MP ENSYSTEMS

SOCIO TECHNICAL FINANCING MODEL FOR TRANSITIONS IN MADHYA PRADESH AND MAHARASHTRA

MARCH
2023





MP ENSYSTEMS

Acknowledgements

This project timeline is from February 2023 to January 2024. During the course of our work so far, we have received valuable assistance from the following individuals and institutions representing policy makers, public and private sector and civil society organisations (CSOs) in Maharashtra and Madhya Pradesh:

Chhindwara, Madhya Pradesh

District Agriculture Dept., District Horticulture Dept., Krishi Vigyan Kendra, District Planning Dept., MP Urja vikas Nigam Ltd., Madhya Pradesh Vigyan Sabha (MPVS), SRIJAN

Singrauli, Madhya Pradesh

Singhdeo Women FPO, Mahan Women FPO

Bhopal, Madhya Pradesh

Madhya Pradesh Vigyan Sabha (MPVS)

Nandurbar, Maharashtra

Collectorate office, District Agriculture Dept., Agriculture Technology Management Agency (ATMA), Krishi Vigyan Kendra, Van Dhan Vikas Kendra, Mahila Arthik Vikas Mahamandal (MAVIM)

Jalgaon, Maharashtra

District Agriculture Dept., Maharashtra Energy Development Agency (MEDA), Krishi Vigyan Kendra, MaxFresh FPC, Mahajan Banana Exports, Rajodak FPC

MP ENSYSTEMS

This document reflects the views of the authors and not that of the parties named above. The overall intent of this document is to develop a deeper understanding of greening of value-chains in selected regions of Madhya Pradesh and Maharashtra.

MP Ensystems Team

The MP Ensystems team for this project consists of Dr Mahesh Patankar, Ira Athale Prem, Prajkta Adhikari, Asmita Ekawade, Hrishabh Chandra, Kaustubh Arekar, Gaurang Jaju, Smitha Lobo, Rutal Deshmukh and Ram Sarovar Agariya.

For more information, contact:

Mahesh Patankar mahesh@mpensystems.com
Ira Prem ira@mpensystems.com
Prajkta Adhikari prajkta@mpensystems.com

Citation

MP Ensystems (2023). Socio-technical- financing model to map transitions in 4 districts in Madhya Pradesh and Maharashtra

TABLE OF CONTENTS

EXECUTIVE SUMMARY

As a part of its mission on greening of rural value chains, the MP Ensystems team is assessing the potential for low carbon development by developing packages of interventions for selected districts located in or near coal mining areas– Jalgaon and Nandurbar in Maharashtra and Chhindwara and Singrauli in Madhya Pradesh. Three of these districts have been designated "aspirational districts" by the Government, as they are among the least developed in the country and there are concerted state and central Government efforts to localise and implement Sustainable Development Goals here.

The objective of this report is to provide the reader with a roadmap of the current socio-economic conditions of farmers and food processors in these districts, propose interventions that raise income while decarbonising the value chain and estimate the long term impact of these interventions on income and GHG emissions.

The average per capita income in some these districts is significantly lower than India's average income. Less than half the GDP of these districts is from agriculture. However, more than half of the districts' population is engaged in agriculture and allied occupations, and agriculture accounts for more than half of the region's land use. These factors indicate low productivity of agriculture in the area, and the possibility of disguised unemployment. Interventions that promote processing the crops of the region (millets, wheat, tomato, potato, oranges etc) using green technologies can lead to gains in farmer income, opportunities for rural employment and reduced greenhouse gas (GHG) emissions.

We propose interventions not only in technology and provision of infrastructure, but also by strengthening social structures, proposing supportive policies and availability of finance, under the STPF (socio-technical-policy-financing) framework. The package of interventions for the selected districts is listed below.

Technological interventions and their expected impacts

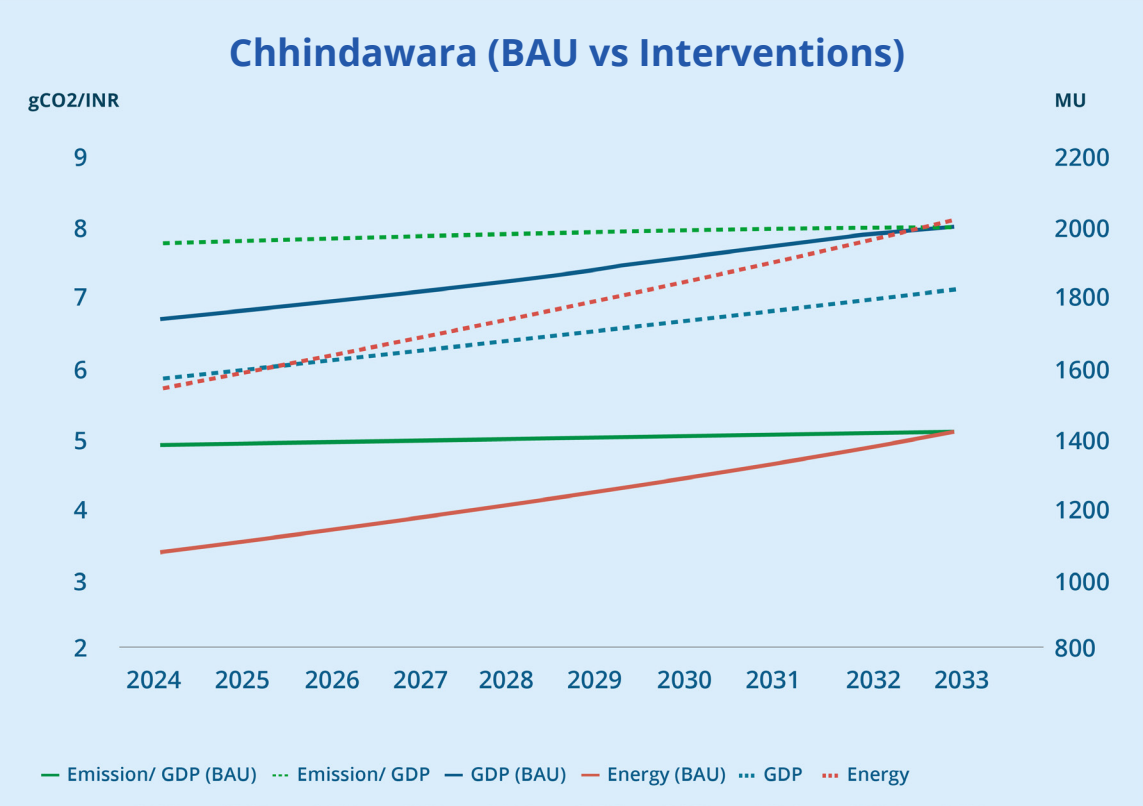
Intervention	Direct Beneficiaries	Specifications	GHG abatement, tCO2	Reduced energy cost/ increased farmer income INR
Solar dryer	Small and medium farmers of chilli, tomato	40 kg capacity		INR 3,10,000
Low-cost cooling	Small scale farmers of vegetables	100 kg capacity Cost INR 28,000		Can raise farmer income by 30%

Freight EV	Medium and large-scale farmers of all crops	E 3-wheeler cost INR 3,66,000	16 over 10 years	Depending on distance covered, total cost of ownership can be less than ICE vehicle
Small Rooftop Solar PV	Setting up processing for small and medium farmers of turmeric, millets	3 kW solar rooftop system Cost INR 1,23,538	80 over 25 years	1st year savings INR 21,000
Rooftop Solar PV for large cold storage plant	Owners of existing large cold storage facilities for crops such as potato, tomato, oranges, strawberries	134kW solar rooftop system Cost INR 87,35,304 Annual O&M INR 112, 500	3,700 over 25 years	1st year savings INR 13,95,000
Vertical axis wind turbine	For small medium and large operations of processing, cold storage	3kW turbine costs INR 50,000	80 over 25 years	Depends on wind speed at the location
RE based Distributed Cold storage	For large facilities or at community level, e.g. at district mandi	5MT capacity Cost INR 12,10,000 Annual maintenance INR 1,50,000	56 over 10 years	Net revenue depending on utilisation rate and rate of renting space to other farmers
Agrovoltaics	For owners of degraded land, at community scale	144 kW system on 1 acre of land Medicinals and aromatics planted between the solar panels Cost of PV system INR 72,00,000	3,700 over 25 years	215,477 kWh energy generated annually, which can be sold or used. Additional income from crops

The technology interventions need to be supported by social, policy and financing initiatives:

- Assistance to FPOs in marketing, including building local brands, low waste packaging, standardisation of productsIt removes the need for availing a subscription from each CPO if the user wishes to use their charging station.
- Building awareness of costs and benefits of EE and RE technologies for food processing
- Training and upskilling to rural youth in food processing, waste management, maintenance of EE and RE equipment, EV maintenance and charging infrastructure
- Add provisions in current policies such as PM KUSUM to include beneficiaries with small landholdings to implement agrovoltaics
- Smaller tickets size loans (less than INR 1 crore) for small scale processing units

To forecast the impact of these interventions across the districts, we have applied a modified form of the Kaya Identity. The Kaya Identity is used to project future emissions under different scenarios, such as different population growth rates, economic growth rates, and energy and carbon intensity levels. The chart below compares a business as usual (BAU) scenario to an intervention scenario over 10 years.



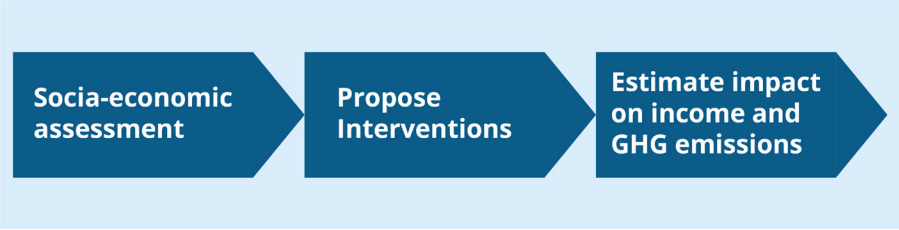
The next steps in this project are to undertake the following activities:

1. Engagement with state government departments including agriculture, horticulture, finance, energy, rural development, skill development and entrepreneurship departments to understand the efforts to boost the rural growth and economy
2. Creating programmatic interventions- The team aims to develop Project Design Documents (PDDs) for packages of practices listed in the STPF section. Aggregating these individual, interlinked projects and enabling finance from investors and governments will lead to large-scale impacts.

1. INTRODUCTION

As a part of its mission on greening of rural value chains, the MP Ensystems team is assessing the potential for low carbon development by developing packages of interventions for aspirational districts in Maharashtra and Madhya Pradesh. The objective of this report is to provide the reader with a roadmap of current conditions of farmers and food processors, propose interventions that raise income while decarbonising the value chain and estimate the long term impact of these interventions on the trajectory of GDP and GHG emissions.

We have gathered secondary data on the selected districts' incomes, agricultural profile, land, water and energy use. This socio-economic data, along with information gathered from site visits, interviews with policy makers, farmer producer organisations (FPOs), civil society organisations (CSOs) and other participants in rural value chains provides a basis for understanding the districts' current infrastructure, farming practices, technologies, social structures and awareness levels. This evaluation forms the basis for estimating the interventions and costs of transitioning to a low-carbon high growth regime. We have proposed a package of interventions through a socio-technical-policy-financing framework that can be applied to green the value chain and raise income. Finally, we have estimated long-term impacts of these interventions on the regions' income and greenhouse gas (GHG) emissions.



This document is organised as follows: Section 2 includes an assessment of the selected districts' GDP, along with associated energy, water, land-use and socio-economic indicators. This section also includes notes from field visits to the districts in March 2023.

Section 3 contains a socio-technical-financing framework that assesses the requirements for the transition to low carbon high growth. The section includes a case study and estimates the expected impact of interventions on farmer income and GHG emissions.

In Section 4, we have developed a localised model, based on the Kaya Identity- in which GHG emissions are expressed as the product of population, per capita GDP, energy intensity and carbon intensity. The chapter includes 10 year projections of the districts' energy intensity

(from electricity), carbon intensity, GDP and GHG emissions if the interventions proposed in Section 3 are implemented.

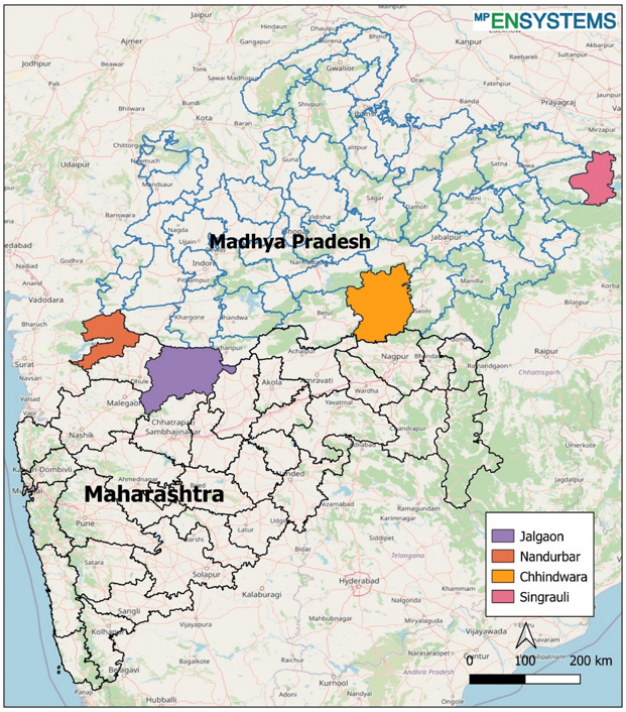
The concluding chapter describes the next steps in the project- engagement with state governments to socialise these findings and partner with governments and financing bodies to develop and implement programmatic interventions.

2. ASSESSMENT OF DISTRICT GDP AND SOCIO - ECONOMIC DATA

In 2018, the Government of India identified the most underdeveloped districts in the country on the criteria of health, education, agriculture, water resources, financial inclusion, skill development and infrastructure. 112 districts were selected and included in the Aspirational Districts Programme (ADP). In order to developing these districts and achieve localisation of the Sustainable Development Goals, the government is following an approach of convergence of central and state government schemes, collaboration of officials and competition of these districts through rankings.

We have selected the aspirational districts of Jalgaon and Nandurbar in Maharashtra due to their proximity to coal mining areas, their vulnerability to climate change, and the concerted state Government efforts to build resilience in these regions. We have also selected two mining-affected districts, Chhindwara and Singrauli in Madhya Pradesh where we have worked in 2022. Singrauli is an aspirational district of Madhya Pradesh.

Figure 1. Map of selected districts



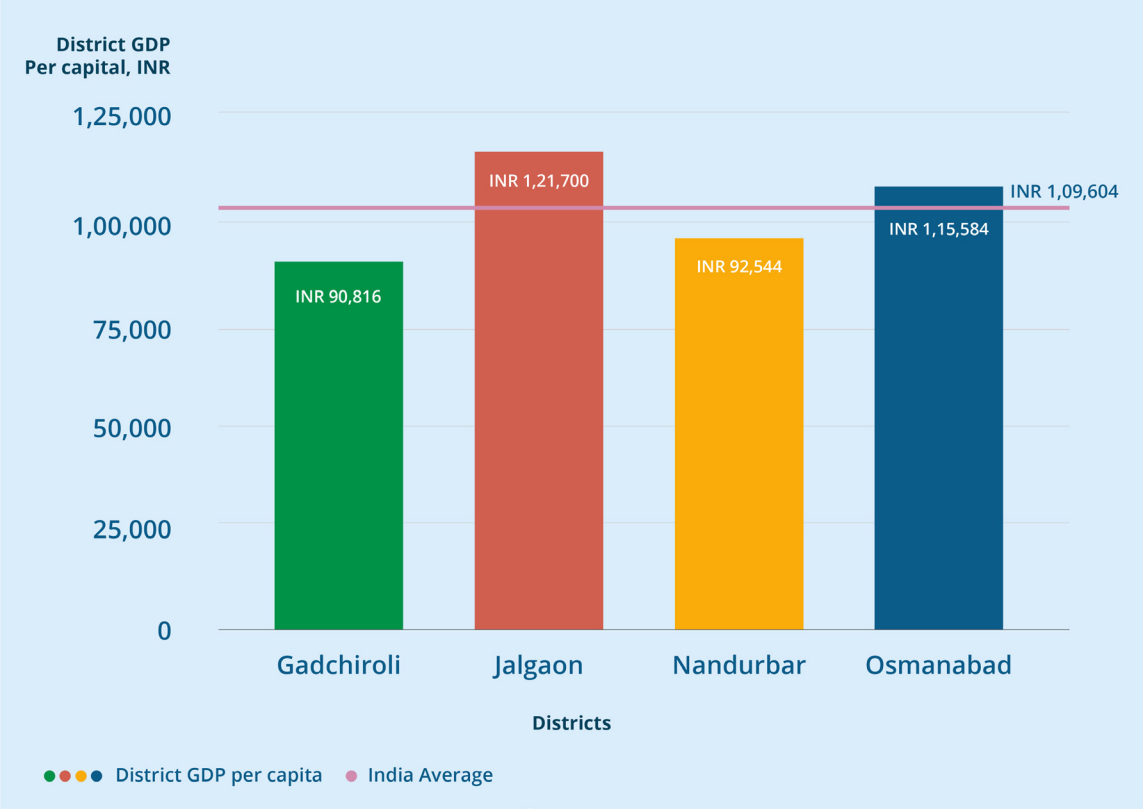
Source: MP Ensystems research 2023, Geographical Analysis 2023

The current phase of the project involves assessing the socio-economy of these four districts in India, to provide insights into the current social, technical, economic status of the region, which will be used as the basis determining interventions for transitioning to a low-carbon high growth regime.

