

Paper:

Potential of Rice-Based Food Processing Industries Along Eastern Plains of River Ganga

Shyamli Singh[†]

Indian Institute of Public Administration IP Estate
ITO (Ring Road), New Delhi 110002, India

[†]Corresponding author, E-mail: shyamli.env@gmail.com

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The Indo-Gangetic plains are considered to be the most fertile land area within India. It contains alluvium type of soil which is rich in nutrients and have high water retention capacity. According to many agricultural think tanks, including Food and Agriculture Organization (FAO), the northern belt of Uttar Pradesh (U.P.) and Bihar are the only states having naturally sustainable soil conditions for the cultivation of water-intensive rice crops in India and are also among very few regions of Asia. This paper will be an attempt to propose an integrated system where Sustainable Development Goals (SDGs) targets like poverty, well-being, economic growth, innovation and infrastructure, and sustainable communities will be addressed. With the optimum production of rice in the region and with the support of government schemes like the *Pradhan Mantri Kisan Sampda Yojana* scheme for overall growth and development of food processing units, food processing industries can be established in selected pockets of eastern Uttar Pradesh and Bihar. The food processing industries based on rice processing will produce varied local sweets such as *Anarsa*, *Laktho*, *Thekua*, etc., and food products that can get a vital push from the government's One District One Product (ODOP) scheme. With the help of the Agricultural and Processed Food Products Export Development Authority (APEDA), the products can be promoted for international exports as well. Also, it will address the much-known menace of outmigration (4–5 million of workforce per annum) from states and will provide local human capital with income growth and identity. A whole integrated system can be built where linkages from farm to market can be created which will reap farmers: good prices and regular procurement, food industries: good promotion of products plus profits, and local people: economic and social protection. Therefore, by using locally climate suited crop and government supported food parks or industrial system, the holistic aim of 3P's – people, planet, and profit, will be realized.

Keywords: water intensive, sustainable soil conditions, integrated system, human capital

1. Introduction

The regions of eastern Uttar Pradesh and Bihar are well known for their soil fertility. The region has large accumulated soil which has its origin from the Himalayan sediments (Banguar and Khaddar). Therefore, the natural productivity or productivity without technology intervention of the crops is quite suitable for the sustenance of crop production. Agriculture in the rural eastern plains of Uttar Pradesh and Bihar needs to maintain its productivity while enhancing its biophysical sustainability [1].

The rice-wheat cropping system (RWCS) is the backbone of Indian farming, especially in the northwestern region. In the RWCS, the farmers in north-western India generally grow rice as a lowland crop from June to October, followed by wheat as an upland crop from November to April [2]. But ongoing RWCS adoption in northwest India has led to significant problems and a plateau in this system's productivity [2]. The puddling in rice cultivation destroys soil structure, leading to poor soil aeration and soil compaction [2]. Therefore, the continuous adoption of the RWCS has resulted in a hardpan at shallow depths that halts the root penetration/proliferation into the soil and thus affects the growth of the succeeding wheat crop [2]. Therefore, promoting food production that is climate-adapted is urgently needed. Taking into account the physiological conditions of Ganga's eastern plains which are well-drained alluvial soil due to high annual average rainfall and mineral-rich Himalayan soil, less land gradient or relatively plain area, hot and humid conditions, and drained by many tributaries. All these conditions are quite favorable for water-intensive crop production such as rice.

Currently, five major rice-producing states in India are West Bengal, Uttar Pradesh, Punjab, Tamil Nadu, and Andhra Pradesh. Although conditions are only favorable for the Ganga floodplain region of Eastern states, the production data indicates the resource exploitation being done in other states or the practice against the suitable agro-climatic region. The continuous practice of rice cultivation in areas not suitable for its agro-climatic zone will create many challenges to deal with. Some of the contemporary challenges before us posed by human negligence and climate change are exhausting nutrient pool in soil, deteriorating soil health, groundwater depletion, escalat-



ing production cost, labor scarcity, environmental pollution due to crop residue burning and enhanced greenhouse gas emissions, climatic vulnerabilities, and herbicide resistance in weed species [2]. The food security in the region is significantly impacted by natural disasters such as floods, droughts, and cyclones. These catastrophes can impede rice cultivation and other agricultural activities thereby reducing food availability and output. Thus, food security as a result may be jeopardised. In order to guarantee a steady supply of processed rice products to support food security during disasters, the potential of rice-based food processing enterprises becomes essential. To reduce the negative consequences of disasters on food security, the sectors that process rice must tread towards resilience.

