Synthesis Report: TEEBAgriFood Initiative in Uttar Pradesh

Project: The Economics of Ecosystems and Biodiversity: Promoting a Sustainable Agriculture and Food Sector

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Introduction

TEEB and TEEBAgriFood Framework

The Economics of Ecosystems and Biodiversity (TEEB), a global initiative, hosted by the United Nations Environment Programme (UNEP) was initiated with the aim to make "nature's invisible values visible". The TEEB initiative seeks to draw attention to the invisibility of nature in the economic choices we make across the domains of international, national, and local policy-making, public administration, and business. TEEB sees this invisibility as a key driver of the ongoing depletion of ecosystems and biodiversity. The TEEB India initiative was launched in 2011 focusing on forests, inland wetlands, and marine and coastal ecosystems. The overall study report was released at the 21st session of the UNFCCC COP held in 2015 in Paris.

The 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

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

TEEB Agriculture and Food Systems (TEEBAgrifood)[1] is an offshoot of TEEB, especially applied to food systems and hence is likely the first of its kind to address food systems. The aims of TEEBAgriFood are bold and ambitious: to contribute a framework approach for better understanding and managing the impacts and externalities of agriculture and food value chains, and to bring together a global network of scholars and decision-makers dedicated to disclosing and valuing those impacts. The TEEBAgriFood Framework offers a structured approach to valuation that helps decision-makers recognize the wide range of benefits provided by ecosystems and biodiversity, demonstrate their values in economic terms and where appropriate, capture those values in decision-making.

[1] https://teebweb.org/our-work/agrifood/understanding-teebagrifood/evaluation-framework/

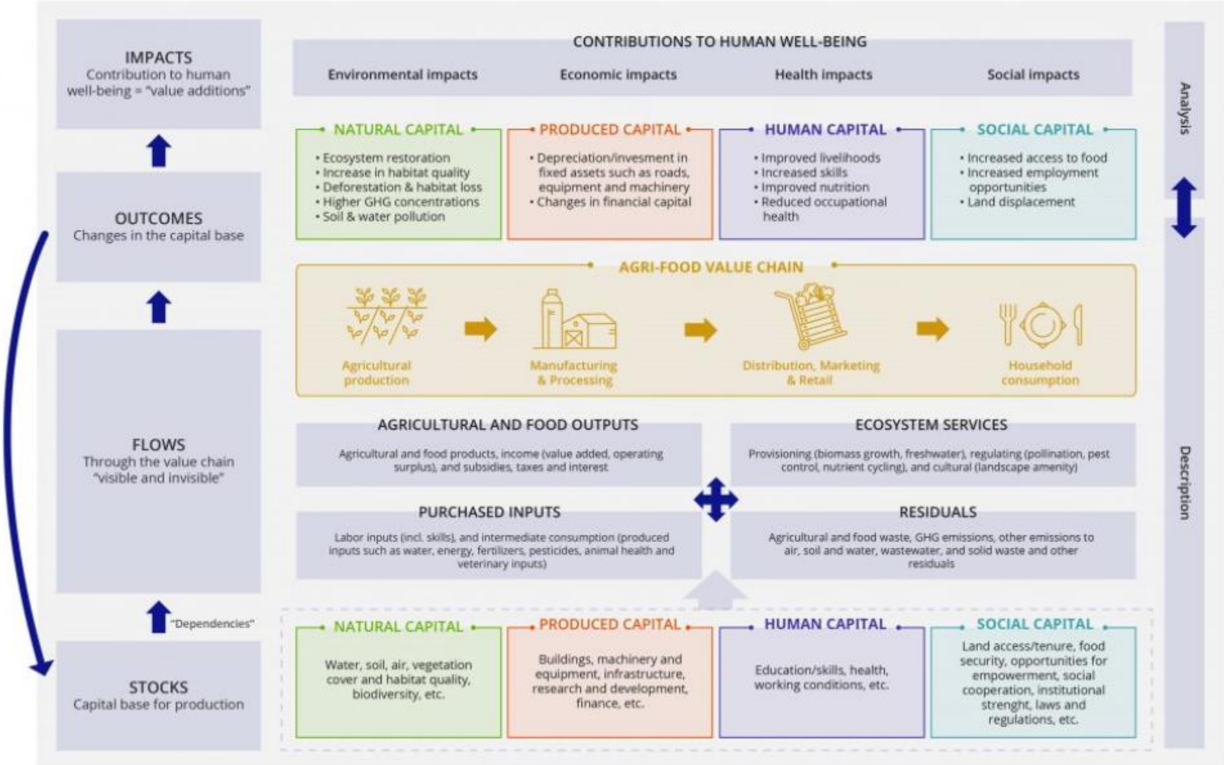

Figure 1: TEEB for Agriculture and Food framework

TEEBAgriFood applications in India under the EUPI funded project "Economics of Ecosystems and Biodiversity: Promoting a Sustainable Agriculture and Food Sector"

The UNEP global project titled "Economics of Ecosystems and Biodiversity: Promoting a Sustainable Agriculture and Food Sector" and funded by the European Union was launched in 2019 and was implemented in 7 countries, namely, Brazil, China, India, Indonesia, Malaysia, Mexico, and Thailand.

In India, the TEEBAgriFood 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). As per the guidance of the PSC, the project focusses on evaluating the environmental and socioeconomic costs and benefits of scaling programmatic interventions of the Government of India on organic farming and agroforestry in three states, namely the Ganga basin states of Uttar Pradesh and Uttarakhand, and Assam in the Northeast Region of India. The analyses contributes to informing national and state priorities and commitments such as Doubling Farmers Income, crop diversification, land degradation neutrality and biodiversity conservation targets.

TEEBAgriFood Initiative in Uttar Pradesh

Uttar Pradesh, with around 16.5% of India's total population, is India's fourth largest and most populated state (Census 2011). Encompassing an area 240,928 square kilometres (7.33% of the nation's geographical area), the state's economy ranks third among all Indian states, with a Gross Domestic Product (GDP) of INR 20.48 trillion (USD 260 billion). Agricultural activities form an integral part of the livelihoods of most people in rural areas in Uttar Pradesh. Agricultural households account for 74.8% of all rural households in the state (NSSO 2020). Moreover, Uttar Pradesh holds an important position in India's food grain production, contributing around 20% to the nation's total output. In 2020, the state generated 56 million tonnes of food grain, owing to its fertile areas within the Indo-Gangetic Plain (IGP) and the presence of irrigation infrastructure like canals and tube wells.

In recent years, Uttar Pradesh has witnessed a substantial increase in organic certified land from 106,292.39 hectares in 2015-16 to 159,307.73 hectares in 2020-2021, with a total cultivated organic farm area of 67,442.61 hectares. The government is striving to transform Uttar Pradesh into a hub for organic agriculture, intending to implement organic farming (OF) initiatives in areas along the banks of the river Ganga. Cluster farming is also being introduced as an initial step to ensure organized farming practices and enhanced quality control. Moreover, farmers in Uttar Pradesh are adopting various Agroforestry models, gaining additional benefits in terms of both monetary returns from timber and improved farm productivity.

In this regard, the TEEBAgriFood study of Uttar Pradesh conducted between 2019-2023 supports the government’s vision of upscaling organic farming and agroforestry in the state. It underscores the potential for creating a carbon sink, preventing soil erosion and nutrient loss, and, consequently, boosting farmer incomes by enhancing policy measures related to organic farming and agroforestry. By making visible the invisible benefits of nature and highlighting the associated trade-offs of policy choices through scientific evidence, the project assesses the impacts of decisions on natural, social, human, and produced capital.

