A SCOPING STUDY
The Potential to Promote Climate Smart Agriculture
for a Resilient Odisha

Data-Driven Prioritisation of Districts for Climate-Smart Agriculture in Odisha

April 2025

CSTEP | Center for Study of Science, Technology and Policy (CSTEP)

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MESSAGE FROM
THE DEPUTY CHIEF MINISTER

Odisha is committed to advancing agricultural development that is both climate-resilient and future-ready. As we navigate the evolving challenges of climate change, water stress, and changing resource demands, the need for informed, data-driven action has never been greater and visible.

This report series marks an important step in that direction. Drawing on assessments of resource use, greenhouse gas emissions, and climate risks, it presents a composite baseline that can guide how and where we act. The district-level insights and rankings serve as a compass, helping us identify areas where the alignment of interventions can be most impactful.

The insights emerging from this study offer a timely opportunity to guide future policy decisions and support the expansion of Climate Smart Agriculture across Odisha.

I appreciate the efforts of the Department of Agriculture and Farmers' Empowerment, the Climate Resilience Cell, and our knowledge partners for producing this valuable body of work. Odisha is proud to be at the forefront of resilient and climate-informed agricultural planning and action.

(K. V. Singh Deo)

Sri Kanak Vardhan Singh Deo
Deputy Chief Minister,
Agriculture & Farmers' Empowerment and Energy,
Government of Odisha

FOREWORD

Climate change is no longer a distant concern – it is an everyday reality for our farmers. Building resilience into our agricultural systems requires data-driven insights that can inform bold yet practical decisions on the ground.

This scoping study presents one such effort. By identifying districts where climate risks, resource pressures, and emissions converge, we now have a stronger foundation to design pilots, prioritize investments, and deliver interventions that will make a difference where they are most needed.

The findings of this study provide valuable insights for the uptake and implementation of Climate Smart Agriculture practices and will support district teams in planning for future climate risks while ensuring productivity and sustainability. I appreciate the efforts of the Climate Resilience Cell of this department, our technical partners, CSTEP, and the support of the Gates Foundation in advancing this important agenda.

Dr. Arabinda Kumar Padhee, IAS
Principal Secretary to the Government,
Department of Agriculture and Farmers' Empowerment,
Government of Odisha

The Odisha landscape, rich with natural beauty and agricultural charm, showcases the region's blend of tradition and nature.

Mayur Kakade

EXECUTIVE SUMMARY

Odisha's agricultural and allied sectors, which are vital to the state's economy, face growing threats from climate change and its associated extremes. This scoping report series aims to identify priority districts for targeted interventions to enhance resilience in these sectors. The analysis integrates three key components—Resource Use Profiling (RUP), Greenhouse Gas (GHG) Emissions Inventory, and Climate Risk Assessment (CRA)—to examine the nature, extent, and intensity of climate impacts on agriculture and allied activities.

The findings provide a triangulated approach to identify districts with high resource use, high GHG emissions, and significant climate risks. These insights will inform the development of District-Level Climate Action Plans and promote the adoption of Climate Smart Agriculture (CSA) practices. The report series is divided into three parts. Part 1 explores RUP and GHG emissions, while Part 2 focuses on climate risks and these are synthesized in this report to identify priority districts for CSA interventions to maximize climate resilience and sustainability. For context, this executive summary also provides an overview of the methods and key findings from all Parts of this report series.

PART 1 A

Resource Use Profiling

The resource use profiling section of the study provides a detailed examination of the inputs required for paddy cultivation in Odisha, focusing on the intensity and efficiency of fertilizer, manure, pesticide, water, and mechanization use. Paddy was selected for this assessment as it is widely cultivated across all districts and accounts for a substantial share of input usage.

The assessment measured the application of Nitrogen (N), Phosphorus (P), Potassium (K), manure and pesticide in paddy farming. Water Use Efficiency (WUE) was analysed using Biophysical Water Productivity, which evaluates the amount of water needed to produce one kilogram of paddy. Regions where more water was used to produce the same amount of crop, highlights poor water use efficiency. Additionally, the study assessed the level of mechanization in paddy cultivation, which directly affect labour productivity and energy use.

The analysis highlights considerable variation in resource-use patterns across Odisha's districts, as captured by the RUP index. Districts such as Balangir, Khordha, Jajpur, Gajapati, Kandhamal, and Deogarh exhibit high RUP index scores driven by high water use, low levels of mechanisation, and high cumulative input application—particularly excessive manure use combined with low fertiliser use. These patterns indicate a pressing need for resource optimisation through CSA practices.

Conversely, districts like Kalahandi, Nabarangpur, Kalahandi, Subranapur, Sambalpur, and Bargarh register low RUP index scores, reflecting relatively efficient water use and better mechanisation, along with lower organic manure use but higher application rates of fertilisers and pesticides. While these districts perform better overall, targeted improvements in input balancing and mechanisation are still necessary.

Taking into account both aggregate and component-level inefficiencies, **Balangir**, **Nabarangpur**, and **Bargarh** have been identified – through consultations with the Department of Agriculture and Farmers' Empowerment, Government of Odisha – as priority districts for implementing resource-efficient CSA interventions.

PART 1 B GHG Emission Inventory

The GHG emissions inventory section provides a detailed assessment of greenhouse gas emissions from Odisha's agriculture and allied sectors over the period 2014 to 2023. Unlike the RUP, which focused solely on paddy cultivation, this inventory evaluates emissions from multiple sources: CH4 emissions from paddy cultivation, and livestock (including enteric fermentation and manure management), fertilizer application (resulting in nitrous oxide - N_2O emissions), and fuel consumption by farm machinery (leading to carbon dioxide - CO_2 emissions). The analysis encompasses all crops in the district, following the methodology outlined by the GHG Platform of India.