India is the second largest rice producer and the largest exporter of rice worldwide. Rice production in India expanded from 53.6 million tons in FY1980 to 120 million tons in FY2020–2021. Rice is one of the main grains of India [3]. The data clearly outlines heavy potential India holds in rice production. In recent times, the focus of the Government of India has been on being an exporter country and therefore, central schemes nowadays are launched with the main focus on end-to-end support to all the stakeholders involved.

The Purvanchal region which is known for its high food-based productions, like Bihar is one of the highest producers of vegetables and the second highest producer of fruits in India [4]. Therefore, the region holds potential for the establishment of food processing units. Some major food-based processing units are Maize processing, modern rice mills, vegetables based, litchi processing, Makhana, etc. [5].

At the national level, government is framing an ecosystem that will lead to food processing industry growth. Through the Ministry of Food Processing Industries (MOFPI), the Government of India is taking all necessary steps to boost investments in the food processing industry in India. The Ministry has also been implementing two more flagship schemes:

- The Production Linked Incentive (PLI) Scheme to modernize and enhance the competitiveness of the food processing industry by manufacturing specific categories of food products having a high potential for growth in output and value addition for six years till 2026–2027.
- PM Formalization of Micro Food Processing Enterprises (PMFME) Scheme for providing financial, technical, and business support for the up-gradation of existing micro food processing enterprises [6].

In India, a variety of rice-based products are prepared, consumed, and distributed due to the diversity of religion, ethnicity, culture, and traditions [7]. Each region of the country is characterized by different dishes made out of rice while grains are common to the Indian diet. Although most of these products are still prepared at home only, the organized market for these rice-based products is still at

a nascent stage and therefore, lacks sufficient evidence-based data. Some of the dry products prepared from rice like Puffed Rice, Flattened Rice, Rice Papad, Rice Upma, Dosa/Chakuli, etc. find their place in the market as they have a longer shelf life [7].

The paper focuses on these niche areas: identifying the building factors for the creation of farm-to-market linkages, exploring the economic scalability of migrant workers going to be accommodating in the industry and the potential of diverse marketable finished products from Rice in the eastern Ganga Plains.

2. Characteristics: Food Industries and Population

2.1. Farm to Industry Linkages

A mega food park is an integrated facility that provides for storage and processing. The concept of mega food parks is to put forward a coordinated balance between the nearby agricultural produce and the available food processing units by the Ministry of food processing. The Scheme of Mega Food Park aims at providing a mechanism to link agricultural production to the market by bringing together farmers, processors, and retailers to ensure maximizing value addition, minimizing wastage, increasing farmers' income, and creating employment opportunities, particularly in the rural sector.

The Mega Food Park Scheme, which is based on the "Cluster" approach, aims to build state-of-the-art support infrastructure in a well-defined agro-horticultural zone for the construction of contemporary food processing units in the industrial plots made available in the park with a well-established supply chain. Mega food park typically consists of supply chain infrastructure including collection centers, primary processing centers, central processing centers, cold chain, and around 25–30 fully developed plots for entrepreneurs to set up food processing units [5].

For farmers to develop strong backward linkages of their products or stakeholders through which they will facilitate their produce to suppliers, they need to have close coordination with community help groups, farmer producer organizations, self-help groups, farmer's groups, non-governmental organization (NGO), etc.

2.2. Industry and Market Linkages

Investment and quality insurance of the produce is heavily dependent on industrial processing, hence the role of the creation of a special purpose vehicle (SPV), a special body or legal entity created for managing a specific purpose apart from the parent body, has become significant in creating the capitalization atmosphere of the produce. State Government, State Government entities, and Cooperatives are not required to form a separate SPV for the implementation of the Mega Food Park project.

By understanding the importance of the required mechanism for the food processing linkages, the government

has initiated a group of schemes to make stakeholders realize and pursue their actions. The scheme aims to the development of modern infrastructure and common facilities to encourage groups of entrepreneurs to set up food processing units based on a cluster approach by linking groups of producers/farmers to the processors and markets through a well-equipped supply chain with modern infrastructure [8].

2.3. Population and its Occupational Characteristics

Through effective reallocation of labor, which enables employees to take advantage of better opportunities across sectors and regions, labor migration raises productivity and wages. As a result, migration is now a crucial factor in both family welfare and economic development. Along with the primary project elements, the technical civil work and plant and machinery costs. Costs for “Utilities” required for the plant, such as water pipeline, Diesel Generator (DG) set, boiler, solid waste treatment plant, and Effluent Treatment Plant (ETP), are also taken into account when determining eligible project costs. However, the cost of human labour is of utmost importance because workers are the key players in the development of each state’s economic status.

