Potential role of Agroforestry in Food Systems Transformation

The Economics of Ecosystem and Biodiversity (TEEB) for Agriculture and Food Initiative,

Uttar Pradesh, India

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TEEB AgriFood Asia, Africa, Europe Regional Symposium

22 June 2022, 12.30 (IST)

भाकृअनुप ICAR

UNEP

TEEB

Valuing the Invisible

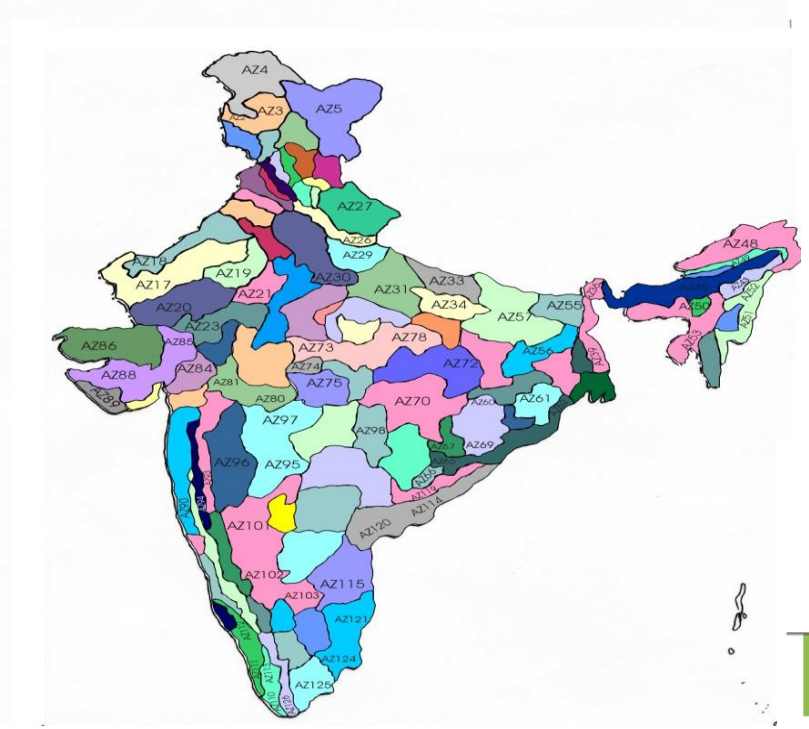
ICAR-Indian Institute of Farming Systems Research

1952 : Simple Fertilizer trial
1964 : AICARP
1989 : PDCSR (AICRP on CS)
2004 : PDCSR (AICRP on CS and NPOF)
2010 : PDFSR (AICRP on IFS and NPOF)
2014 : IIFSR (AICRP on IFS and NPOF)

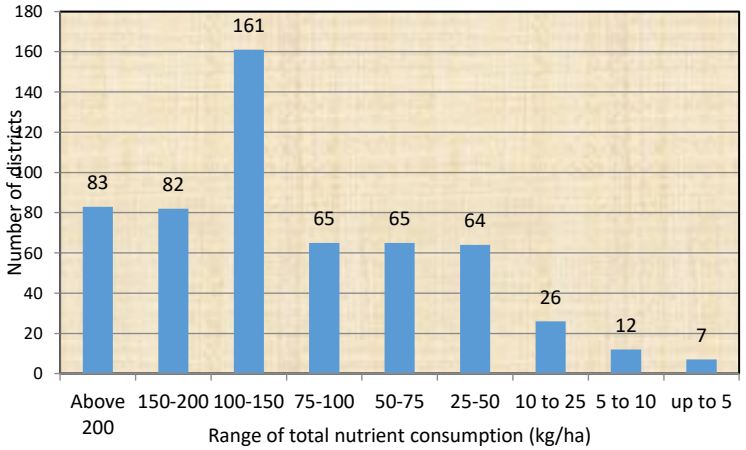
Research Themes

- Integrated Farming Systems (includes AF systems)
- Cropping Systems and Resource Management
- Organic Agriculture Systems
- Natural Farming

Indian Agriculture: Over view



*Area under the system/practice (million ha)
*Scale of adoption (number of farmers in millions)
**Geographical spread (number of states)



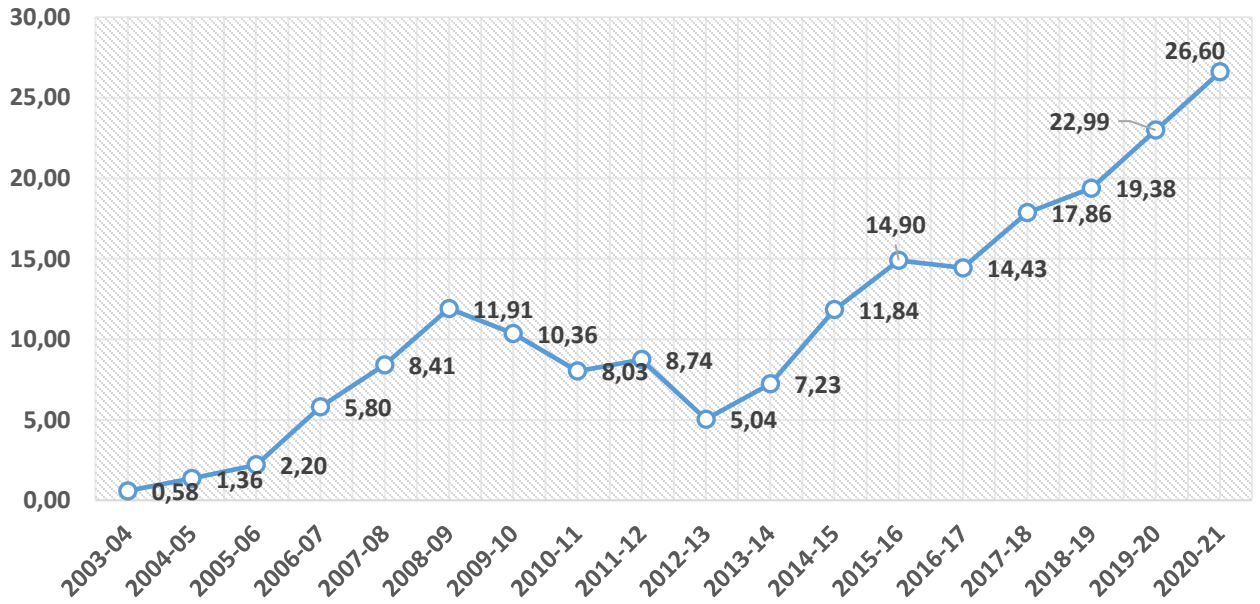
239 districts consume <100 kg/ha of nutrients

