UNEP- TEEB Project

TEEB Implementation: Promoting a Sustainable Agriculture and Food Sector

OPTIONS FOR TEEB AGRIFOOD INDIA PROJECT

Agriculture and food policies are often evaluated in silos using narrow lens such as 'productivity per hectare' to measure success. This partial assessment leads to an imperfect understanding of the inter linkages and impacts of agriculture and food systems on environmental and human health. 'Eco-agri-food' systems is a collective term encompassing the vast and interacting complex of ecosystems, agricultural lands, pastures, farmer livelihoods, infrastructure, technology, policies, culture, and institutions that are variously involved in growing, processing, distributing, and consuming food.

TEEB is a global initiative focused on drawing attention to the economic benefits of biodiversity including the growing cost of biodiversity loss and ecosystem degradation. 'TEEB for Agriculture and Food' (TEEBAgriFood) seeks to review the economic interdependencies between human (economic and social) systems, agriculture and food systems, and biodiversity and ecosystems. In doing so, it addresses the economic invisibility of many of these links while exploring how biodiversity and key ecosystem services deliver benefits to the agriculture sector and also beyond, itself being a key contributor to human health, livelihoods and well-being.

As a next step, the EUPI TEEB Agrifood India project seeks to identify a policy question which will merit the application of the TEEBAgriFood evaluation framework and will be relevant for policy makers to fill gaps in science so as to facilitate evidence based decision making. In this options paper, based on desk research an attempt is made to identify **four policy priority options** for consideration. These options are 1) Evaluating Zero Budget Natural Farming 2) Promoting sustainable Land Management for Agriculture in Drought Prone Areas 3) Strengthening agroforestry initiatives in India 4) Moving towards a sustainable rice agronomy.

The next few sections gives the brief context, challenges, scope for TEEB framework application , opportunity for policy impact for each of these options.

Summary Table of Four Options

Option 1: Evaluating Zero Budget Natural Farming

What is ZBNF?

Zero Budget Natural Farming (ZBNF) is a farming practice involving natural growth of crops without adding any fertilizers and pesticides. The word 'Zero Budget' refers to the zero net cost of production of all crops (inter crops, border crops, multi crops).

Why is TEEB for this option ?

Multi-location studies are needed to scientifically validate the long-term impact and viability of the model before they can be scaled up

What should the study do?

- Go beyond productivity per hectare analysis
- Assess impact on soil health and yields for different crops overtime
- Identify potential region with opportunity for impact

Option 2 : Promoting sustainable Land Management for Agriculture in Drought Prone Areas

What is SLM ?

- It is defined as "**use of land resources …** to meet changing human needs, while simultaneously ensuring the **long-term productive potential of these resources** and the maintenance of their environmental functions".(IPCC Report- Climate Change and Land, 2019)
- Climate change exacerbates land degradation (IPCC Report- Climate Change and Land, 2019)

Why TEEB for this option ?

- To investigate, land-water- climate change and agriculture with a systems approach in drought prone areas

What should the study do?

- Scenario Analysis for agriculture (modelled with climate variability)

- Human and Social dimensions included- impact of climate variability on land-water-crops- biodiversity and livelihoods
- Identify potential region with opportunity for impact

Option 3: Strengthening agroforestry initiatives in India

What is Agroforestry?

- It is defined as land-use systems whereby a combinatory approach is utilized for the cultivation of woody perennials such as trees, shrubs, palm, bamboo etc. along with crops and/or animals within the same land management unit

Why TEEB for this option?

- More research needed to identify different agroforestry models suitable for diverse ecological landscapes
- Comprehensive assessment of agroforestry including economic as well as environmental benefits. Majority of studies quantify and monetize economic benefits of agroforestry produce.

What should the study do?

- Quantify value of environmental benefits
- Identify potential region with opportunity for impact

OPTION 4: Moving towards a sustainable rice agronomy

What is 'Sustainable Rice Agronomy' ?

- Agronomy conventionally seeks to maximise yields for profit, rather than to optimize outcomes for poor farmers.
- Combines sustainable rice production with Agronomy

Why TEEB for this option ?

- Holistic systems approach with medium and long-term studies are required to evaluate the benefits and trade-offs associated with the adoption of the diggerent rice management practices . Kumar et al., (2018).

What should the study do?

- A range of approaches to sustainable rice production, depending on the context for instance, conservation agriculture practices such as zero-tillage, dry direct seeding of rice,

Option 1: Evaluating Zero Budget Natural Farming

Brief Context

Zero Budget Natural Farming (ZBNF) is a farming practice involving **natural growth of crops without adding any fertilizers and pesticides**. The word 'Zero Budget' refers to the **zero net cost of production** of all crops (inter crops, border crops, multi crops)[1,2].

Of all the states, Andhra Pradesh is expanding the scope of ZBNF most rapidly. So far in Andhra Pradesh the method is used by 580,000 farmers in 3011 Villages covering an area of 260,000 (in ha)[3]. The state aims to scale it up to 6 million farmers, cultivating eight million hectares of land from conventional synthetic chemical agriculture to ZBNF by 2024[4].

Other states in India including Karnataka and Kerala among others are at various stages of practicing ZBNF[5,6]. The Finance Minister of India in the budget speech of 2020 emphasised on scaling up organic farming practises including ZBNF. Therefore, central and state ministries of Government of India through its recent policies and programs are giving it a push.

The country has significantly increased its fertilizer usage in recent years. In 1977, the country had a total NPK (nitrogenous, phosphatic and potassic) fertilizer consumption of 4.3 million metric tonnes (mmt) and per hectare usage of 24.9 kg, however by 2019 total consumption rose to 27.3 mmt and per hectare usage stood at 137.6 kg. The rampant overuse of urea and imbalance in fertilizer usage has led to a worsening of soil quality that has resulted in falling crop response to fertilizers, which, in turn, has affected farm productivity and farmers' profitability adversely[7]. ZBNF by reducing excessive usage of chemical fertilizers has the potential to reduce the need for fertilizer subsidies.

Challenges and Opportunities

A desk research showed that there is a growing body of documentation about the impact of ZBNF in the form of farmers success stories, newspaper articles, as well as reports and scientific journals. Increase in yields and increase in income due to decrease in input costs have been pointed out by different sources

[1] Government of Andhra Pradesh, (2020). Zero Budget Natural Farming. Available at: http://apzbnf.in
[2] The movement of ZBNF in India was initiated by Mr Subhash Palekar, a farmer from the state of Karnataka, who won the Padam Shri for his initiative. For more details: http://apzbnf.in/
[3] Government of Andhra Pradesh, (2020). Zero Budget Natural Farming. Available at: http://apzbnf.in
[4] Agarwal, M., (2018). Andhra Pradesh's push for zero budget natural farming inspires others. Available at: https://india.mongabay.com/2018/09/andhra-pradeshs-push-for-zero-budget-natural-farming-inspires-others/
[5] Bhosale, J. (2019). Zero Budget farming has few takers in the state where it originated. Available at: https://economictimes.indiatimes.com/news/economy/agriculture/budget-2019-zero-budget-farming-has-few-takers-in-the-state-where-it-originated/articleshow/70089472.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
[6] Details provided by Government Press in Annex 1
[7] ICRIER. (2019). Supporting Indian Farms the Smart Way. Academic Foundation. Available at: https://icrier.org/pdf/Supporting_Indian_Farms_the_smart_way.pdf

as the positive impacts of ZBNF. With respect to decrease in input use, studies show that the increase in yield is not uniform in fact there is wide regional variation in reduction of input use within the range 27 to 90%. With regard to yields, studies point towards differences in impact across high input and low input systems from nitrogen use of ZBNF, with low inputs systems having high yields but not high input systems. What remains clear, is that although there is growing evidence that ZBNF has had positive impact on yields and income, more needs to be check the robustness.

For reader's understanding, in this section the information available on the impact of ZBNF is broadly classified in 3 groups based on degree of credibility about the source of information.

Group 1: Blogs based on farmers success stories: Between March 5 and April 19, 2018, ten blogs about the successful application of ZBNF were published on the website of AZBNF (Andhra Pradesh Zero Budget Natural Farming). Most blogs document farmer success stories pointing towards an **increase in yield** and **increase in income** due to low expenditure made on inputs specifically by the savings made from using little or no fertilizers. For instance, one blog mentions that Andhra Pradesh has some unique varieties of mango[8] which were facing a decrease in flowering rate (3-10%), ZBNF practises helped in increasing the flowering rate of these mango orchards. Blogs also document that the yield loss in periods of less rainfall was lower for farmers that practiced ZBNF. Another blog mentions a teacher-turned-farmer who switched to 100% ZBNF practises and later crop cutting experiments conducted on his field showed that the yield of his field was more than double the district average (160 tonnes versus 73 tonnes per hectare).

Group 2: News based on primary information at news websites: Independent news reports, including from platforms like downtoearth and moongbay based on conversations and inquiries from people working on the field, have supported ZBNF method by writing that ZBNF leads to reduction in water consumption[9], better climate resilience and successful inter-cropping[10].

