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SYNTHESIS REPORT

Evidence of the Multifunctional Performance of the Akole Landscape in Maharashtra, India

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CGIAR Multifunctional Landscapes Program

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Contents

Summary

The report provides the evidence on the multifunctional performance of the Akole landscape, in Ahmednagar district, Maharashtra, India. Akole Landscape is located within the Western Ghats, a UNESCO world heritage site for rich and unique biodiversity. The landscape's performance was synthesized across agronomic, economic, environmental, and social dimensions, based on the assessment from 2022 to 2024. The report highlights the key challenges, existing data and evidence gaps that need to be addressed for effective landscape planning, and opportunities for sustainable development through various nature positive and agroecological interventions at scale.

The Akole Landscape is situated within the Sahyadri mountains of the Western Ghats and is characterized by a predominantly tribal, rural community heavily reliant on agriculture and forest products. The landscape is highly vulnerable to environmental degradation (soil erosion, low water retention, and deforestation), unsustainable practices (loss of crop diversity, excessive tillage and fertilizer use), and climate change (change in rainfall pattern, drought, pest and disease outbreak). This assessment integrates data to identify critical bottlenecks and measure the initial impact of targeted nature positive and agroecological interventions in the landscape.

Although Akole is rich in biodiversity and traditional system of knowledge, in the recent decades the landscape experiences a growing economic pressure often led to a shift towards nature-negative practices. Economically, the over-reliance on the crop income and low livelihood diversification creates severe vulnerability to weather shocks (droughts/floods), pests, and market price fluctuations. This further limit the households to cope with agriculture failure. The region experiences high climatic variability, leading to frequent droughts and erratic rainfall. Ecologically, steep slopes, thin vegetative cover, and high-intensity rainfall lead to significant soil erosion and nutrient depletion. Continuous monocropping and high use of chemical fertilizers contribute to deteriorating soil quality and loss of productivity over time. In the rocky-hilly terrain of Akole, the poor water use efficiency coupled with lack of localized water harvesting structures further limits the groundwater recharge. The social dimensions of the landscape indicate more than half of the population is below poverty line in the Akole landscape with low literacy rate and a fraction of tribal community under moderate to severely acute malnutrition owing to limited access to the basic services. The report also highlights the critical data gap such as human health and well-being to assess the social performance of the landscape.

The report advocates for a paradigm shift from purely production-focused agriculture to a **Multifunctional Landscape approach** centered on sustainability, resilience, and equity. Integrating diversified income streams and natural resource management through nature positive and agroecological interventions is crucial to enhance resilience against increasing climate variability, water scarcity, and market volatility. The current income structure of Akole is environmentally and economically unsustainable given the changing climate. Adoption of the Multifunctional Landscape framework is critical for long-term regional resilience of the landscape.

1. Description of the Akole Landscape

1.1 Geographical Characteristics of Akole

Akole Landscape is located within the Western Ghats, which are the biodiversity hotspot in India recognized as a UNESCO world heritage site for its rich biodiversity and endemism. It lies between 19°32'23"–19°37'11" N and 73°42'21"–73°46'44" E, covering ~85 km² area in the Ahmednagar district of Maharashtra, which is India's second largest state (BAIF 2024). The Akole landscape also lies within the Pravara River basin, which originates in the Sahyadri ranges (Western Ghats) and flows through Akole Tehsil. The Paravar River is the major tributary of the Godavari River, the second longest river in India after the Ganges River. India has 28 states and 8 union territories; each state is divided into districts which is further divided into subdistricts often called as tehsil / taluka for revenue and land administration. In Ahmednagar district of Maharashtra, Akole comprises of group of villages often called as Akole cluster falls under Akole tehsil (Chavan et al. 2024). It is further divided into two sub-clusters: Kalsubai, spanning villages across high, mid, and low elevations; and Igatpuri, located in the foothill plains. These clusters are typically defined for specific development projects in the rainfed areas. The Akole cluster consists of 10 villages, of which 6 villages (Jahagirdarwadi, Bari, Panjare, Peth, Chichondi, and Murshet) are in Ahmednagar district, and 4 villages (Adharwad, Wasali, Indore, and Khed) are in Nashik district (**Figure 1 and 2**). The elevation gradient spread across diverse agro-ecological landscapes comprising forests, cultivated lands, and rugged mountainous terrain.

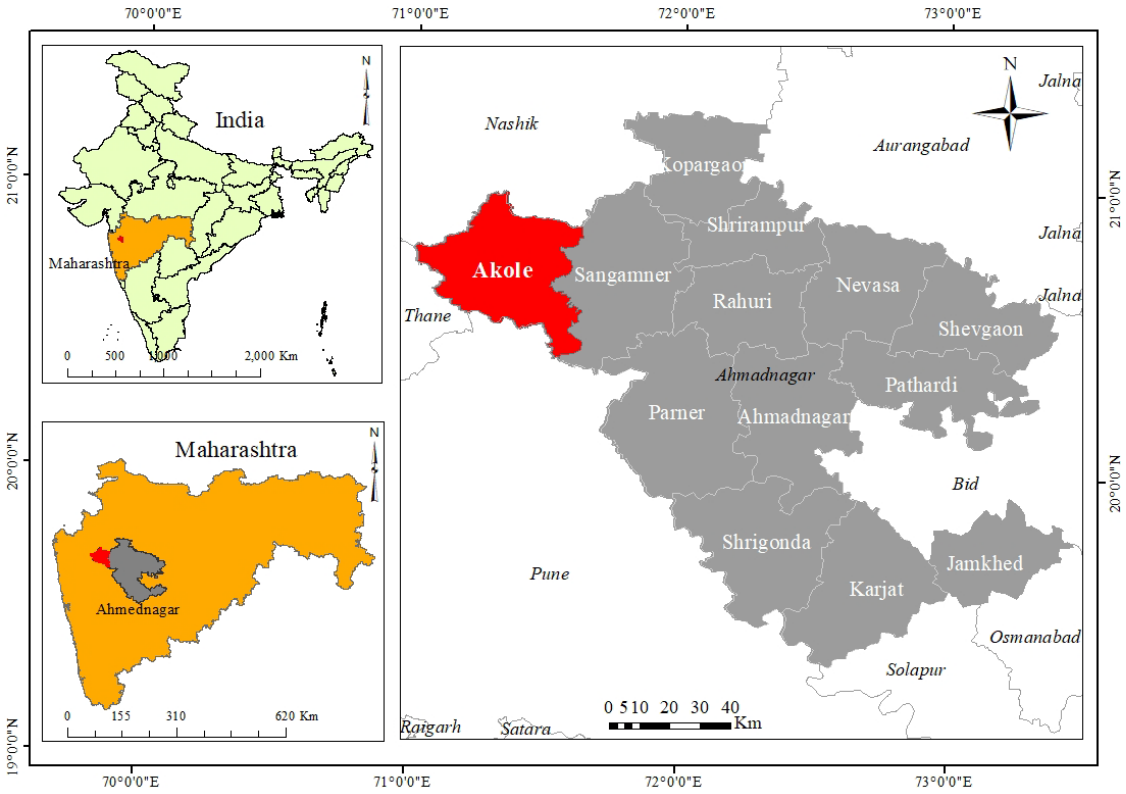

Figure 1. Geographical location of Akole, Ahilyanagar (previously Ahmednagar), Maharashtra, India (developed by authors using ArcGIS)

