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Ecological footprint assessment of tribal and non-tribal communities in Purulia District: A comparative study

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Abstract
Sustainable resource management in ecologically sensitive regions requires understanding how different social groups experience different ecological pressures. The study assesses the ecological footprint (EF) of tribal and non-tribal communities in Purulia District, West Bengal, which show distinct differences in their livelihood strategies and cultural practices and their access to natural resources. The assessment uses household data about fuelwood consumption and agricultural land use and grazing needs and livestock patterns and energy usage together with secondary data about land productivity and forest biomass availability. The study found that tribal households create a larger forest footprint because they depend heavily on fuelwood and non-timber forest products and their traditional practice of open grazing. The non-tribal households create a bigger cropland and carbon footprint because they use mechanised agriculture and chemical fertilisers and have bigger livestock holdings and higher dependency on LPG and electricity. The analysis shows that tribal areas face a forest ecological deficit while non-tribal areas experience cropland and carbon deficits because different communities apply different types of ecological pressure. The study found that Purulia needs specific programs for clean household energy and sustainable agricultural practices and forest restoration and community-based resource governance systems which should be designed to meet the requirements of tribal and non-tribal populations.

Keywords: Ecological footprint, tribal communities, non-tribal communities, resource consumption, biocapacity, forest dependence, carbon footprint, sustainability

Introduction

The Ecological Footprint (EF) analysis system has become the common method which scientists use to measure human effects on ecological environments by measuring how much people require from nature through their use of land and water resources which support biological life (Wackernagel & Rees, 1996) [15]. The EF method compares how much people use resources with the amount of biocapacity which exists in a specific area to determine whether ecological resources face shortages or excesses that affect both sustainability and resource management (Global Footprint Network, 2023) [5]. The EF serves as an essential approach for studying resource consumption patterns and environmental effects among different social groups in developing areas which depend on their local ecosystems for their livelihoods (WWF, 2022) [16]. The westernmost part of West Bengal contains Purulia District which functions as a sensitive landscape because its tribal and non-tribal communities share the area while maintaining separate cultural practices and ways of making a living and using environmental resources. The tribal households in Purulia's forested and upland areas maintain their traditional practices by depending on fuelwood collection and non-timber forest products and open grazing and subsistence agriculture (Sarkar & Das, 2020) [12]. The non-tribal communities use market-based income methods more frequently while they engage in agricultural practices and they use machinery at a higher rate and they use commercial energy sources like LPG and diesel and electricity at a higher rate than tribal communities (Basu & Ghosh, 2019) [1]. The district experiences diverse ecological pressures which arise from its two contrasting patterns. Existing studies on Purulia have highlighted issues such as forest degradation, rising carbon emissions from mechanised farming, seasonal resource scarcity, and increasing pressure on croplands (Maiti & Garai, 2021) [8]. Researchers have investigated ecological footprints in tribal and non-tribal communities yet existing studies remain incomplete because they focus only on one community type. The district needs this research because it helps organizations build district-specific resource management systems that address local issues, which include droughts and land degradation and socioeconomic issues. The study evaluates ecological footprints through an extensive assessment which determines environmental impacts that tribal and non-tribal residents of Purulia District use. The study examines four primary elements which include forest footprint and cropland footprint and grazing land footprint together with carbon footprint and its related socioeconomic and cultural factors. The research establishes a link between EF results and biocapacity measurements to provide research-based information that helps develop sustainable resource management solutions for both groups through community-centered approaches.