Group 3: Journals and evidence-based research studies

There is a growing mass of scientific literature that is investigating the impact of ZBNF particularly in Andhra Pradesh. A preliminary investigation points towards the following literature:

[8] Andhra Pradesh is particularly famous for 'baginapally' and 'totapari' varieties of mangoes with Krishna, Chittoor Vizianagram, West Godavari, Guntur as the major mango growing districts in the state

[9] The Better India. (2020). 5-layer mini forest in 5-Acre Land boosts Karnataka Farmer's Annual Income to 25 Lakh.https://www.thebetterindia.com/224417/karnataka-farmer-zero-budget-natural-farming-mini-forest-earns-lakhs-india-gop94/

[10] Niyogi D.G. (2018). Andhra farmers taste success with Zero Budget Natural Farming. Down to Earth. Available at: https://www.downtoearth.org.in/news/agriculture/andhra-farmers-taste-success-with-zero-budget-natural-farming-59445

1) RySS in Andhra Pradesh has commissioned research studies using crop cutting data[11]. These are available on the official AZBNF website. Two institutions conducted these studies and their main conclusions are summarized here:

a) CEEW (2018a, 2019b) [12] assessed linkages between ZBNF and Sustainable Development Goals. Using data from Crop Cutting Experiments (CCEs) of both commercial and food crops conducted in all 13 districts of Andhra Pradesh, and information on programme-level policies and interventions provided by RySS, they conclude that ZBNF farmers in AP have witnessed a sharp decline in input costs and an improvement in yields. The study also mapped the possible social, economic and environmental impacts of ZBNF programme in Andhra Pradesh vis-à-vis specific targets under each sustainable development goal. Their findings show that the ZBNF program has potential to help achieve most of the SDGs. They also conclude that Andhra Pradesh could save nearly INR 2100 crores (~USD 292 million) in fertiliser subsidies annually if it is scaled up Zero Budget Natural Farming (ZBNF) to all six million farm families in the state by 2024.

b) Centre for Economic and Social studies (2019) [13] conducted another study using crop data for Kharif 2018-19 for 130 villages using detailed household questionnaire surveys. Their findings also support the proposal that there is a reduction in costs through the application of ZBNF practises. The authors present evidence from different types of crops.

Cost of Inputs per Acre		
	ZBNF inputs	Chemical Inputs
Paddy	Rs.1706	Rs.5361
Maize	Rs.1866	Rs. 2440
Groundnut	Rs.1117	Rs. 1510
Cotton	Rs.1159	Rs. 3659
Tomato	Rs.2058	Rs. 6760
Bengal gram	Rs.1835	Rs. 3315

Yield of crops (Quintals/ acre)			
Crop	ZBNF	Non ZBNF	Yield Significantly Differ between ZBNF and Non-ZBNF
Maize	20.81	15.95	*Significant

[11]It is also conducting research **in collaboration with University of Reading**, UK World Agro Forestry Centre, Nairobi, FAO & resource NGOs/Civil Society Organizations like Centre for Sustainable Agriculture, Hyderabad. The results of those studies are not yet available on the public domain

[12] Ibid

[13] Galab, S. et al. (2019). Impact Assessment of Zero Budget Natural Farming in Andhra Pradesh – Kharif 2018-19 : A comprehensive approach using crop cutting experiments. CESS. Available at < http://apzbnf.in/reports/>

Groundnut	5.40	4.66	Not Significant
Cotton	4.53	4.27	Not Significant
Bengal gram	7.08	6.88	Not Significant
Tomato	151.85	149.15	Not Significant

All crops showed a decrease in cost of inputs, however for. Some crops there was a regional variation to this response. For instance, the percentage of reduction in the cost of inputs for paddy ranged from 27 per cent to 90 per cent depending on the district. The extent of decline in cost of inputs is pronounced in case of high value crop like Cotton and vegetable crop like Tomato compared to other crops like Maize, groundnut or Bengal gram. The levels of biological input use could be higher in case of Cotton and Tomato as the levels of chemical inputs is higher in them. As far as yield is concerned, Maize is an exception, as under ZBNF, its yield is significantly higher than that under non-ZBNF.

In addition, there are independent evaluations of universities and research institutes, that gave different positions on the impact of ZBNF.

Bharucha et al. (2020) use data from crop cutting experiments in Andhra Pradesh to find statistically significant differences between ZBNF and non-ZBNF yields and farmer incomes at multiple locations and with a variety of crops, as well as preliminary results on farmers' experiences with crop health and household transitions following the adoption of ZBNF[14]. ZBNF yields were higher than non-ZBNF yields across all districts except one (the district of West Godavari, where yields were 7% lower, likely due to anaerobic soil due to water logging, which is a normal phenomenon in the delta region). Costs of cultivation under ZBNF conditions were lower, and net incomes higher, than non-ZBNF for all crops.

Kumar et al (2019) undertook a study during January-June 2019 covering 55 and 124 ZBNF-adopting farmers and 50 and 61 non-ZBNF farmers in Karnataka and Andhra Pradesh, respectively. Their findings show a significant reduction in the costs of cultivation of all the crops. However, the effect on crop yield is not conclusive. ZBNF-farmers in Karnataka had better yields in finger millet, but lower yield in paddy and sugarcane. While in Andhra Pradesh, yield advantage was visible in paddy to ZBNF[15]. As a percentage of non ZBNF farmers in the sample, the yield (q/ha) was 111.8 in AP for paddy and 134.6 in Karnataka for finger millet reflecting an increase in yield. The yield for sugar cane (q/ha) decreases in both states as a percentage of non ZBNF farmers, 97.9 in AP and 82 in Karnataka.

Smith et al. (2020) show that a strict ZBNF system is likely to reduce soil degradation and could provide yield benefits for low-input farmers. They compared the nitrogen potentially available in a ZBNF system with the national average fertilizer application rate of India. This includes a wide range of different

[14] Zareen, P.B., Sol, B.M. & Jules, P., (2020). Towards redesign at scale through zero budget natural farming in Andhra Pradesh, India, International Journal of Agricultural Sustainability, 18:1, 1-20, DOI: 10.1080/14735903.2019.1694465

[15] Kumar, R., Kumar, S., Bs, Y., & Meena, P. (2019). Natural Farming Practices in India: Its Adoption and Impact on Crop Yield and Farmers' Income. Indian Journal of Agricultural Economics, 74, 420–432.

systems, from high-yielding, high-input systems to low-input systems with lower yields. Their analysis found that in low-input systems, nitrogen supply is expected to increase with conversion to ZBNF, whereas in high input systems, it is more likely to decline. Yield increases associated with increased nitrogen supply may, in part, explain the observation from 88% of farmers that converting to ZBNF has achieved increased yields in the first season after conversion26. Further research is needed in higher-input systems to ensure that mass conversion to ZBNF does not limit India's capacity to feed itself[16].

Indian Council of Agriculture Research with Central Research Institute for Dryland Agriculture (ICAR-CRIDA) conducted a primary survey along with soil sample collection in 2-3 districts of Karnataka, Andhra Pradesh and Maharashtra states during April to June 2019, covering 295 natural farming practicing and 170 non-practicing farmers. The preliminary observations from the survey indicates that there is mixed effect on crop yield, depending upon the crop, however, farmers are able to sell the produce at premium price, due to it being organic[17]. The final results of this paper are not yet in public domain.

ZBNF is also receiving some critical reviews by scientists, journalists and civil society practitioners. The announcement in the budget that the country shall go back to basics, was received with criticism. Most critics point out the lack of thorough evaluation about the impact of ZBNF.

- Saldanha (2018) points out that it is unclear why Andhra Pradesh which for several years had practised Community Managed Sustainable Agriculture (CMSA) initiative from 2015-16 replaced it by ZBNF[18].
- Aggarwal (2019) notes that chemical free farming was practised widely in the country before the Green Revolution, and asks if it was so effective why was the Green Revolution needed.[19].
- In the discussions documented in national media[20,21], senior officials of the government have highlighted that **studies are needed to scientifically validate the long-term impact of the model** before they can be scaled up and promoted country-wide. They have highlighted the **need to assess the productivity, quality, effect on soil nutrition, adoption of natural farming and its effect on crop yield and farmers' livelihood in the long run**. The National Academy of Agricultural Sciences, the country's premier academic body for agricultural scientists, in a letter written to the Prime Minister also suggested the need for scientific validation before upscaling.

[16] Smith, J., Yeluripati, J., Smith, P., & Nayak, D. R. (2020). Potential yield challenges to scale-up of zero budget natural farming. Nature Sustainability, 3(3), 247–252. https://doi.org/10.1038/s41893-019-0469-x

[17] ICAR-NAARM. (2019). Newsletter. Available at: <https://naarm.org.in/wp-content/uploads/2019/07/Newsletter_April-June-2019-ICAR-NAARM.pdf>

[18] Saldanha, L. F. (2018). A review of Andhra Pradesh's climate resilient zero budget natural farming programme - India Environment Portal | News, reports, documents, blogs, data, analysis on environment & development | India, South Asia. Retrieved from http://www.indiaenvironmentportal.org.in/content/460170/a-review-of-andhra-pradeshs-climate-resilient-zero-budget-natural-farming-programme/

[19]Agarwal, K. (2019). Zero Budget Natural Farming: Another Case of 'Raw Wisdom' over Science. Available at: <https://thewire.in/agriculture/zero-budget-natural-farming-science-research>

[20]The Hindu. (2019). Agricultural scientists write to PM urging 'scientific validation' of the approach. Available at: <https://www.thehindu.com/news/national/govt-should-stop-promoting-zero-budget-natural-farming-pending-proof-scientists/article29386358.ece>

[21]Jebaraj, P. (2019). What is zero budget natural farming?. Available at: < https://www.thehindu.com/sci-tech/agriculture/what-is-zero-budget-natural-farming/article28733122.ece>

Such literature and discussions highlight the need for more investigation into impact and scalability for implementation of the ZBNF to other states and ultimately at national scale. A perspective paper of uNEP by Raghuram (2020) infact has apltly summarized this, suggests that limited successes or failures can be easily cited either to promote or deride any model in the short term. While in the long run, these practises can overcome the initial problems or policy hurdles to become true alternatives to established models of agriculture, it is premature to say that one of these models can offer a comprehensive solution, their impact may vary depending on model, crop, place or time[22].