Puri and Bhadrak emerged as the districts with the highest per-hectare GHG emissions. These areas are characterized by lowland topography with extensive deep-water and flood-prone rainfed rice ecosystems, which contribute significantly to emissions.

PART 2 Climate Risk Assessment

The climate risk assessment section evaluates the risk of Odisha's agriculture and allied sectors to three key climate hazards: drought, flood, and heatwaves, using the IPCC AR5 Risk Assessment Framework, 2014. Tropical cyclone risk was incorporated at a later stage of this assessment, as cyclones have been frequently occurring events impacting Odisha. Separate risk assessments were conducted for three cyclone categories based on wind speed: 60–90 km/h, 90–120 km/h, and 120 km/h and above. The assessment analyses the probability of hazard occurrence, exposure of agriculture, livestock and fisheries assets to these hazards, and the inherent vulnerability of these sub-sectors across districts. The hazard, exposure and vulnerability scores are then aggregated to provide relative risk scores that may be used to identify districts most at risk to the selected hazards.

According to the assessment:

- Nuapada, Balangir, Mayurbhanj, Malkangiri, Ganjam, Subranapur, and Sundargarh, were found to be most at risk to droughts.
- Flood risk across the state was generally low. However, Kendrapara, Balasore, and Bhadrak emerged as being relatively more at risk to floods, followed by Boudh, Cuttack, Puri, and Jajpur, mainly due to their low-lying topography and proximity to the coast.
- Dhenkanal, Angul, Ganjam, Sundargarh, Mayurbhanj, Keonjhar, and Sambalpur were found to be most at risk to heatwaves.
- Balasore and Mayurbhanj face the highest risk of severe tropical cyclones due to a high probability of occurrence, with Balasore's risk heightened by exposure of agriculture, livestock, and fisheries. Nayagarh and Boudh are most at risk to cyclones with wind speeds of 60–90 km/h due to the high probability of occurrence and inherent vulnerability.
- Districts like Sundargarh and Mayurbhanj are highly at risk to multiple hazards (heatwaves and droughts), highlighting a need for multi-hazard resilience strategies to address compounded climate impacts. Additionally, Balasore and Mayurbhanj face compounded risks from both flooding and severe tropical cyclones.

Establishing the Baseline

The baseline in this scoping study was established by integrating the findings from the above three assessments.

- The RUP identified districts with high input use but low water-use efficiency and low mechanisation where resource use efficiency could be optimised.
- The GHG inventory identified high-emission areas where interventions are needed to reduce emissions and improve sustainability, and
- The CRA identified districts most at risk to droughts, floods, heatwaves and tropical cyclones, which require targeted resilience and adaptation strategies.

The baseline was formed by combining the district-level findings into an overall baseline index. The districts were ranked based on their cumulative performance across these three indicators (RUP, GHG and CRA). For example, Bhadrak and Puri emerged as districts with high per-hectare GHG emissions and significant climate risks, especially to floods, making them a priority for intervention. Balangir ranked high due to high climate risk to droughts as well as high resource-use, while Jajpur's ranking was primarily driven by high resource-use, particularly high input application rates.

By synthesising these data points, the baseline provides a clear picture of Odisha's current environmental, climatic, and agricultural status. It identifies priority areas for risk reduction, emissions mitigation, and resource optimisation, forming the foundation for developing District-Level Climate Action Plans and scaling up CSA practices across the state.

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Abbreviations

Abbreviated form	Expanded form
CRA	Climate Risk Assessment
CSA	Climate Smart Agriculture
GHG	Greenhouse Gas
GSVA	Gross State Value Added
RUP	Resource Use Profiling
SAPCC	State Action Plan for Climate Change
WUE	Water Use Efficiency

OPPOSITE PAGE: Adivasi women from the Desia Kondh tribe selling vegetables in the Kunduli market, in Odisha. Oscar Espinosa

1. Introduction

Understanding the challenges faced by Odisha's agriculture and allied sectors requires a thorough grasp of the state's geographical and climatic context. Odisha is India's eighth-largest state, covering 4.7% of the country's land area, with a coastline of 450 km along the Bay of Bengal. The state's geographical area spans 155,707 sq. km, bordered by Chhattisgarh to the west and Andhra Pradesh to the south. The state's topography mainly comprises fertile coastal plains, central highlands, and uplands in the west and northwest. The Mahanadi River and other rivers like Subarnarekha and Brahmani together make-up for the state's prominent river systems. Chilika Lake, located on the east coast of the state, is a notable brackish water lagoon (Geography of Odisha, 2012). Therefore, the state presents a diverse landscape, ranging from fertile coastal plains to central highlands, along with its complex river systems that play a significant role in shaping its agricultural productivity.

Odisha's topography also exposes it to frequent climate extremes, such as floods, droughts, and tropical cyclones, which have a direct impact on the state's economy and food security. The state experiences a tropical climate with three main seasons – summer, monsoon, and winter – along with annual tropical cyclones that influence its rainfall patterns, receiving an average 1451.2 mm annually, that varies across districts (OSDMA, 2024). Approximately 75% to 80% of this rainfall occurs during the southwest monsoon, which is uneven and erratic, leading to recurrent floods and droughts of varying severity (OSDMA, 2024). The state's annual mean temperature is 29.68°C (85.42°F) and it is 3.71% higher than India's average temperatures (Weather and Climate, 2024).

