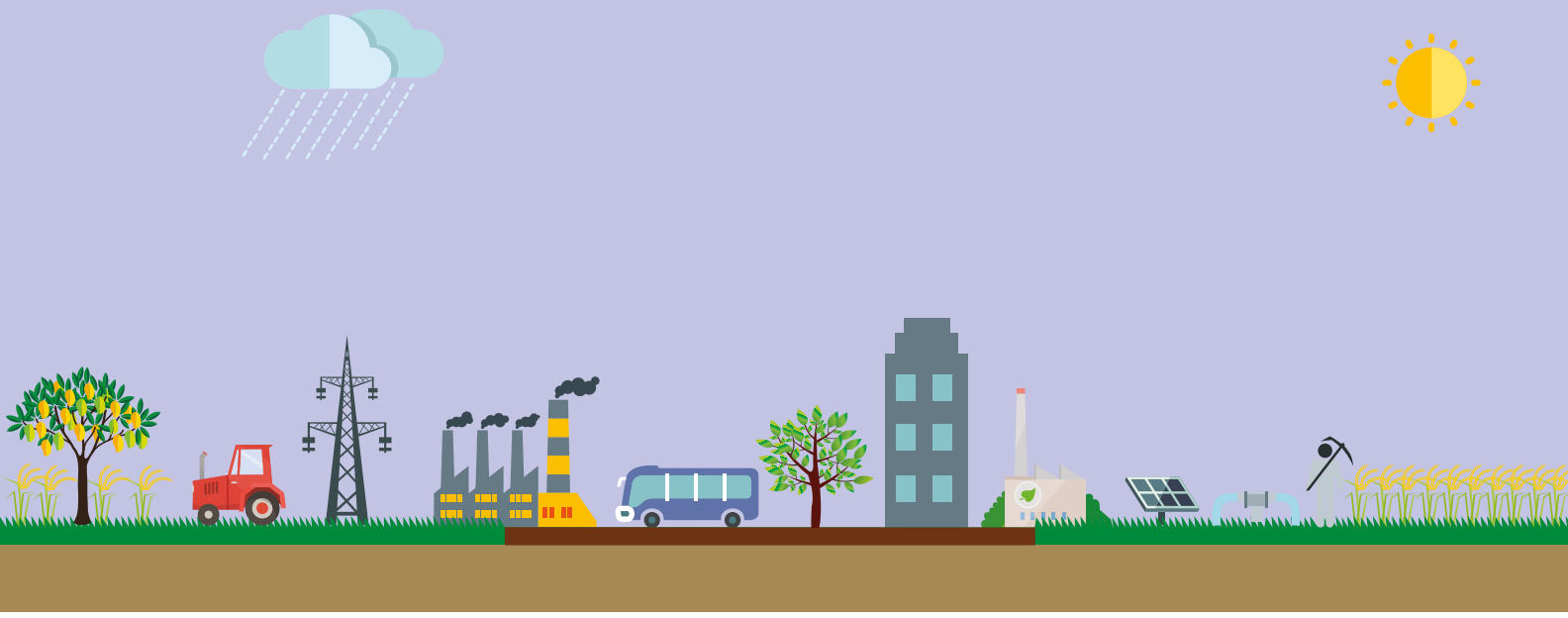
Climate Resilient Green Growth Strategy for Punjab

Towards an Inclusive Development Agenda

Summary for Policymakers



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Partners

The Energy and Resources Institute

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Contents

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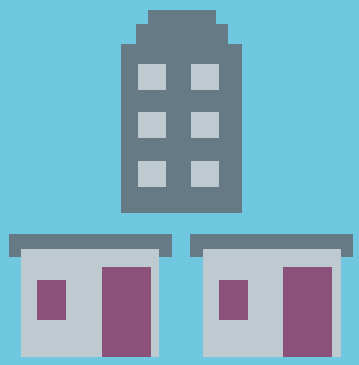
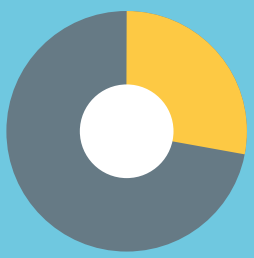
1 Context

Punjab, located in the north-western border of India, is a small state occupying less than 2 per cent of the geographical area and inhabited by little more than 2 per cent of the total population of the country. With only 1.57 per cent of total geographic area of country, the State contributes significantly to India's food security. The State contributes 13–14 per cent of total food grain production of the country. Punjab falls in the Indus basin and is drained majorly by three rivers—the Ravi, Beas, and the Sutlej—and other drainage channels including the Ghaggar draining the southern parts.

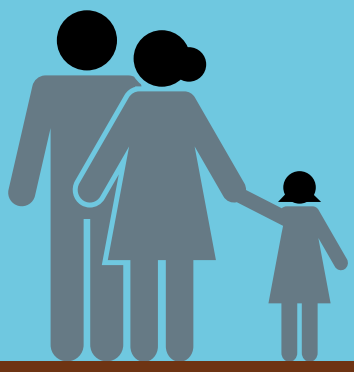
Punjab is one of the fastest developing states in India. The State has posted a steady growth during the last decade. It also achieved its growth target in the Eleventh Plan period. In terms of both net state domestic product as well as per capita incomes, the growth rate has been consistent. There has been a sectoral shift in the Punjab economy and the share of agriculture has fallen, while the share of tertiary sector has increased. Tertiary sector contributes a significant share of in the State's domestic product followed by the secondary and primary sector. Punjab has done better than India's average in socio-



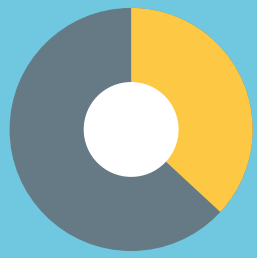
28%
Share of Industry Sector in GSDP



27.7
Million People

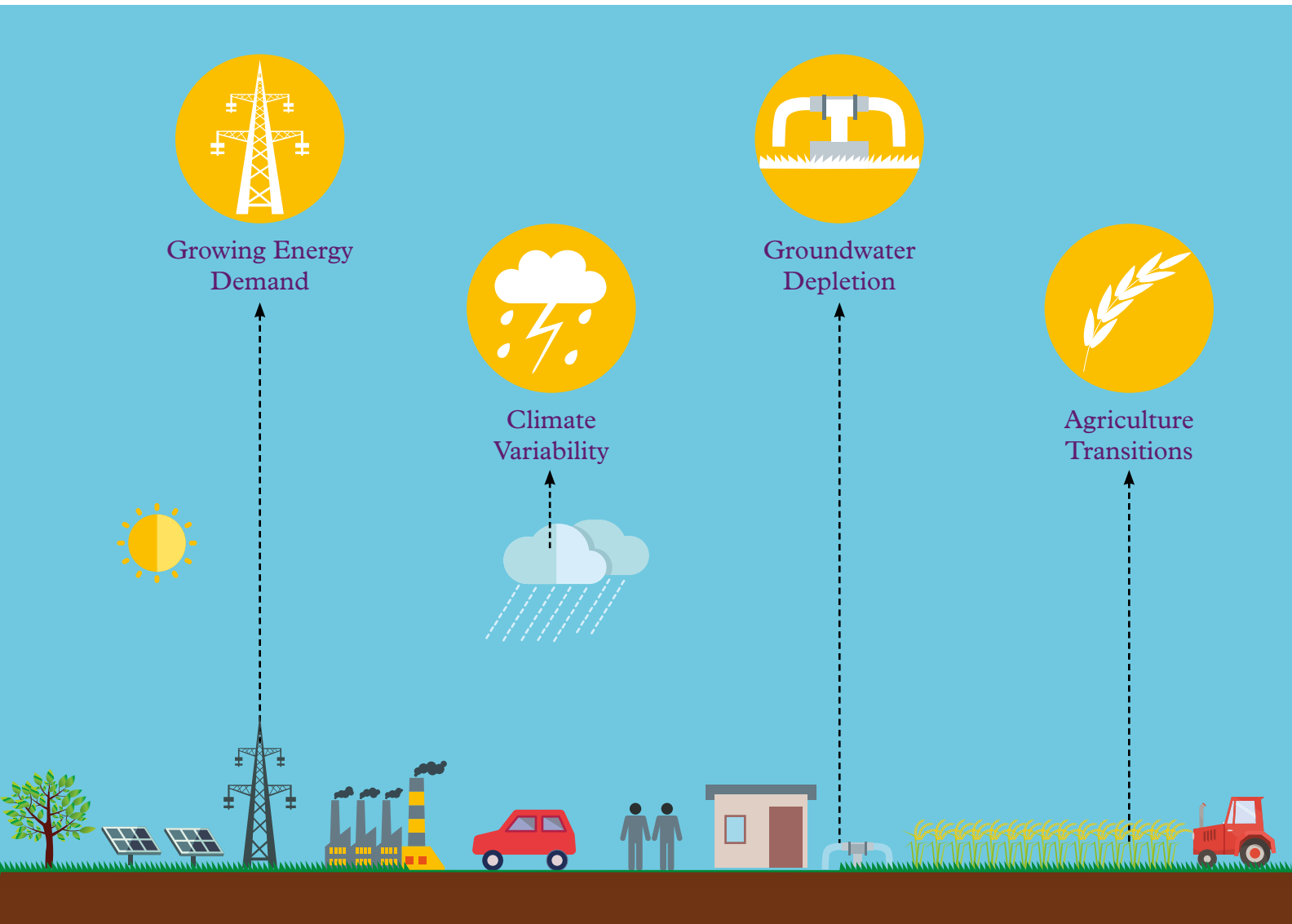


37%
Urbanization



economic development indicators, such as income and life expectancy but lags behind in gender-related indicators. While the productivity of rice and wheat crops have almost been fully exploited, there is a stagnation in the growth process, decline in real farm incomes and over exploitation of natural resources vis-à-vis soil heath and water quality and quantity.

Groundwater is a major source of water for agricultural, industrial, and domestic uses. Over exploitation of groundwater for use in agriculture has resulted in water stress, especially in central districts of the State. Status of biological diversity in the State indicates that agricultural biodiversity conservation is as important as wild biodiversity to support its agricultural base. In wake of climate change, socio-economic and ecological vulnerability increases and risk-based approaches become even more relevant. Thus, greener growth and sustainable development needs to take into account impacts of climate variability while strengthening policy interventions.



2 Motivation

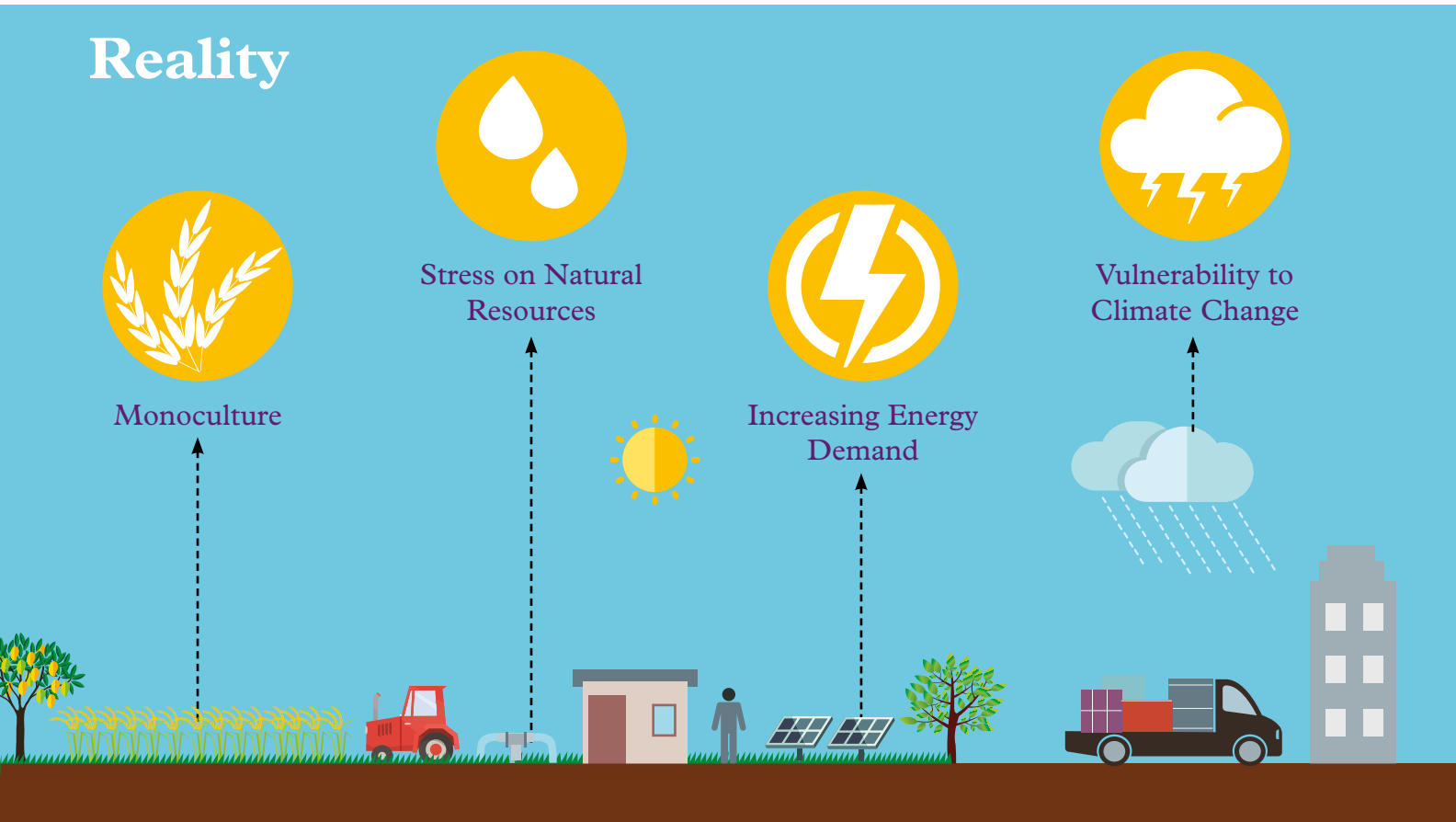
As per the Punjab State Action Plan on Climate Change, sectors of the economy will need to grow with lesser impacts on environment, managing wastes, natural resources, and enhancing energy efficiency. The need to balance development and growth objectives with environmental sustainability necessitates the choice of pursuing a green growth for Punjab.