Aim of the study

The primary objective of the study was to assess the impacts of upscaling Organic Farming (OF) and AgroForestry (AgF) policy measures on natural, human, social, and produced capitals, specifically in terms of supporting ecosystem services and the flow of such services. The overarching aim was to provide evidence to:

- Inform policy about the long-term impacts of OF on ecosystem services, produced capital as well as livelihoods and health.

- Inform policy, institutional and governance solutions that take a food systems approach, promoting coherence across different policy areas (e.g. agriculture, trade and food).
- Support spatial planning of agricultural production to maximize ecosystem services.
- Evaluate the economic case for scaling up OF and AgF.
- Inform sustainable food production policy interventions, such as policies related to pollution, pesticide and fertilizer use, sustainable value chains, market linkages and certifications.

Study Area

The selection of the study area for TEEBAgriFood assessments in Uttar Pradesh was guided by thorough consultations with stakeholders at both state and national levels[2]. Adopting a comprehensive approach, five districts—Aligarh, Bulandshahr, Meerut, Hamirpur, and Mirzapur—were chosen to ensure a comprehensive evaluation across diverse socio-economic and agroecological areas.

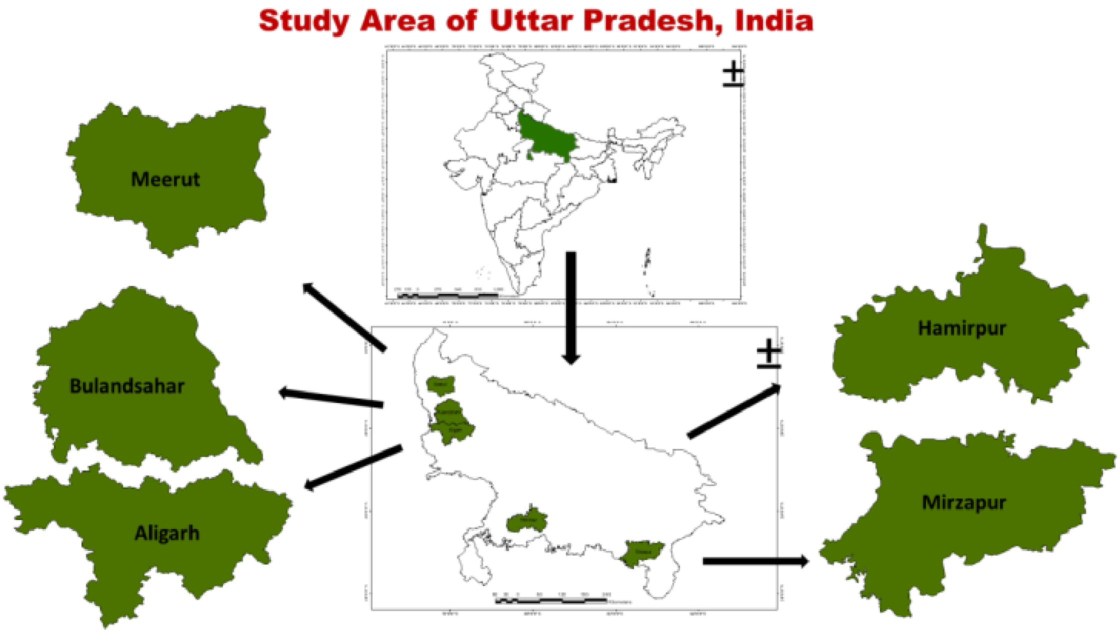

Figure 2: Study area for TEEBAgriFood Assessment in Uttar Pradesh

Each of the selected districts – Aligarh, Bulandshahr, Meerut, Hamirpur, and Mirzapur – contribute to the comprehensive evaluation of the region due to their unique agricultural landscape. In western Uttar Pradesh, Aligarh, Bulandshahr, and Meerut are characterized by the predominant sugarcane-ratoon-wheat cropping system. This system thrives in the region due to the abundance of irrigation resources, specific soil types, and the significant presence

[2] https://teebweb.org/our-work/agrifood/country-implementation/eupi2019/india/

of sugar factories, offering favorable conditions for local farmers. On the other hand, Hamirpur, located in the Bundelkhand region, represents an underdeveloped area in Uttar Pradesh. Meanwhile, Mirzapur, situated in the eastern part of the state within the Vindhyan zone, relies heavily on agriculture as the primary occupation, serving as the main source of income for its residents. Overall, analysing the regional contribution to the output from agriculture and allied activities in Uttar Pradesh reveals that western Uttar Pradesh plays a pivotal role, contributing 49.6% of the total output. Whereas, the Bundelkhand region, represented by Hamirpur, demonstrates the lowest contribution at 5.5%, highlighting regional disparities in economic activities.

Policy Scenario Analysis

To determine whether the policy would be beneficial at a societal level, we also need to consider non-market impacts, including impacts on untraded ecosystem services and biodiversity. Scenario-based policy analysis can help policymakers grasp the interconnectivity of society, the economy, and the environment, resulting in better decision-making. Policy scenario analysis driven by an ecosystems approach employing several modelling tools can play a pivotal role in demonstrating the evidence to the decision makers for sustainable and equitable food systems.

The policy scenario analysis undertaken in the TEEBAgriFood assessments in India involves comparing policy scenarios to business-as-usual and analyzing policy options within a modelling framework. For Uttar Pradesh, the policy scenarios produced focus on scaling up organic farming and agroforestry interventions in the state in accordance with "The roadmap to promote chemical-free and sustainable OF in the state and other regions of the country (2016-17)" with the help of the policies; PVKY, RKVY, and the National Agroforestry Policy[3] and Namami Gange. Six scenarios were created, considering different policy interventions (BAU, optimistic, and pessimistic) and climate change projections (RCP4.5 and RCP8.5). The assessment period for these scenarios is until 2050 presenting decadal assessments for clarity. The scenarios developed for Uttar Pradesh are presented in the table below:

[3] https://faolex.fao.org/docs/pdf/ind203552.pdf

Business-as-Usual (BAU) Scenario	Pessimistic Scenario	Optimistic Scenario
• Builds on existing policies and initiatives (as of 2021) and Government of India's Vision Document for Organic Agriculture • **Organic Agriculture:** Area under organic farming increases from the current 0.4% (67,442 ha) of the total cultivated area to 6.5% (1,069,848 ha) at a growth rate of 10% per year as per currently observed trends • **Agroforestry:** Area under agroforestry remains at 3% of the geographical area of the state (as per trends on Tree Cover in the India State of Forest Reports)	• Assumes the emergence of unforeseen factors that may possess a threat to current goals and hamper the modernization and green transformation of Uttar Pradesh • **Organic Agriculture:** Area under organic farming increases from 0.4% to 1% of the total cultivated area in the state due to low yields and weak policy support • **Agroforestry:** Area under agroforestry decreases to 1% of the total cropped area due to increasing land use change, especially contributed by growing urbanization	• Assumes progress in agricultural modernization by organic policies and initiatives implemented under India's Vision Document for Organic Agriculture • **Organic Agriculture:** Area under organic farming grows at 22% per year from the current 0.4% (67,442 ha) to 87% (14,476,019 ha) of the total cultivated area in the state • **Agroforestry:** Area under agroforestry covers 12% percent of the geographical area of the state (contributing to the attainment of National Forest Policy targets of 33% Forest and Tree Cover)

Capitals Assessed

The TEEBAgriFood framework applies a capitals approach to build resilience, mainstream best practices, protect biodiversity and contribute to a more sustainable food system. The four capitals include – produced, natural, human and social. This approach is designed to be universally applicable across multiple scales and contexts. It allows for a thorough understanding of the stocks, flows, outcomes, and impacts within eco-agri-food systems by incorporating the long-term values of these capitals and the changes in these capitals it aids in making formed policy decisions and evaluating the trade-offs.

