Synthesis Report: The Economics of Ecosystem and Biodiversity (TEEB) for Agriculture and Food Application in Assam

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Contents

I.   Background:

TEEB and TEEBAgriFood Framework

The Economics of Ecosystem and Biodiversity (TEEB), a global initiative, hosted by the United Nations Environment Programme (UNEP) was initiated to make **nature's invisible values visible**. The initiative seeks to draw attention to the invisibility of nature in the economic choices we make across the domains of international, national, and local policymaking, public administration, and business. TEEB sees this invisibility as a key driver of the ongoing depletion of ecosystems and biodiversity.

The principal objective of TEEB is to mainstream the values of biodiversity and ecosystem services into decision-making at all levels and it does this by offering a structured approach to valuation that helps decision-makers to

- o   Recognize the wide range of benefits provided by ecosystems and biodiversity.
- o   Demonstrate their values in economic terms.
- o   Where appropriate, capture those values in decision-making.

The TEEB for Agriculture and Food (TEEBAgriFood) framework is an offshoot of the TEEB framework and is specifically applied to food systems. It was developed to apply holistic systems thinking to the economics of agriculture, which is concerned with complex and extensive eco-agri-food value chains representing the vast and complex network of ecosystems, agricultural lands, pastures, farmer livelihoods, infrastructure, technology, policies, culture, and institutions that are variously involved in growing, processing, distributing, and consuming food.

The TEEBAgriFood Framework includes four elements - stocks, flows, outcomes, and impacts- which capture the set of interactions in the food system. The stocks of eco-agri-food systems comprise the four different "capitals" – produced, natural, human, and social capital. These stocks underpin a variety of flows encompassing production and consumption activity, ecosystem services, purchased inputs, and residual flows. The framework captures the positive and negative impacts and externalities across the entire agri-food value chain and assesses its impacts on human, social, produced, and natural capital.
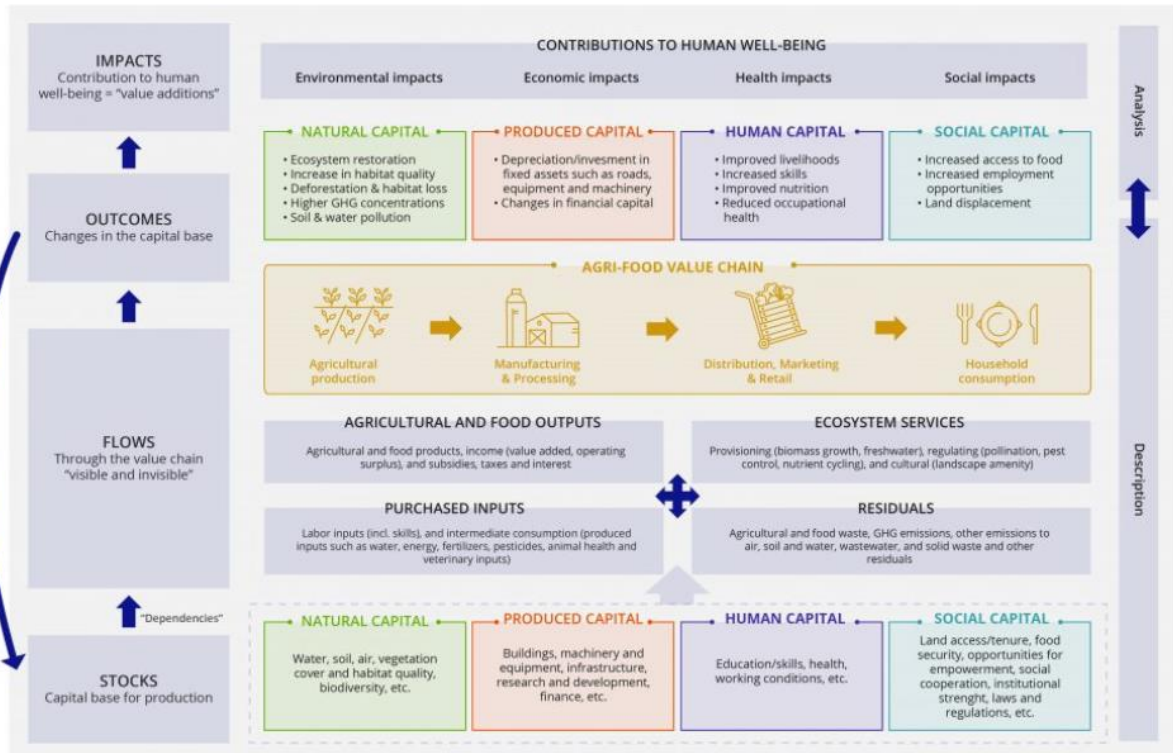
Figure 1: TEEBAgriFood framework, (more information on the TEEBAgriFood framework is available at: https://teebweb.org/our-work/agrifood)

TEEBAgriFood Initiative in India

The UNEP global project titled "Economics of Ecosystems and Biodiversity: Promoting a Sustainable Agriculture and Food Sector", hereinafter referred to as TEEBAgriFood Initiative, funded through the European Union Partnership Instrument (EUPI) was launched in 2019 and implemented in 7 countries, namely, Brazil, China, India, Indonesia, Mexico, Thailand, and Malaysia.

The TEEBAgriFood application in India began in 2019 with the aim to assess organic farming and agroforestry, initially in the Ganga Basin region of India covering two states - Uttarakhand and Uttar Pradesh, and later expanded to Assam in the last year of the project. In India, the project is guided by the Project Steering Committee (PSC) co-chaired by the Ministry of Agriculture and Farmers' Welfare (MoAFW) and the Ministry of Environment, Forests and Climate Change (MoEFCC).

The framework has been applied to assess the impacts of government policies and programmatic interventions on organic farming and agroforestry with the aim to inform planning processes by providing comprehensive scientific evidence to support the scaling of organic farming and agroforestry interventions. This is achieved through modeling and economic valuation conducted for various scenarios spanning from 2020 to 2050. Six

scenarios, comprising Business-as-Usual (BAU), Optimistic, and Pessimistic policy scenarios, along with climate scenarios (RCP 4.5 and RCP 8.5), have been assessed taking 2020 as the base year. The idea was to undertake scenario building, biophysical modeling, and valuation to assess the costs and benefits associated with policy inaction compared to those associated with policy action for conserving nature and biodiversity.