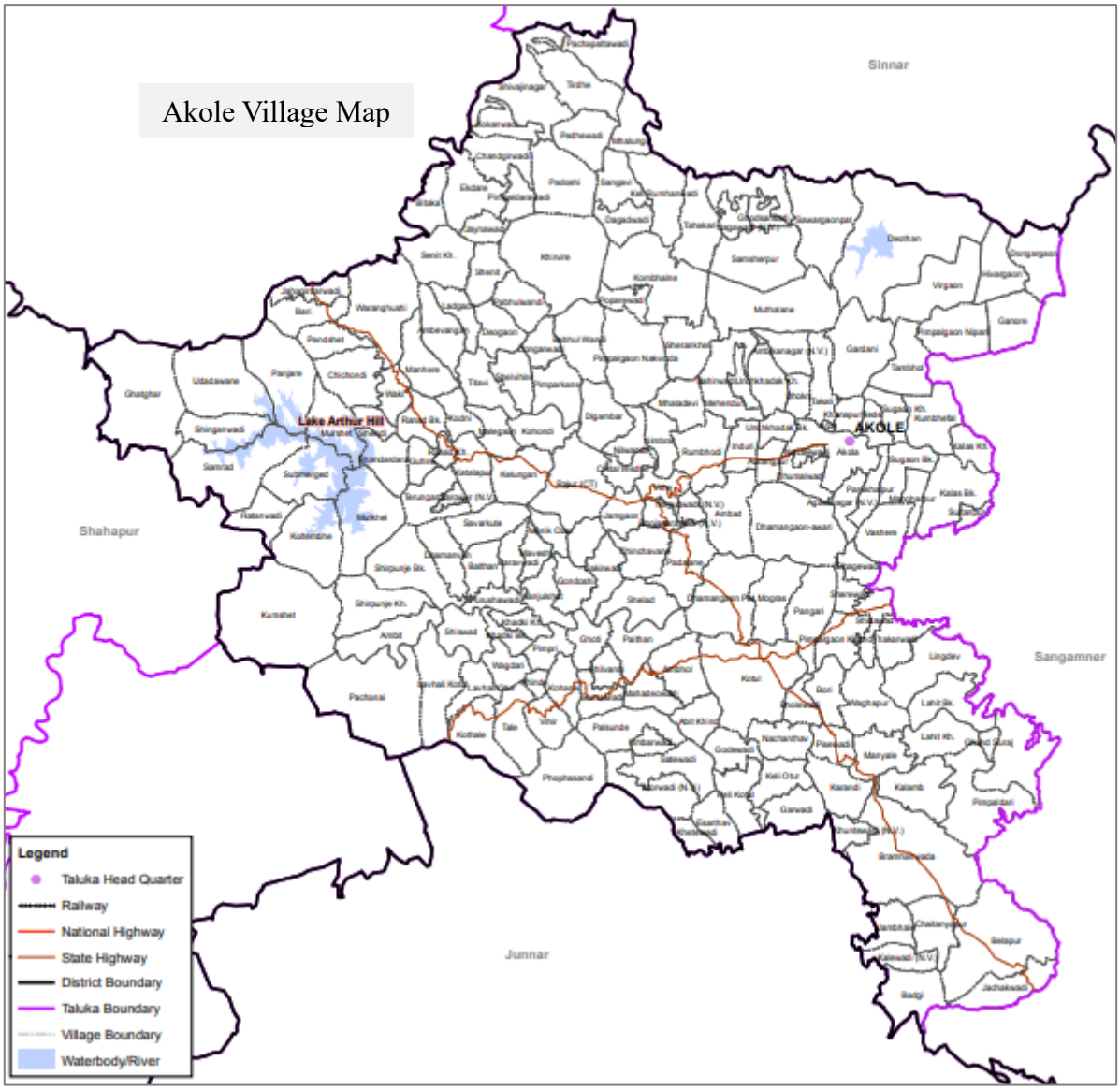

Figure 2. Village map of Akole tehsil, in Ahmednagar, Maharashtra, India (*Source*: Scribd.com, Village Map: Taluka: Ahmednagar District: Ahmednagar | PDF | Remote Sensing | Nature).

This boundary was chosen because key landscape functions and development activities are managed at the district administrative level. For urban areas, the local governance is handled by the Akole Nagarpanchayat (town council/ notified area council). For rural areas the Akole block development officer handles the local governance. Both urban and rural governance comes under the purview of District Collector- a senior Indian Administrative Officer (IAS) heading the district's administration in India. In defining the landscape boundaries, we worked with local government and non-government partners to define their individual and collective zones of influence, and the areas within which we aim to work jointly.

Historically, Akole is part of the Great Maratha Emperor Chhatrapati Shivaji Maharaj which is evident through the presence of Patta Fort (Vishramgad). The landscape also represents the role of tribal community in the freedom struggle, a center for resistance against colonial oppression and exploitative money lenders in the pre-independence era (Uttamrao 2019, Kauthale et al. 2021). The area is home to diverse tribal communities such as the Thakar, Warli, Katkari, and Mahadev-Koli. Owing to the natural and cultural features of Akole, the region attracts local tourists mainly during monsoon, offering opportunities for trekking,

mountaineering, bird watching, boating, fishing, and wildlife safaris (Salunke 2020). Apart from tourism, majority of the population in the region depends on agriculture and livestock production for livelihoods.

Cluster: *Group of geographically connected nearby villages for administrative, development and economic purposes.*
Blocks*: administrative area identified within the districts above the villages for targeted growth and aspirational programs.*
Tehsil*: A subdivision within a district, managing local administration and revenue*
Gram Panchayat*: fundamental local self-governance body for villages, headed by a Sarpanch*
Nagar Panchayat*: urban local body for transitional areas (moving from rural to urban) functioning under the Panchayat Raj system to provide civic amenities.*

1.2 Environmental Characteristics

The landscape interlinked with surrounding forest ecosystems, rainfed farmlands, and irrigated areas, underscoring its role as an open and interconnected system. These natural and institutional boundaries are further influenced by community land-use patterns, administrative jurisdictions, and agro-climatic gradients, making the region a dynamic socio-ecological unit within the Paravara River Basin (Uttamrao 2019). Pravara River flows near the cluster, major reservoirs like Bhandardara, are vital for ensuring domestic water supply and supporting agricultural operations, providing food security and water security for local communities. The extent of the landscape within which we aim to work was co-defined in consultation with the national partners (Sikka et al. 2023).

The tropical vegetation of the landscape is characterized by deciduous and semi-evergreen forests. Forests cover around 27% of the land area in Akole tehsil and are known for Kalsubai Harishchandragad Wildlife Sanctuary (Bapurao 2021). These forests, particularly dense in the western region, host a rich variety of native flora such as Aashing (*Rhododendron arboreum*), Gulchadi (*Polianthes tuberosa*), Hirda (*Terminalia chebula*), Bahava (*Cassia fistula*), Beheda (*Terminalia bellirica*), and diverse grasses. Protected areas like the Kalsubai-Harishchandragad and Rehekuri Wildlife Sanctuaries help preserve the region's biodiversity. Wildlife includes species like sambar, chital, porcupine, barking deer, Indian giant squirrel, leopard, wolf, and tiger, along with 142 bird species and various reptiles. (BAIF 2024; Sawarkar 2014). Despite the presence of rivers, reservoirs, and groundwater, water retention in the soil is low due to the high infiltration capacity of red soils and erratic rainfall -marked by intense short bursts followed by prolonged dry spells. As elevation increases toward the uplands, water availability decreases, resulting in a decline in rice cultivation and an increase in millet cultivation. Lined ponds and reservoirs exist but remain underutilized due to poor infrastructure and maintenance. Additionally, widespread soil erosion, affecting 73% of households, threatens long-term agricultural sustainability and productivity (Geoffrey et al. 2025). Deforestation is rampant due to rising fuelwood demand, land conversion for agriculture, and rural development.

1.3 Climate

The climate of Akole is classified as tropical wet and dry, marked by hot summers and generally dry conditions except during the southwest monsoon season. Maximum temperatures typically range between 35°C and 41°C, while minimum temperatures fall between 4°C and 15°C. Since Akole is located in the rain shadow region of the Western Ghats, the average annual rainfall is 508.9 mm which is much lower than in the adjoining regions with higher elevations ranging from 2000 to 3000 mm annually (Bapurao 2021). In recent years, farmers have observed delayed onset of monsoons in some years, followed by short bursts of high-intensity rainfall, which often result in crop damage, soil erosion, and deterioration of soil conservation structures.

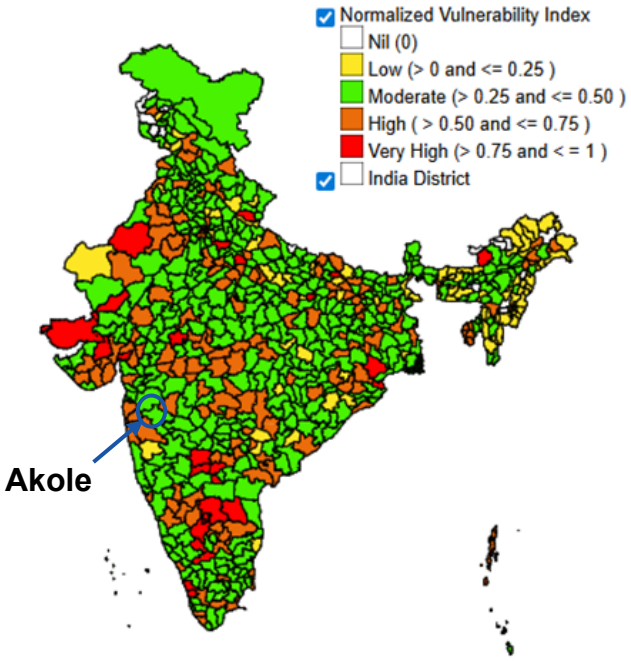

Figure 3. Drought vulnerability index of India by Indian Meteorological Department (IMD 2025)

Additionally, prolonged dry spells during critical crop growth stages, such as rice tillering, have led to considerable yield losses. As pe the Indian meteorological department (IMD), the drought vulnerability index of Akole landscape is 0.5 (Figure **3**) indicating moderate to high vulnerability in the landscape (IMD 2025). These climatic fluctuations have also contributed to a rise in pest and disease incidence, particularly in hybrid rice varieties, due to late sowing and stress conditions.

