



THE TRANSFORMATIVE ROLE OF INFRASTRUCTURE IN ECONOMIC GROWTH AND AGRICULTURAL DEVELOPMENT IN ODISHA

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Abstract: Infrastructure development drives economic growth, fosters human development, and reduces transaction costs across sectors. Odisha, with 61.80 lakh hectares of cultivated land, faces challenges in agricultural productivity due to declining Net Sown Area and underutilised irrigation potential. The state has prioritised irrigation expansion through targeted schemes like BKVY and Mega Lift Irrigation projects, while watershed programs address sustainability in rainfed regions. Energy infrastructure has seen remarkable progress, achieved 95% village electrification and promoted renewable energy. Post-harvest infrastructure enhancements by OSAM aim to minimise losses and improve farmer incomes. Infrastructure development is a cornerstone of economic growth and agricultural advancement, particularly in a state like Odisha, where agriculture remains a primary livelihood for over 60% of the population. Investments in transportation, irrigation, energy, and industrial facilities have catalysed economic diversification and productivity gains in Odisha. Emphasis on multi-sectoral infrastructure growth ensures socio-economic transformation and sustainable development in Odisha.

Keywords: Infrastructure Development, Agricultural Productivity, Irrigation, Sustainable Growth

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INTRODUCTION

NABARD (National Bank for Agriculture and Rural Development) was established on July 12, 1982, by transferring the agricultural credit functions of RBI and the refinance functions of the then Agricultural Refinance and Development Corporation (ARDC).

It is a key Development Bank with a mandate to promote the prosperity of rural areas by providing and regulating credit for agricultural development, small-scale industries, and allied activities (Tripathy, 2010a). It has significantly contributed to minor irrigation, horticulture, animal husbandry, post-harvest management, and rural infrastructure, supporting farm and non-farm sectors, including rural industries and handicrafts. NABARD's efforts have led to the advancement of agro-industries, including fruit and vegetable processing and artisan crafts.

In addition to its developmental role, NABARD coordinates rural credit institutions and supports the government, RBI, and other organisations in rural development initiatives. It provides training, research, and financial assistance to enhance the capacity of banks, cooperatives, and rural organisations. Furthermore, NABARD regulates cooperative banks and Regional Rural Banks (RRBs).

NABARD has catalysed various pioneering initiatives such as the Self-Help Group Bank Linkage Programme, watershed development, and the upliftment of tribal communities. It also promotes rural livelihoods through community-managed sustainable natural resource management projects. Institutional development initiatives like strengthening Rural Credit Cooperatives and RRBs have facilitated a sustainable rural financial system, enhancing credit access for farmers and rural entrepreneurs (Tripathy, 2010a; Verma & Jha, 2021; Tripathy, 2022).

SUBSTANTIAL GROWTH AND FORMALISATION IN AGRICULTURAL CREDIT ECOSYSTEM

At the national level, over the past decade, agricultural credit has demonstrated consistent growth, averaging a robust 13% annually, and this upward trajectory is anticipated to culminate in FY25 with agricultural credit reaching an impressive ₹ 27-28 trillion, surpassing growth rates in many other sectors (Kumar, 2025). This significant expansion in agricultural credit reflects a

broader and more granular transformation in the credit ecosystem, marked by a substantial decline in reliance on informal credit sources and an evident shift toward the formalisation of rural credit mechanisms, which is particularly beneficial to rural communities by offering access to lower interest rates and enhancing profit margins compared to traditional informal lending practices. To further strengthen this growth, the government has been setting ambitious annual targets for ground-level credit (GLC) for scheduled commercial banks (SCBs), regional rural banks (RRBs), and rural cooperative banks (RCBs), with the provisional figures for FY24 indicating that ₹25.1 trillion has already been disbursed, exceeding the initial target of ₹20 trillion by a notable 25%. Complementing these efforts is the government's agri-stack initiative, aimed at digitising land records and incorporating three critical layers: the farm layer for land records, the farmer layer for KYC details, and the crop layer for data on agricultural production, with NABARD playing a pivotal role in partnership with this initiative, ensuring that the integration progresses across states at varying levels of maturity. Moreover, with approximately 100,000 cooperative societies nationwide, the ongoing digitisation drive has already computerised 50,000 societies, and plans are underway to digitise an additional 67,000 within the current fiscal year.

Despite NABARD's extensive role in rural development and credit formalisation, limited research exists on it. There is limited region-specific research on the integrated impact of infrastructure-led interventions, such as mega lift irrigation, mechanisation, and renewable energy, on agricultural productivity in Odisha. Additionally, the effectiveness of market linkages and post-harvest infrastructure in reducing losses and enhancing farmer incomes remains underexplored in the state's diverse agro-climatic zones. Expanding the scope of Kisan Credit Cards (KCCs) to include not only land-owning farmers but also small-scale farmers and individuals engaged in allied activities like animal husbandry and fisheries highlights the holistic approach to agricultural development, which now encompasses over 74 million active KCC accounts with an outstanding credit of ₹8.9 trillion as of June 30, 2023 (Kumar, 2025). Through collaborative campaigns and state-level interventions, NABARD fosters an inclusive rural financial ecosystem to ensure subsidised credit access across the agricultural spectrum.

OBJECTIVES

The objective of this paper is to focus on infrastructural development for enhancing agricultural productivity in Odisha, with a broad emphasis on the following:

1. To investigate methods to increase the gross cropped area by enhancing irrigation, improving groundwater efficiency, conserving soil moisture, adopting modern mechanisation, and promoting diverse cropping patterns.
2. To boost irrigation capacity through mega lift irrigation, rainwater harvesting, and watershed programs to rehabilitate degraded lands, enhance soil fertility, and maximise existing infrastructure use.
3. To establish robust market linkages, advanced storage, and processing units to reduce post-harvest losses while integrating renewable energy to power rural agriculture, ensuring productivity and sustainability.