As the application in Assam only began last year, the state had a considerably compressed timeframe relative to the original four-year project period (2019-2023). Consequently, the entire process was cut short, leading to the decision made during consultations with the state government and the Project Steering Committee (PSC), to conduct a comprehensive statewide study. It is important to note that the assessment in Assam, while valuable, was not conducted to the same extent and scope as it was carried out in the other two states - Uttar Pradesh and Uttarakhand - where applications began much earlier. Therefore, within the constrained timeframe, the study attempted to provide as much information as possible on the potential benefits of organic farming and agroforestry, and it offered a fair understanding of the status of the four capitals.

II.   Rationale for extension of the project to the third state

In addition to Uttarakhand and Uttar Pradesh, discussions held at state and national level consultations and deliberations during PSC meetings recommended the extension of the TEEBAgriFood application to a third state to enable holistic evidence-based policy and program design for sustainable agri-food chains in the country. Given various options for extension of the TEEBAgriFood application, Assam was selected as it provided a variation in agroecology, not covered in other valuation studies in the country, further strengthening the case for OF and AgF. It was also noted that the prominence of the humid climate of Assam has a high potential for both practices. Upon the recommendations of the PSC, ICAR-Central Agroforestry Research Institute, Jhansi, was identified as a partner for carrying out analytical work in Assam. An agreement to this effect was signed in July 2023. The project concluded in December 2023.

The few other considerations for choosing Assam for the extension of the project include:

- Assam having shown positive inclination under Pradhan Mantri Krishi Vikas Yojana (PKVY), also provided an opportunity for the assessment of the Mission Organic Value Chain Development for the North-East Region (MOVCD-NER) which is an important Government intervention on organic farming for North-East India.

- Recommendation by PSC pointed out that more focus is required on agroforestry. Assam appeared as a promising state, first because communities in the state have a long history of traditional agroforestry practices through Baree (homestead garden) systems. Secondly, the interventions under the National Bamboo Mission and the

recent incentives of Govt of Assam for promoting tree planting on private lands were prominent, and the project was placed well to strengthen evidence on environmental and socio-economic benefits of agroforestry interventions.

- The efforts of the state to promote agroforestry to be able to contribute to overall biodiversity could be well captured in some of the other initiatives of the government. These included setting up of the Assam Agroforestry Development Board in the year 2021, simplification of procedures for planting and felling of trees, and registration of wood-based industries in the State. Furthermore, the project also aligns with the Trees Outside Forests Initiative (TOFI) launched by the Ministry of Environment, Forest, and Climate Change in 2022.

With the consideration that impact vis-à-vis biodiversity and livelihood outcomes and governance (i.e. the potential for results-uptake), and distributional aspects (i.e. ensuring that the project is pro-poor and recognizes the gender dimension of the change evaluated) can be well captured in Assam, the endorsement for the extension of the project to Assam was received in March 2023 from the Ministry of Agriculture and Farmers Welfare.

III.   Current Status of Organic Farming and Agroforestry in Assam

Assam is mostly considered an organic state because of the lower levels of fertilizer consumption when compared to other states of the country. Out of Assam's total cultivated area covering 4.3 million hectares, around 3.092 million hectares (39.42 percent of the total area) remain untouched by chemical or inorganic fertilizers. This increase in conscious organic farming is particularly evident among growers of ginger, turmeric, oranges, pepper, and pineapples across Assam[1]. There is evidence of inspiring stories of agripreneurs who are offering avenues of upscaling organic farming in the state. It lays a strong foundation for positive prospects under organic farming in the State.

The total area under the organic farming certification process in the state has experienced an annual growth rate (CAGR) of around 11.40 percent during the period 2013-2023, with a coefficient of variation at 37 percent. The state has recorded 15897 MT of organic production during 2021-22, with only 5.87 MT exported, valued at Rs. 29 Lakhs. However, the production during 2022-23 declined to 14,498 MT[2].

The state initially made some contributions to the development of organic clusters under MOVCD-NER. Ten (10) clusters were formed in Chirang, Cachar, Dhemaji, Majuli, Golaghat, Kamrup, Sonitpur, Kokrajhar and Nalbari districts of Assam with a target to attain 500

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[1] Das, P. (2020, February). Organic agriculture in Assam. Journal of Emerging Technologies and Innovative Research, 7(2), 444-448.

[2] https://www.apeda.gov.in/apedawebsite/organic/data.htm

hectares of area in each. As per the recent data, approximately 20000 hectares of organic cultivated farm area are covered under MOVCD-NER. This also involves the promotion of 40 farmer-producer organizations (FPOs). The scheme has a special component aimed at helping the state build up post-harvest infrastructure. As of now, there are 32 numbers of collection/aggregation units, 16 custom hiring centers, 13 processing units, and transportation units, established under the scheme[3]

Furthermore, in the past, the state has undertaken noticeable initiatives for the promotion of organic farming. This is evident from 8100 hectares under PKVY across 10 districts, with 220 clusters involving 6913 farmers. Approximately 3920 hectares were reported under organic farming under RKVY (till 2016-17), and 300 hectares were covered under CM's Organic Farm scheme[4]. Additionally, the state has a significant and determining presence of Self-Help Groups (most are women's groups) under DAY-National Rural Livelihood Mission (DAY-NRLM) counting 339955 members, with a cumulative membership strength of 3793997 members across all social groups[5]. About 1027 local groups have been formed under organic interventions, out of which about 75 percent have been registered in the PGS portal. The program has also helped set up three large producer companies, with 534 mahila kisans (women farmers) as shareholders. There are around 144 organic vegetable retail outlets and 203 established custom hiring centers.

On the other hand, Assam is also known to have an age-old practice of agroforestry. Currently, the total agroforestry area in Assam accounts for 0.70 million hectares[6], about 8 percent of the total geographic area. "Baree", the homestead gardens known in the area, is the most popular agroforestry system throughout Assam. Most Assamese households in rural areas are known as the proud owners of the "Baree", where nuts, coconuts, and some low-maintenance leafy greens are grown, thereby aiding communities with various ecosystem services. As deliberated during the second stakeholder consultation, there are about 27 lakh homestead gardens across the state[7].

Under DAY-NRLM, around 2.07 million Mahila Kisans (women farmers) have been covered under agro-ecological practices (AEP), and approximately 2.3 million mahila kisan households are reported to have agri-nutri gardens[8]. Assam State Rural Livelihood Mission (ASRLM), under its initiative for home gardens of Self-Help Group (SHG) members, is initially estimated to cover about 6000 members.