Punjab at present has more than 80 per cent of its total geographic area under agriculture with wheat and paddy being the dominant crops. The increasing trend of paddy and wheat cultivation has brought the crop diversification index down. Increasing temperatures due to climate variability are likely to decrease wheat and paddy productivity. It becomes extremely relevant to understand the impact of climate variability and cropping patterns on water and soil parameters.

Growth of paddy cultivation in Punjab is largely attributed to provisions of high yielding varieties of paddy, minimum support price, assured irrigation resources, and evolved markets for paddy crops. Punjab produces around 17 million tonnes of paddy straw of which about 15 million tonnes of paddy straw produced in the State is being burnt in the fields every year.

Increasingly, natural resource management is gaining policy relevance in Punjab with the government stating clear intent on crop diversification, water conservation, and increasing tree and forest cover.

The State has polices such as the Punjab Preservation of Sub Soil Water Act of 2009, which mandates that no farmer can sow paddy before the 10th of May. Agriculture Policy for Punjab 2013 advocates that the strategy for agriculture development has to address the sustainability concerns while achieving the overall growth objectives. As per the policy, area under paddy should be restricted to 16 lakh hectares for maintaining the ground water balance. The draft Policy for Management and Utilization of Paddy



Straw in Punjab 2013 provides information on alternative options for utilizing paddy straw and challenges collection and storage of the straw. The State, under the Green India Mission, envisions increasing area under forest and tree cover from 6.87 per cent to 15 per cent of the total geographic area by the year 2022, which is a highly ambitious target.

The New and Renewable Sources of Energy Policy of 2012 seeks to promote renewable energy in the State, including power generation from biomass and agricultural residue. Moreover, World Bank has declared Punjab as the best state in terms of solar power installation.

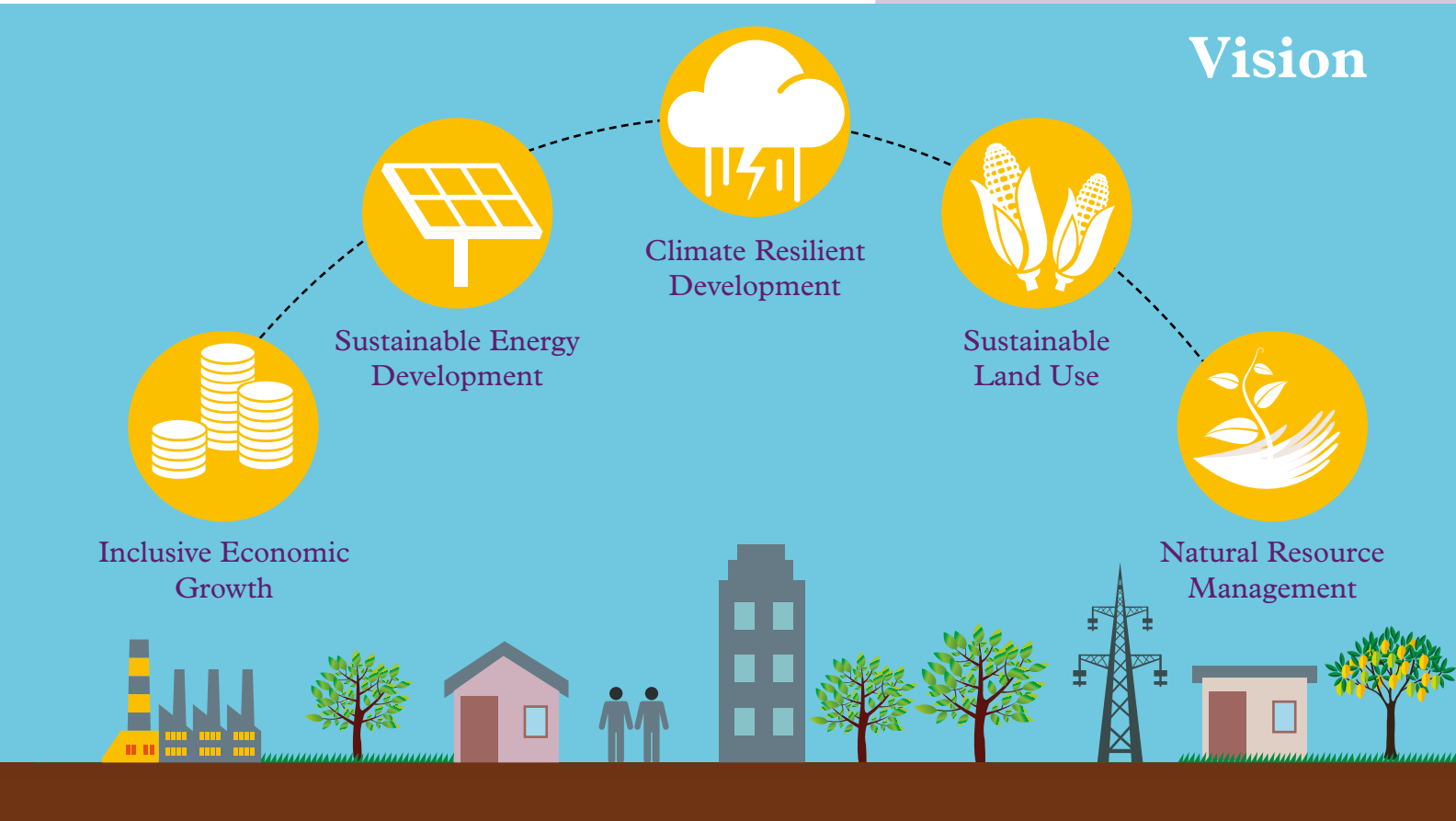
Climate change and resulting climate variability will have an impact on natural resources in the State. Given that the State's developmental activities are dependent on natural resources, for developing a climate-resilient green growth strategy, it becomes important to understand as to what will be the impact of climate variability on the soil and water parameters. In addition, for considering inclusive development aspects, it becomes relevant to understand developmental activities considering socio-economic aspects and perceptions of communities.

What is Green Growth?

Green growth involves rethinking growth strategies with regard to their impact(s) on environmental sustainability and the environmental resources available to poor and vulnerable groups.

(Para 3.15, Thirteenth Finance Commission Report)

The Ministry of Environment, Forests and Climate Change recognizes green growth and poverty eradication to contribute to the vision of sustainable development.



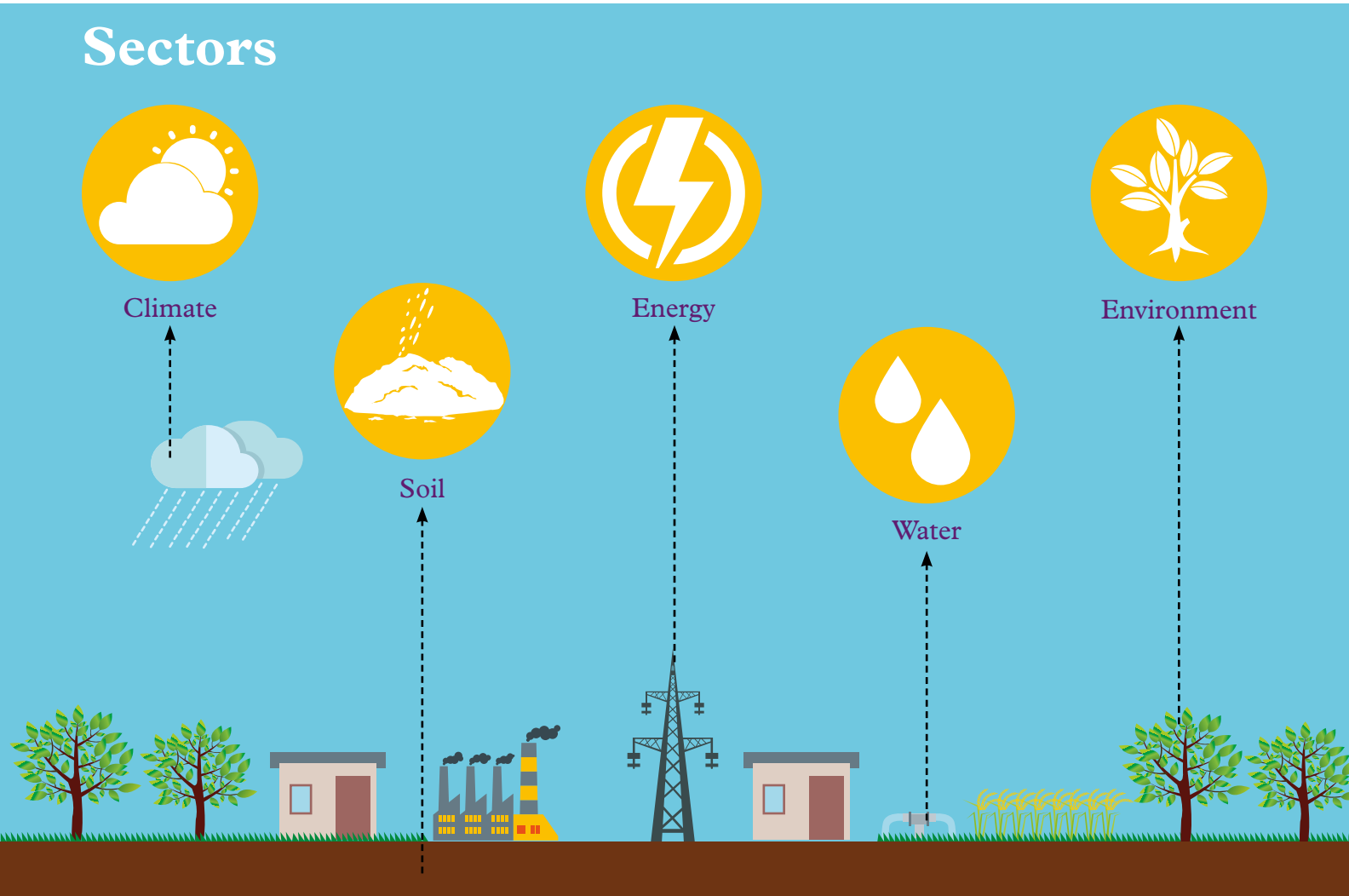
3 Approach

This document synthesizes five analytical components[1] for understanding aspects to inform decision-making for:

- Climate Variability
- Soil and Water
- Power Generation
- Sector-wise Opportunities
- Field Case Studies

The analytical framework included three models (climate modelling, soil, and water assessment tool (SWAT), and energy modelling), case studies from field visits, and a comprehensive review of sector-wise interventions in Punjab.

Climate modelling for Punjab provides an analysis and evaluation of observed climatological information and assessment of near future climate variability over the State. Analysis methods included review of literature, obtaining the observed climatological data for the State and its trend analyses. A high-resolution dynamical model is used to simulate (under A1B scenario) a baseline run from 1970–2000 and for near future (2030s: 2020–50) to arrive at future climate variability over the study domain area.



In this integrated assessment, the SWAT component takes inputs from spatial analysis as well as the climate model. The model takes into consideration parameters, such as drainage network, land use cover pattern, soils, elevation, and climatic parameters for simulating water balance (rainfall, surface and ground water quantity, evapotranspiration, base flow, and amount of water retained in soil), yield (crop and tree), and soil parameters.

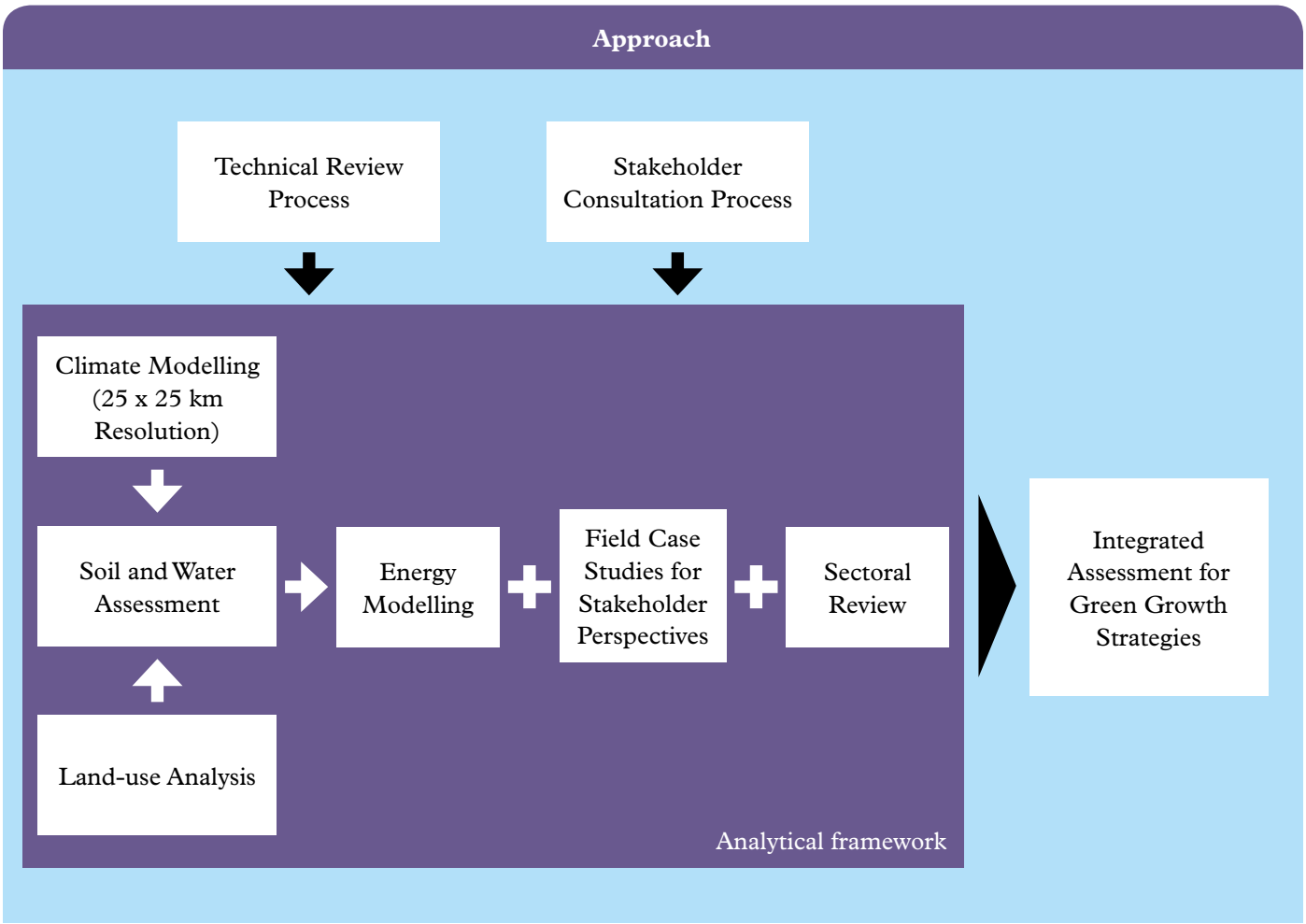
The energy analysis intends to project a possible scenario associated with various growth scenarios in the State. This will inform the State into the possible implications of existing sector plans and policies on energy security and finance of the State. The analyses attempt to capture a broad range of aspects of the State's power sector, from supply to demand, which will aid in the planning and decision-making process of the State.