METHODOLOGY

The methodology for this study relies primarily on available secondary data sources covering the period 2012 to 2023 and published research papers, with an exclusive focus on the comprehensive analysis provided in the *State Focus Paper 2020-21: Odisha*, published by the National Bank for Agriculture and Rural Development (NABARD), Odisha Regional Office. The report serves as the foundational document, offering detailed insights into agricultural credit trends, rural development initiatives, and institutional interventions in Odisha.

AGRICULTURAL LAND USE AND CROPPING PATTERNS IN ODISHA

Agricultural land use and cropping patterns describe how land is employed for crop production and the diversity of crops cultivated. These practices are carefully selected to maximise yields, efficiently utilise resources, and reduce the risk of crop failure. Cropping patterns vary widely: mono-cropping involves cultivating a single crop repeatedly on the same land; mixed cropping entails growing multiple crops together on a single plot; intercropping pairs crops with complementary growth habits to enhance productivity; sequential cropping involves planting different crops in succession on the same land; and relay cropping overlaps planting, where a second crop is sown before the first is

harvested, minimising fallow periods. The choice of cropping pattern depends on factors such as climatic conditions (temperature, rainfall, and weather), soil type (affecting nutrient availability and drainage), irrigation access, and market demand, which drives economic viability.

In Odisha, a state with a total geographical area of 155.71 lakh hectares, cultivated land spans 61.80 lakh hectares, representing about 39.69% of the total area. However, the expansion of cultivated land has faced challenges. The Net Sown Area (NSA) declined from 56.24 lakh hectares in 2007-08 to 52.92 lakh hectares in 2011-12 and from 56.31 lakh hectares in 2016-17 to 53.60 lakh hectares in 2017-18. This reduction coincided with a 2.2% drop in the Gross Cropped Area (GCA), primarily attributed to pest infestations. Cereals dominate the GCA at 50.1%, followed by pulses (25.1%), oilseeds (7.4%), and vegetables (8.3%). Rice, the staple crop, accounts for 46% of the GCA; though its share has decreased over the past decade, pulses and vegetables have gained prominence. Cropping intensity rose to 156% in 2017-18, driven by state efforts to encourage multiple cropping, improve irrigation, and resolve natural disaster risks (Government of Odisha, 2023).

Table 1: Agricultural Land Use in Odisha

| <i>Indicator</i> | <i>Value (Lakh Hectares)</i> | <i>Percentage of Total Area</i> | <i>Source</i> |
|-------------------------|------------------------------|---------------------------------|--|
| Total Geographical Area | 155.71 | 100% | Directorate of Economics and Statistics, Odisha (2017-18) |
| Cultivated Land | 61.80 | 39.69% | Odisha Economic Survey 2020-21 |
| Net Sown Area (2007-08) | 56.24 | - | Directorate of Agriculture and Food Production, Odisha (Annual Report) |
| Net Sown Area (2011-12) | 52.92 | - | Odisha Economic Survey 2012-13 |
| Net Sown Area (2016-17) | 56.31 | - | Directorate of Economics and Statistics, Odisha (2016-17) |
| Net Sown Area (2017-18) | 53.60 | - | Odisha Economic Survey 2020-21 |

Source: Data sourced from official Odisha government reports and surveys.

Table 1 shows that in Odisha, cultivated land occupies 39.69% of the total 155.71 lakh hectares. Net sown area fluctuated from 56.24 lakh hectares in 2007-08 to 53.60 lakh hectares in 2017-18, per various surveys, indicating a slight decline in agricultural land use over the decade.

Table 2: Cropping Patterns and Crop Distribution in Odisha (2017-18)

| <i>Crop Category</i> | <i>Share in Gross Cropped Area (GCA)</i> | <i>Key Crop Example</i> | <i>Source</i> |
|----------------------|--|-------------------------|--|
| Cereals | 50.1% | Rice (46% of GCA) | Odisha Economic Survey 2020-21 |
| Pulses | 25.1% | Green Gram, Black Gram | Directorate of Agriculture and Food Production, Odisha (2017-18) |
| Oilseeds | 7.4% | Groundnut | Odisha Agriculture Statistics 2017-18 |
| Vegetables | 8.3% | Potato, Onion | Odisha Economic Survey 2020-21 |
| Others | 9.1% | Sugarcane, Spices | Directorate of Economics and Statistics, Odisha (2017-18) |

Source: Data compiled from Odisha Government Agricultural Statistics and Economic Surveys.

Table 2 shows that cereals dominate 50.1% of the gross cropped area in Odisha, followed by rice at 46%. Pulses cover 25.1%, oilseeds 7.4%, vegetables 8.3%, and others 9.1%, per 2017-18 and 2020-21 data, showing a diverse yet cereal-heavy agricultural focus.

TRANSFORMATIVE ROLE OF INFRASTRUCTURE

Infrastructure development is a cornerstone for fostering economic growth, catalysing the adoption of modern technology, enhancing human development standards, and facilitating trade and commerce across borders (Tripathy, 1994). The absence of adequate and efficient infrastructure imposes high transaction costs that hinder the economy from achieving its full potential, even when progress is made in other domains. Physical infrastructure, encompassing transportation, power, and communication networks, fosters backwards and forward linkages that stimulate growth. In contrast, social infrastructure, including essential services such as water supply, sanitation, sewage disposal, education, and healthcare, directly improves the quality of life.

Odisha's economy has witnessed significant growth, with its Gross State Domestic Product (GSDP) projected to grow at 10.57% in 2023-24, outpacing the national average. Infrastructure investments have been pivotal, particularly in roads, railways, and industrial zones. The state's GSDP increased by 54.93% over the past five years, reflecting an annual average growth rate of 5.3%.