Parameter	Position	Significance
Geographical area	328.7 m ha	2.4 % of world land
Total Population (2021)	1.392 billion	17.5 % of world population
Net Area Sown (2016-17)	139.42 m ha	70.77 m ha (50.8 %) under rainfed
Gross cropped area (2016-17)	200.20 m ha	143.6 % cropping intensity
Agri. contribution to total GVA (2019-20)	18.4 %	58 % population depends on agriculture
Rainfall	125 cm	Mainly during July-September
Agro-climatic zones	15	Micro level: 131 NARP zones
Agro-ecological zones	20	8 zones have <150 days of LGP
Food grain production in 2021-22 (Second advance estimate)	316.06 mt	Requirement in 2050 is 405 mt for 1.7 billion (Panjab Singh, 2019)

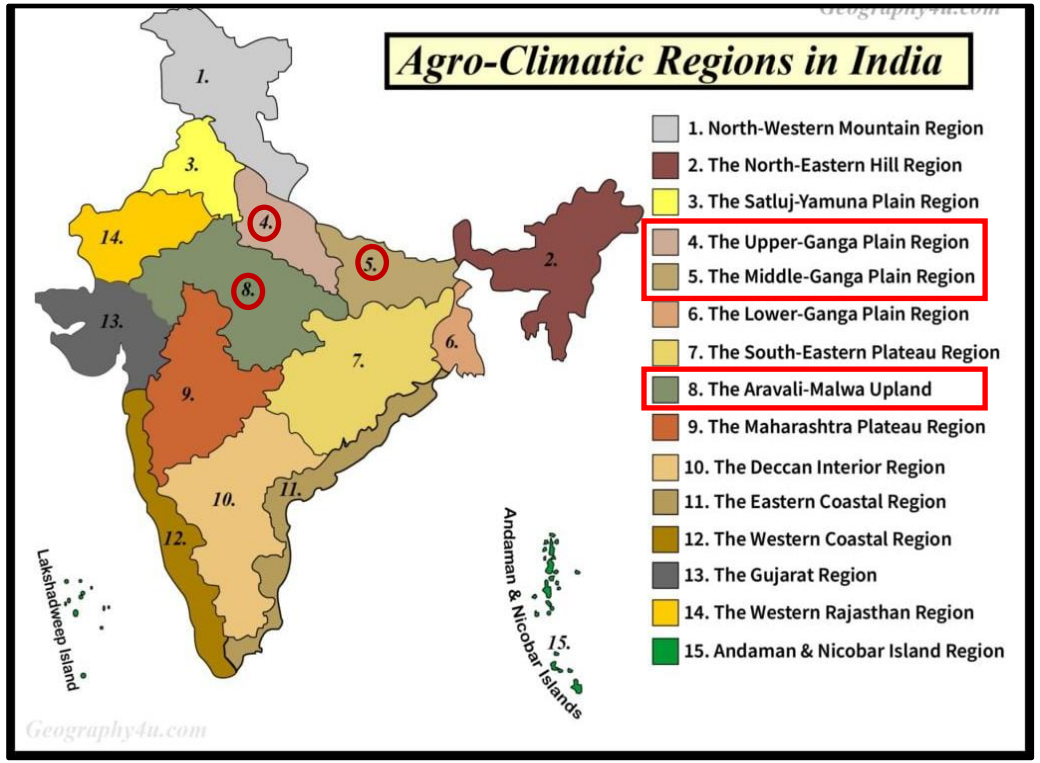
Chemical Free Farming (Organic Farming) in India: Overview

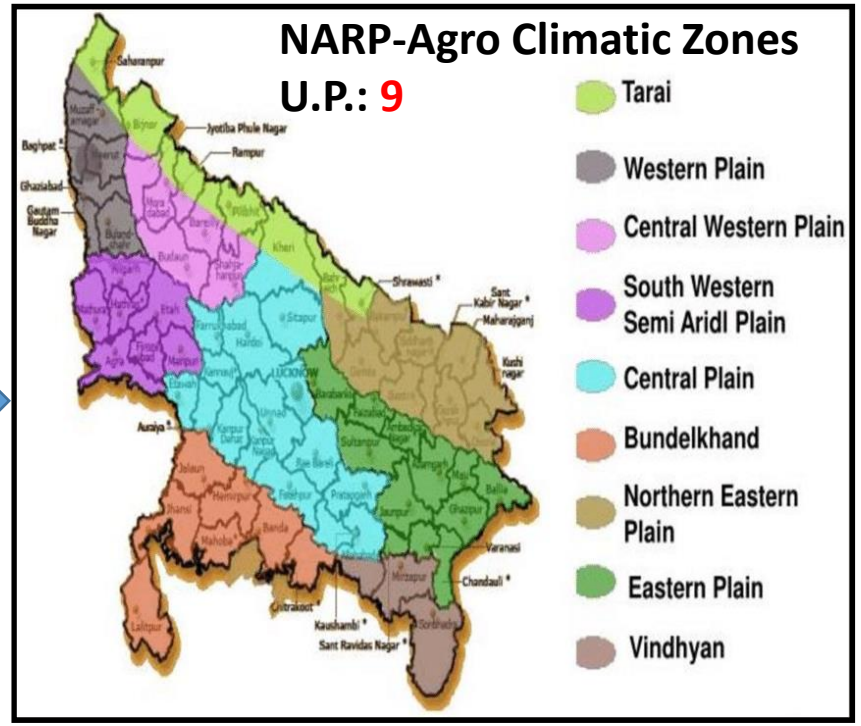
- 2.66 m ha under third party certification + in –conversion
- 0.73 m ha under PGS certification
- 4.7 % of global area under organic farming
- 2.4 % of net cultivated area in India
- 10 % of net cultivated area by March 2030