With 80% of the annual rainfall occurring within a three-month period, the state witnesses frequent flooding. While the coastal areas witness tropical cyclones and flooding, in-land districts are exposed to droughts and heatwaves. The state is also prone to earthquakes with many districts lying between seismic zones 1 and 2 (OSDMA, 2024). Odisha is thus highly at risk to the impacts of climate change, particularly tropical cyclones, floods, droughts, heatwaves and coastal erosion (IANS, 2023; MoHHW, 2022; Shankar et al., 2022). These extreme events increasingly jeopardize the state's economically crucial agriculture and allied sectors.

Despite these impacts, the contribution of agriculture and allied sectors to the state's GVA has increased from 18.9% in 2018-19 to 21% in 2023-24 (Odisha Economic Survey 2023-24). Livestock, the second-largest sub-sector after crops, contributes to 16.7% of the GVA from agri-culture and allied activities (Odsiha Economic Survey 2023-24). Fisheries has been the fastest-growing sub-sector, with a 13% average annual growth rate over the past five years, supporting 15 lakh fishers and three lakh aquaculture farmers (World Bank, 2021).

Despite adverse impacts, crop production has increased its contribution to the state's GVA from 18.9% in 2018-19 to 21% in 2023-24.

1.1. Overview of agriculture and allied sector

The state lies in the agro-climate zone I-VII of the country and as per the varying micro-climate at district level, has over 10 agro-climatic zones. The soil types range from fertile alluvial soil in the coastal plains, mixed red and black soil in the central tableland, to low- fertility red and yellow soil in the northern plateau, and red, black, and brown forest soil in the eastern ghats. (Hoda et al. 2017). The soils vary across the state from highly acidic to slightly alkaline to light sandy to stiff clay (Directorate of Agriculture and Food Production, Government of Odisha, 2019). Agriculture and allied activities are a major source of livelihood and income for 80-85% of the rural population in Odisha (Caritas India, 2021). The major crops cultivated in the state's agro-climatic zone, are, paddy, diverse horticultural and non-paddy crops, like cashew, coffee, millets, maize, pulses, oilseeds, onions, sweet potatoes, and fruits and vegetables (APEDA, 2023). The state's land use land cover map is presented in Figure 1 to give a broad overview of resource distribution.

Odisha is home to some of India's most vulnerable populations, with 32.6% being below the poverty line, as per the 2011 Census of India. According to the NITI Aayog's Multidimensional Poverty Index 2023, Odisha saw a notable reduction in poverty, with the percentage of people living in multidimensional poverty dropping from 29.34% in 2015–16 to 15.68% in 2019–21. This improvement translates to 62.6 lakh individuals moving out of poverty during the period. Yet, Odisha still ranks 12th out of 17 major states in terms of multidimensional poverty, highlighting the need for continued efforts. Over the years, the state has been taking measures to address agriculture-related concerns in terms of land use, income disparities, issues of water use efficiency and crop production. The state government has been implementing agricultural policies in convergence with public and private players. Some of these policies include – SAMRUDHI Agriculture Policy 2020, Shree Anna Abhiyan, Odisha Organic Farming Policy, etc.

The western and southern regions of Odisha are particularly known for pulses, oilseeds, and cotton, supported by schemes like the National Food Security Mission (NFSM) and the Shree Anna Abhiyan, while the coastal districts produce more rice, vegetables, and horticulture crops, promoted through initiatives like the Paramparagat Krishi Vikas Yojna (PKVY) and the Mission for Integrated Development of Horticulture (MIDH).

In the fiscal year 2023-24, the livestock sector's contribution was 16.7% to the total Gross State Value Added (GSVA). According to the Livestock Census of 2019, Odisha accounts for 3.4% of India's total livestock and 3.22% of the nation's poultry. Cattle represent much of the livestock in Odisha, making up more than 55% of the population and contributing to 5.12% of India's total cattle count (Odisha Economic Survey, 2023-24). A predominant portion of the livestock in the state is owned by landless laborers and small-scale farmers (Singh & Sonwani, 2023). In terms of fisheries, the state boasts an upward trend in the industry, enhanced by its extensive coastline stretching 480 km and enriched by six primary rivers, alongside numerous smaller waterways and lakes (Annual activities report, 2018-19).

1.2. Sustainability of the agriculture and allied sector

The State Action Plan for Climate Change (SAPCC), Version.2 for the period 2021-30 reported that climate change has both a socio-economic and a socio-political cost, and the plan envisages addressing the drivers of climate risk as climate change has the potential to aggravate water stress and enhance food insecurity. As highlighted in Odisha State Action Plan on Climate Change (2018), on an average, 900,000 hectares of agricultural production is lost every year due to disasters. The frequency and intensity of extreme weather events, such as droughts, floods, and heatwaves, have been rising, exacerbating the vulnerabilities of rural communities and jeopardizing food security across the state (Mishra et al., 2016; Sahoo & Moharaj, 2024).

Building resilience of these climate sensitive sectors, and of the people dependent on them is imperative to ensure sustainable production, food and nutrition security for all and is one of the key goals of the state.