A specific study on the migratory patterns in the Ganga basin, in Bihar, or in the eastern Ganga plain was conducted by the Indian Institute of Population Sciences (IIPS). Men without or within families are more likely to emigrate from the area. The highest emigration occurs in the traditional migration pockets of Saran, Munger, Darbhanga, Kosi, Tirhut, and Purnia. Seasonal migration is highest in Kosi, Tirhut, and Purnia divisions [9].

Migration from eastern Uttar Pradesh and Bihar has always been high towards comparatively richer western states of the country [9]. A widespread tendency of migration toward Gulf nations has been noticed recently. The study by IIPS also shows that the average annual remittances for the group under study from the region were above Rs 25,000 in Bihar and Rs 40,000 in Uttar Pradesh [9].

3. Scenario and Potential – Rice Based Food Products

3.1. Status of Food Security and India

India and Food Insecurity: India is the country with the largest stock of grain in the world; 120 million tons (as of July 1, 2021) accounts for a quarter of the world’s food-insecure population [10].

Providing food and nutritional security for our expanding population poses a severe danger to our country’s food security in the context of dwindling agricultural land availability and land-holding size. Intensification and integration of crop and allied enterprises is the area where our farmers require an extended hand. Adoption of a modern rice-based farming system approach will help farm-

ers to understand the interaction and linkage of different farm resources which helps in resource recycling and ultimately leads to reduction of input cost and enhancement of productivity and profitability of the system [11].

3.2. Existing Practices and Potential – Rice Based Food Products

Millions of people’s cultures, diets, and economies have all been influenced by rice. “Rice is life” for more than half of humanity. The United Nations declared 2004 to be the “International Year of Rice” due to its strategic importance. The importance of rice is as follows:

- More than 60% of the world’s population depends on rice as a major food source [12].
- Ready-to-eat items such as popped and puffed rice, instant or rice flakes, canned rice, and fermented products are manufactured.
- Rice husk is used as animal feed, to make paper, and as a fuel source.
- Rice straw is used as cattle fodder, to thatch roofs, and in cottage industries to make hats, mats, ropes, sound-absorbing materials, straw boards, and litter.

More attention was paid during the ninth five-year plan to popularizing location-specific high-yielding rice varieties that had been released or announced in the previous three years for the favorable rain-fed and irrigated areas and in the previous five years for the problematic areas, such as rain-fed upland and lowland, coastal saline, saline-alkaline lands, and high altitude cold stress areas [13]. A total number of 33 lakh seed mini kits of 419 location-specific high-yielding varieties of rice were distributed in different rice growing states during the ninth five-year plan [13].

Important components of poultry and dairy feed include rice by-products. Rice husk and bran are byproducts of paddy milling that we receive. A little over 5% of the paddy that is processed is rice bran. Under the hull, there is a pericarp, or outer cuticle layer, called rice bran. It is eliminated throughout the milling process. About two decades ago, the majority of rice bran was burned because it was viewed as almost a waste. It is now thought to be very nutrient-dense. Rice bran, which is high in natural Vitamin B and protein, is fed to cattle [12]. With rising customer demand for the rice bran oil that is extracted, the processing of rice bran has recently picked up speed.

3.3. Use of Rice and its By-Products Like Rice Husk, Rice Bran, and Paddy Straw

On a weight basis, rice plants yield 50% rough rice and another 50% straw. When the rough rice is milled, brown rice, milled rice, germ, bran, broken rice, and husk are produced. Each of these elements has distinct qualities and can be applied in various ways. The utilization pattern of these components directly or as derivatives decides the extent of value addition in rice.

The following discusses further utilization of rice-based products.

3.3.1. Utilization of Regular/Broken Rice

- Rice flour's special qualities also make it a top option for creating resistant starch, a food component that mimics the effects of fiber in the body and hence offers those advantages.
- Gluten-free rice bread is a highly popular value-added product made from rice broken on old rice stocks in Japan [12].

3.3.2. Utilization of Rice Bran

- The most valuable by-product of the rice milling business is rice bran. It has 14%–15% protein, 18%–20% fat, and only a small amount of minerals and vitamins [12]. So it is possible to maximize financial gain by using rice bran wisely in a variety of ways.
- De-oiled bran is most commonly used as animal feed or as fertilizer.