2.1 District GDP

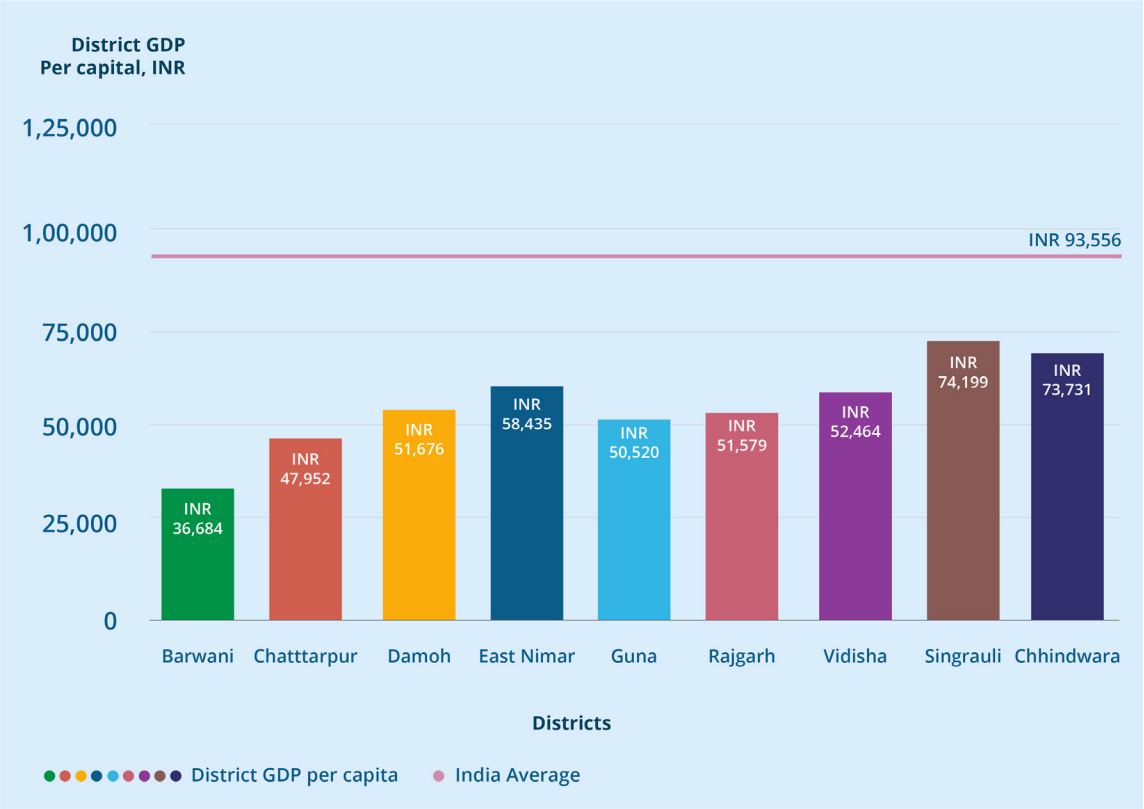
The charts below shows the GDP per capita of the four selected districts, along with other aspirational districts in the state. Apart from Jalgaon, all the selected districts have a per capita income below the Indian average.

Figure 2. Estimated per capita income in aspirational districts of Maharashtra, 2019



Source: District Domestic Product of Maharashtra Report 2011-12 to 2019-20, Census of India, 2011

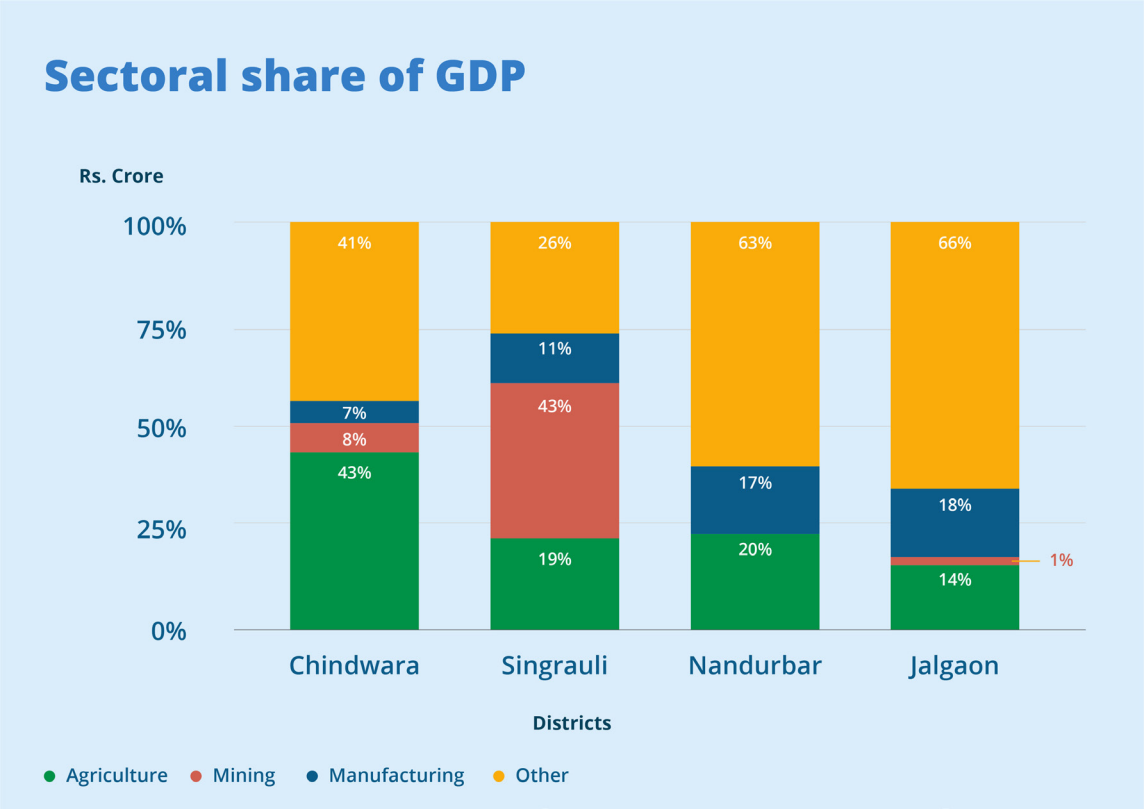
Figure 3. Estimated per capita income in aspirational districts of MP, 2016



Source: District Domestic Product of Maharashtra Report 2011-12 to 2019-20, Estimates of State Domestic Product 2011-12 to 2016-17, Madhya Pradesh, Census of India, 2011 [2]

The chart below compares components of GDP in the selected districts. Chhindwara district has a high percentage of its GDP coming from agriculture and allied sectors[3], while Singrauli has a significant contribution to its GDP from the mining sector. It should be noted that the Maharashtra and Madhya Pradesh district GDP totals are not directly comparable, since the data is for 2019 and 2016 respectively.

Figure 4. Share of GDP by sector, 2016-19

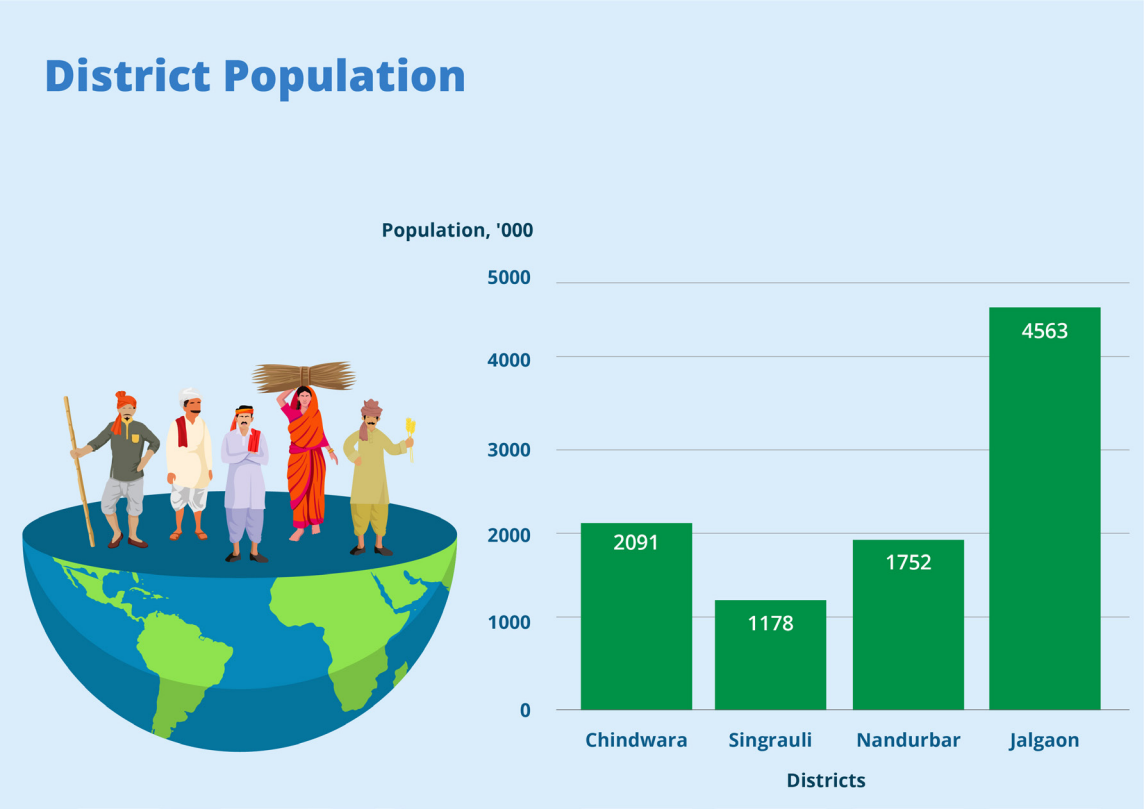


Source: (District Domestic Product of Maharashtra Report 2011-12 to 2019-20, Estimates of State Domestic Product 2011-12 to 2016-17, Madhya Pradesh, .)

2.2 Socio-economic indicators

Jalgaon is the largest of the selected districts, as seen in the figure below.

Figure 5. District population, 2011



Source: (Census, 2011)

As seen in the table below, the districts are predominantly rural. Chhindwara, Singrauli and Nandurbar are also home to a sizeable tribal population, mainly living in the Satpura range which runs through these districts.

Table 1. Population distribution in selected districts, 2011

Taluka Name	Urban	Rural	Scheduled Caste	Scheduled Tribe
Chhindwara	24.16%	75.84%	11.1%	36.8%
Singrauli	19.25%	80.75%	12.8%	32.6%
Nandurbar	30.2%	60.8%	4.6%	45.6%
Jalgaon	31.74%	68.26%	7.2%	5.3%

Source: (Census, 2011)

The table below highlights some key socio-economic indicators of the four districts.

Table 2. Socio-economic indicators in selected districts, 2011

Indicator	Jalgaon	Nandurbar	Chhindwara	Singrauli
Sex ratio (females per 1000 males)	925	978	964	920
Literacy rate (%)	79.7	63.0	72.2	60.4
Human Development Index (HDI)	0.723	0.604	0.654	0.542
Percentage of households with electricity connection	93.7	51.5	66.1	53.5
Infant Mortality Rate (per 1000 live births)	24	37	50	62
Maternal Mortality Ratio (per 100,000 live births)	64	182	159	186

Source: (Census, 2011)

Jalgaon outperforms the other districts on all parameters apart from sex ratio. The infant mortality rate and maternal mortality ratio are higher in Singrauli and Nandurbar compared to Chhindwara and Jalgaon, highlighting the need for better healthcare facilities and interventions in these districts to improve the health outcomes of the population.

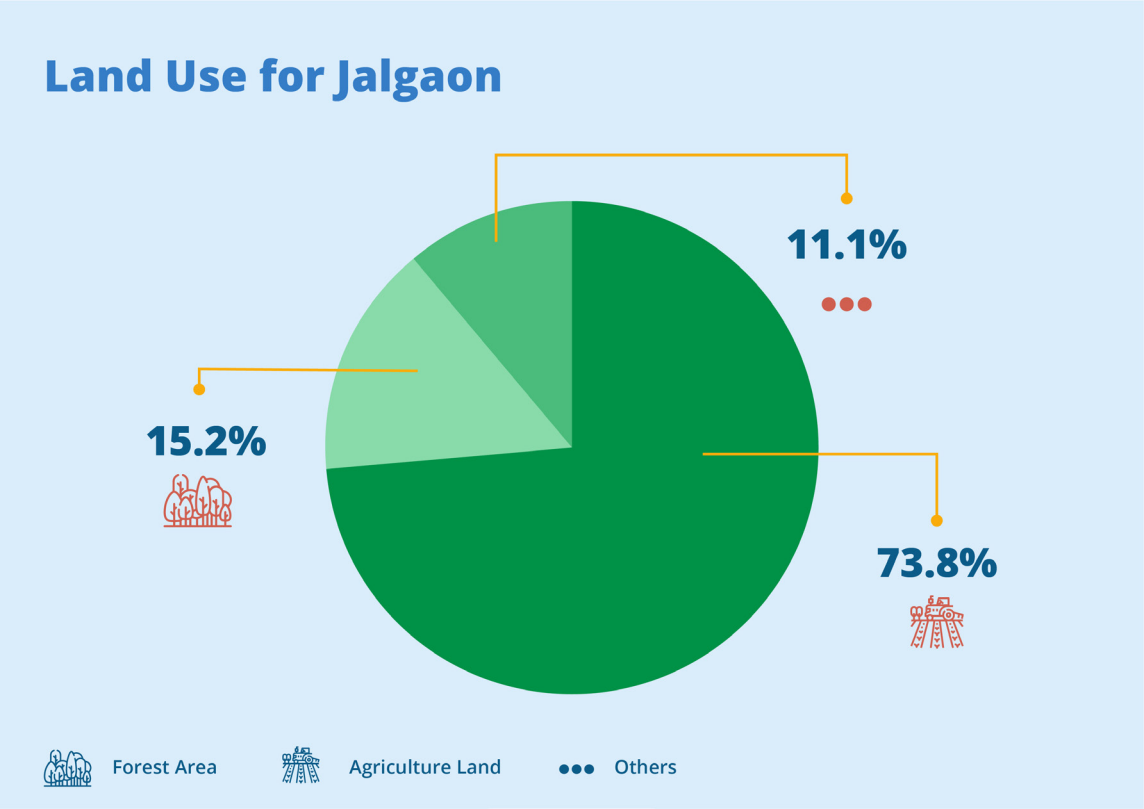
Air and water pollution, as measured by Maharashtra State Pollution Control Board (MPCB) showed Jalgaon's Air Quality Index (AQI) was in the moderate AQI range of 50-100 (MPCB, 2021). AQI data was not available for Nandurbar, Chhindwara and Singrauli. However, during our site visit to Singrauli, we learned that due to the number of power plants located in the district, run by NTPC, Reliance Power, Adani Power, Hindalco and Coal India, fly ash and soot have polluted the region's air, soil and water, affecting the local population's health.

2.3 Land Use

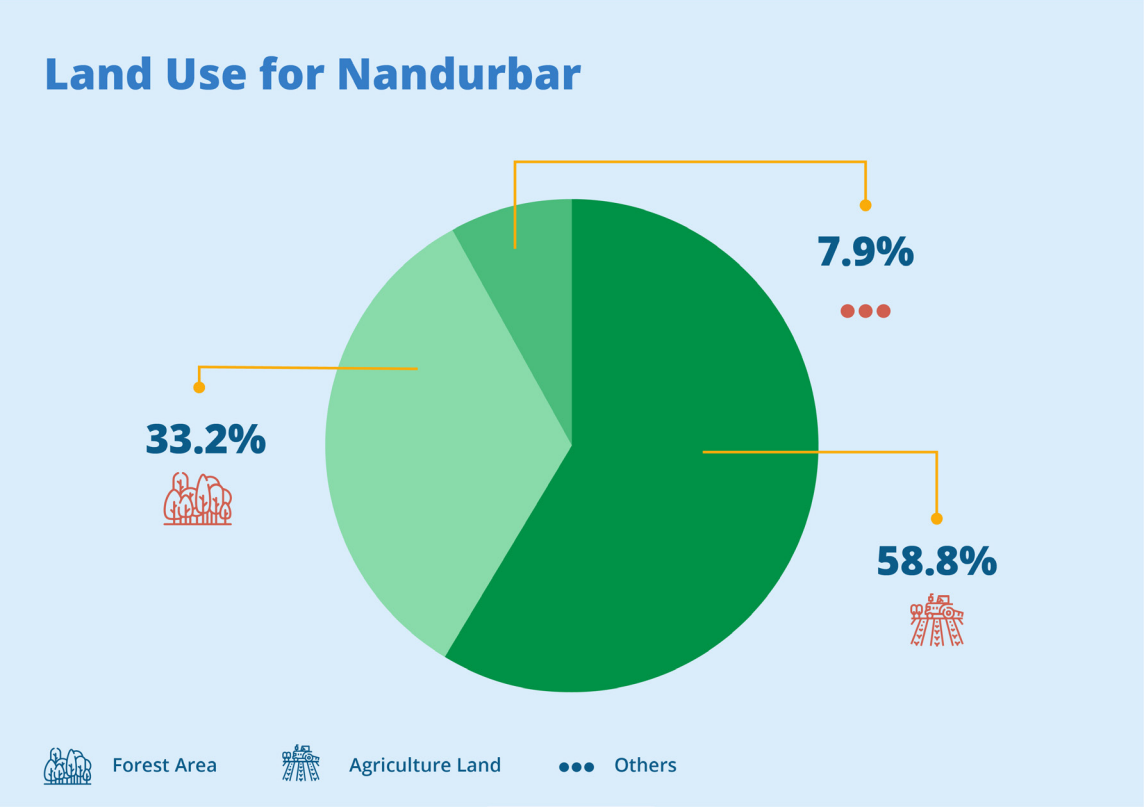
The charts below show the share of land use for agriculture, forest and other uses (including waste land and fallow land).

Most of Jalgaon district is classified as agricultural land, though as seen in section 2.1, only 14% of the district's income is from agriculture. Singrauli has a considerable mining area. And Chhindwara district has a large forest area. The land use data for Maharashtra is for 2015-16, while that for Madhya Pradesh is from 2022.