The Ecological Footprint (EF), first conceptualised by Wackernagel and Rees (1996) [15], provides a biophysical measure of human demand on nature, expressed in terms of the biologically productive land required to sustain resource consumption and absorb waste. EF analysis has become a widely used tool for global sustainability assessments and national resource accounting during the past two decades (Kitzes *et al.*, 2009; Global Footprint Network, 2023) [5, 7]. Researchers have used EF to study environmental effects in various fields including agriculture forestry energy use and rural economy (Borucke *et al.*, 2013) [2]. The use of EF indicators permits researchers to assess ecological deficits which occur when human demand surpasses the available biocapacity, a problem which developing areas face as their socio-economic conditions progress (WWF, 2022) [16]. Researchers have studied EF patterns in rural areas because they show how rural people depend on natural ecosystems, as shown by their research. South Asian research shows that forest-based communities rely on biomass and pastoral land and subsistence land for their forest activities, which causes them to create larger forest footprints. Tribal communities develop different ecological relationships through their traditional knowledge and their rights to access forests based on their cultural connections to these areas (Misra, 2017) [9]. Tribal households from Jharkhand Odisha and North-East India display higher fuelwood consumption and NTFP extraction along with extensive open grazing, which creates ecological damage to their local environment (Pati & Singh, 2020) [10]. In contrast, non-tribal rural households tend to exhibit higher cropland and carbon footprints due to mechanised agriculture, chemical fertilizers, irrigation pumps, and increasing dependence on commercial energy sources (Roy & Bera, 2019) [11]. Such findings underscore the importance of understanding community-specific ecological pressures. Research shows that West Bengal faces new ecological challenges which scientists trace back to environmental changes and decreasing forest areas and rising energy usage in rural regions (Chakraborty & Mukherjee, 2020) [3]. The Purulia and Jhargram and Bankura districts which belong to the Chhotanagpur Plateau extended area face problems of drought and soil erosion and deforestation (Maiti & Garai, 2021) [8]. The studies show that tribal blocks in these districts depend more on forests for their fuel and fodder needs as well as their economic activities whereas non-tribal people depend more on advanced agricultural practices and commercial energy sources (Basu & Ghosh, 2019) [1]. The research shows that West Bengal tribal and non-tribal community's exhibit different resource usage patterns but the research lacks systematic assessments which use ecological footprint analysis for comparison. Researchers investigate forest dependence and agricultural methods and energy consumption in their studies but they fail to combine these elements through a comprehensive biocapacity- footprint relationship model. The literature shows that multiple social and cultural aspects of a community affect its ecological footprint variations. The patterns of resource usage in a community get determined by five factors which include the type of livelihood and the size of landholdings and the level of income and the adoption of technology and the availability of energy (Zhang *et al*., 2019) [17]. Tribal people use less modern technology to cultivate their small farms because they depend on conventional power sources which makes them exploit their forest and pasture areas more (Das & Mishra, 2021) [4]. Non-tribal families enjoy superior market access and better infrastructure and contemporary technological solutions, which results in them creating larger agricultural fields and more greenhouse gas emissions (Hossain & Rahman, 2020) [6].Cultural practices also play a key role: tribal groups often engage in ritualistic, seasonal, and community-based resource extraction that reinforces forest dependence, whereas non-tribal groups demonstrate market-driven consumption behaviour (Sharma & Singh, 2018) [13].

The existing research examines environmental problems found in tribal areas and agricultural communities but fails to provide studies that compare ecological footprints of tribal and non-tribal households within district boundaries. Only a small number of studies combine forest, cropland, and grazing and carbon elements to create an EF assessment while even fewer studies measure ecological deficit/surplus in areas with mixed socio-cultural backgrounds such as Purulia. The region requires a comparative study because its socio-ecological vulnerability and diverse livelihood practices need sustainable resource management solutions that fit local communities. The major objectives of the present study are as follows: 1.To assess the ecological footprint of tribal and non-tribal households in Purulia District, 2.To compare the forest, cropland, grazing land, and carbon footprints between tribal and non-tribal communities to identify differences in ecological pressure.3,To analyse the socioeconomic, cultural, and livelihood factors that influence variations in ecological footprint across the two groups.4,To evaluate the biocapacity status and ecological deficit/surplus in tribal- and non-tribal-dominated areas of the district.5,To examine the extent of dependence on forest resources among tribal households and the degree of agricultural and energy-related pressures among non-tribal households.6.To recommend strategies for reducing ecological stress through community-based sustainable resource management.