Cultivated area under organic farming (certified + in-conversion, lakh ha)



- 45 fold increase from 2003-04
- Last 6 years Annual growth rate: 22 %
- Export: 1041 million USD
- NPOP
- PKVY
- MOVCD-NER
- MODI-Ladakh
- JKPY
- LAC
- ICAR-AI-NPOF for technology backstopping





Geographical coordinates of state

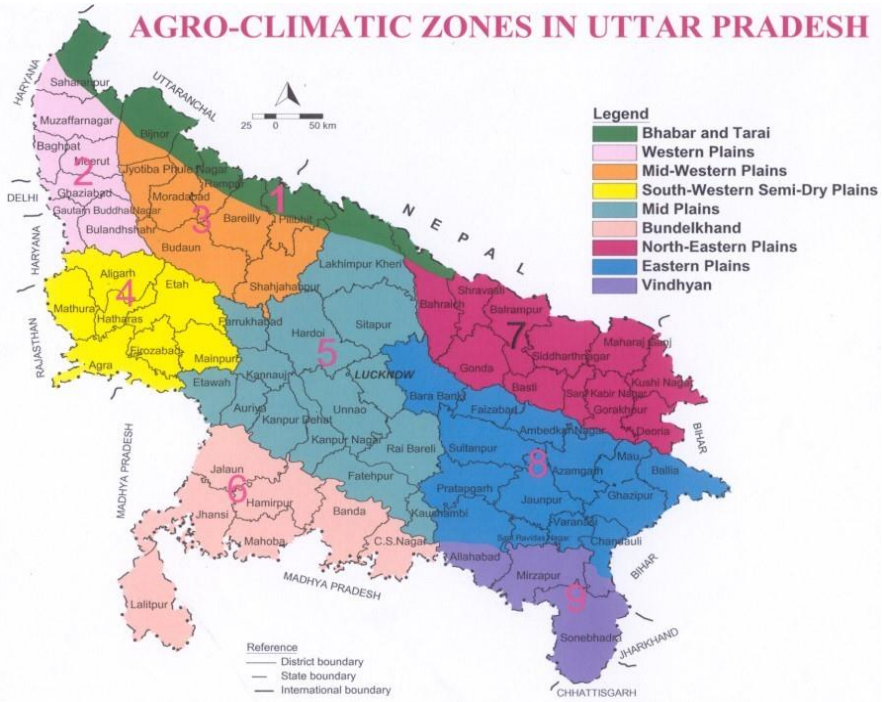
Latitudes	23°52 to 31°28'N
Longitudes	77°3' to 84°39'E
Altitudes	300 meters (NW) 6o meters (E)

Special features of state

Population	199.8 million (16 %)
Male	104.5 million
Female	95.3 million
Agro climatic zones	3 (Planning Commission), 9 (NARP)
Total geographical area (m ha)	29.44 (9 %)
Total cultivated area (m ha)	24.17
Net cultivated area (m ha)	16.57 (12 %)
Forest area (m ha)	1.65

Significance of Uttar Pradesh in India

- **16.17 % of India's population**
- **5th in geographical area with 7.3 % of India's land area**
- **Flat, fertile plain with elevations ranging from 60 to 300 m**
- **Subtropical climate**
- **Himalayas**, the **Gangetic plain**, and the **Vindhyan hills and plateau**.



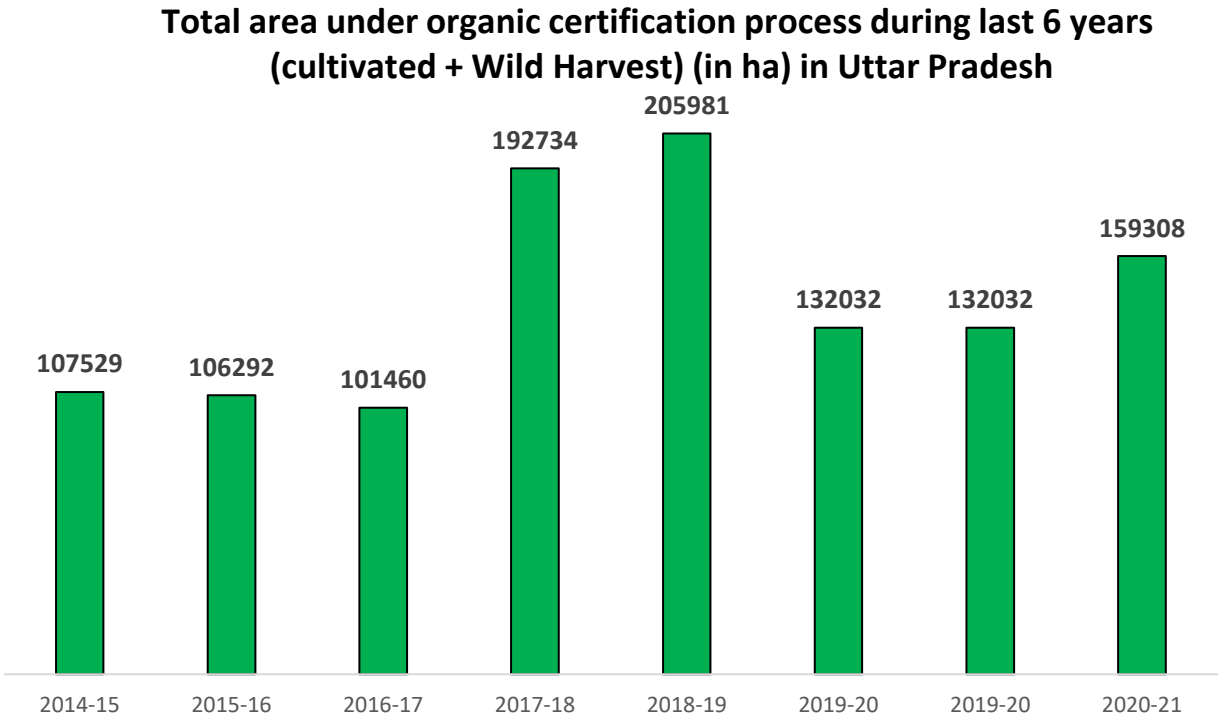
Reporting Area for LUS (ha)	Classification of Reporting Area (ha)		Net Sown Area (ha)	Cropping intensity	Irrigated Area	Source-wise
	Forests	Barren and Un-culturable Land				
241,70,454	17,14,612	4,41,811	165,37,678 (68 %)	162 %	53 %	Canal (15 %), Tank (<1 %), **Well (83 %)** Other sources (<1 %)