The list on literature is non exhaustive and is only mentioned to indicate that there is a growing body of scientific evidence that supports success of ZBNF but equally the jury is still not out. Although there is a growing body of literature based on farmer success stories, newspaper articles, as well as scientific journal publications, there is more that needs to be done to test the robustness. To test the case for large scale applicability and sustainability, there is a need for deeper analysis using land use data to compare organic farming with conventional methods, comparing baseline scenarios with alternate scenarios modelled over a long time frame. The impact of such an assessment will be able to give greater clarity to understand the impact of ZBNF on not only the immediate natural ecosystem services but also the impact on human, produced and social capital. As most studies are focussed on Andhra Pradesh, **multi-location studies are also needed to scientifically validate the long-term impact and viability of the model** before they can be scaled up and promoted country-wide.

Scope for TEEB Application in ZBNF

The TEEB evaluation framework can provide a platform to assess trade-offs across different part of the agrifood value chain linked to the ZBNF practices to provide a holistic understanding about the positive or negative effects of ZBNF on human, social, produced and natural capital.

Sample checklist

Value Chain	Agricultural Production	Manufacturing and processing	Distribution, marketing and retail	Household consumption
Outcomes (change in capital)				
Natural capital	Crop diversity, Soil Health,			Sales of principal crops

[22] UNEP, (2020). Zeroing in on farm budgets or zero budget natural farming? UNEP Perspective Series No. 37. Available at: <https://www.unenvironment.org/resources/perspective-series/zeroing-farm-budgets-or-zero-budget-natural-farming-unep-perspective>

	Ground water level			
Produced capital		Value added industries, bioenergy plants		
Human capital	Farmer training and knowledge benefits		Employment in organic farming	Food security
Social capital	Indigenous knowledge			
Flows				
Outputs				
Agricultural and food production	Yield per hectare			
Income / operating surplus	Income from sale of crops	Value added income		
Purchased inputs to production				
Labour	Labour cost			
Intermediate inputs (fuel, fertilizer, etc.)	Fertilizer use per hectare			
Provisioning		Food production Habitat provisioning, Production of energy		
Regulating		Soil fertility, Nutrient recycling Pest control, ground water recharge		

Cultural	Traditional fertilizer knowledge			
Residual flows				
Food waste				
Pollution and emissions (excess N & P, GHG emissions, etc.)	GHG emissions per hectare	GHG emissions of the linking to consumer (Transport/ Online etc)		

Legend
Descriptive information available
Quantitative information available
Monetised information available
Not included in study

Utilising such a framework provides a common basis to compare assessments, a tool for decision-makers to take informed decisions. The framework can also help decision-makers quickly identify any blind spots in the information base used to support decision-making. Overall, the framework will allow for a broadening of our understanding and conversations around agricultural and food systems in the given context of ZBNF and natural farming.

The TEEBAgrifood evaluation framework is currently actively being used in some project countries to test scenarios of moving towards organic farming and its impacts on yield and farmer livelihoods. Such analysis can be beneficial in evaluating the scope of scaling up of natural farming in India. Therefore, applying TEEB evaluation framework on ZBNF will provide a unique opportunity to further investigate the impact of this agroecological practise on the entire value chain including its implications for human, social, natural and produced capital.

Opportunity for Impact

The government is proactively taking steps to promote organic farming with particular emphasis on ZBNF. This shows the opportunity for impact and for mainstreaming results.

FOR ZBNF:

- **Promotion of ZBNF in the Finance Minister's Speech:** In July 2019, in the interim budget, the FM promoted Zero Budget farming and said that the country shall go back to basics. She emphasised the need to replicate this ZBNF model, which is already in practise in several states[23]. In February 2020, during presentation of the detailed budget, within the scope of allocation for Agriculture and Allied sectors she mentioned two things within the context of zero budget (??) natural farming, 1) "the government shall encourage balanced use of all kinds of fertilizers including the traditional organic and other innovative fertilizers" 2) there will be "strengthening organic farming in the country, within the context of developing Integrated farming systems in rainfed areas with multi-tier cropping, bee-keeping, solar pumps, solar energy production in non-cropping season, and also ZBNF".

FOR ORGANIC FARMING:

- **Online platforms of Government for promoting organic farming:** A portal called **Javakheti** portal was launched by the Ministry of Agriculture and Farmers Welfare to promote organic farming globally. It facilitates organic farmers to sell their organic produce and promoting organic farming and its benefits. The portal links various stakeholders like regional councils, local groups, individual farmers, buyers, government agencies and input suppliers for the all-inclusive development and promotion of organic farming. Almost 0.22 million farmers are already registered in this portal[24].
- Soil Health Card (SHC) program of this ministry aims to address Soil Health for the first time in a consistent manner by working with state governments to evaluate soil fertility across India. SHCs describe the status of soils with respect to 12 parameters, and provide crop-specific fertiliser recommendations to help farmers improve productivity by maintaining soil health.
- **Jump in budgeted expenditure for organic farming**: Two central schemes are actively supporting the scaling up of organic farming, both under the Ministry of Agriculture and Farmers Welfare.

    - Paramparagat Krishi Vikas Yojana[25] was launched in 2015 to promote organic farming among small and marginal farmers has in the last four years covered 7 lakh hectares and 8 lakh farmers. Andhra Pradesh, Karnataka, Himachal Pradesh, and Kerala have taken up natural farming on a large scale. Andhra Pradesh alone has brought 2 lakh hectares under natural farming under this scheme.

    - The Javakheti portal falls under the wider scheme for promote Organic farming in the country. An analysis of the annual budget of Ministry of Agriculture over the past three years reveals that although the share of National Project on Organic Farming (NPOF) is relatively small when compared to big budget schemes of the Ministry of Agriculture and

[23] Page 12, https://bsmedia.business-standard.com/_media/bs/data/general-file-upload/2019-07/Budget_Speech.pdf
[24] PIB, (2020). Agroecology and Natural Farming could accelerate inclusive economic growth in India. Available at: <https://pib.gov.in/PressReleasePage.aspx?PRID=1628285>
[25]This is subcomponent of the Soil Health Scheme (SHS) under the National Mission for Sustainable Agriculture, which is one of the eight Missions under the National Action Plan on Climate Change (NAPCC).

Farmer's Welfare such as PM KISAN which has a budget of almost Rs. 7000 crore INR (70 billion), the NPOF witnessed a substantial increase in allocation, an increase from Rs. 2 crore INR (20 million INR) to 12.5 crore INR (125 million INR)

- **In addition, to the above schemes directly related to organic farming, there is Pradhan Mantri Krishi Sinchayee Yojana** (PMKSY) which is a major the inter-ministerial scheme of the Government of India, accounting for a major share in the budgets of the Ministry of Agriculture and Farmers Welfare, Ministry of Jal Shakti and Ministry of Rural Development. The TEEB study results can provide a platform to assess different components of the scheme, such as Per Drop More Crop, water shed management, Har Khet Ko Pani (water to every field), using scenario analysis methods.

- In an online high level discussion of NITI Aayog, the central think tank of Government of India, on 29th May 2020, **several experts underlined the importance of sustainable agriculture[26]**.
    - Minister of Agriculture stated, "Natural farming is our indigenous system based on cow dung and urine, biomass, mulch and soil aeration [. . .]. In the next five years, we intend to reach 20 lakh hectares in any form of organic farming, including natural farming [….].' He concluded by highlighting that the need of the hour, in light of the covid-19 pandemic, was to have 'food free from chemical fertilisers and pesticides', while not ignoring the need to feed and nourish the country.
    - Another expert noted that it would be a mistake to view natural farming as a step backwards to the farming techniques of our forefathers, but rather, as the high level panel of experts report on Agroecology to the Committee on Food Security of FAO so clearly demonstrated, it is based on cutting-edge science of the future that recognises the need for systemic approaches to dealing with complex adaptive systems that are the basis of a healthy natural world. Working with nature, understanding how to do so will help us 'build back better' as one expert noted.
    - Member (Agriculture) of NITI Aayog called for more research to ensure that natural farming could truly live up to its expectations. The need for innovation, science and technology was endorsed by experts who noted the importance of regenerating soils and building on biodiversity as two key elements, along with use of natural inputs readily available to farmers in this knowledge intensive approach.
    - Principal Scientific Adviser to the Government of India further reiterated the importance of natural farming by highlighting the country is 'running behind yields at the cost of diversity and nutrition'. To protect our planet there is need for change in our attitude towards use of chemical fertilisers and pesticides. Technology can help in changing the way we farm and will enable the poorest of the poor to enhance their nutrition status and livelihoods.