Material and Methods

The research examines two types of regions which include tribal areas that cover Balarampur and Bagmundi and Bandwan and Manbazar II and Purulia I and Purulia II and Raghunathpur and Kashipur. The two areas represent different landscape types because they have different levels of forest coverage and agricultural development and patterns of human activity. The current research uses a mixed-method methodology which combines quantitative and qualitative methods to study both tribal and non-tribal areas of Purulia district. The research team gathered primary information through household surveys and focus group discussions and key informant interviews which they conducted in Balarampur and Bagmundi and Bandwan and Manbazar II and Purulia I and Purulia II and Raghunathpur and Kashipur. The researchers used stratified sampling to achieve equal representation from tribal and non-tribal regions while purposive sampling enabled them to choose respondents who had expertise in local leadership and forest management and resource collection by women. The researchers used a structured questionnaire to collect information about demographic characteristics and livelihood activities and resource usage and environmental and socio-economic change views of respondents. The research team obtained secondary data from Census reports and District Statistical Handbooks and satellite images and published literature to evaluate changes in land use and forest cover and development patterns. The researchers used GIS techniques to process spatial data which they used to create maps of study blocks and discover differences in physical attributes and socio-economic conditions. Data analysis used descriptive statistics and cross-tabulation and thematic interpretation methods to create a complete understanding of regional differences and livelihood patterns.

The ecological footprint is calculated using the standard formula:

A. $EF=\sum(Ci/Pi)\times EQFi$

Where Ci= consumption of resource *i*, Pi= productivity/yield of resource *i*, and EQFi= equivalence factor for the corresponding land category.

B. Biocapacity (BC) is computed as:

$BC= A\times YF\times EQF$

Results and Discussion

The examination of ecological pressure on different social groups needs combined study between two different ecological footprint measurement systems and the socioeconomic factors that people experience. The EF method allows communities to measure their resource consumption against their natural resource capacity which shows how their economic activities affect the environment (Wackernagel & Rees, 1996; Global Footprint Network, 2023) [5, 15]. In the Purulia District which contains socio-ecological sensitive areas, EF-based comparison helps to reveal ecological damage sources and sustainability problems, because tribal and non-tribal households maintain different resource usage methods (Sarkar & Das, 2020) [12]. The research shows that tribal groups depend on forest and pastoral resources and traditional energy systems more than non-tribal groups, who create higher pressure through agricultural machinery and commercial energy usage (Basu & Ghosh, 2019; Misra, 2017) [1, 9]. The current research identifies district-level results which support existing patterns that research shows of distinct social groups. Global environmental assessments define ecological deficit as the situation when human needs exceed what ecosystems can naturally regenerate (WWF, 2022) [16] and Purulia results show these same ecological patterns.

The Ecological Footprint of Tribal and Non-Tribal Households

The ecological footprint reflects the amount of biologically productive land and resources required to support the consumption patterns of different social groups. In Purulia District, tribal and non-tribal households show notable differences in their dependence on forest, cropland, grazing land, and energy resources. Assessing these variations helps identify how each group contributes to ecological pressure and how their resource-use behaviours influence the district's overall biocapacity.

Table 1: Total Ecological Footprint of Tribal and Non-Tribal Households (Values expressed in global hectares per household per year — gha/household/year)

Community	Total Ecological Footprint (gha)
Tribal	3.72
Non-Tribal	3.41

Source: Field Survey, 2025

The results show that tribal households have a 3.72 gha ecological footprint which exceeds the 3.41 gha footprint of non-tribal households. The two communities use resources in different ways because their resource consumption patterns show only a small difference between them. Tribal households have a higher ecological footprint because they depend more on forest resources such as fuelwood and non-timber forest products and open grazing land. The practices create an increased need for forest areas which can produce biological resources and for land which can be used for grazing. Non-tribal households show a lower total ecological footprint because they use less forest resources but they depend more on agricultural land and modern energy systems. The observed difference shows that social groups experience ecological pressure because their livelihood practices and cultural traditions and modern infrastructure access differ from each other. The higher EF of tribal households shows that tribal-dominated forest areas face ecological stress because their forest ecosystems are vulnerable and need sustainable forest management and clean energy solutions.

Ecological Footprint Differences between Tribal and Non-Tribal Groups

Comparing the forest, cropland, grazing land, and carbon footprints of tribal and non-tribal communities helps reveal how differently each group interacts with natural resources. These footprint components reflect variations in livelihood practices, energy use, agricultural activities, and dependence on forest ecosystems. By analysing these differences, it becomes possible to understand which group exerts higher ecological pressure on specific resource types and how their consumption patterns contribute to overall environmental stress in the region.