1.4 Demographic Characteristics

According to the 2011 Census, the total population of Akole tehsil is 291,950. Within the Akole cluster, which comprises of 10 villages, the total population stands at 15,007, of which 7,109 reside in the Kalsubai sub-cluster and 7,898 in the Igatpuri sub-cluster. The average household size among sampled households is 6 members. Approximately 80% of the population in the central and eastern parts of Akole tehsil rely on agriculture. Around 42% of families in the Kalsubai sub-cluster work as casual labourers post-harvest, and 28% of households seasonally migrate to nearby urban areas for wage labor. Pastoralism is also significant, especially among Dangi cattle herders from Kanadi, Mahadev Koli, and Thakar communities. In Kalsubai, 753 families rear cattle, 376 rear goats, and 439 families maintain backyard poultry. A small salaried population of 63 individuals is also recorded in the sub-cluster. In terms of gender distribution, Akole tehsil has 147,880 males and 144,070 females (Geoffrey et al. 2025). Languages spoken include Marathi dialects, Ahirani, Bhili, and Pauri Bareli. The population comprises 4.6% of Scheduled Castes and 47.9% of Scheduled tribes respectively.

1.5 Social and Cultural Characteristics

The tribal communities in Akole Taluka predominantly follow Hinduism. Culturally, these communities are deeply rooted in traditional knowledge systems, particularly in herbal medicine, which is orally transmitted across generations and used to treat various ailments, including snakebites. Tribal settlements, commonly known as Vadis, consist of houses traditionally constructed using baked earth with tiled roofs or mud walls plastered with clay and cow dung. Pastoralist groups, such as the Dangi cattle herders, continue to follow customary migration routes, reflecting a strong link to ancestral practices (Gaykar et al. 2011; Khyade et al. 2011). Staple foods include cooked rice, pulses, curry, and traditional flatbreads like bhakari made from Nagali (finger millet) or Bajra (pearl millet). Some tribal groups also consume wild meat such as rabbit, crab, and wild pig and indulge in locally brewed liquor made from the flowers of *Madhuca longifolia* (mahua flowers).

1.6 Land Use Characteristics

The Akole cluster, exhibits a diverse land use pattern influenced by its topography and agro-ecological conditions (Figure 4). Approximately 46% of the landscape is under cropland. 7% of the land is covered by forest, much of which falls within the Kalsubai-Harishchandragad Wildlife Sanctuary. Built-up areas account for about 3%, representing rural settlements and infrastructure, while 40% comprises rangeland. Water bodies occupy approximately 6% of the total area, the most significant being the Bhandardara Dam (Arthur Lake) on the Pravara River. The land use reflects a multifunctional landscape that integrates agriculture, livestock, conservation, and rural livelihoods.

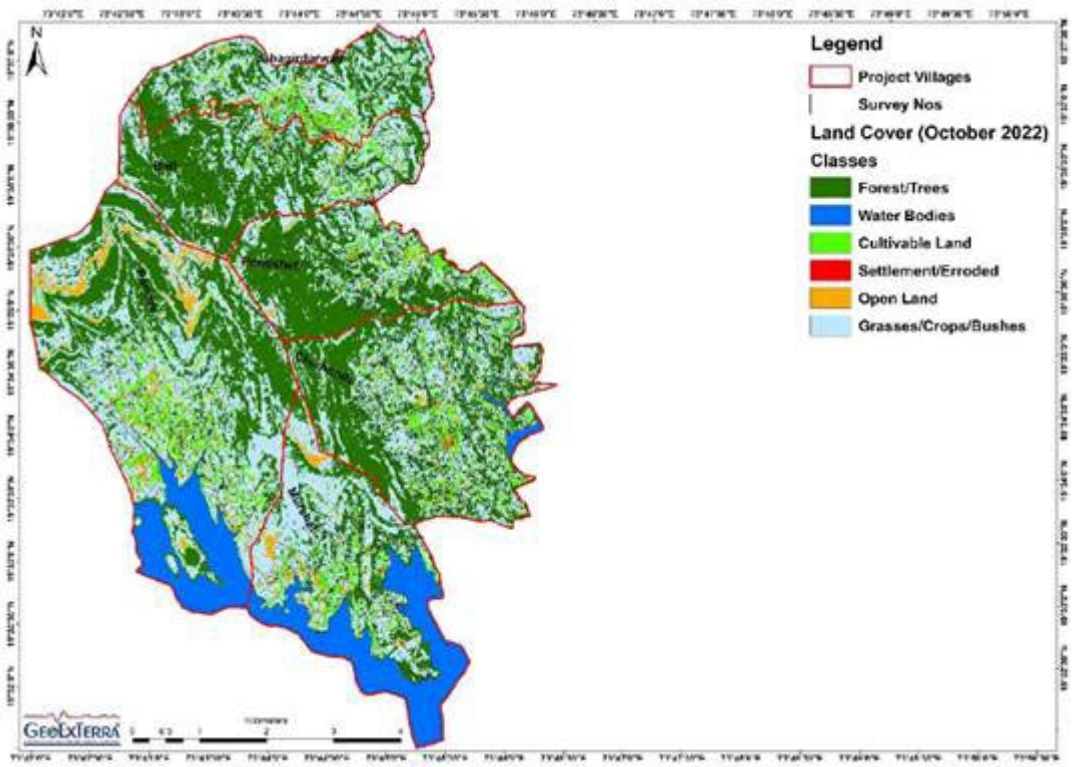

Figure 4. Land use and land cover including trees and vegetation of Akole, Ahmednagar, October 2022 (*Source:* BAIF and GeoExterra 2023).

The acquisition of land for construction of Nilwande Dam on the Pravara river has displaced hundreds of families, disrupted their livelihoods and not adequately addressing livelihood restoration. Living on the forest fringe gives the community access to forest products and grazing opportunities. However, this often also leads to human-wildlife conflicts, crop raiding, loss of life, livestock, or damage to property (Deshmukh, et al. 2024).

1.7 Production and Market

On average, about 56% of the total agricultural production is sold in local markets, while the remaining 44% is used for self-consumption. Livestock products serve both consumption and sale purposes. However, income from livestock remains limited, and only a portion of households are actively involved in livestock markets. Overall, most agricultural and livestock products are either consumed within the household or sold locally, with minimal export outside the Akole landscape (Kauthale 2021).

1.8 Employment

Communities in the region are increasingly participating in both tourism and service sector employment. Beyond tourism, residents are engaged in various service-based occupations. Akole hosts several Farmer Producer Organizations (FPOs). Agro-processing industries—including cooperative sugar factories, dairy units, and rice mills—provide employment in both service and industrial sectors. Approximately 42% of households in the Kalsubai sub-cluster work as casual labourers within their villages or nearby areas. Additionally, about 28% of households undertake seasonal migration to urban centers for unskilled daily wage work in sectors such as construction, transport, and loading/unloading. A portion of the population is also employed in salaried roles across various fields (BAIF 2024; Geoffrey et al. 2025).

1.9 CGIAR Engagement in Akole Context

The primary CGIAR-supported initiative is the “Nature-Positive Solutions for Shifting Agri-Food Systems to More Resilient and Sustainable Pathways (Nature Positive Initiative)” initiative. Major Focus of the Nature Positive Initiative is given below:

1. Land degradation and natural resource depletion
2. Limited evidence and knowledge within the agricultural research-for-development (AR4D) community
3. Absence of viable business models to catalyze public-private partnerships in sustainable agriculture

Key findings: Environmental degradation, unsustainable practices, and climate vulnerability continue to threaten Indian agriculture; Soil erosion affects 73% of surveyed households, with higher rates in control households (81%) compared to treated ones (65%); Only 33% of households had adopted erosion control measures; Food insecurity was pronounced in Ahmednagar, marked by the lowest daily per capita calorie intake. Access to agricultural extension services remained uniformly poor across regions. Communities frequently experienced climate-related shocks (e.g., erratic rainfall, droughts) and pest/disease outbreaks, particularly in Nashik and Ahmednagar.