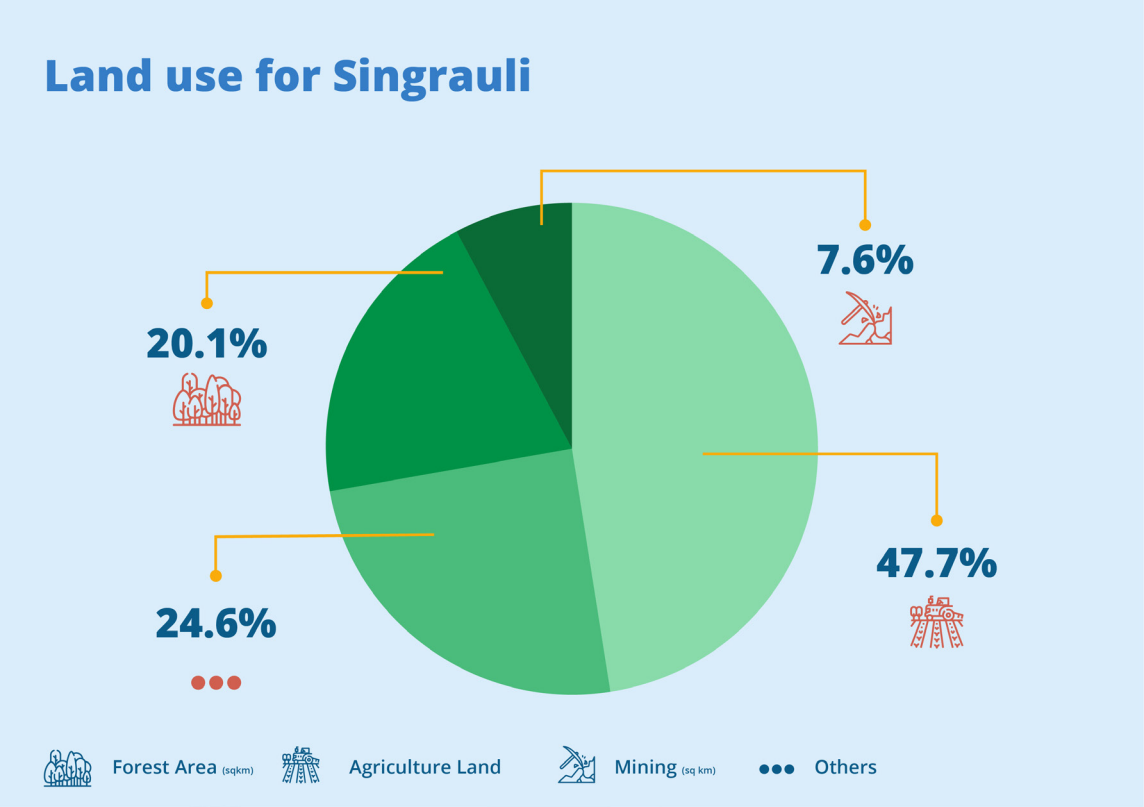
Figure 6. District land use, 2016-22



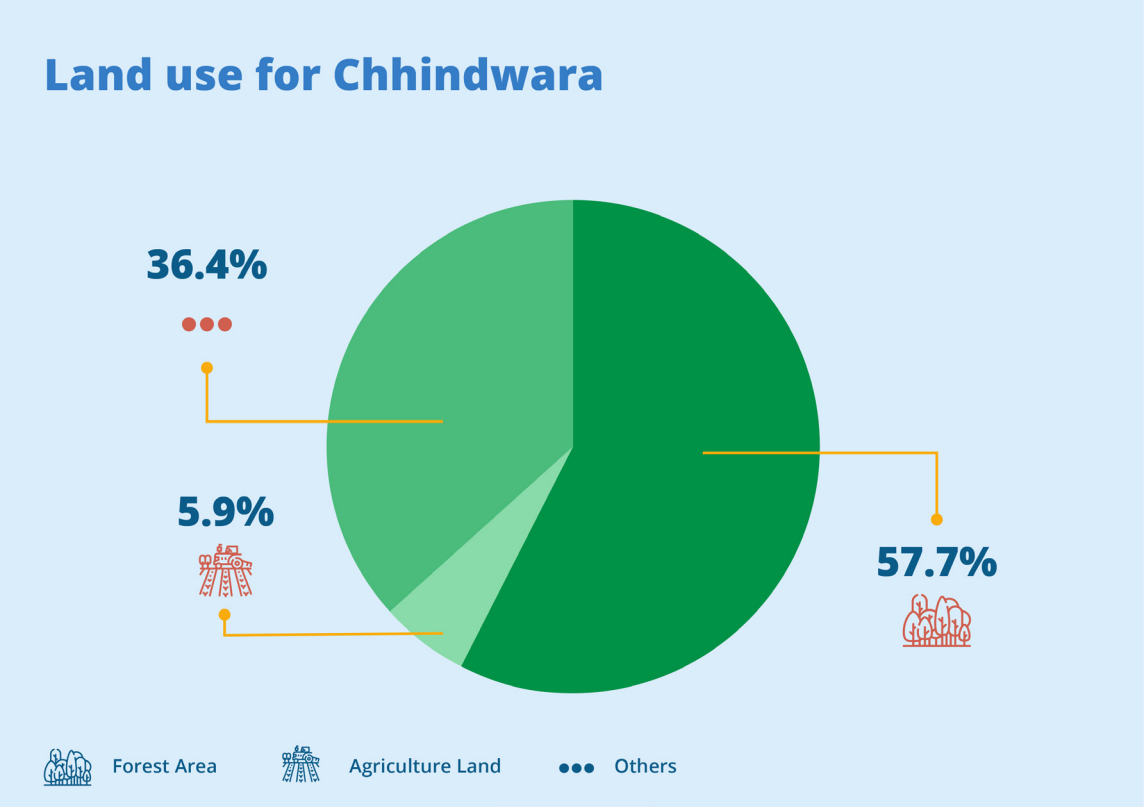
Source: (District and category wise distribution of Land Use / Land Cover in Maharastra, 2015-16)



Source: (District and category wise distribution of Land Use / Land Cover in Maharastra, 2015-16)



Source: (Economic Survey, Madhya Pradesh, 2021-22)

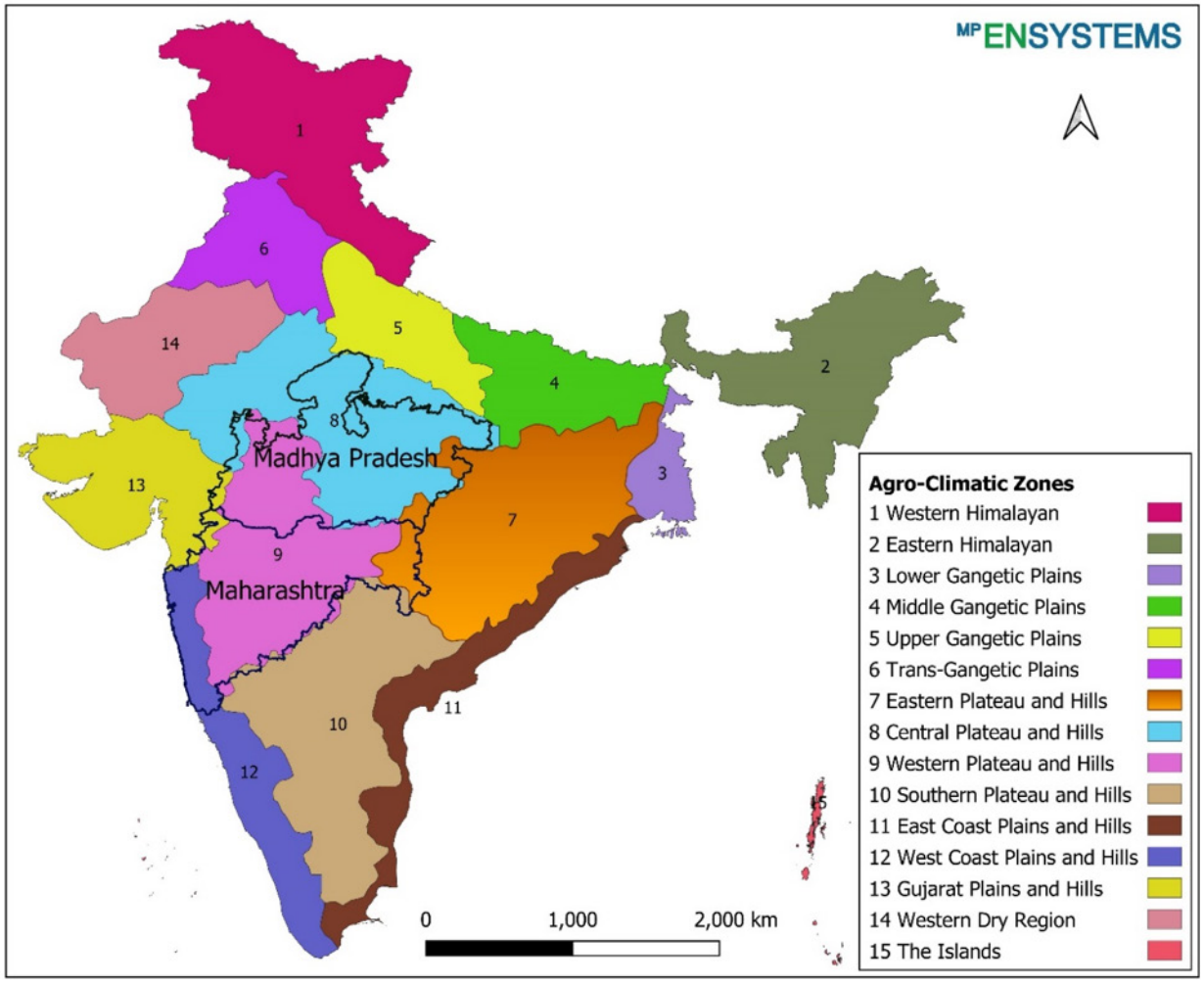


Source: (Economic Survey, Madhya Pradesh, 2021-22)

2.4 Agricultural sector

Agro-climatic zones are geographic regions characterized by distinct climate, soil, and environmental factors that influence agricultural production. India is divided into 15 agro-climatic zones based on the rainfall, temperature, and soil characteristics. The map below displays India's agro-climatic zones, with Maharashtra and Madhya Pradesh highlighted to indicate the zones they belong to.

Figure 7. Agro-climatic zones India

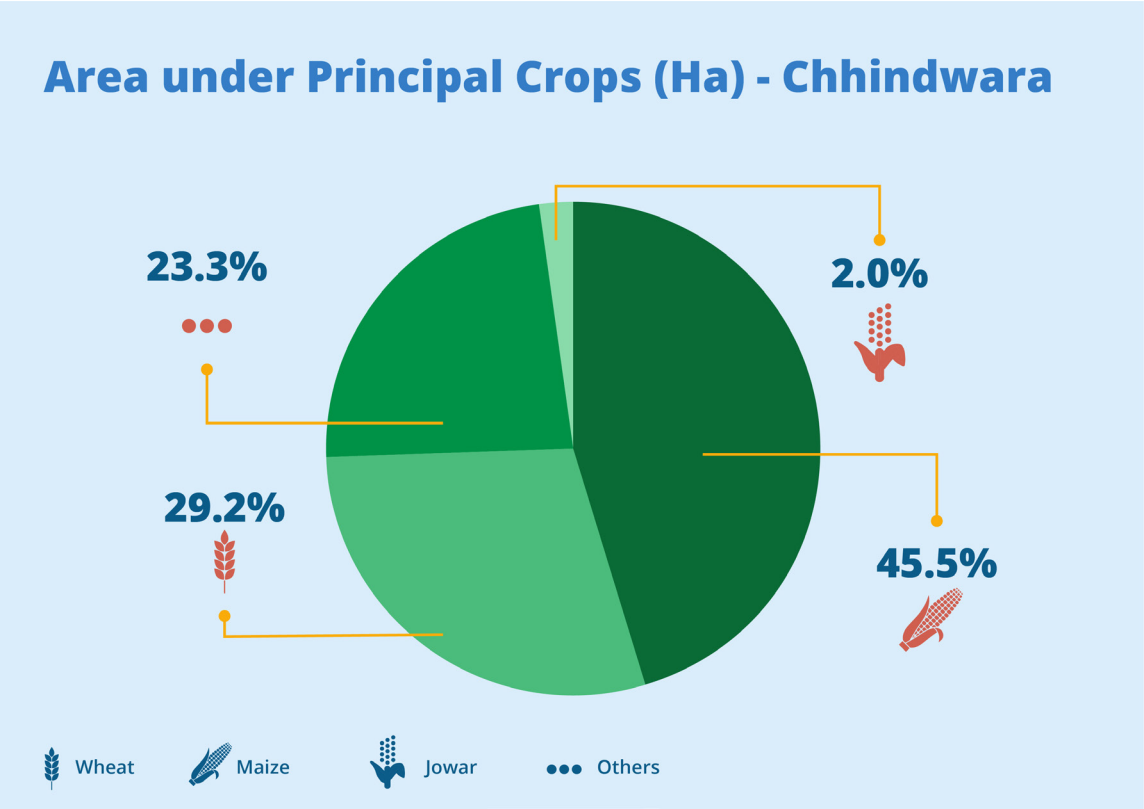


Source: MP Ensystems Research, 2023, ICAR 2023

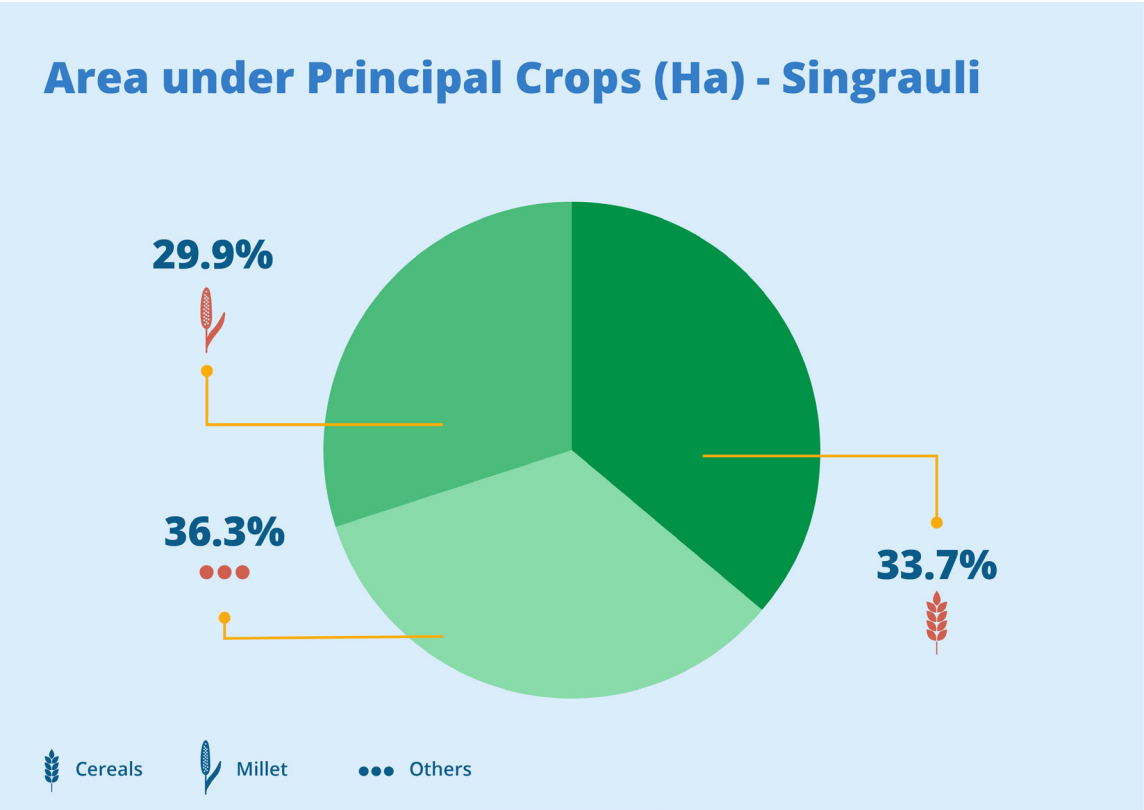
The charts below represent the area under principal crops (in hectares) for each district. The chart shows that the primary crops grown in Chhindwara district are wheat, maize, jowar, and others (paddy, gram, toor, urad, groundnut, soyabean). The area under maize is the highest among all crops in the district. The cultivation of wheat is also significant, while jowar and others occupy a smaller area of cultivation. The primary crops grown in Singrauli district are cereals, millets, and other crops (pulses, oil seeds, fibre, horticulture and plantation crops). The primary crops grown in Jalgaon district are cotton, sorghum, maize, black gram, and other crops (wheat,

sesamum, groundnut). The area under cotton is the highest among all crops in the district. The primary crops grown in Nandurbar district are cotton, sorghum, pearl millet, maize, and other crops (paddy, soybean, wheat, chick pea, groundnut).

