Agroforestry in India: area estimates and methods

With the adoption of the National Agroforestry Policy in the country, India became a pioneer in promoting the inclusion of woody perennials (trees, shrubs, palms and bamboos) in food production systems, i.e. agricultural land. Effective planning and management are vital for the success of any policy and in this regard, it is mandatory to estimate the area under agroforestry. Given the importance of agroforestry in the climate emergency era, its contribution is well recognized since the inception of systematic studies on agroforestry in 1970 (refs 1, 2). Estimation of agroforestry areas have been estimated since the 2000s at different scales by different agencies. One estimate at the global scale reported that 43% of all agricultural land has at least 10% tree cover, implying the practice of including trees in farmlands[3]. Recently, the Global Forest Resources Assessment 2020 released by Food and Agriculture Organization (FAO) has reported 45.4 million hectares of land under agroforestry[4].

India has always been a pioneer in estimating the area under agroforestry. Earlier attempts at the country level revealed estimates varying from 17.45 to 23.25 M ha (refs 5, 6) and many regional estimates have also been reported[7–9]. There are studies predicting the potential area suitable for agroforestry in India[10]. Despite such predictions, there are no actual estimates to date. The ICAR-Central Agroforestry Research Institute, Jhansi, a dedicated research institution for agroforestry in the Asia-Pacific region, undertook the mapping of agroforestry areas using geospatial technologies. The preliminary work on 13 out of 15 agroclimatic zones (ACZs) reported an area of 23.25 M ha (ref. 11). In the present study, we carried out a complete analysis for all 15 ACZs of India.

For area estimation, sub-pixel classification and object-based image analysis methods were used for medium-resolution (LISS III – 23.5 m) (Figure 1) and high-resolution (LISS IV/Sentinel 2 – 5.8/10 m) (Figure 2) remote sensing data respectively. The accuracy of the estimation was >75% and >90% for sub-pixel classification and object-based image analysis methods respectively.

The overall area under agroforestry for all 15 ACZs of India was 28.427 M ha, which is about 8.65% of the total geographical area of the country (328.747 M ha). Among the 15 ACZs, seven (1, 3, 5, 7, 11, 12 and 13) had more than 10% area under agroforestry. ACZs 1, 5, 7, 10, 11 and 13 had more than 2 M ha area under agroforestry (Table 1). The Western Himalayan Region and the Eastern Plateau and Hilly Region recorded more than 4 M ha area under agroforestry. Across the ACZs, the Upper Gangetic Plain Region had a greater area (15.55%) under agroforestry while the lowest was in the Western Dry Region (2.45%) and the Island Region (2.48%) (Figure 3). According to the Global Forest Resources Assessment 2020 of FAO[4], Asia has the largest area under agroforestry, which is about 31.2 M ha. Comparing agroforestry area in Asia as reported by FAO, with the agroforestry area reported in this study; it can be presumed that more than 75% of the agroforestry area is in India. However, it is not a fact and should not be misinterpreted. Globally, only 71 countries report areas under agroforestry to FAO for the biannual Global Forest Resources Assessment, but no actual estimation is reported.

Thus, India has become the first nation to have systematically mapped the country-wide agroforestry area. According to India State Forest Report, 2019 of the Forest Survey of India[12], the extent of trees outside the forest area is 29.38 M ha, i.e. 9.5 M ha of tree cover and 19.88 M ha of forests outside the Reserved Forest area. Thus, the agroforestry area estimate includes 9.8 M ha tree cover (rural and urban). Moreover, the agroforestry area reported in this study indicates tree and crop canopy areas. Hence, it is recommended not to equate the agroforestry area to trees outside the forest area. To avoid misconceptions in the future, there is a need for collaboration between the agriculture and forest ministries for mapping

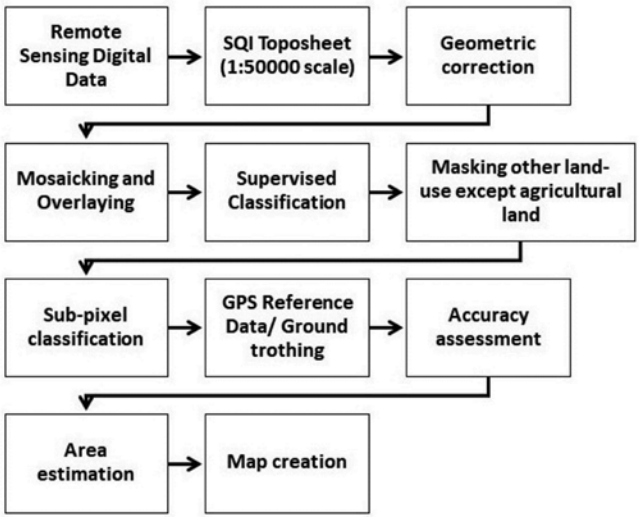

Figure 1. Framework for mapping agroforestry using sub-pixel classification method for medium resolution.

