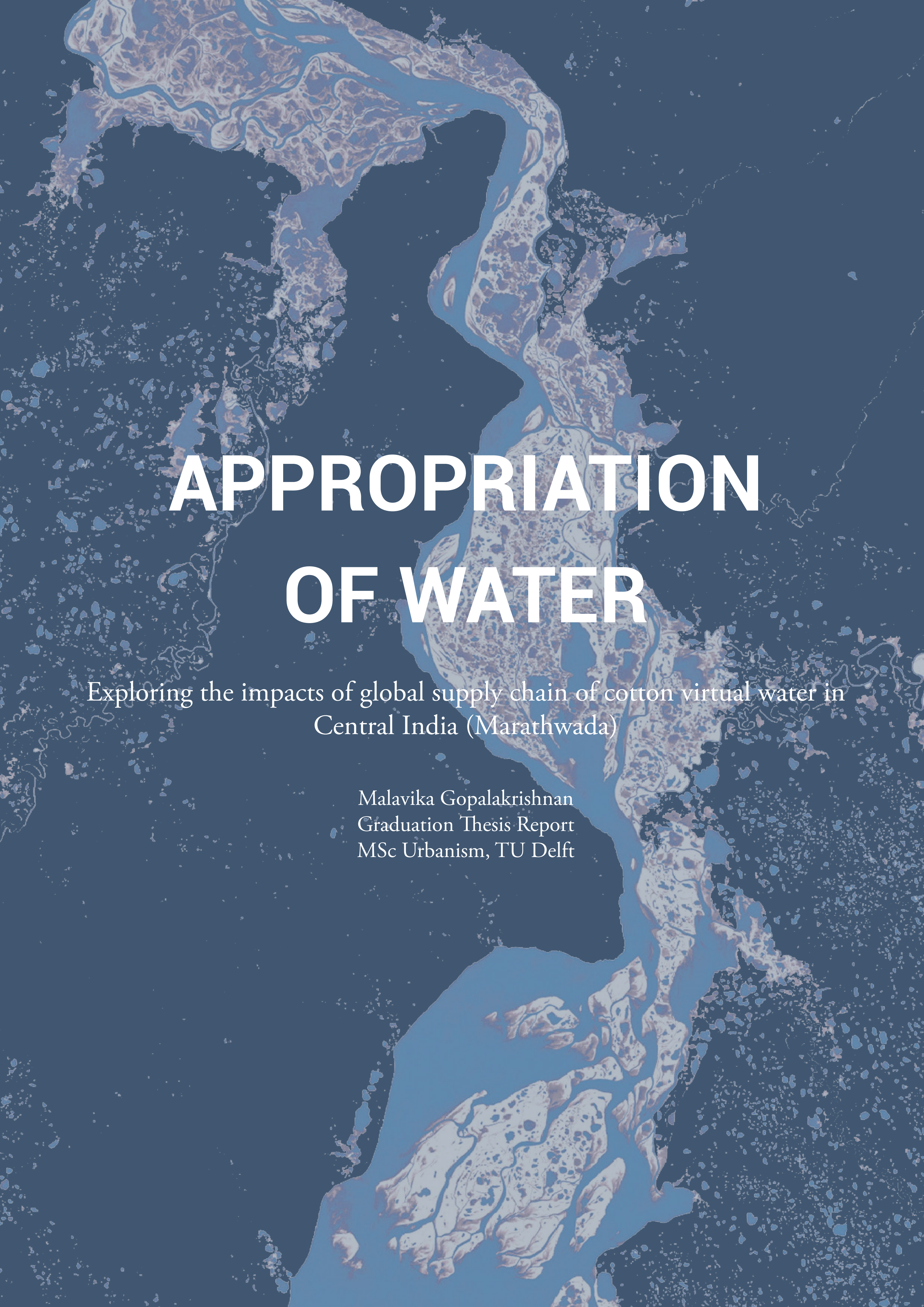

APPROPRIATION OF WATER

Exploring the impacts of global supply chain of cotton virtual water in Central India (Marathwada)

Malavika Gopalakrishnan
Graduation Thesis Report
MSc Urbanism, TU Delft

COLOFON

MSc Graduation Thesis Report
Appropriation of Water: Exploring the impacts of global supply chain of cotton virtual water in Central India (Marathwada)

June 2020 | Delft, Netherlands

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Research Group: Urban Metabolism

MSc Architecture, Urbanism and Building Sciences - Track Urbanism
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Fieldwork partially funded by:

EFL STICHTING
TU Delft | Global Initiative
TU Delft
TU Delft Department of Urbanism BK Bouwkunde

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Fig 1.0 Upper Godavari basin
Source: by author based on open GIS data

Acknowledgments

This thesis was possible because of the kind and generous support of many individuals. I would like to extent my sincere thanks to all of them.

I am most grateful to my supervisors Dr. Alexander Wandl and Dr. Diego Sepulveda Carmona for guiding me and challenging me to delve deeper and successfully navigate the complexities of the research. Their constant supervision and support was the most important in completing this thesis successfully. I would also like to extend my gratitude to Prof. Sevil Sariyildiz for her time and support in chairing my graduation committee.

I am highly indebted to SOPPECOM, Pune and team especially Mr. K J Joy, Ms. Sarita Bhagat, Dr. Neha Bhadbhade and to Mr. Hari Nage for helping me conduct the field-work and interviews. I am also grateful to EFL Stichting and TU Delft Global initiatives for providing me the funding to undertake the fieldwork to Marathwada, Maharashtra.

I would like to thank the entire urban metabolism research team for their guidance and support in helping me hone and improve my capabilities. To all of my distinguished teachers at TU Delft, I would like to thank you for sharing your knowledge and wisdom. My sincerest thanks to my colleagues and mentors at Vereninging Deltametropool for their support and help.

I couldn't have done this without the help and support of my friends and family who were always there for me. My mother for her constant guidance and support especially during the fieldwork. I am also thankful to the forever patience of my partner and best friend who helped me persevere in the toughest of times.

Lastly, I also thank the farmers and kind hearted people of Marathwada who graciously welcomed me into their homes and shared their stories with me. I dedicate this to you.

Thank you all.

Contents

Fig 1.1 Every drop counts
Source: www.Flickr.com

01 Defining the problem

1. 1 Abstract

The phenomenon of 'globalisation of water' (A. Y. Hoekstra & Hung, 2005) talks about the importance of recognizing the adverse effects on local freshwater resources from a global perspective. The trade of water through the export and import of products result in 'virtual water flows' (Arjen Y. Hoekstra & Mekonnen, 2012), which leads to many counties externalizing their water footprint with serious consequences leading to water stress, scarcity and pollution elsewhere. Lenzen et, al. talks about the trade of scarce water through water intensive crops and their consequences on water stress in exporting regions (Lenzen et al., 2013). This leads to a vicious circle of water stress which has several impacts on environment and society. However, the extent of these impacts is not fully researched upon. This thesis hopes to investigate the spatial, socio-economic and environmental impacts that is associated with virtual water trade, and how they can be improved to obtain a sustainable and balanced water footprint in water scarce regions.

Key words: Globalisation of water, water footprint, virtual water trade, water scarcity, urban metabolism.

Fig 1.2 Global Trade of Scarce water
Source: Dolganova, et, al. 2019

1. 2 Personal Motivation

Every summer, most of India faces extreme droughts and dry weather, resulting in ground water depletion and water stress. This leads to the failing of agriculture crops in most of rural farmlands and extreme water shortages in urban areas. The impacts on the society due to these events can be seen at multiple levels. With low yields, and more prominent climate extremities, many farmers aren't able to profit and sustain a living. This has resulted in an unprecedented agrarian crisis with a shocking number of farmers suicides. Water shortages and scarcity became a normalcy, with most of the groundwater levels depleting. However, is this only a problem of local water management issues or are there global impacts associated with this?

The answer is yes. It is important to look at the issue of water from a more global perspective. Most of the freshwater consumption is based on the agriculture sector and we cannot solve the problem of availability of water without understanding where and why this water is used and to whom it is supplied to. It is shocking that India has one of the biggest water footprints in the world, yet many in India do not have enough access to water. So, the question remains, where does all this water go? To look at the bigger picture means to see beyond the local problems regarding water and to understand and analyse the system. This means that the consumption of some products elsewhere has consequences in scarcity in other places. By looking at it from a systemic perspective, it is possible to diagnose the problem better and look at long term solutions.

Fig 1.3 Water Shortage in India
Source: https://www.economist.com

1. 3 Introduction

"When the well is dry, we realise the worth of water" – Benjamin Franklin

Freshwater is one the five basic needs which is indispensable for human survival and cannot be substituted. The amount of freshwater is that is available for human use is only 2.5% of the total water available on earth (Postel, Daily, & Ehrlich, 1996). With growing populations and climate change, the demand for existing freshwater supplies for agricultural, household and industrial demands are increasing and putting immense pressure on water sources. According to Arnell et, al. an estimate of 5 out of 8 people will be living under conditions of extreme water scarcity or water stress by 2025 (Arnell, 1999).

Almost 70% of the available water is used for agricultural purposes (Darrel Jenerette & Larsen, 2006). But as more land is cultivated to meet the growing food demands, this leads to extreme conditions of drought, ground water depletion and so on. In most countries with severe water stress, this has several consequences on the society. In most developing countries, this put acute pressure on the livelihoods of people and has grave social implications. In India, the resulting consequences of a bad season will lead to the lands running dry, crops failing, ground water resources depleting and as a result has resulted in farmer suicides, political tensions between states leading to water conflicts and so on. This is called as the vicious cycle of water stress and requires careful understanding of the agents and factors.

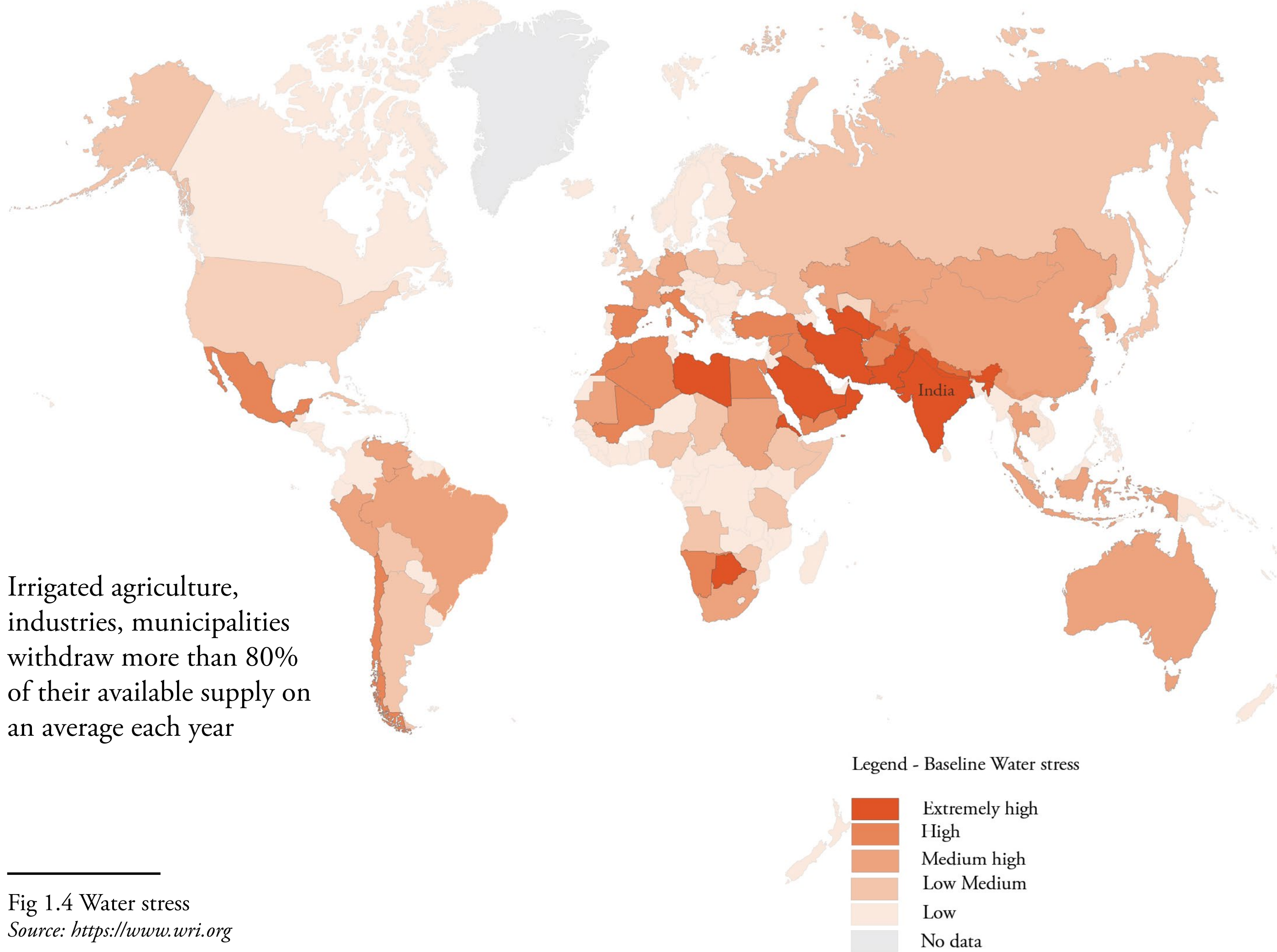


Fig 1.4 Water stress
Source: https://www.wri.org

Source : World Resource institute aqueduct water risk atlas 2019

Fig 1.5 Village woman walking for miles to fetch water
Source: https://static.timesofisrael.com/