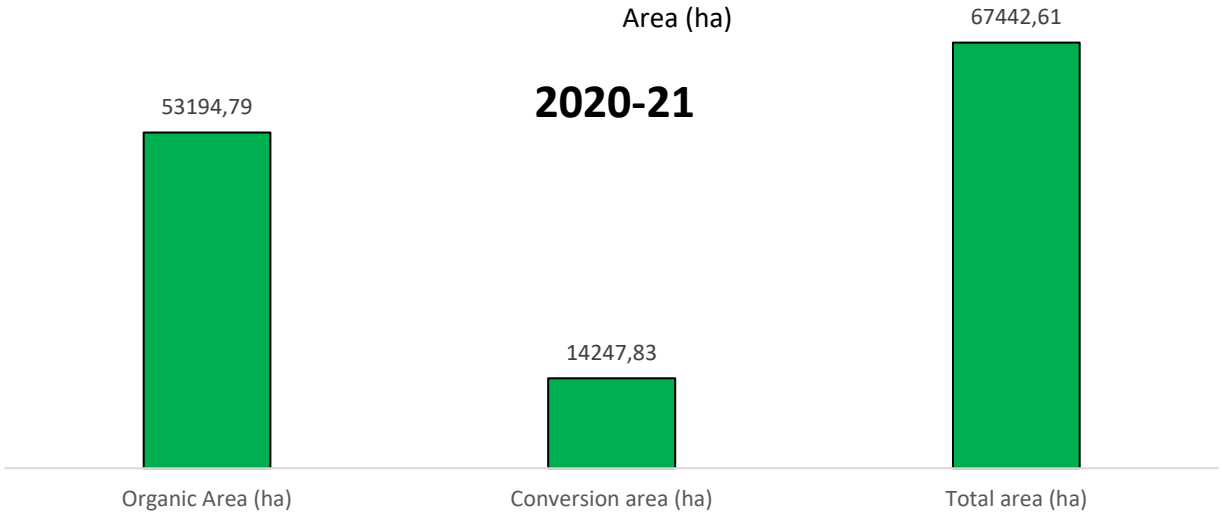
Cultivated area under Organic Farming (2020-21): 67,442 ha (0.40 % of NSA), Export value: 40.96 million USD

Importance of the state for India in food and agriculture

Particulars	Area (m ha)	Share (% of All India)	Production (m t)	Share (% of All India)	Productivity (t/ha)	
					Uttar Pradesh	India
Rice	5.81	13.28	13.27	11.75	2.28	2.58
Wheat	9.75	32.98	31.88	31.98	3.27	3.37
Nutricereals	1.99	8.23	3.89	8.29	1.95	1.94
Maize	0.75	7.87	1.48	5.14	1.98	3.03
Total food grain	19.83	15.54	51.25	17.99	2.58	2.23
Total pulses	2.27	7.56	2.21	8.75	0.97	0.84
Oilseeds	1.09	4.41	1.15	3.66	1.05	1.27
Sugarcane	2.23	47.21	177.01	46.98	79.3	79.6

Significance of Organic Farming in Uttar Pradesh





Export (organic produce) 12141.77 tonnes

Export value: (40.96 million US$)

TEEB Study

Objectives

- Impact of organic farming on ecosystem services, produced capital as well as livelihoods and health
- Policy, institutional and governance solutions
- Spatial planning of agricultural production to maximize ecosystem services
- Economic case for scaling up organic farming and agroforestry
- Sustainable food production policy intervention, such as policies related to pollution, pesticide and fertiliser use, sustainable value chains, market linkages and certifications.

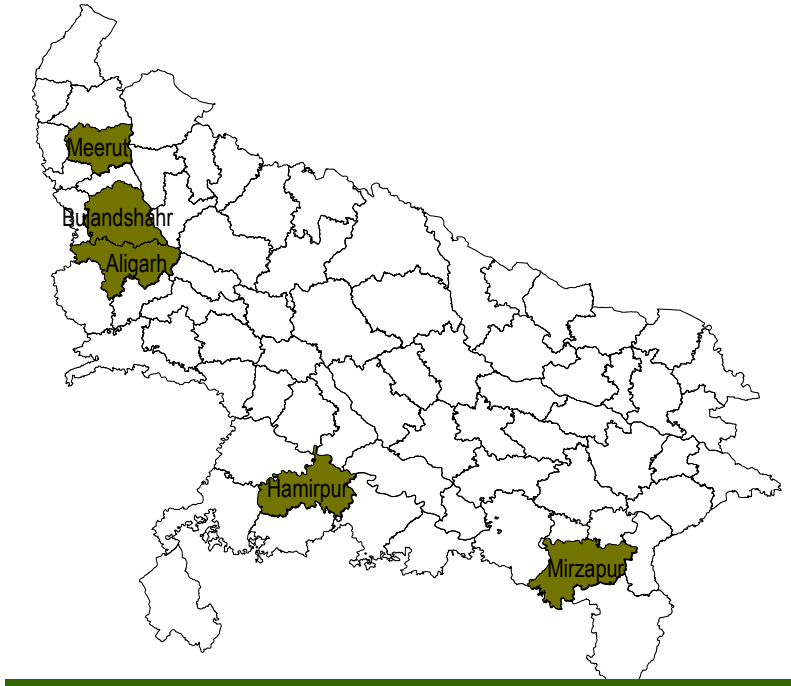
- Organic Farming (PKVY & Namami Ganga)
- Agroforestry (Har Med par Ped= Trees on every bund; NAP)