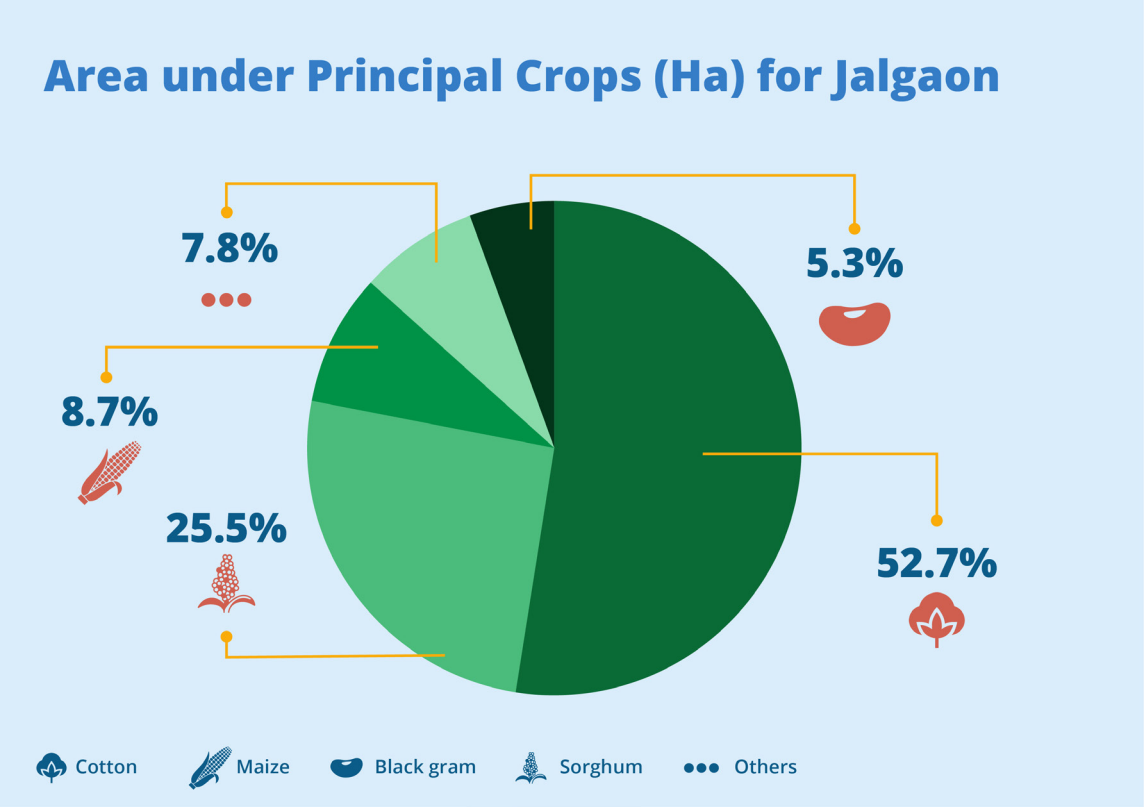
Figure 8. Principal crops in the selected districts



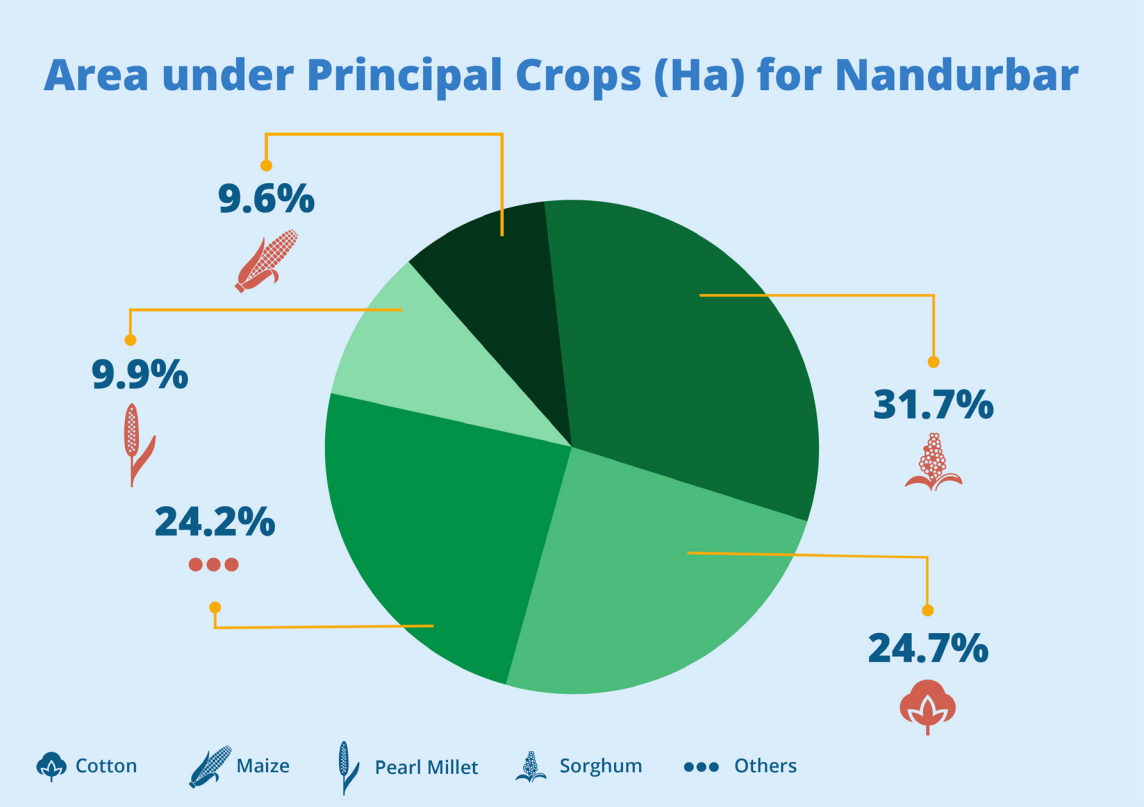
Source: (Economic Survey, Madhya Pradesh, 2021-22)



Source: (Economic Survey, Madhya Pradesh, 2021-22)



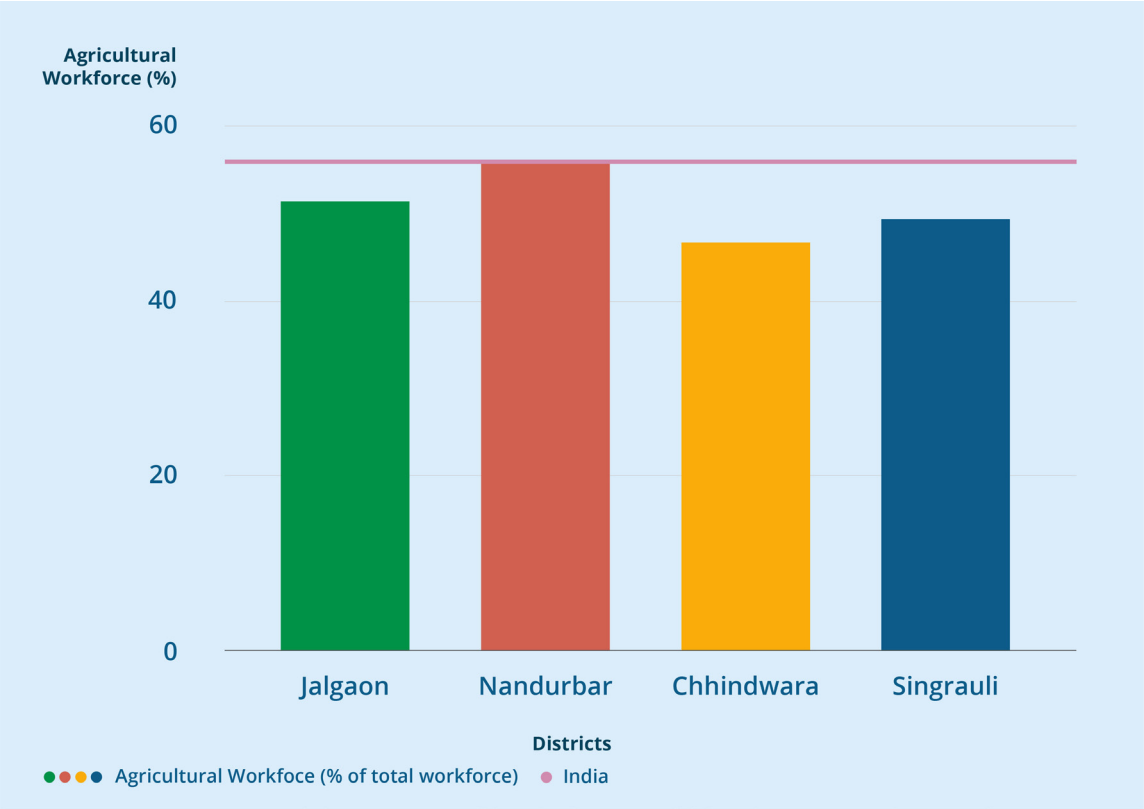
Source: (Agriculture Contingency Plan for District: JALGAON, 2008-09)



Source: (Agriculture Contingency Plan for District: NANDURBAR, 2008)

The chart below shows the share of population in agriculture in the four districts:

Figure 9. Share of agriculture workers in population



It is noteworthy that Singrauli, Jalgaon and Nandurbar all have 20% or less of the district GDP from agriculture, yet agriculture accounts for over 40% of the workforce, indicating low productivity and disguised unemployment in the sector. Part of this workforce includes migrant agricultural labour. Census data show the in-migration of 20-44 year olds is similar in all the districts, averaging 1% for migrants within the states and 0.7% from outside the state. However, this data does not capture some of the seasonal migration in these districts and data on out-migration from these districts is not available.

Farmers are working collectively to access resources, such as finance, inputs, technology, and information, to increase their bargaining power and improve their access to markets through groups such as Farmer Producer Organisations (FPOs), co-operatives, self-help groups (SHGs) and Mahila Bachat Gat (womens' saving groups). These umbrella organisations can lead to increased agricultural production, improved access to credit, extension services, and improved agronomic practices, resulting in increased yields, reduced input costs, increased incomes, and improved livelihoods for farmers, as well as increased economic activity and improved quality of life for their communities. The focus of some of the FPOs in the region is on processing of millets, pulses, spices such as turmeric and chilly, which require low input in terms of investment towards post-harvest machinery to be installed.

The table below lists an estimate of the number of FPOs by the Small Farmers Agri-Business Consortium (SFAC) – a society promoted by the government. However, our field visits indicated that there are likely to be many more FPOs in the selected districts than listed below.

Table 3. FPOs in selected districts

Under Central Sector Scheme for Formation and Promotion of 10,000 FPOs (2021)		
State	**District**	**Number of registered FPOs**
Maharashtra	Jalgaon	11
	Nandurbar	9
Madhya Pradesh	Chhindwara	12
	Singrauli	1
FPOs promoted by Small Farmers' Agri-Business Consortium other than the Central scheme		
Maharashtra	Jalgaon	2
	Nandurbar	0
Madhya Pradesh	Chhindwara	3
	Singrauli	1

Source: (SFAC India, 2021)

Box 1. Importance of Millets

Millets are largely grown in the rural regions of Chhindwara, Singrauli and Nandurbar. The tribal population is heavily reliant on millet cultivation and has begun millet processing. Millets are a good source of protein, fibre, key vitamins and minerals. There are a multitude of health benefits associated with the consumption of millets, including cardiovascular health, prevention of diabetes, et al. The significance of millets has also been recognised globally as the United Nations has announced 2023 as the International Year of Millets.

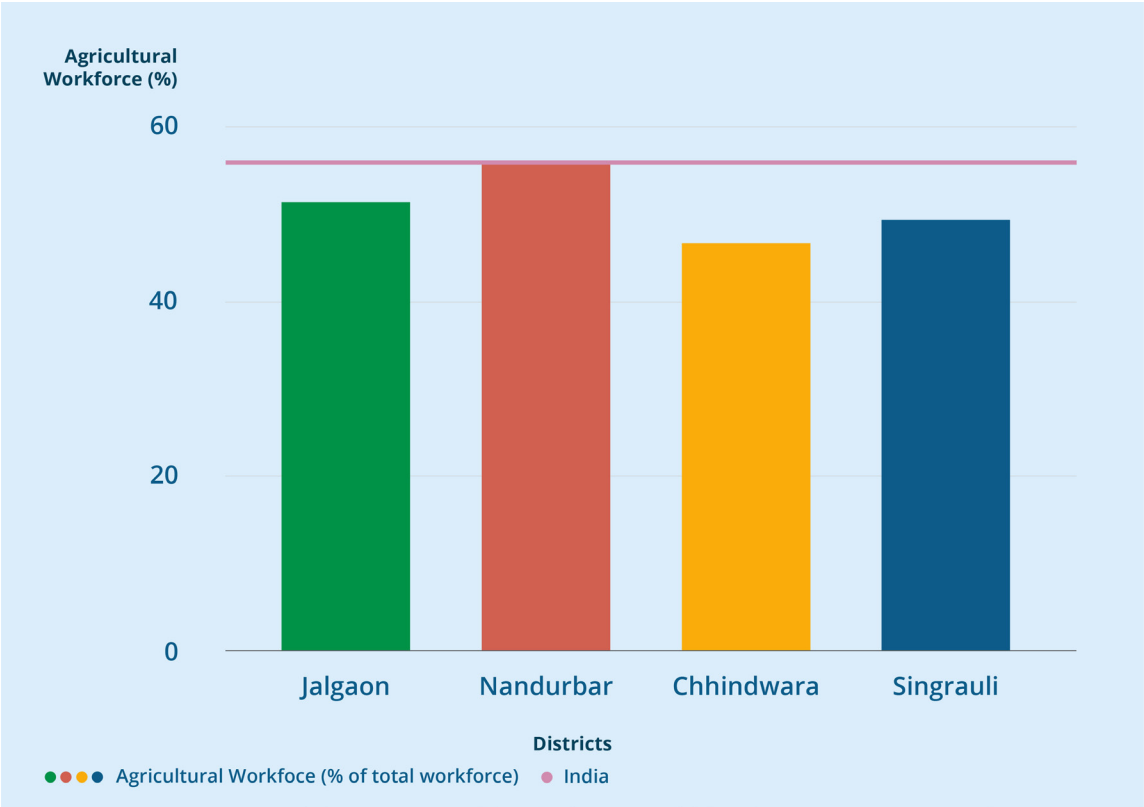
India too has been promoting millets at various international forums including G20 summits to enhance awareness of millets. The common millets in the region are kodo, kutki, jowar, bajra, sanwa, kangni, cheena and ragi.

Source: Raheja Solar, 2022

Box 2. Importance of Turmeric

Turmeric is a deep, golden-orange spice known for adding colour, flavour and nutrition to foods. Turmeric has several medicinal properties and hence is highly recommended for daily use. The types of turmeric used for sowing in this region are Basith haldi and Jawli haldi (desi variety) and Sonia haldi and Sukhana haldi (improved variety). The uses of these varieties range from cooking to medicinal usage, especially black haldi is of great value for medicinal use. Some possible benefits of turmeric include boosting metabolism, prevention of Arthritis, reducing cholesterol in blood, improving kidney health, etc.

Figure 9. Share of agriculture workers in population



Source: MP Ensystems research, 2023

The team visited the four districts in March 2023, where they interacted with the government, civil society organizations, NGOs, FPOs and other locals. The interactions brought light to traditional wisdom-based actions of tribal communities that influence agricultural practices and allied activities, described below along with the importance of millets and turmeric in their daily food consumption.

Observations from site visits

- **Millets are a major source of food for the tribals. The consumption of millets is vital in fulfilling their nutritional requirements and keeping them healthy.**
  Kangi: Traditional storage made of cane/bamboo

- **The millet seeds used for farming are passed on by generations to the next and are 80 to 100 years old. They are stored in dark corners in bamboo storage boxes called 'Kangi' which are raised at a height to prevent mice from entering them. They are preserved by laying teak leaves in layers. The bamboo used for creating the 'Kangi' are washed in water and stored in salt water for anti-termite treatment. The bamboo is then sun dried and later moulded to create storage boxes.**
- **The sowing practice currently for millets is through the broadcasting method, which then does not depend on hiring labour. This method leads to lower productivity and more stones in the harvest, and requires an additional process of destoning.**
- **The farm-level activities are typically driven by tribal women, while men help in negotiations with traders to sell the produce at the market.**
- **As the agriculture is largely rainfed in this region, the cropping season is limited to the monsoon months of August to October. The land stays fallow the other months and hence locals migrate to nearby towns like Surat, Vadodara etc, in Gujarat in search of jobs.**

Tribal women undertaking strawberry farming

- **The grown millets are a major part of the diet of these farmers, and 70-80% of the millet production is reserved for their own consumption, whereas the surplus is sold in nearby mandis.**
- **The millets and other pulses, reserved for self-consumption are dehusked and ground at individual capacity at homes using 'Musal' and 'Jaata' respectively.**

'Musal' used for dehusking at homes

'Jaata' used for grinding at homes

- **The socio-economic conditions appeared better in the tribal regions, with residents owning jeeps, bikes, motorcycles and concrete houses. However, basic needs in terms of education, health and hygiene are often not available locally, with villagers dependent on nearby talukas.**
- **The district of Chhindwara is famous as a major producer of horticultural crops including a variety of vegetables, maize as well as potato, which is procured by major supply-chain partners on contract. The oranges of Chhindwara are a major item of export to numerous countries via Nagpur.**

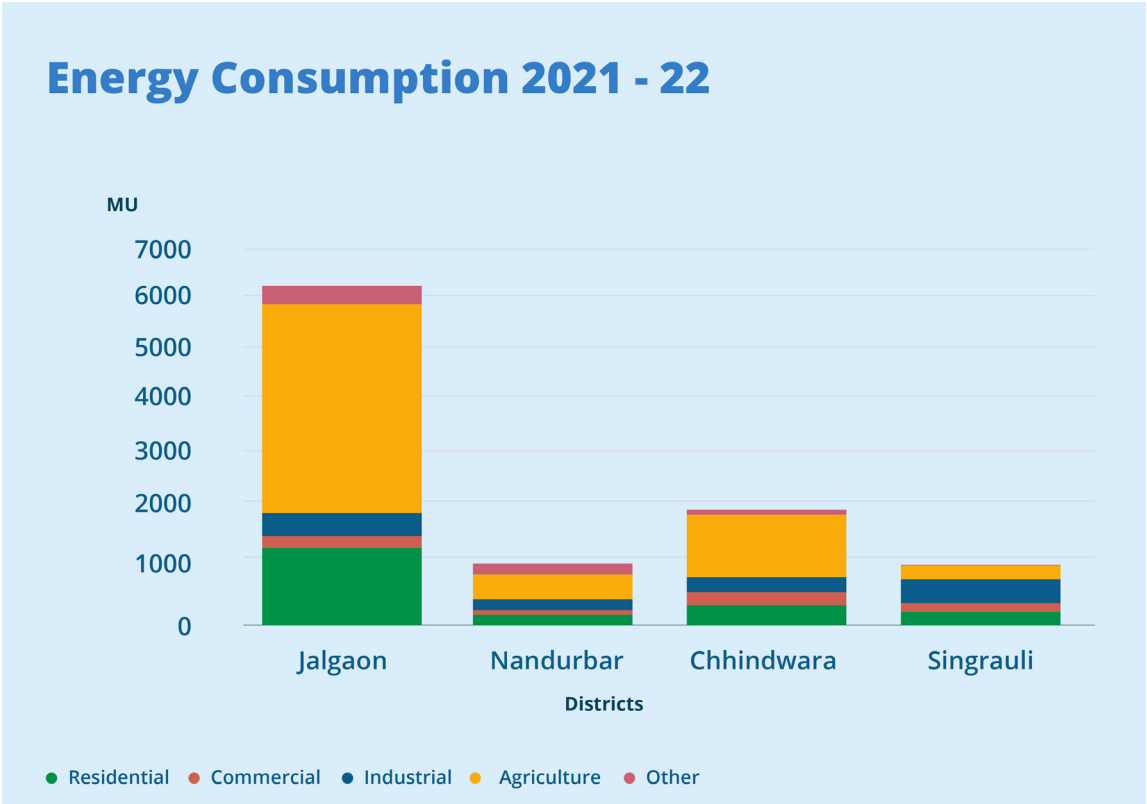
Millet processing unit at Tamia, Chhindwara

Members of Satpuda Naisargik Bhagar Prakiya Udyog with district government officers marking 'International year of Millets' at Molgi, Nandurbar

2.5 Energy Consumption

The chart below provides information on energy consumption (in million units or MU) in the four selected districts for the year 2021. The energy consumption is categorized into five sectors: residential, commercial, industrial, agriculture, and other (including public, institutional, temporary, advertising hoardings, EV charging etc).