- There is also a great scope for **synergizing the outcomes of the TEEBAgrifood project with ongoing approved projects of Global Environment Facility** in India. For instance, a project was

[26] https://pib.gov.in/PressReleasePage.aspx?PRID=1628285

recently approved in cycle 7 of GEF, 'Transforming agricultural systems and strengthening local economies in high biodiversity areas of India through sustainable landscape management and public-private finance', with 6 million USD of GEF project financing and 70 million USD project co-financing form Government of India, and it is expected to run for a period of 60 months.

Option 2: Sustainable Land Management for Agriculture in Drought Prone Areas

Brief Context

The United Nations defines sustainable land management (SLM) as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions"[27].

India supports 18 % of the world human population, 15 % of the global livestock population, but endowed with only 2.4 % of world land area[28]. There is an increasing pressure on land to meet the needs of growing population, the second highest in the world. With approximately 4% of the world's freshwater resources and as much as 17.6% of the world's population, India is also very vulnerable to droughts[29].

Desertification / land degradation analysis of India as a whole reveals that 96.4 million ha of the country is affected by land degradation, representing 29.3% of the Total Geographic Area (TGA) of the country, of which 23.9% is contributed by 9 states, Rajasthan, Maharashtra, Gujarat, Jammu & Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana in descending order. All other remaining states contribute less than 1% (individually) to desertification/land degradation. Land degradation affects nearly 700 million people living in rural India who are dependent on forest and agriculture for their livelihoods, including tribal communities, women and small holder famers[30].

The causes of desertification and land degradation are numerous and complex. The most significant processes of desertification/ land degradation are water erosion (11.0%), vegetation degradation (8.9%) and wind erosion (5.6%)[31]. Factors that intensify this include the extension of crop cultivation to marginal and low potential lands or to lands vulnerable to natural hazards, shifting cultivation, improper crop rotations, overuse of agrochemicals, and mismanagement of the irrigation system. Underlying causes include poverty among agricultural households, land fragmentation, insecure land tenure, open access nature of some resources, and policy and institutional failures. According to a report by The Energy and Resources Institute (TERI) prepared for the Ministry of Environment, Forest and Climate Change, Government of India, desertification, land degradation and drought cost India almost 2.54% of its Gross Domestic Product (GDP) in 2014. Around 30% of India's total geographical area is currently impacted by land degradation[32].

---

[27] FAO. (2005). Sustainable Land Management. [online] Available at: http://www.fao.org/land-water/land/sustainable-land-management/en/

[28] UNFCCC 2nd BUR of India

[29] 2nd BUR of India to UNFCCC

[30] Space Applications Centre. (2016). Desertification and Land Degradation Atlas of India. SAC-ISRO. [online] Available at <https://www.sac.gov.in/SACSITE/Desertification_Atlas_2016_SAC_ISRO.pdf>

[31] Ibid

[32] TERI. (2018). Economics of Desertification, Land Degradation and Drought in India: Vol 1 – Macroeconomic assessment of the costs of land degradation in India. New Delhi: The Energy and Resources Institute. [online] Available at: <https://www.teriin.org/sites/default/files/2018-04/Vol%20I%20-%20Macroeconomic%20assessment%20of%20the%20costs%20of%20land%20degradation%20in%20India_0.pdf>

India is also vulnerable to extreme weather events like droughts. During 1996-2015, nearly 17.5 million people annually were simultaneously affected by droughts, respectively[33]. Several news media report that incidents of droughts and water shortages are increasing in India where millions of people get affected[34]. The deccan region of India in particular is vulnerable to extreme droughts. India Meteorological Department (IMD) observational network for the period 1901-2010 shows increasing trends in the frequency of dry days in most parts of the country during winter, pre-monsoon and southwest monsoon seasons[35].

Land is a vital resource for producing food, preserving forests and biodiversity, facilitating the natural management of water systems and acting as a carbon store. Therefore, appropriate land management is extremely important so as to protect and maximize these services for wellbeing of the society[36].

In the face of climate change and variability, the productivity and sustainability of a land-use system is determined by the interaction between land resources, climate and human activities. The IPCC Climate Change and Land report (2019) notes with high confidence that climate change exacerbates land degradation.

Challenges and Opportunities

Over-extraction of ground water for agricultural pumping is major cause of concern for land. There are over 30 million pumps in Indian agriculture. The majority of these are electric pumps. Agriculture consumes over 20% of all India's power generation and much of this comes from the demand from agricultural water pumping[37]. Electricity subsidies have reduced the cost of power for agricultural use. With very low power prices, farmers extract more water than required which adversely impacts groundwater resources. Last year, the budget announced an expansion of the existing KUSUM scheme. The KUSUM scheme[38] targeted installing 1.75 million stand-alone and one million on-grid solar pumps by 2022. While this may be good for decarbonizing the coal-dominated power supply system of the country[39], it adversely impacts the ground water situation. Overuse of irrigation pumps fueled by subsidized electricity have resulted in groundwater depletion in several states of north India, like Punjab and Haryana. Subsidized electricity has also incentivized switching to water intensive crops, adding to the over-use of ground water. More than 60% of irrigated agriculture and 85% of drinking water supplies are dependent on groundwater. An increasing number of aquifers are reaching unsustainable levels of

[33] UNESCO, (2019). World Water Assessment Programme, The United Nations World Water Development Report 2019: Leaving No One Behind [online], Available at: <https://unesdoc.unesco.org/ark:/48223/pf0000367306>
[34] https://www.bbc.com/news/world-asia-india-36089377, https://www.lowyinstitute.org/the-interpreter/india-s-latest-crisis-600-million-people-struggle-drought, https://www.business-standard.com/article/current-affairs/nearly-half-of-india-under-drought-40-population-severely-affected-119040300143_1.html
[35] UNFCCC India's 2nd BUR
[36] Parmpara MoEFCC Publication
[37] The Indian Express. (2014). Farmers pay 56 paise per unit of electricity. [online] Available at : <https://indianexpress.com/article/cities/ahmedabad/farmers-pay-56-paise-per-unit-of-electricity/>
[38] Economic Times. (2020). Government expands PM KUSUM scheme for solar pumps, targets to cover 20 lakh farmers. Available at : <https://economictimes.indiatimes.com/news/economy/agriculture/budget-2020-govt-expands-pm-kusum-scheme-for-solar-pumps-targets-to-cover-20-lakh-farmers/articleshow/73833089.cms?from=mdr>
[39] Central Ground Water Board

exploitation. If current trends continue, it is estimated in 20 years about 60% of all India's aquifers will be in a critical condition[40].

Monoculture of crops in drought prone areas is another factor contributes to ground water shortages by adversely affecting the cycle of ground water replenishment. Intensive farming practices, particularly with wheat, rice and high water-use crops like sugar cane, have facilitated soil degradation and droughts. For example, sugarcane requires 2,500mm of water annually and rainfall in Marathwada is between 500-700mm. Promotion of such water intensive crops in water scarce regions have adverse effects, causing a depletion of groundwater level[41].

Desertification and drought is also a social issue and a women's health issue. Women travel long distances to fetch water in part due to land degradation. Rural women farmers find themselves at the forefront of those impacted by land degradation. As per NSSO report, 80% financially independent women are engaged in farm-related activities in India. Out of them, 33% are working as agricultural laborers and 48% are self-employed farmers[42].

Local officials grappling with adaptation issues, have already started finding solutions to delayed monsoons due to climate change for security of crops in the regions. In Punjab, for instance, they initiated legal action which delayed the sowing season of paddy by five days, resulting in saving 24 million litres of water[43]. Earlier, the government had delayed sowing dates in 2008 and 2015 to June 10 and June 15 respectively. In 2019, it was further delayed to June 20. The five-day delay in paddy sowing reduced the time between paddy harvest and wheat sowing by 10 days. Not only has this helped in improving productivity by conserving water; it also showcased the adaptive capacity of the local system to respond to the delayed monsoon trend due to climate change.

Thus, there is a need to further investigate, land-water- climate change and agriculture in a holistic manner at other drought prone areas[44]. Sustainable land management for agriculture requires an interdisciplinary systems approach to see the impacts of these sectors across a wide ranging dimensions, including human, social, produced and natural capital, in the context of extreme weather events like droughts. The chapter on climate change in Volume 2 of the Economic Survey of India 2019 mentions that it is necessary to look at systems instead of individual components or short-term outcomes; look at the interrelated feedback from other sectors; and promote cooperation among sectors while reducing competition for scarce resources.