Climate Smart Agriculture (CSA) offers a strategic approach to transforming and reorienting agricultural systems to ensure food security while also achieving mitigation and adaptation in the face of climate change. According to Estimation of Odisha's Carbon Footprint, study (CII, 2015), the agriculture sector emissions contribute to about 25% of the total greenhouse gas (GHG) emissions of 98.5 megatons of $CO_{2\text{-eq}}$ reported for the state, clearly indicating opportunities for formulating strategies to reduce emissions from the sector. CSA encompasses practices that not only help adapt to changing climatic conditions but also mitigate greenhouse gas emissions, enhancing the sustainability of agriculture. Thus, CSA offers a unique opportunity for the state to meet the larger climate goals collectively, while ensuring farmers lives and livelihoods are protected. The steps taken towards generating baseline knowledge and information for advancing agriculture resilience and sustainability in Odisha are detailed in Figure 1.

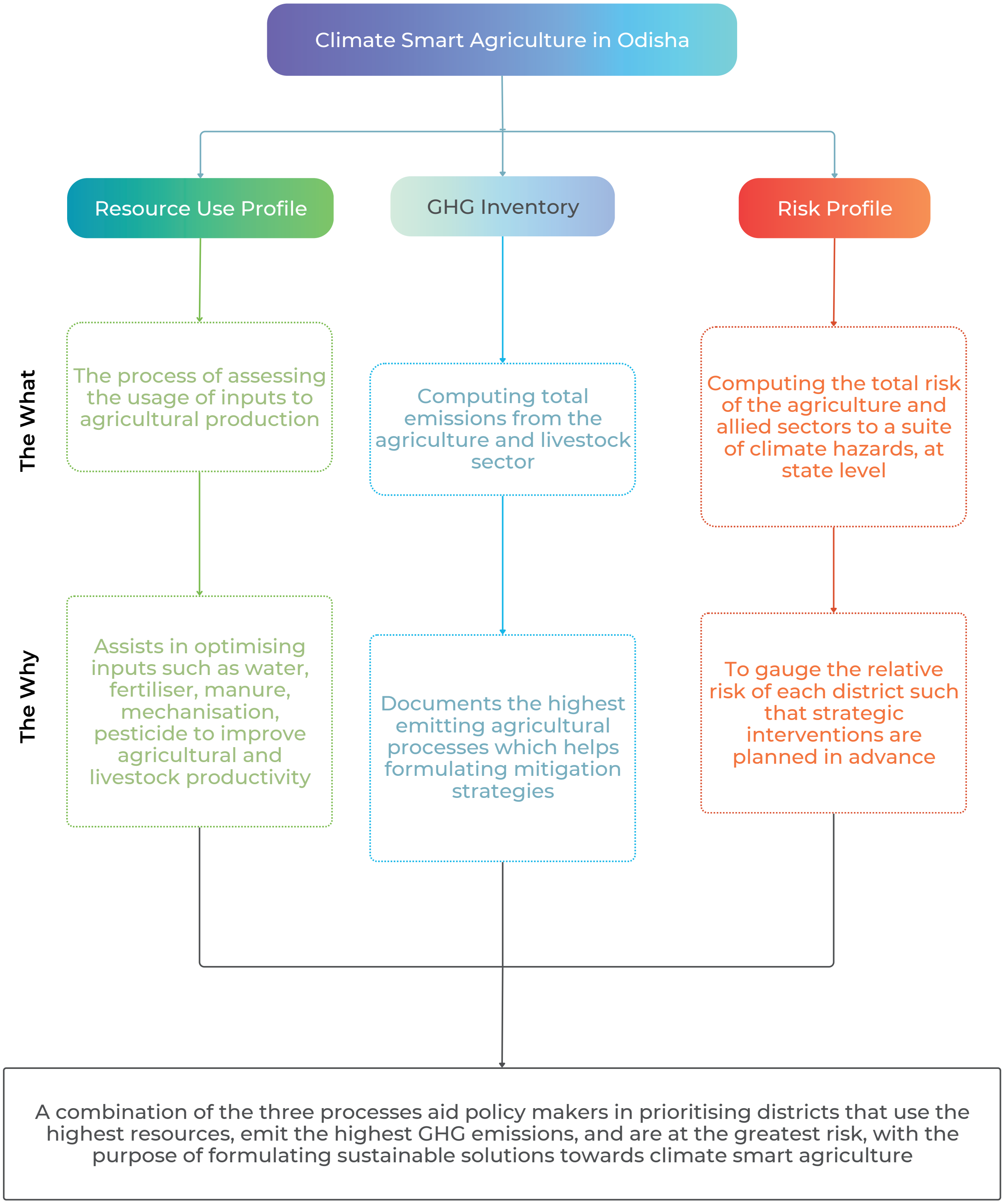

Figure 1: Steps taken towards generating baseline information to advance agriculture resilience and sustainability in Odisha

OPPOSITE: Odiya farmer operating a power tiller. Manoranjan Mishra

2. Objective

The overarching objective of this scoping study is to enable prioritization of districts in Odisha for building resilience, improving resource use efficiency and reduce emissions or sequester emissions from the agriculture and allied sector, while factoring in current sectoral resource use patterns, greenhouse gas emissions, and climate risks to the sector. This assessment is envisaged to be the foundation for developing District Action Plans aimed at building resilience and sustainability and for the implementation of CSA practices on a pilot basis.

The objective of this report is to detail the methodology used to undertake baseline assessment of the agriculture and allied sectors and to present the results of the assessment. This information will guide decision-makers and planners in identifying districts with high resource use, GHG emissions, and those with significant risks to droughts, floods and heatwaves, enabling them to roll out a comprehensive package of CSA interventions that address resource use inefficiencies, mitigate emissions from crop and livestock production, as well as build resilience and empower farmers to adapt to climate change impacts, wholistically.