Table 2: Component-wise Ecological Footprint Comparison (gha/household/year)

EF Component	Tribal	Non-Tribal
Forest Footprint	1.92	0.68
Cropland Footprint	0.71	1.44
Grazing Land Footprint	0.67	0.41
Carbon Footprint	0.42	0.88

Source: Field Survey, 2025

The assessment of ecological footprint through its individual components shows entire resource use patterns of Purulia District tribal communities to differ from their non-tribal counterparts. Tribal households exhibit a substantially higher forest footprint (1.92 gha) relative to non-tribal households (0.68 gha), which indicates their strong dependence on fuelwood and NTFP collection and open grazing. Their cultural practices together with their livelihood activities shape their dependence on forest resources, which increases their impact on forest ecosystems. Non-tribal households show a higher cropland footprint of 1.44 gha than tribal households who have a footprint of 0.71 gha. Non-tribal areas create this pattern through their combination of large landholdings and intensive agricultural practices and chemical input usage and mechanized farming methods. Their agricultural activities demand more biologically productive cropland, indicating higher pressure on soil fertility and water resources. The grazing land footprint follows a similar trend to forest use: tribal households (0.67 gha) exert greater grazing pressure due to larger cattle and goat populations, which depend heavily on village commons and forest edges. The non-tribal households (0.41 gha) show stall-feeding as their main method and they keep fewer animals than other groups. Non-tribal communities have a carbon footprint of 0.88 gha, which exceeds the carbon footprint of 0.42 gha found in tribal households. Non-tribal areas see widespread use of LPG and electricity and diesel engines and mechanised agriculture, which creates this difference, while tribal households depend mainly on biomass energy and consume little fossil fuels.

Socioeconomic and Cultural Factors

Socioeconomic and cultural characteristics play a crucial role in shaping household consumption patterns and resource-use behaviour. Factors such as income level, education, occupation, landholding size, household size, traditional practices, and cultural dependence on forest resources directly influence the ecological footprint of different communities. Understanding these determinants helps explain why ecological pressure varies between groups and highlights the underlying social and cultural drivers that contribute to differences in environmental impact.

Table 3: Socioeconomic and Cultural Factors Affecting Ecological Footprint

Factor	Tribal Communities	Non-Tribal Communities
Livelihood Base	Forest work, NTFP collection, pastoral activity	Agriculture, services, skilled labour
Energy Source	Predominantly fuelwood	LPG, electricity, diesel
Landholding Size	Small or marginal	Moderate to large
Livestock Pattern	More cattle/goats → open grazing	Fewer animals → stall feeding
Cultural Practices	Strong forest attachment, traditional tools	Market-oriented consumption
Technology Access	Low mechanisation	Higher use of tractors, pumpsets

Source: Field Survey, 2025

Table 3 shows how different socioeconomic and cultural factors together with livelihood patterns lead to different ecological footprints between tribal and non-tribal groups in Purulia District. The study shows that resource consumption depends on social systems and cultural values and their specific methods of earning a living. The forest-based livelihoods of tribal communities depend on their activities which include collecting fuelwood and harvesting NTFP and practicing pastoralism. The subsistence economy of this community together with limited access to modern energy leads them to depend more on biomass and common grazing areas which results in increased forest and grazing area use. The combination of small landholdings and traditional farming practices limits their agricultural expansion which makes them depend more on harvesting from forested areas. The combination of their traditional tools and low mechanisation and deep cultural ties to forests creates resource-use patterns that lead to higher ecological damage in forested areas. Non-tribal communities primarily work in agriculture and services while performing skilled jobs because they have access to better infrastructure and market connections. The use of LPG and electricity and diesel and mechanised farming leads to higher cropland and carbon emissions for them. The combination of moderate to large landholdings enables farmers to achieve higher agricultural output because their smaller livestock holdings make them depend more on stall feeding which decreases their need for grazing land. Resource selection by people who follow cultural traditions that emphasize market-based consumption patterns results in higher energy consumption, which decreases their need for forest biomass. The table shows that different ecological footprint patterns arise from differences in livelihood opportunities between different structural systems.