Figure 10. Annual energy consumption by sector, 2021



Source: (District Social and Economic Review, Maharashtra, Annual Energy Audit Report, Madhya Pradesh, 2021-22)

Given its larger size, Jalgaon district has the highest total energy consumption among the four districts. In Jalgaon, Nandurbar and Chhindwara, half or more of the total electricity supply is to the agriculture sector. Singrauli district has the lowest total energy consumption among the four districts, with the industrial sector the largest energy consumer.

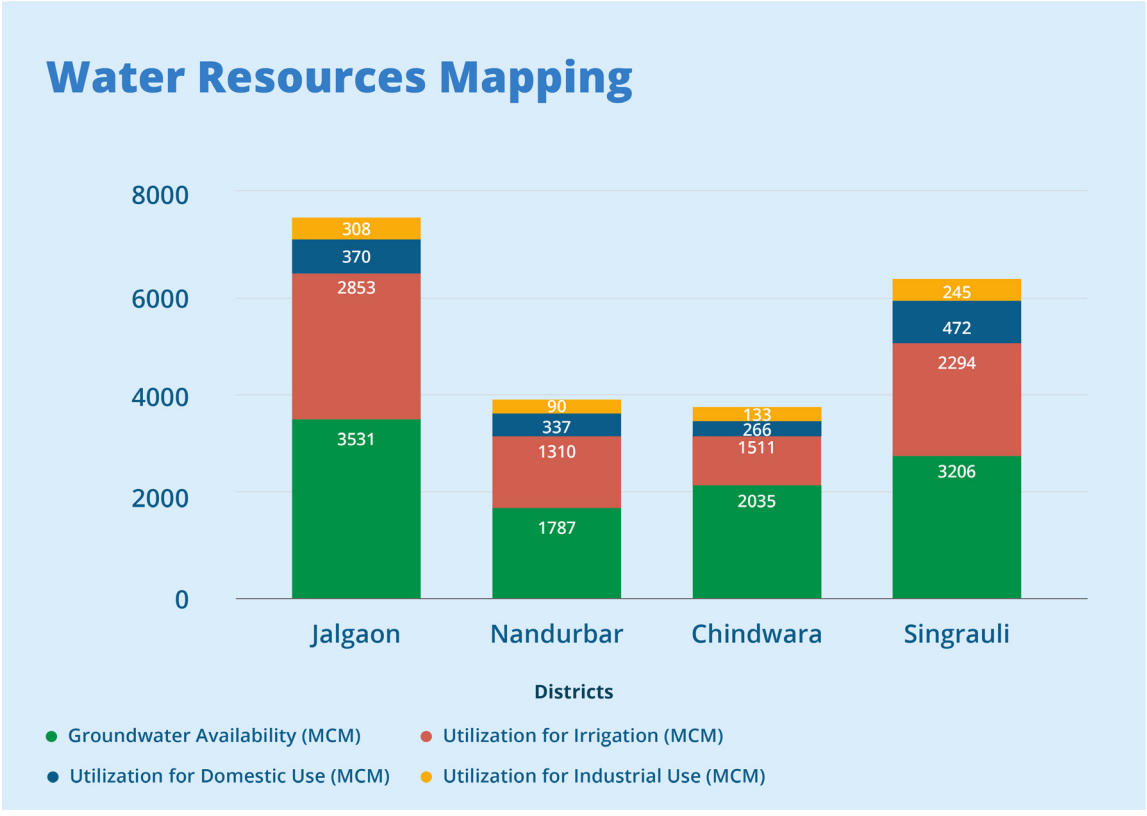
2.6 Water use

Water sources in Jalgaon and Nandurbar include rainfall, Narmada and Tapi rivers, and ground water. Chhindwara receives water from several small rivers, as well as ground water and Singrauli's main water source is the Rihand reservoir.

Surface water, groundwater and recycled wastewater are used in agriculture, industry, domestic and other uses. The data below highlights the availability and use of ground water in the selected districts, based on an assessment from the Central Ground Water Board. Data was not available on the use of surface water and recycled wastewater.

Jalgaon district faces severe water scarcity due to over-exploitation of groundwater. The district has a high level of groundwater extraction and as a result, the groundwater level is declining at a rate of 1 to 3 meters per year. Chhindwara district faces challenges due to uneven distribution of rainfall and over-exploitation of groundwater in some areas, leading to a decline in the groundwater level. The selection of appropriate crops, use of solar pumps, improved electricity supply and recycling of waste water are all important factors to optimise water use in the districts.

Figure 11. Districts' groundwater availability and uses



Source: (Aquifer Mapping and Management of Ground Water Resources, 2021-22)

3. SOCIO-TECHNICAL FINANCING MODEL

The aim of this project is to develop a roadmap for transition for rural districts to a low carbon high growth scenario. This transition involves not only changes in technology and provision of infrastructure, but also enabling social structures, supportive policies at centre, state and district level and availability of finance.

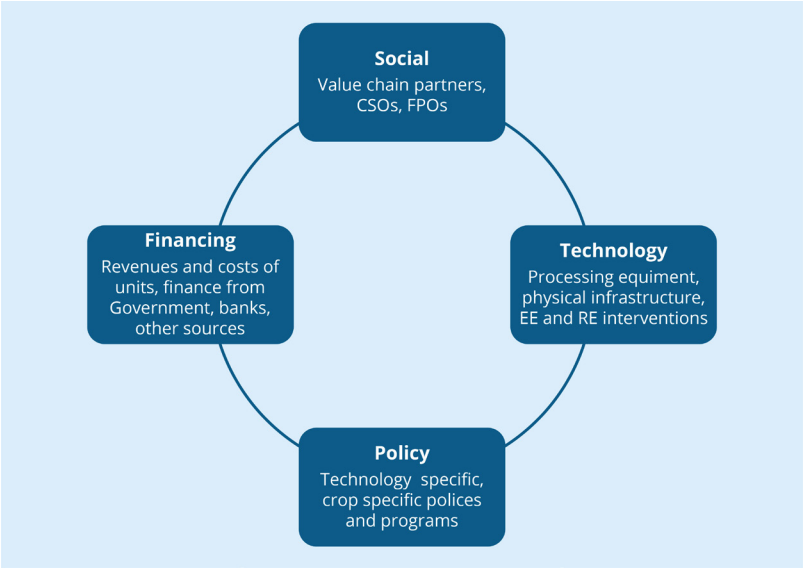
Box 3. How does technological change come about?

Technologies cannot achieve anything on their own without human agency; social structures and organisations implement technologies. New technologies are often difficult to adopt, as regulations, infrastructure, user practices, maintenance networks are aligned to the existing technology. However, new socio-technical systems do eventually move from niche to regime-level. The key to transformation is to understand the process by which the changes can take place and develop ways to speed up the transition.

Source: Geels, 2002

The socio-technical-financing-policy (STPF) framework has been applied by Patankar et al (2010) to a waste to energy project in the dairy sector. We have applied the STPF framework to a case study of two millet processing plants, to understand the key actors and levers for change, as seen in the figure below.

Figure 12. STPF framework in the selected districts



Source: MP Ensystems, 2023

3.1 Comparative case study of millet processing in Chhindwara and Nandurbar, using STPF framework

Chhindwara has a millet processing unit, based out of Harshdiwari village in the Tamia block. The unit manufactures nutritious ready-to-eat products from millets. The processing capacity of the unit is small- approximately 6,000 kg per annum.

In Nandurbar, 10 farmer producer groups with 30 women in each group have set up a processing unit for millets. The processing plant operates for 5 to 6 hours a day and can process up to 1,200 kg millets per annum.

3.1.1 Social

The table below lists the major stakeholders in the Chhindwara and Nandurbar. A comparison of the two districts shows that the network of stakeholders is more extensive in case of Chhindwara, due to the years that have been spent on establishing market linkages and technologies.

Table 4. Stakeholder networks in Chhindwara and Nandurbar

Stakeholder	Chhindwara	Nandurbar
User groups	E-Commerce websites, district authorities, megastore chains	E-Commerce websites, district authorities, megastore chains
Societal groups	MP Vigyan Sabha, Self-Reliant Initiatives through Joint Action (SRIJAN), local Farmers' Producers Organisations (FPOs), Self-Help Groups (SHGs) and Non-government Organisations (NGOs)	Agricultural Technology Management Agency (ATMA), local Farmers' Producers Organisations (FPOs), Self-Help Groups (SHGs) and Non-government Organisations (NGOs)
Research Network	ICAR - Central Institute of Agricultural Engineering (CIAE), ICAR-Agricultural Technology Application Research Institute (ATARI), Atal Bihari Vajpayee Institute of Good Governance and Policy Analysis (AIGGPA)	Krishi Vikas Kendras (KVKs), Yashwantrao Chavan Academy of Development Administration (YASHADA)
Public Authorities	Ministries of Agriculture, Food processing Industries, MSMEs, Rural Development, Power, New and Renewable Energy	Ministries of Agriculture, Food processing Industries, MSMEs, Rural Development, Power, New and Renewable Energy
Financing Network	National Bank for Agriculture and Rural Development (NABARD), Tribal Cooperative Marketing Development Federation of India (TRIFED), Multi-lateral agencies' grants	Mahila Arthik Vikas Mahamandal (MAVIM)
Suppliers	Equipment from ICAR - Central Institute of Agricultural Engineering (CIAE)	Equipment procurement assistance from MAVIM

Source: MP Ensystems Research, 2023

Box 4. Active local stakeholders

The districts covered under this study have experienced positive change partly due to the efforts of Civil Society Organisations (CSOs) working at the ground level. These traditionally backward districts have otherwise received muted interest from the industrial and commercial sector for investment, so the micro approach adopted by some of the organisations working here has transformed the lives of the marginal farmers and the tribal population residing in these districts. Some of the organisations doing commendable work in these 4 districts are:

- **Madhya Pradesh Vigyan Sabha**

  This non-governmental organisation provides low-cost technological solutions to farmers in Madhya Pradesh, Chhattisgarh, and Jharkhand through which they can add value to their farm produce and avail better remuneration for their crops. They have established the solar-powered millet processing unit in Tamia, Chhindwara

- **Self-Reliant Initiatives through Joint Action (SRIJAN)**

  SRIJAN has a network in Madhya Pradesh, Chhattisgarh, Uttar Pradesh, and Rajasthan where it supports rural communities under various government schemes and grants from multilateral agencies. SRIJAN has been involved in processing of custard apple in Chhindwara, while developing marketing linkages for the processed products. They have also been involved in the marketing of maize, millets, and cotton.

- **Mahila Arthik Vikas Mahamandal (MAVIM)**

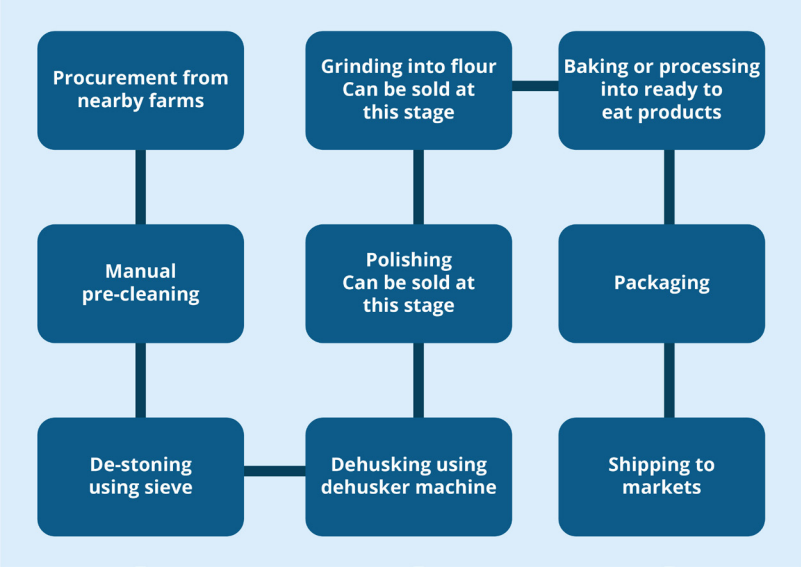
  MAVIM is the nodal agency for the Government of Maharashtra to implement women empowerment programs through Self Help Groups (SHGs). They are working on increasing millet production and value addition of millets while setting up market linkages in Nandurbar district.

Source: MP Ensystems research, 2023

3.1.2 Technology

Millets grown in the region are either consumed by the farmer, sold in the open market, or sent for processing. The figure below shows the manual and mechanical steps in processing millets.

Figure 14. Steps in millet processing (at Chhindwara plant)



Source: MP Ensystems research, 2023

The machinery installed at the Tamia centre in Chhindwara requires low power, with most of the equipment rated around 1 HP to process up to 6,000 kgs annually. The machinery is powered by a 2 kW battery-supported solar rooftop system. A diesel generator acts as emergency backup for the rainy season.

Rooftop solar PV system in Tamia, Chhindwara

Source: MP Ensystems research, 2023

In Nandurbar, the millet processing facility follows the processing stages in the figure above, up to the grinding stage. The machinery runs on grid electricity, without any backup generator. The unit is in Molgi a hilly part of Nandurbar, where power supply is intermittent. When grid power is available, the unit operates 5-6 hours per day and produces processed millets and flour. The use of solar power to power the Nandurbar plant can reduce the dependency on electricity supply, which can irregular in peak demand conditions.

3.1.3. Policies

The government has been actively promoting energy efficiency and renewable energy in food processing, making the value chain efficient, development of backward areas, and is also promoting specific agriculture and horticulture products. Some of the policies and projects at state and central level are in the table below.

Table 5. Government policies promoting greening the rural value chain

Policy	Aim
Centre	
National Mission on Food Processing, 2012	The aims are modernization of food processing industries, establishing of mega food parks and integrated cold chains
Mission for Integrated Development of Horticulture (MIDH), 2015	The scheme promotes horticulture covering fruits, vegetables, root and tuber crops, spices, flowers, plantation crops etc. The interventions include introducing improved varieties and quality seeds, incentives for plantation crops, cluster development, and post-harvest management.
Aspirational Districts Programme, 2018	Aims to quickly and effectively transform the country's most under-developed districts
India Cooling Action Plan, 2019	Promote energy efficiency in post-harvest management
One District One product, 2022	Promotes a single agri/ horticulture product in each district to achieve economies of scale in procurement of inputs, creating infrastructure and marketing products
International Year of Millets, 2023	United Nations has announced 2023 as the International Year of Millets
Maharashtra	
Maharashtra Food Processing Policy, 2017	Funds and infrastructure for food processing parks, land acquisition, integrated cold chain. No specific policies for millets.
Maharashtra industrial promotion subsidy	Policy provides subsidies for setting up large food processing parks. Relaxed eligibility criteria for units in aspirational districts
Project on Climate Resilient Agriculture (POCRA)	Using apps, internet of things (IoT), remote sensing to improve the profitability of farmers in the drought prone regions of Vidarbha and Marathwada (Jalgaon and Nandurbar are in Khandesh, hence out of the project area)
State Of Maharashtra's Agri-Business and Rural Transformation Program (SMART) Project	The project aims to support value-addition in post-harvest processes, facilitate agri-business investments, promote resilience
Maharashtra Agribusiness Network (MAGNET)	Project for development of integrated value chains in horticulture crops
Maharashtra EV policy, 2021	Financial incentives for electric goods carriers (3 and 4 wheelers)

Madhya Pradesh	
Agribusiness and Food Processing Policy, 2012	The policy provides incentives for setting up large food processing industries and assistance with marketing. There are additional benefits to women and SC/ ST beneficiaries
Micro Small and Medium Enterprises (MSME) Development Policy, 2021	The policy aims at employment generation, infrastructure creation and promoting inclusive growth. Subsidies are provided to industries, with additional packages for food processing MSMEs
Madhya Pradesh Electric Vehicle Policy 2019	E goods carriers are to pay lower Motor Vehicle tax, and are exempt from registration fees and parking charges

The processing units at Chhindwara and Nandurbar do not appear to have received specific benefits from any of these policies.

3.1.4. Financing

The table below shows the total costs incurred by farmers and revenues received per kg of millets, depending on the level of value addition. The costs were estimated from site visits and interviews at the units in Chhindwara and Nandurbar. The farmer groups in both districts had small and medium land holdings, ranging from 3 acres to 3 hectares.