The case studies component examines socio-economic aspects related to natural resource management in the State for further understanding the concerns of the local communities and other stakeholder with respect to aspects of crop diversification, paddy straw management, groundwater management, and green cover. This understanding aims to assist policymakers in evolving procedures with respect to planning and implementation of natural resource management programme.

To achieve the objective, field researches studies have been undertaken by TERI researchers in four districts in the State. The research involves structured questionnaire–based interviews with farmers, focussed group discussions (with both men and women), and key person interviews with officials at the state, district, and village levels.

A sector-wise review was undertaken as an additional analytical exercise to identify areas of policy interventions. The review included developing discussion papers for air quality, water, forestry, biodiversity, waste management, renewable energy, demand side management, transport, industry, agriculture, buildings, and climate change.

The project approach was presented in a workshop engaging government officials and experts. Their feedback was used to refine the scope of the project, research questions, and data consistency. The analyses were conducted in consultation with various departments at the state level. In addition, the case studies component facilitated consultations at the district level and at the village level.



Models Used in the Analysis

The climate model used in the study is PRECIS—Providing Regional Climates for Impacts Studies—developed at UK Met Office Hadley Centre. PRECIS is an atmospheric and land surface model of limited area and high resolution. To analyse the future climate over the State, the regional model simulations at 25 km × 25 km resolution is carried out.

The SWAT—Soil and Water Assessment Tool—is a process-based distributed-parameter simulation model. SWAT uses readily available inputs and has the capability of routing runoff and chemicals through streams and reservoirs and allows for the addition of flows and inclusion of measured data from point sources.

Long-Range Energy Alternatives Planning (LEAP) system is a bottom-up scenario-based energy/economy/environment modelling tool that has been applied in the case of Punjab.

An attempt was also made to integrate the three models to understand the inter-dependencies between climate, water, soil, and energy.

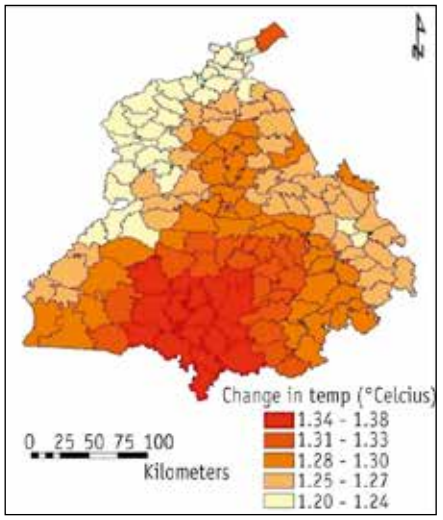
[1] Climate modelling for Punjab, Soil and Water Assessment for Punjab, Energy Analysis for Punjab, Case Studies for Stakeholder Perceptions for Natural Resource Management, and Sectoral Review in Punjab. The four key analytical components of the study are documented separately.

4 Implications for Climate Resilient Development

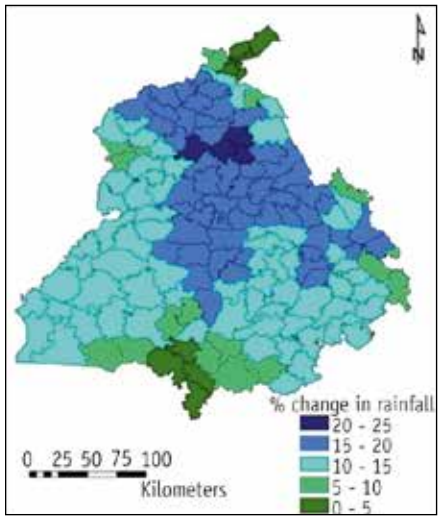
Climate Change

- The climate model used in the study shows overall warming within the study domain area in the near future. Annual mean temperature projected to increase by 1.2–1.4°C for 2021–50 period relative to 1971–2000.
- The mean annual minimum temperature (T_{min}) also is projected to increase over the study domain area in the range 1.2–1.4°C. Mean annual maximum temperature (T_{max}) over the State is projected to increase by 0.5–1.25°C. Relatively larger changes projected for minimum temperatures for the future. This corroborates with the historical trends over India.
- Increase in minimum temperature has many impacts not only on plants and crops but also on human comfort as well. This also indicates that night time temperatures also will increase in the near future relative to the baseline period.
- The analyses of baseline (1970–2000) and near future (2021–50) climate simulations over the study area revealed an increase in future summer monsoon (June–September) precipitation in the near future relative to the baseline period. The increase in mean annual summer monsoon rainfall is in the range of 0–20 per cent of the baseline rainfall.
- The analysis indicates that towards late 2030s and early 2040s, the State will experience higher number of extreme wet days. This implies that in the summer-monsoon season in the near future, there will be more break periods in terms of precipitation.
- A higher level of relative humidity is also expected in the near future.

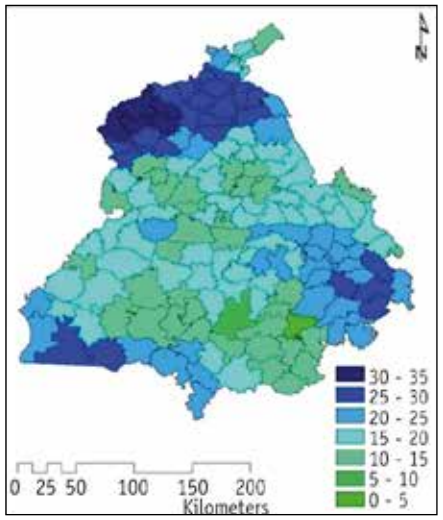
Block-Wise Changes in Annual Mean Temperature (2020–50 w.r.t. 1970–2000)



Block-Wise Changes in June to September Mean Annual Precipitation (2020–50 w.r.t. 1970–2000)



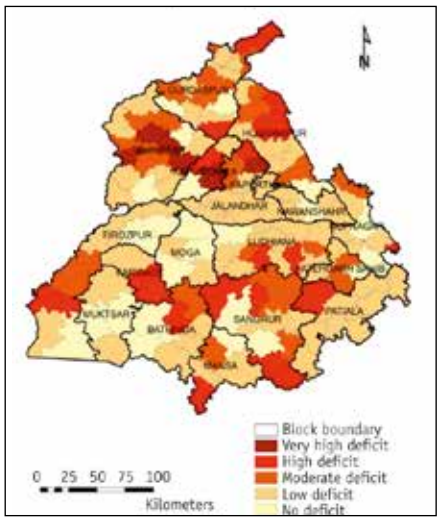
Extreme Wet Days Contribution to the Total Rainfall in Near Future (2020–50)



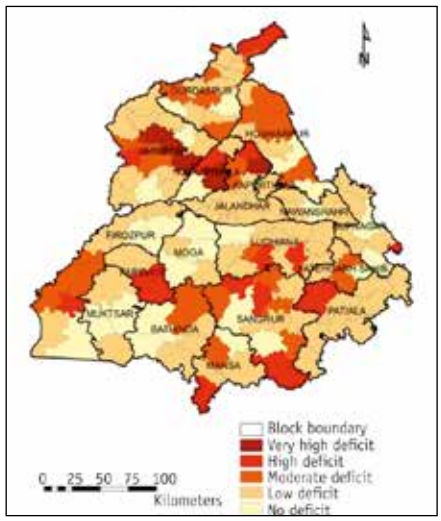
Soil and Water Assessment

- As the State's developmental activities, especially agriculture, are dependent on natural resource management, it becomes important to understand as to what will be the impact of climate variability on the soil and water parameters.
- Industrial water requirement will increase by 10 per cent in 2020 and by 15 per cent by 2030 as compared to 2010 water requirement. Domestic water requirement will increase by 29.8 per cent in 2020 and 64.8 per cent by 2030 as compared to 2010 water requirement. Irrigation water demand is expected to stay around 56.1 billion cubic metres (BCM) during 2020 and 2030 unless crop diversification takes place on a large scale. It is projected that there will be a water deficit of 15.9 BCM in 2020 and 14.4 BCM by 2030 in the State.
- While, basins in the State show increased availability of surface and ground water owing to future climate variability, actual water availability will vary depending upon the existing land use and domestic and industrial water use. Basin-wise crop diversification and physiography of the region will play major role in future water availability.
- Based on the modelling exercise, the reference scenario shows that out of total 146 blocks in Punjab about 85.5 per cent blocks are deficit. Of the 85.5 per cent deficit blocks in this scenario, 40.4 per cent blocks are moderate to high deficit and 45.2 per cent blocks are in low deficit category.

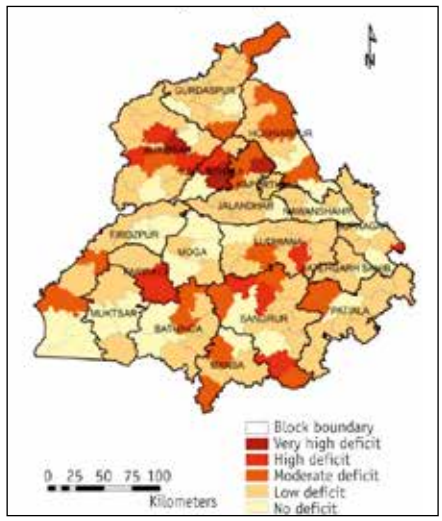
Water Deficit Blocks in Reference Scenario (2030s)



Water Deficit Blocks in Policy Scenario (2030s)

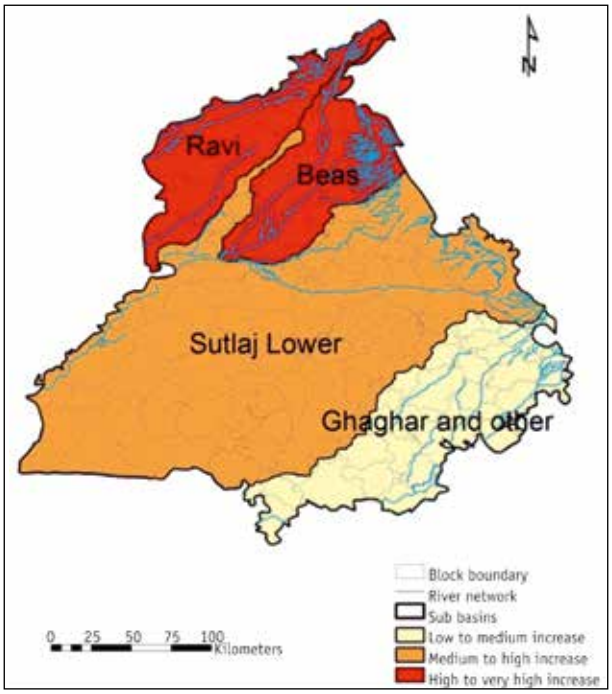


Water Deficit Blocks in Ambitious Scenario (2030s)



- As compared to reference future scenario, policy scenario brings about 66.3 per cent blocks to no deficit to low deficit category but 33.7 per cent blocks still remain in moderate to very high deficit.
- In the ambitious scenario, 71.1 per cent blocks will be no deficit to low deficit blocks and 28.9 per cent blocks will be in the moderate to very high water deficit blocks category. This scenario brings water deficit to the lowest level. Not only does the number of high deficit blocks (30 blocks) under reference scenario reduces to 13 blocks in ambitious scenario, but it also increases the low deficit blocks from 75 reference scenario to 85 blocks in ambitious scenario.
- As soil is an important part of agricultural production system, loss of fertile soil should be considered to be a major factor affecting resilience. Soil formation is a very slow process and hence even moderate soil erosion is not desirable. It was observed that Ravi and Beas sub basin may face very high changes in soil erosion in future (2020–35).
- Evapotranspiration of crops is expected to increase by 6–8 per cent across all basins due to increase in temperature. Hence, actual irrigation requirement will increase by 100 mm to 133 mm for a crop needing 500 mm irrigation water, considering the flood water irrigation method, which is the dominant irrigation method in the State. Therefore, on-farm irrigation management, use of alternate irrigation methods, and conservation agriculture needs special attention.