The Biocapacity Status and Ecological Deficit/Surplus in Tribal- And Non-Tribal-Dominated Areas

Assessing biocapacity alongside ecological footprint helps determine whether an area is living within the limits of its natural resources. In tribal- and non-tribal-dominated regions, variations in resource availability, land productivity, and consumption patterns can lead to either an ecological surplus or deficit. Evaluating these differences provides insight into how far each group’s resource demand exceeds or remains within the local ecological capacity, offering a clearer understanding of sustainability pressures and long-term environmental balance.

Table 4: Biocapacity vs. Ecological Footprint Status

Area Type	Average Biocapacity (gha/household)	Average EF (gha/household)	Status
Tribal-Dominated Blocks	2.84	3.72	Ecological Deficit (-0.88)
Non-Tribal-Dominated Blocks	3.12	3.41	Ecological Deficit (-0.29)

Source: Field Survey, 2025

Table 4 presents a comparative analysis which examines how tribal and non-tribal areas maintain their ecological balance through biocapacity measurements and ecological footprint assessments. The results demonstrate that both regions have developed an ecological deficit because their natural ecosystems cannot regenerate the volume of natural resources that local households consume each year. The tribal-dominated blocks show an average biocapacity of 2.84 gha per household which falls short of the ecological footprint that measures 3.72 gha per household creating an ecological deficit of 0.88 gha. The local environment experiences increased ecological strain because the community depends heavily on forests to fulfill their basic needs which include collecting fuelwood and grazing animals and gathering non-timber forest products. The areas show reduced biocapacity because forest quality has deteriorated and land for productive use has become scarce and natural regeneration rates have decreased. Block areas which do not have tribal populations show 3.12 gha per household biocapacity and 3.41 gha per household ecological footprint which creates a lesser deficit of 0.29 gha. The pressure on the environment remains strong although the tribal areas show less pressure than before. The communities maintain better ecological balance because their members pursue different work options while using more energy from commercial sources which decreases their need for fuelwood and their agricultural output has improved and their landholding size has increased which benefits local biocapacity. The analysis demonstrates that both groups of people surpass their environments ecological capacity yet tribal areas experience more severe ecological disruption. The evidence demonstrates that targeted interventions should focus on forest regeneration and sustainable grazing management and alternative livelihood development.

Resources Dependence Pattern of Tribal Households and Non-Tribal Households

Understanding household dependence on different resource sectors is essential for analysing variations in ecological pressure. Tribal households generally rely more on forest resources for fuelwood, fodder, NTFPs, and livelihood support, reflecting their close cultural and economic relationship with the forest environment. In contrast, non-tribal households tend to exert greater pressure on agricultural land and energy resources due to larger landholdings, higher agricultural activity, and greater reliance on modern energy sources. Examining these contrasting patterns helps clarify how each group contributes differently to environmental stress and overall resource demand.

Table 5: Resource Dependence Patterns

Resource Category	Tribal Households	Non-Tribal Households
Fuelwood Use (kg/year)	2,550	840
NTFP Collection	High	Low
Open Grazing Frequency	High	Moderate/Low
Agricultural Intensity	Low	High
Electricity Use (kWh/year)	280	930
Mechanised Farming	Minimal	Extensive

Source: Field Survey, 2025

The resource dependence patterns across tribal and non-tribal households in Table 5 demonstrate their different ecological impacts and economic activities. The data clearly show that tribal households create more pressure on forest ecosystems, whereas non-tribal households require more agricultural land and commercial energy resources. Tribal households exhibit significantly higher fuelwood consumption (2,550 kg/year), which proves their complete dependence on forests as their main source of daily energy. The people in this region demonstrate high dependence on NTFP collection and they practice open grazing which they do based on their subsistence-based livelihoods and their understanding of traditional ecological knowledge. The practices of the community create cultural value yet they lead to cumulative forest stress which intensifies when the population grows and forest productivity decreases. Non-tribal households exhibit low NTFP dependence and their fuelwood consumption decreases to 840 kg/year because they widely use LPG electricity and other alternative fuel sources. The people show higher electricity use of 930 kWh/year which they combine with their mechanized farming practices to demonstrate their transition into energy-intensive production systems that target market development. The agricultural sector experiences increased pressure for carbon emissions because of agricultural activities which lead to forestland conversion. The community patterns of resource utilization demonstrate two distinct types of ecological stress on the environment.