CGIAR major innovations are: agrobiodiversity enhancement through community seed banks (e.g., in Jahagirdarwadi) and in-situ conservation of landraces via community-led diversity models, decentralized, community-level seed production, improve market linkages for traditional crops, construction and desiltation of lined ponds, rejuvenation of dug wells,

promotion of farm ponds, integrated nutrient management (INM), implemented Integrated Renewable Energy and Sustainable Agriculture (IRESA) model as household-level biogas units, the Circular Bioeconomy Innovation Hub (CBE-IH) is lunched under CGIAR serves as a platform for knowledge exchange, skill-building, and the promotion of circular farming solutions as shown in figure 5 (Taron, et al. 2022; BAIF and GeoExterra 2023; Sikka et al. 2023; Tripathi, et al. 2023; Chavan, et al. 2024; Nandgude et al. 2024; Geoffrey, et al. 2025; Yadav, et al. 2025).

Figure 5. Examples of Nature Positive Interventions in Akole Landscape; (a) Farm Pond with cactus plantation, (b) IRESA Biogas unit at household level, (c) Recharge well, and (d) Trenches for catchment area treatment. The key project reference documents are given in the reference section (*photo:* Shweta Yadav/IWMI).

2. Status of the Multidimensional Performance of the Landscape

The status of the multifunctional performance of the Akole landscape, in Ahilyanagar District (previously Ahmednagar), Maharashtra, India is indicated in terms of agronomic, economic, environmental, and social performances.

2.1 Agronomic Performance

In Akole landscape farmers grow mainly rainfed crops such as paddy in kharif season. Apart from paddy, Bajara (pearl millet), Nagli (finger millet), Varai (little millet), Khurasni (Niger), red gram and groundnut are grown in kharif season (June-October), whereas, in rabi season (October-May) Jowar, Wheat, Gram, Black pea, Lentil, and Wal (Hyacinth bean) are major crops grown in Akole. Out of total cultivable area 95% area under rice crop and only 5 to 10% area from remaining Kharif crops. In Rabi season only 10 to 15% area under crops like Wheat, Gram, Black pea, Lentil and Hyacinth bean due to unavailability of irrigation facilities and waterand 7% of farmers land is left fallow (BAIF 2024). Besides the principal crops stated above, various other crops including fruits, vegetables, condiments, etc., are grown. Around 32% of households grow mango plantation and 1% other plants (BAIF 2024, Geoffrey et al. 2025). The area has a diverse cropping pattern, with a mix of traditional and modern farming techniques.

As per the household survey in March-April 2023 by IFPRI (Geoffrey et al. 2025), out of 313 households in Akole, Ahmednagar, 83% grow rice, 30% grow wheat, 9% other cereals, 8% peanuts, 32% mango, 1% each maize and soybean while the remaining grows vegetables such as tomato and radish. Productivity of the crop type including horticulture crop surveyed in Akole is given in **Table 1 and 2**.

Table 1. Productivity of the crop type surveyed in Akole, Ahmednagar district, Maharashtra, India (*Source:* BAIF 2024).

Crop Type	Yield (Quintal/Ha)	Vegetable Type	Yield (Quintal/Ha)
Paddy	40-45	Tomato	550-600
Finger Millet	20-25	Chilli	150-200
Little Millet	12-15	Eggplant	250-300
Wheat	35-40	Pearl Millet	25-30
Groundnut	25-30	Marigold	300-350
Lentil	15-16	Beans	100-120
Gram	25-30		
Pea	400-500		

Table 2. Area under horticulture crop in Akole, Ahmednagar district, Maharashtra, India (*Source:* BAIF 2024).

Horticulture crops - fruits	Area ('000ha) Total	Horticulture crops Vegetable	Area ('000ha) -Total	Area ('000ha) Total
1	Pomegranate	1	Onion	69.978
2	Kagzi Lime /Acid Lime / Key Lime	2	Tomato	4.173

3	Guava	3	Eggplant	1.786
4	Mango	4	Chilli	1.774
5	Sapodilla (Naseberry)			

The region is famous for the indigenous cattle breed Dangi. As per the survey, >70% of farmers are involved in the livestock activities. The average ownership of livestock units in Akole Ahmednagar is 1.3. Around 52% were involved in bull rearing, 50% in goat rearing and 41% of the households were involved in poultry raising whereas 27% to 23% were involved in cows and draught cattle (**Figure 6**). Only 1.6% of households are involved in fishponds. Livestock diversification is indicated by Gini Simpson index which is for Akole Ahmednagar is 0.29 (BAIF 2024, Geoffrey et al. 2025).

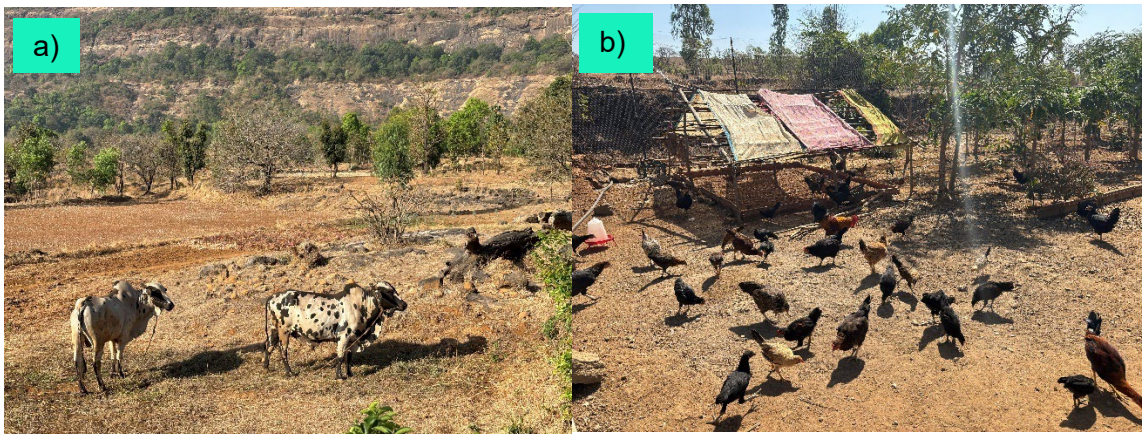

Figure 6. Bull rearing (a) and poultry activities (b) in Akole landscape, Ahmednagar, Maharashtra (*photo:* Shweta Yadav/IWMI).

The key factors that limit achieving optimal productivity in the agricultural sector in the landscape:

1. High drainage density (0.5 to 3.5 km/km2) increases the runoff, and the erosion of nutrient rich topsoil resulting in reduced agricultural productivity (**Figure 7**).
2. Lack of water availability during rabi season, low water holding capacity along with lack of proper water management systems leads to reduced yields.
3. Delayed monsoon has increased the incidence of disease and pest attack in hybrid varieties of rice due to late sowing.
4. Shifting rain pattern - High-intensity rainfall in a short span of time is leading crop loss, soil erosion, damage in soil conservation bunds and intermittent dry spells especially during the tilling stage of rice leading to heavy losses.
5. Imbalance use of Fertilizer such as Urea, DAP – resulting in lodging of the rice, nutrient loss, and contaminating water bodies especially local springs.
6. Loss of crop diversity due to the predominance of mono-cropping by adapting to high-yielding varieties and application of synthetic fertilizers.

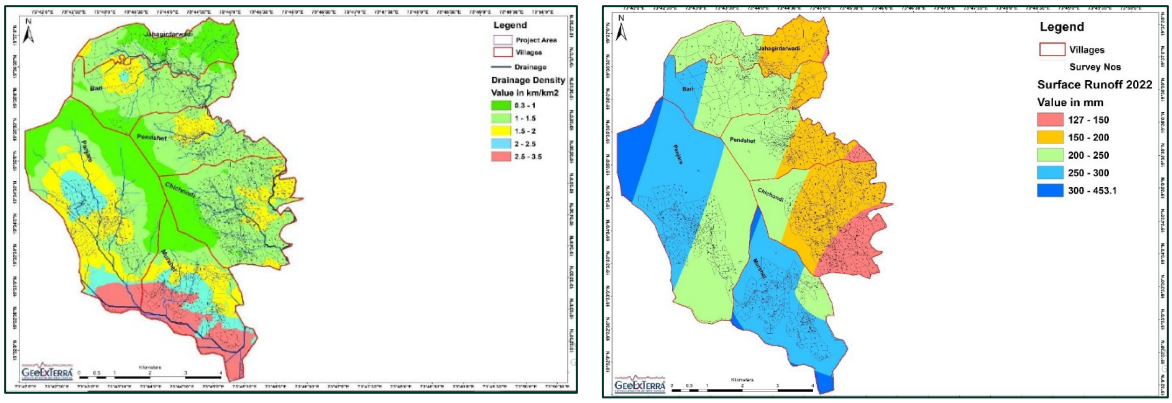

Figure 7. Drainage density and Surface Runoff in the Akole landscape (*Source:* BAIF and GeoExterra 2023).