This holistic strategy of addressing these four capitals together intends to create avenues for supporting various national and international commitments, including most of the sustainable development goals, while also providing an efficient mechanism for implementing an effective system of true cost accounting, where the environmental, social, cultural, and economic cost and benefits are considered, leading to a more comprehensive understanding of the actual cost of production. In this regard, the TEEBAgriFood assessment in Uttar Pradesh looked at assessing various elements under the four capitals presented in the table below.

Table 1: Elements of Capitals assessed under TEEBAgriFood application in Uttar Pradesh

Natural	**Produced**	**Human**	**Social**
• Carbon Sequestration • Soil Loss and Sediment Export	• Crop Production (Economic Yield) • Timber Production (Economic Yield)	• Human Capital (LULC based malaria infestation)	• Sustainable Livelihood Security Index (SLSI)

• Water Provisioning (Yield) • Agrobiodiversity			• Women Empowerment

Summary of Results

1. Natural Capital

Natural capital assessments were undertaken to understand the impact of upscaling organic farming and agroforestry on biophysical parameters such as carbon sequestration, water yield and sediment loss. The assessments broadly indicate an increase in carbon sequestration, reduction in sediment loss and positive impacts in controlling water yield under the optimistic scenarios that considers expansion of area under organic farming and agroforestry. Natural capital in the form of carbon sequestration and water & sediment yield with various land-use policy and climate change scenario in agricultural landscapes also finds linkages with several international and national initiatives:

i. United Nations (UN) SDGs namely; SDG 1 (No poverty), 2 (Zero hunger), 3 (Good health and well-being), 11 (Sustainable cities and communities), 12 (Responsible consumption and production), 13 (Climate action), & 15 (Life on land),
ii. Nationally Determined Contributions (NDCs) of Government of India; 1 (Mission LiFE), 2 (Adopt a climate friendly and cleaner path), 3 (To reduce emissions Intensity), 5 (To create an additional carbon sink), 6 (To better adapt to CC by enhancing investments in development programs), and 8 (To build capacities, create domestic framework, and international architecture for quick diffusion of cutting-edge climate technology).

1.1. Carbon sequestration

Carbon sequestration modelling was undertaken using the Integrated Valuation of Ecosystem Services and Trade offs (InVEST) model for the five districts under study. In base year (2020), the carbon storage potential varied across the districts: Meerut (9.04), Bulandsahar (12.4), Aligarh (9.4), Mirzapur (55.4), and Hamirpur (10.2) million metric tons. District-wise future carbon sequestration values are provided in table 2 below.

Results indicate:

- In a **business-as-usual (BAU) policy** scenario, with the same area coverage for agroforestry and organic farming, the majority of districts experienced a decline in carbon sequestration ranging from -0.1 to -9.7 % under RCP 4.5 and -0.43% to -15.5 % under RCP 8.5 by the end of 2030. Looking ahead to 2050, Carbon sequestration under BAU ranged from 6.3% to -14.5% under RCP 4.5 and 6.1% to -44.6% under RCP 8.5.

- Under **pessimistic policy** as the area under organic farming and agroforestry decreases, carbon sequestration showed a greater decline compared to BAU scenario ranging from -0.7% to -10.1% under RCP 4.5 and -0.8% to -28.3% under RCP 8.5 by 2030 across respective districts. This trend of decline in carbon sequestration further extended up to -0.62% to -15.2% under RCP 4.5 and -1.05% to -45.4 % under RCP 8.5 by 2050.
- On the contrary, under the **optimistic policy** scenario involving a yearly scaling up of organic farming at a rate of 15% (compared to current 10%) and an expansion of agroforestry to up to 33% of the cropped area (compared to the current 10%), the districts of Meerut, Aligarh, and Bulandshahr demonstrate a positive change in carbon sequestration for the total land cover[4], ranging from 0.39 to 0.6 million tons by 2030. Further increasing to 0.68 to 1.27 million tons by 2050.
- A decline in carbon stock in Mirzapur district was observed in future scenarios compared to the base year, attributed to an anticipated decrease in forest cover. The projections indicate a 12.3% decline under RCP 4.5 and a 34.5% decline under RCP 8.5 by the end of 2030, followed by a further decrease of 18.5% and 55.3% under RCPs 4.5 and 8.5, respectively, by the end of 2050. This trend aligns with findings from the Indian State of Forest (ISFR)[5] report, which confirms a substantial loss of 57.62% forest cover during 2019-2021, 1.2% during 2017-19, and 33% during 2015-2017.

1.2. Water yield

Soil and Water Assessment Tool (SWAT) was used to estimate future water yield and sediment loss across the five districts under the predefined land use policy and climate change scenarios. A monetary value of INR. 18.43/ cum for water (Verma et al. 2017) was used to estimate the value of water yield from the districts. District-wise estimates (provided in Table 2 below) indicate that the value of water provisioning services is; for Meerut (0.115), Bulandshahr (0.341), Aligarh (0.324) and Mirzapur (0.692) billion US$ (BUSD) for the base year (2020).

The comprehensive findings from the hydrological modelling indicate a forecasted decrease in precipitation and, consequently, a general reduction in water yield within the watershed until 2030, particularly impacting three districts: Meerut, Bulandshahr, and Aligarh. However, under the optimistic scenario the water yield reductions are lower in 2030, implying the impact of organic farming and agroforestry measures on the increased water holding capacities and watershed health compared to BAU. Furthermore, scenario wise results indicate:

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[4] Total land cover includes sequestration by all land cover classes including forests, not just agricultural land including agroforestry and organic farming practices.

[5] Forest Survey of India Report: https://fsi.nic.in/isfr-2021/chapter-13.pdf

- In **BAU** scenarios, the water yield ranges from 1.74-1709.6 mm (with an economic value of 0.001 to 1.78 BUSD) under RCP 4.5 and 72.5-1779 mm (with an economic value of 0.042 to 1.79 BUSD) under RCP 8.5, across all the districts by 2030. In 2050, the water yield ranges from 257.8-1496 mm (with an economic value is 0.15 to 1.51 BUSD) under RCP 4.5 and 323.7-3721.3 mm (with an economic value of 0.19 to 2.75 BUSD) under RCP 8.5)
- Under the **optimistic policy** scenario, the water yield ranges from 1.76 to 1750.1 mm (with an economic value of 0.001 to 1.76 BUSD) under RCP 4.5 and 86.2 to 1968.6 mm (with an economic value of 0.05 to 1.9 BUSD) under RCP 8.5, across all the district by the end of 2030. In 2050, the water yield is 386.6-2006.8 mm (with an economic value of 0.22 to 1.82 BUSD) under RCP 4.5 and 431-3721 mm (with an economic value of 0.25 to 3.74 BUSD) under RCP 8.5, across all the district.
- Under the **pessimistic policy** scenario, where there is a decline in area under organic farming and agroforestry practices, considering the diminished rainfall in the watershed due to climate change impacts by 2030, the water yield from the watershed declines across districts.

1.3. Sediment Yield (loss)

Considering the value of Rs. 60 /cum for sediment (CWC, 2012), economic value of sediment loss in base year for the five districts is estimated to be: Meerut (0.007), Bulandshahr (0.020), Aligarh (0.019) and Mirzapur (0.042) billion US$ annually.