- Tribal households increase their forest pressure because they rely on biomass and use traditional land methods.
- Non-tribal households put pressure on croplands and energy systems because they use mechanised agriculture and consume more commercial energy.

The results show that sustainability strategies need to target specific communities which require clean energy access and grazing management and forest regeneration for tribal groups while non-tribal households need energy-efficient agriculture and carbon-reduction strategies.

Conclusion

The research found that Purulia District tribal and non-tribal households show different ecological footprints because their livelihood methods and cultural customs and availability of contemporary resources. The forest and grazing footprint of tribal households shows higher values because they depend on fuelwood and NTFP extraction and open grazing which matches existing research about tribal forest-based livelihoods (Misra, 2017; Srinivasan & Kulkarni, 2018) [9, 14]. Non-tribal households create greater environmental damage to croplands and carbon resources because they use mechanised farming methods and chemical products and they depend more on commercial energy sources like LPG and electricity and diesel (Roy & Bera, 2019) [11]. The biocapacity assessment shows that both tribal areas and non-tribal areas face ecological deficits which differ in their deficit magnitude. Tribal regions experience a more severe forest-based ecological deficit while non-tribal areas face moderate deficits that impact both cropland and carbon resources. The evidence supports the conclusion that ecological deficits arise when human consumption exceeds what ecosystems can regenerate according to global research findings (Global Footprint Network, 2023; WWF, 2022) [5, 16]. The study demonstrates that community ecological pressure develops through socioeconomic factors which include landholding size and technology access and energy systems and market relationships (Das & Mishra, 2021) [4].The development of successful sustainability plans requires the identification of these structural and cultural factors that drive these processes. The study results demonstrate that specific community-based methods, which include clean energy transitions for tribal households and climate-smart agricultural practices for non-tribal communities, need to be combined with forest regeneration methods and controlled grazing systems and participatory resource governance, which empowers local communities. The implementation of distinct community-centered approaches establishes that various cultural groups must develop their ecological sustainability practices through methods which specifically suit their particular geographical sites (Sharma & Singh, 2018) [13]. The research shows that ecological footprint analysis needs to be combined with socioeconomic data because this combination helps manage resources sustainably in ecologically vulnerable areas, which shows that the research results contribute to existing academic literature.

Recommendation

The Purulia District needs an integrated community-based approach which combines traditional knowledge with local livelihoods and scientific management to decrease ecological stress in the district. The ecological footprint data from tribal and non-tribal communities shows that different strategic interventions need to be implemented for achieving sustainable development.

a. Strengthening Community Forest Management

- The Joint Forest Management program must empower tribal households with increased authority to make decisions about forest management.
- The project will support community-based forest monitoring activities which include participatory mapping and annual biomass measurement.
- The implementation of controlled grazing areas and rotational grazing systems will decrease natural forest damage through the establishment of fodder development plots.
- The organization will fund small-scale forest regeneration projects which use native tree species preferred by local communities.

b. Promoting Alternatives to Fuelwood and Reducing Biomass Pressure

- The project will extend clean cooking technology access to tribal-dominated areas by providing LPG improved cookstoves and solar cookers.
- Village-based biomass briquette production facilities will use agricultural waste materials to create an alternative to forest wood resources.
- We provide financial assistance through subsidies and soft loans to families who want to install biogas plants at their homes especially those with multiple livestock animals.

c. Enhancing Sustainable Agricultural Practices

- To achieve climate-resilient agriculture with decreased cropland requirements we should promote agricultural practices that require fewer inputs.
- The introduction of integrated farming systems will enable farmers to cultivate both crops and livestock while using agroforestry methods.
- We should promote the use of drip and sprinkler irrigation systems as a replacement for pump-set irrigation systems which consume excessive water in non-tribal regions.
- We provide training for farmer groups and cooperatives about organic nutrient management and soil conservation techniques.

d. Reducing Carbon Footprint and Energy Pressure

- The organization needs to support the widespread implementation of solar home systems, solar-powered pumps and community-based microgrid systems.
- The project aims to support energy-efficient machinery while decreasing the use of diesel fuel in agricultural machinery operations.
- The organization will create carbon education programs at the village level which will involve local youth groups and educational institutions.
- The project requires the establishment of plantation belts around both quarry sites and agricultural land plots to function as carbon sequestration areas.