BELOW: After bidding for fish, women fill their buckets on the beach in Odisha. Supratim Bhattacharjee

3. Methodology

This section outlines the detailed methods used to establish the baseline for all the districts of Odisha. In brief, an **index-based method** was used to aggregate the findings of the three assessments – RUP, GHG and CRA, their results were considered to develop an index, following a similar process used to develop the vulnerability index (Part 2, Section 3.3). The key steps followed are detailed below::

a. Identification and selection of indicators to develop the baseline index: Indicators were selected based on the objectives of the project, which are to enhance crop yields, build climate resilience, lower GHG emissions and enhance resource use efficiency through the promotion of CSA interventions. To achieve these goals, it was necessary to identify districts most suitable for promoting and implementing CSA practices. Districts with the highest climate risks, highest GHG emissions, and lowest resource use efficiency would be the most strategic choices for piloting CSA interventions to maximize impact and demonstrate benefits.

To identify these districts three profiling assessments – resource use, GHG emissions and climate risk profiling were undertaken and this was used to develop an index for the identification of priority districts. Guidance from sectoral experts within CSTEP and validation by the Climate Resilience Cell, Department of Agriculture and Farmers' Empowerment (DA&FE), Government of Odisha helped concretise this approach. The indicators and their sub-indicators are presented in Table 1.

b. Quantification of indicators: The indicators and sub-indicators representing components of resource use, GHG emission and climate risk profiles were quantified as described in Part 1 and Part 2 of this report series, using secondary data provided by the respective agriculture, livestock and fishery departments of the Government of Odisha, as well as by using GIS techniques to quantify some biophysical parameters.

Table 1: Indicators used for development of baseline index

Indicator	Sub-indicator
Resource use profile	Total inputs (fertilizer, manure and pesticide)
	Mechanisation
	Water use efficiency
GHG emission profile	Rice
	Livestock
	Fertilizer
	Diesel
Climate risk profile	Drought risk
	Flood risk
	Heatwave risk

c. Normalisation of indicators:

The results of the three profiling assessments are unitless, however, they do not lie on a scale of 0-1. To bring them on to this scale, they were normalized prior to aggregation. This normalization process is based on their functional relationship with the baseline index value.

There are two types of functional relationships: A positive relationship, where baseline value rises as the value of the indicator increases. In this scenario, the variables have a direct and positive functional relationship with the baseline index value, and normalization is performed using the following equation:

Equation 1: Normalisation when the variable exhibits a positive relationship with the baseline

$$x_{ij} = \frac{X_{ij} - \text{Min } X_{ij}}{\text{Max } X_{ij} - \text{Min } X_{ij}}$$

where X_{ij} is the value of the indicator j corresponding to the region i. In Equation 1, X_{ij} is the variable that is being normalised, and x_{ij} is the normalised value of X_{ij}. All x_{ij} scores will lie between 0 and 1.

Similarly, indicators can have a negative relationship, where baseline index value increases with a decrease in the value of the indicator. Here, indicators have a negative or inverse functional relationship with the baseline index value. In this case, the normalised score is computed using the following equation:

Equation 2: Normalisation when the variable exhibits a negative relationship with the baseline

$$x_{ij} = \frac{\text{Max } X_{ij} - X_{ij}}{\text{Max } X_{ij} - \text{Min } X_{ij}}$$

d. Assigning weights:

Equal weights were assigned to each component of the baseline index, with resource use, GHG emissions, and climate risk each contributing equally. Within resource use, all sub-components were also assigned equal weights. However, the GHG emissions sub-components were weighted unequally, as outlined in Part 1, Section 3.2.5 and Table 2, as there is a significant difference in the contribution of different sources to the emission profile. Different weights were assigned to each climate risk – 50%

Table 2: Weights assigned to indicators and sub-indicators of baseline index

Indicator	Weight	Sub-indicator	Weight
Resource use profile	0.333	Total inputs	0.111
		Mechanisation	0.111
		Water use efficiency	0.111
GHG emission profile	0.333	Rice	0.267
		Livestock	0.060
		Fertilizer	0.005
		Diesel	0.002
Climate risk profile	0.333	Drought risk	0.166
		Flood risk	0.133
		Heatwave risk	0.033
Total	1.000	Total	1.000

to drought, 40% to floods, and 10% to heatwaves – reflecting the agriculture and allied sectors' current prioritization. Droughts are presently viewed as the most critical concern, followed by floods, while heatwaves, although emerging, have yet to receive adequate attention.

e. Aggregation:
Indicators were aggregated by taking a simple sum of normalised weighted scores for each district. This is the baseline index value for each district.

f. Ranking:
Districts were ranked on a five-point scale: very high, high, moderate, low and very low baseline index value for visualisation. This process helps triangulation and identification of districts with the potential for lowering climate risks, improving resource efficiency and reducing GHG emissions so they can be prioritised for comprehensive climate action and the development of district action plans. .

g. Representation of results:
Baseline assessment results are represented as a bar graph and a map

h. Drivers of baseline index values:
The drivers of the baseline index values were identified for each district for the development of targeted interventions.