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[3] https://dirhorti.assam.gov.in/schemes/mission-organic-value-chain-development-in-assam-movcda
[4] https://diragri.assam.gov.in/schemes/detail/paramparagat-krishi-vikasyojanapkvy-0
[5] https://nrlm.gov.in/outerReportAction.do?methodName=showIndex#gsc.tab=0
[6] https://cafri.icar.gov.in/html/Technical_Bulletins/NICRA_Technical_Bulletin.pdf
[7] Dr. Kusum Kumar Deka Principal Scientist, AAU-IRS, Kahikuchi, Guwahati, Assam
[8] https://nrlm.gov.in/outerReportAction.do?methodName=showIndex#gsc.tab=0

IV.   Future Potential of Organic Farming and Agroforestry in the State

The study reveals an overwhelming potential for upscaling organic farming and agroforestry in the state of Assam. The study has provided insight into the potential of organic cultivation on approximately 35.71 percent of the gross cropped area during 2021-22, resulting in moderate carbon stock between 40-60 T Ha^{-1} to high carbon stock between 60-80 T Ha^{-1}.

Under the Business as Usual (BaU) scenario, a yearly growth rate of 11% would result in an organic cultivated area of 47,892 hectares by 2030 to 386,117 hectares by 2050, increasing from 0.61 to 4.92 percent of gross cultivated area. With a pro-organic push, the cultivated organic area could increase by 13 percent annually, reaching 54,269 hectares by 2030 and 625,341 hectares by 2050, almost around 20 percent of the gross cultivated area by 2050. However, a 1% growth rate under the pessimistic scenario would yield only 30,177 hectares by 2050, which is 0.97% of the gross cultivated area.

With a careful pro-organic policy push embedded within the agriculture policy of the state, the short-term vision aims to cover an area of around 20,000 hectares under organic farming in four years, spanning 15 districts and 150 clusters. Centrally sponsored plans such as MOVCD-NER and DAY-NRLM, with maximum outreach in the state, have greater potential for promoting organic cultivation, provided they are backed by appropriate policy convergence. Incentivizing progressive agripreneurs practicing organic farming in the state could yield considerable growth under a public-private partnership model. The Assam Rural Infrastructure and Agricultural Services Society (ARIAS), established in 1998, could play a more meaningful role in sustainable, climate-resilient agricultural development, including promoting organic farming in the state.

Prominent policies of the state, such as the Forest Policy, have a considerable focus on the promotion of agroforestry. This initiative aims to facilitate greening of approximately 10 percent of the total geographical area identified as reclaimable wastelands in the state, while also striving to address land degradation affecting about 10.64 percent of the total geographical area, as assessed during 2018-19[9]. According to a technical report by NITI Aayog[10], Assam has nearly 7.2 percent of its total geographical area highly suitable for agroforestry, with an additional 6.1 percent being moderately suitable. This is also evident from the current modelling results for agroforestry potential that reveals approximately 8.01 lakh hectares, or 10.21 percent of the total geographical area, lies within riparian and restoration zones.

The Cane and Bamboo Policy and other landmark regulations, including the Assam Trees Outside Forest (Sustainable Management) Rules, 2022, Assam Agarwood Promotion Policy

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[9] Desertification and Land Degradation Atlas of India, SAC, ISRO, GoI, 2021.
[10] Greening and Restoration of Wastelands with Agroforestry (G.R.O.W), 2023, Technical Report, Niti Ayog (Based on the assessment done using Agroforestry Suitability Index derived from land use/land cover, wastelands, slope, distance from surface water body and SoC)

2020, Assam Wood-Based Industries (Promotion and Development) Rules, 2022, and the Amrit Brikshya Andolan (Tree-planting initiative) launched during 2023, are expected to have a positive impact in addressing various green-challenges in the years to come. The establishment of the Assam Agroforestry Development Board (AADB) aims to incentivize industry investment in Assam while also encouraging communities to plant commercially important species for supply to the industry. Recently, Assam AADB has been designated as the State Nodal Agency for Agroforestry under RKVY. Initiatives such as Trees Outside Forest in India (TOFI) will further enhance efforts to scale up agroforestry in the state. These collective initiatives signal a promising outlook for the expansion of agroforestry in Assam.

These legal frameworks complement each other, with some initiatives and regulations encouraging tree cultivation whereas setting up of AADB and wood-based industries ensures the marketability of wood and timber products. Before the 1980s, Assam was a major timber market for the Northeastern region, and upscaling agroforestry could revitalize this sector.

V. Design of Scenarios

Considering the past trends, present status of organic farming, and age-old agroforestry, along with proactive policies and plans outlined, three projection scenarios have been created. These scenarios incorporate different policy interventions (BAU, Optimistic, and Pessimistic) along with one IPCC climatic scenario RCP 4.5. The assessment of various elements of the four capitals under these scenarios has been carried out for the years 2030, 2040, and 2050. The BAU scenario reflects the current policies at the national and sub-national levels, while the optimistic and pessimistic scenarios account for positive and negative policy changes and their expected impacts on the expansion of organic farming and agroforestry. Table below provide the details of these scenarios.

Business as Usual (BAU) Scenario	Optimistic Scenario	Pessimistic Scenario
Based on existing policies & initiatives in Assam	Assuming booster to OF and Agroforestry initiatives.	Assumes unforeseen circumstance, unsustainable adoption rates and other natural factors.
Organic Cultivated Area: Based on APEDA timeseries data. Maintains the annual growth rate (CAGR) of 11% to the recorded area during the preceding year.	**Organic Cultivated Area:** Based on APEDA timeseries data. Continues with annual growth rate (CAGR) of 13% to the recorded area during the preceding year.	**Organic Cultivated Area:** Based on APEDA timeseries data. Continues with annual growth rate (CAGR) of 01 % to the recorded area during the preceding year.
Agroforestry: Based on present 0.7 Million Ha (ICAR-CAFRI) & continues to remain 0.70 Million Ha.	**Agroforestry:** Proportionate increase to a Potential of 0.8 m ha deriving from the riparian & restoral zone). For this, an additional annual increase by 0.53 percent of the present 0.7 Million (i. e. 3710 Ha per year) until 2050 is projected.	**Agroforestry:** Proportionate decline in area from the present 0.7 Million Ha by 0.10% (i. e. 700 Ha per year) until 2050.

Figure 2: Scenarios for assessment of four capitals.

VI.   Capitals and Sub-elements for Assessment

The TEEBAgriFood framework encompasses four capital bases - natural, human, produced, and social - known as stock. In India, our focus is on assessing the impacts of expanding organic farming and agroforestry on these capitals. This framework comprehensively evaluates both positive and negative impacts and externalities throughout the agri-food value chain, aiming to support national and international commitments. The table below summarizes the elements assessed and the methodology adopted.