02 Problem Synopsis

2.1 Problem field

Globalisation of water

It is interesting to note that problems of water scarcity are viewed as local water management issue. However, the concept of 'globalisation of water' (A. Y. Hoekstra & Hung, 2005) sheds light to the fact that water scarcity is very much related to the trade of several products. The solution to the local water problems cannot be solved by just intervening where they occur, but more often, the local water depletion, water pollution and water stress are closely linked to the national or even global economy (Arjen Y. Hoekstra & Mekonnen, 2012). According to the study by Hoekstra et, al. shows how many countries like the Netherlands rely on foreign water resources and help illustrate the global dimension of water consumption with significant impacts on pollution elsewhere (Arjen Y. Hoekstra & Mekonnen, 2012). It is therefore important to look at the issue of freshwater availability from a global perspective, or 'global water use efficiency'. The import of water intensive products through the trade of various goods results in international 'virtual water flows'. This talks about the virtual water that is embodied in a particular product during he process of production and distribution (A. Y. Hoekstra & Hung, 2005). In the paper, 'globalisation of water', the authors talk about how improving global water efficiency can result in solving water scarcity in water-poor regions of the world (A. Y. Hoekstra & Hung, 2005). However, this means understanding the flow of products and the embodied water along with this trade how the current system of virtual water trade is functioning.

Water footprint and virtual water trade

In order to analyse the impacts of 'globalisation of water', it is important to understand the concept of water footprint and how that is linked to the virtual water trade between different countries. The water footprint of an individual, community or business is defined as the total volume of fresh water used to produce the goods and services consumed by the individual or community or produced by the business (www.waterfootprint.org). It has three main components: blue, green and grey (Arjen Y. Hoekstra & Mekonnen, 2012). Several countries have externalised their water footprints significantly by importing water intensive products. This brings the need to look at the issue of water scarcity in a more global context due to the external water dependencies of several countries often from water scarce regions due to an increased global virtual water trade.

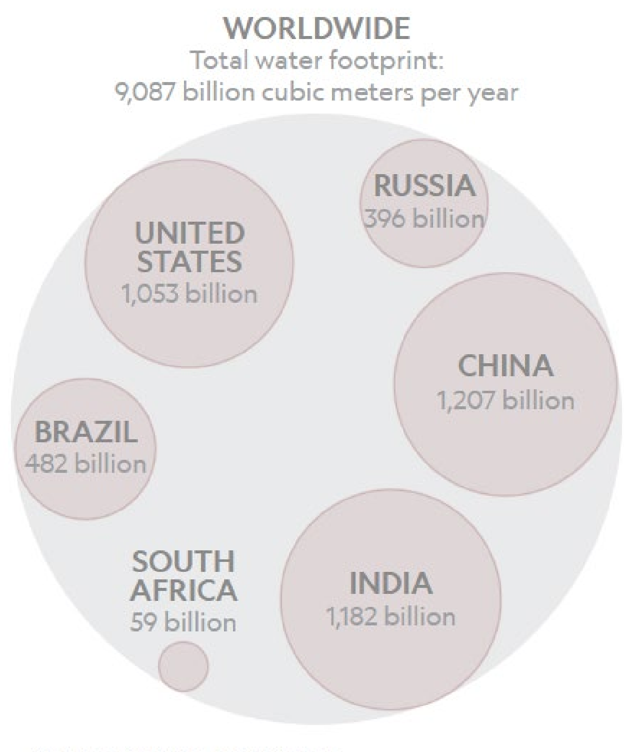


Fig 2.1 Water footprint of Countries
Source: Dolganova, et, al. 2019

“It is often thought that water problems are to be solved locally where they occur. However, generally, local water depletion and pollution are closely tied to the structure of the national or even global economy”

(A.Y Hoekstra, 2013)

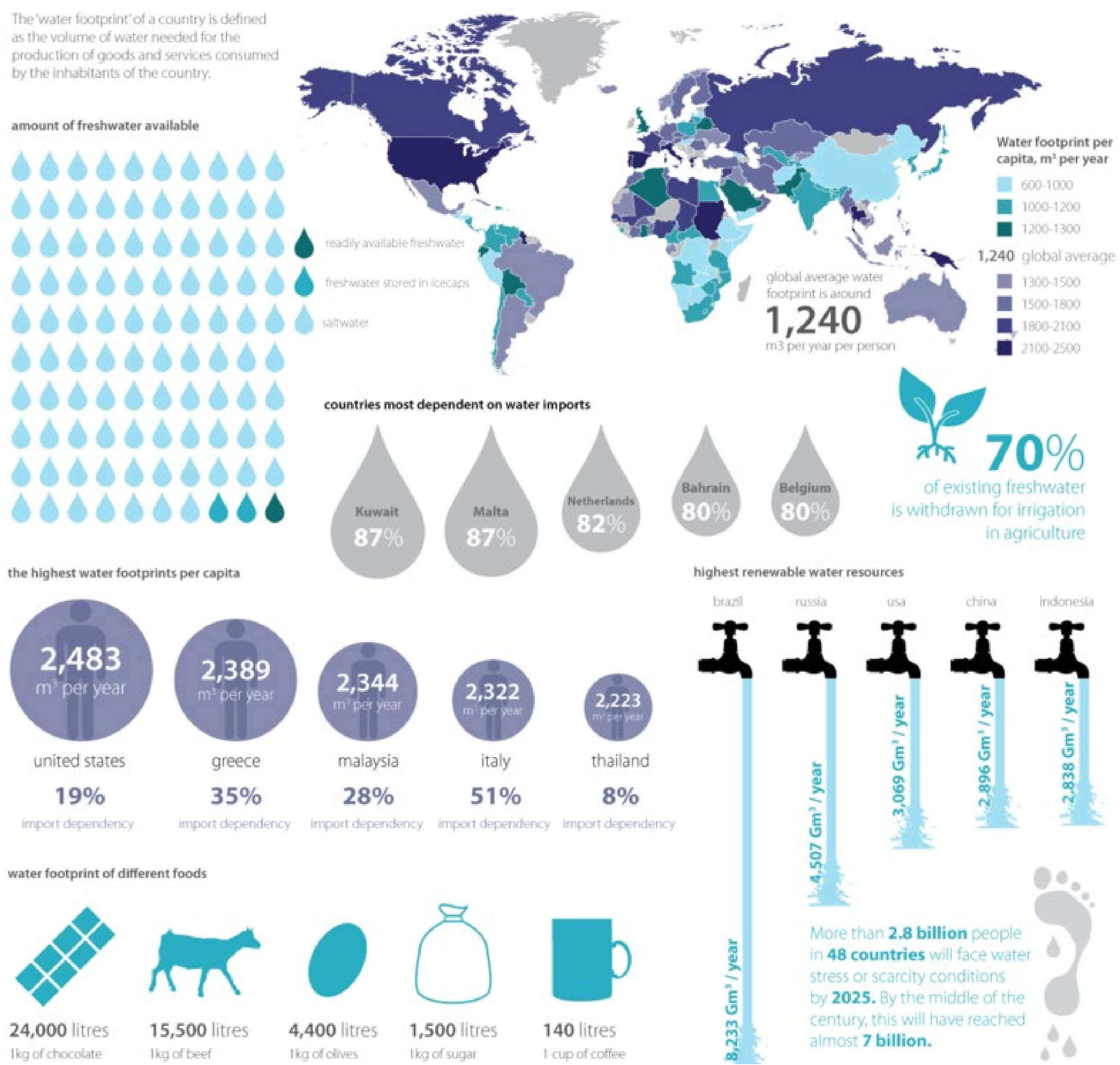


Fig 2.2 Water footprint Concept
Source: https://waterfootprint.org

Global trade of scarce water - An Indian perspective

The international virtual trade of water leads to the distribution of an uneven and imbalanced use of water sources. As most of the fresh water use is associated with the life-cycle of products rather than direct consumer use, almost 90% (Ridoutt & Pfister, 2010), it is highly important to look at water intensive supply chains and their effects on local water depletion. According to a study developed by Lenzen et, al. there is a clear correlation between scarcity and water trade through the international trade of crop and other products from water scarce countries. Their report puts forth India, Pakistan and China as the largest exporters of scarce water to some large importers such as USA, Japan and so on (Lenzen et al., 2013). The supply of some high water-intensive products like cotton, beef, fruit and rice puts forth percentage of embodied water from these countries as a direct reason for local water scarcity. It is an important aspect of addressing scarcity as the ripple effects of some of these supply chains through virtual water trade goes beyond the regional and national boundaries.


Politics & Policy

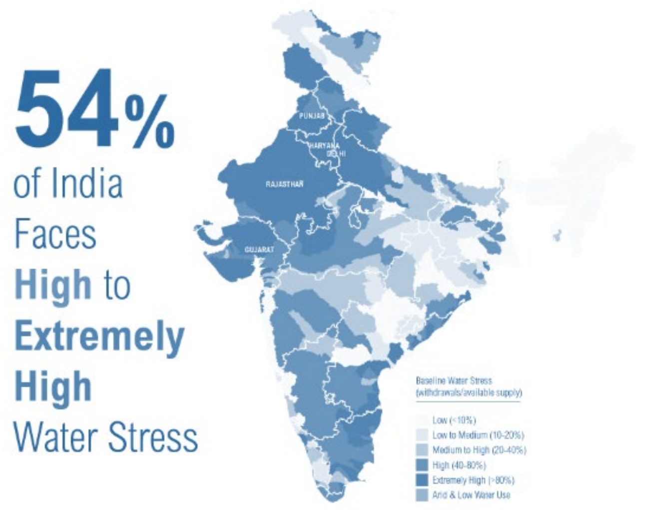
How India's Water Ends Up Everywhere But India

The country is the world's biggest exporter through its crops, shortages in urban areas.