BELOW: Livestock are a vital pillar of Odisha's agricultural sector, generating additional household income, playing an integral role on farms. WIRESTOCK

4.Results

The baseline assessment of Odisha's agriculture and allied sectors reveals a complex interplay between the state's agricultural practices, resource utilization, and climate risks. Over the past decade, Odisha has seen a significant decrease in GHG emissions from the agriculture and allied sectors, primarily due to state-led interventions. The decrease in emissions from 25.1 million tons of CO_2 equivalent in 2014 to 22.2 million tons in 2023 is a positive indicator of the state's progress toward more sustainable agricultural practices and resource use. However, this reduction is uneven across districts, with Mayurbhanj standing out as a major contributor to the state's emissions due to predominance of rice and livestock, which are the dominant sources of emissions from the agriculture and allied sectors.

While essential for the state's food security, rice cultivation can also result in high GHG emissions that need to be moderated. The stable emissions from rice cultivation, except during drought years, and the gradual decline in livestock emissions reflect the sector's dynamic response to both environmental conditions and changes in agricultural practices. However, the increasing nitrogenous fertiliser use, leading to rising N_2O emissions, and

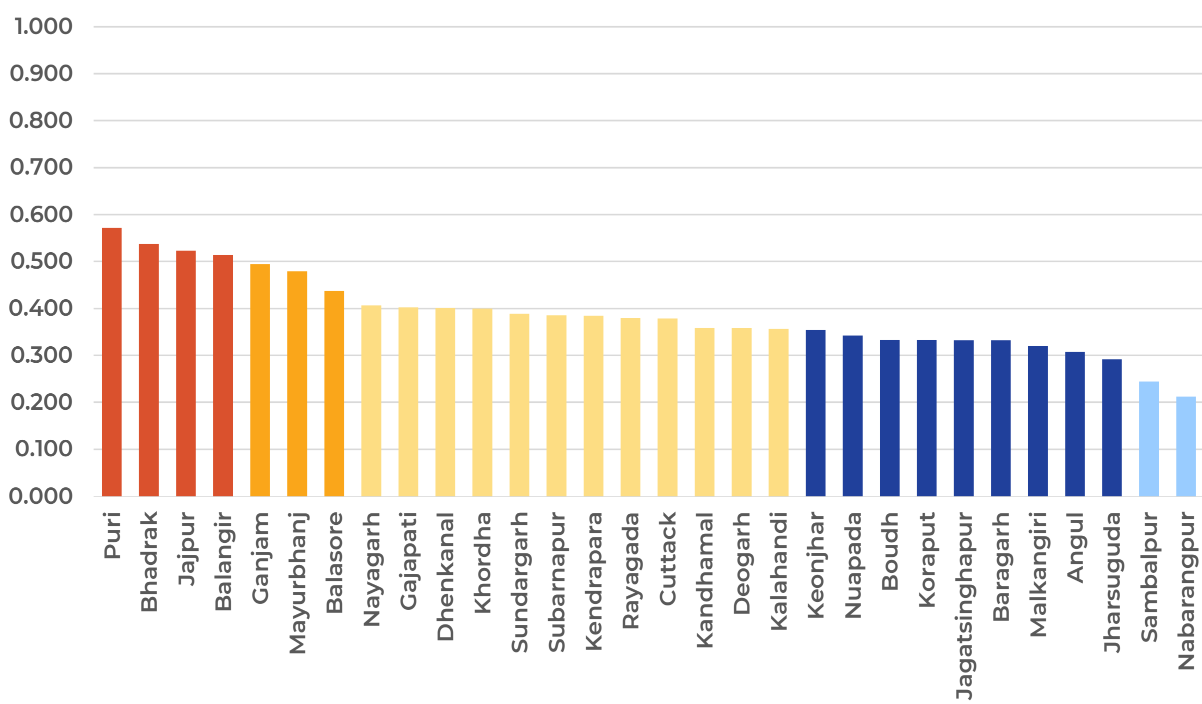

Figure 2: Baseline ranking of the agriculture and allied sector

higher diesel consumption due to an increase in agricultural tractors, despite a decline in diesel pump sets, underscore the challenges in balancing productivity with sustainability. Aggregating GHG emission profiles, climate risk profiles disaggregated by hazards and resource use profiles provided the baseline profile for Odisha.

According to the assessment (Figure 2):

- Puri, Bhadrak, Jajpur and Balangir are ranked as very high mainly due to their high per-hectare GHG emissions from rice cultivation. Additionally, the high risk to droughts and floods, low mechanisation, high input usage, and low water use efficiency drive their overall ranking.

- Similarly, Ganjam, Mayurbhanj, and Balasore are ranked high due to their high risk to droughts, high emissions from rice cultivation, low water use efficiency, high input usage, high risk to floods, and low mechanisation.

- The factors contributing to the baseline ranking is provided in Figure 3 and Table 3.