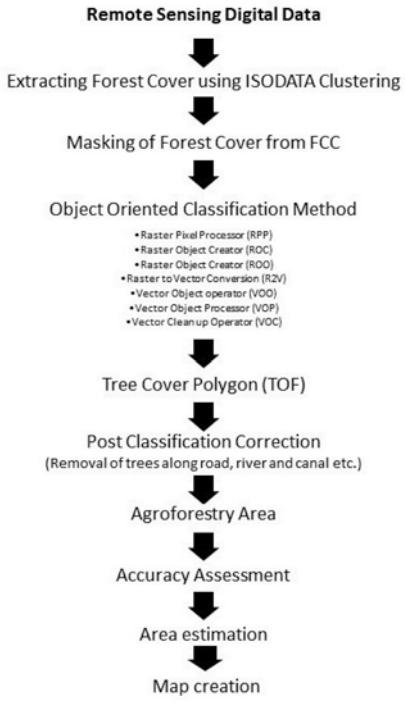

Figure 2. Framework for mapping agroforestry using object-based image analysis method for high resolution.

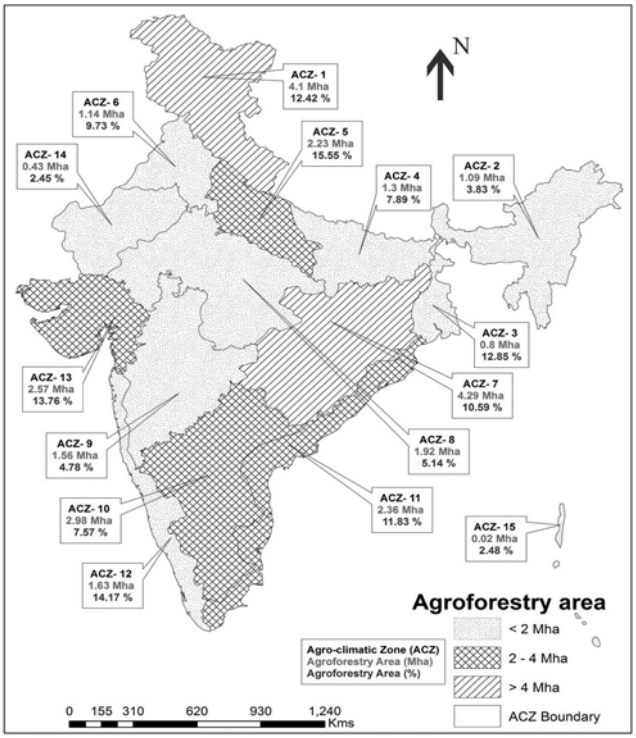

Figure 3. Map showing agroclimatic zone-wise agroforestry area.

Table 1. Extent of agroforestry area in 15 agroclimatic zones (ACZs) of India

ACZ no.	ACZ	Geographical area (M ha)	Agroforestry area (M ha)	Agroforestry area (%)
1	Northern Himalayan Region	32.968	4.096	12.42
2	Eastern Himalayan Region	28.422	1.088	3.83
3	Lower Gangetic Plains Region	6.238	0.802	12.86
4	Middle Gangetic Plains Region	16.526	1.304	7.89
5	Upper Gangetic Plains Region	14.367	2.234	15.55
6	Trans Gangetic Plains Region	11.750	1.143	9.73
7	Eastern Plateau and Hill Region	40.525	4.292	10.59
8	Central Plateau and Hill Region	37.435	1.924	5.14
9	Western Plateau and Hill Region	32.539	1.556	4.78
10	Southern Plateau and Hill Region	39.294	2.976	7.57
11	East Coast Plains and Hill Region	19.948	2.36	11.83
12	West Coast Plains and Hill Region	11.69	1.632	13.96
13	Gujarat Plains and Hill Region	18.673	2.57	13.76
14	Western Dry Region	17.587	0.431	2.45
15	The Island Region	0.785	0.019	2.42
	Total/percentage	328.747	28.427	8.65

trees outside the forest area as recommended by the Expert Committee[13].

The present study did not include Lakshadweep Islands due to the COVID-19 pandemic; this will be addressed in future studies. These datasets will help in the planning and management of agroforestry as well as the implementation of the National Agroforestry Policy in different states of India on mission mode.

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