- Under the future **BAU policy** scenario, the sediment loss is 0.023 to 18.43 MCUM (with an economic value of 0.0001 to 0.1069 BUSD) under RCP 4.5 and 0.91 to 27.17 MCUM (with an economic value of 0.0025 to 0.1075 BUSD) under RCP 8.5, across all the district by the end of 2030. In 2050, the water yield is 2.41 to 14.73 MCUM (with an economic value of 0.009 to 0.09 BUSD) under RCP 4.5 and 4.12 to 42.61 MCUM (with an economic value is 0.011 to 0.165 BUSD) under RCP 8.5, across all the district.
- Under the **optimistic policy scenario**, the sediment loss is 0.025 to 17.762 MCUM (with an economic value of 0.0001 to 0.1057 BUSD) under RCP 4.5 and 1.018 to 31.628 MCUM (with an economic value of 0.003 to 0.1189 BUSD) under RCP 8.5, across all the district by the end of 2030. In 2050, the water yield is 3.565 to 22.132 MCUM (with an economic value of 0.0136 to 0.1097 BUSD) under RCP 4.5 and 5.023 to 42.672.941 MCUM (with an economic value of 0.0151 to 0.2248 BUSD) under RCP 8.5, across all the district.
- **Pessimistic policy scenario** predicts a sediment loss of 0.022 to 18.289 MCUM (with an economic value of 0.0001 to 0.1063 BUSD) under RCP 4.5 and 0.881 to 27.936 MCUM (with an economic value of 0.0025 to 0.1087 BUSD) under RCP 8.5, across all the district by the end of 2030. In 2050, the water yield is 2.097 to 13.231 MCUM (with an economic value of 0.0089 to 0.0871 BUSD) under RCP 4.5 and 3.759 to 36.982

MCUM (with an economic value of 0.0106 to 0.1595BUSD) under RCP 8.5, across all the district.

Table 2: Natural Capital (carbon sequestration+ water yield-sediment loss) value (Billion USD) in different district of Uttar Pradesh.

Districts	**Economic value (BUSD) in 2020**	**Economic value (BUSD) in 2030**					
		BAU		**Optimistic**		**Pessimistic**	
		RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Meerut	2.82	2.80	2.83	2.93	2.96	2.78	2.81
Aligarh	3.42	3.43	3.37	3.62	3.64	3.41	3.35
Bulandsahar	4.15	3.93	4.04	4.10	4.25	3.91	4.03
Mirzapur	18.98	17.69	14.51	17.87	14.93	17.62	14.46
Hamirpur	2.82	3.03	2.96	3.24	3.16	3.00	2.93
		Economic value (BUSD) in 2050					
Meerut	2.82	2.96	2.98	3.25	3.25	2.92	2.92
Aligarh	3.42	4.11	3.98	5.08	4.84	3.99	3.80
Bulandsahar	4.15	4.42	4.48	4.98	5.07	4.32	4.40
Mirzapur	18.98	16.56	12.61	17.23	14.05	16.38	12.37
Hamirpur	2.82	3.05	3.02	3.42	3.39	2.96	2.93

1.4. *Agro-biodiversity:*

Agrobiodiversity serves as a basis for sustainable livelihoods by supporting a range of ecosystem services, including soil fertility, pest & disease control, pollination & its management, etc., thus making its quantification quintessential. The Agro-diversity Index (ADI) under this assessment is derived from 9 indicators: cropping intensity, livestock diversity, mechanization extent, crop diversity, crop-livestock mixed farming, residual diversity, production diversity, perceived soil quality, and cultural ecosystem. The Simpson Index of diversification was used for this assessment.

Higher ADI values indicate a more diverse system, offering greater resilience and climate change impacts and market fluctuations. Under the Organic Farming (OF) the ADI value for Meerut, Bulandsahar, Aligarh, Mirzapur, and Hamirpur, are 57.21 (± 7.00), 53.33 (± 5.79), 51.50 (± 6.64), 57.74 (± 4.42), and 51.35 (± 4.78), while, for the conventional farming system the obtained values are 50.86 (± 6.31), 43.13 (± 5.16), 41.95 (± 5.38), 47.27 (± 4.65), and 43.21 (± 3.67), respectively.

The average ADI values obtained categorizes the target districts under the moderate agro-diversity systems. From the ADI estimates it can be inferred that the Meerut district is relatively more resilient than the other target districts though only by a marginal amount. Suggested policy promotes agrobiodiversity, establishing linkages with SDG 15 (Life on land: protect restore and promote sustainable use of terrestrial ecosystem, sustainably manage forest, combat desertification, halt & reverse land degradation & arrest biodiversity loss) and NDC 5 (additional carbon sink through forest and tree cover).

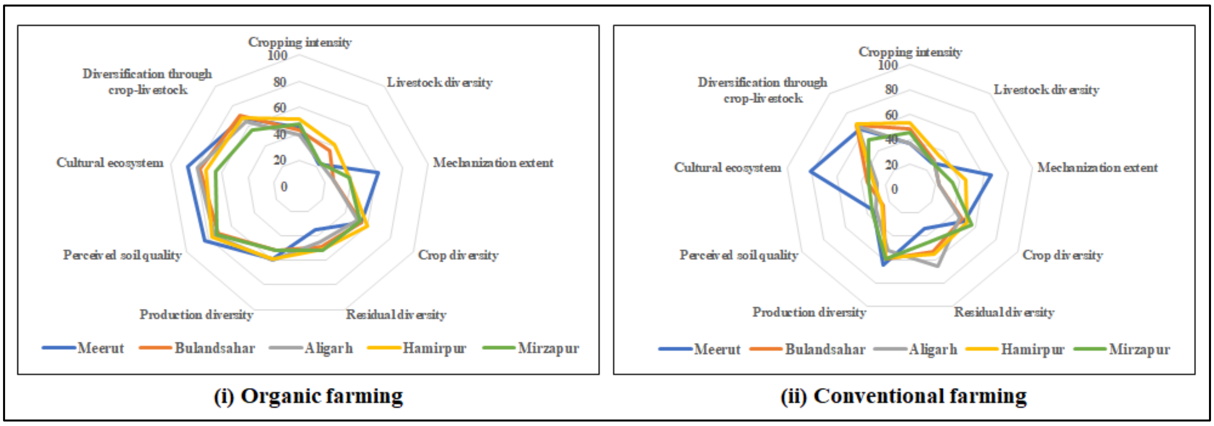

Figure 3: Variation of normalized ADI indicators for (i) Organic, and (ii) Conventional farming systems for the target districts

2. Produced capital

Produced capital stocks are tradable market goods and thus have market prices. Under the TEEBAgriFood assessments in Uttar Pradesh the change in produced capital stock was accounted by estimating the economic yield of crop and timber production under different policy and climate change scenarios. The economic yield of the crop was calculated by determining the maximum selling price for conventional farming and using a price for organic produce that was 20% higher than the maximum selling price for the conventional farming crop.

The analysis reveals the economic yield of the crop in the base year (2020) for the 5 districts as; Meerut (1.82), Aligarh (0.18), Bulandshahr (1.15), Mirzapur (0.39) and Hamirpur (0.34) BUSD. Detailed estimates are provided in the table 3 below.