The area has a diverse cropping pattern, with a mix of traditional and modern farming techniques, the specific data is not available. More than 80% farmers cultivate high yielding hybrid rice variety in the landscape, and <20% farmers cultivate the indigenous varieties of rice (Gari kolpi, Hali Kolpi, Kalbhat, Ambemohar, Kamod, Varangal, Jirwel, Manohar etc.). Akole is also known for traditional knowledge. However, due to economic pressures, the younger generations shift away from traditional practices of agriculture, conservation and exchange of seeds, and harmonious dwelling with the forests. This has resulted in a significant reduction in the intergenerational transfer of knowledge. Only 18% of the households prefer the traditional seeds compared to the improved seed which according to them are more expensive and not easily accessible than the traditional seeds (**Figure 8**).

Figure 8. Community seed bank and traditional seed storage system for wild edible plants in Akole, Ahmednagar (*photo:* Shweta Yadav/IWMI).

The availability of extension services, critical for supporting agricultural productivity, is uniformly limited across all surveyed communities. Communities in Akole, Ahmednagar sites reported low scores, ranging from 1.5 to 1.7, for access to activities like ploughing, planting, herbicide application, and livestock management, indicating minimal agricultural support services regardless of location or treatment status (**Geoffrey et al. 2025)**. As per the survey data, the use of inorganic fertilizer is 43% and the use of organic fertilizer is 58% in Akole, Ahmednagar. Urea is the most used fertilizer in the site. Pesticide application is more prevalent than herbicide use. 27% of the households reportedly used pesticides in Ahmednagar. Whereas, herbicide use is 19%. Nutrient use efficiency data is not available. Around 12% of

households in the study site reported the high crop pests/ diseases which is the most prevalent non-climatic shock. As per the survey in 10 households in Akole. Most used pesticide in the study site is Hamala-250 Ml which contains chlorpyriphos and cypermethrin which are toxic to birds and pests and moderately hazardous to humans (**Manibahi 2024**).

Common infectious livestock diseases reported for the study site is foot and mouth disease, lumpy skin disease, black quarter, anthrax, swine fewer and various haemoprotozoan infection (Krishnamoorthy et al. 2018). Five parasite infections were among the top ten cattle diseases recorded, including fascioliasis, coccidiosis, trypanosomosis, babesiosis, and theileriosis. Bovine babesiosis and theileriosis, which spread by ticks, are considered economically significant (**Waghmare et al. 2022**). By altering animal growth and output, it causes catastrophic losses to livestock farmers.

2.2 Economic Performance

In India, poverty line for urban areas is INR 33 per day (USD 0.38/day) and rural areas is INR 27 per day (USD 0.30/day). In the Akole landscape, 61% of total households fall under the Below Poverty Line (BPL) category. Majority of population is below poverty line in the landscape as show in **Figure 9** (**BAIF 2024**). Agriculture is a seasonal occupation and there is no other perennial source of income. Once the agriculture season is over, 42% families find work in the village or in nearby areas as casual labour. It is observed that 28% households migrate to nearby cities to obtain daily wage work. They do unskilled work, building construction labor, loading unloading of material, painting work, and in brick kilns.

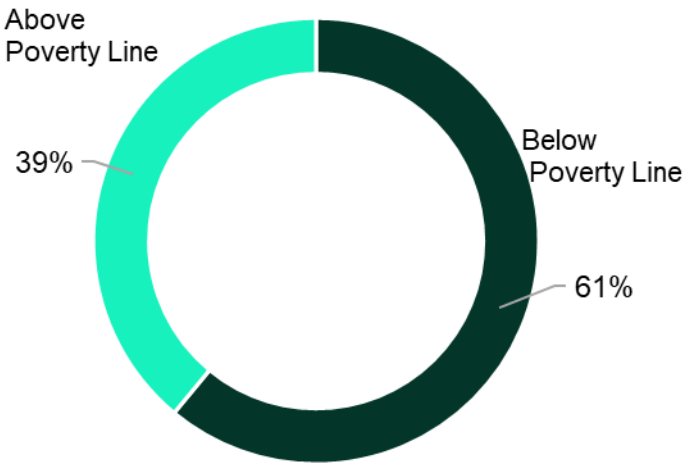

Figure 9. Poverty level in Akole landscape, Ahmednagar, Maharashtra, India (*Source:* developed by authors, data: BAIF 2024)

On average, the number of different income sources in study site in Ahmednagar is 1.4. Around 1215 families are engaged in their own farm. Other major livelihood sources in the sub cluster area are - 63 persons are salaried employees, while 376 families rear goats, 753 Families rear cattle, and around 439 families have backyard poultry. The site attracts tourists mainly from the surrounding districts in monsoon season which supports the livelihood of tribal population for a few months. The data on employed people who are engaged in agriculture is not available. In the landscape, 78% of the household income depends on the crop income and 6% on the livestock income. Non-agricultural income sources, including self-employment and other business ventures, contribute only 11% to household income (**Figure 10**). Total

household expenditure in Ahmednagar is INR 77,028 (USD 847) whereas the per capita expenditure is INR 15,932 (USD 175) and per capita food expenditure is INR 12719 (USD 139) as per the survey conducted in 2023. In the study site, the female only-ownership of productive/agricultural-asset is 4% while the ownership of men is 83%. While, durable asset ownership led by female is only 4%, male is 57% and 39% is joint ownership. Ahmednagar district demonstrates the highest agricultural dependence (i.e., crop, livestock, agricultural wage) contributing >80% of household income.

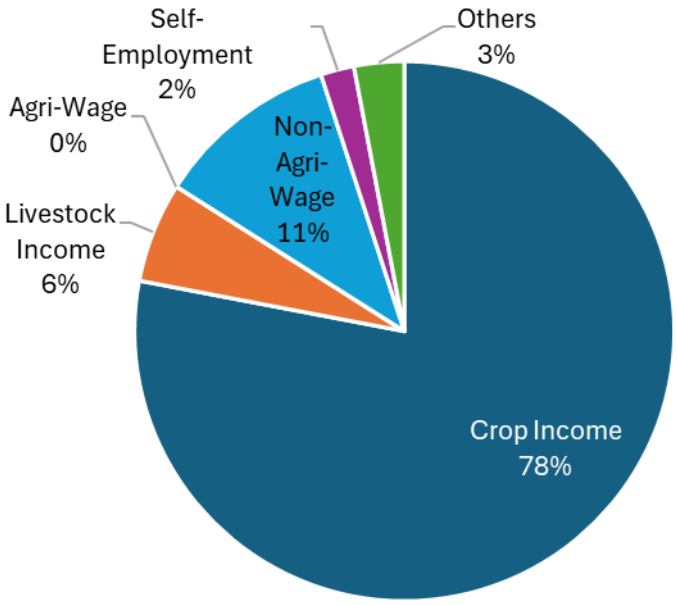

Figure 10. Income sources of households in Akole, Ahmednagar (*Source:* developed by authors, data: Manibahi 2024; Geoffrey et al. 2025).

2.3 Environmental Performance

Akole and the larger Ahmednagar district are prone to droughts, floods, and landslides. Due to erratic and insufficient rainfall, Akole experienced water scarcity most part of the year leading to drought. According to a recent study, the frequency of drought has increased in the last two decades (**Rahase 2023**). Severe drought conditions experienced in 2018. Apart from droughts, the region also experiences flash floods due to heavy rainfall within short span of times leading to landslide during monsoons. The extreme events leads to reduced yield, livelihood loss of small farmers, water scarcity and groundwater depletion. Changes in the rainfall pattern has been observed in the region, which lies in the rain-shadow of the Western Ghats, experiences highly erratic rainfall. Climate change has led to the fluctuations in annual rainfall and an increase in the frequency and intensity of extreme events like droughts and sometimes high-intensity rainfall and decreased overall rainfall in some areas, contributing to drought-like conditions. Community shocks in the last agricultural season was observed in terms of infectious disease COVID-19, rising food prices, land loss, and political/tribal conflicts, affecting at least 1.9 % of households, while environmental shocks such as storms (1.3 %) and floods (1.5 %) are less prevalent (**BAIF 2024, Geoffrey et al. 2025).**

As per the Land cover data of October 2022, 1882.9 ha (39.3%) of the land area belongs to the forest and marginal forest including trees. 193.6 ha (4.0 %) open land having exposed rock outcrops with a very thin veneer of sandy soils. 1826.5 ha 38.1 % is of mixed vegetation

comprised of grasses, standing crops, and bushes are mainly utilized as grazing land during the monsoon.