Table 3: Odisha's GSDP Growth (2018-19 to 2023-24)

| Year | GSDP (₹ Crore) | Growth Rate (%) |
|------------|----------------|-----------------|
| 2018-19 | 4,81,720 | - |
| 2019-20 | 5,11,364 | 6.15 |
| 2020-21 | 5,02,223 | -1.79 |
| 2021-22 | 5,86,000 | 16.67 |
| 2022-23 | 6,50,000 | 10.92 |
| 2023-24* | 7,18,000 | 10.57 |
| *Projected | | |

Source: Odisha Economic Survey 2023-24, Government of Odisha

TRANSPORTATION INFRASTRUCTURE

Transportation infrastructure, encompassing roads, railways, ports, and airports, is a cornerstone of economic development and social progress. In a state like Odisha, with its diverse geography and rich mineral resources, an efficient transportation network is vital for connecting rural and urban areas, facilitating trade, and driving industrial growth. Well-developed infrastructure reduces transportation costs, improves market access, and enhances the movement of goods and people, thereby boosting economic activity (Tripathy, 1994). For instance, Odisha's coastal economic zones, such as Dhamra, have seen increased industrial activity due to improved port and road connectivity,

Table 4: Transportation Infrastructure Development in Odisha (2023-24 Budget Overview)

| Category | Allocation (₹ Crore) | Target (km/ Units) | Details |
|----------------------|-----------------------|--------------------|--|
| New Roads | 5,295 | 2,000 km | Part of a 5-year plan to construct 15,000 km of roads across Odisha |
| Bridges | Included in the above | 20 units | Focus on enhancing connectivity in key regions |
| Rural Infrastructure | 1,500 | - | Aimed at improving rural road networks and accessibility |
| Railways | 320 | - | State contribution for projects like Khurda Road-Balangir and Jeypore-Malkangiri |
| Airports | 275 | - | Development of Shri Jagannath International Airport and other airstrips |

Source: Odisha Budget 2023-24, presented by Finance Minister Niranjana Pujari on February 24, 2023 (prsindia.org).

“Odisha budget: ₹19,452 crore earmarked for roads, railways and airports,” The New Indian Express, February 25, 2023.

which lowers trade costs and attracts investment. Moreover, transportation infrastructure supports social inclusion by linking remote areas to essential services like healthcare and education while also fostering tourism and regional integration. The state's ambitious plans, such as constructing 15,000 km of new roads over five years, reflect its recognition of these benefits, aiming to strengthen its position as an industrial and trade hub in eastern India.

Table 4 provides a broader view of transportation infrastructure investments in Odisha for 2023-24, including roads, railways, and airports. The ₹5,295 crore allocation for new roads aligns with the state's five-year goal of 15,000 km, with 2,000 km targeted for 2023-24 alone. The railway and airport allocations reflect Odisha's commitment to multi-modal connectivity, supporting industrial hubs and tourism.

Table 5: Road Development Progress in Odisha (2023-24 Budget vs. Previous Year)

| Category | 2023-24 Allocation (₹ Crore) | 2023-24 Target (km/ Units) | 2022-23 Allocation (₹ Crore) | 2022-23 Target (km/ Units) | Notes |
|----------------------|------------------------------------|----------------------------------|------------------------------------|----------------------------------|--|
| New Roads | 5,295 | 2,000 km | 4,725 | 3,000 km | Reduced target due to focus on quality |
| Bridges | Included in the above | 20 units | Included in the above | 9 units | Increased focus on bridge construction |
| Rural Infrastructure | 1,500 | - | 1,200 | - | Enhanced allocation for rural roads |

Source: "3,000 km roads; 9 bridges to be constructed by Odisha Govt in 2023-24," Construction World, March 20, 2023 (constructionworld.in). Odisha Budget Analysis 2023-24, PRS India (prsindia.org).

Table 5 compares road development in 2023-24 with the previous fiscal year (2022-23). While the 2022-23 budget allocated ₹4,725 crore for 3,000 km of roads and nine bridges, the 2023-24 budget adjusts the target to 2,000 km but increases bridge construction to 20 units, indicating a shift toward strategic infrastructure priorities. These investments underscore Odisha's efforts to leverage transportation infrastructure for economic growth, regional connectivity, and improved quality of life, particularly in its coastal and rural areas.

INDUSTRIAL INFRASTRUCTURE AND FDI IN ODISHA

Industrial infrastructure drives economic growth and attracts Foreign Direct Investment (FDI) in Odisha. Key developments like the Kalinganagar National Investment Manufacturing Zone (NIMZ) and Special Economic Zones (SEZs) have positioned the state as a manufacturing and industrial hub, leveraging its rich mineral resources and strategic coastal location. The Kalinganagar NIMZ, spanning 40,339 acres, is designed to foster metal and manufacturing industries with state-of-the-art infrastructure, drawing significant investments in steel and downstream sectors. Similarly, SEZs like those at Gopalpur and Info Valley have catalysed export-oriented industries like IT/ITES and pharmaceuticals. 2012-13, Odisha secured FDI commitments of ₹53,000 crore, reflecting its growing appeal to investors. The Make in Odisha Conclave 2022 further underscored this potential, securing investment proposals worth ₹10.5 lakh crore across diverse sectors, with metals and downstream industries leading at ₹5.5 lakh crore. These initiatives boost FDI inflows and generate substantial employment, aligning with Odisha's vision to enhance its industrial ecosystem and contribute to India's manufacturing goals.