- Under the **optimistic policy** scenario all districts show an increase in the value of produced capital. Under RCP 4.5 scenario (0.31% to 0.44 % higher than BaU by 2030 & 12 to 21% higher than BaU by 2050) and under RCP 8.5 (0.29% to 0.49% higher than BaU by 2030 & 11.6% to 26.6% higher than BaU by 2050).
- Whereas, under **pessimistic policy** scenario, economic yield of the crop across all districts declines compared to BaU ranging between -0.45% to -0.65% by 2030 & -5.4% to -8% by 2050 under RCP 4.5. This trend of decline in produced capital under pessimistic policy further extended up to -0.43% to -0.73% by 2030 & -4.3% to 9.98% by 2050 under RCP 8.5.
- For the envisioned land use policies, the optimistic scenario outperforms the other two with the highest produced capital value. Detailed estimates are provided in the table below. Produced capital with suggested policy finds linkages with United Nations (UN) SDGs, namely SDG 1 (No poverty), 2 (Zero hunger), 3 (Good health and well-being), and NDCs 1 (Mission LiFE), 2 (Adopt a climate friendly and cleaner path).

Table 3: Produced Capital value (Billion USD; check unit) in different districts of Uttar Pradesh

Districts	**Economic value (BUSD) in 2020**	**Economic value (BUSD) in 2030**					
		BAU		**Optimistic**		**Pessimistic**	
		RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Meerut	1.828	1.6053	1.7498	1.6123	1.7583	1.5950	1.7371
Aligarh	0.1844	0.1837	0.1954	0.1845	0.1961	0.1825	0.1943
Bulandsahar	1.1515	1.1491	1.1987	1.1541	1.2044	1.1416	1.1902
Mirzapur	0.3155	0.3190	0.3241	0.3200	0.3251	0.3176	0.3227
Hamirpur	0.3409	0.3237	0.2908	0.3251	0.2921	0.3217	0.2889
		Economic value (BUSD) in 2050					
Meerut	1.8289	1.6410	1.5970	1.8816	1.8780	1.5508	1.4917
Aligarh	0.1844	0.2048	0.1632	0.2307	0.1822	0.1951	0.1561
Bulandsahar	1.1515	1.1739	1.1476	1.3672	1.3365	1.1015	1.0768
Mirzapur	0.3155	0.2414	0.2298	0.2930	0.2910	0.2221	0.2068
Hamirpur	0.3409	0.3280	0.3098	0.3792	0.3584	0.3088	0.2915

Area accounts for computation for Meerut=64.1%, Aligarh=29.7%, Bulandsahar=37.8%, Mirzapur=52.9%, Hamirpur=45.8%.

3. Social Capital

3.1. *Sustainable Livelihood Security Index*

The social capital estimates include accounting for the Sustainable Livelihood Security Index (SLSI), which is a combination of three indices: Ecological Security Index (ESI), Economic Efficiency Index (EEI), and Social Equity Index (SEI) for both organic and conventional farming landscapes. The findings from these three indices reveal that while organic farming may not achieve the same level of economic returns as conventional farming, its contribution to ecological security and social equity surpasses that of conventional farming capital showing linkages with SDG 8 (Decent work and economic growth), 10 (Reduce Inequality).

- In terms of **ESI**, all districts showed a higher value under organic farming compared to inorganic farming indicating positive contribution of organic farming towards reducing GHG emissions, increasing soil organic carbon, earthworm density, biomass recycling and legume inclusion in the system. Aligarh holds the highest valuation for both inorganic (5664.9 USD/HH/ha) and organic purviews (9209.2 USD/HH/ha), while, Hamirpur has the lowest inorganic (2464.3) and organic (2820.1 USD/HH/ha), respectively.
- The **EEI** encompasses income from crop production, the total value of land holding, and income from milk production. Results indicate that the values for organic farming was slightly lower compared to inorganic farming practices. Meerut accounts for the highest under the inorganic landscape (64634.6 USD/HH/ha), while the least is observed for the Hamirpur (23270.6 USD/HH/ha). Whereas, Aligarh tops the chart in the organic domain (64903.1 USD/HH/ha), with Hamirpur again being at the lowest (19945 USD/HH/ha), respectively.
- With respect to **SEI** encompassing indicators associated with expenditure on education, expenditure on health, and dietary consumption pattern. Aligarh holds the highest contribution of 3166.2 & 3975.4 USD/HH/ha, while, Hamirpur has the lowest (1692.3 & 1293.7) under the inorganic and organic sects, respectively. Further, Meerut, Bulandsahar, and Mirzapur bequeath 1835.1 & 2376.3, 2798.9 & 3515.6, and 2698.9 & 2035.7 USD/HH/ha SEI, respectively.

Table 4: Social Capital Value (USD/HH/ha) for the target districts of Uttar Pradesh.

District	ESI		EEI		SEI		SLSI		
	Inorganic	Organic	Inorganic	Organic	Inorganic	Organic	Inorganic	Organic	Total
Aligarh	5664.9	9209.2	64368.9	64903.1	3166.2	3975.4	73200.0	78087.7	151287.7
Bulandsahar	3965.9	7248.1	63958.2	64175.3	2798.9	3515.6	70723.0	74939.0	145662.0
Hamirpur	2464.3	2820.1	23270.6	19945.0	1692.3	1293.7	27427.2	24058.8	51486.0
Meerut	2653.9	5231.9	64634.6	64191.1	1835.1	2376.3	69123.6	71799.3	140922.9
Mirzapur	4278.7	3895.2	25367.4	20704.8	2698.9	2035.7	32345.0	26635.7	58980.7

 # value of land capital is included under EEI.

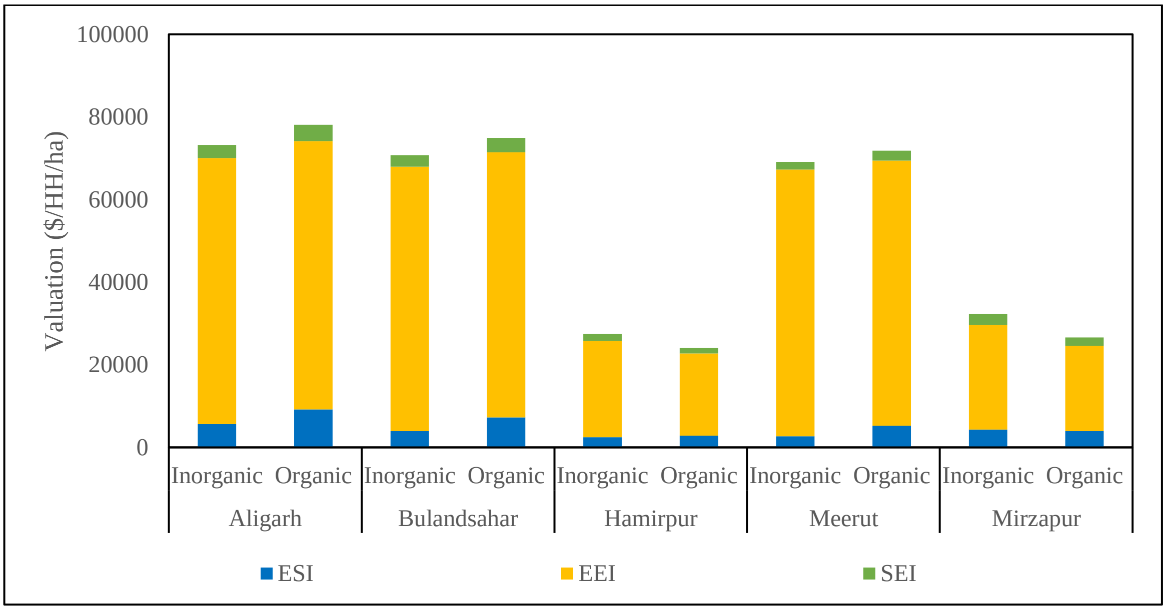

Figure 4: Valuation graph for SLSI

3.2. Women Empowerment

The assessment of Women Empowerment (WE) is based on employment days generated in various farm activities. Crop survey data covers five agri-operations from the 5 target districts:

(i) Land preparation
(ii) Intercultural operation
(iii) Harvesting
(iv) Threshing
(v) Packaging & transport.