Tools: InVest, CROPWAT, GIS

Natural capital stocks, Ecosystem Service Flows, Agriculture outputs & inputs, residuals and Quantitative human and social outcomes and impacts

- Spatial and Time dimension
- Participatory scenario development

Scenario: BaU, Optimistic & Pessimistic

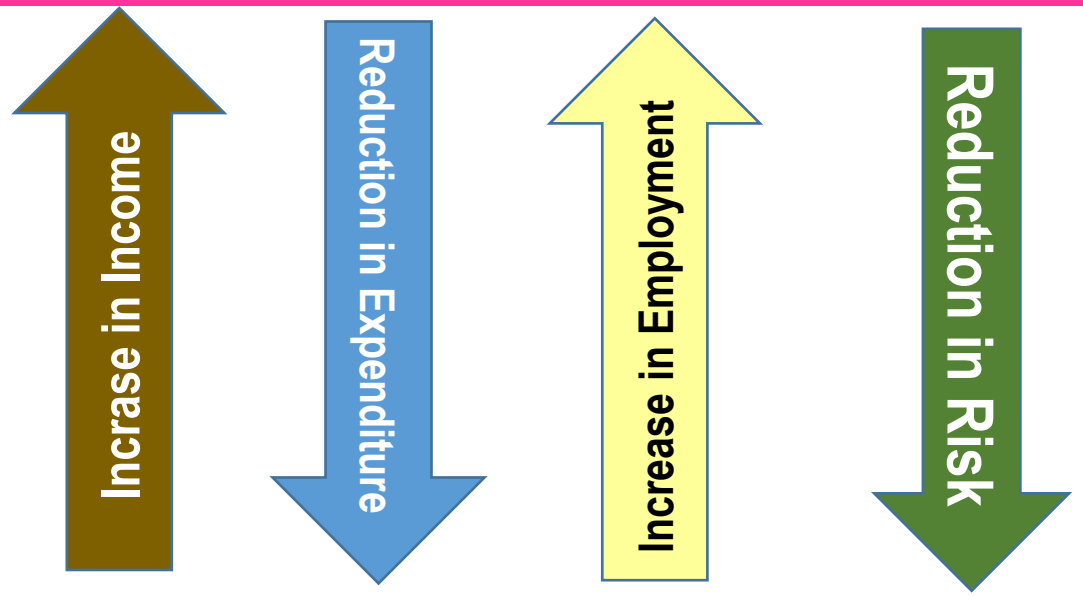


Organic Farming (No. of HH covered by GoI)

Districts	PKVY	Namami Gange
Meerut	169	1094
Bulandsahar	1400	1574
Aligarh	2945	631
Hamirpur	1238	0
Mirzapur	2662	4863
Total	8414	8162

Sustainable Food Systems Assessment

How to achieve Sustainable Food System?



Possible through Integrated Production Systems involving Agroforestry

Sustainability Assessment

- Ecological Security
- Economic Efficiency
- Social Equity

Sustainable Livelihood Security

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LDD Land Degradation & Development

RESEARCH ARTICLE

Sustainable livelihood security of small farmers improved through resilient farming systems in the Semi-Arid Region of India

Natesan Ravisankar, Meraj A. Ansari, Mohammad Shamim, Ashisa K. Prusty, Raghuveer Singh, Azad S. Panwar, Debashis Dutta, Suryanarayana Bhaskar, Jayasree S. Bindhu ... See all authors