e. Strengthening NTFP-Based Livelihoods for Tribal Communities

- The organization will deliver training programs which teach participants how to create value from non-timber forest products through sal leaf plate production and tamarind processing and medicinal plant cultivation.
- The project establishes producer groups controlled by women which will operate in local markets while using online selling platforms.
- The project needs to implement benefit-sharing systems which will protect forest resources through sustainable harvesting practices and maintain forest areas for future generations.

f. Improving Institutional Support and Governance

- The project requires the Forest Department and Panchayats and local NGOs and community institutions to work together more effectively.
- The organization will create an Ecological Monitoring Cell at the district level which will monitor forest area changes and energy consumption patterns and ecological impact metrics.
- The system needs to provide clear information about government programs which support clean energy initiatives and livestock assistance and reforestation efforts.

g. Community Capacity Building and Environmental Awareness

- The organization will provide training sessions which cover sustainable livestock practices and forest conservation methods and household energy savings techniques.
- The program establishes environmental clubs in schools which will operate in both tribal and non-tribal areas.
- The organization uses traditional culture and wall paintings and street theater performances to educate people about environmental protection.

h. Encouraging Participatory Land-Use and Resource Planning

- The project requires villages to develop sustainability plans which combine their forest needs with agricultural requirements and water management systems and grazing needs.
- The project will establish community-based watershed management systems to enhance water security in target areas while community-based watershed management systems will sustain water security and decrease agricultural pressure.
- The project will support micro-level land capability assessments which will help determine suitable areas for cultivation and grazing.

References

1. Basu R, Ghosh A. Agricultural intensification and energy dependency in rural West Bengal. Journal of Rural Development Studies,2019:34(2):112–129.
2. Borucke M, Moore D, Cranston G, Gracey K, Iha K, Larson J, *et al*. accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. Ecological Indicators,2013:24:518–533.
3. Chakraborty S, Mukherjee S. Land degradation and ecological stress in western West Bengal: A regional

analysis. Indian Journal of Environmental Geography,2020:15(1):45–59.
4. Das P, Mishra B. Traditional energy use and environmental implications in tribal communities of Eastern India. Energy and Environment Research,2021:11(3):27–39.
5. Global Footprint Network. National Footprint and Biocapacity Accounts, 2023. Available from: https://www.footprintnetwork.org
6. Hossain M, Rahman S. Mechanization and changing rural landscape in South Asia. Asian Journal of Agriculture and Development,2020:17(1):85–102.
7. Kitzes J, Peller A, Goldfinger S, Wackernagel M. Current methods for calculating national ecological footprint accounts. Science for Environment Sustainable Society,2009:6(1):1–9.
8. Maiti R, Garai S. Forest resource degradation and livelihood challenges in the Chhotanagpur Plateau region. Eastern India Journal of Environmental Studies,2021:9(2):66–78.
9. Misra T. Tribal ecological practices and environmental sustainability in India. Journal of Indigenous Environmental Research,2017:5(1):14–26.
10. Pati S, Singh N. Forest dependence and ecological stress among tribal communities in Jharkhand and Odisha. Tribal Development Review,2020:12(3):55–73.
11. Roy S, Bera S. Energy consumption, agricultural modernization and environmental impacts in rural Bengal. Eco-Regional Studies,2019:28(2):193–210.
12. Sarkar A, Das T. Forest-based livelihoods and socio-economic vulnerability of tribal households in Purulia District, West Bengal. Journal of Regional Livelihood Studies,2020:7(1):21–35.
13. Sharma R, Singh P. Cultural determinants of resource use among tribal and non-tribal groups. Anthropology and Ecology Review,2018:13(2):77–92.
14. Srinivasan V, Kulkarni H. Ecological footprint and forest dependency patterns in South Asian tribal villages. Environment and Development Perspectives,2018:22(4):301–317.
15. Wackernagel M, Rees W. Our ecological footprint: Reducing human impact on the earth. New Society Publishers, 1996.
16. WWF. Living Planet Report 2022: Building a nature-positive society. World Wide Fund for Nature, 2022.
17. Zhang Y, Liu H, Li X. Socioeconomic drivers of ecological footprint variations in developing regions. Sustainability,2019:11(4):1124.