To assess different cropping systems, in Meerut, Bulandsahar, and Aligarh, sugarcane-paddy-wheat-mustard cropping system was considered. Sesame-green pea-wheat-gram system was considered in Hamirpur, whereas in Mirzapur wheat-paddy-mustard-vegetables cropping system was considered. Cumulatively, these crops across all agricultural operations in each of the five districts resulted in the following workdays: Meerut (676), Bulandshahr (683), Aligarh (558), Mirzapur (598), and Hamirpur (518). Notably, under organic farming, women contributed a significant proportion of workdays, accounting for 52.22% in Meerut, 53.15% in Bulandshahr, 53.41% in Aligarh, 55.35% in Mirzapur, and 59.27% in Hamirpur.

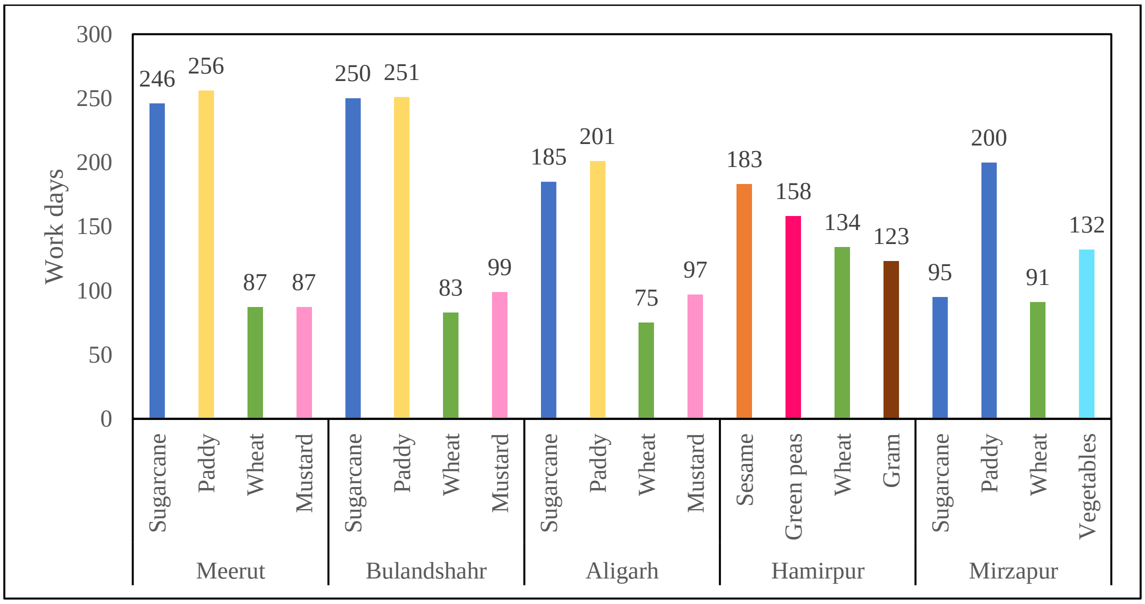

Figure 5: Women work days under all the selected agri-operations for the addressed crops from the target district

Following this, the evaluation of crop valuation (in USD/ha) was conducted for the target districts under both organic and conventional systems. The results indicated that Organic Farming (OF) consistently presented higher premiums compared to the conventional system. The premium was notably larger, ranging from 7.55% to 44.04% in sugarcane, 4.56% to 49.11% in paddy, 42.86% in wheat, 17.29% to 29.75% in mustard, 20.17% in sesame, 43.41% in green peas, 28.48% in gram, and 4.44% in vegetables. Figure 2 provides a visual representation of the percentage increase in premium for the considered crops in the target districts. The suggested policy in this project aims to establish robust linkages with SDG 5 (achieve gender equality and empower all women and girls).

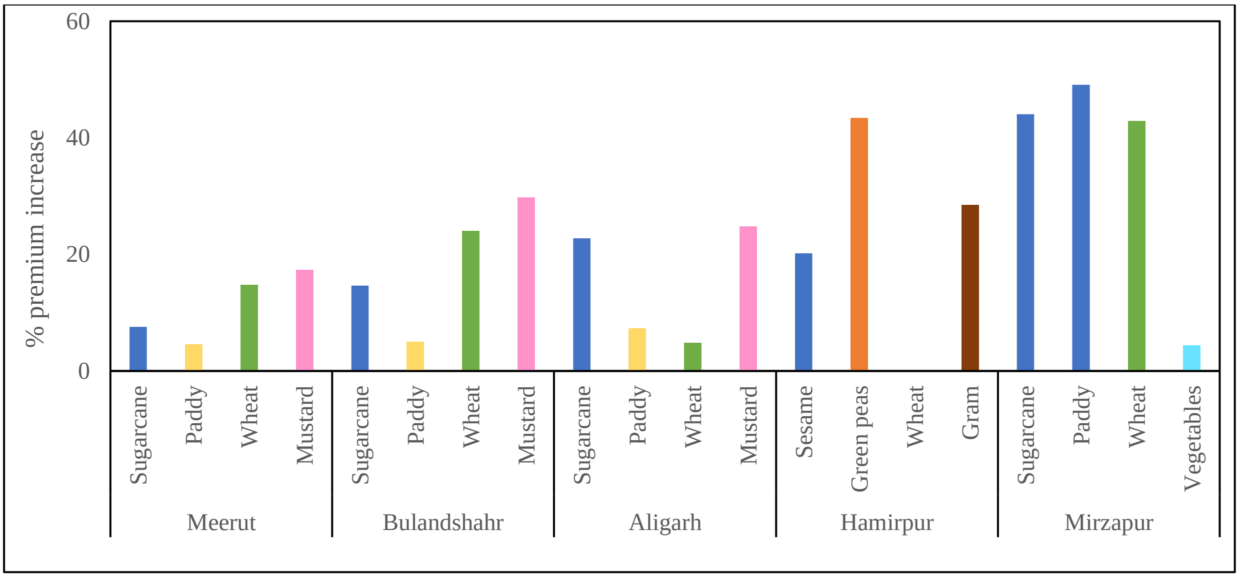

Figure 6: Percentage increase in premium for crops under consideration for the target districts

4. Human Health

Considering several hypotheses and existing research on impact of LULC changes on malaria vector larval habitat availability, productivity, density, and dispersal globally (Dutta and Khan, 1995; Okogun et al., 2005; Munga et al., 2006; Vas et al., 2010); we studied the impact of proposed land use policy (BAU, optimistic and pessimistic) and climate change scenarios on spatial distribution of malaria risk zones using weighted overlay method in GIS.

The results indicated that in base year (2020), 58.31, 59.11, 57.71, 57.95 and 41.61% area come under moderate risk category in Meerut, Aligarh, Bulandshahr, Hamirpur and Mirzapur districts respectively. However, area under high-risk category was less than 1% in all district except Mirzapur (8.1% under high risk). Modeling results indicated that there is no significant impact of change in LULC policy and CC scenarios (BaU, Optimistic and Pessimistic) on spread of malaria in 2030 and 2050 (Figure 4).