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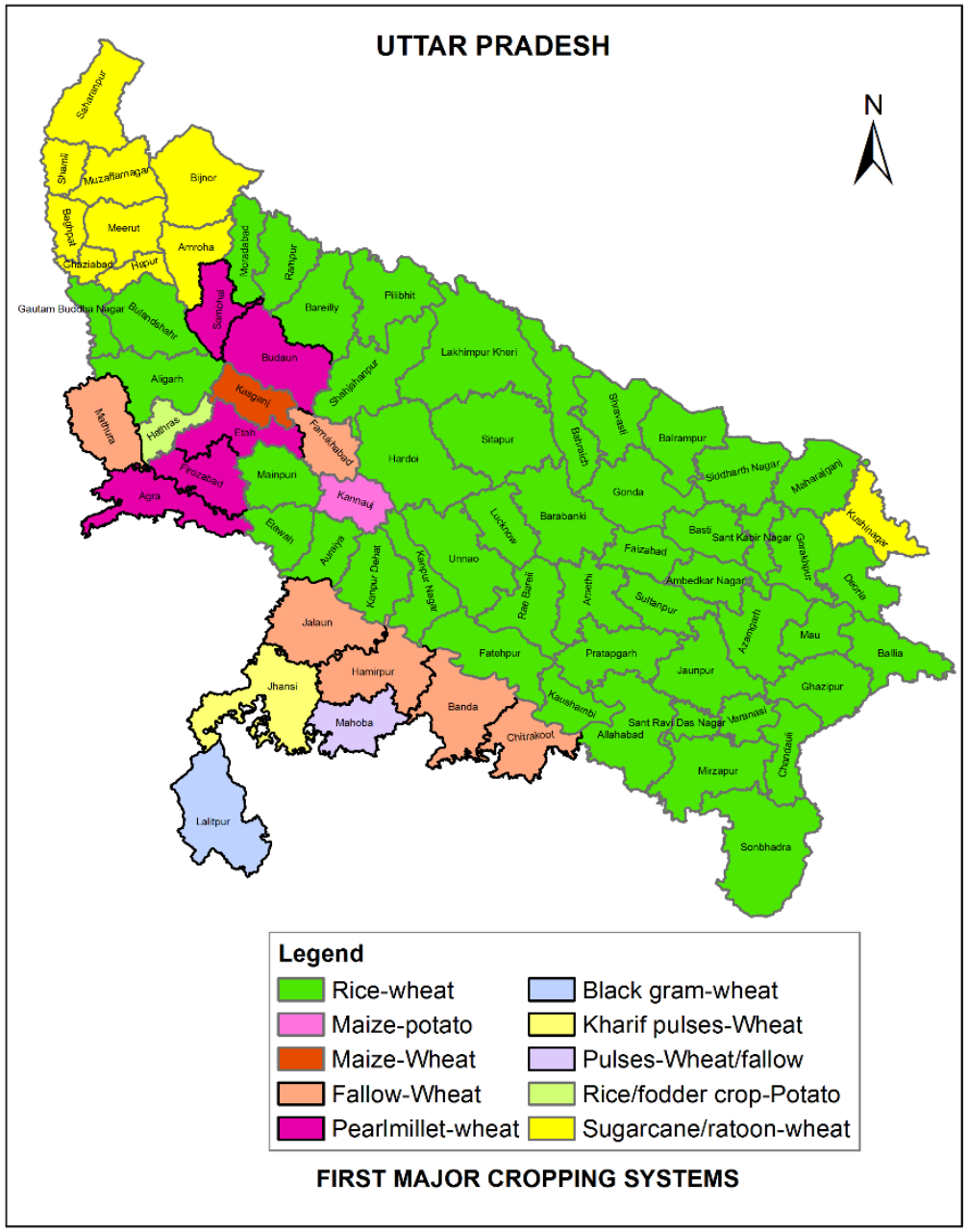
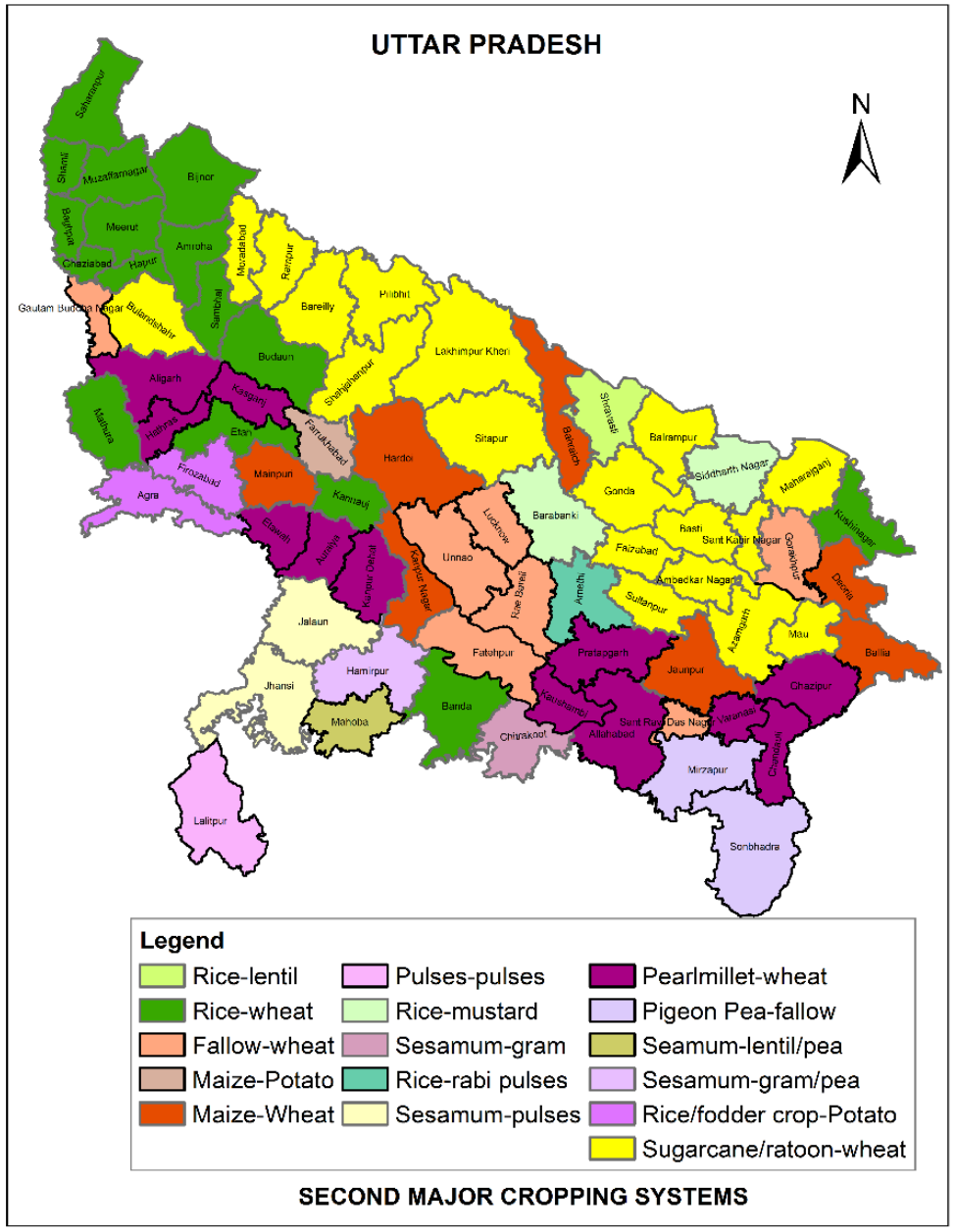
Abstract

Improving the farming systems to attain the household level self-sufficiency, land utilization efficiency and sustainable livelihood security depends on the better socio-economic and ecological aspects of the systems practiced by the small farmers in the semi-arid regions. The higher sustainable livelihood security index (SLSI) in integrated crops-livestock system helps to restore economical and ecological sustainability. The aim of this study was to analyze how various modules of farming in different combinations

Major Food Systems (Uttar Pradesh, India)