Table 6: FDI Inflows and Commitments in Odisha (Selected Years)

| Year | FDI Amount (₹ Crore) | Key Sectors | Notes |
|---------------------------|-------------------------|--------------------------------------|---|
| 2012-13 | 53,000 | Steel, Mining, Manufacturing | Commitments reported by the Odisha government |
| 2020-21 | 1,200 | Renewable Energy, Power, IT | Actual inflows as per DPIIT data |
| 2022-23 | 2,500 (est.) | Metals, Chemicals, Infrastructure | Estimated inflows tied to Make in Odisha Conclave commitments |
| Cumulative (2000-2023) | 14,000 (est.) | Multi-sectoral | Total FDI inflows based on DPIIT and state estimates |

Sources:

2012-13 FDI commitments: Odisha Economic Survey 2013-14, Government of Odisha.

2020-21 FDI inflows: Department for Promotion of Industry and Internal Trade (DPIIT), FDI Statistics, Ministry of Commerce and Industry, Government of India.

2022-23 and cumulative estimates: Extrapolated from Make in Odisha Conclave 2022 outcomes (Invest Odisha) and UNCTAD World Investment Report 2024 trends.

Table 6 shows that Odisha's FDI shifted from ₹53,000 crore in 2012-13 (steel, mining) to ₹1,200 crore in 2020-21 (renewable energy, IT), with

₹2,500 crore estimated for 2022-23 (metals, infrastructure). Cumulative FDI (2000-2023) reached ₹14,000 crore, reflecting sectoral diversification.

Table 7: Investment Proposals from Make in Odisha Conclave 2022

| <i>Sector</i> | <i>Investment (₹ Crore)</i> | <i>Employment Potential</i> | <i>Key Projects</i> |
|----------------------------|-----------------------------|-----------------------------|---|
| Metals & Downstream | 5,50,000 | 3,50,000 | Steel plants, ancillaries at Kalinganagar |
| Power & Renewable Energy | 2,38,000 | 2,00,000 | Solar, wind, and green energy projects |
| Chemicals & Petrochemicals | 76,000 | 80,000 | Paradip PCPIR expansion |
| Logistics & Infrastructure | 1,20,000 | 1,50,000 | Ports, roads, and warehousing |
| Total | 10,50,000 | 10,37,701 | Across 21 sectors |

Sources: Make in Odisha Conclave 2022 Official Report, Invest Odisha (investodisha.gov.in), published December 2022. "Odisha gets investment intents worth ₹10.5 lakh crore at Make in Odisha Conclave," The Economic Times, December 3, 2022.

Table 7 traces Odisha's FDI trajectory, starting with the significant ₹53,000 crore commitment in 2012-13, primarily tied to steel and mining projects like those in Kalinganagar. Actual inflows in recent years (e.g., ₹1,200 crore in 2020-21) are lower due to implementation timelines, but the 2022-23 estimate reflects momentum from the Conclave. Cumulative FDI is an approximation based on DPIIT data and state reports, as Odisha's share in India's total FDI remains modest compared to states like Maharashtra or Gujarat. The metals sector dominates due to Odisha's mineral wealth and the Kalinganagar NIMZ, while power and logistics reflect infrastructure priorities. Employment figures are ambitious and assume full project realisation.

Thus, Odisha's industrial infrastructure, exemplified by NIMZ and SEZs, has been instrumental in attracting FDI and fostering economic development, with the 2022 Conclave marking a significant milestone.

PROGRESS IN IRRIGATION INFRASTRUCTURE

Irrigation infrastructure plays a critical role in ensuring food security, enhancing agricultural productivity, and reducing the risk of crop failure, as it provides a reliable and controlled water supply to crops, which is essential for sustained agricultural production. The importance of irrigation infrastructure is evident

in its ability to contribute significantly to food security by guaranteeing a steady water source. This is especially crucial in regions where rainfall is erratic or insufficient to meet crops' water needs. Moreover, irrigation can lead to increased agricultural productivity, as it not only boosts crop yields but also allows for the cultivation of a larger area of land, thereby expanding the agricultural output and helping to meet the growing food demands. Furthermore, irrigation serves as a vital tool for reducing the risk of crop failure, as it enables farmers to manage water supply efficiently, making them more resilient to climatic shocks such as droughts or uneven rainfall patterns. The development of irrigation infrastructure also generates employment opportunities, as it requires a significant workforce to construct, operate, and maintain irrigation systems, providing jobs in rural and urban areas. Moreover, the availability of reliable irrigation helps stabilise farmers' livelihoods, particularly in drought-prone areas, where it can mitigate the financial risks associated with crop failure and income loss. The need for irrigation infrastructure arises from various factors, such as the requirement for drought compensation, where irrigation can be used during periods of insufficient rainfall or when rainfall patterns are unpredictable, thus ensuring crops receive the necessary water. Moreover, irrigation has the potential to transform wastelands into productive agricultural land, thereby increasing the area available for cultivation and improving overall land utilisation. Irrigation protects crops, safeguarding them from potential damage caused by frost and inhibiting weed growth, which can otherwise reduce crop yields. Furthermore, implementing irrigation systems can prevent soil consolidation, ensuring it remains suitable for farming by maintaining its structure and preventing compaction, which can negatively affect crop growth and soil fertility.

Irrigation remains a priority area for the Odisha government, as highlighted in the State Agricultural Policy 2013, which aims to ensure assured irrigation for at least 35% of cultivable land in each of the state's 314 blocks. Despite significant achievements, 80 blocks are yet to meet this target. By March 31, 2018, the state had created an irrigation potential of 59.16 lakh hectares, although only 34.4 lakh hectares (41.1% of the GCA) were utilised. This utilisation rate has declined alarmingly from 80.5% in 2007-08 to 58.14% in 2017-18.

Underutilising irrigation potential highlights the need for improved schemes such as Biju Krushak Vikas Yojana (BKVY), Jananidhi, and Mega Lift

Irrigation projects. The government has identified 174 projects in 15 clusters to provide irrigation to 2.14 lakh hectares of land using water from rivers such as Vansadhara, Indrabati, and Mahanadi. Substantial investments, averaging 31% of the state's capital outlay over seven years, have been allocated for irrigation and flood control projects. These efforts include support from NABARD under schemes like RIDF and Integrated Water Management Projects.