---

[40] The World Bank. (2012). India Groundwater: a valuable but Diminishing Resource. [online] Available at: <https://www.worldbank.org/en/news/feature/2012/03/06/india-groundwater-critical-diminishing>

[41] Torgalkar, V. Marathwada; growing cultivation of cash crop depleted groundwater. Available at <https://www.firstpost.com/india/sugarcane-emerges-as-likely-culprit-in-drought-hit-marathwada-growing-cultivation-of-cash-crop-depleted-groundwater-5572261.html>

[42] NSSO, India

[43] Chaba, A.A., (2019). Punjab: Extended monsoon, delayed paddy harvesting affects sowing of wheat. [online] Available at: https://indianexpress.com/article/india/punjab-extended-monsoon-delayed-paddy-harvesting-affects-sowing-of-wheat-6144165/

[44] Thambi, S. (2020). Implementing the Budget with a nexus approach. [online] Available at: <https://www.thethirdpole.net/hi/2020/02/14/implementing-the-budget-with-a-nexus-approach/>

Selecting right land uses for given biophysical and socio-economic conditions, and implementing SLM, is essential for minimizing land degradation, rehabilitating degraded land, ensuring the sustainable use of land resources (i.e. soils, water and biodiversity) and maximizing resilience[45].

There is need for more research for sustainable land management in drought prone areas in the context of climate change and climate smart agriculture. This should incorporate components of building climate resilience and vulnerability through adaption measures in the agriculture sector.

Opportunities for Impact

- National Mission for Sustainable Agriculture which comes under the Sustainable Agriculture Mission, one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC). NMSA aims at promoting sustainable agriculture through a series of adaptation measures.
- Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is an inter-ministerial scheme of MoJS, MORD and MoAFW. It helps extend the coverage of irrigation and improve water use efficiency with end-to-end solutions for source creation, distribution, management, field application and extension. Several states are leveraging PMKSY to address the scarcity in water available for Irrigation due to climate change resilience.

Scope for TEEB Application in SLM for agriculture in drought prone areas

Sample checklist

Value Chain	Agricultural Production	Manufacturing and processing	Distribution, marketing and retail	Household consumption
Outcomes (change in capital)				
Natural capital	Impact on groundwater and surface water quantity and quality		Impact of Industrial water use and pollution	
Produced capital				

[45] Thambi, S. (2020). Implementing the Budget with a nexus approach. [online] Available at: <https://www.thethirdpole.net/hi/2020/02/14/implementing-the-budget-with-a-nexus-approach/>

Human capital	In disability adjusted life years (DALYs), Health costs related to pesticide use, Moderation of extreme events			Food security
Social capital				
Flows				
Outputs				
Agricultural and food production	Yield/ hectare Crop rotation pattern	Value added in the agri product		
Income / operating surplus	Income			
Purchased inputs to production				
Labour	Wages			
Intermediate inputs (fuel, fertilizer, etc.)	Use of Fertilizers, fuel			
Provisioning	Water consumption by different crops			
Regulating	Watershed management, Freshwater saving, Nutrient cycling, Soil fertility enhancement, Pest control,			

	Groundwater recharge, Genetic diversity			
Cultural				
Residual flows				
Food waste				
Pollution and emissions (excess N & P, GHG emissions, etc.)	Water pollution from pesticides			

Legend

- Descriptive information available
- Quantitative information available
- Monetised information available
- Not included in study

Option 3: Strengthening agroforestry initiatives in India

Brief Context

Agroforestry is defined as land-use systems whereby a combinatory approach is utilized for the cultivation of woody perennials such as trees, shrubs, palm, bamboo etc. along with crops and/or animals within the same land management unit[46]. Agroforestry varies based on the spatial and temporal use of the land unit where practices adopted range from simple forms of shifting cultivation to complex intercropping systems[47]. Agroforestry systems can be classified into agrisilvicultural systems (combination of forestry and crops), silvipastoral systems (forestry and pastoral system) or agrosylvopastoral systems (combination of forestry, pastoral and cropping). Well-managed agroforestry systems have the potential to highly benefit farmers and rural communities, besides benefits from the production of food, fodder, timber and non-timber forest products (NTFPs), agroforestry techniques are widely accepted to aid in the long-term maintenance of soil health and productivity, improvement of water retention capacity, enhancement of soil organic carbon (SOC) storage, increasing carbon sequestration, while also diversifying the range of market products to increase farmers' income[48].

As per an assessment carried out by Central Agroforestry Research Institute (CAFRI) through 12 agro-climatic zones in India, a total area of 23.25 million hectares is under agroforestry in India, i.e. 8.69% of the total geographical area; the study also indicates that the maximum area under agroforestry is in the Upper Gangetic Plains and the West Coast Plains and Hill regions, while the agro-climatic zone with the least coverage is the Western Dry regions (CAFRI, 2019)[49]. Though agroforestry techniques have been integral to traditional farming systems throughout India, since the 1960s, driven by the need to meet food security requirements, agriculture in India has heavily relied on high-input chemical-based mono-cropping techniques to increase food production per unit area.

Globally, from 1998 to 2013, approximately 20 per cent of the Earth's vegetated land surface showed declining trends in productivity due to climate change and biodiversity loss[50]. It has also been estimated that agricultural production would need to increase by approximately 60% by the mid-century in order to meet food security requirements of the estimated world population of 9.3 billion persons[51]. As is the case globally, a significant portion of India's managed, and natural ecosystems are also degrading. With increasing demographic pressure and the demand for food, fodder and energy needs, degradation of natural resource bases and climate change, the adoption of sustainable land management practices in agricultural intensification and diversification assumes greater importance for ensuring long-term productivity and for reducing the pressure on forests in India. Furthermore, in the wake of the current

[46] Lundgren B. and Raintree J.B. (1982). Sustainable agroforestry. In: Agricultural Research for Development- Potential and Challenges in Asia (eds.) B Nestle. IS NAR
[47] Nair, P.K.R. (1993). An introduction to agroforestry. Kluwer Academic Publishers, Dordrecht, The Netherlands.
[48] Sanz, M.J. et al. (2017). Sustainable Land Management contribution to successful land-based climate change adaptation and mitigation. A report of the Science-Policy Interface. Bonn: United Nations Convention to Combat Desertification (UNCCD).
[49] ICAR-CAFRI, (2019). Agroforestry Annual Report 2018-19. Jhansi: ICAR-Central Agroforestry Research Institute.
[50] United Nations Convention to Combat Desertification (UNCCD), (2017). Global Land Outlook (1st Ed.). Bonn: United Nations Convention to Combat Desertification.
[51] United Nations Convention to Combat Desertification (UNCCD), (2017). Global Land Outlook (1st Ed.). Bonn: United Nations Convention to Combat Desertification.

COVID pandemic, a driver of large-scale reverse migration of millions of migrant labor to rural areas, agroforestry provides an avenue for livelihood diversification, employment and expanding the safety net against the vagaries of natural and man-made disasters.

Given the potential of agroforestry to diversify and sustain production and build social institutions, several policy initiatives in India have placed emphasis on agroforestry. These include National Forest Policy 1988, the National Agriculture Policy 2000, Planning Commission Task Force on Greening India 2001, National Bamboo Mission 2002, National Policy on Farmers 2007 and the Green India Mission in 2010[52]. In the year 2014, the Government of India adopted the National Agroforestry Policy (NAP), which seeks to address the bottlenecks impeding large scale implementation of agroforestry measures and became the world's first country to adopt a comprehensive agroforestry policy. The Policy recognizes challenges such as stringent legislative and regulatory measures with respect to tree felling, transportation and processing, the lack of institutional financing and insurance coverage and weak market infrastructure for agroforestry products as impediments for expansion of agroforestry practices in the country.

At the national level, agroforestry is housed in the Ministry of Agriculture and Farmer's Welfare, with a sub-mission on agroforestry (SMAF) launched in the year 2016-17, under the National Mission of Sustainable Agriculture (NMSA); the broad objectives are to expand tree plantation in farm lands, popularize agroforestry models and provide knowledge and capacity building support to the agroforestry sector[53]. The implementation of the agroforestry policy has been dovetailed with interconnections to several national level programmes including the Mahatma Gandhi Rural Employment Guarantee Programme (MGNREGA), Integrated Watershed Management Programme (IWMP), National Rural Livelihood Mission (NRLM), and the National Bamboo Mission (NBM) among others.

Challenges and Opportunities

Review of literature indicates that agroforestry meets almost half of the demand of fuelwood, 65 per cent of small timber demand, 70-80 per cent of wood for plywood, 60 per cent of raw material for paper pulp and 9-11 per cent of green fodder requirement for livestock, in addition to the regulating, supporting and cultural services[54]. Further, agroforestry being a labour intensive land-use system as compared to monocrop systems, it is estimated it can generate up to 943 million person-days in India while also contributing to increased income from agroforestry produce[55].

Studies carried out by CAFRI indicate that poplar-based agroforestry systems in the trans-Gangetic plains zone can increase farm profitability with an annual income of INR 3.64 lakhs per hectare as compared to a rice-wheat cropping system which yields a net annual income of INR 1.66 lakhs per hectare, thereby having the potential to double farmer's income within a period of 7 years[56]. The same study also suggests the potential tripling of a farmer's income if monetary value can be derived out of the carbon sequestered

[52] MoA, GoI. (2014). National Agroforestry Policy. New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture

[53] MoA&FW, GoI, (2019). Annual Report 2018-19. New Delhi: Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare

[54] NRCAF. (2013). Vision 2050. Jhansi: National Research Centre for Agroforestry.

55 Dev, I. et al., (2018). Role of Agroforestry in current scenario. Jhansi: ICAR-Central Agroforestry Research Institute.