Capital	Elements	Methodology
Natural	Carbon Sequestration	CASA model for estimation of NPP and Remote Sensing data for validation.
	Soil Erosion	Revised Universal Soil Loss Equation (RUSLE)
Produced	Rice and Tea Yield Bamboo Projections	Econometric Models/Trend

Social	Women Empowerment through Self-help groups (SHGs) Farmers Producer Organisation Social Capital Index	Analysis
Human	Workforce Literacy	

VII.   Stakeholder Consultation

As part of the TEEBAgriFood initiative in Assam, which began in July 2023, two stakeholder consultations were held in Guwahati. The first consultation was held in September 2023, with a focus on sharing the draft scoping report and reaching a consensus on the scenarios developed for upscaling organic farming and agroforestry. Additionally, the consultation also focused on promoting the idea of putting theoretical concepts into practical actions by creating a dynamic and evolving landscape, showcasing best practices for sustainable food systems based on the results emerging from the analysis in the project, and serving as a reference point to inform policy and programmatic interventions. There was an agreement from various stakeholders present on the establishment of the TEEBAgriFood Learning Landscape to foster and demonstrate the sustainable growth of organic farming and agroforestry.

The second stakeholder consultation, held in November 2023, brought together representatives from the government of Assam and other stakeholders to discuss the draft results of the assessment conducted in Assam. The state representatives acknowledged the results presented during the meeting and offered continued support for furthering the project's objectives. They recognized the significance of the study in determining the scale of organic farming and agroforestry in addressing unique challenges posed by climate change. Key points that emerged from the deliberations include:

- Recognition of challenges and required actions for upscaling agroforestry and organic cultivation based on the results presented under different policy scenarios for years 2030, 2040, and 2050.

- The government's initiatives to address impediments to the growth of agroforestry through new rules and regulations and emphasis on promoting self-help initiatives, with the government facilitating a supportive mechanism for positive outcomes in the future.

- Acknowledgment of the study's role in reorienting government strategies at both central and state levels towards organic farming and agroforestry and anticipating that the study will aid in grounding ideas for upscaling these two practices, particularly in

addressing the challenges related to marketing to ensure the sustainability of initiatives.

Consultations, as an integral part of the process, provided an opportunity to discuss the rationale behind pursuing organic farming and agroforestry in Assam by delving into existing initiatives and efforts aimed at transitioning towards sustainable agricultural practices, as well as explored how the TEEBAgriFood initiative can contribute to this endeavor.

VIII.   Key Results

The assessment in Assam was conducted within a compressed timeframe, focusing on projecting the expansion of organic farming and agroforestry. These projections were estimated using historical trends to determine the hectarage under each practice in 2030, 2040, and 2050. Additionally, the assessment aimed to evaluate future trajectories and the state's capacity to accommodate structural changes, particularly in production, human, and social capital. For instance, elements such as Self-Help Groups (SHGs) and Farmers Producer Organizations (FPOs) were assessed for their potential expansion in 2030, 2040, and 2050, providing insight into the capacity that can be attained in the projected years. The assessment of organic farming and agroforestry are summarized below followed by the assessment of four capitals:

Organic farming: The trend assessments indicate that Assam can witness an increase in the organic cultivated area to gross cropped area from a minimum of 0.97 percent under the pessimistic scenario to 4.94 percent under BaU to the highest 20 percent under the optimistic scenario by 2050. In hectares, the area under organic will increase from 30177 hectares in the pessimistic to 386117 hectares in BaU to a maximum of 625341 hectares in the optimistic scenario by 2050. This can result in a corresponding level of increase in the organic farm production as well as soil organic carbon stock from 3 to 37 and 59 million Mg/Ha under different scenarios. The projection of organic carbon stock is based on the value of 94.70 Mg Ha-1 (0-100 cm depth)[11]. The study also assessed the total soil carbon stock in tons per hectare for each agroclimatic zone.

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[11] Rekwar, R. K. & Ahmed, N (2022), Soil Organic Carbon Fractions under different land use systems of Jorhat District, Annals of Plant and soil Research 24(2); 2016-220 (https://doi.org/10.87815/apsr.2022/10151)

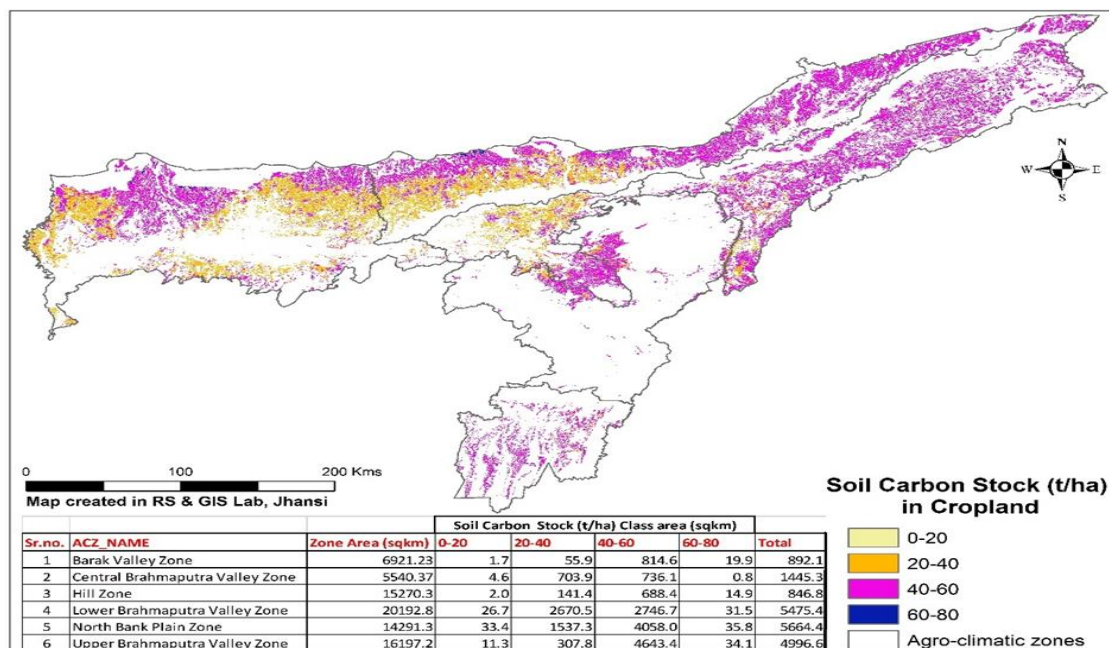| Sr.no.	ACZ_NAME	Zone Area (sqkm)	0-20	20-40	40-60	60-80	Total
1	Barak Valley Zone	6921.23	1.7	55.9	814.6	19.9	892.1
2	Central Brahmaputra Valley Zone	5540.37	4.6	703.9	736.1	0.8	1445.3
3	Hill Zone	15270.3	2.0	141.4	688.4	14.9	846.8
4	Lower Brahmaputra Valley Zone	20192.8	26.7	2670.5	2746.7	31.5	5475.4
5	North Bank Plain Zone	14291.3	33.4	1537.3	4058.0	35.8	5664.4
6	Upper Brahmaputra Valley Zone	16197.2	11.3	307.8	4643.4	34.1	4996.6