3.3.3. Utilization of Rice Straw

- At farmers' levels, rice straw is mainly used for thatching, as cattle feed.
- Rice straw is used in making certain fancy products like bags, wall hangings, etc.
- Rice straw is cut into pieces and then used for making beds for growing mushrooms.
- Rice straw along with other fibrous materials can be used to prepare pulp for making boards.

3.3.4. Utilization of Paddy

- Paddy is mainly used for consumption as whole milled rice either in raw or parboiled condition.
- Beaten rice/poha is a value-added product made from paddy and is popular in all parts of India.
- Paddy when directly propped in hot sand produces a white expanded product called Khai. After removing the husk, it is consumed as a snack food.

3.3.5. Utilization of Brown Rice

- When the outermost layer of paddy (husk) is removed, the resultant product is brown rice. It is rich in vitamins B1, B2, B3, B6, and Iron as compared to polished white rice. Brown rice can be stored well in hermetic storage or freezing condition [12].

3.3.6. Utilization of Polished White Rice

- Polished white rice is mainly consumed as a staple food after cooking. A few value-added products like quick cooking rice and rice cake, canbe, puddings, other bakery items, and fermentation products.

3.3.7. Utilization of Parboiled Rice

- Consumed as a staple food in many parts of India. The value of this product mainly depends on its quality in terms of size (short and long), color, texture, smell, etc. The few value-added products that can be made from parboiled rice are: quick cooking parboiled rice and puffed rice. Further value can be of the puffed rice by making puffed rice balls with jaggery and other ingredients.

3.3.8. Utilization of Rice Broken

- Brings one-third the value of whole rice grain in the market for direct consumption such as in the form of Idli/Dosa or sold as poultry feed.
- This low-value material can be converted into value-added products like rice noodles, vermicelli, rice alcohol, rice flour, and rice ethanol.
- Rice flour is used in many foods including baby foods, chips, and crackers.

4. Existing Government Policies: Takeaways and Suggestions

Ministerial Actions and Central Level Schemes

An inter-ministerial task force led by the Secretary (Agriculture) was established in December 2009 to make short and medium-term recommendations on efficient management of water, power, and other inputs to maximize agricultural production on a sustainable basis, including that of the Eastern India region [11]. The task force's main proposal was to encourage creative precision farming methods and to encourage efficient water management, in conjunction with the state governments. To stabilize the rice-based cropping system in the Eastern states, it offered specific recommendations for increasing rice yield in the Eastern states through the creation of suitable infrastructure [11].

Table 1 represents some highlights of the major measures of the Government of India for food processing. Some suggestions of other initiatives within the scheme are provided below in **Table 2**.

5. Measures to Address the Key Challenges

The following actions can be taken to address the difficulties associated with rice cultivation ongoing in unsuitable areas:

- Management of soil nutrients: Restoring soil nutrients and preserving soil fertility can be accomplished by implementing sustainable soil management techniques like crop rotation, the use of organic manures, green manuring, and integrated nutrient management.

Table 1. Major measures of the Government of India for food processing.

S. No	Schemes/Initiatives	Components or utility of schemes
1.	National mission on food processing	MOFPI launched a Centrally Sponsored Scheme (CSS): National Mission on Food Processing (NMFP) in 2012 for implementation through States/UTs. The NMFP envisages the establishment of a National Mission as well as corresponding Missions at the State and District level. The basic objective of NMFP is the decentralization of implementation of food processing-related schemes for ensuring substantial participation of State Governments/UTs. The mission is expected to improve the Ministry's outreach significantly in terms of planning, supervision, and monitoring of various schemes apart from playing a more meaningful role in policy formation.
2.	PM Kisan Sampada Yojana	Launched in 2015 by MOFPI. This scheme is aimed at promoting entrepreneurs in setting up food processing units, closer to agricultural areas. Development of cold storage facilities, specialized packaging units, warehousing facilities, etc., and other preservation facilities are eligible for grants under the scheme. The scheme provides a grant in aid of 35% of the eligible project cost in most states and 50% of the project cost in the northeast and Himalayan states. The development of agricultural facilities under the scheme intends benefits investors, entrepreneurs, farmers, farmer organizations, and agriculture cooperatives.
3.	PMFME	PMFME Scheme, an initiative under Aatmanirbhar Bharat Abhiyan , is being implemented by MOFPI with an outlay of 10,000 Crore over five years from 2020–2021 to 2024–2025. The scheme aims to augment the existing individual micro-enterprises in the unorganized segment of the food processing industry and formalize two lakh micro food processing enterprises with a special focus on supporting groups such as Farmer Producer Organizations (FPOs), Self-Help Groups (SHGs) engaged in Agri-food processing sector.