Table 8: Irrigation Development in Odisha

| <i>Parameter</i> | <i>Details</i> |
|--|--|
| Policy Target (State Agricultural Policy-2013) | Assured irrigation for at least 35% of cultivable land in each of Odisha's 314 blocks |
| Blocks Yet to Meet Target | 80 |
| Irrigation Potential Created (as of 31st March 2018) | 59.16 lakh hectares |
| Utilisation of Irrigation Potential | 34.4 lakh hectares (41.1% of GCA) |
| Decline in Utilisation Rates | 80.5% in 2007-08 to 58.14% in 2017-18 |
| Key Schemes to Address Underutilisation | Biju Krushak Vikas Yojana (BKVY), Jananidhi, Mega Lift Irrigation Projects |
| Identified Projects and Coverage | 174 projects in 15 clusters to irrigate 2.14 lakh hectares using rivers like Vansadhara, Indrabati, and Mahanadi |
| Capital Outlay for Irrigation | Averaged 31% of the state's capital budget over seven years |
| Support from NABARD | RIDF and Integrated Water Management Projects |

Source: National Bank for Agriculture and Rural Development. (2020). State focus paper 2020-21: Odisha. Odisha Regional Office. National Bank for Agriculture and Rural Development. (2020). State focus paper 2020-21: Odisha. Odisha Regional Office.

Table 8 depicts Odisha's 2013 policy, which aimed for 35% irrigation across 314 blocks but had 80 lags. Irrigation potential hit 59.16 lakh hectares by 2018, yet utilisation dropped from 80.5% (2007-08) to 58.14% (2017-18). Schemes like BKVY and 174 projects target 2.14 lakh hectares.

WATERSHED DEVELOPMENT AND SUSTAINABILITY

Watershed development and sustainability are crucial for the conservation of natural resources, improvement in water quality, and the promotion of economic development, as healthy watersheds serve as the foundation for maintaining ecological balance, improving livelihoods, and fostering resilience

against environmental changes (Tripathy, 2009, 2010b, 2013, 2015b). The importance of watershed development lies in its provision of numerous ecosystem services, such as water storage, flood control, and nutrient cycling, all of which are essential for maintaining the health of both natural and human systems. These services contribute significantly to the stability of the local environment, ensuring that natural resources remain available for future generations. Moreover, watershed development plays a pivotal role in economic development, particularly in rural areas, where it creates job opportunities, enhances agricultural productivity, and supports local economies through the sustainable management of water resources (Tripathy 2010b, 2017b, 2020, 2023). Through improving soil quality and water availability, watershed development can lead to higher crop productivity, enhancing farmers' income and strengthening the overall rural economy. In addition to economic benefits, healthy watersheds help to reduce vulnerability to climate change, natural disasters, and the spread of invasive species by providing a buffer that mitigates the effects of these environmental challenges, ultimately contributing to increased resilience in the face of changing conditions (Tripathy, 2013, 2015a, 2020, 2023). The need for watershed development is evident in addressing the growing water demands, particularly in regions where water resources are limited, as well as in reversing the ecological damage caused by human activities and poor management practices that threaten the health of water resources.

Climate change further exacerbates the problem, making it even more critical to ensure the sustainable management of watersheds to safeguard water availability for both people and ecosystems (Tripathy, 2015b, 2017b, 2019). Sustainable watershed management strategies include selective logging, which focuses on harvesting mature trees while preserving young ones to maintain the ecological integrity of forests; streamside management, which involves leaving undisturbed strips of trees along streams to filter runoff and prevent soil erosion; proper grazing practices that involve rotating livestock, controlling animal numbers, and limiting access to water bodies to reduce overgrazing; and public outreach initiatives that aim to educate local communities about the importance of watershed conservation and their role in its management. Through these efforts, watershed development programs seek to balance water resources' conservation, regeneration, and sustainable use, ensuring long-term ecological health and economic stability (Tripathy, 2017b; Tripathy & Prasanna, 2023).

To mitigate the challenges in rainfed areas, the government of Odisha has undertaken watershed development projects, including the National Watershed Development Projects for Rainfed Areas (NWDPPRA), which aimed to treat 1.18 lakh hectares in 2017-18. Additional programs such as the Integrated Watershed Management Programme (IWMP) and NABARD-supported watershed projects facilitate soil and water conservation, bring cultivable wastelands under agriculture, and ensure sustainable land use.

In 2023, Odisha made notable strides in watershed development by constructing various water conservation infrastructure, including river embankments, farm ponds, and water harvesting structures, significantly improving water management and agricultural productivity across the state. Specifically, 167 river embankments were created, along with 241 hectares of plantations aimed at conserving soil and moisture, while around 260 farm ponds were constructed to store water for agricultural use. Furthermore, the state constructed 170 check dams and 160 diversion weirs to enhance water storage and improve irrigation systems, alongside the creation of 1,320 water harvesting structures and 460 percolation tanks designed to capture and retain rainwater for groundwater recharge. Moreover, 670 groundwater recharge structures were built to augment underground water reserves, and approximately 54,000 hectares were covered under advanced irrigation techniques, including drip and sprinkler systems, which help in efficient water use for agriculture. In 2024, the state planned to continue its commitment to watershed development with the launch of the Watershed Yatra Campaign, which includes key activities such as Bhoomi Poojan, Lokarpan, Watershed Mahotsav, and Shramdan, all aimed at obilizing public participation and raising awareness about the importance of watershed conservation. In addition, the state has set a target to construct 360 kilometres of field channels to facilitate efficient water distribution to agricultural lands, thus enhancing irrigation and improving crop yields. These ongoing watershed development projects are designed to resolve the challenges faced by degraded and rainfed land, improving their productivity while also strengthening local institutions and ensuring that the management and execution of watershed projects become more efficient, sustainable, and community-driven (Tripathy, 2023, 2015a).