Table 6. Costs and revenues of millet production in selected units, 2023

Product sold (per kg)	Cost, INR	Revenue, INR
Millet grains	15	20-25
Millet flour	22-24	30
Millet ready to eat products	70-80	100-385

Source: MP Ensystems Research, 2023

The table below details the capital investment required for the Chhindwara plant.

Table 7. Fixed costs of millet processing

Cost Heads	Price in INR
Grain cleaning & sorting sieves	40,000
De-stoner machine	50,000
Dehusking machinery	50,000
Rotary glaze machine with blower & water pump	60,000
Rice polisher	45,000
All structural equipment, main line & pipe line etc.	1,00,000
Flour mill	1,00,000
Other accessories	50,000
Cost of solar panel machinery (10 kW)	5,00,000
Dough maker	65,000
Bread Cutter	60,000
Others (weighing machine, packaging machine)	20,000
Printer (for labelling)	45,000
Total Machinery (INR Lakh)	**11.85**
Land, Buildings & Civil Work (INR Lakh)	**8.0**
Total Costs	**19.85**

Source: MP Ensystems Research, 2023 [4]

In addition to the capital costs above, the FPO had the following operational costs

Table 8. Operating costs of millet processing

Cost heads	Annual Cost
Total wages – supervisor, accountant, 3 semi-skilled workers	6.0
Utilities cost, INR lakhs [5]	0.5
Total cost, INR lakhs	6.6

Source: MP Ensystems Research, 2023 [6]

The average annual income from producing millet snacks at Tamia is INR 35-40,000. In comparison, the farmers/ food processors at Nandurbar have an average annual income of INR 25-30,000. The Tamia unit also generates more employment for semi-skilled workers.

The return on investment of both plants could not be determined, as both units were set up using donor funds. The millet producing unit in Chhindwara was funded by the Ministry of Tribal Affairs, NABARD (under its Livelihood and Enterprise Development Program) and multilateral donor agencies.

In the case of Nandurbar, the total project cost was INR 25 lakh, with financial support through the Tejaswini programme of MAVIM, under the funds allocated by IFAD (International Fund for Agricultural Development), a UN agency. Equity of 3% was raised by mahila bachat gat members. While both units are successful in generating income and employment, they have not received finance from mainstream financing conduits. In order to scale up farm-gate processing, easy access to concessional finance at a large scale is needed.

Box 5. Benefits of farm-gate food processing

India is the world leader in production of several agricultural commodities. Investment by the Government and private sector has led to rising food production and improved farm productivity. Despite this, farmer income has not risen in line with GDP growth. Meanwhile, the food processing industry has expanded and is now the country's fifth largest sector.

India's food processing levels are at 10%, compared to 55% in developed countries, in part due to lack of infrastructure and societal preferences for fresh food. However, increasing urbanisation, rise in disposable incomes, change in preferences and e-commerce have created an opportunity for food processed at the farm gate to be provided to urban consumers (KPMG 2021).

The Government is targeting doubling farmer income by 2023. Improving post-harvest storage, transport and implementing additional processing units can lead to increase in farmer income and provide local employment opportunities.

Currently available mainstream sources of finance for greening and expansion of food processing units include:

Table 9. Financing for greening the value chain

Source of Finance	Benefits
Government financing schemes	
Pradhan Mantri Formalisation of Micro Food Processing Enterprises (PMFME)	• Food processing entrepreneurs through credit-linked capital, get subsidy @35% of the eligible project cost with a maximum ceiling of Rs.10 lakh per unit • Seed capital @ Rs. 40,000/- per SHG member for working capital and purchase of small tools. • Credit linked grant of 35% for capital investment to FPOs/ SHGs/ producer cooperatives • Support for marketing & branding to micro units
Central Sector Scheme on Formation and Promotion of 10,000 new Farmer Producer Organizations (FPOs)	• Up to Rs. 18.00 lakh per FPO for a period of 3 years • Provision for matching equity grants up to Rs. 2,000 per farmer member of FPO with a limit of Rs. 15.00 lakh per FPO • Provision of a credit guarantee facility up to Rs. 2 crores of project loan per FPO from the eligible lending institution to ensure institutional credit accessibility to FPOs
Agriculture infrastructure fund	• 1 lakh crore Agri Infrastructure Fund for farm-gate infrastructure for farmers • long term debt financing facility for investment in viable projects relating to postharvest management Infrastructure and community farming assets • Interest rate subvention and credit guarantee for eligible borrowers
Self-employment schemes, MP	• MP Government to provide subsidy for rural youth to set up small scale food processing units • For primary processing units up to INR 25 lakh, 40% to be provided as subsidy, the remaining as bank loans
Banking sector	
NABARD schemes	NABARD provides refinance to agricultural financing institutions, along with other functions to support agricultural development such as area based schemes, agriclinics, financial literacy programs etc.
Banking sector	District central cooperative banks, primary agriculture credit society, cooperative banks, commercial banks are all required to lend to agriculture and allied activities under the Priority Sector Lending rules
Other	Corporate social responsibility (CSR) funds, bilateral and multilateral financing, vendor finance, supply chain finance

3.2 Proposed interventions

Based on the case study above and visits to other rural enterprises (see Annexure 1 for case studies on processing units in Jalgaon and Singrauli), this section describes targeted interventions that can plug existing gaps for agricultural enterprises in the region.

3.2.1 Social

The selected districts have strong networks of grassroots organisations which aim at livelihood support. These organisations, along with district authorities can undertake the following efforts to build stronger links in the supply chain:

- Awareness of climate smart agriculture practices to enhance productivity
- Awareness campaigns among consumers to build demand for millet grains and value added products
- Assistance to FPOs in marketing, including building local brands, low waste packaging, standardisation of products
- Assisting in obtaining FSSAI and other food safety and quality certifications
- Building awareness of costs and benefits of EE and RE technologies for food processing

3.2.2 Technical

The technologies [7] in the table below can be implemented in the processing units in the selected districts depending on the agriculture/ horticulture product being processed.

Table 10. Expected benefits from proposed technology interventions

Intervention	Direct Beneficiaries	Specifications	GHG abatement, tCO2	Reduced energy cost/ increased farmer income INR
Solar dryer	Small and medium farmers of chilli, tomato	40 kg capacity Cost INR 34,000		INR 3,10,000
Low-cost cooling	Small scale farmers of vegetables	100 kg capacity Cost INR 28,000		Can raise farmer income by 30%
Freight EV	Medium and large scale farmers of all crops	E 3 wheeler cost INR 3,66,000	16 over 10 years	Depending on distance covered, total cost of ownership can be less than ICE vehicle
Small Rooftop Solar PV	Setting up processing for small and medium farmers of turmeric, millets	3 kW solar rooftop system Cost INR 1,23,500	80 over 25 years	1st year savings INR 21,000
Rooftop Solar PV for large cold storage plant	Owners of existing large cold storage facilities for crops such as potato, tomato, oranges, strawberries	134kW solar rooftop system Cost INR 87,35,304 Annual O&M INR 112, 500	3,700 over 25 years	1st year savings INR 13,95,000
Vertical axis wind turbine	For small medium and large operations of processing, cold storage	3kW turbine costs INR 50,000	80 over 25 years	Depends on wind speed at the location
RE based Distributed Cold storage	For large facilities or at community level, e.g. at district mandi	5MT capacity Cost INR 12,10,000 Annual maintenance INR 1,50,000	56 over 10 years	Net revenue depending on utilisation rate and rate of renting space to other farmers
Agrovoltaics	For owners of degraded land, at community scale	144 kW system on 1 acre of land Medicinals and aromatics planted between the solar panels Cost of PV system INR 72,00,000	3,700 over 25 years	215,477 kWh energy generated annually, which can be sold or used. Additional income from crops

Source: MP Ensystems, Jan 2023

3.2.3 Policy

Policy interventions recommended in the selected districts include:

- Training and upskilling to rural youth in food processing, waste management, maintenance of EE and RE equipment, EVs maintenance and EV charging infrastructure
- Adding provisions in current policies supporting installation of agrovoltaics with subsidies under component A of PM KUSUM scheme. The tribal population in these districts owns small landholdings and hence cannot benefit, due to the minimum landholding requirements to avail the subsidy

3.2.4 Financing

As seen above, most financing schemes are for large scale food processing plants in industrial food parks. Finance of smaller tickets sizes (e.g. loans of less than INR 1 crore) are needed for small scale processing units. To reduce transaction costs, banks can provide financial packages for specific technology interventions, listed above.

3.3 Scale up

Based on past and current studies in the region, farmer groups supported by governments, financing agencies and other stakeholders can install efficient processing equipment, to raise incomes, without a corresponding rise in GDP. We propose the following suite of technological interventions that can be introduced in a phased manner across the selected districts of Maharashtra and Madhya Pradesh for produce of the region, including turmeric, millets, strawberries, bananas, potato, maize etc. These proposed suites of technological interventions will also lead to rise in employment opportunities and ultimately leading to improvement in livelihood conditions in these districts. The local youth workforce of the selected districts can be trained and equipped to handle the technological interventions, which will generate employment and curb migration to other districts and states.

The expected benefits are in the table below.

Table 11. Expected benefits from scale up of technology interventions

Intervention	Beneficiaries	Technical Potential, MW	Economic Potential, MW	Market Potential, MW	Cost, INR crore	GHG Reduction, tCO2	Payback period, years
Low-cost cooling option	6,72,495 agri households	672500	134500	13500	37.7		0.6
Solar dryer	6,72,495 agri households	2690000	538000	53800	182.9		0.3 years
Freight EVs	6,72,495 agri households	67300	13500	1350	49.2	21519.8	4.7
Rooftop PV for small processing plant	75 processing plants with 3 kW of rooftop PV	0	0	0	0.0	889.5	7.4
Rooftop Solar PV for large cold storage plant	37 cold storages with capacity of 5-20 MT	5	1	0	0.7	2705.5	9.6
RE based Distributed Cold storage	At 37 mandis	4	1	0	1.8	828.8	3.1
Agrovoltaics	97,88,000 ha of degraded land and wastelands	1400	280	28	140.9	723920.5	8.4

Source: MP Ensystems, Jan 2023

THE ASSUMPTIONS FOR THE TABLE ARE:

- Rooftop solar PV- applied to existing and new cold storages in the selected districts- minimum one cold storage facility per taluka. Connected load at each cold storage is 115 kW (135 Solar PV DC capacity, 100 kW AC capacity)
- There are 44 lakh agricultural workers in the selected districts based on the 2011 census. We assume 15% of them are agricultural households owning land of 1 hectare or more.
- 25% of households to install 4 solar dryers each.
- Agrovoltaics on degraded and wastelands. 0.1% of land is covered by agrovoltaics
- Solar based small cold storage systems with solar capacity of 5 kW installed at 1 mandi at each taluka.
- 10% of households with 1 E-3W each.
- Technical potential is estimated as RE in MW that can be generated, based on farming households, existing solar insolation, number of agricultural households in the selected districts.
- Economic potential is based on costs and benefits of interventions. It is estimated at 20% of technical potential at this stage.

- Market potential depends on availability of products, policy support, awareness. It is estimated at 10% of economic potential. As the market develops, more interventions will become available, and the economic and market potential are expected to increase.
- The benefits or costs of the table above cannot be added, as some interventions are substitutes of each other.

4. LOCALIZED MODEL TO ASSESS COST OF TRANSITION TOWARDS LOW-CARBON HIGH GROWTH

The interventions proposed in section 3 are expected to lead to a rise in GDP, without a corresponding rise in GHG emissions. A metric for predicting and measuring change in carbon emissions, economic growth and energy intensity can help in tracking progress. One way to achieve this is through the application of a modified form of the Kaya identity, a metric that breaks down GHG emissions into four factors: population, economic output, energy intensity, and carbon intensity.

The Kaya Identity is used to project future emissions under different scenarios, such as different population growth rates, economic growth rates, and energy and carbon intensity levels. These projections can help inform policymakers and the public about the potential impacts of different policy choices on greenhouse gas emissions and the climate.

The Kaya identity states that total carbon dioxide (CO2) emissions are equal to the product of four factors:

$$CO_2 \text{ emissions} = \text{Population} \times \text{GDP per capita} \times \text{Energy intensity} \times \text{Carbon intensity}$$

Where:

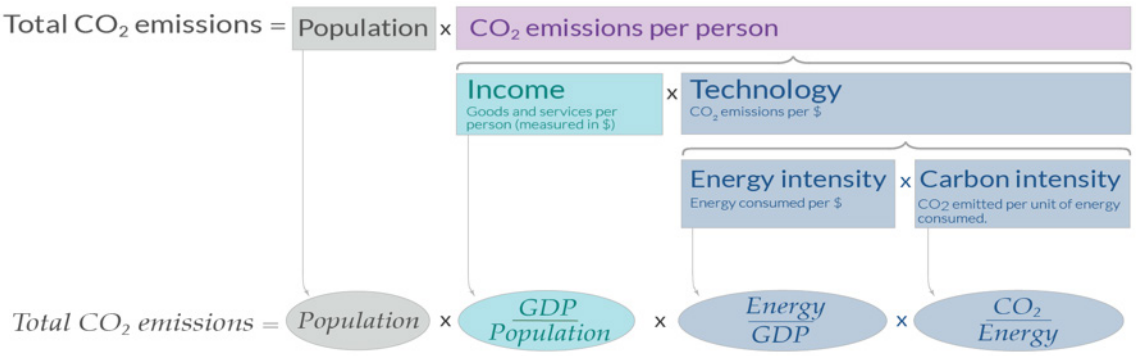
Population is the number of people in a given area or country

GDP per capita is the economic output per person

Energy intensity is the amount of energy used per unit of economic output

Carbon intensity is the amount of CO2 emitted per unit of energy used

Figure 13. Kaya Identity



Source: OWID 2022

4.1 Modified Kaya identity for the selected districts

The Kaya identity can be calculated for the selected districts by utilizing either total CO2 emissions or CO2 emissions per unit of GDP (which is obtained by multiplying energy intensity by carbon intensity) for the district, as a metric for evaluating the effectiveness of interventions in reducing emissions.

In this report, we have modified the Kaya identity to focus on electricity consumption of the district, as electricity is a major energy input in the agriculture value chain processes and infrastructure (processing plants, cold chains etc). This method provides a better understanding of the impact of greening interventions in the value chain. For a fuller understanding of the district's emission intensity, data on biomass and petroleum products can be included at a later stage.

Data required for calculating modified kaya identity indicators, is taken from different sources for districts in Madhya Pradesh and Maharashtra, hence direct comparison between districts might be inaccurate.

The table below compares the four selected districts in terms of their greenhouse gas emissions and economic performance.

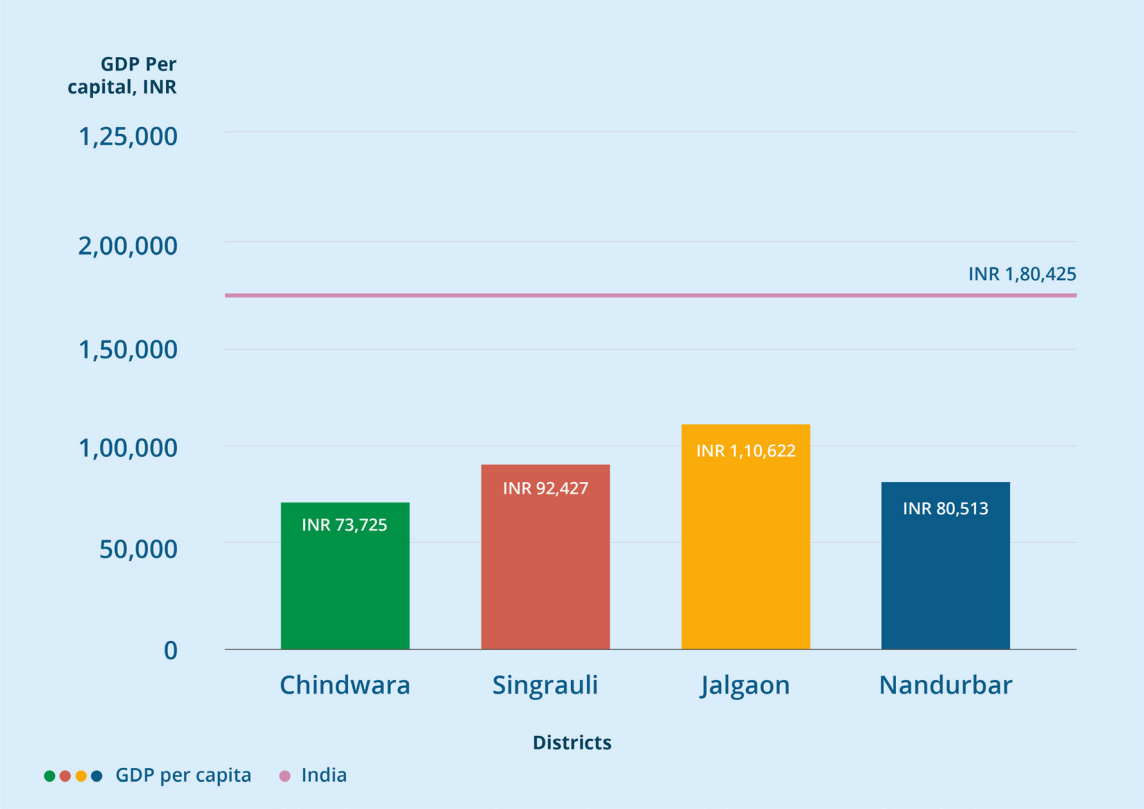
Table 12. District level modified Kaya Identity indicators