Figure 3: Soil Carbon Stock (t/ha) in cropland as per agroclimatic zones of Assam (CAFRI, Jhansi)

Agroforestry: The study estimates that around 10 percent of the total geographical area has been identified as a potential agroforestry zone under riparian (High Flood Frequency but not permanent water bodies) and restoration (Tree Deficit Located within Wastelands/Highly Degraded Areas), and 27 percent of the TGA has been identified as a normal zone (non-flood zones) suitable for agroforestry. These potential zones can contribute well to the current government initiatives, such as the Trees Outside Forest Initiative (TOFI), which aims to increase forest cover by about 38 percent (Economic Survey of Assam 2022-23), among others.

The projection indicates that the area under agroforestry is expected to increase from the current 0.70 million hectares to 0.80 million hectares by 2050 under the optimistic scenario. This expansion is anticipated to have a significant positive impact on soil carbon stock, increasing from 57 million tonnes in 2030 to 63 million tonnes by 2050 under the optimistic scenario. The average soil organic (0-90 cm depth) was assessed at 79.16 tons of carbon per hectare (T C Ha^{-1}).[12]

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[12] The soil organic carbon in agroforestry system existing on farmers' field in different states was higher than pure crop. For instance, the SOC in agroforestry system varied from 53.47 to 104.84 t C ha^{-1} in the top 0-90 cm soil layer. Hence the average of 79.16 T C ha^{-1} was used for evaluation purpose (Based on ICAR-CAFRI study).
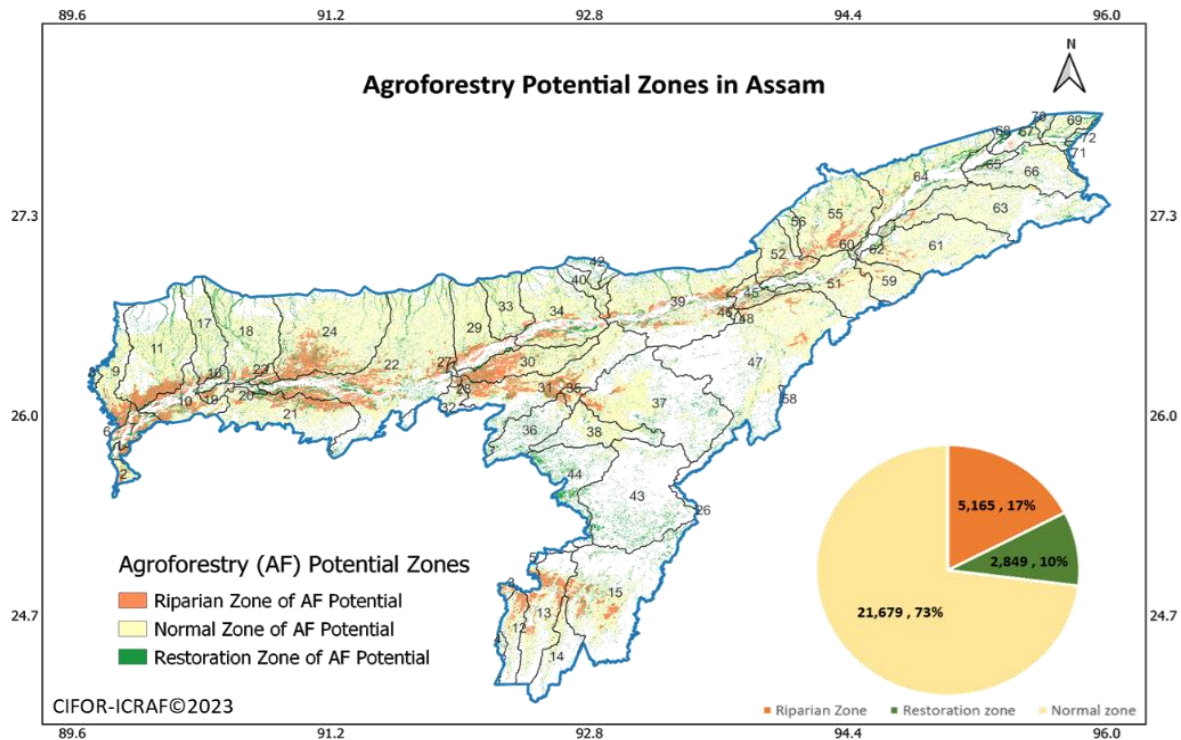
Figure 4: Agroforestry Potential Zones in Assam (CIFOR-ICRAF,2023)

Net Primary Productivity (NPP): NPP was used as a proxy indicator to assess carbon sequestration potential. NPP provided insights into vegetation cover trends, which in Assam show a declining trend from 150 Kg C/m2 in the base year 2022 to 56 Kg C/m2 in 2050, valued at 0.17 billion US dollars under existing land use. This highlights a decrease in green cover and underscores the need to transition from conventional practices to preserving forest cover and enhancing overall biodiversity through the adoption of sustainable agriculture practices. It is imperative to mention that an increase in tree cover through prominent agroforestry models in the state, careful management of harvest intensity, and lengthening of harvest rotation in prospective areas such as riparian and restoration zones would be a meaningful policy instrument for strengthening the future carbon stock in the state. Furthermore, arresting vegetation degradation (~6 percent TGA) and reclaiming wastelands (10 percent TGA) through agroforestry and sustainable agriculture practices would help in halting the projected decline in NPP in the future.

Soil Erosion: The impact of climate change under the RCP 4.5 scenario on aggravating the soil erosion issue of the state was assessed. At present, significant inter and intra-zonal variations in soil erosion/loss exist during 2013, 2017, and 2022. The highest soil loss, from medium (20-30 tons ha^{-1}yr^{-1}) to very high >40 tons ha^{-1}yr^{-1}) is observed in Hill agro-climatic zone (averaging 56.43 percent area), followed by Barak Valley (averaging 43.55 percent area), Lower Brahmaputra (average 26.81 percent area), North Bank (average 21.68 percent area), Central (average 17.99 percent area), and Upper Brahmaputra zones (average 17.92 percent area).