By David Fickling
July 6, 2019, 2:00 AM GMT+2

The last drop. Photographer: ARUN SANKAR/AFP

Fig 2.3 India's water crisis
Source: https://washingtonpost.com



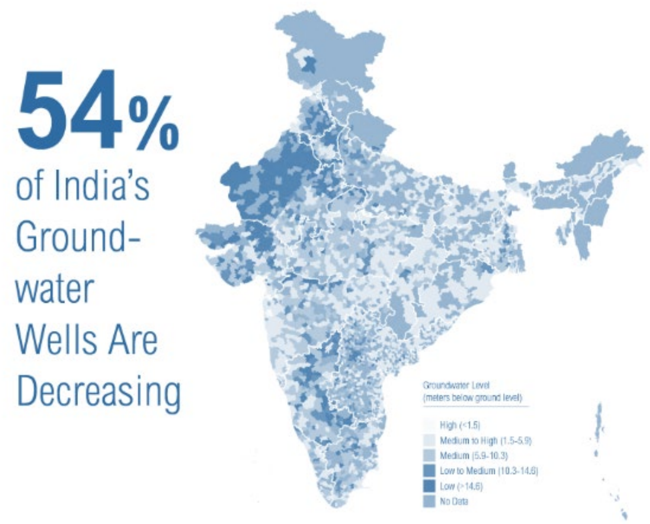


Fig 2.4 Water stress in India
Source: https://indiawatertool.in

For generations, due to fertile soils and seasonal precipitations, the agriculture sector is one of the biggest producers of GDP in the country. With a rapidly growing population of about 1.6 billion by 2050, the demand for food and agricultural products are under extreme pressure. Coupled with climate change, this has serious consequences in the availability of water for consumption as well as production. More than 50% of India faces extreme water stress and ground water depletion. As the largest exporter of virtual water of the planet, almost 95% of India's water ends up everywhere but in India. This means that country needs to seriously evaluate the use of water in its production and export of products and how that has major socio-economic impacts. With business as usual, India and several other countries facing water shortages will have significant impacts on global consumption and food security. With most of the world being fed by food sources from water scarce countries, this means with water depleting in these countries, there will be severe consequences within and globally.

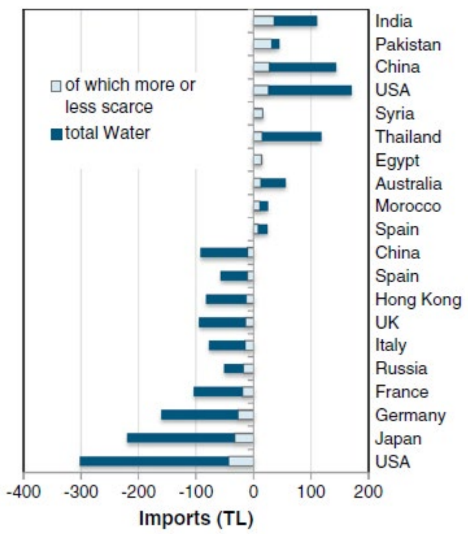


Fig 2.5 Top 10 exporters of Scarce water
Source: Lenzen et, al. 2013

Fig 2.6 Drought stricken central India
Source: https://qz.com

European Union is the biggest importer of Indian virtual water

European Union is the biggest importer of Indian virtual water when comparing the net virtual water flows of the global market according to Dolganova et, al. 2019. The most water intensive product that is the biggest export is Indian cotton. Incidentally, the most water scarcity footprint of the products imported by EU is also cotton. From this we can clearly understand the importance of cotton trade dominating the supply chain of virtual water from India and EU.

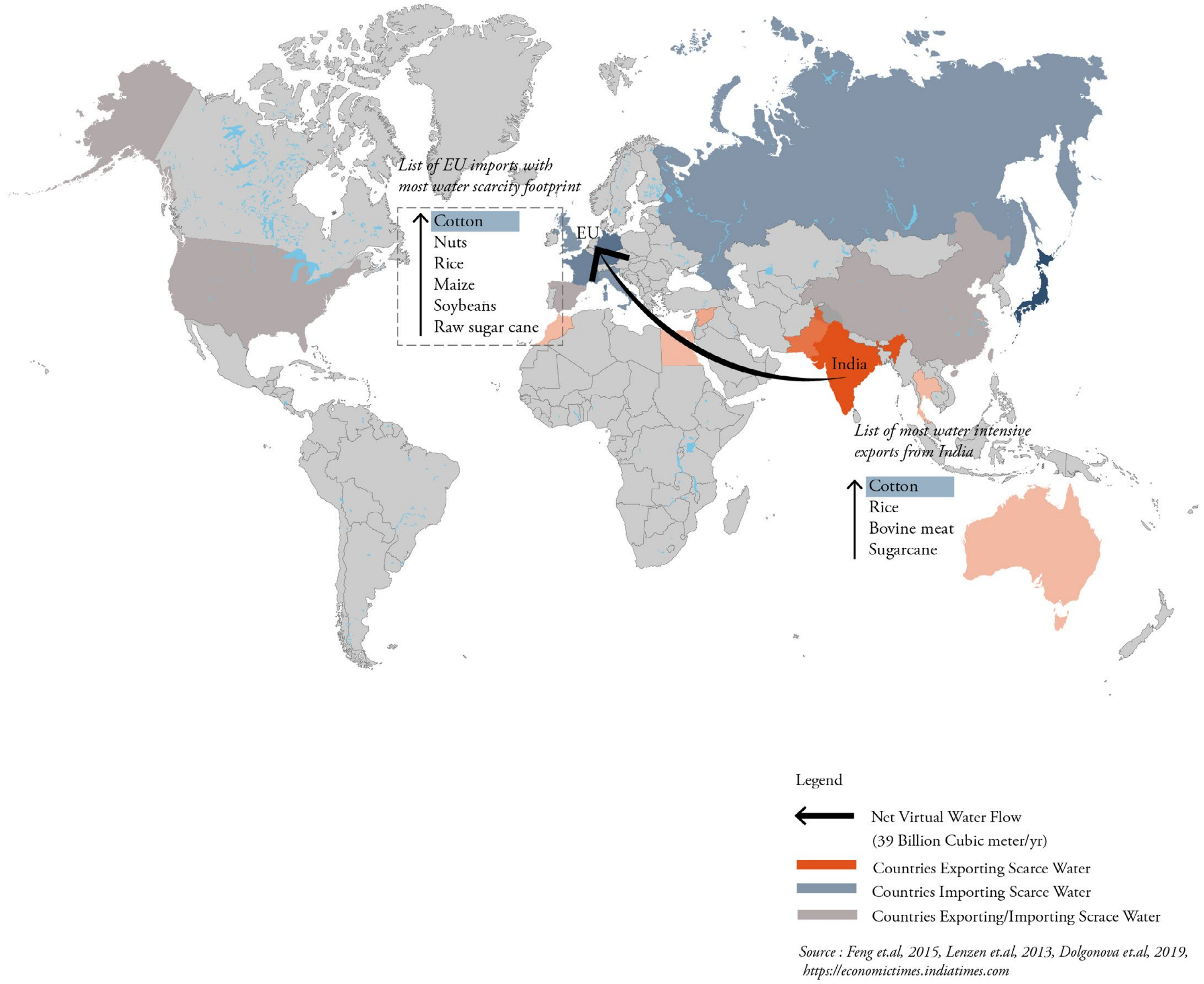


Fig 2.7 Map : Trade of Scarce water
Source: by author

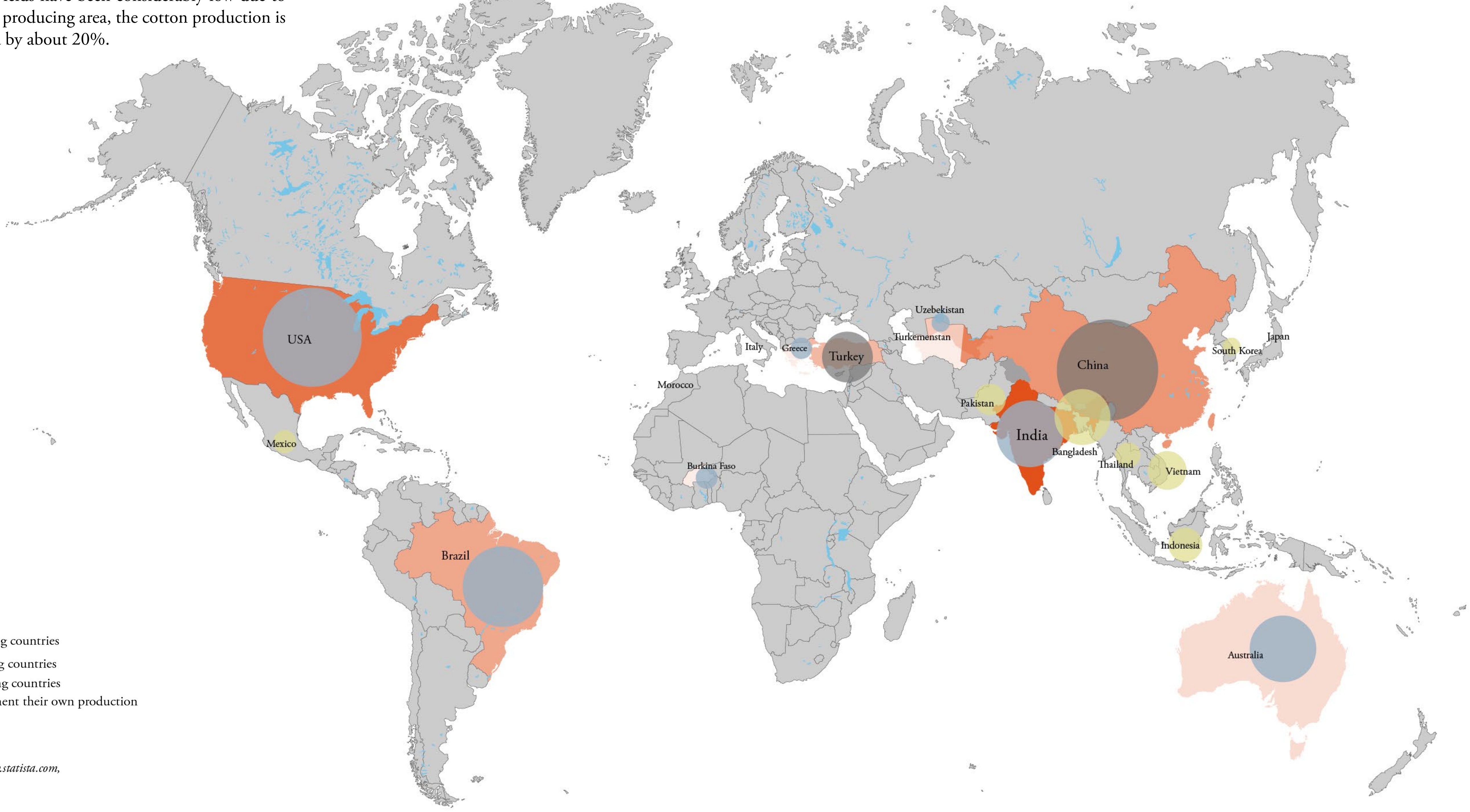
2.2 Context

World trade of cotton

India is the world's biggest producer of cotton

India is the biggest producer of cotton overtaking China in 2018 and the 4th biggest exporter in the world. India produces about 25% of the global cotton production. The Indian cotton industry is worth $6.3 billion (2018). In 2018, India produced about 370 lakh bales (1 bale is 500 pounds or 230 kg, roughly) and out of which exported about 52 lakh bales. Even though the yields have been considerably low due to the extreme drought in major producing area, the cotton production is still expected to grow in India by about 20%.

Fig 2.8 World trade of cotton
Source: by author



Legend

- Major Cotton producing countries
- Major Cotton exporting countries
- Major Cotton importing countries
- Countires that supplement their own production

Source : http://sff.arts.ac.uk, https://www.statista.com, Ministry of Textiles, Govt of India.