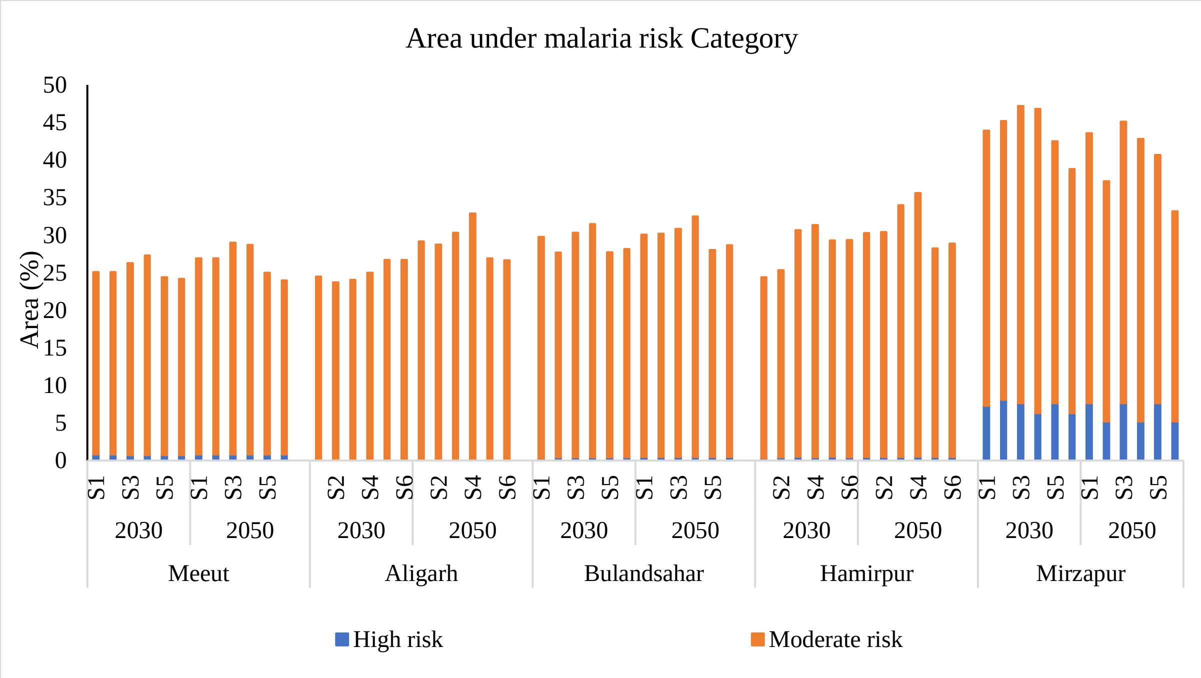

Figure 7: Area (%) under malaria risk zone in different district with various land use and CC scenarios.

Project Outcomes

Some of the key outcomes from the TEEBAgriFood project implementation in Uttar Pradesh include:

- Monetization of ecological benefits accrued from organic and agroforestry under changing climatic scenario.
- Planned way of expanding organic agriculture in the state without affecting the overall production with environmental co-benefits.
- Policy framework and realignment of ongoing schemes/new schemes to meet the SDGs.
- Gender equity through empowering farm women.
- Recommendation of Research Advisory Committee (RAC) to extend the ecosystem services estimation and valuation through AICRP-IFS centres (PAN India)
- Inclusion of ecosystem services in B.Sc. Natural farming syllabus in the agriculture universities by the Indian Council of Agricultural Research, New Delhi (Annexure 3)

Scope for Scaling

The study provides a compelling case for the implementation of the optimistic scenario, offering a holistic approach to sustainable agriculture that addresses economic, environmental, and social dimensions while aligning with global and national sustainability goals. Results from this study suggest that under the optimistic scenario, incorporating a 15% expansion in the current organic area and a 33% expansion in agroforestry, higher carbon sequestration, water yield, produced capital, and sustained livelihood security are ensured compared to BaU and pessimistic scenarios.

Specifically, the economic valuation of natural capital highlights the substantial contribution of the optimistic policy in terms of natural capital worth billions of dollars for all investigated districts, surpassing both Business-as-Usual (BaU) and pessimistic policies under various climate change (CC) scenarios in 2030 and 2050 (detailed estimates are provided in Annexure 1). This calls for the adoption and scaling up of the suggested interventions to larger land acreages, aligning with missions like Namami Gange advocating for organic farming along the Ganga River. The study's outcomes may be scaled up to an area of 2.5 million hectares, showing implementation linkages with missions/sub-missions like Sub Mission on Agroforestry and National Mission for Sustainable Agriculture.

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Annexure: Valuation of Natural Capital

Table: Valuation of Natural capital (BUSD) under different policy and climate change scenario for the years 2020, 2030 & 2050.

District	Indicators	2030						2050						2020
		BAU		Optimistic		Pessimistic		BAU		Optimistic		Pessimistic		
		RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	
Meerut	Water	0.001	0.042	0.001	0.050	0.001	0.041	0.151	0.189	0.226	0.252	0.148	0.176	0.115
	Sediment	0.000	0.003	0.000	0.003	0.000	0.002	0.009	0.011	0.014	0.015	0.009	0.011	0.007
	C Storage	2.800	2.782	2.926	2.907	2.781	2.764	2.803	2.778	3.006	2.980	2.759	2.735	2.854
	Total economic value	**2.801**	**2.827**	**2.927**	**2.960**	**2.783**	**2.808**	**2.963**	**2.978**	**3.246**	**3.247**	**2.915**	**2.921**	**2.976**
Aligarh	Water	0.422	0.366	0.423	0.450	0.422	0.371	1.014	0.897	1.596	1.379	0.971	0.804	0.324
	Sediment	0.025	0.022	0.025	0.027	0.025	0.022	0.061	0.054	0.096	0.083	0.058	0.048	0.019
	C Storage	2.986	2.983	3.170	3.166	2.961	2.958	3.038	3.033	3.383	3.376	2.957	2.952	2.982
	Total economic value	**3.433**	**3.371**	**3.619**	**3.643**	**3.408**	**3.351**	**4.112**	**3.984**	**5.075**	**4.837**	**3.987**	**3.804**	**3.326**
Bulandshahr	Water	0.006	0.120	0.006	0.153	0.006	0.122	0.436	0.519	0.703	0.808	0.402	0.494	0.341
	Sediment	0.000	0.007	0.000	0.009	0.000	0.007	0.026	0.031	0.042	0.048	0.024	0.030	0.020
	C Storage	3.921	3.916	4.097	4.092	3.901	3.897	3.953	3.935	4.239	4.218	3.896	3.879	3.920
	Total economic value	**3.928**	**4.043**	**4.104**	**4.254**	**3.908**	**4.026**	**4.415**	**4.485**	**4.984**	**5.074**	**4.322**	**4.402**	**4.282**
Mirzapur	Water	1.781	1.791	1.762	1.982	1.772	1.812	1.507	2.754	1.829	3.746	1.451	2.659	0.692
	Sediment	0.107	0.107	0.106	0.119	0.106	0.109	0.090	0.165	0.110	0.225	0.087	0.160	0.042
	C Storage	15.805	12.614	16.006	12.833	15.739	12.538	14.959	9.692	15.288	10.084	14.846	9.553	17.508
	Total economic value	**17.693**	**14.513**	**17.873**	**14.934**	**17.618**	**14.458**	**16.556**	**12.610**	**17.226**	**14.055**	**16.384**	**12.371**	**18.241**
Hamirpur	C Storage	3.033	2.960	3.236	3.163	3.003	2.929	3.052	3.015	3.424	3.388	2.964	2.927	3.230

Table: Predicted value of water yield (WY), Sediment Yield (SY) and C sequestration under different policy and climate change scenario for the years 2020, 2030 & 2050.