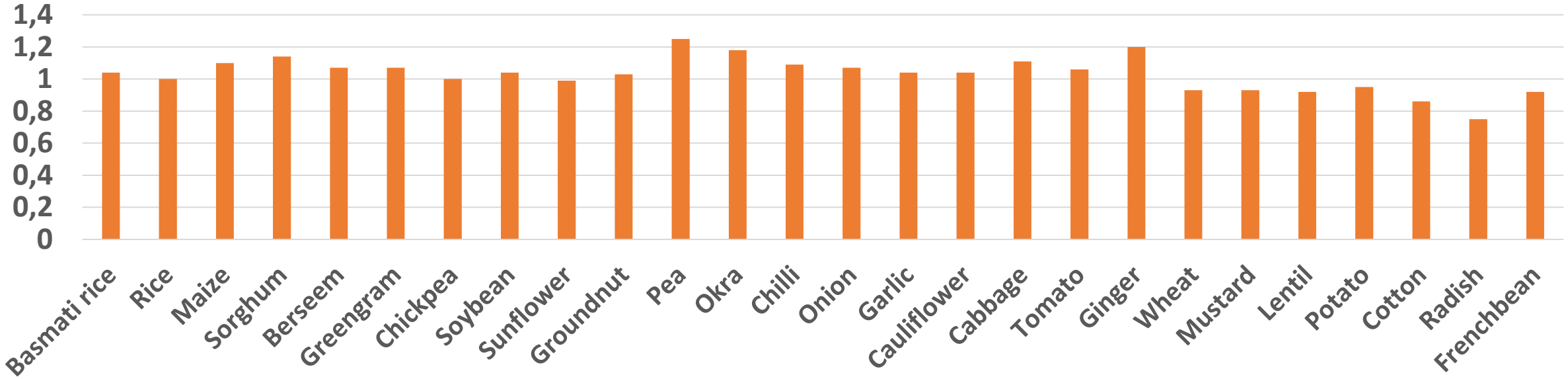


FIRST MAJOR CROPPING SYSTEMS



SECOND MAJOR CROPPING SYSTEMS

Organic vs Inorganic Yield ratio



Major Agroforestry Systems

Poplar-*based*

Eucalyptus-*based*

Shisham-*based*

Melia-*based*

Teak-*based*

Bamboo-*based*

Ardu-*based*

Mulberry-*based*

- 1.86 m ha under agroforestry and Uttar Pradesh ranks First in the country
- Currently 10 % of cropped land is under agroforestry

Quantified benefits from Agroforestry in Uttar Pradesh (ICAR-CAFRI, Jhansi)

- Crop yield increased by 20 to 60% and the cropping intensity by 35%
- Long lasting recharge of shallow dug wells with 2–6-meter water column and regulated stream through base flow (from 2.2 to 7% of annual rainfall) has been observed
- Input cost reduced and farmers' net income has doubled in a span of 4-5 years
- Protect and stabilize ecosystems, increasing forest/tree cover
- Promote resilient cropping and farming systems to minimize the risk during extreme climatic events.
- Encourage and expand tree plantation in integrated manner with crops and livestock to improve productivity, employment, income and livelihoods.

Agroforestry Model	Suitable Intercrops			Carbon sequestration (t C ha^{-1})
	Kharif	Rabi	Annual	
Poplar based	Pearl millet, cowpea, sorghum (for initial 3 years only)	Wheat, potato, mustard, oats, berseem (up to 6 years)	Sugarcane (for initial 2 years), turmeric and ginger (3rd year onwards)	55 (6-year old)
Eucalyptus based	Pearl millet, cowpea, sorghum, soybean, cotton	Wheat, potato, barley, oats, berseem	Turmeric, ginger	75 (6-7 years)
Melia based	Blackgram, cowpea, greengram, okra and groundnut	Sorghum, vegetables, wheat	Ginger, turmeric, banana, papaya, sandal	70-90 (in 5-6 years)
Teak based	Black gram, soybean, cotton, red gram and sesame	Sorghum, cowpea and linseed		3.80 (7 years) 5.77 (12 Years) & 58.52 (25 years)
Shisham based	Paddy, soybean and pulses	Wheat, mustard, barley	Napier hybrid grass	34 (12 years of rotation)
Ardu based	Pulses and legumes, sorghum, bajra, cluster bean	Wheat, mustard and barley; Grasses– *Cenchurus ciliaris, Panicum antidotale*		9.64
Mulberry based	Napier-Bajra hybrid or Setaria anceps grass pulses, beans, soybean and wheat can be cultivated			31.10 (20 years)

Field-scale assessment of Ecosystem Services from OF & Agroforestry system

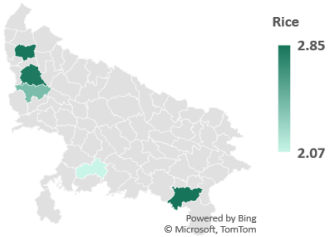
Districts	Net Cultivated area (ha)	Organic Farming (4 % scale in ha)	Forest (ha)
Aligarh	305083	12203	2487
Bulandsahar	299082	11963	8448
Hamirpur	283360	11334	24084
Meerut	196399	7855	21314
Mirzapur	210990	8439	121586

Provisioning services	• System productivity: Gross productivity, production from trees (fodder leaves/ wood/Fuel etc.)
Regulating services	• Water regulation (Runoff, nutrient loss, soil moisture content, infiltration etc.)
	• Erosion control (Soil loss/Sediment trapping efficiency)
	• Climate regulation (Carbon sequestration potential)
	• Soil Biology (Microbial population, Earthworm, Enzymatic activities etc.)
Habitat/ Supporting services	• Diversity of plant community, habitat for macro fauna • Soil fertility (Soil organic matter, Physico-chemical properties of soil)
Cultural	• Spiritual • Recreation • Aesthetic value