Cotton - A thirsty crop

10,000 Litres of water = 1 kg of cotton ⟶ 2500 Litres of water = 1 T shirt   8000 Litres of water = 1 pair of jeans

Cotton produced in India (2017-18)= 6.25 billion kg = 62500 billion Litres of Water

Cotton is one of the largest water intensive products produced worldwide

Cotton is the most used natural fiber in the textile and clothing industry, with about 40% of textile production made out of cotton. From the agriculture field to the market, cotton impacts water resources at various stages. Although there are several steps to cotton production and manufacture, the most important ones that impacts water are the agriculture stage and the industrial stage (processing of cotton to form cotton products). All these process influence blue, green and grey water footprint. The blue water footprint is from the evaporation of infiltrated water from rain-fed growth, the green water is the groundwater withdrawal or additional irrigated water required and the pollution of water due to fertilizers and pesticides result in grey water footprint (Chapagain et, al., 2006).

Fig 2.9 shows the water footprint of cotton consumption in the EU 25 countries and how much is externalised. About 84% of EU's cotton water footprint is externalised (Chapagain et, al., 2006) and lies mainly India. The EU heavily depends on Indian water resources for its consumption of cotton and textile. Almost one third of Indian cotton production is by irrigation, and this puts additional pressure on the surface and ground water in India. EU25 has huge impacts on the pollution of water resources mainly in India and Uzbekistan from the use of pesticides and fertilizers used to grow cotton as well as the chemicals used during the processing phase. This water footprint shows how dependent EU is on Indian and other water resources outside the continent. Therefore, it is important to understand the dependency between the two systems while looking at the issue of water scarcity in India.

Almost 84% of the water footprint of the EU25 region related to cotton consumption is located outside of Europe, with major impacts particularly in India and Uzbekistan

(Chapagain et, al. 2006).

Fig 2.9 Impacts of EU 25 Cotton consumption. 1997-2001.
Source: Chapagain et,al. 2006

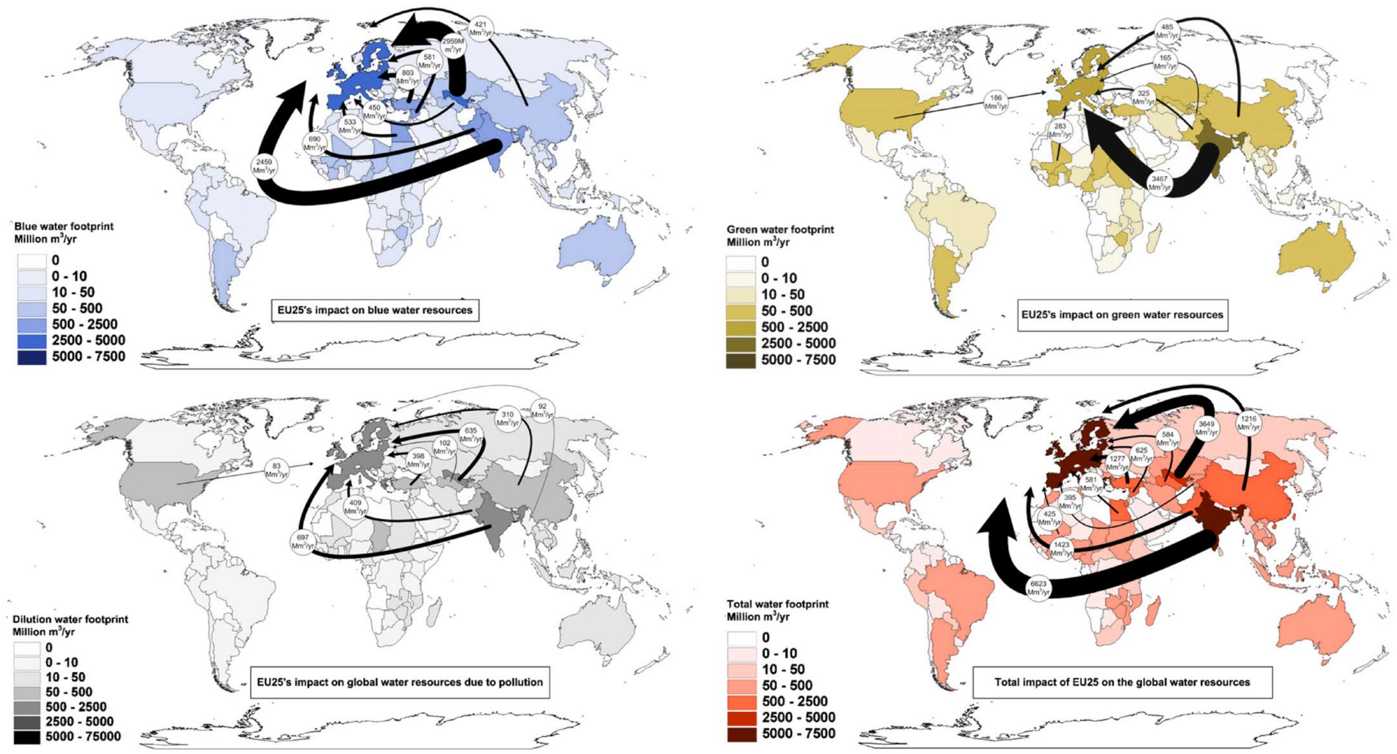


Fig 2.10 Cotton farm, Yavatmal, India (July 2018)
Source: https://toxicexports.publiceye.ch/

2.3 Problem Statement

India is facing acute water stress and water scarcity in more than half of the country. It is also one of the largest exporters of virtual water through agricultural products and the largest exporter of scarce water. The globalisation of water and the virtual water trade within and outside of India has significant effects on water scarcity and stress in the country. These lead a multitude of spatial, socio-economic and environmental issues related to water which are interlinked and related to the supply chain of products and commodities from India such as cotton. However, the spatial impacts of globalisation of water, more specifically the change in land use related to the consumption elsewhere and how that effects the socio-economic structure is not yet fully researched upon.

Fig 2.11 Cotton farm, Yavatmal, India (July 2018)
Source: httpstheprint.in

2.4 Research Aim

It is impossible to solve the problem of water scarcity without understanding the drawbacks of the current system and how the impacts of one leads to the other, and this cycle continues. It is still not researched upon, the consequences of such large agro-industrial landscapes as part of the urbanisation and globalisation have severe impacts on the society. The main aim of this research is to clearly understand this relationship, and analyse the current networks that form the system of virtual water trade using the trade of cotton from India to the Europe as an exemplary project. Further, the issue of water depletion and scarcity is always seen at the local level. So it is important to look at this issue at the scale where it is most visible and see if by changing the current system of cotton production in India, and if this can result in significant improvements be made at various scales but most importantly where the problem is most affected. To summarise, this thesis will look at the issue of globalisation of water and try to understand the various elements of the system through analysing an exemplary product chain such as cotton using the various spatial, socio-economic and environmental impacts.

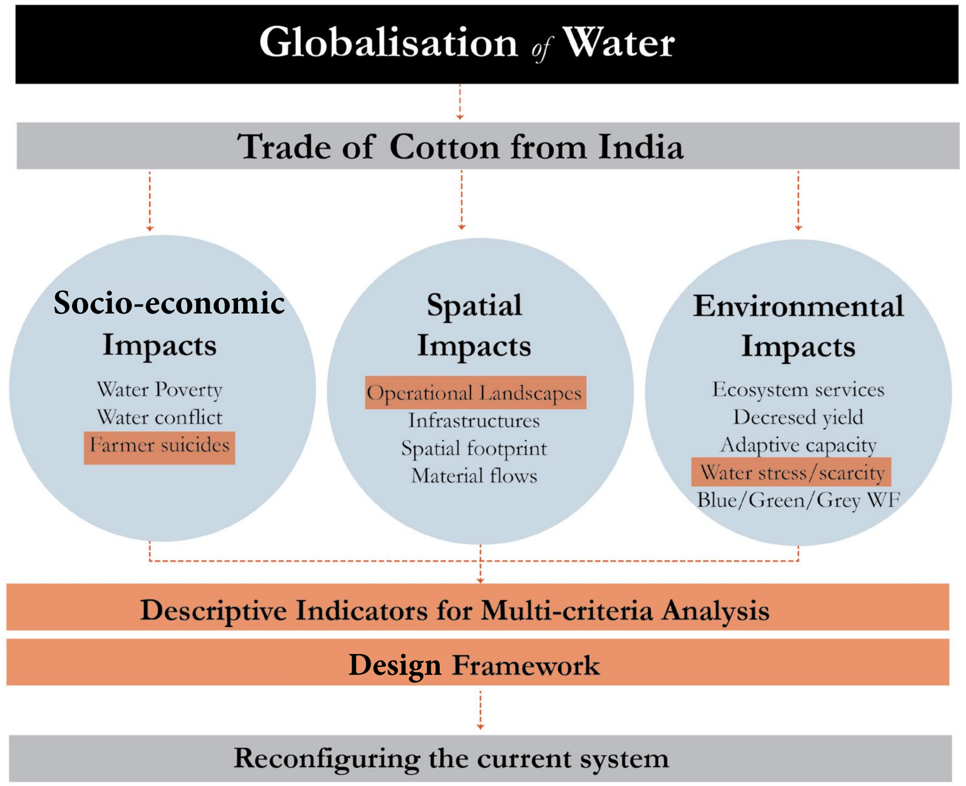


Fig 2.12 Problematisation and approach
Source: by author

This brings to the main research aim of this thesis:

- **To understand the link between the supply chain of cotton and its water footprint through virtual water trade as a contributor to water stress and scarcity in India.**
- **To analyse the spatial, socio-economic and environmental impacts of this virtual water flows and the possible solutions to re-organise the current system by providing impact pathways to achieve a more sustainable water footprint for cotton production in India.**
- **By using the example chain of cotton to provide a clear framework for analysis of such similar chains and to clearly define the elements of system of globalisation of water.**

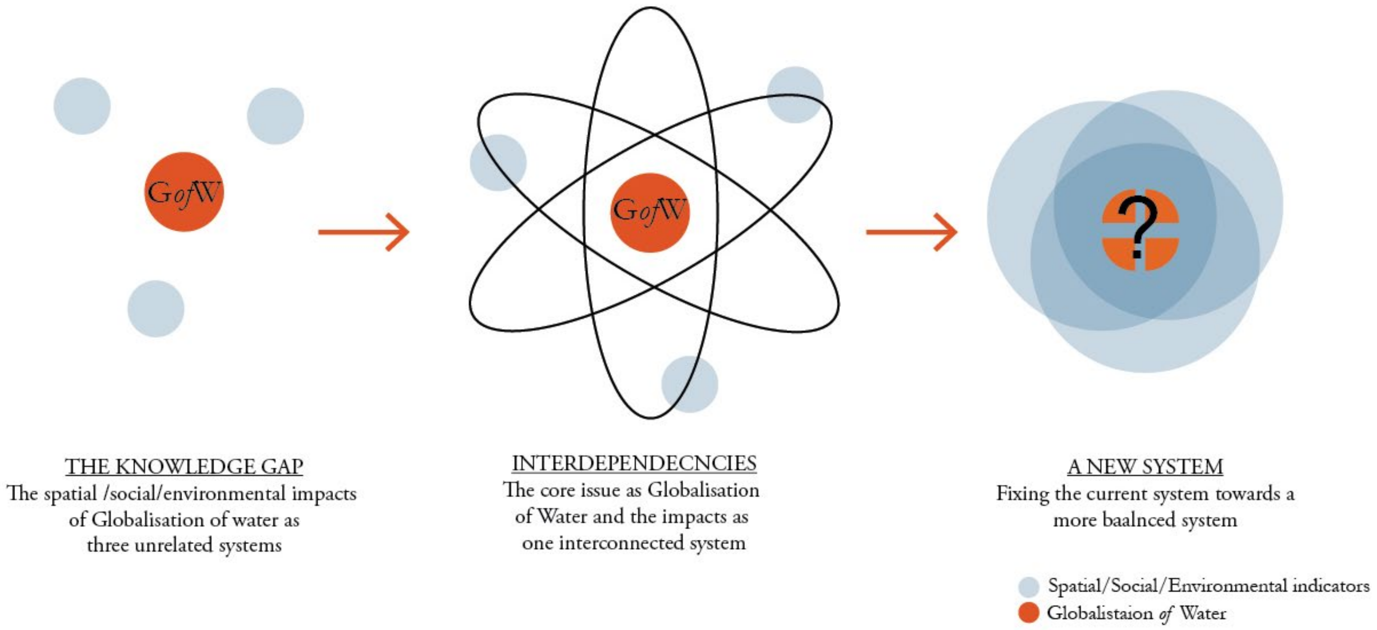


Fig 2.13 Research framework
Source: by author

2.5 Research Question

RQ: To what extent can the impacts of globalisation of water be minimized in order to achieve a more just and sustainable water footprint in cotton supply chains?