Change in Soil Erosion by Water
in Punjab
(2030s w.r.t. baseline)

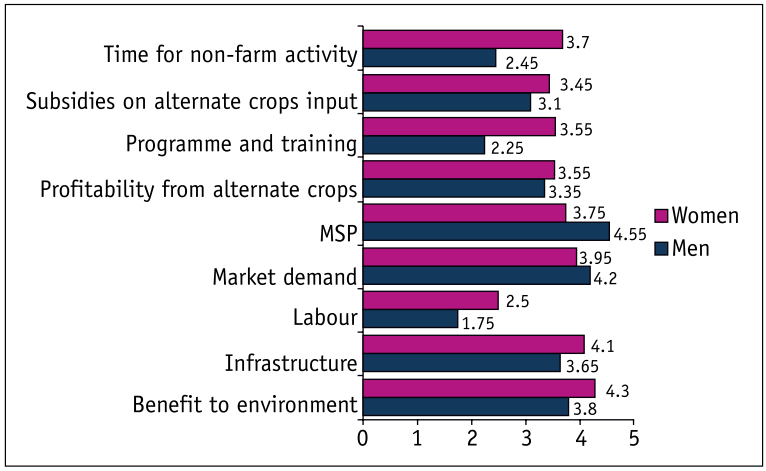


5 Stakeholder Perspectives on Natural Resource Management

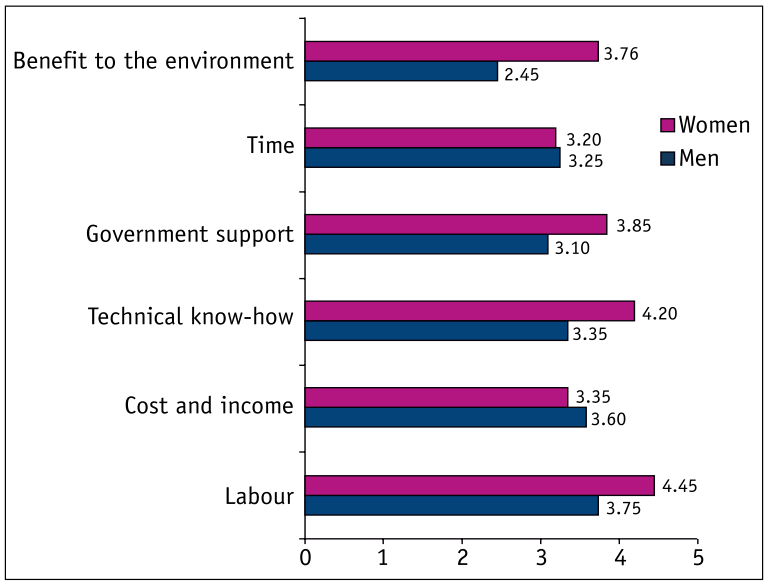
- To understand stakeholder perspectives, a field research was done by TERI researchers in seven villages across four districts of Amritsar, Faridkot, Rupnagar, and Sangrur. Using structured questionnaire, 208 farmers were individually interviewed. Questionnaire-based farmer interactions and focussed group discussions were carried out to understand the farmer perspectives on status of forest and tree cover, ground water, paddy straw management, and crop diversification. Moreover, key person interviews were undertaken to understand bottom-up implementation perspectives regarding these issues.
- Considering perspectives from village communities, important insights emerge related to the gender dimension of drivers. Women give higher preference for positive environmental externalities and labour while male farmers give higher weightage for economic-drivers. Since women also seemed to be open to new technical know-how, it would be important for the State's policymakers to consider the gender dimensions while refining their interventions on crop diversification.
- Structured questionnaire were used in Amritsar and Rupnagar for understanding aspects of crop diversification. In both the districts, depletion of groundwater, deterioration of soil health, and burning of crop residues were perceived as the most important significant impacts of the rice–wheat cropping system. In Amristar, farmers preferred to diversify to either maize, vegetable cultivation, or diversify into dairying activities; while in Rupnagar, farmers wanted to diversify to vegetable, maize, and pulses. In terms of constraints, some key factors include inadequacy of labour, lack of policy support including higher minimum support price for alternate crops, subsidies, and state procurement.
- Stakeholder opinion gathered from field research suggests that lack of effective market linkages, unstable market demand, and economic returns for the proposed alternate crops have failed to create a conducive environment for farmers to confidently venture out of paddy and wheat. There is a need for the State government to focus on the farm gate to market linkage for the alternative crops so that there is a stronger incentive for the farmers to diversify to alternative crops.
- Field interaction revealed that farmers are aware of the negative impacts paddy straw burning exert on their local environment and community. Further, imposition of restrictions by the State government making paddy straw burning an offence has made farmers more open to accept alternative residue management practice. To address the issue of paddy straw burning, the paddy straw management needs to be made cost effective for the farmers.
- Farmers were found waiting for many days in the grain market to fetch a good price for their produce. Lack of timely access to market information for price discovery leave them with a narrow window between harvesting of paddy and sowing of Rabi crop, thereby pushing farmers to burn paddy stubble
- For paddy straw management, both men and women felt that availability of labour would aid them most in paddy straw management. Benefit to environment is a motivation for women whereas cost and income received higher consideration by men.

- In terms of environmental benefits, farmers felt that Happy Seeder resulted in the most environmental benefits. The ownership and maintenance cost per annum is estimated as highest for making bales from paddy straw followed by seeding next crop with standing paddy stubble and incorporation of paddy straw into soil. Whereas, in terms of operating costs per acre, Happy Seeder is the most expensive followed by Mulcher and Baler.

Factors Influencing Diversification of Cropping Pattern for Men and Women



Factors Influencing Paddy Straw Management and Utilization for Men and Women



- Structured questionnaire–based farmer interactions were carried out to help understand community viewpoints on the issue of forest and tree cover. Farmer interactions highlighted that the government can play a major role in checking deforestation and maintaining records of the already existing tree tracts. Majorly, the farmers are not involved in agroforestry but do view it as an option for crop diversification, which could help in increasing the tree cover in the State. The most popular choice of tree for agroforestry came out to be Poplar, Eucalyptus, and fruit trees, such as Mango and Kinnow.

- In order to understand the scenario of tree cover in the villages, a participatory spatial mapping was conducted. Largely, both men and women were not receptive to the idea of large-scale agroforestry that would involve plantation of trees on their agricultural land or along roads that pass through agricultural lands; that is because they were of the belief that the tree shadows and leaf-fall would affect the crop growth.Small holding farmers might not adopt agroforesty even though large-scale farmers can adopt it when the returns are higher from agroforestry in comparison to the possible crop yield losses due to agroforestry.
- The farmers also informed that mostly all fields have some Guava, Kinnow, *Jamun*, Mango, and Litchi trees. Teak gives good timber in 25 years and does not require much water. Speaking from their experience, farmers informed that Eucalyptus and Poplar extract quite a lot of water, shed leaves, and spoil crop yields. Presently, Eucalyptus and Poplar are the only

Stakeholder Perspective on Aspects around Green Cover

Stakeholder	Issues	Existing initiatives
Village headman	• Deforestation • Water scarcity • Lack of adequate awareness	• Sporadic awareness campaigns • Saplings distributed for free or at subsidized rates
Forest office	• Unavailability of land for forestry • Getting funding for forestry-related projects (being a rich state Punjab is not considered for funding easily) • Problems in implementation of ongoing projects as most of them do not get a timely funding • Low survival rate of trees in water logged areas • Depleting levels of ground water • Illegal cutting of trees, if they are along an agriculture field causing hindrance in crop growth and for fuel purposes	• Punjab Compensatory Afforestation Fund Management and Planning Authority and Compensatory Afforestation Plan for afforestation activities in Punjab • For the past 10 years, the departmental planting of Eucalyptus taking place in which cremation grounds, schools, colleges, government offices, and residences are targeted • Surveys conducted to understand the demand for trees and then free saps are handed out throughout villages • Planting of Bamboo, Mulberry, and Khair near Shivaliks; Sesame, Neem, and Dek being planted in the southern belt; while Babul and *Acacia modesta* being planted in sandy areas across Punjab • Awareness campaigns regarding benefits of trees and knowledge dissemination camps teaching proper handling of various tree species so as to ensure their long survival being held all across the State
Agricultural office	• Often small farmers are not willing to venture into agroforestry. However, boundary plantation of fast growing tree species are adopted by small and marginal farmers • Difficulty in growing any major kharif crops in rotation with Poplar once it becomes three years or older. Rabi crops can be grown in rotation with Poplar viz., Poplar-Wheat cycle.	• Establishment of wood *mandis* providing licenced wood at Ludhiana, Hoshiarpur, and Jalandhar as these districts have more agroforestry as compared to other districts • Campaigns being held to propagate agroforestry with poplar being the first choice of tree crop

commercial agroforestry crops even though farmers retain Babul, Khair, Neem trees in their farms at a non-commercial scale.

- A majority of farmers are of the opinion that the quality of ground water has degraded over the last few years and that the availability has also become worse.
- Interaction with farmers revealed that on an average an electric pump-set needs to be changed in five to ten years with a new pump costing around ₹1 lakh. While on an average the cost for maintenance of a pump-set comes around ₹7,000–8,000 annually. The expenditure on electricity for farm activities is zero as the government provides free electricity for agricultural use.
- Field interactions revealed that while there was widespread compliance to the Punjab Preservation of Subsoil Water Act 2009, senior bureaucrats at the district level stressed the need for emphasis on an awareness and education campaign on the need for groundwater savings. The stakeholder consultation with government officials in February 2014 revealed that the government intends to electrify all the tube wells by 2015, which is estimated to cost ₹700 crores and electricity consumption would be monitored only at the feeder level and not at the tube well level. This would worsen the fiscal deficit of the State government.
- There is scope to encourage and promote construction of artificial recharge structures at village level keeping in view the field conditions, availability of recharge, feasibility, lithology of the area and ground water quality. There is a need to include and foster construction of groundwater recharging structures at the policy level so as to have a holistic development. Research studies and analytical insights from the exercise points to the opportunity to design a holistic Ground Water Demand–Supply Management policy capturing the unique challenges and opportunities for way forward.

Stakeholder Perspective on Aspects of Groundwater Management

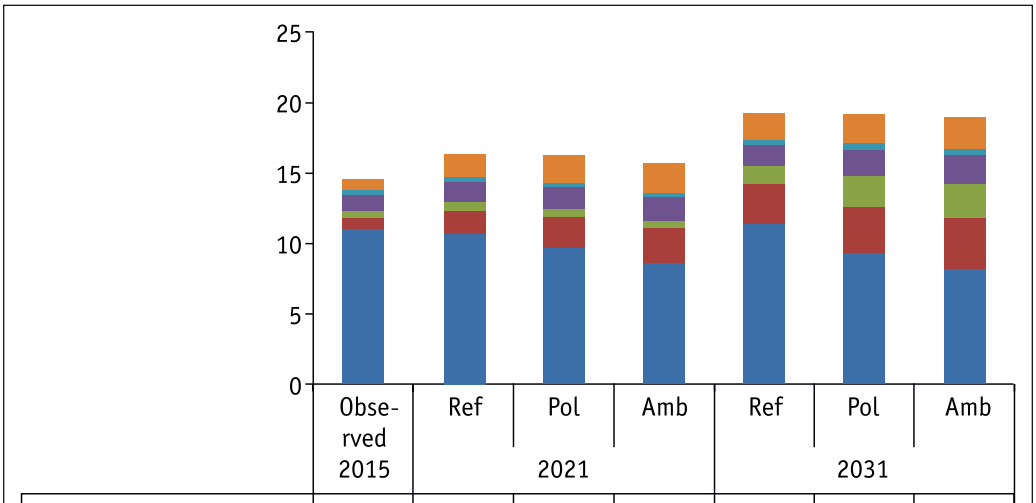
Stakeholder	Issues	Existing initiatives
Village headman	• Declining groundwater levels • Deteriorating groundwater quality • Water logging, especially in the southwest regions of the State	• Awareness campaigns • Construction of water harvesting structures • Planting of Eucalyptus in water logged areas
Soil and water conservation office	• Declining groundwater levels • Deteriorating groundwater quality • Water pollution due to over utilization of fertilizer and pesticide by the farmers	• Construction of micro irrigation structures and renovation of ponds is being undertaken in various parts of the State for groundwater recharge • Awareness campaigns
Groundwater cell	• Declining groundwater levels • Deteriorating groundwater quality • Lack of awareness amongst people regarding water conservation measures	• Promotion of some water conservation measures and spread of awareness activities • Promotion and construction of some water harvesting structures across the State

6 Implications for Energy Development

- Punjab has done well in terms of economic growth and per capita income. Agriculture will have a stable growth rate, though service and industry sector can move towards an incremental growth at a rising rate impacting the per capita income of the State, which can also experience an increasing pattern in future. In terms of population projection, the rural and urban population growth rate is expected to gradually attain a stabilization in future though it will continue to grow.
- The installed capacity and electricity generation in Punjab has grown almost eight times from 1970–71 to 2011–12. The generation has increased at a CAGR of 6.5 per cent from 1970–71 to 2011–12. Coal-based electricity generation accounted for more than 65 per cent of the total electrical energy generation in Punjab followed by hydro at 32 per cent and renewables at 3 per cent for 2011–12.
- The State needs to rely more on solar, biomass, and co-generation route of renewable energy supply followed by hydro and waste to fulfil the 2 per cent renewable energy purchase obligation. However, this will happen only when there is more than 20 per cent improvement in the capacity utilization factor of solar, biomass, and other renewable energy sources (RES) followed by a reduction of their power tariff within the range of ₹3.00–6.00 per unit.
- From an energy balance accounting conducted for the State model baseline situation, total energy demand was 9.68 million tonnes oil equivalent in 2010–11. Through energy balance accounting, industrial sector contributed 32 per cent, followed by transport at 25 per cent in 2010–11. More than 88 per cent of the coal was consumed in the power sector for electricity generation and the rest 12 per cent was consumed in the industrial sector for captive power generation in 2010–11.
- A new modified LEAP model is developed for the state of Punjab. Here, energy demand comprises primary and secondary energy demand. The various end-use sectors are agriculture, industry, transport, residential, and commercial sectors. Energy efficiency aspects in all these sectors are considered while estimating total energy demand from these sectors.
- For green growth and development, constraints of pollutants such as particulate matter (PM_{10} and $PM_{2.5}$) are imposed on the model. The underlying assumption is that while the state grows, it also has to check the impacts of the growth on the pollutants. The annualized economic costs of these pollutants are to the tune of 2 per cent of the State GDP every year and hence it has been used as a constraint bound in the model.
- The scenarios were developed in the LEAP-Punjab model under different sets of options—the clean energy substitution measure, the industrial energy efficiency measure, energy conservation in buildings, other energy conservation measures, motor vehicle control measure, RES measures, capacity utilization measures, public transport measures, transport modal shift, motor fuel efficiency, and clean coal technology.