Forests cover 27.7% of Akole's geographical area. The forests, particularly dense in the western region, host a rich variety of native flora such as Aashing, Gulchavi, Hirda, Bahava, Beheda, and diverse grasses. Protected areas like the Kalsubai-Harishchandragad and Rehekuri Wildlife Sanctuaries help preserve the region's biodiversity. Wildlife includes species like sambar, chital, porcupine, barking deer, Indian giant squirrel, leopard, wolf, and tiger, along with 142 bird species and various reptiles (**BAIF 2024; Sawarkar 2014**).

The tolerable soil loss limit of Maharashtra ranges from 2.5 to 12.5 t/ha/year. The annual average soil loss of Akole is estimated using the RUSLE (Revised Universal Soil Loss Equation) method in ArcGIS by MPKV Rahuri an IWMI project partner. The estimated annual average soil loss of Aloke ranges from 1 to 1069 ton/ha/year with a mean value of 50.4 t/ha/year. Around 90% of the area is under no risk of soil erosion (<9 t/ha/year), 1 ha area is at the low risk of soil erosion (9-22 t/ha/year), 38 ha area under medium risk (22-45 t/ha/year), and 45 ha area (0.9%) is at high risk of soil loss 45-75 t/ha/year (**Figure 11**).

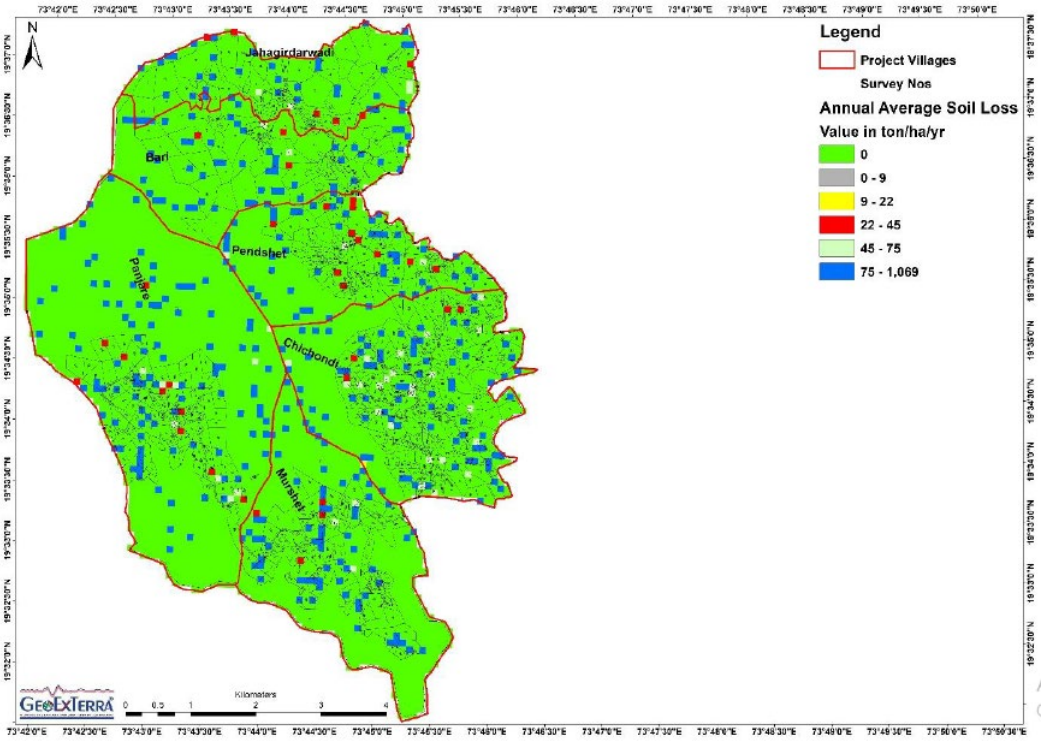

Figure 11. Annual average soil loss in Akole , Ahmednagar, Maharashtra (*Source:* BAIF and GeoExterra 2023).

Soil loss and carbon loss were estimated for two small watersheds of chichundi village, in Akole, Ahmednagar (**Figure 12a and 12b**). The findings indicate that annual carbon loss in the watershed ranges widely, from as low as 0 to as high as 973 kg/ha/year, with an overall average of 612 kg/ha/year. This substantial loss of carbon within the soil not only signifies a depletion of an essential element but also has important consequences for broader ecological functions.

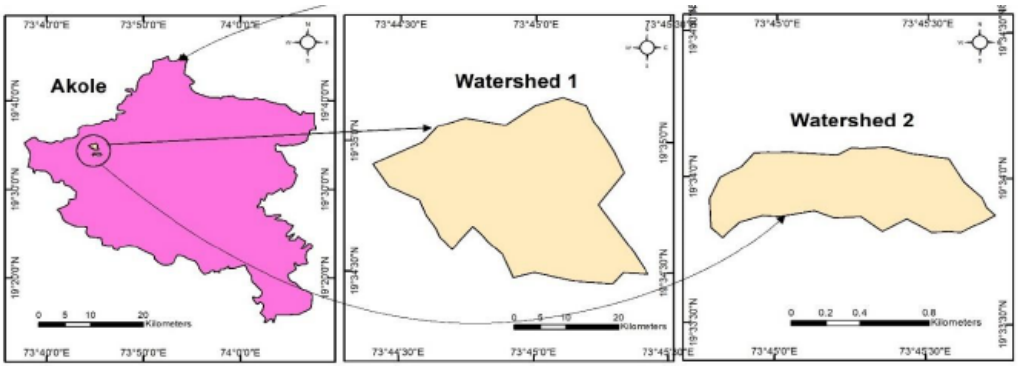

Figure 12. (a) Location of watershed-1 and watershed-2 in the Chichundi Village, Akole, Ahmednagar in 2023 (*Source:* Nandgude et al. 2024; Yadav et al. 2025).

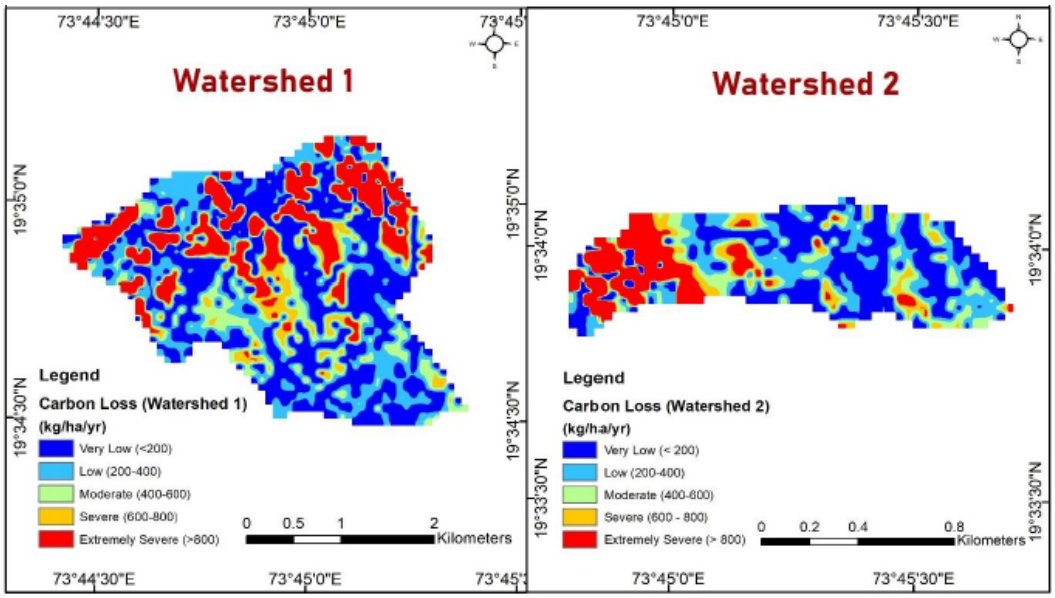

Figure 12. (b) Carbon loss map of the watershed 1 and 2 in the Chichundi Village, Akole, Ahmednagar in 2023 (*Source:* Nandgude et al. 2024; Yadav et al. 2025).