Attributed to intensified and uneven rainfall, projections suggest an increase in average yearly soil loss from 22 tons/hectare in 2030 to 31 tons/hectare in 2050 compared to the base year 2021 where soil loss measured at 20 tons/hectare under RCP 4.5. This provides insights into soil erosion dynamics at the state level. The augmentation of agroforestry in these regions will reduce soil erosion in 5165 sq.km (~7 percent of TGA), and efforts might be needed to complement tea-based agroforestry in West Karbi Anglong, Kamrup Metro, and parts of Marigaon as well as Nagaon districts to further prevent soil loss.

Rice Yield: Assam stands out as one of the leading surplus rice-producing states with coverage of 60 percent of the total cultivated area[13]. Given the significant extent of rice production, prioritizing the shift to organic methods could prove highly beneficial. The clusters formed under the initiative MOCVD-NER to promote organic farming include rice as one of the targeted crops alongside turmeric, ginger, gourd, and other horticulture species.

As per the assessment, rice production is highest in the pessimistic scenario compared to both BAU and optimistic scenarios. However, when assessed under RCP 4.5, the difference in production among the three scenarios is not significant. Additionally, the optimistic scenario anticipates higher produce value due to premium pricing.
Analysis reveals that compared to the BAU scenario, the projected value of paddy will be higher by 6 percent, 14 percent, and 25 percent in 2030, 2040, and 2050 respectively in the optimistic scenario. In the pessimistic scenario, it is assumed that the adoption of organic farming would be still less, leading to excessive usage of chemical inputs including fertilizers. Consequently, there will be no price incentive for the produce, resulting in no increase in farm price levels and leading to a decline in the value.

Tea Agroforestry: Assam is globally renowned as the "Tea State of India". Its lush-green tea gardens, spanning 3,47,203 hectares of area, cover around 4.42 percent of the geographical area of Assam. Contributing to one-seventh of global tea production, Assam plays a significant role in the tea industry. The state produces around 50.79 percent of the total tea production in the country.
Analysis reveals that under optimistic scenario the value of tea in Assam is increasing from 3.46 percent in 2030 to 12 percent in 2050 compared to BAU scenario. However, in the pessimistic scenario, the value is expected to decline by 0.40-1.42 percent from 2030 to 2050. Despite the pessimistic scenario having a smaller area compared to BAU and optimistic scenarios, higher yields resulting from conventional tea plantation practices using increased inputs of chemical fertilizers are assumed. The analysis of climatic factors and spatial suitability for tea cultivation indicates that the suitable areas for expansion will be distributed

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[13] https://dirhorti.assam.gov.in/

across the North Bank, South Bank, Upper Assam, and parts of the Karbi Anglong region of Assam.

While production is higher in the pessimistic scenario compared to the optimistic scenario both for tea and rice due to the continued use of synthetic fertilizers and pesticides, it is crucial to recognize that input costs are notably higher in the pessimistic scenario, a factor that is not very significant in the optimistic scenario where organic farming has been considered. Additionally, the cost of using chemical applications can also be assessed in terms of its impact on human health. Considering the positive spin-offs of the optimistic scenario, which include potential benefits for human health and the environment, the overall outcome would likely be more favorable.

Bamboo Projections: Bamboo is not only integral to the economy but also deeply ingrained in the cultural and social traditions of the region. It holds a promising future in Assam, serving as a major source of both natural and home-grown cultivation in the entire northeast region. This is also evident from the assessments and the existing policies/initiatives including The Assam Bamboo and Cane Policy, 2019, and the National Bamboo Mission.
In Assam, both the area under bamboo and production of bamboo are projected to increase significantly in the optimistic scenario. Carbon stock is expected to rise from 1.90 million mg/year in 2030 to 3.16 million mg/year in 2050 under an optimistic scenario. Additionally, the number of cane and bamboo units is projected to reach 1030 by 2050, from 619 in 2030, employing approximately 10,699 individuals in 2050.

Workforce: The value of the workforce has been assessed using agriculture gross value added (in US dollars). AGVA is a useful metric for assessing the economic contribution of the agricultural sector and can indirectly provide insights into the productivity and contribution of the agricultural workforce. AGAV is calculated at around 1600 USD per worker in the optimistic scenario by 2050.

Literacy: The literacy rate is projected to increase 15 to 20 percent in optimistic scenario in the assessment. With the help of literature, it is anticipated that if the literacy rate is improved, it will have a positive impact on OF and AgF. However, the impact of organic farming and agroforestry on literacy has not been established in the current assessment or within existing literature.

Women Empowerment through SHGs: Self-help groups (SHGs) registered under the Deen Dayal Upadhyaya Antodaya Yojana – National Rural Livelihood Mission (DAY-NRLM) were assessed to project the future trajectories of SHGs in the state. The number of SHGs reported in 2021-22 were around 6758 and trend analysis suggests this figure could increase up to 27,815 by 2050 in the optimistic scenario, indicating significant potential for livelihood enhancement and women's empowerment through these institutions. SHGs help in providing women with access to financial services and serve as a medium to disseminate information

on various crucial issues such as health, education, government schemes, market opportunities etc. Additionally, they offer avenues for skill development and capacity building through structured training programs and workshops. By fostering collective advocacy, providing social support, and granting decision-making authority, SHGs serve as mediums for promoting values that empower women, contributing significantly to their overall upliftment.

Farmers' Producer Organization: The data on farmer producer organizations (FPOs) in the state was sourced from Tata Cornell Institute FPOs platform for India for 9 years from 2014 to 2022. The trend assessment indicates that Assam can witness an increase in the number of FPOs in the optimistic scenario from 667 in 2030 to 6442 in 2050. Social capital can be enhanced through FPOs which aim to ensure community involvement, foster innovation in development, advocate for policies, empower women, and promote resilience and sustainability.

Social Capital Index: SCI is based on the quantification of three dimensions, namely, permanent pasture and grazing land, social forestry and area under still water. The social forestry dimension captures community management and sustainable land use practices, directly and indirectly impacting agrobiodiversity. Indicators include robust community network, knowledge-sharing and skills, and collaborative farming practices within social forestry. Further, the permanent pasture and grazing land dimension is captured through indicators on ecosystem health and habitat diversity and the area under still water dimension captures elements of aquatic biodiversity.