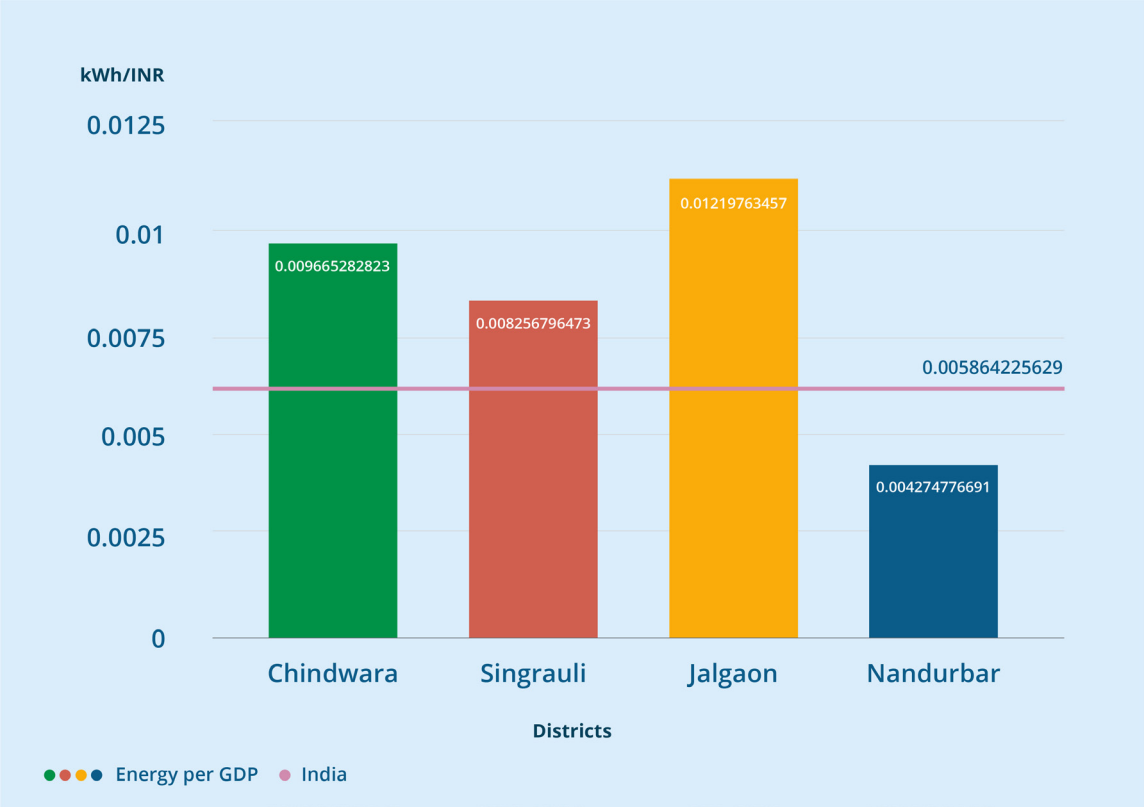
Modified Kaya Identity	Unit	Chhindwara	Singrauli	Jalgaon	Nandurbar	India
Emission per capita	kg CO2/ capita	563	603	1,066	272	836
GDP per capita	INR / Capita	73,725	92,428	1,10,622	80,514	1,80,426
Energy per GDP (Electricity)	kWh/INR	0.01	0.008	0.012	0.004	0.006
Emission per GDP	g CO2 / INR	7.6	6.5	9.6	3.4	4.6

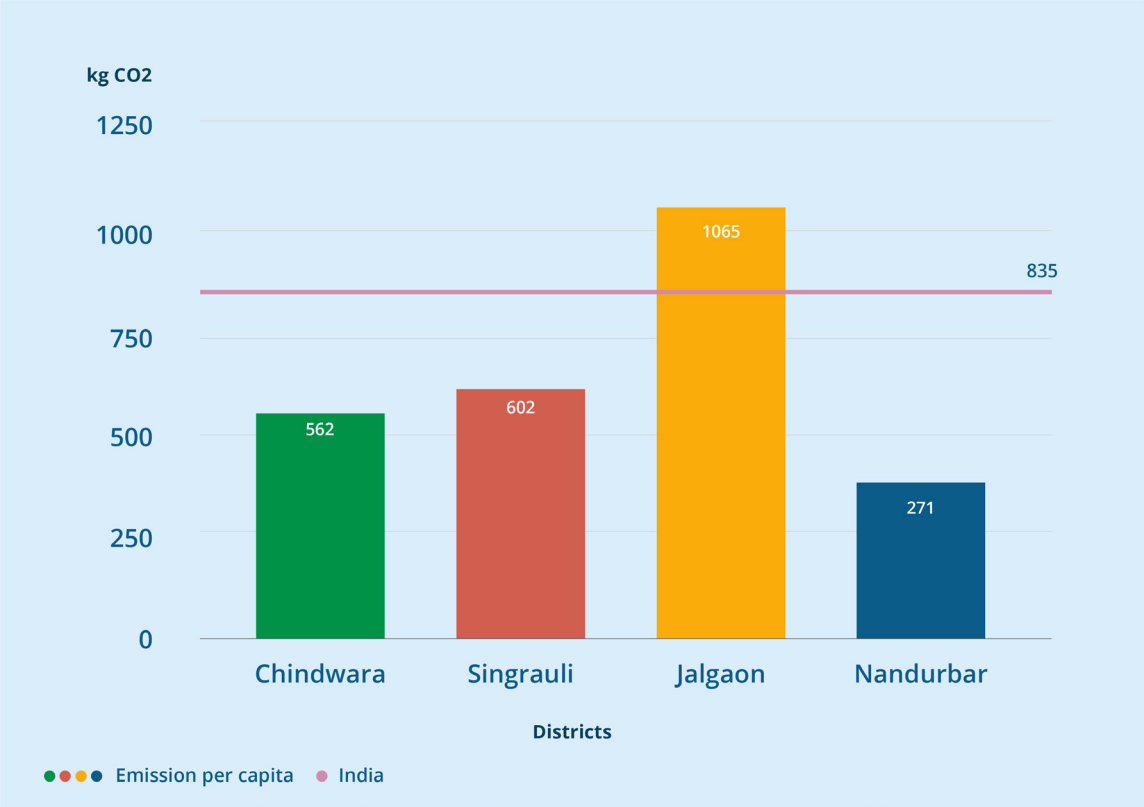
Source: IEA 2021, CEA 2021, MAHADES 2021, MPPKVVC 2022, DSES Chhindwara 2020, DSES Singrauli 2020, OWID 2022

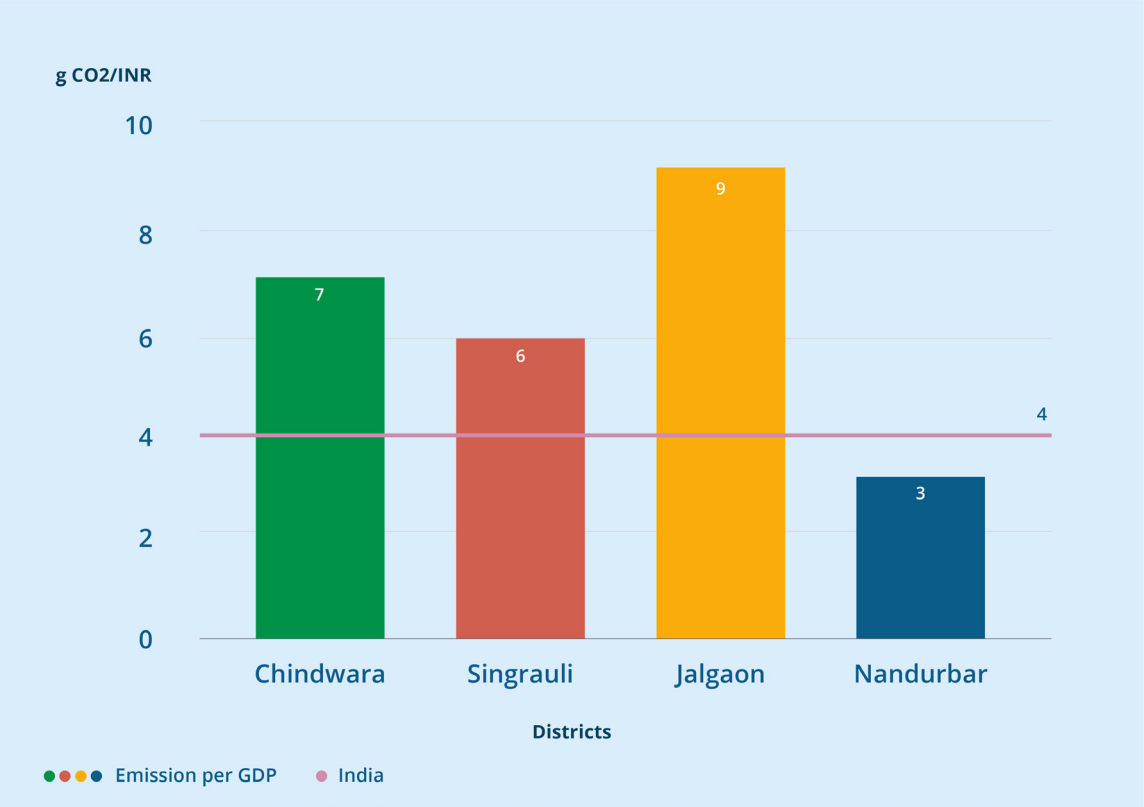
Data from table is summarized in graphical format for better understanding of factors related to district emissions.

Figure 14. Components of Kaya Identity in selected districts









Source: IEA 2021, CEA 2021, MAHADES 2021, MPPKVVC 2022, DSES Chhindwara 2020, DSES Singrauli 2020, OWID 2022

4.2 Projections of Kaya Identity for the selected districts

In this section we have compared the trajectory of the Kaya Identity across 10 years in a business as usual (BAU) scenario and a scenario of post-harvest interventions in rural enterprises, as described in the STPF chapter. The table below shows the components of the Kaya Identity with and without and greening interventions.

Table 13. Kaya Identity in 2033- BAU

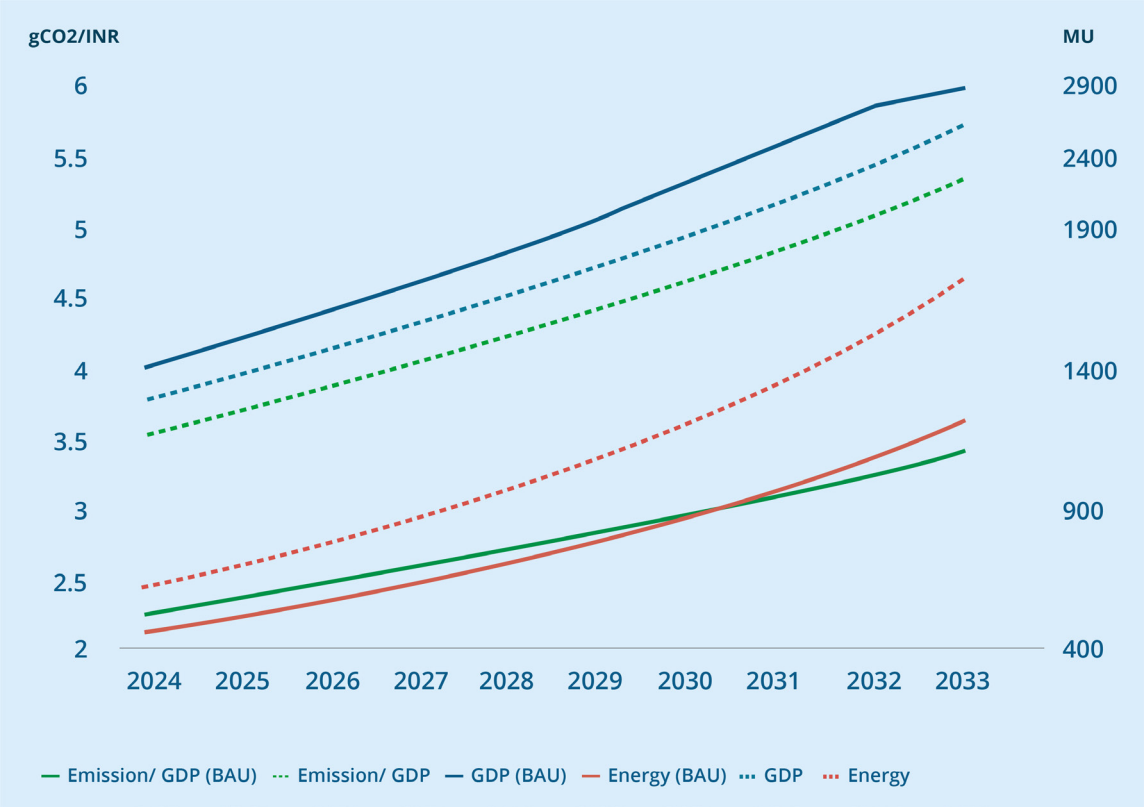
Kaya Identity	unit	Chhindwara	Singrauli	Jalgaon	Nandurbar
Emission per capita	kg CO2/ capita	632	677	1196	305
GDP per capita	INR / Capita	247547	310343	371435	270339
Energy per GDP	kWh/INR	0.004	0.003	0.005	0.002
Emission per Energy	kg CO2/ kWh	0.71	0.71	0.71	0.71
Emission per GDP	g CO2 / INR	2.55	2.18	3.22	1.13

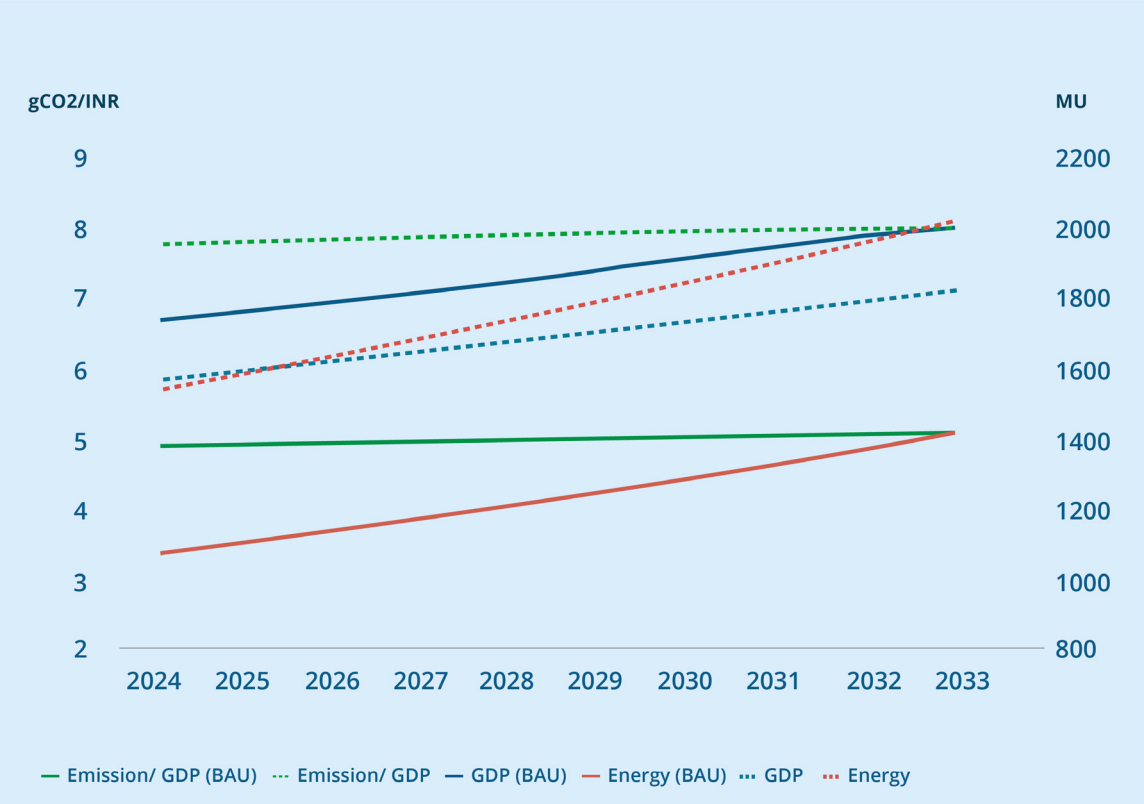
Kaya Identity in 2033- After post-harvest interventions

Kaya Identity	unit	Chhindwara	Singrauli	Jalgaon	Nandurbar
Emission per capita	kg CO2/ capita	619	690	1172	299
GDP per capita	INR / Capita	272301	341377	408578	297373
Energy per GDP	kWh/INR	0.003	0.003	0.004	0.001
Emission per Energy	kg CO2/ kWh	0.71	0.71	0.71	0.71
Emission per GDP	g CO2 / INR	2.27	2.02	2.87	1.01

The charts below show the expected trajectory of the components of the Kaya Identity for 2 districts over the next 10 years.

Figure 15. BAU vs Interventions scenarios, 2023-2033

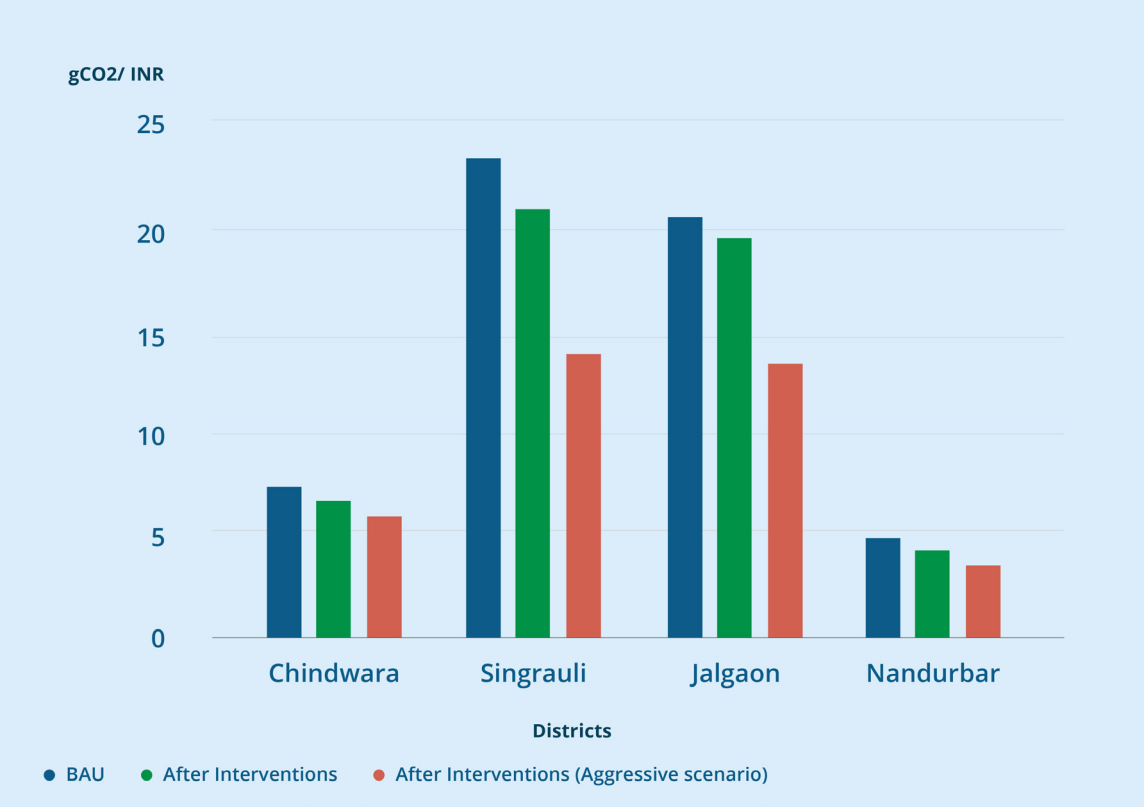




Source: MP Ensystems research 2023

Overall, the interventions seemed to have a positive effect on reducing emission intensity of GDP in all locations. However, the changes in emission intensity are less significant, due to the interventions in the post-harvest sector being additional, i.e. not replacing current electricity powered processing plants, but setting up greenfield RE systems. If the selected districts set net-zero emissions targets [8] , decarbonisation of residential, commercial, industrial and government sectors will lead to greater fall in the emission intensity of GDP, as seen in the third scenario below.