[56] Singh, M. et al., (2018). Agroforestry for doubling farmers' income: a proven technology for trans-gangetic plains zone of India. Indian Farming 68(01): 33-34.

by the agroforestry systems. Another study of enhancing farmer's income through agroforestry reports a net annual return in the range of INR 1-1.5 lakh per hectare from bamboo based agroforestry systems[57], INR 89,000 from groundnut-casuarina based agroforestry systems and a 19% higher net annual return from soybean based agroforestry systems[58].

While studies that quantify and/or monetize the environmental benefits are few, the estimated potential of agroforestry to sequester carbon is highly varied ranging from 0.25 to 19.14 Tonnes C/(ha.yr)[59], with a moderate density agroforest estimated to sequester 5-6 Tonnes C/(ha.yr)[60]. Apart from quantitative estimates for carbon sequestration, review of literature reveals that few valuation studies have made an effort to capture the value of other environmental benefits from agroforestry. A study carried out on the impact of shelterbelt on the yield of crops indicates an increase in cotton yield in the range of 4-10% depending on the orientation of the tree belt in Haryana[61].

Although agroforestry provides a tremendous scope for moving the agriculture sector towards sustainability, there have been several challenges in its expansion. Prior to the adoption of the National Agroforestry Policy, due to the nature of agroforestry, neither classified fully into the agriculture or the forestry sector, there lacked an institutional setup at a national level for its promotion[62]. Consequently, it also did not attract the required attention of a dedicated and focused public policy and for the lack of feasible agroforestry models, financial institutions were also not able to lend support to its expansion. In addition, its growth and development is also influenced by various policies of the economy including credit, trade, taxation, power, transportation etc[63]. While this policy has been able to address several of the roadblocks for the expansion of agroforestry, review of literature reveals several challenges that continue to persist and include:

1) Insufficient research on agroforestry models suitable for the diverse ecological landscapes throughout the country, which has resulted in the over emphasis on few species for agroforestry[64].
2) Shortage of superior planting material and improved seed varieties[65].

[57] Kumar et al., (2015). The potential of bamboo cultivation as a way forward in improving livelihood: A case study. Allahabad: Sam Higginbottom Institute of Agriculture Technology and Sciences.
[58] Singh, V.S. and Pandey D.N., (2011). Multifunctional Agroforestry Systems in India: Science-Based Policy Options. Jaipur: Climate Change and CDM Cell, Rajasthan State Pollution Control Board
[59] Dhyani et al., (2016). Potential of agroforestry systems in carbon sequestration in India. Indian Journal of Agricultural Sciences 86(9):1103-12.
[60] Singh VP, Sinha RB, Nayak D, Neufeldt H, van Noordwijk M, Rizvi J. (2016). The national agroforestry policy of India: experiential learning in development and delivery phases. ICRAF Working Paper No. 240. New Delhi, World Agroforestry Centre. DOI: http://dx.doi.org/10.5716/WP16143.PDF
[61] Puri, S. et al. (1992). Effect of windbreak on the yield of cotton crop in semiarid regions of Haryana. Agroforestry Systems 18: 183-195, 1992. The Netherlands: Kluwer Academic Publishers.
[62] Singh VP et al. (2016). The national agroforestry policy of India: experiential learning in development and delivery phases. ICRAF Working Paper No. 240. New Delhi, World Agroforestry Centre.
[63] Dagar, J.C. et al. (2014). Agroforestry Systems in India: Livelihood Security and Ecosystem Services, Advances in Agroforestry 10, Springer India
[64] MoA, GoI. (2014). National Agroforestry Policy. New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture.
[65] MoA, GoI. (2014). National Agroforestry Policy. New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture.

3) Lack of research on the success of agroforestry systems at an ecosystem or landscape level as most research focuses on small plots of land[66].
4) Lack of marketing infrastructure for agroforestry produce in the country.
5) Limited agricultural extension services for the smooth dissemination of research results on the different aspects of agroforestry.
6) Impediments in permissions to import wood and wood products under an open general license (OGL) resulting in low prices of timber harvest, discouraging farmers from agroforestry[67].

Criticism to the expansion of agroforestry has been that because of the commercial interests in agroforestry, there is a potential for the conversion of agricultural land into manufacturing enterprises, thereby potentially leading to increase in negative impacts on the environment[68]. Further with increase in private sector involvement, questions have also arisen as to the provisions for benefit sharing between community/landowners and private players.

The scope for application of the TEEB evaluation framework for the assessment of agroforestry systems in India is wide-ranging with a host of different agroforestry systems under practice, and important as it forms an integral part of India's strategy to meet the objectives of mitigation of and adaptation to climate change and improving the livelihoods for farmers. Different combinations of agrisilviculture have been suggested by CAFRI throughout the agro-climatic zones of India and have been considered as an integral component of the NMSA strategy in moving toward sustainable agriculture in India. Some of agroforestry systems that have been recommended by the All India Coordinated Research Programme on Agroforestry (AICRP-AF) and CAFRI include the following tree species[69] –

- Morus-Grewia based systems for the Western Himalayas,
- Alder-based systems for the North-Eastern Hill region,
- Poplar-based systems for the Indo-Gangetic region, Aonla (Indian gooseberry),
- Khejri-based systems for semi-arid and arid regions
- Teak-based systems for tropical regions
- Acacia based systems for humid and sub-humid regions

Large cardamom and alder-based agrisilvicultural systems in the state of Sikkim, known to be the first organic state is India, provides an outstanding example of how agroforestry plays a vital role in employment generation among meeting other diverse needs with the share of gross income from large cardamom being next to that from cereals in the state.

Agroforestry is also recognized as an important component of India's strategy in achieving its India's Nationally Determined Contribution (NDCs) to the United Nations Framework Convention on Climate

[66] Sharma, P. et al. (2017). Agroforestry Systems: Opportunities and challenges in India. Journal of Pharmacognosy and Phytochemistry SPI: 953-957.
[67] Singh VP et al. (2016). The national agroforestry policy of India: experiential learning in development and delivery phases. ICRAF Working Paper No. 240. New Delhi, World Agroforestry Centre.
[68] Hindustan Times. (2018). India must re-evaluate its agroforestry policy. https://www.hindustantimes.com/editorials/india-must-re-evaluate-its-agroforestry-policy/story-BaBpWdZsM3vVsuMdkGq46K.html
[69] Dhyani et. al. (2016). Innovative agroforestry for livelihood security in India. World Agriculture. Available at: <http://www.world-agriculture.net/article/innovative-agroforestry-for-livelihood-security-in-india>

Change (UNFFCC) with the target of reduction of 33-35 per cent of emission intensity of its GDP by 2030 from 2005 levels, and further, in increasing forest cover to 33 per cent of its geographical area as envisaged in the National Forest Policy. Thus, there is a need to assess significant externalities of the agroforestry systems. Given that the nature of externalities can be both positive and negative, both agrisilvicultural and agrosylvopastoral systems need to be evaluated in order to avoid the promotion of interventions that do not achieve the intended targets or have hidden negative impact. Evaluation of externalities would reveal the true value of benefits in shifting to agroforestry systems.

A sampling of literature, with a sample size of 50, pertaining to the benefits of agroforestry in India indicates a high number of studies that quantify and monetize the economic benefits of agroforestry produce, however the number of **studies that quantify the value of the environmental benefits were few**. The sampling exercise was able to find 4 out of 50 literature works where the quantification of the environmental benefits of agroforestry have been accounted, with the majority consisting of valuation related to carbon sequestration benefits. Though the sampling does not ascertain the extent of evaluation of environmental benefits of agroforestry in India, it becomes apparent that there is a need for increasing assessment of the agroforestry systems in a comprehensive manner.

Scope for TEEB Application in Agroforestry

The TEEBAgriFood evaluation framework offers a platform through which a comprehensive evaluation of agroforestry systems under implementation (or intended for scaling up) can be assessed across the entire value chain, revealing the impacts and dependencies that occur in the eco-agri-food systems complex[70].

Sample checklist

Value Chain	Agricultural Production	Manufacturing and processing	Distribution, marketing and retail	Household consumption
Outcomes (change in capital)				
Natural capital	Groundwater and surface water, soil health, air quality, genetic diversity			
Produced capital	Agroforestry produce timber, NTFPs	Value added agroforestry products		Sales of direct agroforestry produce

[70] TEEB AgriFood. (2019). Project Summary: The Economics of Ecosystems and Biodiversity – Promoting a sustainable agriculture and food sector. [online] Available at <http://teebweb.org/agrifood/wp-content/uploads/2019/01/EUPI-TEEB-AgriFood_Extended-Project-Summary.pdf>

				and value added products
Human capital	Manpower, Farmer Training,	Manpower employed in manufacturing processes	Manpower employed in distribution, marketing of agroforestry goods	Food security
Social capital	Community knowledge of agroforestry practices			
Flows				
Outputs				
Agricultural and food production	Agroforestry yield			
Income / operating surplus	Income	Income for manufacturing	Income from sale of goods	
Purchased inputs to production				
Labour	Wages			
Intermediate inputs (fuel, fertilizer, etc.)			Costs of distribution and marketing	
Provisioning	Food and energy production, habitat provisioning			
Regulating	Soil fertility, flood protection, prevention of soil erosion, water purification, pest control, carbon			

	sequestration, windbreak			
Cultural	Tourism and recreation, spiritual inspiration, related festivals			
Residual flows				
Food waste				
Pollution and emissions (excess N & P, GHG emissions, etc.)	Water pollution, soil degradation and erosion, air pollution from residual burning, GHG emissions	GHG emissions, air pollution, water and land pollution from manufacturing	GHG emissions	

Descriptive information available	
Quantitative information available	
Monetized information available	
Not included in study	

At present, the TEEBAgrifood evaluation framework is actively being used in some project countries to test scenarios of moving towards sustainable agriculture and its impacts on yield and farmer livelihoods.

