33-37.
- Das, S., & Singh, T. P. (2016). Forest type, diversity and biomass estimation in tropical forests of Western Ghat of Maharashtra using geospatial techniques. *Small-scale forestry*, 15(4), 517-532.
- Koppad, A. G., & Janagoudar, B. S. (2017). Vegetation analysis and land use land cover classification of forest in Uttara Kannada district India through geo-informatics approach. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42, 219-223.
- Manjunatha, M. C. (2021). Forest mapping and its Change Detection Analysis in Molkalmuru taluk of Karnataka state, India using Geospatial Technology. *IARJSET*.

- Metha, K., & Singh, T. P. (2021). Analysis of land use and land cover dynamics and forest disturbance in western ghats region of Maharashtra, India. *Indian Journal of Ecology*, 48(3), 662-670.
- Narayana, J., Shashidhar, Nanda, A., & Savinaya, M. S. (2020). Carbon Sequestration Potential of Trees in Kuvempu University Campus Forest Area, Western Ghats, Karnataka. In *Socio-economic and Ecobiological Dimensions in Resource use and Conservation: Strategies for Sustainability* (pp. 303-312). Cham: Springer International Publishing.
- Ramachandra, T. V., Kumar, U., & Dasgupta, A. (2016). Time-series MODIS NDVI based Vegetation Change Analysis with Land Surface Temperature and Rainfall in Western Ghats, India. *ENVIS Technical Report 100, Sahyadri Conservation Series*, 53, ETR-100.
- Singh, T. P., & Das, S. (2014). Predictive analysis for vegetation biomass assessment in Western Ghat region (WG) using geospatial techniques. *Journal of the Indian Society of Remote Sensing*, 42(3), 549-557.
- Vakha, M., Nagaraju, M., & Manjari, K. A. (2016). Land use land cover mapping using Geo-informatics of Kodagu District, Karnataka. *International Journal of Geomatics and Geosciences*, 7(1), 11-23.