Sub research questions:

1. What is the link between virtual water trade and water scarcity in India?

2. What are the various spatial, socio-economic and environmental impacts of the virtual water trade in India?

3. Why is the current system of cotton production in India (Marathwada) unsustainable and unjust?

4. How can an improved system be developed in a more just way that there is fewer negative externalities of virtual water trade and create more spatially just system?

5. How can a design of a new system contribute to water resilience and empowerment of local communities?

6. How can a sustainable supply chain of cotton be developed that integrates multiple scales?

7. How can futures scenarios be envisioned that can guide policy makers to make effective choices ?

03 Research Framework

3.1 Defining the Approach

Introduction

To formulate a conceptual framework for understanding the metabolic processes related to virtual water flows, the theories related to the concept of urban metabolism and their evolution over time need to be assessed. Further it is essential to look for a framework to be able to analyse these metabolic processes to understand the problematisation and give it a spatial dimension. The order that is followed in this way to come up to the conceptual framework is by understanding the problem, how to frame the problem precisely and a possible approach to analyse the problem. In the earlier chapters, the problem field was clearly defined through understanding the context and problem field and through a clear problem statement. The other two part of the conceptual framework, the framework and approach will be looked at from looking at the existing theories and frameworks and moulding them to analyse the metabolic processes related to virtual water flows.

Urban metabolism in spatial planning for cities

The application of the concept f urban metabolism is essential to look at the problem from a spatial perspective. The urban metabolism study looks at the sum total of all the socio-economic and technical process that happen in a city associated with growth, production of energy and elimination of waste (Kennedy, Pincetl, & Bunje, 2011). However, there is a need to integrate urban metabolism studies to spatial planning and design as well as governance strategies. Kennedy et, al. talks about how urban metabolism studies can form the basis of sustainable urban design as well as policy analysis. However, the paper also points out the need to integrate social and economic indicators while assessing the metabolic flows (Kennedy et al., 2011). For example, in this case of water footprint assessment, high farmer suicide rates and lowered crop yield due to water shortage are both related to virtual water flows. They also talk about 'reconstruction' of the current system and how to sustain and develop ideas to obtain water and other resources without depleting regional or global resources and at the same time disrupting global communication. But it is possible that some sort of disruption is needed to achieve this reconstruction.

Therefore, while talking about the globalisation of water as the problem, the definition of 'urban' is limited to the administrative boundaries but the metabolic processes go beyond these boundaries. Hence it is important to understand the application of spatial planning of metabolic flows from a more planetary perspective.

Concept of 'planetary urbanisation' and 'territorial metabolism'

The concept of planetary urbanization challenges the idea of city and how the broader landscapes of urbanisation extends beyond the realm of what is conventionally called urban. These extended landscapes are part of the urbanization which can no longer be differentiated as 'rural' and 'urban' and how this impacts the city and vice versa. The process of planetary urbanization talks about the need to form a new epistemology of the definition of 'urban' and this explained as thesis by Brenner et al., (Brenner & Schmid, 2015). In the paper, the authors define urban as a process and not a form that is bounded by units or settlements. This helps us to visualize the patterns of agglomerations across the terrestrial landscapes transcending beyond geographical boundaries. It means looking at the interactions as socio-metabolic processes within and beyond the metropolitan centers and even nations.

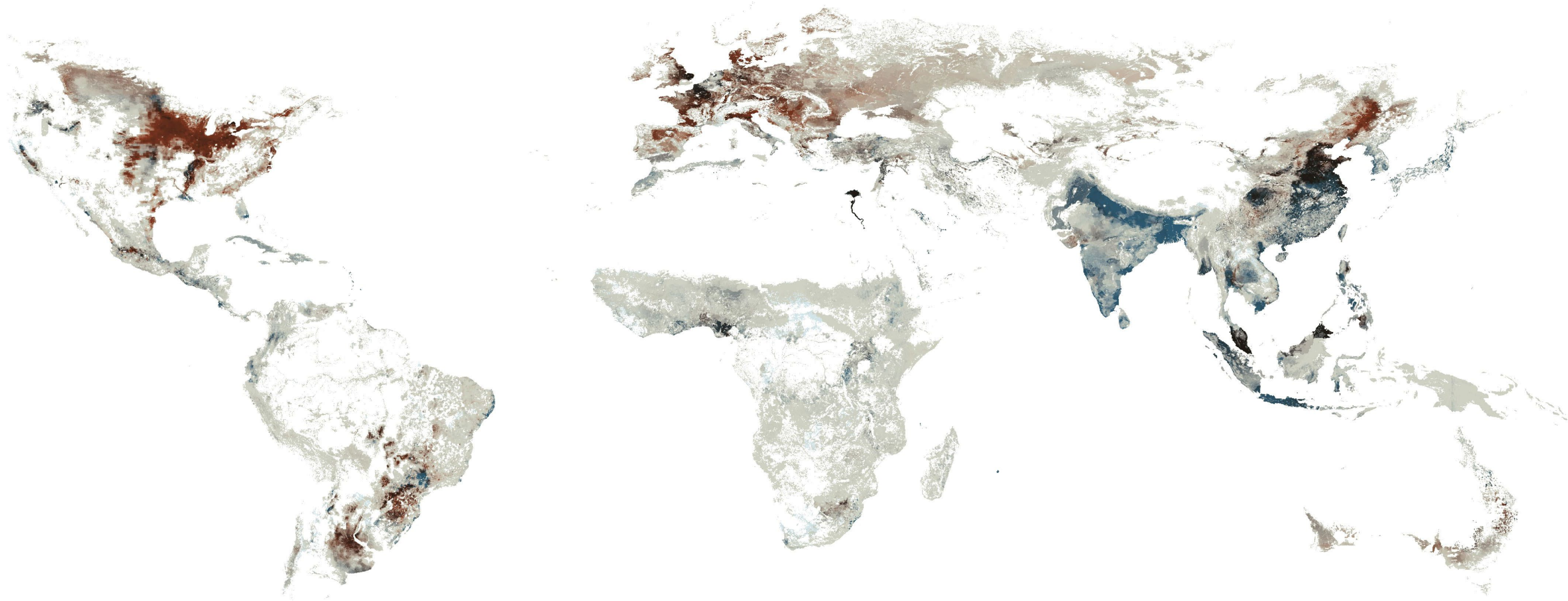


Fig 3.1 Planetary geographies of food and feed production. Blue shades are areas producing food for humans and red shades are areas producing feed for livestock.
Source: Katsikis (2019)
https://technosphere-magazine.hkw.de/

3.2 Theoretical Framework

The main component that dominate these socio-spatial interactions are related to the agro-industrial export zones and their tremendous expansion over the last decade. These has resulted in major transformation of 'rural' and 'peri-urban' zones into productional zones for food and industry. This essentially implies that the small villages in the outskirts of Mumbai in India are linked to possibly the biggest supermarket chains like Walmart in the US. Similarly, these all have associated water footprint and dependent on the local water resources as talked about in the earlier paragraphs, this means looking at the planetary boundary for freshwater should be an essential tool in making urban planning decisions and policy decisions. However, due to the spatial variability, water scarcity is a very regional or local issue, but it is important to look at interactions across scales with the global system as an indicator to assess and deal with scarcity.

Therefore, it can be understood that the lines of extent 'urban' and 'rural' is very blurred and not concretely separated as we think from a metabolism point of view. To understand the Globalisation of water and the spatial impacts related to, it is important to look at it from a more territorial scale. Here, territory is not the conventional geo-political boundaries but rather the 'production territory' or the extent to which the supply chains of products cross over (Sohn, Vega, & Birkved, 2018). Sohn et, al. defines this 'territory' as the 'geographic space managed by various stakeholders that is characterized by a regional identity' (Sohn et al., 2018).

However, defining the 'production territory' is only the initial step as it is still important to have a clear framework to analyze the metabolic flows that come and go out of this territory. For this purpose, we need to understand how the system of production relates to the ecosystem or natural system in this case, related to the water and hydrology that is present.

Telecoupling Framework

Across the world, landscapes are becoming increasingly interconnected in a highly globalised world. There is not just socio-economic connections but also increasingly ecologically connections explained by the concept of planetary urbanisation. TO understand such complex interactions, it s extremely difficult without a proper framework of anaylsis. Therefore, the telecoupling framework proposed gives as an ideas to help navigate these complex interactions in a more reasonable way (http://www.telecoupling.org). Telecoupling interactions can be defined as interactions of multiple coupled natural and human entities or systems or landscapes over large distances (Liu et al., 2013). These are occurring during many interactions across the globe such as trade and transfer of products and resources, water transfers, , payments and financial transaction involving ecosystem services, investments in foreign countries, migration of people and tourism and travel. They are also formed when information exchanges and flows, the spread of diseases (like the corona-virus) and invasion by species. Telecoupling framework looks at these interactions from a cross-scale cross-border perspectives to flows of agents over time. This framework provides exciting new opportunities to research and understand the interconnections of landscapes and ecologies and their impacts across space and time.

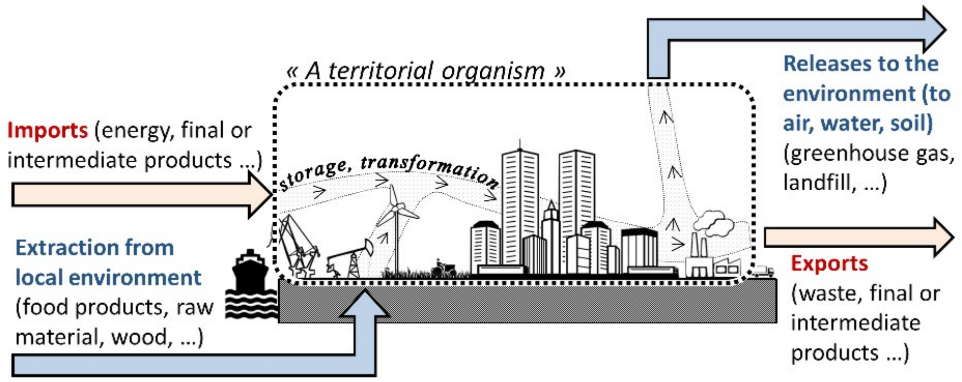


Fig 3.2 Territorial metabolism
Source: Benoit Ribbon

In order to fully understand such complex interactions, which are integrated across various coupled human and natural systems, there is a need for an evaluation and assessment framework. The concept of 'telecoupling' by Liu, et, al defines this as socio-economic and environmental interactions between coupled human and natural systems (Liu et al., 2013). This provides a framework for evaluating the impacts of global trade on environment through ecosystem services, wellbeing, etc. The authors look at such complex global interactions, at the coupled level, by evaluating three interrelated components, which they define as agents, causes and effects across three systems, the sending, receiving and spillover systems (Liu et al., 2013). The agents are the factors that facilitate the telecoupling, causes are the socio-economic and environmental manifestations that generates these systems, and effects are the consequences or impacts of these. For example, in the trade of Cotton between India and the EU, the sender is India, the receiving system is EU and spillover systems could be Bangladesh or China where it is processed. In this example, the cotton and the associated products form the agents, the causes are the need for textile and fashion industries, and the effects are the various socio-economic impacts this trade creates in India, for example water shortage and so on. This helps to form a common language to help integrates various human and natural elements, like land, water, climate, organisms and humans and their interactions over long distances, for example through trade, flows of services etc.