Table 2. Suggestions of other initiatives within schemes.

Attract FDI	The Government of India aims to boost growth in the food processing sector by leveraging reforms such as 100% foreign direct investment (FDI) in the marketing of food products and various incentives at the central and state government levels along with a strong focus on supply chain infrastructure.
Human resource enhancement	Creation of infrastructure facilities for degree/diploma courses in the food processing sector. Entrepreneurship Development Programme (EDP). Food Processing Training Centres (FPTC). Training at recognized institutions at state/national level.
Mega food parks	A mega food park is an integrated facility that provides for storage and processing. Additionally, value additions to a large number of players in the food processing industry. Under the Mega Food Park Scheme, the Government of India provides financial assistance up to Rs 50.00 Crore per Mega Food Park project. Most food parks have the following services, tetra-packaging, food testing laboratories, drying chambers for spices and agricultural produce, cold storage, warehousing, packaging, and printing facilities. Examples: Srini Mega Food Park at Chittoor (Andhra Pradesh), Godavari Mega Aqua Park at West Godavari (Andhra Pradesh), etc.

- Water conservation: Using effective irrigation systems, such as sprinkler irrigation, drip irrigation, and water harvesting methods, can help conserve water and prevent the groundwater table from being depleted.
- Soil health management: Implementing techniques like conservation tillage, cover crops, and crop residue management can aid in preserving the health of the soil and lowering soil erosion.
- Mechanization and technology adoption: Mechanization and the use of contemporary technologies like sensors, remote sensing, and precision agriculture can help to alleviate the labour shortage, boost output, and enhance production efficiency.
- Sustainable production practices: Implementing sustainable production techniques like integrated pest management, limiting the use of agrochemicals, and promoting the use of bio-pesticides can help lower

production costs and advance environmental sustainability.

- **Herbicide resistance management:** Using techniques like intercropping, crop rotation, and integrated weed management strategies can help manage weed species' herbicide resistance.
- **Policy and institutional support:** Support from policies and institutions, such as subsidies, insurance, credit, and technical assistance, can aid in encouraging the adoption of sustainable practices, lowering production costs, and enhancing farmers' quality of life.

6. Integrated System

An integrated system that addresses these Sustainable Development Goals (SDGs) can be proposed, which includes:

1. **Poverty reduction:** Food processing businesses based on rice can offer employment opportunities, particularly to the rural populace, which can aid in lowering poverty levels in the area.
2. **Well-being:** Rice-based food processing enterprises may provide nutrient-dense food items like rice flakes and rice bran oil that can enhance consumers' health and quality of life.
3. **Economic development:** By opening up new markets, boosting productivity, and encouraging entrepreneurship, the expansion of rice-based food processing companies can boost the region's economy.
4. **Innovation and infrastructure:** These are required for the growth of rice-based food processing enterprises, including processing units, storage facilities, and transportation networks. To encourage innovation and the development of infrastructure, the government and other stakeholders must make investments in R&D and implement supportive policies.
5. **Sustainable communities:** By guaranteeing fair access to resources and fostering a circular economy, the growth of rice-based food processing enterprises can support sustainable communities. The companies can generate electricity using rice husk, a left-over from the processing of rice, which can cut waste and encourage sustainable practices.

6.1. Building Factors for the Creation of Farm-to-Market Linkages

1. **Infrastructure:** Building links between farms and markets requires the development of infrastructure, such as roads, bridges, and storage facilities. The efficient movement of rice from the farms to the processing facilities and finally to the markets will be made possible by this infrastructure.

2. **Processing units:** Establishing processing facilities in the area will help farmers process their rice locally and cut down on post-harvest losses. The local community may be given employment possibilities by the processing facilities.
3. **Financing:** Farmers need access to capital to expand their operations, buy supplies, and set up processing facilities. To create links from farm to market, the government and financial institutions might offer loans and other forms of financial assistance to farmers.
4. **Training and education:** Farmers and processors must receive training on the most effective agricultural, processing, and marketing practises. To improve the education and training of farmers and processors, the government and other interested parties could provide training and education programmes.