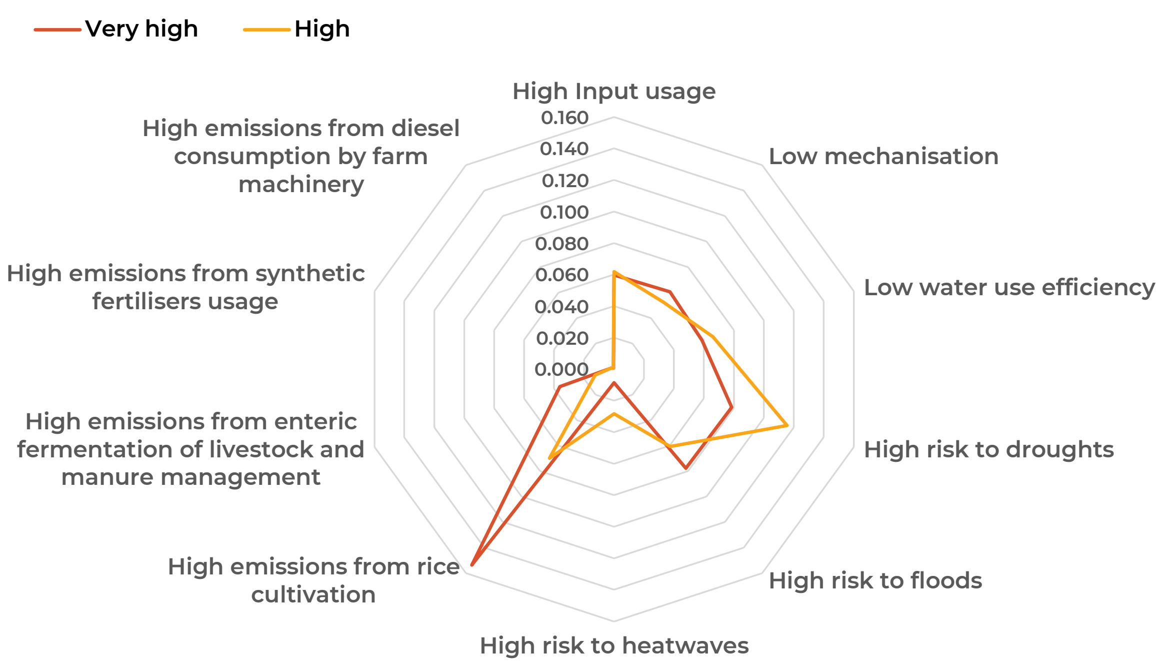

Figure 3: Drivers of baseline ranking of the agriculture and allied sector

Class	High Input use	Low mechanisation	Low water use efficiency	High risk to droughts	High risk to floods	High risk to heatwaves	High emissions from rice cultivation	High emissions from enteric fermentation and manure management	High emis-sions from synthetic fertilizers use	High emissions from diesel consumed by farm machinery
Very high	0.060	0.061	0.059	0.078	0.078	0.009	0.154	0.036	0.002	0.001
High	0.062	0.053	0.066	0.116	0.061	0.028	0.070	0.013	0.002	0.001
Moderate	0.034	0.076	0.050	0.090	0.049	0.020	0.052	0.012	0.001	0.000
Low	0.031	0.068	0.026	0.077	0.047	0.017	0.041	0.023	0.001	0.000
Very low	0.012	0.062	0.003	0.091	0.021	0.019	0.007	0.008	0.004	0.001

Not a significant driver
Moderate driver
Significant driver

Table 3: Drivers of baseline ranking of the agriculture and allied sector

5. Conclusion

This scoping study provides a critical foundation for prioritising districts in Odisha to pilot Climate-Smart Agriculture practices based on their rankings in resource use efficiency, greenhouse gas emissions, and climate risks. By integrating these factors into a comprehensive baseline index, the study provides a prioritisation of districts for targeted pilot interventions for addressing climate risks, reducing GHG emissions and optimising resource use. Nine districts have been identified to develop district action plans that would enable the piloting of climate resilient agriculture and climate smart agriculture practices (Figure 4).

Bhadrak, Puri, Jajpur and Balangir were identified as the highest priority districts, as they have relatively high climate risks, high resource use and high GHG emissions, cumulatively. These districts will require a comprehensive package of interventions, including practices to reduce GHG emissions from paddy cultivation, precision agriculture practices for optimising resource use, and techniques for building climate resilience.

Similarly, following this methodology, Bargarh and Nabarangpur have been identified for CSA practices aimed at improving resource use efficiency; Puri for practices that reduce GHG emissions, and Nuapada, Kendrapara, and Angul for interventions focused on building resilience to droughts, floods, and heatwaves, respectively (Figure 4). Since tropical cyclone risk was incorporated at a later stage of the assessment, it was not considered for district prioritization. However, among the nine selected districts, Kendrapara ranks high across all three categories of tropical cyclones, in addition to its high flood risk.