Conventional vs Organic Farming

Rice

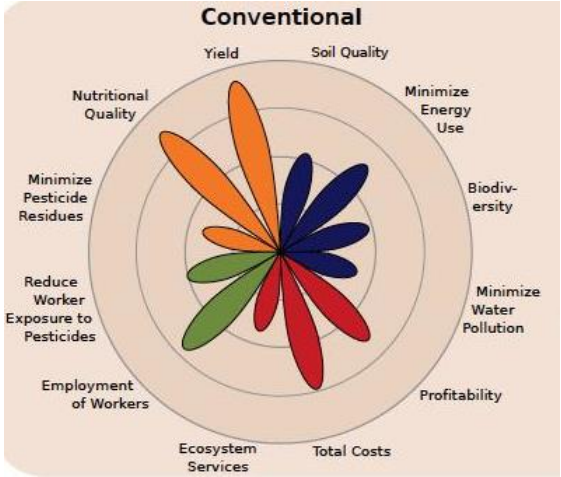
Conventional Farming	Organic Farming
Variety	Coarse Paddy: Saket -4 ; Basmati: Pusa Basmati-6, Pusa Basmati-2, Basmati- 370
Nutrient Management	Macronutrients, Micronutrients
Practices	Conservation agriculture, Integrated crop management
Insect pest Management	Chemical control
Productivity	2.59 t/ha

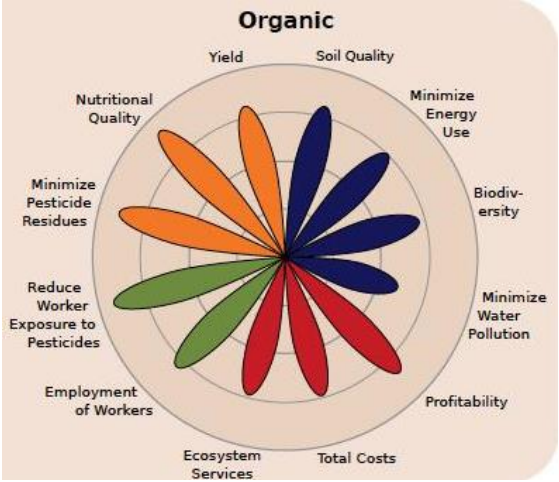


Rice productivity (Farmer Practice)

Organic Farming	
Variety	Coarse Paddy: Saket -4 ; Basmati: Pusa Basmati-6, Pusa Basmati-2, Basmati- 370
Nutrient Management	Biofertilizers/FYM, Vermicompost, Ghanjeevamrit, Other Concoctions
Practices	Crop rotation, Cover crops, Intercropping
Insect pest Management	Bio control agents, Biopesticides, Herbal extracts
Productivity	3.51 t/ha

Rice productivity (Experimental plot under organic)





Case Studies on IOFS models

Nature Day event of UN-Climate Change Conference (UK 2021; COP26)

6 November 2021

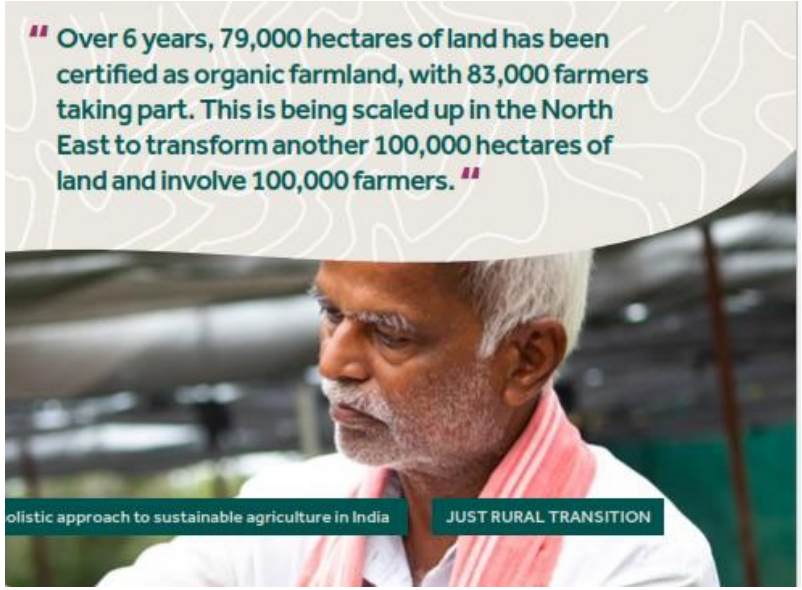


Table 8 – Success story 2: Mr. Abbas Chichali, Farmer, Khagdara, Bicchiwara, Dungapur, Rajasthan

Sr. No.	Particulars	Actions
1	Number of birds	700
2	Name of breed	Ankleswar and Pratapdhan
3	Housing System Type	Backyard system with free range (day in openside area and night in covered area
4	Forage & living area	3 hectares
5	Watering facilities	Tube well and plastic waterer, automatic
6	Feed	Maize grain + Azolla and Lucerne
7	Total egg production	60-70 per day
8	Total Meat Production (sale of live birds)	150 cocks at INR 800 per cock 200 hens at INR 600 per hen
9	Mortality	70 (10% of total)
10	Total cost (9 month)	Chicks 700 at INR 110 = INR 77000 Feeds = INR 72,000 Labour = INR 40,000 Total = INR 189,000
11	Gross revenue	Eggs sold= 1600 at INR 20 = INR 32,000 Total cock sales = 150 cocks at INR 800 = INR 120,000 Total hen sales = 200 hens at INR600 =INR 120,000 Total = INR 272,000
12	Net return	INR 83,000
13	B:C Ratio	1:1.44
14	Employment generation	135-mandays
15	Business status	• Transforming conventional organic production to organic poultry
16	Innovation	• Online Marketing • Integration with fish production, goat and livestock
17	Technology	• New dual-purpose high yielding Pratapdhan & Ankleswar breed
18	Standards	• Organic certification is under process
19	Feedback	• Organic farming of poultry birds reduces use of antibiotics and helps in maintaining pesticide-free environment (and therefore trade-off cost) • Positive effect on environmental aspects should be considered and incentives should be given to poultry grower

Citation

N. Ravisankar, MerajAlam Ansari, Raghavendra, KJ, M. Shamim, Raghuveer Singh, A.K. Prusty, A.S. Panwar and S. Bhaskar. Case Studies on Organic Farming in India, All India Network Programme on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram

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- 9 Case studies: MOVCD-NER, IOFS in Meghalaya and Sikkim, Organic farming interventions in Chhattisgarh, Himachal Pradesh, Kerala, Tamil Nadu and Rajasthan

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