Conclusion

To conclude, the theoretical framework defines a clear framework and approach which can form a conceptual framework for this thesis. This is done by first understanding the concept of urban metabolism and its extension to spatial planning. This is further taken elaborated by challenging the conventional definition of 'urban'. The concept of planetary urbanization and territorial metabolism helps elaborate the problem of globalisation of water to a more territorial spatial planning perspective and define the productive territory which will be understood by metabolic flow analysis. Finally, the productive territory and the virtual water trade will be analysed using the framework of telecoupling, by looking at the three systems that make the framework.

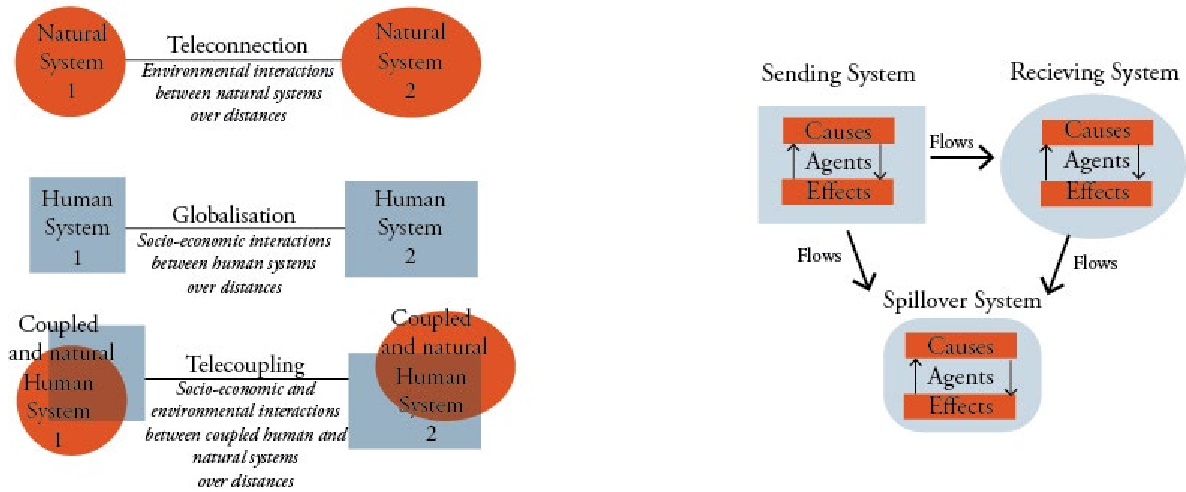


Fig 3.3Telecoupling concept
Source: Liu et al., 2013

3.3 Conceptual Framework

Telecoupled virtual water networks

The current knowledge gaps in the understanding of the interdependencies between socio-economic, spatial and environmental factors of the virtual water trade forms the underlying theme for this thesis. Through this thesis, the main aim is to look at these interdependencies happening in complex global interactions over regional and international boundaries and assess how these has resulted in the specific problem of water stress in India. This is done through the framework of telecoupling, by identifying the sending, receiving, and spill over system in virtual water trade, and the socio-economic, spatial and environment impacts of it in India (sending system) that is currently present. This helps in finding an approach to understand the shortcomings of the current system and possible solutions to change.

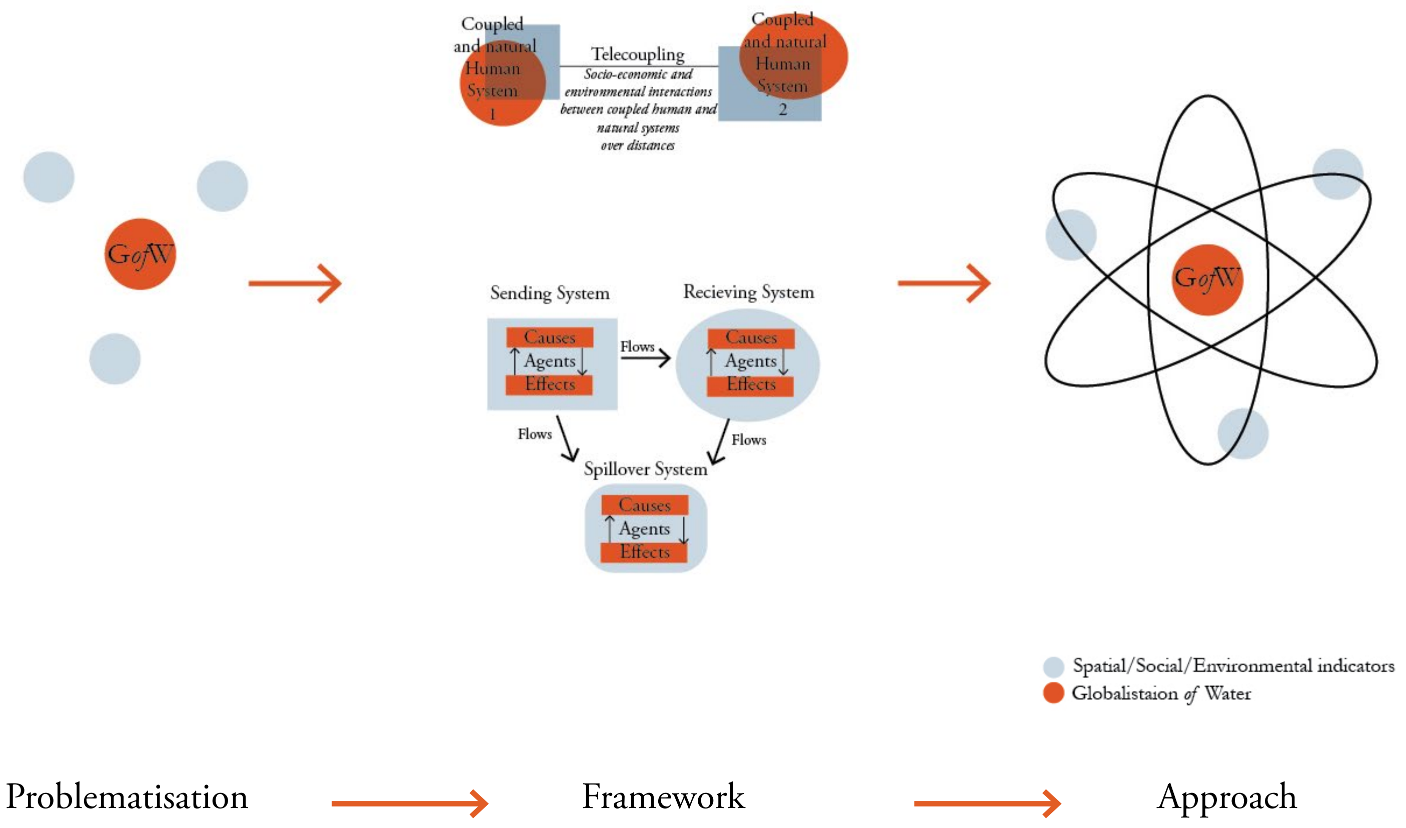


Fig 3.4 Process
Source: by author

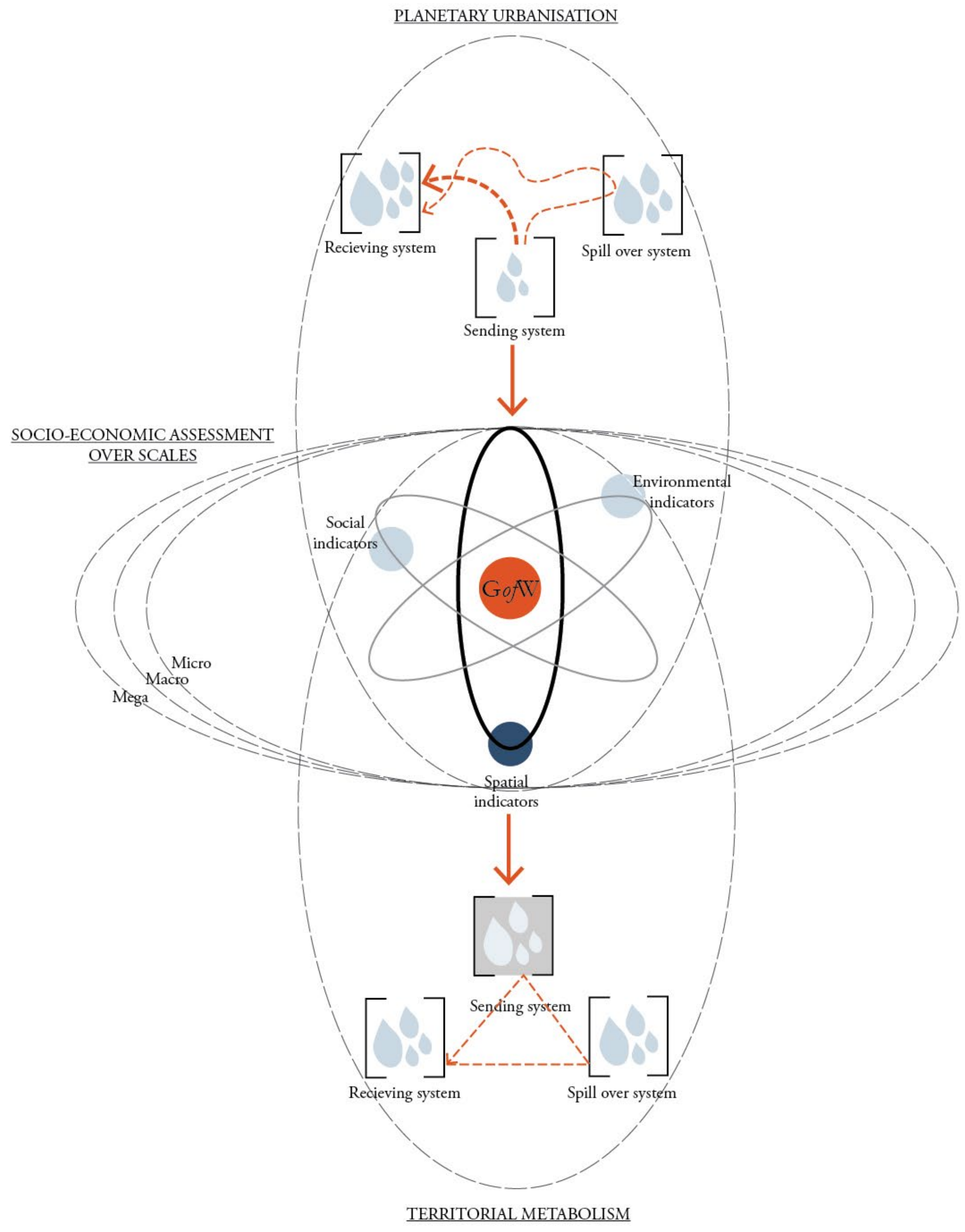
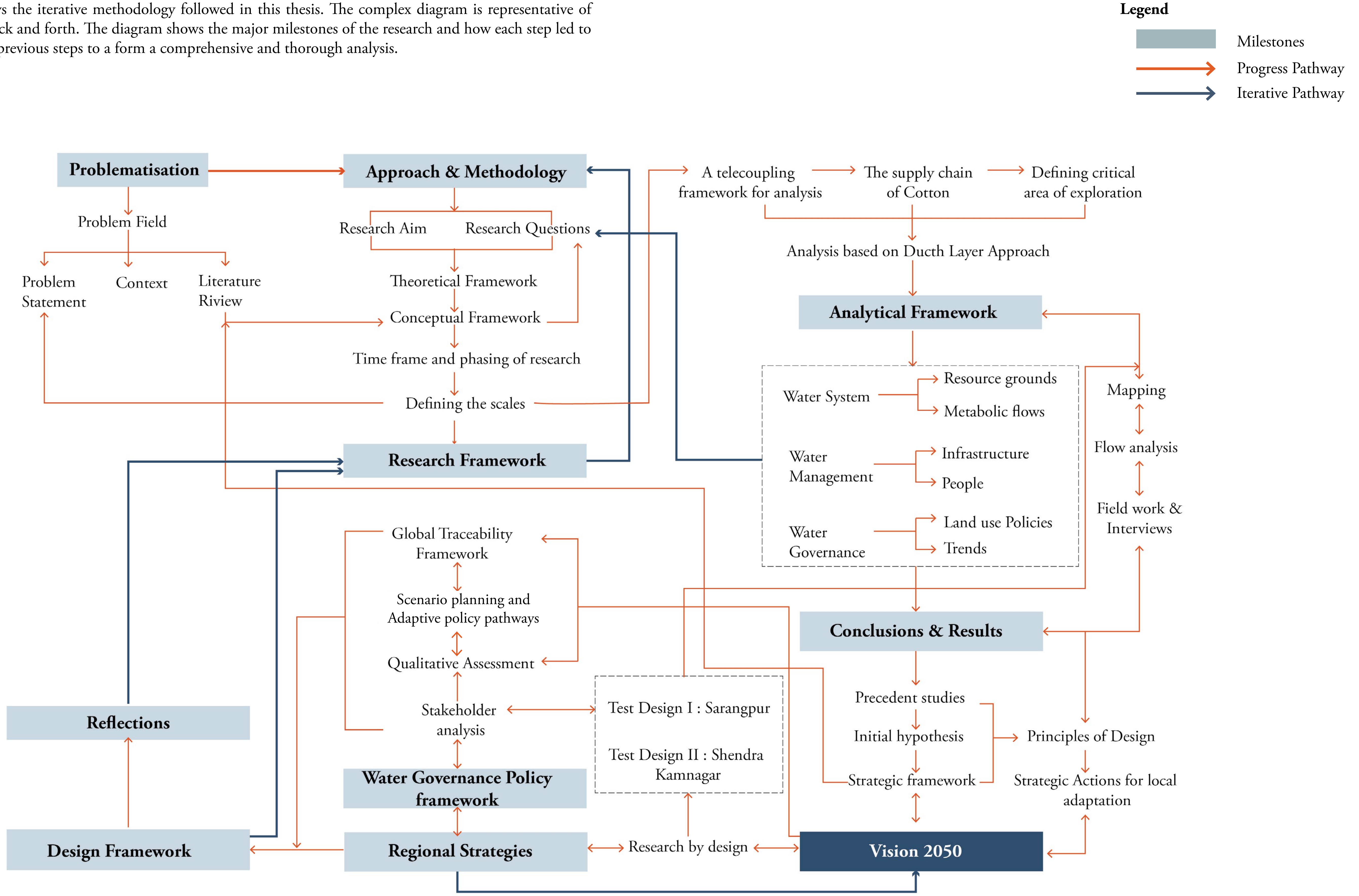