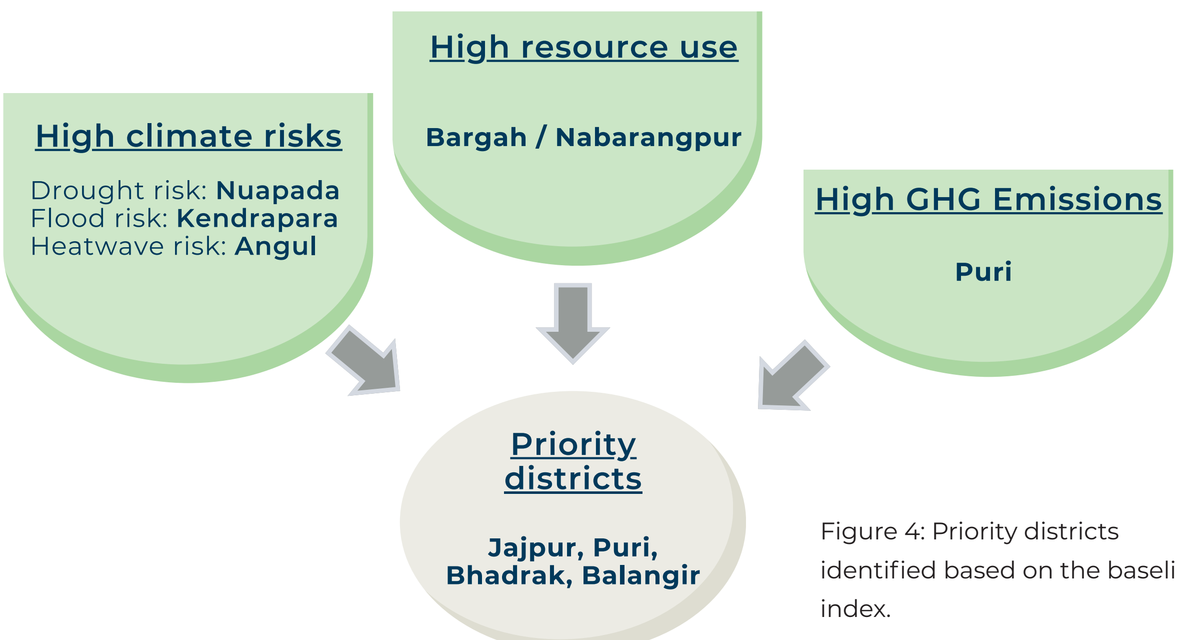

Figure 4: Priority districts identified based on the baseline index.

This study thus lays the groundwork for the development of District Action Plans, offering a roadmap to enhance sustainability, empowering farmers, and mitigating the climate risks to the state's agricultural sector

6. References

1. APEDA. (2023). E-Catalogue for Export of Millets and Value-Added Products. Retrieved from APEDA Government of India: https://apeda.gov.in/milletportal/files/Odisha_Millet_Value_Added_Products_Catalogue.pdf
2. Caristas_India. (2021). Documentation of Traditional Climate Resilient Crops and Agricultural Practices in the Selected Blocks of Odisha. Retrieved from Caritas_India: https://caritasindia.org/GlobalProgramIndia/wp-content/uploads/2022/03/Documentation-of-Traditional-Climate-Resilient-Crops-and-Agricultural-practices-in-the-selected-blocks-of-Odisha.pdf
3. Confederation of Indian Industry, CII. (2015). Estimation of Odisha's carbon footprint. Final_Odisha_Carbon_Footprint_Report.pdf (climatechangecellodisha.org)
4. Department of Agriculture and Farmers Empowerment. Gov of Odisha. (2020). Executive Summary of SAMRUDHI- Agriculture Policy 2020. https://agri.odisha.gov.in/sites/default/files/2021-05/Executive%20Summary%20of%20SAMRUDHI%20-Agriculture%20Policy%202020%20in%20English_0.pdf
5. Directorate of Agriculture and Food Production. (October 2019). *Odisha Millets Mission.* Government of Odisha.
6. Govt of India. (2012). Geography of Odisha. Retrieved from India.gov.in: https://web.archive.org/web/20150204220248/http://www.archive.india.gov.in/knowindia/state_uts.php?id=81
7. Government of Odisha. (2018-19). Fisheries Sector. Retrieved from Annual Activities Report: https://fisheries.odisha.gov.in/upload/files/06_34_50pm88f4d58b39 5801f700bd2bb2cdda3d73.pdf
8. Government of Odisha. (2022). Shree Anna Abhiyan. Retrieved from Odisha Millet Mission: https://milletsodisha.com/resources/annualreports
9. Government of Odisha. (2022-23). Odisha_Economic_Survey. Planning and Convergence. Department Directorate of Economics and Statistics. Odisha Economic Survey-2022-23 (Digital Version) Final.pdf
10. Hoda, A., Rajkhowa, P., & Gulati, A. (2017). Working Paper 337: Transforming Agriculture in Odisha: Sources and Drivers of Agriculture Growth. New Delhi: Indian Council for Research on International Economic Relations.
11. IANS. (2023). 10 cyclones in 12 years; eroding coastline: Odisha impacted by climate change. https://timesofindia.indiatimes.com/india/10-cyclones-in-12-years-eroding-coastline-odisha-impacted-by-climate-change/articleshow/99005986.cms
12. Mishra, D., Sahu, N. C., & Sahoo, D. (2016). Impact of climate change on agricultural production of Odisha (India): A Ricardian analysis. Regional Environmental Change, 16(2), 575–584. https://doi.org/10.1007/s10113-015-0774-5
13. MoHHW. (2022). State Action Plan for Climate Change and Human Health—Odisha. https://ncdc.mohfw.gov.in/wp-content/uploads/2024/05/19.SAPCCHH-VERSION-1-Odisha.pdf
14. OSDMA. (2024). Odisha State Diaster Management Authority. Retrieved from osdma.org: https://www.osdma.org/state-profile/#gsc.tab=0
15. Sahoo, D., & Moharaj, P. (2024). Assessing agricultural vulnerability to climate change through dynamic indexing approach. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-024-34738-0
16. Shankar, S., Dutta, A., & Singh, A. (2022). Understanding Changing Climate And Food Security In Rural Odisha. https://tigr2ess.globalfood.cam.ac.uk/news/understanding-changing-climate-and-food-security-rural-odisha
17. Singh, V., & Sonwani, S. (2023). Entrepreneurship and Self-employment through Livestock among Scheduled Tribes. *Journal of Livestock Science*, (14)
18. World Bank. (2021). Dealing with the Pandemic. https://agri.odisha.gov.in/sites/default/files/2021-05/Covid-19Covid-19-%20Impacton%20Agriculture-Allied-Sectors-Odisha_%20Dealing-with_the-pandemic.pdf
19. The Odisha Economic Survey. (2023-24). Government of Odisha. Accessed at https://odisha.neva.gov.in

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