Odisha's watershed development, under schemes like PMKSY, enhances sustainability by conserving soil and water, boosting agriculture, and improving

livelihoods. Over 3,000 watersheds are being implemented, fostering resilience and ecological balance in rural areas.

Table 9: Watershed Projects under PMKSY in Odisha (2023-24)

| Category | Projects | Area Covered (Ha) | Investment (₹ Crore) |
|----------------------------|----------|-------------------|----------------------|
| Ongoing Watersheds | 3,000+ | 1,50,000 | 900 |
| New Micro Watersheds (KBK) | 314 | 1,67,000 | 100.57 |
| Rainfed Area Development | - | 50,000 | 250 |

Source: Odisha Economic Survey 2023-24, Directorate of Soil Conservation and Watershed Development (soilodisha.nic.in).

Table 9 reveals that Odisha's watershed projects span 3,000+ ongoing efforts covering 1.5 lakh hectares (₹900 crore), 314 new KBK micro watersheds over 1.67 lakh hectares (₹100.57 crore), and rainfed development across 50,000 hectares (₹250 crore), boosting agricultural resilience.

Table 10: Sustainability Outcomes of Watershed Programs (2022-23)

| Outcome | Achievement | Districts Covered | Beneficiaries |
|-------------------------|----------------|-------------------|---------------|
| Groundwater Recharge | 25% increase | 30 | 2,50,000 |
| Soil Erosion Reduction | 30% reduction | 25 | 1,80,000 |
| Multi-cropping Adoption | 15,000 farmers | 20 | 75,000 |

Source: "Rejuvenating Watersheds for Agricultural Resilience," World Bank Report, 2022 (worldbank.org); Odisha Watershed Development Mission (soilodisha.nic.in).

Table 10 infers that Odisha's initiatives boosted groundwater recharge by 25% across 30 districts, benefiting 2.5 lakh people, reduced soil erosion by 30% in 25 districts for 1.8 lakh, and enabled multi-cropping for 15,000 farmers across 20 districts, aiding 75,000.

ADVANCEMENTS IN ENERGY INFRASTRUCTURE

Energy infrastructure development is vital for fostering economic growth, ensuring environmental sustainability, and mitigating the impacts of climate change, as it underpins the operations of businesses, enhances the quality of life, and contributes to a more sustainable and resilient energy system. One of the primary reasons for the importance of energy infrastructure development is its role in economic growth, as access to reliable and affordable energy is essential for industrial production, creating jobs, and stimulating various

industries, thus driving the economy forward. Moreover, developing renewable energy infrastructure significantly promotes environmental sustainability by reducing emissions, conserving water, and facilitating a transition toward a more sustainable energy system that minimises the negative environmental impact of fossil fuels. Regarding climate change mitigation, renewable energy sources such as wind, solar, and hydropower can significantly reduce carbon emissions, helping curb global warming and lessen the effects of climate change on vulnerable communities and ecosystems (Tripathy, 2015b, 2019). However, several challenges to energy infrastructure development must be resolved, including ageing infrastructure, which can lead to frequent power outages, disrupting daily life and critical services, and limited access to electricity in many developing countries, which hinders economic development and quality of life. Moreover, the reliability of energy infrastructure can be a concern, as frequent blackouts and fluctuations in electricity access can undermine both productivity and public confidence in the system. At the same time, affordability remains a barrier for many, especially in low-income regions where the cost of electricity can prevent families and businesses from accessing energy. Despite these challenges, there are numerous opportunities for advancing energy infrastructure development, mainly through the widespread adoption of renewable energy, which has become more affordable and accessible, making it a viable alternative to traditional fossil fuels. Moreover, improving energy efficiency can significantly reduce overall energy consumption, thus reducing costs and environmental impact. Furthermore, the digitalisation of energy systems offers the potential to streamline administrative processes, improve operational efficiency, and reduce lead times for infrastructure construction and development, all of which can accelerate the transition to a more sustainable and reliable energy future.

Energy infrastructure is the backbone of Odisha's economic and social development, fueling industrial expansion, agricultural modernisation, and rural upliftment. With an installed power capacity of 8,124.91 MW as of March 2024, Odisha primarily supports its mineral-based industries, such as steel and aluminium, through thermal power (65.1%). Investments in hydropower and renewables enhance sustainability, while rural electrification drives mechanised farming and agro-processing, reducing dependency on manual labour and boosting productivity. Reliable energy access also improves

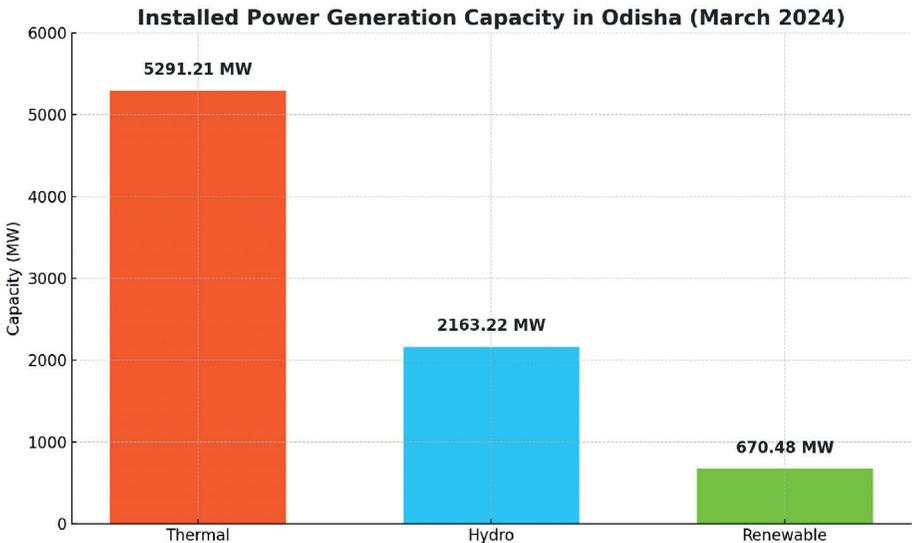
living standards, powering healthcare, education, and small-scale enterprises, positioning Odisha as a key player in India’s energy landscape.