A total of 38 surface and groundwater locations were studied in 2023 for water level, and water quality parameters. The diameter of dug wells in the area ranges from 3 to 9 m. The depth of the water level varies from 0.5 to 8.4 m below ground level. In-situ water samples were tested for water quality parameters i.e., Temp, pH, EC, and TDS. The temperature of the water varies from 20.4 – 31.5°C.

The pH is alkaline and varies from 7.81 to 11.03. The pH of most of the water samples is found to be higher than the prescribed limit (6.5 – 8.5) as per the Bureau of Indian Standards-1992. The electrical conductivity (EC) of groundwater ranges from 80 - 740 µS/cm and is found within the desired limit. The concentration of TDS ranges between 50-396 mg/l and is also within the recommended limit of 500 mg/l (**Figure 13**)

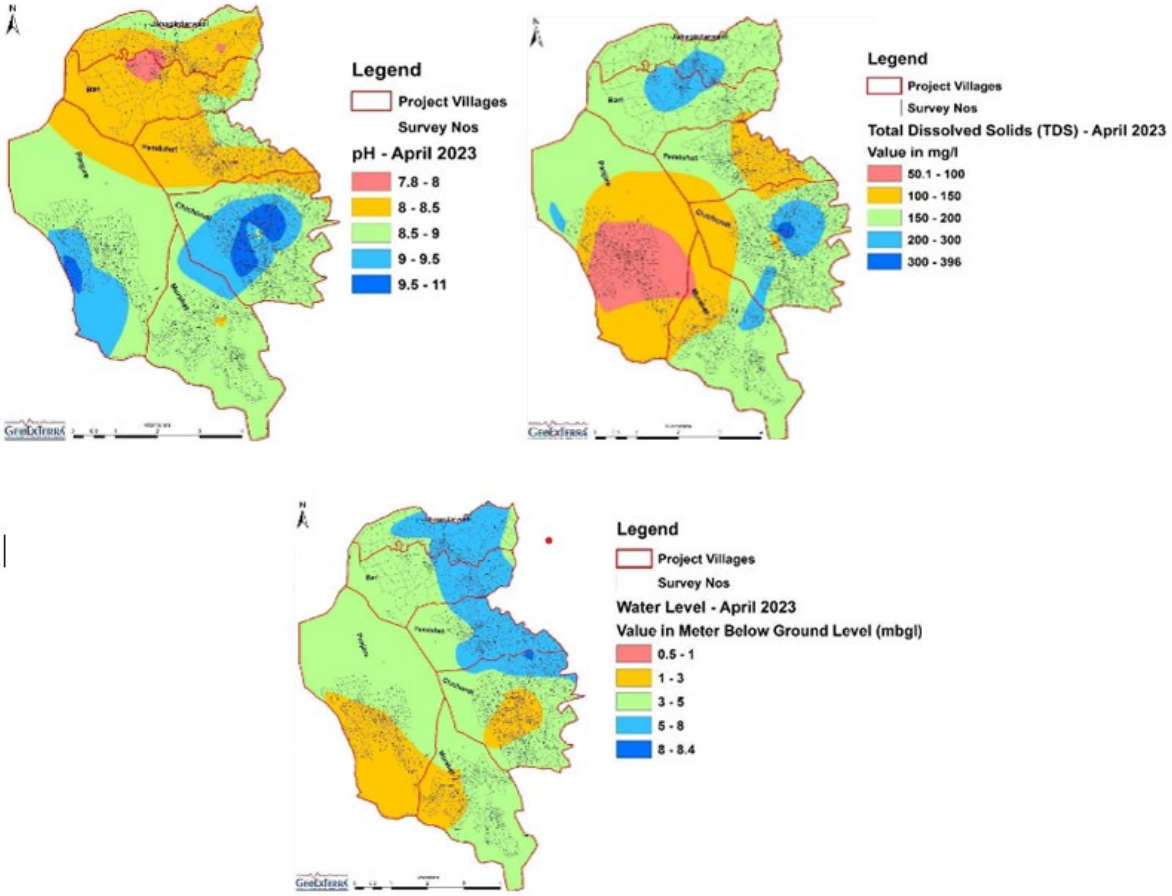

Figure 13. pH, TDS of surface and groundwater and Water level of the groundwater wells in Akole, Ahmednagar (*Source:* BAIF and GeoExterra 2023).

2.4 Social Performance

Social performance of Akole landscape is influenced by several factors such as climate change, limited resource accessibility and availability, limited income sources and low literacy. Since 2020, on average 74% of households are vulnerable to both climate related and non-climate related shocks in Akole, Ahmednagar out of 313 households surveyed. Climate-related shock was experienced by 69% of the household where change in the rainy season is a major contributor (29%) while drought accounts for 7% of the climate-related vulnerability. Non-climate-related shocks also play a significant role, though at lower levels than climate events. Non-climate related shocks were experienced by 5% of the households, where high crop pests/disease are the major contributor of the non-climate-related vulnerability (12%) followed by high prices of the major food items (3%) and illness of household members (2%) in Ahmednagar. High crop pests/diseases emerge as the most prevalent non-climate shock in the landscape (**Geoffrey et al. 2025**).

In the landscape, out of the households surveyed, 34% have never been to school, whereas 26% have primary education, 19% have secondary education and 21% with tertiary education (**Figure 14**). Changing weather patterns in the landscape increases the risk to crops, livestock and livelihoods, where 78% of the households depend on the crop income and 7% depends on livestock income as a secondary source of agricultural income (**Geoffrey et al. 2025).**

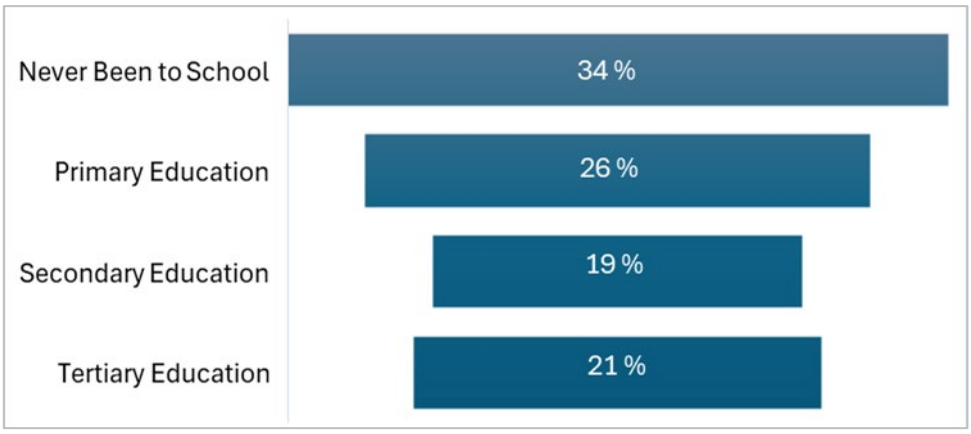

Figure 14. Education status of the Akole landscape based on the survey of 313 households (*Source:* developed by authors, data: Geoffrey et al. 2025).

Ahmednagar district is tribal district of Maharashtra;the population in this region depends on the natural resources and collection of forest products. Pockets of malnutrition have been observed in the Akole landscape. Out of 19259 tribal children observed, around 16% suffer from moderately acute malnutrition (MAM) and 4% suffer from severe acute malnutrition (SAM) (Popatrao, et al. 2025). Because the situated in Sahyadri mountain remote area and it does not have proper transportation facilities as well as medical facilities as well. As per the household survey by **Geoffrey et al. (2025)**, the daily per capita consumption of calories is low in the Akole, Ahmednagar with only 1404 kcal. The Household Dietary Diversity Score (HDDS) for Ahmednagar was 6.4, points to the potential influence of regional agricultural and economic factors on access to a variety of food groups.

The traditional methods of irrigation such as flooding, check basin and border irrigation result in poor conveyance and porous soils. Ground water has emerged as the prime source of drinking and irrigation. Above 90%, present ground water withdrawal is being used for irrigation purposes thus contributing largely to food security of the landscape (BAIF 2024).

Women and youth empowerment in Akole, Ahmednagar, is primarily driven by various **Non-Governmental Organizations (NGOs)** and local initiatives, which focus on vocational training, education, health, and the formation of **Self-Help Groups (SHGs)** to promote economic independence and social change. Other government organization also play key role in agriculture development, livelihood and women empowerment such as Indican Council for Agriculture Research (ICAR) and National Bank for Agriculture and Rural Development (NABARD).