Opportunities for policy impact

- Agroforestry forms an integral part of India's strategy in achieving its India's Nationally Determined Contribution (NDCs) to the UNFFCC and further, in increasing forest cover to 33 per cent of its geographical area as envisaged in the National Forest Policy.
- India's leadership in adopting the National Agroforestry Policy and the promotion of expansion of agroforestry systems is laudable; a comprehensive evaluation of the benefits of implementing agroforestry systems along with externalities under the TEEBAgriFood evaluation framework would likely strengthen advocacy for scaling-up, where a truer value of benefits is reflected in shifting to agroforestry systems.
- The Nation Mission for a Green India or the commonly used 'Green India Mission' of MoEFCC, is one of eight missions outlined under India's National Action Plan on Climate Change (NAPCC). Launched in 2014, the mission is aimed at protecting, restoring and enhancing India's diminishing

forest cover and responding to climate change by increasing green cover across India by five million hectares (mha) and increasing the existing quality of tree cover in another 5 mha. Further it also aims at improving ecosystem services and increasing livelihoods.

- The Ministry of Agriculture and Farmers Welfare has a Sub-mission on Agroforestry (SMAF) under the National Mission for Sustainable Agriculture aims to encourage and expand tree coverage on arable land, ensure availability of quality planting material, popularize agroforestry models and create knowledge support in the area of agroforestry.
- The Mission for Integrated Development of Horticulture (MIDH) is an umbrella scheme consisting of the National Horticulture Mission, the Horticulture Mission for North-east and Himalayan States, Central Sector Schemes of the National Horticulture Board, the Coconut Development Board and the Central Institute of Horticulture with an aim to promote the holistic growth of the horticulture sector. Agroforestry initiatives is integral for the success of the mission.

Option 4: Moving towards a sustainable rice agronomy

Brief Context

The global area under rice cultivation is nearly 157 million hectares, of which 44.1 million hectares are in India[71]. Rice accounts for 23.3% of gross cropped area, 43% of total food grain production, and 46% of the cereal production in the country[72]. India is the second largest producer of rice, accounting 23.5% of the global production; it is also the largest exporter of rice in the world, accounting for 26.4% of the global exports[73].

The Indo-Gangetic Plains (IGP) is a primary area for the rice-wheat cropping system, spanning an area of 13.5 million hectares, of which 10.3 million hectares are in India[74]; the cropping system provides food for more than a billion people. Situated in the IGP, the north-western states of Punjab and Haryana is a vital region for the food security of India, contributing to approximately 84% of the wheat and 54% of the rice output in the country[75].

While the methods of promoting high yielding varieties (HYVs) and providing input subsidies through the Green Revolution was able to achieve high productivity, thereby tripling the production of cereals over the last five decades, in recent decades, yields of rice and wheat have plateaued or have started to decline. In the 1980s, rice production and productivity increased at an annual compound growth rate of 3.62 per cent and 3.19 per cent respectively, however in the 1990s, it decreased to 1.61 per cent and 1.3 per cent respectively[76]. This indicates that meeting the nutrition demands of a growing population has been at the cost of the environment; multiple studies reveal the growing concerns over groundwater depletion, deteriorating soil fertility, increase in salinity, declining input-use efficiency and increasing cultivation costs and serious implications on human health.

With concerns over soil fertility and productivity and low input-use efficiency, the National Food Security Mission (NFSM) was launched in 2007-2008. This mission aims to increase the production of rice, wheat and pulses through area and productivity enhancement, restoring soil fertility and productivity and creating employment opportunities[77]. The strategy is to extend improved technologies including distribution of HYV seeds, micro-nutrients/soil ameliorants, integrated nutrient and pest management,

---

[71] FAOSTAT, 2018.
[72] Vyankatrao, N.P. (2017). Impact of climate change on agricultural production in India: effect on rice productivity. Bioscience Discovery 8(4): 897-914.
[73] MoAFW, GoI. Commodity Profile for Rice, March-2019. Available at <http://agricoop.nic.in/sites/default/files/Rice%20profile_March%2C%202019.pdf>
[74] Kumar et al., (2018). Can productivity and profitability be enhanced in intensively managed cereal systems while reducing the environmental footprint of production? Assessing sustainable intensification options in the breadbasket of India. Agriculture, Ecosystems and Environment 252 (2018), pp 132-147.
75 Chauhan BS, Mahajan G, Sardana V, Timsina J, Jat ML. 2012. Productivity and sustainability of the rice-wheat cropping system in the Indo-Gangetic Plains of the Indian subcontinent: problems, opportunities, and strategies. Adv Agron. 117: 315-369.
76 Chauhan BS et al. 2012. Productivity and sustainability of the rice-wheat cropping system in the Indo-Gangetic Plains of the Indian subcontinent: problems, opportunities, and strategies. Adv Agron. 117: 315-369.
[77] MoA&FW, GoI, (2019). Annual Report 2018-19. New Delhi: Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare

improved resource management tools, efficient water application technologies and engage in capacity building activities of farmers.

There are a range of approaches to sustainable rice production that could be included in a TEEB AgriFood study, depending on the context. This TEEB study could assess different agronomic management practices for enhancing rice productivity as well as soil fertility[78], the study could include: weed management, crop rotation; conservation agriculture; integrated nutrient management among others.

It is important to assess the implications of externalities of the conventional rice cultivation systems in India as compared with a shift to sustainable practices such as that of conservation agriculture and/or integrated crop and resource management practices. Cconservation agriculture (CA) include practices such as zero-tillage, dry direct seeding of rice, retention of crop-residue as mulch, precision irrigation and crop diversification. Though there are several improved management practices that have been developed to confront issues of the rice-wheat system in the northwestern region of India, Kumar et al. (2018) highlight that a holistic systems approach with medium and long-term studies are required to evaluate the benefits and trade-offs associated with the adoption of the CA-based management practices[79];

Challenges and Opportunities

Declining yields of rice and wheat in the northwestern Indo Gangetic Plateau (IGP) is a concern in meeting food security requirements for a growing Indian population. It is estimated that to meet a projected Indian population of 1.8 billion by the mid-century, India would need to double its current cereal production, in addition to meeting the requirements for livestock and poultry[80]. Land availability for expansion of agriculture in meeting food security requirements also poses a problem with areas for non-agricultural use rapid increasing and further need of public policy support to reclaim currently uncultivable lands.

Over-extraction of groundwater to meet the high demand of water resources used by the rice-wheat system has resulted in both the depletion of quantity of groundwater resources and the quality of the groundwater. While rice cultivation has high irrigation water requirement, this is further aggravated by the rice-wheat cropping system which has been practiced over five decades in the northwestern IGP region with porous soils not ideal for rice cultivation. Studies indicate that the rate of depletion of the groundwater in Indian Punjab during the 1993-2003 decade was 0.55 m/yr[1] with 101 out of 143 blocks of the state being declared as dark zones[81]. The lowering of groundwater tables is expected to increase the

[78] Mahender Kumar, Tuti, Sreedevi, Surekha, & Babu, (2016). Towards Improving Productivity and Sustaining Soil Health. SATSA Mukhapatra – Annual Technical Issue. 20. 15-25

[79] Kumar et al., (2018). Can productivity and profitability be enhanced in intensively managed cereal systems while reducing the environmental footprint of production? Assessing sustainable intensification options in the breadbasket of India. Agriculture, Ecosystems and Environment 252 (2018), pp 132-147.

[80] Swaminathan, M.S., Bhavani, R.V., 2013. Food production & availability: essential prerequisites for sustainable food security. Indian J. Med. Res. 138, 383–391.

[81] Chauhan BS et al. 2012. Productivity and sustainability of the rice-wheat cropping system in the Indo-Gangetic Plains of the Indian subcontinent: problems, opportunities, and strategies. Adv Agron. 117: 315-369.

energy requirement for pumping of groundwater, increase costs for tube-well infrastructure and degrade groundwater quality.

High intensity rice production has resulted in salinization, water-logging, heavy-metal and pesticide contamination, loss of soil biodiversity, soil erosion, culminating in the loss of soil fertility and productivity. Studies indicate both macro and microelement deficiencies in the soil, however especially that of sulfur and zinc due to intensive rice cultivation; a study indicates that 25 per cent of all soil samples taken from a study area in the northwest IGP region resulted in sulfur deficiency, while over 55% of soils tested in northern India from 90,000 soil samples were found to be zinc deficient[82]. The reduction of soil fertility is directly coupled to the over-application of fertilizers, also leading to leaching and eventual water pollution.