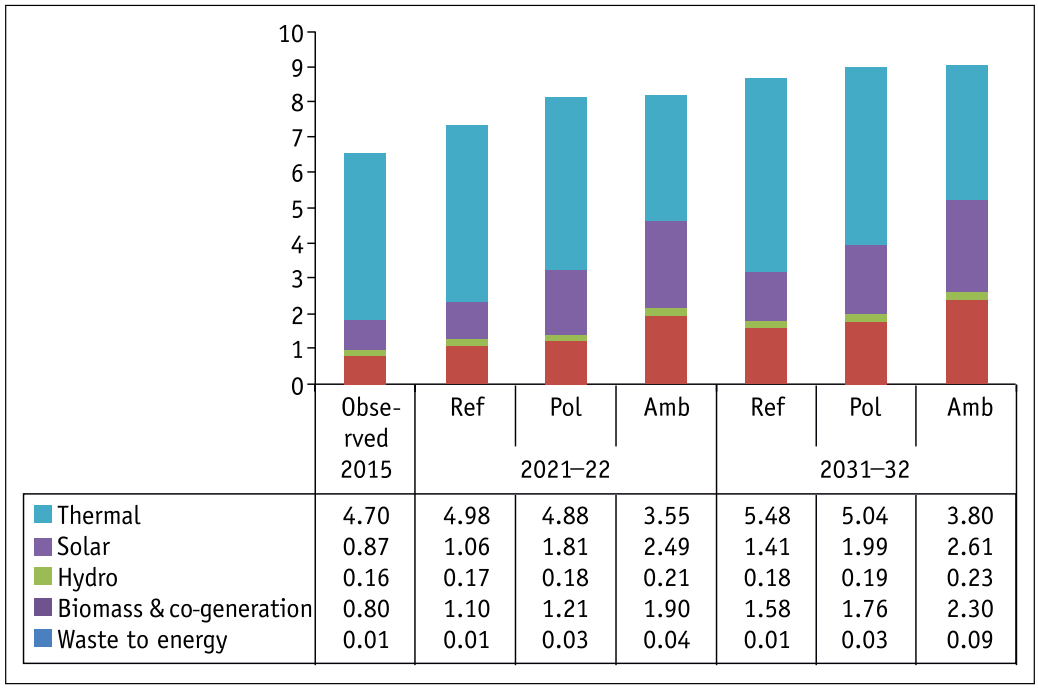
- Primary energy supply from coal will reduce as the State economy transits from a reference to a policy and ambitious scenario. The increase in renewable energy–based primary energy supply will also mean a rise in the capacity addition for RES.
- It emerges that as a result of crop diversification measures, the energy consumption will go down in 2020s and 2030s.
- Through targeting of reduction in electricity subsidies, electricity subsidy as a percentage of gross state fiscal deficit can be reduced from the observed 73 per cent (in 2012) to 10 per cent in the ambitious scenario of 2031.
- Owing to the structural changes, an energy demand reduction of 33 per cent can happen in structural economy change (SEC) scenario of 2031 in comparison to the reference scenario of 2031. The energy demand reduction can happen from efficient energy demand management practices in agriculture and industry. However, owing to a structural change and shift to a service sector–oriented economy with a balanced agriculture and industry sector share, there will be a marginal rise of energy demand in the transport, service, and commercial sector.
- The State can create a perspective plan of green growth and development of Punjab involving strategic planning and including sectoral plans with a focus on structural transformation.

Scenario-wise Primary Energy Supply in Punjab (Mtoe)



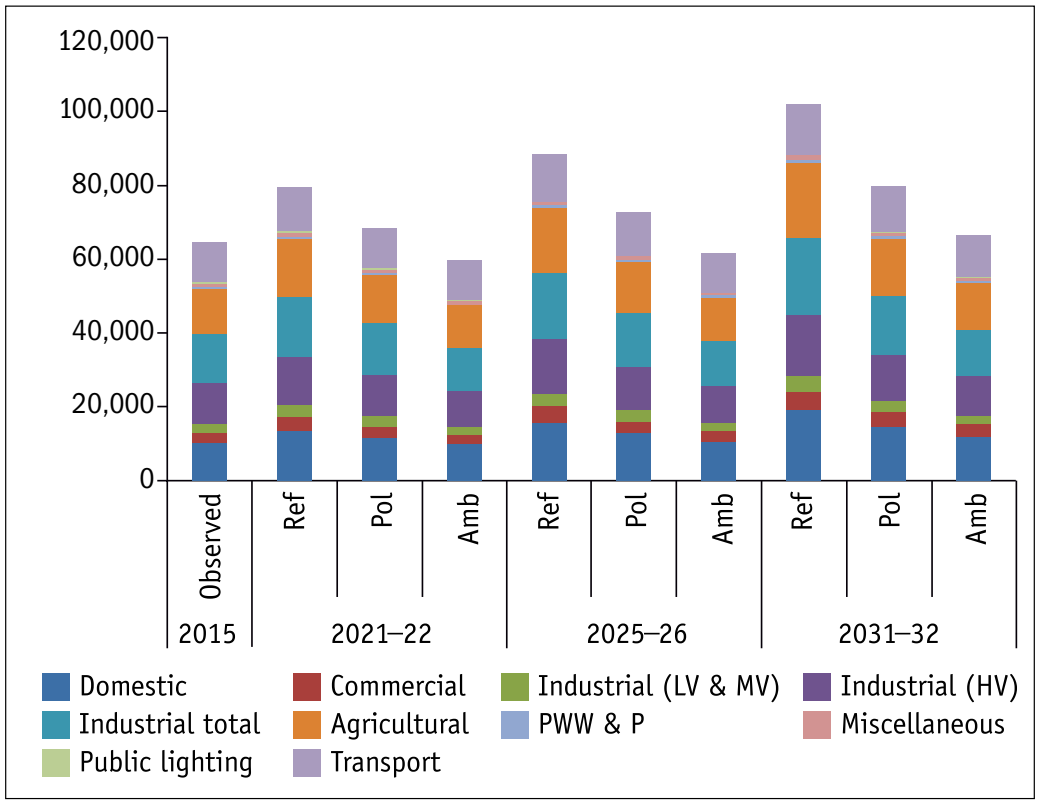
	Obse-rved 2015	Ref 2021	Pol 2021	Amb 2021	Ref 2031	Pol 2031	Amb 2031
Bagasse	0.80	1.63	1.93	2.12	1.87	2.10	2.13
Waste to energy	0.28	0.32	0.34	0.35	0.36	0.42	0.50
Biomass & co-generation	1.20	1.45	1.58	1.62	1.52	1.90	2.10
Solar	0.49	0.54	0.57	0.59	1.22	2.20	2.40
Hydro	0.80	1.71	2.17	2.38	2.87	3.20	3.50
Coal	11.00	10.68	9.70	8.70	11.40	9.40	8.30

Scenario-wise Generation Capacity (GW)

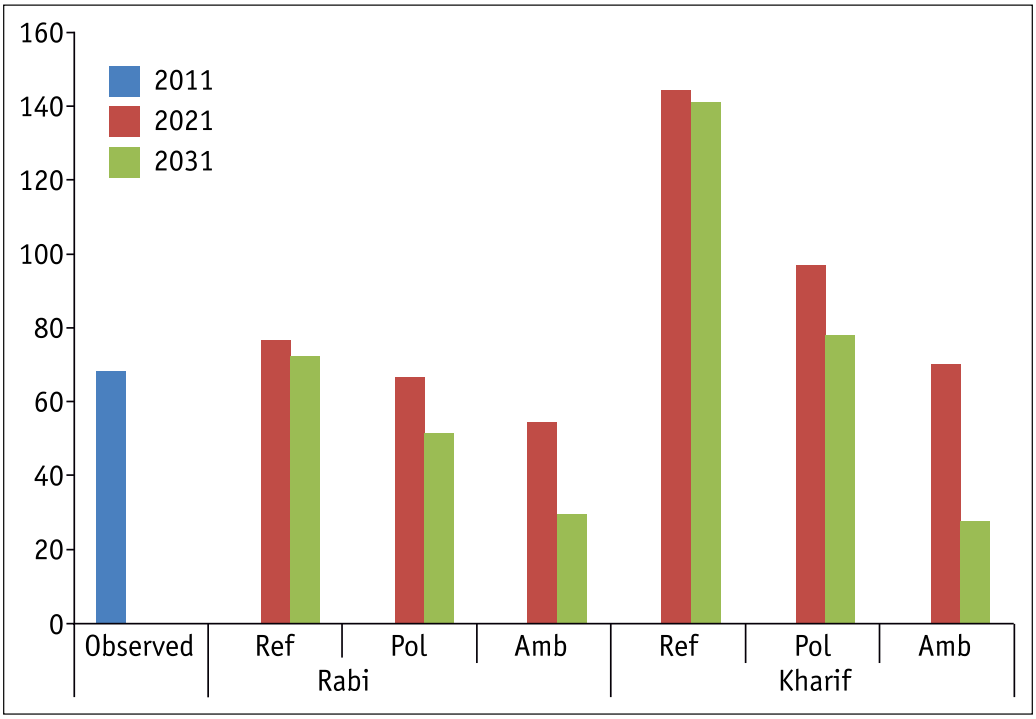


	Obse-rved 2015	Ref	Pol	Amb	Ref	Pol	Amb
		2021–22			2031–32		
Thermal	4.70	4.98	4.88	3.55	5.48	5.04	3.80
Solar	0.87	1.06	1.81	2.49	1.41	1.99	2.61
Hydro	0.16	0.17	0.18	0.21	0.18	0.19	0.23
Biomass & co-generation	0.80	1.10	1.21	1.90	1.58	1.76	2.30
Waste to energy	0.01	0.01	0.03	0.04	0.01	0.03	0.09

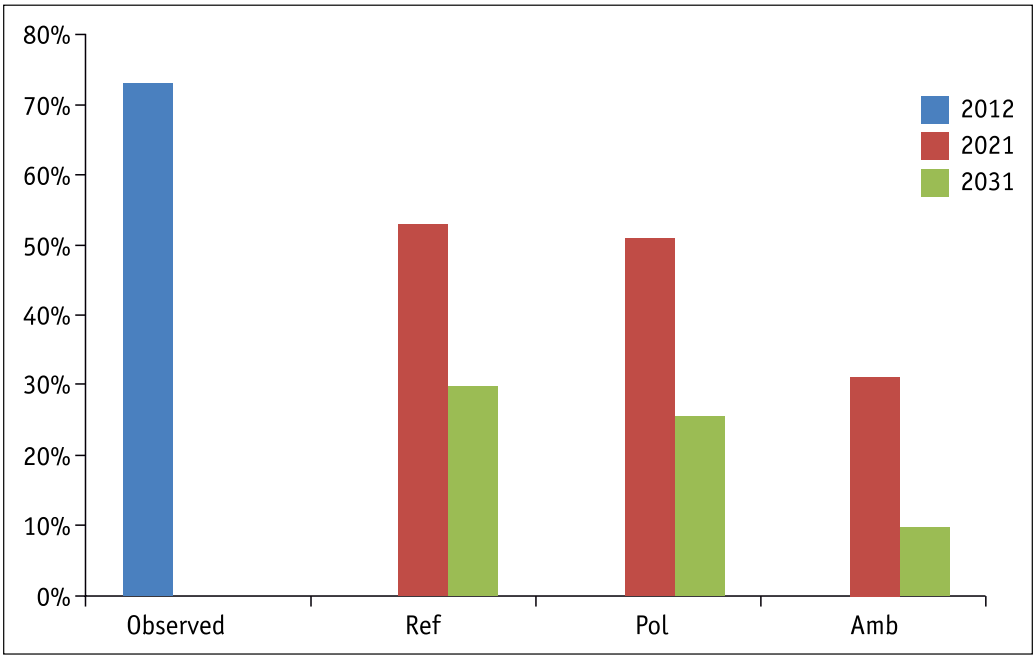
Scenario-wise Energy Demand across Sectors (GWh)



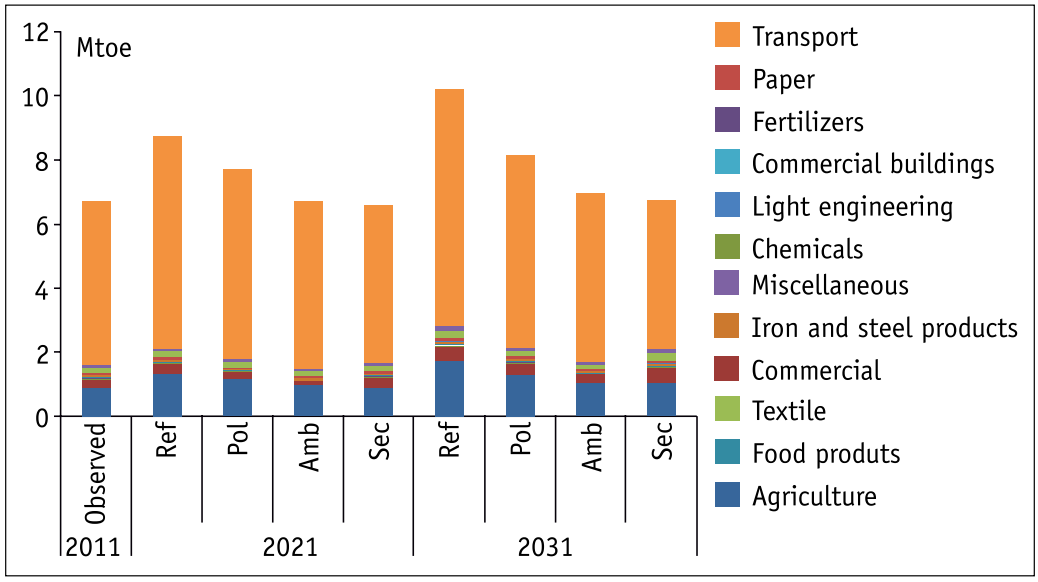
Energy Consumption of Rabi and Kharif Crops Across Scenarios (GWh)



Electricity Subsidy as a Percentage of Gross State Fiscal Deficit for Different Cropping Scenarios



Impact of SEC in Energy Demand (Mtoe)