Odisha has made significant strides in achieving 95% village electrification under the “24x7 Power for All” scheme. By March 2019, all 50,359 villages in the state were electrified, and 96.71 lakh households had access to electricity. Despite an installed capacity of 5,486 MW, only 57.5% was utilised in 2018-19, with energy consumption rising steadily. Investments in renewable and non-conventional energy sources have also been prioritised to meet future demands sustainably.

Table 11: Installed Power Generation Capacity in Odisha (March 2024)

| Source | Capacity (MW) | Percentage (%) | Key Contributors |
|--------------|-----------------|----------------|--------------------------------------|
| Thermal | 5,291.21 | 65.1 | NTPC, OPGC, Vedanta |
| Hydro | 2,163.22 | 26.6 | OHPC (e.g., Upper Kolab, Balimela) |
| Renewable | 670.48 | 8.3 | Solar (Aditya Solar), Wind, Biomass |
| Total | 8,124.91 | 100 | State and Central utilities combined |

Source: Central Electricity Authority (CEA), “Installed Capacity Report,” March 2024 (cea.nic.in). Odisha Economic Survey 2023-24, Energy Department, Government of Odisha.



Here is the vertical bar chart showing the installed power generation capacity in Odisha as of March 2024

Table 11 highlights that Odisha's power capacity totals 8,124.91 MW, with thermal dominating at 65.1% (5,291.21 MW) via NTPC and Vedanta, hydro at 26.6% (2,163.22 MW) from OHPC, and renewables at 8.3% (670.48 MW), led by solar and biomass.

Table 12: Growth of Power Capacity and Rural Electrification in Odisha (2019-2024)

| Year | Installed Capacity (MW) | Renewable Share (MW) | Rural Households Electrified (Lakh) | Notes |
|---------|-------------------------|----------------------|-------------------------------------|-------------------------------------|
| 2019-20 | 6,912.00 | 413.00 | 48.50 | Pre-Saubhagya completion |
| 2021-22 | 7,450.30 | 550.20 | 55.70 | Saubhagya scheme impact |
| 2023-24 | 8,124.91 | 670.48 | 57.20 | Full rural electrification achieved |

Source: Ministry of Power, Government of India, "Saubhagya Dashboard" (saubhagya.gov.in), updated March 2024.

Odisha Renewable Energy Development Agency (OREDA) Reports, 2023-24 (oredaodisha.com).

CEA Monthly Reports, 2019-2024 (cea.nic.in).

Table 12 reflects Odisha's energy mix as of March 2024, with thermal power (e.g., NTPC's Talcher plant) dominating due to coal availability. Hydropower from Odisha Hydro Power Corporation (OHPC) and growing renewable sources, including solar projects under OREDA, diversify the grid. The data aligns with CEA's official figures.

This table tracks capacity growth and rural electrification over five years. The increase from 6,912 MW in 2019-20 to 8,124.91 MW in 2023-24 reflects infrastructure upgrades, while renewable capacity nearly doubled. Rural electrification will reach 57.2 lakh households by 2024, fulfilling the Saubhagya scheme's goal of 100% coverage and enhancing agricultural and rural economic activity. Thus, Odisha's energy infrastructure supports its industrial backbone, promotes sustainability through renewables, and drives inclusive growth via rural electrification.

ENHANCING POST-HARVEST INFRASTRUCTURE

Enhancing post-harvest infrastructure in Odisha is critical for reducing agricultural losses, improving farmer incomes, and ensuring food security. With significant paddy, vegetables, and fruit production, the state faces post-harvest losses of 20-30% due to inadequate storage, cold chains, and processing facilities. Initiatives like the Odisha Agriculture Policy 2020 and partnerships

with organisations such as the Asian Development Bank aim to develop modern infrastructure, including warehouses and cold storage, to bolster value addition and market linkages, supporting sustainable agricultural growth.

Improving post-harvest infrastructure is crucial for reducing food loss and waste, ensuring more food reaches those in need, and significantly alleviating food insecurity and poverty, particularly in rural and marginalised communities. One of the key benefits of enhancing post-harvest infrastructure is the improvement of food safety, as efficient infrastructure helps prevent the growth of mold, bacterial contamination, and spoilage, thereby ensuring that food remains safe for consumption (Tripathy, 2017a, 2021). Moreover, such infrastructure helps maintain the nutritional quality of harvested produce by providing proper storage and handling, preserving vital nutrients and extending fresh food's shelf life.

Regarding food security, post-harvest infrastructure contributes to reducing food loss and waste by facilitating better handling, storage, and transportation, thus ensuring that more food is available to meet the growing demand, especially in developing countries facing high food insecurity. Furthermore, the development of post-harvest infrastructure can empower small-scale farmers and local communities by providing them with the tools and systems necessary to improve their productivity and access to markets, which, in turn, can help alleviate poverty by increasing their income and economic opportunities. Key components of post-harvest infrastructure include cold storage units, which help to preserve perishable goods by providing optimal storage conditions; refrigerated carriers, which ensure that produce remains fresh during transportation; and packaging systems, which protect harvested crops from damage and contamination during handling and distribution. Information and warehouse management systems also play a pivotal role by tracking and managing the flow of produce, ensuring that it is stored, processed, and distributed efficiently (Tripathy, 2017a, 2021).