High content of silica in rice residue lengthen the process of decomposition and therefore farmers in northern India have resorted to the method of crop-residue burning for its disposal; the practice leads to a loss of organic matter content and nutrient replenishment of the soil. Further this has adverse effects for the ambient air quality standards within the region.

The challenges of moving towards more sustainable models of rice cultivation also lies in the size of the number of small and farmers in the country. Over 78% of farmers are small and marginal who have less access to resources that increase efficiency and productivity[83].

The Intergovernmental Panel on Climate Change (IPCC) has projected a rise in temperature in the range of 0.88°C -3.16 °C by 2050[84]. Studies predict a decline in rice productivity by 0.75 tonnes per hectare with a 2°C rise in temperature[85]. Further, it is also predicted that the frequency of heat wave due to extreme weather could limit crop yields. Wetland rice is also a key source of GHG emissions where irrigated rice contributes to 60% of the methane emissions from all rice systems in South and Southeast Asia, whereas rainfed and deep-water rice contribute to 24% of the methane emissions; studies indicate that the rice-wheat cropping sequence as carried out in the northwestern IGP region however restricts the generation of methane[86]. Mitigation and adaptation strategies for both the farm and farmer need to be further strengthened, increasing resilience to climate variability and change.

Scope for TEEB Application in sustainable rice agronomy

The TEEB AgriFood framework offers a platform, whereby the assessment of rice cultivation can be made between different systems of rice cultivation, a policy scenario evaluation or a trade-off analysis between

[82] Shukla, A. K., and Behera, S. K. (2011). Zinc management in Indian agriculture: Past, present and future. Indian J. Fert. 7, 14-33.

[83] http://drdpat.bih.nic.in/Status%20Paper%20-%2009.htm

[84] IPCC. (2007). Summary for policymakers. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson (Eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 7e22). Cambridge: Cambridge University Press.

[85] Wassmann, R. et al. (2009). Regional vulnerability of climate change impact on Asian rice production and scope for adaptation. Adv. Agron. 102, 91e133.

[86] Jain, M. C. et al. (2000). Methane emissions from irrigated rice fields in northern India (New Delhi). Nutr. Cycl. Agroecosyst. 58, 75-83.

a specific environmental impact or ecosystem service and a management practice. An example is provided as under:

Sample Checklist

Value Chain	Agricultural Production	Manufacturing and processing	Distribution, marketing and retail	Household consumption
Outcomes (change in capital)				
Natural capital	Groundwater, surface water, soil health, air quality			
Produced capital		Rice husk briquettes		Energy for cooking and heating
Human capital	In disability adjusted life years (DALYs), Health costs related to pesticide and fertilizer use, Moderation of extreme events			Food security
Social capital				
Flows				
Outputs				
Agricultural and food production	Grain yield			
Income / operating surplus	Income			
Purchased inputs to production				
Labour	Wages			

Intermediate inputs (fuel, fertilizer, etc.)	Cost of Urea, NPKS, diesel, farm equipment			
Provisioning	Grain yield, production of energy from rice husk, habitat provision			
Regulating	Soil fertility enhancement, nutrient recycling, pest control, groundwater recharge, genetic diversity, freshwater saving and watershed management			
Cultural	Traditional Rituals and related festivals Spiritual inspiration, tourism			Access to consumption of traditional rice varieties
Residual flows				
Food waste				
Pollution and emissions (excess N & P, GHG emissions, etc.)	Water pollution from fertilizers and pesticides, air pollution from residual burning, GHG emissions			

Descriptive information available	
Quantitative information available	
Monetized information available	
Not included in study	

Opportunities for impact

- National Food Security Mission (NFSM) was launched in 2007-08 to increase the production of rice, wheat and pulses through area expansion and productivity enhancement; restoring soil fertility and productivity; creating employment opportunities; and enhancing farm level economy[87]. The basic strategy of the Mission is to promote and extend improved technologies of package of practices of crops through various types of demonstrations.
- National Policy for Farmers 2007 aims to improve economic viability of farming and increase net income of farmers[88].
- National Mission for Sustainable Agriculture (NMSA) is one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC) and aims at promoting sustainable agriculture by devising appropriate adaptation strategies/ dimensions.
- Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is an inter-ministerial scheme of MoJS, MoRD and MoAFW. It helps extend the coverage of irrigation and improve water use efficiency with end-to-end solutions for source creation, distribution, management, field application and extension.
- Rashtriya Krishi Vikas Yojana (RKVY) was launched as a flagship scheme of the Ministry of Agriculture, Cooperation & Farmers Welfare in 2007-2008 to incentivize States to draw up comprehensive agriculture development plans, taking into account agro-climatic conditions, natural resources and technology for ensuring more inclusive and integrated development of agriculture and allied sectors.

[87] MoA&FW, GoI, (2019). Annual Report 2018-19. New Delhi: Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare

[88] https://pib.gov.in/newsite/PrintRelease.aspx?relid=117468

ANNEX 1

States practicing ZBNF[89]

1. **Karnataka** – has initiated implementation of ZBNF on pilot basis in an area of 2000 ha in each of the 10 Agro Climatic Zones of the State through the respective State Agriculture/ horticulture Universities as demonstrations/scientific experimental trials in farmer's fields and in the research stations of the concerned universities.
2. **Himachal Pradesh** - is implementing State funded scheme 'Prakritik Kheti Khushal Kisan' since May, 2018, the details of which are as:
   2018-19- 2669 farmers, Area: 357 ha.
   2019-20- 19936 Farmers, Area: 1155 ha.
   The findings of studies conducted by the state indicated that ZBNF practice showed an improvement in soil quality within a single cropping season and incidence of Invasive leaf miner was significantly less in ZBNF system as compared to the organic farming and conventional farming.
3. **Kerala** – only awareness programmes, trainings and workshops to draw interest of farmers towards ZBNF has been imparted.
4. **Andhra Pradesh:** During the last three years, the program has been able to reach to 163,000 farmers in 972 villages until 2017-18, through program support funding from Government of India schemes – Rashtriya Krishi Vikas Yojana (RKVY) and Paramparagat Krishi Vikas Yojana (PKVY) towards program support. The program is receiving a Technical Support Grant from Azim Premji Philanthropic Initiatives (APPI). As on date, the program is present in all 662 mandals of the state, 3015 villages, working with 354,000 farm families. 500,000 farm families will be reached during this year, 2018-19 with 7,500 CRPs and 85,000 women SHGs[90].

[89] PIB. (2019). Zero Budget Natural Farming, Available at: <https://pib.gov.in/PressReleseDetailm.aspx?PRID=1593123, 22 Nov 2019 5:07pm>
[90]Government of Andhra Pradesh. (2020). Zero Budget Natural Farming: a transformative program. [pdf] Available at: http://apzbnf.in/wp-content/uploads/2018/10/20th-sept-zbnf-concept-note-2.pdf

ANNEX 2

In general, all the four options listed in the paper will contribute to meeting international commitments and frameworks of UNCCD, UNFCCC and UNCBD. Specifically,

- Commitments under UNFCCC: Prime Minister made an announcement to raise the country's ambition for land restoration from 21 million ha to 26 million ha between now and 2030[91]. This will involve restoring land productivity and ecosystem services to degraded agricultural, forest and other wetlands through a landscape restoration approach. Also, at the CoP, the Prime Minister announced India's intention to set up a global technical support institute for member countries of the UNCCD for capacity building and support in order to help countries achieve the goal of Land Degradation Neutrality (LDN), to further develop a scientific approach and to facilitate the use of technology to address land degradation issues.
  The 2018–2030 Strategic Framework of UNCCD sets five strategic objectives that are meant to guide the actions of all UNCCD stakeholders and partners in the period 2018–2030. Strategic objective 3 highlights, (a) to mitigate, adapt to, and manage the effects of drought in order to enhance resilience of vulnerable populations and ecosystems. The project study will directly contribute to this work. India also supported the decision 1/COP 13 regarding mainstreaming gender-responsiveness into drought initiative. India also supported the introduction of drought as a new strategic objective in the UNCCD 2018−2030 Strategic Framework to be implemented through national action programme.
- Commitments under UNFCC: Among the India's UNFCCC commitments most relevant to the present project are: i) the Nationally Determined Contribution (NDC) under the UNFCCC's Paris Agreement to sequester 2.5 to 3 billion tons CO2eq by 2030 through improved forest and tree cover; ii) Bonn Challenge to restore 21 Mha of degraded and deforested lands (iii) achieve land degradation neutrality.
- Commitments under UNCBD: India as party to the UNCBD has mapped its national biodiversity targets to the Aichi Biodiversity target. India released its action plan for implementation of India's National Biodiversity Action in 2019[92]. National Biodiversity Target number 2 aims at integration of values of biodiversity in national and state planning processes and poverty alleviation programmes. It is relevant to all other NBTs. The project study once commissioned will directly feed into realizing this target.

[91] PIB, (2019). India will restore 26 million hectares of degraded land by 2030: Prime Minister Shr. Narendra Modi. [online] Available at: https://pib.gov.in/PressReleseDetailm.aspx?PRID=1584542

[92] MoEFCC, (2019). India's National Biodiversity Action Plan: An Overview 2019. [pdf] Available at: <https://www.cbd.int/doc/world/in/in-nbsap-other-en.pdf>