6.2. Economic Scalability of Migrant Workers Accommodating in the Industry

Migrant labourers in the area may find employment opportunities in the rice-based food processing sector. The sector may offer job openings in logistics, transportation, and processing facilities. Workers from other countries can help the economy and the region as a whole prosper. However, it is important to make sure that migrant workers' rights are upheld and that they receive fair pay and working conditions.

6.3. Potential of Diverse Marketable Finished Products from Rice in the Eastern Ganga Plains

Numerous marketable finished products, including rice flour, rice noodles, rice flakes, puffed rice, and rice bran oil, can be made from rice through processing. Demand for these products is rising both domestically and abroad. The creation of value-added rice products has the potential to boost farmers' and processors' incomes as well as the local economy. To ensure the marketability and sustainability of these products, market research must be conducted to accurately identify the potential markets. To boost these products' demand and market share, the government and other stakeholders can help with their marketing and promotion.

7. Conclusion

The paper highlighted many of the aspects of both backward and forward linkages for the appropriation of the farm-to-market product. Backward linkage is from farm to industry and the forward linkage means from industry to market linkage in terms of availability of raw materials, financial assistance, and other aspects. The social and economic scenarios of the eastern plains are reported which will be helpful in different aspects of policy implementation schemes formulation. Both micro and

macro level components are necessary to jot down and frame an integrated system that will flourish environment, and social and economic systems in the eastern plains of Ganga. Micro components here are suppliers, consumers, resellers, and general public, while the macro components are economic factors, natural forces, social and cultural forces. The pre-existing schemes are required to be in sync with the adoption of food parks or farm-to-market working chain models. The rice production and associated integrated system has addressed SDGs targets like poverty, hunger, well-being, economic growth etc. This will help us to achieve Goal 1, i.e., No Poverty, by improving the rice varieties and enhancing the rice production and income along food value chains. Growth in rice production also contributes to the economic growth of the nation which is another Goal 8. Increased rice productivity will help in alleviating hunger (Goal 2) through low prices of rice as most of the world's population and even poor are dependent on rice as it is the staple diet and it also makes up to 70% of calorie intake. Also by adapting climate smart rice varieties and management techniques it helps in mitigating climate change. Farmers are already planting drought-tolerant varieties that IRRI produced and released in a number of nations. They include Sookha (Sukkha) Dhan variants in Nepal, Sahbhagi Dhan in India, and Sahod Ulan in the Philippines. In the context of the mega-variety "Swarna," the ICAR-National Rice Research Institute (NRRI) has created CR Dhan 801 and CR Dhan 802 with submergence and drought tolerance capabilities. Adopting new innovative farming technology and resilient infrastructure for better rice production. India being very diverse in its Agro climatic region and Ganga eastern plains with its all-nutrient rich soil and humus presents very sustainable physiological conditions for the production of rice varieties. Therefore, the initiation of a market economy for the feasibility of the immense potential of rice can create a good system of economy and further engage the respective region's human resources fruitfully. The emigration pattern suggests that it is skewed and it likely to be inclined towards production-based states like Maharashtra, Punjab, Gujarat, etc. which possess a high pressure on those states' resources too.

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Name:

Shyamli Singh

Affiliation:

Assistant Professor, Indian Institute of Public Administration

Address:

ITO (Ring Road), New Delhi 110002, India

Brief Career:

2012- Faculty & Coordinator, Centre for Environment and Climate Change, Indian Institute of Public Administration

Selected Publications:

- "A Handbook for Entrepreneurs on Solid Waste Management: A Step towards Atmanirbhar Bharat," Cambridge Scholars Publishing, Feb., 2022.
- "The Effects of Heat Exposure on Tropical Farm Workers in Malaysia: Six-Month Physiological Health Monitoring," *Int. J. of Environmental Health Research*, Vol.33, No.4, pp. 413-429, 2022.
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- "A Review on Solid Waste Management and its SWOT Analysis in Ganga Basin," *Trends in Biosciences*, Vol.13, No.17, pp. 1281-1291, 2020.

Academic Societies & Scientific Organizations:

- Life membership of the Int. Society of Environmental Botanists
- Life membership of Indian Society for Technical Education (LM.68113)
- Co-editor, Indian Pollution Control Association Newsletter
- Young Scientist IRDR Young Scientist - Integrated Research on Disaster Risk, Beijing, China
- Member of Scientific Committee of Asian Conf. on Indoor Environmental Quality in collaboration with ISHARE, SIE and IAQA