Technological advancements in cooling and cold storage, solar dryers, and hermetic grain storage further enhance the capabilities of post-harvest infrastructure by providing cost-effective and sustainable solutions for preserving food quality, particularly in areas with limited access to electricity or modern storage facilities. To maximise the value of agricultural produce, a comprehensive post-harvest infrastructure system is essential, including

processing, grading, packaging, transportation, and storage facilities, which help reduce losses, improve market access, and increase economic returns for farmers and communities.

The Odisha State Agricultural Marketing Board (OSAM) has spearheaded efforts to improve marketing facilities, create storage capacities, and establish market linkages for farmers. Modernised market yards, integrated cotton markets, and maize mandis provide farmers with competitive pricing and reduce post-harvest losses, which currently stand at approximately 30%.

Table13: Post-Harvest Infrastructure Development in Odisha (2023-24)

| <i>Infrastructure Type</i> | <i>Units Planned</i> | <i>Capacity (MT)</i> | <i>Investment (₹ Crore)</i> | <i>Key Focus Areas</i> |
|----------------------------|----------------------|----------------------|-----------------------------|-----------------------------|
| Warehouses | 50 | 1,00,000 | 150 | Paddy, pulses storage |
| Cold Storages | 20 | 50,000 | 200 | Vegetables, fruits |
| Processing Units | 10 | 25,000 | 100 | Value addition (e.g., rice) |

Source: Odisha Agriculture Policy 2020, Department of Agriculture & Farmers' Empowerment, Government of Odisha; Annual Report 2023-24, Odisha State Agricultural Marketing Board (osamboard.org).

Table 13 reflects Odisha's ongoing efforts to enhance post-harvest infrastructure under the 2020 Agriculture Policy, targeting key crops. Investments focus on reducing spoilage and enabling market access, with data sourced from state government plans.

Table 14: Post-Harvest Losses and Infrastructure Impact (2022-23)

| <i>Crop</i> | <i>Estimated Loss (%)</i> | <i>Loss Value (₹ Crore)</i> | <i>Infrastructure Intervention</i> | <i>Beneficiaries</i> |
|-------------|---------------------------|-----------------------------|------------------------------------|----------------------|
| Paddy | 20-25 | 1,500 | Warehouses, drying platforms | 5,00,000 farmers |
| Vegetables | 25-30 | 800 | Cold storages, pack houses | 2,00,000 farmers |
| Fruits | 20-25 | 300 | Cold chains, processing units | 1,00,000 farmers |

Source: "Post-Harvest Management in Odisha," Odisha Economic Survey 2023-24; FAO Report on Post-Harvest Losses in India, 2022 (fao.org).

Table 14 underlines the scale of post-harvest losses and the impact of infrastructure interventions, drawing from economic surveys and FAO

estimates. It shows significant benefits to farmers through reduced wastage and improved earnings.

CONCLUSION AND SUGGESTIONS

Infrastructure development, encompassing agriculture, irrigation, energy, and post-harvest sectors, is a critical enabler of Odisha's socio-economic transformation. The state can unlock its full potential by resolving gaps and leveraging government initiatives, ensuring sustainable growth and improved quality of life for its citizens.

Infrastructure Investment for Agriculture: Strengthening irrigation infrastructure and implementing advanced water management practices, such as rainwater harvesting and soil moisture conservation, will significantly boost agricultural productivity. This will ensure sustainable cropping patterns and mitigate the adverse effects of climate variability.

Promotion of Diversified Cropping Systems: Encouraging mixed and intercropping systems alongside modern crop varieties can enhance soil fertility and increase farmers' income. This approach can help reduce dependency on monocropping while also addressing the impacts of pests, diseases, and climate change.

Enhance Watershed Management through Community Participation: The government of Odisha should prioritise community-led watershed management initiatives by involving local farmers, tribal communities, and grassroots organisations in planning, implementing, and monitoring watershed projects. Encouraging active participation ensures that these projects align with local communities' needs and practices, leading to sustainable land use, effective water management, and the protection of natural resources. Furthermore, it will empower local communities to manage their water resources, fostering long-term ownership and resilience against climate change.

Promote Sustainable Agricultural Practices with Integrated Watershed Programs: The state should integrate watershed management with sustainable agricultural practices, such as agroforestry, organic farming, and soil conservation techniques, to maximise the benefits of water conservation efforts. Encouraging the adoption of climate-resilient crops and providing training on efficient water usage and crop diversification will help improve the productivity of rainfed areas, reducing dependency on traditional irrigation methods and

contributing to overall food security. Moreover, government schemes should incentivise farmers to adopt water-saving technologies like drip irrigation that are compatible with watershed development objectives.

Invest in Multi-Purpose Water Conservation Structures: Odisha should focus on expanding the construction of multi-purpose water conservation structures like farm ponds, check dams, and percolation tanks. These structures provide water for irrigation and support livestock, drinking water, and groundwater recharge. These structures can significantly enhance water availability during dry spells and buffer the impacts of erratic rainfall, particularly in vulnerable regions. Moreover, linking these water conservation efforts to crop planning will help ensure optimal water usage and minimise waste during agricultural cycles.

Improve Data Collection and Monitoring Systems for Watershed Projects: Implementing advanced data collection and management systems for monitoring watershed health, water availability, and agricultural productivity can provide critical insights into the effectiveness of ongoing initiatives. Odisha should invest in digital platforms and satellite technology to track watershed conditions, water usage patterns, and the success of conservation practices in real-time. This data-driven approach would enable more informed decision-making, facilitate the adaptive management of resources, and help evaluate the impact of past interventions, ensuring that the state's watershed development projects achieve long-term sustainability.

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