Figure 16 Emissions intensity of GDP: BAU, farm gate interventions, aggressive scenarios



Source: MP Ensystems research 2023

THE ASSUMPTIONS IN THE PROJECTION ARE:

- The interventions are expected to lead to a growth in farmer income of 12% annually, with spill over effects in other sectors including employment, services and commercial activity, leading to an overall 10% increase in district GDP.
- Population growth rate used is India's current growth rate of 0.8%.
- We assume the move to EE and RE will reduce the rise in electricity consumption to 2%. For aggressive scenario, if the greening interventions are contributed through other sectors like transport etc., it can help in further reduction of energy consumption. In aggressive scenario, greening interventions will contribute to reductions by 30%
- India's emission factor for electricity has been used to estimate GHG emissions, and annual decrease in grid emission factor is considered to be 1% accounting for India's RE targets.
- Current district wise growth rates for electricity consumption, GDP are in the table below

Table 14. GDP, electricity growth rates in selected districts, 2023

2023	Chhindwara	Singrauli	Jalgaon	Nandurbar
GDP growth (%) annual	1.58%	0.3%	3.41%	6.85%
Electricity consumption growth (%) annual	3.00%	15%	13%	13%

Source: MPPKVVL, 2023, MERC, Ministry of Agriculture, District Domestic Product

5. WAY FORWARD

During the site visits conducted by the team to the selected districts, we have identified several opportunities to strengthen post-harvest processing of several products with integration of EE and RE technologies, which will boost GDP while keeping the GHG emissions in control.

Over the next three months, the team plans to undertake the following activities:

1. **Engagement with state government departments** including agriculture, horticulture, finance, energy, rural development, skill development and entrepreneurship departments to understand the efforts to boost the rural growth and economy. The team has in past already engaged with Atal Bihari Vajpayee Institute of Good Governance and Policy Analysis (AIGGPA) in Madhya Pradesh. The team will now be focusing on partnering with the said institution in Madhya Pradesh and with Yashwantrao Chavan Academy of Development Administration (YASHADA) in Maharashtra.
2. **Creating programmatic interventions** as recommendations to both the state governments. The team aims to develop Project Design Documents (PDDs) for packages of practices listed in the STPF section, at multiple sites in the districts. The task includes estimating the total cost of the interventions, and the investment required, employment generation potential. Aggregating these individual, interlinked projects and enabling finance from investors and governments will help achieve large-scale impacts.

ANNEXURE 1. SINGRAULI AND JALGAON CASE STUDIES

Singrauli millets processing unit

Singrauli is a major region for the production of millets, especially in the tribal belts which include jowar (Sorghum), bajra (Pearl millet) and sanwa (Barnyard millet). Deosariya Women FPC in the Deosar block in Singrauli has been trying to encourage farmers to expand the area under millet cultivation while providing an avenue for better prices through value addition via its processing unit (established in 2023). The FPC has set up a millet processing unit in the district for value addition to the millet value chain by processing the grains into other products like rice, flour, etc.

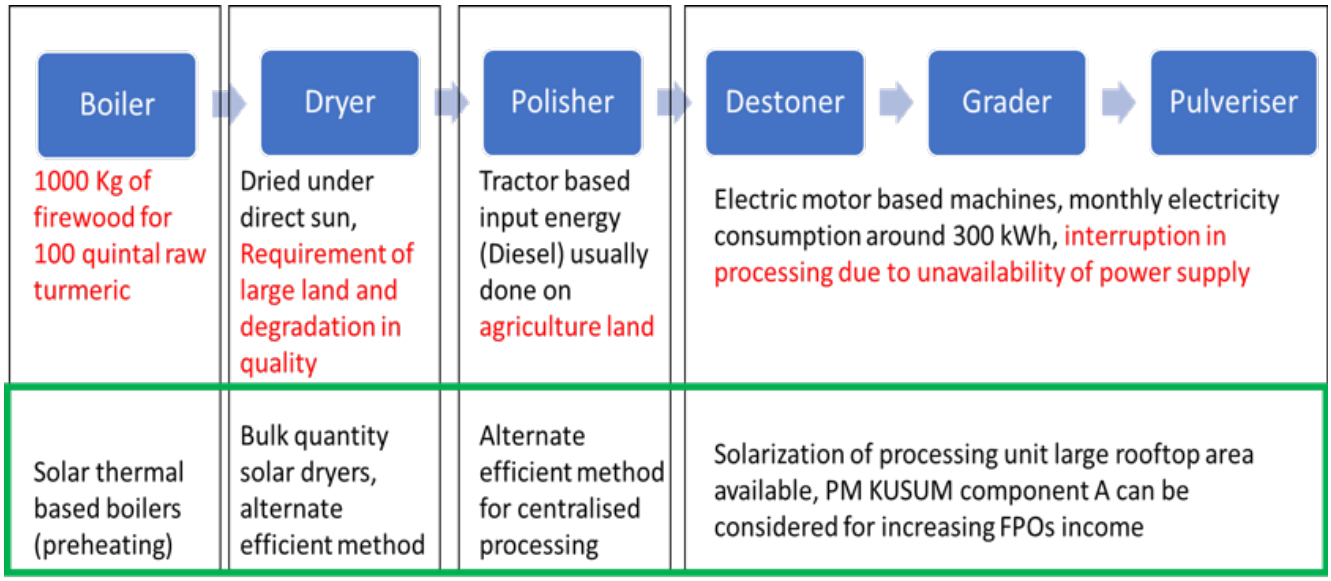
The total cost of the processing plant is around Rs 20 lakhs, and the installation of this scheme was made possible with government support. The millets being processed here are sold in the form of millet rice, which approximately doubles the value of millets as compared to selling in the open market. The FPC plans to expand soon by installing two machines: Destoner and Polisher, to further refine and improvise the product.

The FPO has further empowered women in the area as the day-to-day functioning of the processing unit is being carried out by women through SHGs. The FPC itself includes farmers from nearby villages as its shareholders, and hence the success of this processing unit will ultimately benefit the farmers themselves, creating a self-sustaining and profitable ecosystem.

Jalgaon turmeric processing unit

Rajodak farmers is an FPO with 128 farmers and has successfully set up a turmeric processing unit in Rozode village in Jalgaon district in 2020 during Covid times. Turmeric is procured from the FPO associated farmers and is processed for making turmeric powder.

Turmeric processing involves six stages which are boiling, drying, polishing, destoning, grading and pulverization. The flow diagram below shows the steps involved in turmeric processing, constraints at each step and potential interventions:



For destoning, grading and pulverization electric motor-based machines are used which are installed inside the processing plant premises. Boiling is the most energy intensive process and firewood is used as the primary energy source. Drying takes place on open fields, which leads to issues related to availability of land and quality degradation. Technology interventions can help make this process less emission intensive as well as economically more feasible.

Processing of turmeric leads to value addition of around 40 Rs/kg, which is sold at markets in Sangli, as earlier the sale price gained by selling turmeric was comparatively less than at the local market.

The project cost is INR 34,00,000 (Subsidy INR 16,50,000 + loan INR 17,50,000). Project is implemented under the POCRA scheme and the project planning was done in-house.

Some of the opportunities at this unit are:

- Solar thermal based boiling process can eliminate or reduce firewood consumption in the process, which will save cost of boiling and emissions for burning of firewood
- Alternate methods can be developed for drying turmeric to enhance the quality of product, bulk quantity solar dryer can be considered for turmeric drying
- Solarization of the processing plant can be considered for reducing the electricity cost and to ensure the reliable power to the plant
- Cold storage for turmeric can be set up, which can increase productivity and improve the utilization of processing units

ANNEXURE 2. KAYA IDENTITY OVERVIEW

The Kaya identity is a simple mathematical equation that helps to explain the factors that contribute to greenhouse gas (GHG) emissions. It is named after Japanese energy economist Yoichi Kaya, who first introduced the concept in the early 1990s. The identity is a specific application of the I = PAT identity, which relates human impact on the environment (I) to the product of population (P), affluence (A) and technology (T).

The Kaya identity states that total carbon dioxide (CO2) emissions are equal to the product of four factors:

CO_2 emissions = Population x GDP per capita x Energy intensity x Carbon intensity of energy

Where:

Population is the number of people in a given area or country.

GDP per capita is the economic output per person

Energy intensity is the amount of energy used per unit of economic output

Carbon intensity of energy is the amount of CO_2 emitted per unit of energy

The Kaya identity provides a useful framework for analyzing and designing climate change policies and strategies because it helps to identify the main drivers of GHG emissions and to quantify the potential impact of different policy interventions. Here are a few ways in which the Kaya identity can be used:

- Setting emissions targets: By using the Kaya identity, policymakers can set targets for reducing emissions based on specific combinations of population growth, economic development, energy use, and carbon intensity of energy. For example, a country might set a target of reducing emissions by 30% by 2030 by reducing energy intensity by 20% and carbon intensity of energy by 10%.
- Prioritizing policy interventions: The Kaya identity can help policymakers to identify the most effective policy interventions for reducing emissions by identifying main drivers. For example, if the main driver of emissions in a particular country is population growth, policies aimed at reducing birth rates and promoting family planning could be more effective than policies aimed at reducing energy use.

- Evaluating the effectiveness of policies: The Kaya identity can also be used to evaluate the effectiveness of different policy interventions in reducing emissions (using GHG emissions as metric for policy results). For example, policymakers can use the identity to compare the emissions reductions achieved through policies that focus on energy efficiency, renewable energy, carbon pricing, and other approaches.
- Planning for the future: Finally, the Kaya identity can be used to plan for future emissions reductions. Policymakers can use projections of population growth, economic development, and energy use to estimate future emissions levels and to identify the policy interventions that will be most effective in reducing emissions over the long term.

While the Kaya identity provides a valuable framework for analyzing greenhouse gas emissions, it is important to recognize its limitations. The Kaya identity breaks down greenhouse gas emissions into four factors, which may oversimplify the complexity of emissions and their underlying drivers. It also focuses exclusively on greenhouse gas emissions and does not account for other important environmental impacts, such as air and water pollution, land use changes, and biodiversity loss. The identity assumes that the relationships between population, economic output, energy intensity, and carbon intensity are constant over time, which may not hold true. The accuracy of the Kaya identity depends on the quality and availability of data on population, economic output, energy use, and carbon emissions, which may be limited or unreliable in some regions.

Despite these limitations, the Kaya identity remains a useful tool for understanding greenhouse gas emissions and identifying opportunities for reducing emissions while promoting economic growth. It can be used in conjunction with other analytical methods and contextual information to develop comprehensive strategies for sustainable development.

REFERENCES

[1] List of districts https://my.msme.gov.in/MyMsme/List_of_AspirationalDistricts.aspx

[2] Per capita income for the district has been calculated using district GDP for latest available year and census population data. District GDP data is for the year 2019 in Maharashtra and 2016 in MP; population data is from 2011 census.

[3] Agriculture and allied sectors include farming, fishery, horticulture, animal husbandry, dairy farming, poultry and milk production.

[4] Costs and market prices from interviews at Tamia plant, Chhindwara

[5] Salaries and utilities are estimated to increase by 10% annually

[6] Costs and market prices from interviews at Tamia plant, Chhindwara

[7] The technologies and their benefits have been studied in detail in the previous phase of this project and are available in the report Greening Rural Value Chains in Madhya Pradesh, MP Ensystems Advisory Pvt Ltd. 2023

[8] Cities such as Mumbai and Sanchi, Madhya Pradesh aim to become net-zero by 2050 or later

Aquifer Mapping and Management of Ground Water Resources. (2021-22). Retrieved from https://cgwb.gov.in/AQM/AQM-Reports.html

Agriculture Contingency Plan for District: NANDURBAR. (2008). Retrieved from https://agricoop.nic.in/sites/default/files/Nandurbar.pdf

Agriculture Contingency Plan for District: JALGAON. (2008-09). Retrieved from https://agricoop.nic.in/sites/default/files/Jalgaon.pdf

Agro climatic zones in India & MP Ensystems Research. (2023). Retrieved from http://apps.iasri.res.in/agridata/19data/chapter1/db2019tb1_2.pdf

Census. (2011). Retrieved from https://censusindia.gov.in/census.website/data/census-tables

CEA (2021), Grid emission factor data (2020-2021). Retrieved from https://cea.nic.in/cdm-co2-baseline-database/?lang=en

District and category wise distribution of Land Use / Land Cover in Maharastra. (2015-16). Retrieved from Bhuvan - NRSC: https://bhuvan-app1.nrsc.gov.in/2dresources/thematic/LULC503/MAP/MH.pdf

District Social and Economic Review, Maharashtra, Annual Energy Audit Report, Madhya Pradesh. (2021-22). Retrieved from https://mahades.maharashtra.gov.in/publications.do?pubId=DSA, https://www.mpez.co.in/ShowProperty/UCMRepository/Contribution%20Folders/Jabalpur/pdf/AnnualEnergyReport_MPPKVVCL_2021-22.pdf

District Domestic Product of Maharashtra Report 2011-12 to 2019-20, Estimates of State Domestic Product 2011-12 to 2016-17, Madhya Pradesh. (.). Retrieved from http://des.mp.gov.in/Portals/0/Estimates_SDP_2011-12-2016-17.pdf, https://mahades.maharashtra.gov.in/files/report/DDP_Final_04.08.2021.pdf

DSES Chindhwara (2020), District Social and Economic Review - Chhindwara (2019-20). Retrieved from http://www.chhindwara.nic.in/sites/default/files/1.pdf

DSES Singraulli (2020), District Social and Economic Review - Singrauli (2019-20). Retrieved from http://singrauli.nic.in/en/public-utility/district-social-and-economic-review/

Economic Survey, Madhya Pradesh. (2021-22). Retrieved from https://www.im4change.org/docs/Economic_Survey_2021-22.pdf

First Advance Estimates of National Income. (2018-19). Retrieved from https://pib.gov.in/Pressreleaseshare.aspx?PRID=1558931

Geels, Frank W. “Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study.” Research policy 31.8-9 (2002): 1257-1274.

Geographical Analysis (2023). Shapefiles of India https://geographicalanalysis.com/download-free-india-shapefile-including-kashmir-and-ladakh

IEA (2021), India Energy outlook 2021, Retrieved from https://www.iea.org/countries/india

Indian Census. (n.d.). B-04: Main workers classified by age, industrial category and sex (total). Retrieved from https://censusindia.gov.in/2011census/C-series/c-04/DDW-0000C-04.xls

ICAR (2023). Agro climatic zones of India http://apps.iasri.res.in/agridata/19data/chapter1/db2019tb1_2.pdf

KPMG (2021). Food processing: key to doubling farmer income https://kpmg.com/in/en/blogs/home/posts/2021/07/food-processing-key-doubling-farmers-income.html

MAHADES (2021), District Social and Economic Review, Maharashtra, Retrieved from https://mahades.maharashtra.gov.in/publications.do?pubId=DSA,

Millet Advisor (2023). Introduction and types of millets https://milletadvisor.com/millets-types-of-millets/

MP Ensystems. (January, 2023). Greening Rural Value Chains in Madhya Pradesh, MP Ensystems Advisory Pvt Ltd.

MPCB (2023). Ambient Air Quality Monitoring Network https://www.mpcb.gov.in/air-quality/Jalgaon/0000000149?fdate=06-03-2023&tdate=06-04-2023

MPPKVVCL (2022), Annual energy report (2022). Retrieved from https://www.mpez.co.in/ShowProperty/UCMRepository/Contribution%20Folders/Jabalpur/pdf/AnnualEnergyReport_MPPKVVCL_2021-22.pdf

OWID (2022), India GDP data and Kaya identity, Retrieved from https://ourworldindata.org/

Patankar, Mahesh, Anand Patwardhan, and Geert Verbong. “A promising niche: waste to energy project in the Indian dairy sector.” Environmental science & policy 13.4 (2010): 282-290.

SFAC India. (2021). Retrieved from http://sfacindia.com/PDFs/List-of-FPO%20identified-by-SFAC/List%20of%20FPOs%20in%20the%20State%20of%20Maharashtra.pdf?var=9958569.25855

MP ENSYSTEMS

MP Ensystems Advisory Pvt. Ltd.

Mumbai I Bengaluru I Goa

Ground floor, Dwaraka,

Pushpadhanwa Society

Madan Mohan Malviya

Road Mulund (West),

Mumbai, 400080

India

Ph: 022 25925215

info@mpensystems.com

www.mpensystems.com