Fig 3.5 Conceptual Framework
Source: by author

3.4 Research Methodology

The diagram shows the iterative methodology followed in this thesis. The complex diagram is representative of processes going back and forth. The diagram shows the major milestones of the research and how each step led to the refinement of previous steps to a form a comprehensive and thorough analysis.



Research Methods

1. Literature review

In his thesis, one of the most important research methods used is the literature review. This step formed crucial from the very start of the project. The literature review helped to formulate the research and to have a clarity in understanding the subject. The literature review was used in two specific areas of research, (1) to guide the conceptual framework and the framework of analysis and (2) to formulate the vision and strategies. This proved to fine tune the research in theoretically sound and empirically proven way and legitimize some of the choices in regard to the principles and overall goals of the research.

Leading up to the conceptual framework, the literature review helped in defining and understanding the problem field and discovering the existing knowledge gap that is persistent with the broader issue of ‘Globalisation of Water’. This step was crucially in framing the research questions and critically analysing the impacts. The various research papers referred for the theoretical framework helped in formulating a method of analysis, namely the telecoupling framework in this case. Furthermore, the literature review has guided the overall research in answering the various research and sub research questions throughout the project as well as formulating the vision and strategies for water resilience. Leading up to the vision, based on water governance literature explained as the “notions” (chapter 6) to guide in framing the principles of design, the vision as well as the strategic framework (chapter 7). These notions are integral part of formulating the water governance policy framework (chapter 8) which looked at the planning process in involving stakeholders from vision to implementation.

2. Dutch Layer approach

The Dutch layer approach is an established method of analysis in spatial planning developed in the Netherlands in 1998. From ‘the layers model’ this was developed into an approach to planning and design known as the ‘Dutch layers approach’. The approach follows three layers, namely the substratum, networks and occupation layer forming a set of priorities and conditions from bottom to top for understanding various tasks of spatial planning (van Schaick & Klaasen, 2011). However, it is important to understand that it is not a ready-made format for design and planning and requires adapting based on the specific context (van Schaick & Klaasen, 2011).

In this thesis, this approach was used in designing the analytical framework (section 5.3, chapter 5) and formulating the various layers of analysis. The approach was adapted and contextualized based on the specific requirements needed to answer the research questions, and to understand the chosen critical region better. This approach was adopted as the project involves combining the different socio-economic, spatial and environmental impacts as a means to understand the issue of water scarcity in the region. Therefore, this approach proved as an important method to simplify and comprehend the different layers and their interrelationships.

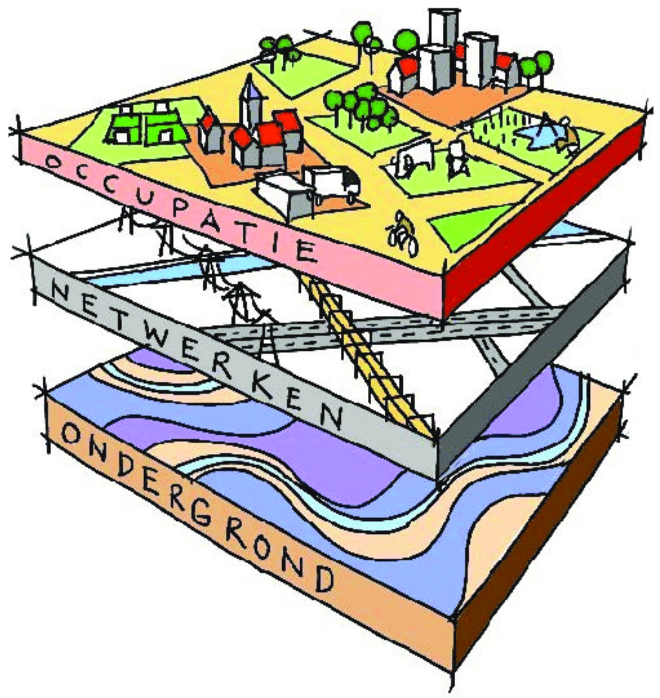


Fig 3.6 Dutch layer approach
Source: Esch, Marjolein. (2015)

3. Fieldwork and Interviews

Through this graduation project, the aim is to understand the consequences of large-scale export oriented agro-industrial landscapes as part of the urbanisation and globalisation and the severe impacts they have on the farming communities in central India. These are producing landscapes on which the supply chain of cotton for consumption in various parts of the world is based upon. However, little is known about these landscapes in remote locations and the impacts this supply chain has on their local resources and everyday livelihood. To fully showcase and research this impacts, it is crucial to experience, document and listen from the farming communities and various local stakeholders themselves to showcase the research in a just way. The issue of water depletion and scarcity is always seen at the local level. So, it is important to look at this issue at the scale where it is most visible. By putting a face to these problems, they become real and relatable. Not just to understand, but to provide with design recommendations and future research, it is vital to hear the plight and needs of these communities and represent them in a clear way. For this reason, the fieldwork to Marathwada, in central India (section 5.6, chapter 5) proved as a useful method.

The fieldwork was conducted over a span of two weeks from 21st January 2020 to 4th February 2020 in collaboration with the local NGO, SOPPECOM, Pune. An extensive fieldwork and interviews were carried out in the upper Godavari basin in Marathwada region, Central India. The fieldwork involved visiting the cotton producing and manufacturing villages in proximity such as Gangapur, Aurangabad, Beed and Parli in the state of Maharashtra, India and interacting with various stakeholders in the region. The outcomes from the fieldwork proved to be an inevitable part for the research and framing the vision and strategies for the region as explained in Chapter 6.

Fig 3.7 Interviews with farmers
Source: Photograph by Author

Fig 3.8 Interviews with farm labourers in Marathwada, January 2020
Source: Photograph by Anitha P

4. Precedent studies

Precedent studies can be defined as, ‘something done or said that can be used as an exemplary case study to justify a similar kind to carry out a subsequent act’ according to Merriam Webster dictionary. In this thesis, there were several precedents that were studies to analyse and formulate the vision and design strategies as well as while testing the case (Chapter 6 and 7). The proved as inspiration to innovate as well as understand the works that were already done before. These helped in fine tuning the project concept and coming up with real world solutions and thought-provoking ideas. These also formed as a justification in adopting some strategies over the other based on the exemplary cases. This provided a certain degree of truth to the strategies that were formulated and an easier way to explain as well as communicate some of the relevant ideas.

The relevant precedents used in the thesis are mentioned and elaborated in section 6.2 (Chapter 6). Some of the relevant examples used were the Israeli water management and conservation systems, Water boards and governance framework from the Netherlands, European Unions water directive framework, exemplary self-help group and organizational models such as Kudumbasree from Kerala State, India and various locally adapted methods and indigenous faring practices and irrigation techniques.

5. Research by Design

Research by Design can be defined as both a process of studying as well as designing through the act of design, that is used as an essential approach in understanding complex environmental and social problems (Roggema, 2016). It can be explained as a form of inquiry that forms the backbone of the design process as well as strategies for development. In this kind of research, the strategies which are at the macro level (such as regional) can be informed based on the micro scale contexts and specific challenges that come into being during he process of design. Therefore, even though the results or the design outcomes are highly contextual there is an inherent transferability in term so of the processes and underlying challenges experienced. Hence, this can lead to a discourse that is accessible and useful in other such situations and projects. The rationalisation of the overall research happens through the process of design and the act of designing. So, there is a direct relationship between the analyses and inferences as well as the proposals for future scenarios. This is a kind of experimental practice which has can link multiple issues and complexities.

An extension of this form of design is also used while formulating the policy pathways and imagining the different scenarios for future. As a result, they also take into consideration the various externalities that may arise in the real world. However, the method should be altered and adapted in practice. Through the design of the test cases an elaboration of the methods is given which can be used as a uniform approach in practice and can be adapted based on the context (Roggema, 2016). Therefore, it also gives a flexibility in terms of defining the strategies at the different scales.

6. Scenario planning and Dynamic Adaptation Policy Pathways (DAPP)

Traditional methods of planning look at various design outcomes based on the expected or most probable future. However, with changing climate and more uncertain futures, it is important to challenge the traditional by thinking radical. In a world were ‘extremes are termed as the new normal’, it is important to that we as planners and designers look for conventional strategies of mitigation as they are merely looking at the current problem in hand. However, with complex problems in a coupled human and natural systems, it is inevitable that we look at approaches that pushes the boundaries of current imagination in order to at least have a chance at an acceptable future. Therefore, scenario planning becomes a crucial framework to assess and imagine changes for an uncertain future. Bohensky et al., defines scenario planning as ‘a set of plausible not probable narratives that has the ability to depict alternative pathways to the future’ (Bohensky, Reyers, & Van Jaarsveld, 2006). It is important to understand the difference between plausible and probable, as probable might not be what is describable or necessary. Not just that scenarios also help in simplifying the complexities as a number of possible states or outcomes (Schoemaker, 1995).