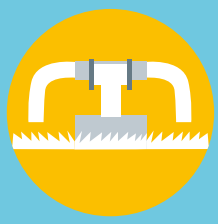
7 Sectoral Review
Challenges

34% Electricity Consumed in Industrial Sector

31% Electricity Consumed in Agriculture Sector

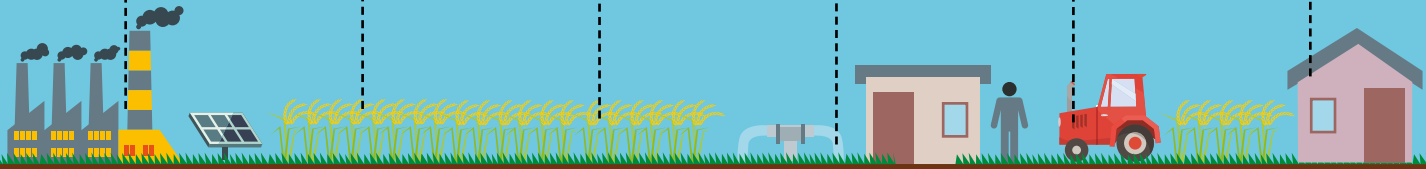
98% of Total Cropped Area Irrigated

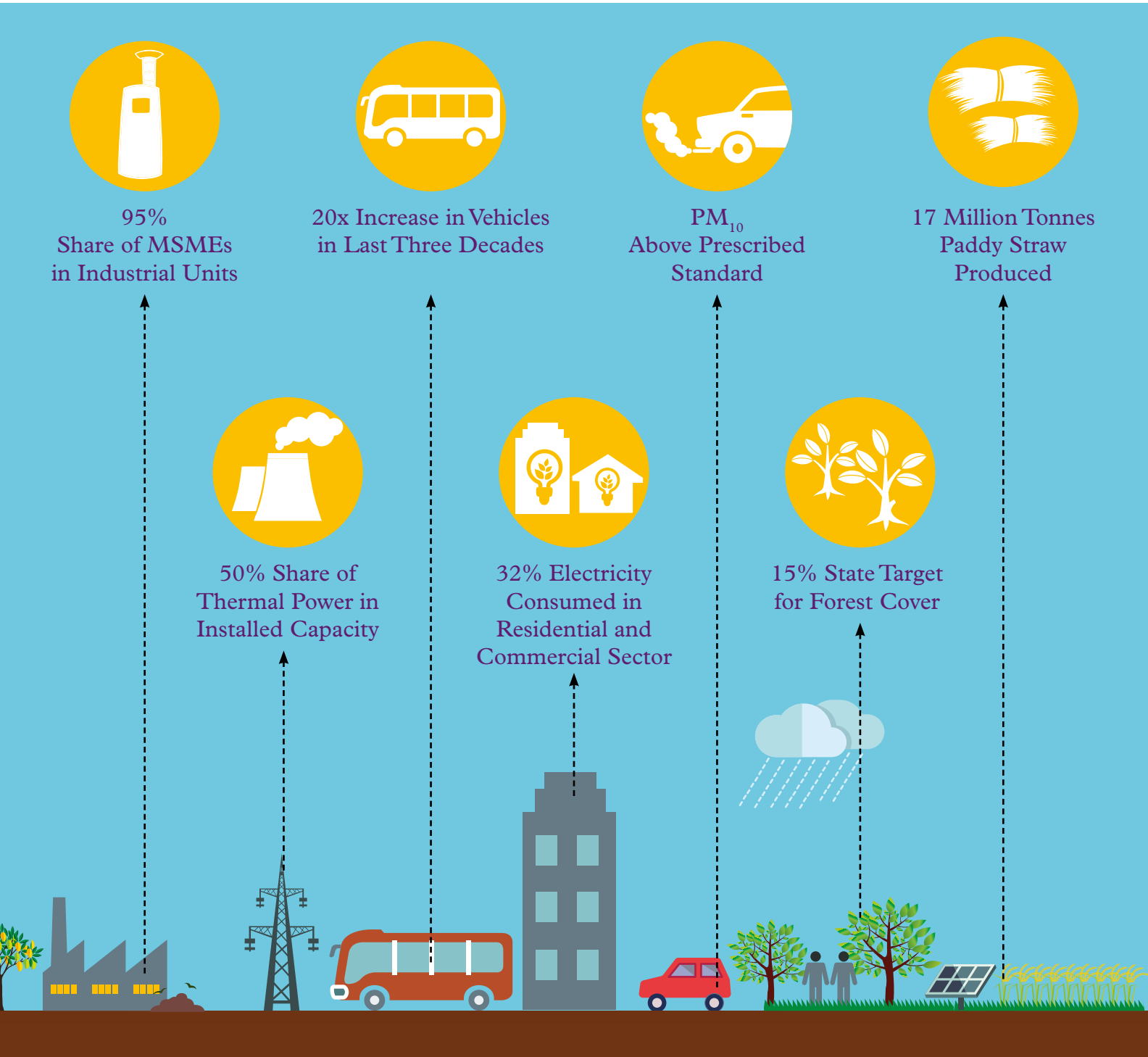
84% Area Under Agriculture



80% Blocks are Over-exploited in Terms of Groundwater

27% Sewage Treated in Class-I cities




95%
Share of MSMEs
in Industrial Units
20x Increase in Vehicles
in Last Three Decades
PM_{10}
Above Prescribed
Standard
17 Million Tonnes
Paddy Straw
Produced
50% Share of
Thermal Power in
Installed Capacity
32% Electricity
Consumed in
Residential and
Commercial Sector
15% State Target
for Forest Cover

Opportunities

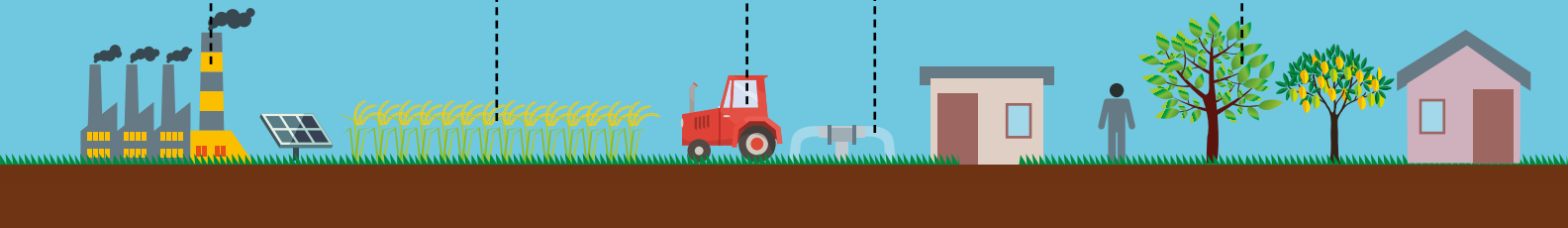
Industry
- Energy audits
- Fuel switch
- Cogeneration
- Energy efficiency
- Best operating practices and technologies

Cross-cutting Issues
- Rural-urban transitions
- Inter-linkages between water, energy and agriculture
- Employment and livelihoods

Forestry & Biodiversity
- State Biodiversity Board capacity building
- Assess status of biodiversity
- Measure ecosystem services
- Tree and forest cover
- Agroforestry

Agriculture
- Crop diversification
- Integrated land use policies
- Climate resilient agriculture

Water
- Formulate groundwater policy
- Integrated water resource management
- Water monitoring stations
- Irrigation water use efficiency
- Water and soil conservation
- Strengthen water users association



Waste Management
- Waste database
- Sewage treatment
- Waste recycling
- Enhanced acidification and methanation technologies

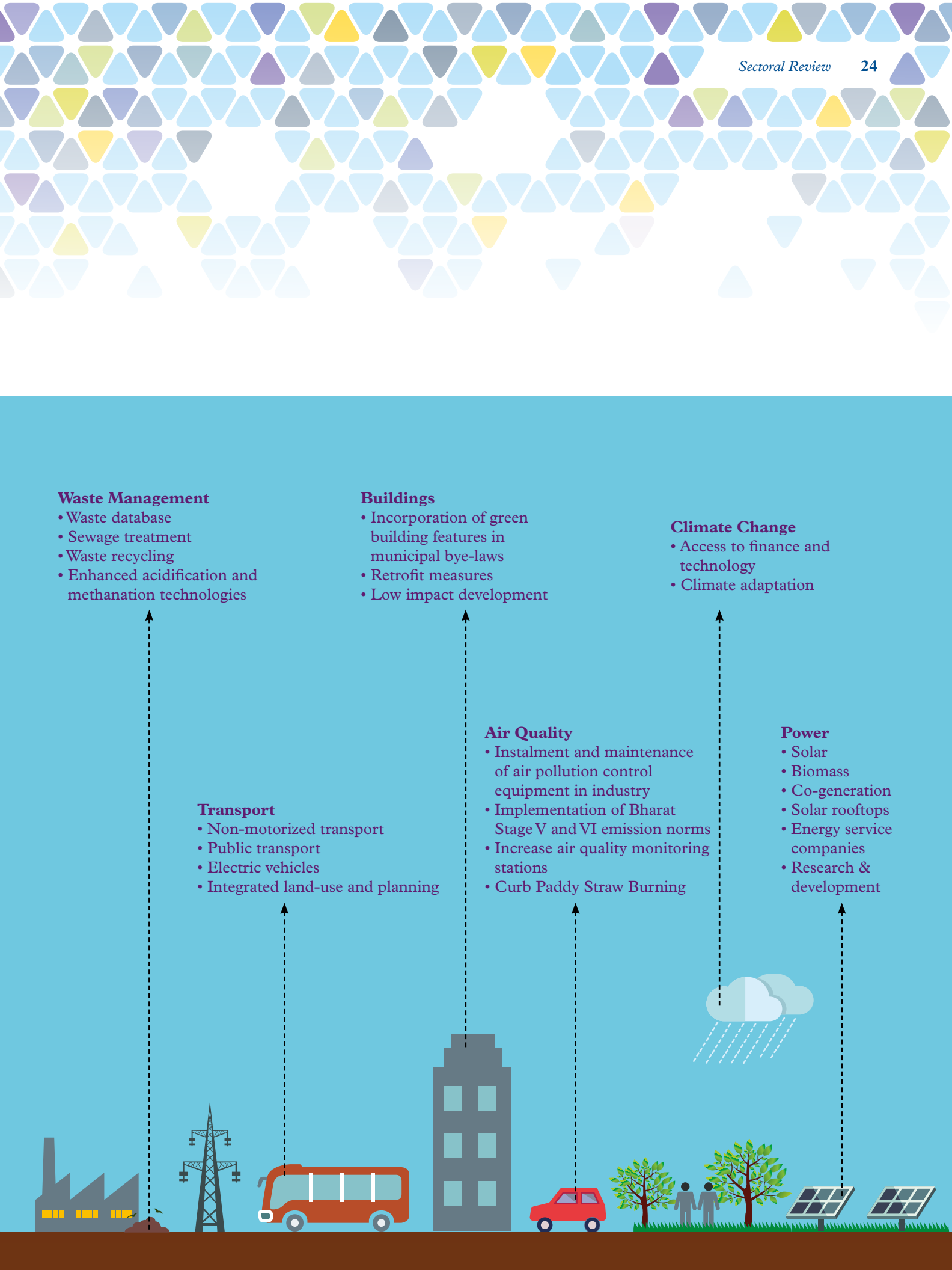
Buildings
- Incorporation of green building features in municipal bye-laws
- Retrofit measures
- Low impact development

Climate Change
- Access to finance and technology
- Climate adaptation

Transport
- Non-motorized transport
- Public transport
- Electric vehicles
- Integrated land-use and planning

Air Quality
- Instalment and maintenance of air pollution control equipment in industry
- Implementation of Bharat Stage V and VI emission norms
- Increase air quality monitoring stations
- Curb Paddy Straw Burning

Power
- Solar
- Biomass
- Co-generation
- Solar rooftops
- Energy service companies
- Research & development



Forests

Challenges

- Moderately dense forest area has increased slightly by 13 sq. km from 2005 to 2013. The open and scrub forests constitute 60 per cent of the forest cover, which is largely degraded due to high demand of forest products and encroachments. It has increased by 220 sq. km between 2005 and 2013.
- As per 2011 census estimates, households consume 13.4 thousand tonnes of firewood in Punjab, which is far beyond the sustainable production in the State.
- There has been decline in area under fodder crops in the State from average area of 7.8 lakh hectares during 1990–94 to 5.83 lakh hectares area during 2005–09.
- Economically important species, such as *Acacia nilotica* and *Dalbergia sissoo* are declining rapidly in the State.
- Weed infestation especially of *Lantana camara* is a serious threat to forest in areas of Punjab. According to an initial survey, a forest area of over 500 sq. km have been lost in the State due to the invasion of *Lantana camara* and this will continue, if remained unchecked.

Opportunities

- The State has proposed a free supply of 90 lakhs clonal Eucalyptus plants to farmers under Rashtriya Krishi Vikas Yojana of 2014–15 to promote agroforestry.
- The State is coming up with agroforestry research centre and centralized clonal nursery for production of 20 lakh Eucalyptus plants per year is being set up.
- The State has set up an ambitious target to increase area under forest and tree cover from 6.82 per cent (3,271 sq. km) to 15 per cent (7,554 sq. km) by 2022 under the Green Punjab Mission of the State Action Plan on Climate Change.
- In the last 46 years, the State has been able to increase the forest cover merely by 2.77 per cent, which is around 1,396 sq. km (30 sq. km on an average annually). By undertaking 100 sq. km annually under green cover, this will help achieve the target of approximately 13 per cent (6,547 sq. km) by 2047.
- Of this 13 per cent area, around 2–3 per cent area could be targeted from the private lands in the form of agroforestry plantations. Rest could be taken from the forest land, community private forest land and waste land, etc., across the State. Species, such as Shisham, Kikar, Drek, and Eucalyptus could be encouraged based on the site specific conditions.
- Area under agroforestry can be increased from 0.37 per cent to at least 2–3 per cent of the geographical area in the State by 2047. Agroforestry can not only help in increasing tree cover but also meeting the demand-supply gap of forest products.
- The productivity of planting material can potentially be increased manifold by using superior planting stock raised through tree breeding programmes as well as through clonal technology and tissue culture. Annual productivity of a seed-raised Eucalyptus plantation presently is only 6 to10 cu. m per ha, which can be increased up to 40 to 50 cu. m per ha annually with the introduction of genetically-improved plants.

Biodiversity

Challenges

- The revised National Forest Policy envisages a forest cover of 33 per cent; however, Punjab has only 3.52 per cent area under forests. Hence, the rich diversity of 1,897 Angiosperms, 428 bird species, 131 fish species have been confined to smaller areas like Shivalik hills.

- As Punjab has 84 per cent land area under agriculture, cropland ecosystem forms the dominant ecosystem in the State. However, agricultural diversity has reduced significantly post green revolution. For example, out of 49 varieties of wheat and 27 varieties of rice, only three and nine varieties are being used, respectively.
- Of the total 373 large/medium industrial units in Punjab, 310 units utilize bio-resources as major raw material.