The district-wise social capital index has been constructed utilizing existing data sets (till 2017). The value of SCI ranges from 0 to 1 where 0 indicates the lowest sustainability whereas 1 represents the highest value, indicating a better position in terms of social capital, closely intertwined with the success of organic farming and agroforestry.
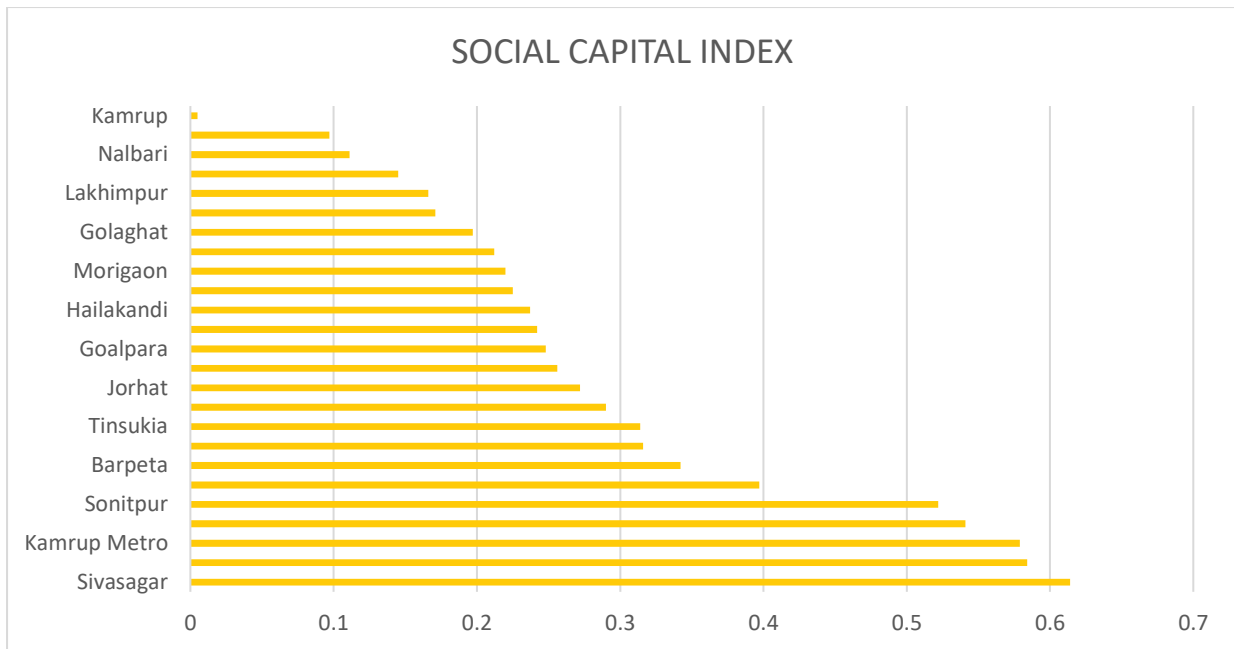
Figure 5: Social Capital Index values for Districts in Assam

The chart represents estimated index values, districts with higher index values are considered more robust in terms of social capital. Sustainable practices and collective commitment contribute to maintaining a balance in ecosystems, preserving traditional knowledge related to diverse crop cultivation, and avoiding the negative impacts of intensive agriculture on biodiversity contributes to an overall robust system. The three elements overall symbolize community responsibility for maintaining a balance between agricultural needs and environmental conservation, and the collaborative efforts of communities in respective districts contribute overall to a resilient and diverse agricultural landscape.

IX.   Limitations and desired avenues for future research

The TEEBAgriFood Initiative in India commenced in 2019 and concluded in 2023, with Assam's inclusion in the project occurring in its final year. This led to a condensed examination focused on the state-wide study, derived from recommendations provided by various stakeholders. While this presented significant challenges, it also opened avenues for continued research in Assam. The broad challenges and opportunities can be summarized as:

- The state-level assessment is challenged by the diverse physiographic and socio-economic conditions across regions. To address this, the upcoming phase proposes studying one district from each agro-climatic zone to better capture the overall state dynamics.

- The current recommendations and plans, which are often structured according to administrative boundaries rather than agro-climatic zones are a major challenge. As said, the focus is on providing recommendations at the district or block level.

- All findings are based on secondary data and projections, highlighting the need for ground verification in the future to enhance credibility.

- Modelling exercises at the state level using satellite imagery and remote sensing data have inherent limitations. Further analysis of similar datasets will enhance the reliability of the results. Addressing limited data availability can be achieved through micro-level studies.

- Provides opportunity for mapping of where specifically in Assam organic farming could be expanded, based on land use plans as well as suitability assessments. The current study already takes this into account for agroforestry and it effectively highlights the spatial expansion, providing a detailed delineation of riparian, non-flood, and restoral zones. This careful planning is essential for expanding on the ground with the support of well-thought-out policy implementation.

- Conducting a comparative study of conventional practices would provide compelling evidence for expanding the area under OF and AgF. Currently, the absence of such a comparative study presents an opportunity to enhance our understanding and draw definitive conclusions.

- Projections for the expansion of organic farming (OF) and agroforestry (AgF) in Assam have been estimated based on historical trends to obtain hectarage under each practice in 2030, 2040, and 2050. Moving forward, Assam presents an opportunity to assess the impact of these changes on the four capitals and their sub-components.

- The future research avenues also indicate a shift from focusing solely on the production aspect of the value chain to post-production considerations, including manufacturing, processing, distribution, marketing, and household consumption. Adding to this, in Assam, there should be an emphasis on transitioning organic product certification towards a market-driven approach, as voluntary certification models may prove insufficient. Without initiatives driven by market demands, conventional practices with robust market linkages will persist, impeding the scaling up of organic farming and agroforestry.

X.   Key takeaways from the study

The state-level study provides a broad overview of the status and challenges in assessing the elements concerning organic farming and agroforestry, revealing the potential for upscaling organic farming to nearly 35.71 percent of the gross cropped area (GCA). With a policy boost, this could also result in bringing 20 percent of the GCA area under organic cultivation.

Despite spatial variations in positive and negative growth in agroforestry area, achieving the additional 0.7 million – 0.8 million potential area would be possible by 2050 under the optimistic scenario with careful upscaling policies.

The current assessment in Assam has provided valuable insights into the expansion of agroforestry and organic farming, contributing to existing policies in the state. The study's contributions include:

- Action Plan on TEEBAgriFood Learning Landscape
- Facilitating targeted investments to promote and expand Organic Farming and Agroforestry in the State.
- Enabling convergence of allied programs/projects in the state for organic farming, and agroforestry, including bamboo, and establishing institutional mechanisms like the Assam Agroforestry Development Board
- Push for developing skill development programs focused on organic farming and agroforestry, including bamboo.
- Creating opportunities for the voluntary carbon market in Assam. Strategic action plan for soil & water conservation in vulnerable zones.
- Push for developing market clusters in areas identified for potential organic farming and agroforestry including pricing policy.