3. Existing Evidence of the Multidimensional Performances of Agroecological, Regenerative and Nature-Positive Approaches Relevant to the Context of the Akole Landscape

The Akole cluster, promoting sustainable agriculture and environmental resilience through Nature positive interventions, such as in Jahangirwadi village, strengthening of a community-managed seed bank, which conserves traditional seeds to supports on-farm genetic diversity. Over 800 farmers benefit from this seed bank by borrowing indigenous seeds for cultivation and returning a portion post-harvest, creating a self-sustaining circular seed economy. This enhances crop resilience and reduces dependence on commercial seed markets. In parallel, 10 IRESA biogas units have been installed to promote circular bioeconomy practices. Each unit converts cow dung into biogas, replacing around 5 LPG cylinders per household annually and reducing firewood usage. The resulting 3 tonnes of biogas slurry per unit per year is used as organic fertilizer, lowering synthetic input use and improving soil health. These units collectively reduce 47 tCO_2e in greenhouse gas emissions. Water management has also improved through lined pond construction, dug well rejuvenation, and farm pond promotion, enhancing water availability and recharge. Simultaneously, Integrated Nutrient Management (INM) strategies are being tested across the landscape to reduce fertilizer use and maintain soil quality. The Circular Bioeconomy Innovation Hub (CBE-IH), launched under the Consultative Group for International Agricultural Research (CGIAR), supports these efforts through capacity building and promotion of regenerative farming practices.

Unlike conventional agriculture, which prioritizes a single perspective (agronomic yield), evidence regarding agroecology, regenerative agriculture, and nature-based solutions (NbS) confirms that these approaches act as "multidimensional levers" for sustainability. The shift in the agronomic perspective moves from maximizing the yield of a single crop to optimizing the total system productivity and resilience. Evidence from the FAO's TAPE (Tool for Agroecology Performance Evaluation) shows that agroecological farms reduce dependency on synthetic inputs by 20–30%, replacing them with biological cycles (nitrogen fixation, natural pest predation) (FAO 2025). Economic evidence highlights a shift from "high-revenue, high-cost" models to "high-margin, low-risk" frameworks. Regenerative farms often report higher net profits due to the drastic reduction in seed, fertilizer, and pesticide costs, despite slightly lower gross yields. Agroecology reduces GHG emissions by eliminating synthetic nitrogen and sequestering atmospheric CO_2 into the soil and woody biomass. Developed under the CGIAR Initiative on Agroecology HOLPA (Holistic Localized Performance Assessment) tool provides a rigorous, multi-perspective look at how agroecology and regenerative approaches perform in real-world landscapes (Sanchez et al. 2024). In India, HOLPA baseline data shows that farms adhering to agroecological principles (recycling, synergy) report a significant reduction in dependency on external synthetic fertilizers. HOLPA pilots in India utilized bioacoustics to prove that agroecological landscapes support a higher richness of beneficial insects and birds, which provide "pest control services" that replace chemical interventions (Sanchez et al. 2024).

4. Critical Data, Evidence, and Information Gaps

There are critical data gaps to generate evidence-based information for Akole landscape in terms of agronomic, economic, environmental, and social performance. Data on social performance still needs to be updated at the landscape level to generate the evidence. Furthermore, the health of humans, livestock health and diseases are missing at the landscape level. **Table 3** illustrates the key data gap for evidence generation in Akole Landscape.

Table 3. Data gaps in the Akole Landscape, Ahmednagar, Maharashtra (*Source:* Taron, et al. 2022; BAIF and GeoExterra 2023; Sikka et al. 2023; Tripathi, et al. 2023; Chavan, et al. 2024; Nandgude et al. 2024; Geoffrey, et al. 2025; Yadav, et al. 2025).

Data Type	Data Gap: Akole Landscape
Geographical	Key groups and institutions working with stakeholders. Actor Mapping (implementing and research actors, community and producer actors, governance and policy actors, market and value chain actors)
Agronomic	Data on livestock type; total production and average productivity of livestock and fishery products; productivity in different farm types; %of modern and traditional farming practices; % and rate of fertilizer and pesticide use; crop health; damage and harvest losses due to weeds, pest, diseases; hazardous and biological pesticide use in the landscape; area under integrated pest management; water consumption; Water use efficiency; data on livestock health and veterinary drugs.
Economic	Population involved in alternative income streams; local value addition in different key value chains; key private sector actors in the landscape; key local, domestic, and export markets for agriculture/livestock/fishery products and value chain.
Biodiversity and Environmental	Keystone /protected species, biodiversity data; ecosystem health, GHG emission from Land uses; nutrient flow; energy use efficiency; current and potential carbon sequestration; climate change adaptation and resilience status; climate risk index; mechanism to respond climate events.
Social	Land use conflicts; human health and wellbeing; health burden related to agri-food system; sustainable consumption patterns, proportion of population unable to afford a healthy diet; degree of participation of different demographic groups in formal or informal governance and decision-making processes regarding land use and natural resource management.

5. Methodological Approach

The Akole Landscape is a predominantly tribal, rural block with limited urbanization, where the economy relies heavily on agriculture and forest products. The methodological approach is driven by the data and assessment from two main group of partners mainly (1) CG Centers: IWMI, Alliance Bioversity, IFPRI, ICRISAT, and WorldFish provide the scientific and global framework, expertise, and technical guidance for the assessment; and (2) Implementing partners: BAIF, NIASM, and MPKV Rahuri are the local and national organizations/institutions contributed to the on-the-ground activities, data collection, and practical application along with the CG centers. The synthesis report is based on the assessment period from 2022 to 2024 in the Akole Landscape. The methodology employs the mixed method approach combining, (1) desktop research, (2) technical reports, scoping studies, knowledge products, (3) stakeholders' survey/interviews, and (4) field data assessment (**Figure 15**). The detailed findings of on-ground survey, scoping studies and data collection on Akole Landscape is also reported in BAIF and GeoExterra 2023; Tripathi, et al. 2023; Nandgude et al. 2024; Geoffrey, et al. 2025; and Yadav, et al. 2025.

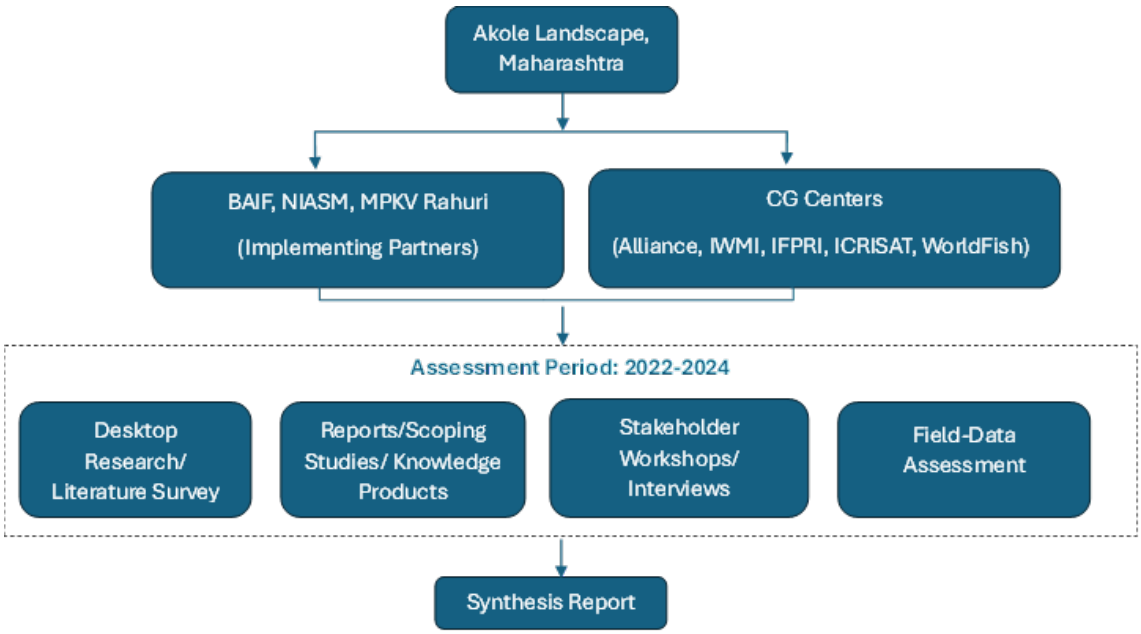

Figure 15. Methodological approach for Akole landscape synthesis document (*Source:* developed by authors).

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