Opportunities

- Development of a detailed plan to build up Harike Wetland Wildlife Sanctuary for native and migratory birds.
- Strengthening of staff and capacities of the State Biodiversity Board in order to meet the National and Aichi Targets. Focus on addressing the fiscal gaps by assessing the financial resources identified by Punjab State Action Plan on Climate Change.
- With the help of State Biodiversity Board and State Forest Department of Punjab, the State can develop a mechanism to assess the conservation status of the existing flora and fauna in a participatory way. It will involve processess of species for monitoring, developing baseline, and developing a monitoring mechanism. Instruments such as People's Biodiversity Register would be important for this recording the presence of species.
- There is also a need to measure ecosystem services in the State.

Air Quality

Challenges

- Around 16 million tonnes of paddy and 8 million tonnes of wheat straw are burnt in the agricultural fields every year leading to air pollution in the State and nearby areas.
- Around 1.68 million small scale industries and 425 large and medium scale industries are presently functioning in Punjab. In 2011–12, around 13,070 industrial units in Punjab were put under red category (highly polluting) industries by the Central government.
- Number of registered vehicles in the State reached approximately 63 lakhs in 2012, which is almost double of the figure a decade ago.

Opportunities

- Looking at the growth rate of vehicles, more stringent steps should be taken with regard to air quality measures in transportation sector. Instead of following chronological order for the norms.
- Government should conduct awareness programmes at community level to sensitize the public about the growing levels of pollution due to vehicles and promote public transport systems.
- Government should ensure regular vigilance of open burning activities. New sustainable technologies should be introduced in the State.
- Instalment of Air Pollution Control Equipment in all industrial units should be made mandatory.
- In brick sector, government should emphasize on adoption of cleaner technologies like vertical shaft brick kiln and tunnel kilns.
- In order to have more regular control, number of air quality monitoring stations in the State should be increased.

Water

Challenges

- The depleting water table is a cause of grave concern as it has given rise to water quality issues in Punjab. The cumulative fall in groundwater in Central Punjab during last three decades is more than 9 m (SAPCC 2014).
- Annual deficit of groundwater availability is 14.31 BCM as on March 2009 (SAPCC 2014).
- Consumption of synthetic fertilizers and pesticides in Punjab is the highest amongst all states and union territories in India. Over use of fertilizers and pesticides has resulted in high Nitrate, Organo-Chloride, and Organo-Phosphates in drinking water sources.

Opportunities

- Punjab is yet to formulate a ground water policy. It needs to develop an implementation framework for policies and mechanisms for operationalizing them.
- New technologies for construction of underground storage tanks and reservoir for surface water needs to be explored.
- Given the over-exploited groundwater tables and deteriorating groundwater quality in most of the blocks in Punjab, there is a critical need to develop a comprehensive water conservation and management plan to rejuvenate water bodies and restore lakes and rivers that ensures the replenishment of water to the local aquifers and in general improves the water availability scenario in the State.
- Treatment of municipal and industrial effluents should be mandatory before disposal to water bodies. Effective legislation at the state level would check these polluting sources. Developing mechanisms is essential to facilitate all major commercial/ institutional/industrial service entities to move to zero liquid discharge in a defined time frame.
- Integrated wastewater management by treatment, recycle, and re-use by identifying and designing innovative solutions for domestic and/or industrial sectors with appropriate use of decentralized and/or centralized options.
- There is an urgent need to strengthen the institution of Water Users Association along with a management information system platform with innovative information and communication technology tools and technologies for an integrated and efficient monitoring.

Agriculture

Challenges

- The mono-cropping regime is responsible for leeching the soil of the basic nutrients and affecting the soil health. About 70 per cent of the geographical area has soil micro-nutrients imbalance.
- Approximately 17 million tonnes of paddy straw is generated annually in Punjab of which 88 per cent of the paddy straw generated is burnt on site causing air, water, and soil pollution.
- The rapid increase in agricultural production has come at the expense of water resources. The stage of groundwater development has reached 170 per cent in Punjab.
- Punjab at present faces a challenge of increasing the area under forest and tree cover from 3,271 sq. km (6 per cent of total geographic area) to 7,554 sq. km (15 per cent of total geographic area) by the year 2022.

Opportunities

- Promoting and properly implementing crop diversification programme started in 2013–14 in the original green revolution states on a large scale.
- Application of twin blade combines for paddy harvesting needs to be explored.
- Ensure effective implementation of all strategies mentioned under the 'Draft Policy for Management and Utilization of Paddy Straw in Punjab—2013'.
- Need for pest, weed, and disease management in crops through development of integrated pest, weed, and disease management packages; mapping of pests and diseases already present in various crops; development of weather-based pest and disease early warning system; and monitoring of pests and diseases through e-pest surveillance GPS-based devices.
- Paddy straw can be used for cardboard manufacturing, ethanol, power generation, and mushroom cultivation.

Waste management

Challenges

- According to the Central Pollution Control Board, the sewage generation in class I cities in Punjab was 1,528 million litres per day (MLD) but the treatment capacity was only 411 MLD. Similarly, in class II towns, the generation rate was 157.4 MLD and the treatment capacity was only 42.8 MLD.
- Lack of segregated waste could be a challenge for processing of the solid waste. A greater role of private players for source segregation through door-to-door collection is still to be seen.
- Cities typically spend more than half of their waste budget in collection alone (mainly on labour and fuel), although the collection rate remains low and the transport of waste inefficient. Spending on other segments of the waste management chain such as appropriate treatment, recovery and disposal technologies, and facilities is generally rather low.

Opportunities

- Punjab being a rapidly urbanizing state has a generation of organic waste. Technologies, such as enhanced acidification and methanation can be used for utilizing waste. Sectors that generate organic waste in large amounts—such as food and fruit processing industries, hotels, community kitchens, and vegetable markets—can make the best use of the technology.
- Technologies, such as, GPS, GIS, remote sensing, online web services, and cloud computing can find real-time application in waste management. For example, trucks and bins can be installed with remote optical sensors that can constantly record the data of type and amount of waste collected at various locations and create a database. Increased investment in basic collection services, the transport of waste and cleaning up dumpsites is a starting point for greening the sector.
- Availability of land for processing and disposal of waste is always a huge challenge in front of urban local bodies. Punjab Urban Development should earmark land for this issue. The authority allocating the land should have robust mechanism to prevent public discomfort when the facility finally starts functioning.
- The government must encourage policies in such a way that private sector is encouraged to invest, establish, and operate facilities in the waste management sector.
- It is highly recommended that the government should focus more on mass awareness and encouraging community participation. It is also advisable that the current engagement of the informal sector in waste handling is thoroughly understood and policies are framed accordingly.
- Economic incentives and disincentives serve to motivate consumers and businesses to reduce waste generation and dispose of waste responsibly, thereby contributing to increased demand for greening the waste sector.

Renewable energy

Challenges

- Lack of Renewable Purchase Obligations (RPOs) has led to concerns about the final purchase of renewable power. The State DISCOMS will have to start taking RPOs seriously and State regulatory authorities would have to hold the DISCOMS responsible and penalize them for failing to comply on purchase obligations. Instead of forcing defaulters to buy Renewable Energy Certificates (RECs) to cover shortfall in power purchase, states are allowing the obligated entities to 'carry forward' deficits to the next financial year.
- Weak financials of DISCOMS will keep them from meeting commitments and affects the effectiveness of instruments that have been put in place for deployment of renewables.
- Acquisition of land is a critical aspect for infrastructure development and the approval processes and inability of the State governments to provide an effective single-window clearance to developers has caused considerable challenges.
- A robust system setting a time bound target for getting all approvals without having to follow up with different State government departments needs to be put in place for renewable energy developers.

Opportunities

- As of March 2015, Punjab's installed capacity of renewable energy consists of solar power (200 MW), biomass power (63 MW), small hydro (135 MW), waste to energy (1 MW), and cogeneration power (410 MW). It has also been given an award by the Ministry of New and Renewable Energy for being one of the best performing states in terms of capacity addition of renewables.
- Punjab has also set a target of increasing the percentage of renewable energy in the total energy mix to 15 per cent by 2022. It targets an installed capacity of 5,400 MW renewable capacities by 2022, which includes 300 MW from biomass, 680 MW from co-generation, 4,200 MW from solar, 200 MW from small hydro, and 20 MW from waste to energy. Punjab has large solar and biomass potential.
- Exploit the potential power from its extensive canal systems (about 250 MW). Use unproductive land to promote development of Solar Parks by Private Sector Developers (by purchasing of agricultural land or acquiring government land).
- A 1,000 MW Solar park can be developed under PPP model. All possible incentives should be extended to companies setting up solar parks under the State's industrial policy and investment promotion schemes.
- Encourage solar power generation and promote Stand Alone, Rooftop, and integrated power projects to achieve installed capacity of 1,000 MW with net-metering agreement between consumers and DISCOMS.
- Promote 'farm-level solar power generation', where landowning farmers can install solar power projects of 2–3 MW capacity.
- Energy generation from agroresidues, such as cotton stalks, paddy straw, and paddy husk. A target of 600 MW power generation should be set in this sector. Additionally, the existing industries like sugar, paper, and others have an estimated unexploited potential of 500 MW of co-generation.
- Introduce scientific processing and treatment of Municipal, Urban, and Industrial solid waste. Such waste to energy projects can be developed to target an additional 50 MW power generation. Increase coverage of solar street lighting in rural areas by putting 3,000 solar lighting systems each year.
- Create conducive conditions for attracting private sector investment in renewable energy projects along with broader public participation.
- Support research and development, demonstration, and commercialization of new and emerging technologies in renewable energy sector.

Demand Side Management

Challenges

- The maximum restricted demand met has increased from 8,834 MW in 2010–11 to 9,074 MW in 2012–13 while the unrestricted demand has increased from 9,399 MW in 2010–11 to 11,520 MW in 2012–13.
- It has been forecasted that the demand and energy requirements are expected to double in the next 15 years.
- The peak deficit has decreased from 16.9 per cent to 13.4 per cent.

Opportunities

- Special focus on promotion of energy efficient appliances in households, street lighting, government and private establishments, and water pumping needs in agriculture sector.
- Increase the State Energy Conservation Fund and monitor its utilization.
- Implement cluster-specific energy-efficient demand side management solutions targeting medium- and small-scale industrial enterprises.
- Formulation of effective customer outreach and communication programmes for active involvement of consumers in demand side management and energy efficiency.
- Develop Centre for Excellence to address research and development (R&D) and demonstration issues related to demand side management and energy efficiency.
- Undertake impact analysis of the demand side management regulations and business models for incorporating modifications to make policies more effective. Need to commission regulatory impact studies on tariff-based interventions.

Buildings

Challenges

- Punjab is a progressive state and has introduced several appropriate legislations/policy/programmes/missions to look at several key concerns of the buildings sector. However, in spite of the appropriate legal framework, the sector faces several barriers to greening the building sector.
- The current focus of the several efforts is limited to only energy efficiency and some bit of measures to introduce rainwater harvesting (for storage and/or recharge) with limited success. The increased influence of glass architecture for commercial buildings is very much on the rise, which results in non-use of daylight (due to excessive glare), large cooling loads, and increased energy and water demand.
- The regulatory frameworks for implementation of Punjab Energy Conservation Building Code (ECBC) and its subsequent integration in the building bye-laws and specifications of materials/rates in the State Public Work Department is yet to be done.
- The existing capacities of the local authorities to monitor the implementation of the State code are inadequate and a simplified, robust framework needs to be built in to achieve/over achieve the targets as defined in the Sustainable Habitat Mission of Punjab SAPCC. Data collection in this sector also needs to be enhanced.
- Climate change could further worsen urban flooding in the State. This needs to be prevented by adequate strategies such as mandatory provision of sustainable urban drainage systems at neighbourhood scale apart from major urban planning interventions on micro/macro watershed management and retrieval and conservation of water bodies.

- Currently, there is also absence of clear cut strategies for reduction in urban heat island effect (in spite of the mention as one of the objectives of the Sustainable Habitat mission).

Opportunities

- Implementation of the Punjab Sustainable Habitat Mission and creation of an enabling environment to overcome the various technological/financial barriers.
- All new commercial buildings need to be Punjab ECBC compliant.
- The entire existing building stock to be made energy efficient and water wise in a phased manner with at least 20 per cent stock to be retrofitted by 2020.
- Incorporation of green/energy efficiency features in Municipal bye-laws and all related documents (e.g., State specifications, plinth area rates) followed by the State government is a must for achieving the environmental benefits associated with greening of building sector.
- Need to integrate the principles of low impact development/sustainable urban drainage systems at all zonal plans, neighbourhood plans (new and retrofit) on a priority basis in areas more prone to urban flooding/flash floods. To begin with, three to four cities/towns may be taken on a pilot basis, which could be expanded in the next phase.
- Alternate building materials that perform equal or better than the conventional ones to bring in environmental sustainability and building up a database for the entire supply chain to promote such materials.
- Capacity building at various levels including skilled manpower for enabling green construction.
- Attractive financing solutions for developers for investing in energy efficient buildings, energy service companies, and communicating through various media the benefits of green buildings at no incremental cost.
- Life cycle costing of the property and potential savings on annual electricity bills should be made available to the buyers along with the property brochure, including attractive financial models for affordable housing sector.
- Creation/strengthening of Centres of Excellence to promote green buildings and neighbourhoods are needed.

Industry

Challenges

- The major challenges in the micro, small, and medium enterprises (MSMEs) sector include among others—lack of awareness on energy-efficient (EE) technologies/practices and financing options, lack of off-the-shelf technological solutions, poor quality of local service providers, limited capacities of unit level workers to deploy EE technology, limited channels of communication between MSMEs, technology providers and financial institutions, and lack of institutional support at the cluster level.
- Mandi Gobindgarh has one of the worst air quality in the State and has been classified as a critically polluting town. About 4 million tonne of steel is rolled per annum in the cluster. The total annual energy consumption of the cluster is estimated as 142,000 tonne of oil equivalent (toe). The equivalent emissions are estimated to be 753,000 tonnes of CO_2.
- The Jalandhar hand tools cluster is also very energy intensive. About 950 MSMEs in the cluster produce over 50,000 tonne of hand tools per annum. The total amount of energy consumed in the cluster is about 19,901 toe annually, which mainly includes electricity.
- In Punjab, the annual electricity sales to the industry sector, including low tension and high tension consumers, is 17.384 BU or about 37 per cent of the total electricity sold. Studies estimate the electrical energy saving potential in Punjab's industrial sector to be between 7–10 per cent, which is around 1.2 billion units.