In addition to the above, the study recommends taking certain actions such as establishing vocational/diploma courses to ensure knowledge partners, as recommended by the New Educational Policy. It also suggests that district-level plans, including the district credit plan, District Agricultural Contingency Plans, Lead Bank Scheme, and other existing schemes/tools, should support organic farming and agroforestry activities in the state to ensure and achieve holistic convergence.

Suggestions for scaling up activities in organic farming and Agroforestry:

- **Going Beyond Brahmaputra Basin:** Focus on promoting organic farming and agroforestry in upland areas to improve crop yields and benefit farmers in regions with lower productivity.
- **Risk Prevention for Smooth Transition:** Enabling automatic enrolment of farmers transitioning to chemical-free farming into the government's crop insurance scheme like the PM Fasal Bima Yojana (PMFBY).
- **Providing Support to Agri MSMEs:** Providing support to microenterprises producing inputs for chemical-free agriculture and agroforestry nurseries by establishing district/block level sale shops and distributing Quality Planting Material.
- **Peer Farmers as Inspiration:** NGOs and progressive farmers who have been promoting and practicing sustainable agriculture across the country can be leveraged

for this purpose through farmer-to-farmer extension. The government should facilitate an ecosystem in which farmers learn from and support each other during the transition.

▪ **Leveraging Community Institutions:** Community institutions (FPOs, KVKs, SHGs) can be targeted for awareness generation, inspiration, and social support. There is also a need to upskill agricultural extension workers on sustainable agriculture practices, with a special emphasis on organic farming and agroforestry.

XI.   TEEBAgriFood Learning Landscape

In furthering the impact of the study and its modest objectives that suitably address climate challenges, sustainability of the intervention is sought through an innovative approach: setting up of TEEBAgriFood learning landscape(s) (TAFLL) in Assam, representative of its socio-ecological production profile. These landscapes embody sustainability, equity, reciprocity, and inclusivity, fostering adaptive learning at the community-ecosystem interface. With a significant area under organic and natural organic farming by default, Assam has immense potential to grow organic crops and emerge as one of the leading suppliers of organic products in the global market. With the policies and plans in place, backed by pro-organic initiatives and mechanisms, the state presents a case for a demonstrative model. Further, with agroforestry deeply rooted in the lifestyles of diverse communities in the state and recent policy changes are the opportune moments to upscale agroforestry in potential areas across the state. The overall idea of TAFLL is to-

- Showcase best practices for sustainable food systems based on the results emerging from the analysis in the project.
- Serve as a reference point to inform policy and programmatic interventions.
- To translate the learnings gained in Uttar Pradesh, Uttarakhand, and Assam to the partner farmers so that it becomes a 'living-learning landscape'.
- To adapt from other TEEBAgriFood implementing countries and extend the underlying principles to other parts of these 3 States as well as other ecological zones in India.

Two case studies have been proposed for the learning landscape in Assam: one in Majuli in the Brahmaputra floodplains, and another in Diphu, in the Karbi Anglong district. The principal criteria for selecting such learning landscapes have mainly been their contrasting socio-ecology or unique Assamese signatures of agro-farming practices, their potential in promoting both agroforestry and organic farming and their ability to enable adaptive in-situ learning for various sustainable agro-farming models through experimentation and technology cooperation at the community-ecosystem interface over space and time. This would require a comprehensive delivery mechanism presented in the figure below:
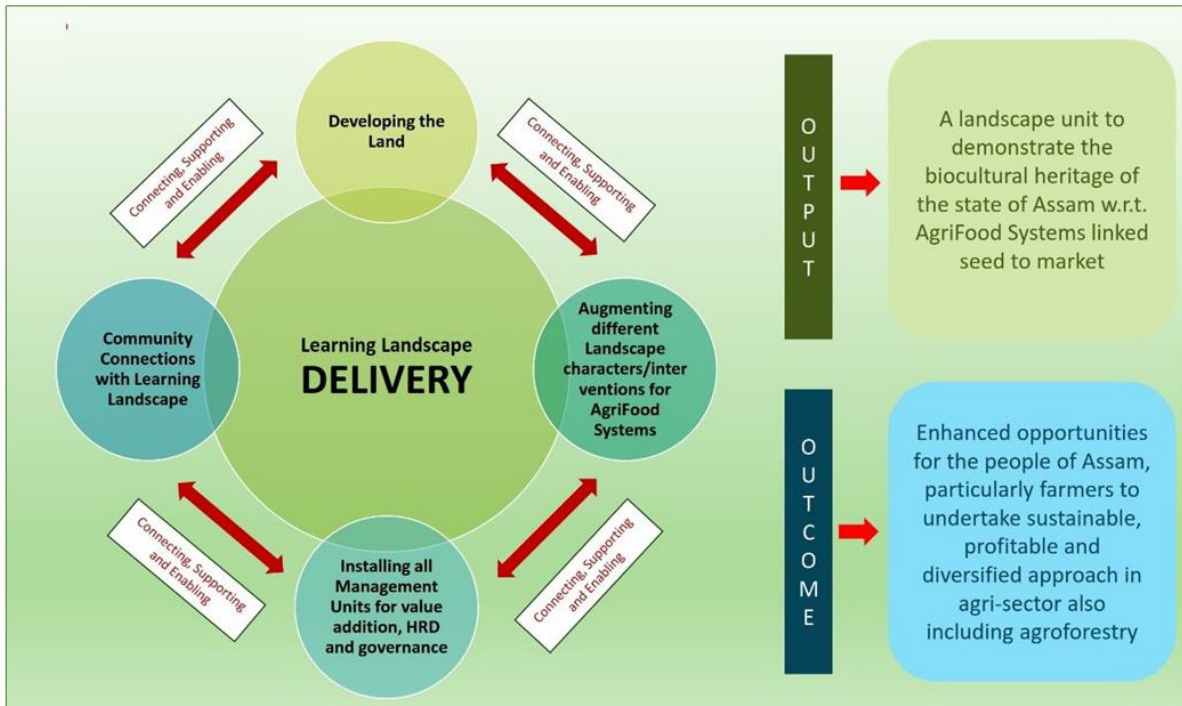
Figure 6: TEEBAgriFood Learning Landscape Delivery Model

The concept plan of TEEBAgriFood Learning Landscape was positively acknowledged by the State Government representatives during the consultation with the recognition that it offers greater scope of learning at the micro level.

XII.   References

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