		2030						2050						
		BAU		Optimistic		Pessimistic		BAU		Optimistic		Pessimistic		2020
District	Indicators	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	RCP 4.5	RCP8.5	
Meerut	WY (mm)	1.748	72.554	1.757	86.206	1.719	71.022	257.832	323.742	386.819	431.383	252.867	301.488	197.301
	SY (Mcu.m)	0.023	0.910	0.025	1.018	0.022	0.881	2.412	4.157	3.565	5.023	2.097	3.759	0.720
	C Storage (Million t)	9.030	9.003	9.430	9.400	8.972	8.947	9.079	9.042	9.723	9.680	8.939	8.904	9.043
Aligarh	WY (mm)	530.864	460.419	532.356	565.592	530.113	465.857	1274.539	1127.429	2006.817	1733.885	1221.124	1010.651	407.262
	SY (Mcu.m)	2.794	5.415	2.776	6.582	2.852	5.618	7.190	10.583	13.058	14.195	6.071	8.987	1.435
	C Storage (Million t)	9.460	9.450	10.044	10.032	9.380	9.373	9.624	9.611	10.719	10.695	9.370	9.354	9.449
Bulandshahr	WY (mm)	7.488	143.099	7.451	182.586	7.397	145.870	521.161	620.108	840.742	965.676	481.004	590.285	408.040
	SY (Mcu.m)	0.036	1.440	0.036	1.747	0.034	1.474	3.918	7.089	6.195	9.640	3.020	6.583	1.218
	C Storage (Million t)	12.389	12.335	12.893	12.837	12.328	12.275	12.517	12.459	13.405	13.341	12.324	12.271	12.402
Mirzapur	WY (mm)	1769.625	1779.460	1750.088	1968.657	1760.315	1799.814	1496.710	2735.241	1816.712	3721.321	1441.467	2640.915	687.402
	SY (Mcu.m)	18.428	27.167	17.762	31.628	18.289	27.936	14.726	42.609	22.132	72.941	13.231	36.982	6.348
	C Storage (Million t)	50.076	39.967	50.711	40.660	49.868	39.725	47.395	30.706	48.437	31.950	47.038	30.268	55.471
Hamirpur	C Storage (Million t)	9.609	9.377	10.252	10.021	9.514	9.280	9.670	9.554	10.848	10.733	9.391	9.274	10.239

Annexure: NF 226 Valuation of Ecosystem Services 3(2+1)

Course Title: **Valuation of Ecosystem Services**
Course Code: **NF 226**
Credit Hours: **3(2+1)**
General Objective: To familiarize the students, understand with key concepts and processes in Ecosystems, complexity, visible and invisible benefits. This course will provide an in- depth understanding with skills and knowledge on Ecosystem Services and Valuation.
Specific Objectives:

1. To orient the students with basic concepts of Ecosystems
2. To provide a glimpse of Services from Ecosystems
3. To impart skills on quantification and valuation of ecosystem services

Theory

Practical

Learning Outcomes

At the end of the course, students will be able to:

1. Understand the fundamental concepts of ecosystem services
2. List out the visible and invisible benefits of ecosystems
3. Gain expertise in quantification of ecosystems
4. Learn about valuation of ecosystems services

Teaching Methods/ Activities

- Lectures/ Participatory Lecture
- Assignment (Reading/ Writing)
- Students' presentation
- Group/ Team activities
- Hands on experience

Suggested readings

https://teebweb.org/our-work/nca/understanding-nca/
NAAS. 2020. Payment for Ecosystem Services in Agriculture. http://naas.org.in/Policy%20Papers/policy%2094.pdf
Baskaran, R., Cullen, R., and Takatsuka,Y. (2009) Estimating the value of agricultural ecosystem
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Costanza, R., d'Arge, R., De groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S.,
O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., and van den Belt, M. (1997b) The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

Lecture Schedule
Theory

Topic	No. of Classes
TEEB, UNEP, UNFCC, CoPs, WTO and ecosystem services	1
Definition, concepts, significance and objectives of ecosystem services (ES)	1
Kind of ecosystem services and their indicators	1
Functional categorization of ecosystem services	1
Definitions and concepts of Natural capital, produced capital, social capital and human capital	1
I-Provisioning ecosystem services and their indicators (eg. Food, Fiber, Fuel, Biochemical, Genetic resources etc.)	1
II-Provisioning ecosystem services and their indicators (eg. Food, Fiber, Fuel, Biochemical, Genetic resources etc.)	1
I-Regulating ecosystem services (eg. Climate regulation, Water regulation, Water purification, Disease regulation etc.)	1
II-Regulating ecosystem services (eg. Climate regulation, Water regulation, Water purification, Disease regulation etc.)	1
I-Cultural Services (Recreation and eco-tourism, Spiritual and Religious, Aesthetic, Educational etc.)	1
II-Cultural Services (Recreation and eco-tourism, Spiritual and Religious, Aesthetic, Educational etc.)	1
Supporting ecosystem service (Soil formation, Nutrient recycling, Primary production, Supporting biodiversity etc.)	1
Definition, concepts of ecosystem dis-services	1
Difference between ecosystem services and ecosystem disservices	1
I-Framework and method for estimation and valuation of provisioning ecosystem services	1
II-Framework and method for estimation and valuation of provisioning ecosystem services	1
I-Framework and method for estimation and valuation of regulating ecosystem services	1

II-Framework and method for estimation and valuation of regulating ecosystem services	1
I-Framework and method for estimation and valuation of cultural ecosystem services	1
II-Framework and method for estimation and valuation of cultural ecosystem services	1
I-Framework and method for estimation and valuation of supporting ecosystem services	1
II-Framework and method for estimation and valuation of supporting ecosystem services	1
Valuing ecosystem services in the total economic value (TEV) framework	1
I-Payment of Agri-ecosystem services (PAES)	1
II- Payment of Agri-ecosystem services (PAES)	1
Sustainable livelihood security and their valuation	1
Indigenous agri-practices and ecosystem services	1
Modern agri-practices and ecosystem services	1
Good agricultural practices (GAP) for improving ecosystem services	1
Carbon trading and ecosystem services	1
Tangible benefits of the ecosystem services	1
Intangible benefits of the ecosystem services	1
Total	**32**

Practical:

Topic	No. of Classes
Exposure visits on nature positive agri-practices	1
I- Concepts on tools used in estimation and valuation of ecosystem services eg. InVest model	1
II- Concepts on tools used in estimation and valuation of ecosystem services eg. InVest model	1

III- Concepts on tools used in estimation and valuation of ecosystem services eg. InVest model	1
Methodology for calculation of provisioning ecosystem services valuation	1
Methodology for calculation of regulating ecosystem services valuation	1
Methodology for calculation of cultural ecosystem services valuation	1
Methodology for calculation of supporting ecosystem services valuation	1
I-Exposure visits of Agri, Agroforestry and Forest systems and comparative estimation of carbon sequestration	1
II-Exposure visits of Agri, Agroforestry and Forest systems and comparative estimation of carbon sequestration	1
Calculation of total economic value (TEV) of ESSs	1
I-Calculation and valuation of Sustainable livelihood security index based on economic efficiency index (EEI), ecological security index (ESI) and social equity index (SEI)	1
I-Calculation and valuation of Sustainable livelihood security index based on economic efficiency index (EEI), ecological security index (ESI) and social equity index (SEI)	1
Calculation of Agrobiodiversity index	1
Calculation and valuation of women empowerment	1
Payment carbon credit in lieu of ecosystem services	1
Total	**16**