Opportunities

- One of the least cost-proven strategies for achieving sustainable growth of the industrial sector is to improve the end-use energy efficiency of industrial equipment/processes.

- The State industries on their own should explore fuel switch over (from coal to low carbon fuels like natural gas and biomass).
- Adoption of best available technologies such as cogeneration; EE lighting; EE equipment such as IE motors, air compressors, and pumps can reap savings of about 10–15 per cent.
- A government push for adoption of sector-specific cleaner technological options in major energy consuming sectors, such as cement, textiles, pulp and paper, and iron and steel is crucial as it can provide 25–50 per cent energy savings.
- Programmes to promote energy efficiency in building need to be supported as such practices need less investment, are easier to adopt, and provide 10–20 per cent energy savings.
- Further, adequate finance needs to be provided. Innovative financing schemes for the MSME sector to be introduced. Local financial counsellors have to play a major role for bridging the gap between financial institutions and MSMEs. Lastly, the local service providers at the regional level like consultants, fabricators, masons, and so on, need to be strengthened for dissemination of cleaner technologies.
- The State government should promote energy audits in the industries (including MSMEs) to identify the energy saving areas. Benchmarking of specific energy consumption is required to access and compare present status of performance/ technologies in our industrial sectors to best technologies and practices worldwide.
- The government needs to support industry adoption of energy management protocols, mandate minimum energy performance standards for electric motors, and implement a package of measures to promote energy efficiency in MSMEs.
- In the long run, innovation will be crucial. The government has to develop infrastructure that nurtures R&D of new EE technologies matching the best available worldwide.
- Public–private participation is required for Research, Development, Demonstration, and Deployment for clean technologies in the MSME sector to invest in cost-effective technological solutions customized to local conditions. Government needs to set up 'incubation centres' and incentivize cluster level fabricators to develop local low-cost technological solutions.

Transport

Challenges

- The modal share of public transport in the State is low and has declined over the years. The fleet strength and capacity is extremely low at 63 buses per 10 lakh population available for intercity operations as against the national target of 500 buses per 10 lakh population.
- The existing road network in the State faces capacity constraints. Increase in total vehicles has far surpassed the rate of growth of road transport and infrastructure in the state leading to capacity bottlenecks in the existing road network.
- Five main cities from Punjab namely, Ludhiana, Amritsar, Khanna, Jalandhar, and Gobindgarh among the top 100 most polluted cities in the world.
- The number of fatalities due to road accidents in the state has increased by 26 per cent over the last decade, making road safety a major concern area. About 3,500 lives are lost every year in road crashes in the State.
  - 65 per cent of the total road accidents were reported in urban areas
  - 83 per cent of the road fatalities are reported on National Highways and State Highways
  - Six major cities of Punjab—Patiala, SAS Nagar, Ludhiana, Amritsar, Jalandhar, and Bathinda—account for roughly 50 per cent of the total accidents in the State.

Opportunities

- There is need for removal of road capacity bottlenecks and further strengthening of the State road network.

- Develop safe and adequate public transport systems for both intercity as well as intra-city travel. At the regional level, the government must look at expanding the capacity of the regional bus and rail systems.
- Accessibility of public transport stations should be improved by way of provision of adequate non-motorized transport infrastructure facilities in cities. Adequate measures should be taken to improve and integrate informal modes in city transport systems.
- Encourage integrated land-use and transport planning in cities.

Climate change

Challenges

- Temperature and precipitation changes might also adversely impact agriculture. Given that agriculture constitutes 26.9 per cent of the state GDP and engages 70 per cent of the population, the impacts can cascade into a number of socio-economic impacts in the State.
- The strategies identified under the SAPCC are still at a broad scale while adaptation will essentially be implemented at local level considering the local vulnerabilities. Funds need to be supplemented for implementation of adaptation strategies.
- A greenhouse gas inventory for the state needs to be prepared for long-term mitigation planning.

Opportunities

- Devising a framework for applying the adaptation strategies and interventions identified under the SAPCC at the local level is required.
- Mainstreaming of adaptation into state development plans is required to further facilitate action on adaptation while addressing some of the financial gaps.
- Tapping funding opportunities from international funding mechanisms, other sources of funding through different models, and involving private funding sources can assist in addressing financial gaps.
- Reduced greenhouse gas emissions from the agricultural sector through on farm mechanization and fertilizer applications will be a key focus area for Punjab. Sustainable habitat through adoption of mass public transportation and city planning will also remain critical in climate change mitigation strategy planning.

Cross-cutting Issues

Challenges

- There has been a sectoral shift in the State's economy and the share of agriculture has fallen, while the share of secondary sector has increased from 24.74 per cent to 28.30 per cent and tertiary sector from 42.59 per cent to 50.86 per cent.
- While public investment in agriculture has declined in the country, in Punjab the farmer's own investment has increased over the decades.
- In the 1971–2011 period, there was a decline of 3.23 lakh holdings. This decline was primarily due to decrease in number of marginal and small holdings, which decreased by 68.23 per cent and 24.86 per cent, respectively. This decline was due to the unviability of farming for small and marginal holders and farmers from these size groups were either selling or mortgaging their land to the medium and large farmers leading to further consolidation.

Opportunities

- The government will need to consider implications of a rapidly urbanizing state.
- Also, the State will need to look into the structural economy dynamics.
- Punjab represents an example where there is need to better understand the inter-linkages between water, energy, and crop cultivation. The nexus thinking is based on the understanding that the human pressure on natural resources is affecting the resource base.
- The identification of the linkages across the key natural resource sectors and jointly improving their efficiency is needed for human well-being and environmental sustainability.

8 The Way Forward

The study provides an assessment of long-term sustainability challenges in the State using a suit of analytical tools and field case studies. Implementation of climate-resilient green growth strategies requires concerted policy action and interventions. Following key interventions areas are recommended to foster climate-resilient green growth in the state:

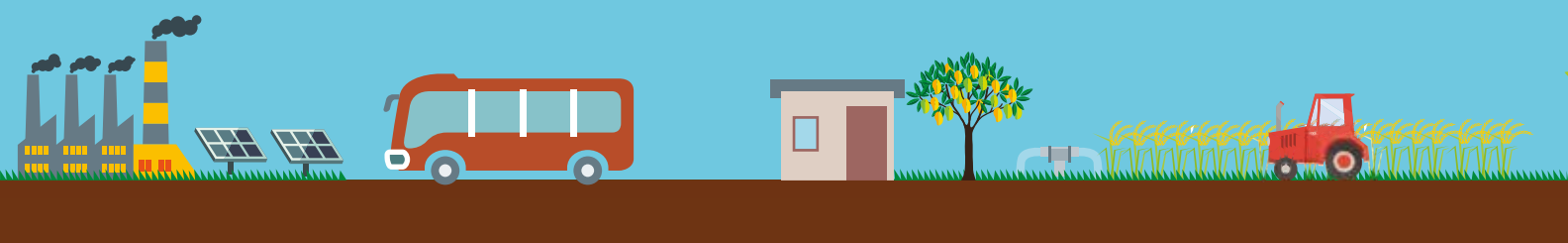
Information for Climate-resilient Interventions: Interventions need to evolve in order to respond to climate change impacts including extreme climate events, soil erosion, and surface water runoff. Information on climate impacts and risk management strategies will be required for the agriculture sector along with detailed socio-economic and agronomic vulnerability assessment. Pilot projects can be taken up to generate knowledge while engaging with the communities.

Addressing Data Gaps: Collecting and synthesizing existing and new data is needed to build strong evidence for facilitating preparation of strategies as well as evaluation of existing policy initiatives. Data can be collected using existing and new management information systems focusing on data quality and different parameters of data.

Climate Resilient Interventions

Mobilizing Finance

Data & Monitoring



Mobilizing Finance: Financing is critical to the implementation of climate-resilient green growth interventions. In addition to public finance, the role of private sector, banking institutions, international financing and development agencies Punjab.

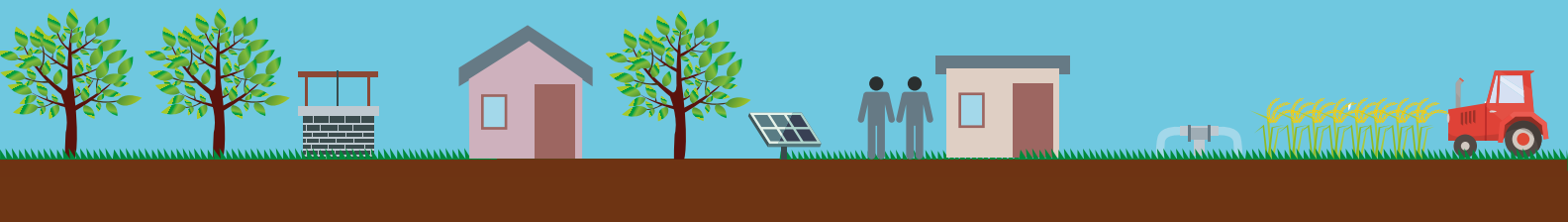
Commissioning Pilots and Technology Demonstration: Pilots need to be commissioned in opportunity areas. Technology demonstration should be encouraged in areas of renewable energy, waste management, renewable energy for cold storage applications, and natural resource management. This will help in up-scaling of technologies.

Capacity Building: Enhancing financial, technical, and institutional capacities of government as well as the voluntary sector is essential for the implementation of climate resilient green growth strategies. A detailed assessment of capacity building needs, for priority sectors, becomes essential. A greater engagement between government, research & academia, not-for-profit organizations, and private sector is needed to support coordination and implementation.

Pilot Projects

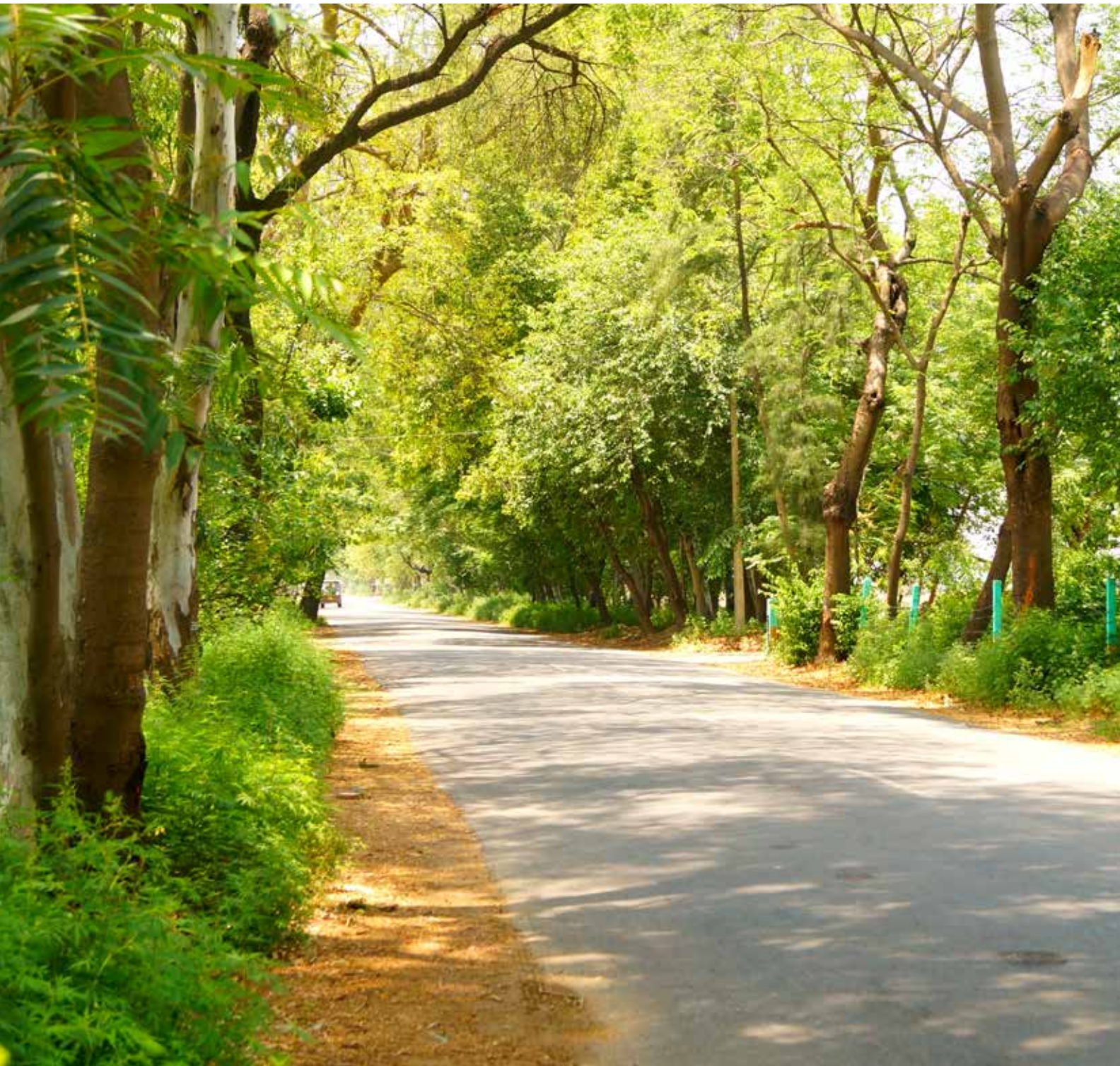
Mainstreaming Environmental Sustainability in Decision-making Processes

Capacity Building



Mainstreaming in Decision-making Processes: Climate-resilient green growth strategies need to be looked at as cross-cutting issue requiring policy coherence and inter-departmental coordination. For further mainstreaming of environmental sustainability in decision-making processes, the government can adopt green budgeting for the State of Punjab wherein all departments can prepare environmental budget statements. This would encourage pro-active mind-sets among policy makers as they would then reflect on activities undertaken in their respective departments.

Understanding Emerging Issues: The State needs to better understand and be prepared for growth drivers including urbanization and change in structural dynamics. According to emerging needs, skill development and vocationalization of education is urgently needed. This is crucial for planning and implementation of sustainable and inclusive development.



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