The accuracy of a future plan is affected by various uncertainties due to the dynamic changes, inherent randomness, non-linearity etc. The challenge is to develop a plan that would be successful in providing outcomes for a various plausible scenario, and dynamically adapt over time. The concept of ‘transient scenarios’ talks about unfolding various scenarios and their dynamic adaptation over time (Haasnoot et al., 2013). Therefore a new paradigm to create strategic vision for the future was proposed by Haasnoot et al., known as ‘Dynamic Adaptive Policy Pathways’ (DAPP) (Haasnoot et al., 2013). The DAPP approach identifies two main principles for planning under uncertainty, adaptive policymaking as well as establishing tipping points (Kwakkel, Haasnoot, & Walker, 2015). In DAPP a plan is conceptualized over time as a series of actions, and the action adapts as it reaches tipping point when it is no longer able to meet its requirements (Kwakkel et al., 2015). The DAPP approach allows the scenarios established to go through adaptive pathways and finally result in the most probable outcomes for each of these scenarios and assess their robustness.

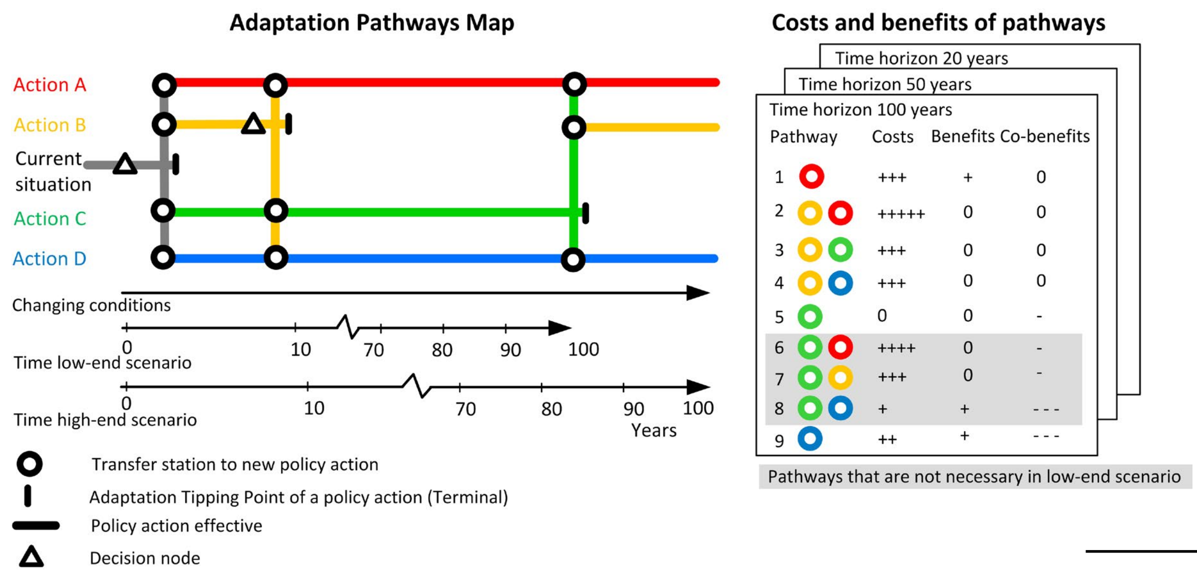


Fig 3.9 Dynamic Adaptive Policy Pathways’ (DAPP)
Source: Haasnoot et al., 2013

Time frame and phasing of the research

The time frame and phasing of the research is based on the deliverables required for each evaluation point (P1-P5). The phasing follows the problem statements and defining the approach till P1. Refining the methodology and framework and initial analysis leading to conclusions were between P1 and P2. Fieldwork, analysis and working towards a vision till P3. Elaborating the vision, strategies, policy framework, test design cases, scenarios and pathways was scheduled between P3 and P4. The period from P4 to P5 will be used for evaluation of the pathways, critical reflection and refining of the overall thesis.

The entire research was an iterative process going back and forth between research, design and reflections at several stages.

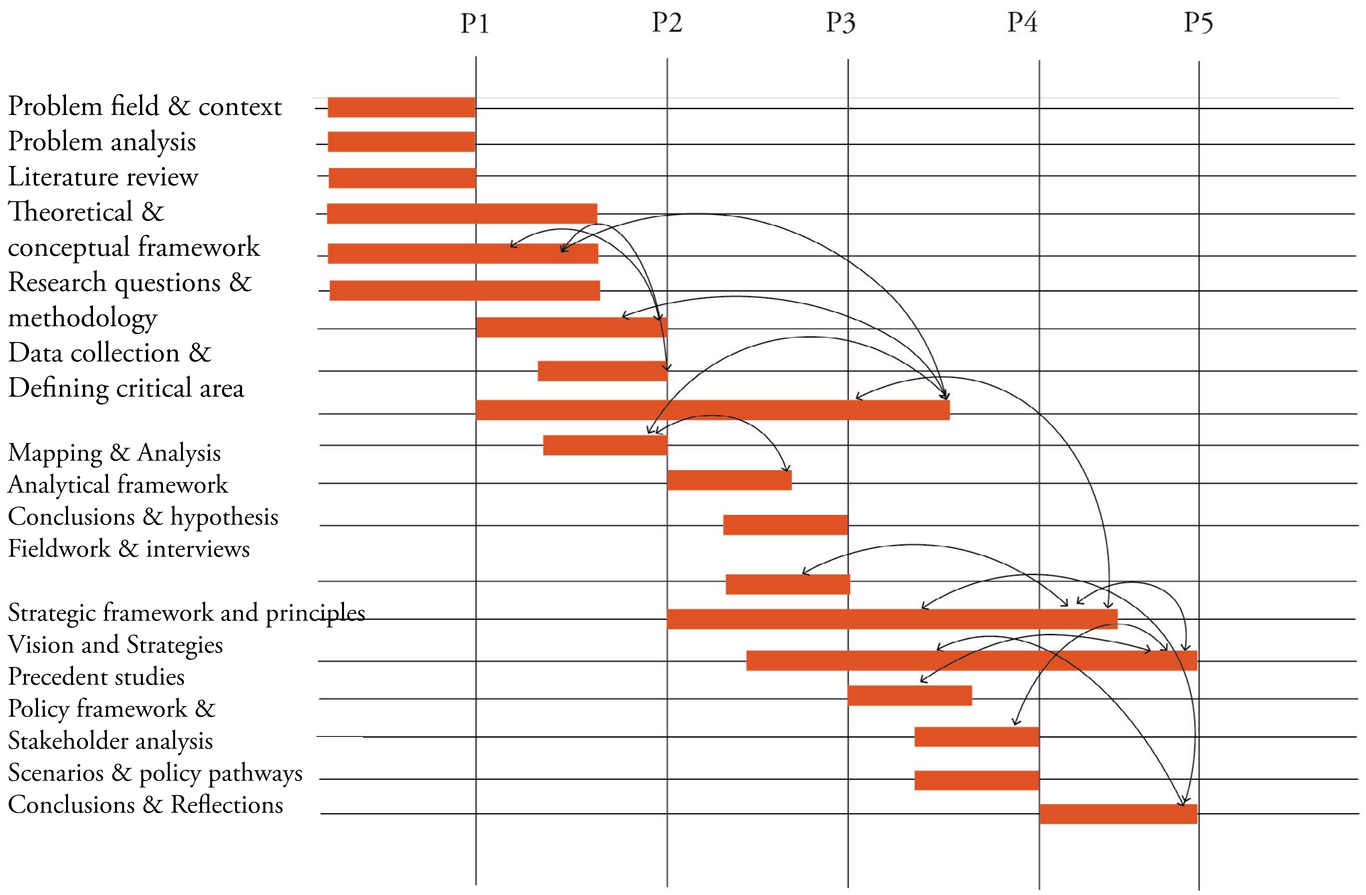


Fig 3.10 Timeline
Source: by author

Defining the scales

This project, looks at the integration of scales from the macro level(national/global) to the micro level(regional/local). This is done using the telecoupling framework, which provides a framework for analysis on the basis of sending, receiving and spillover systems. This thesis will mainly focus on the sending system, which will be defined in the coming chapters. The scale of analysis will move from national, to regional to local to provide strategies that are integrating all the scales and looking at the problem from a global perspective.

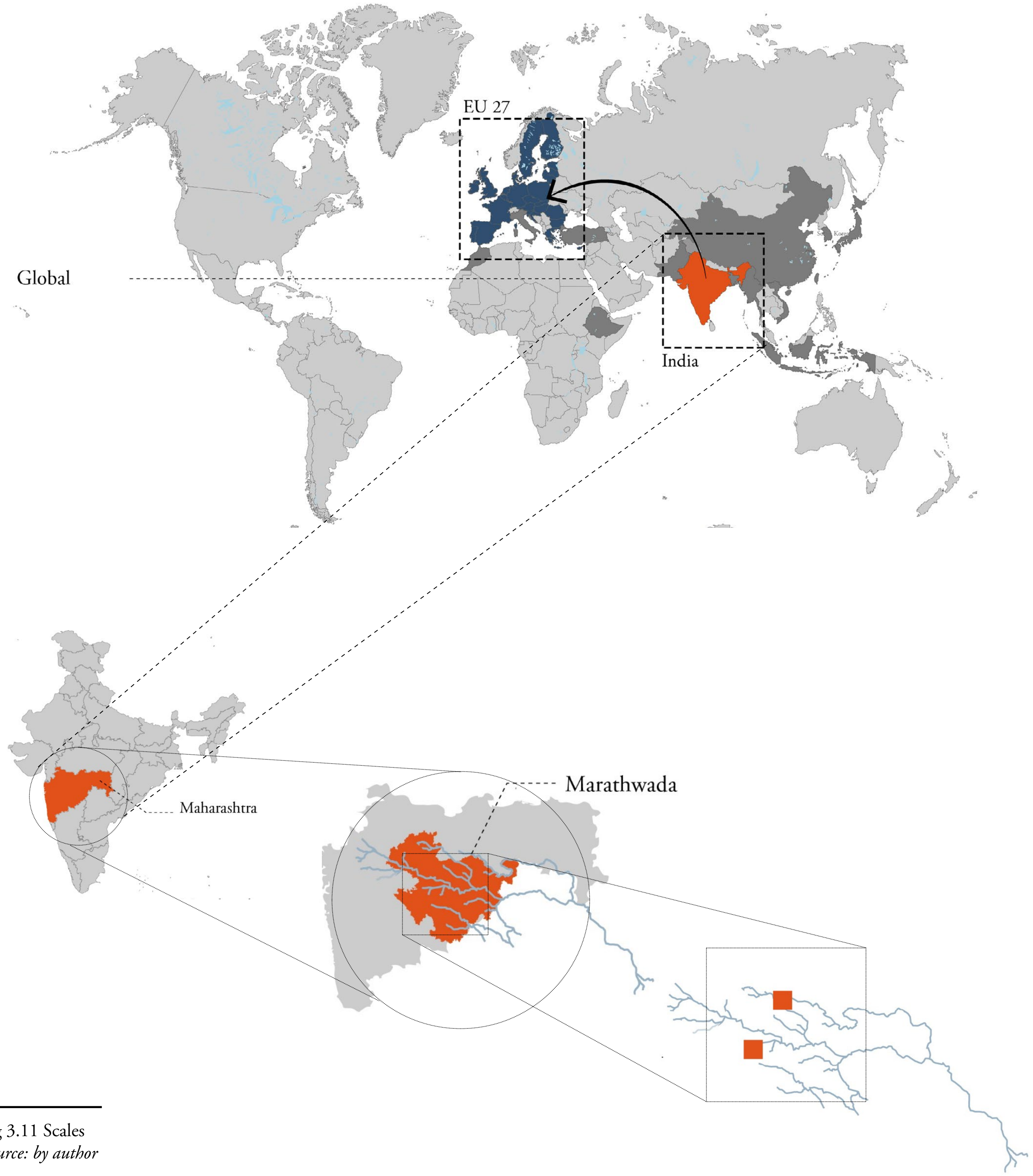
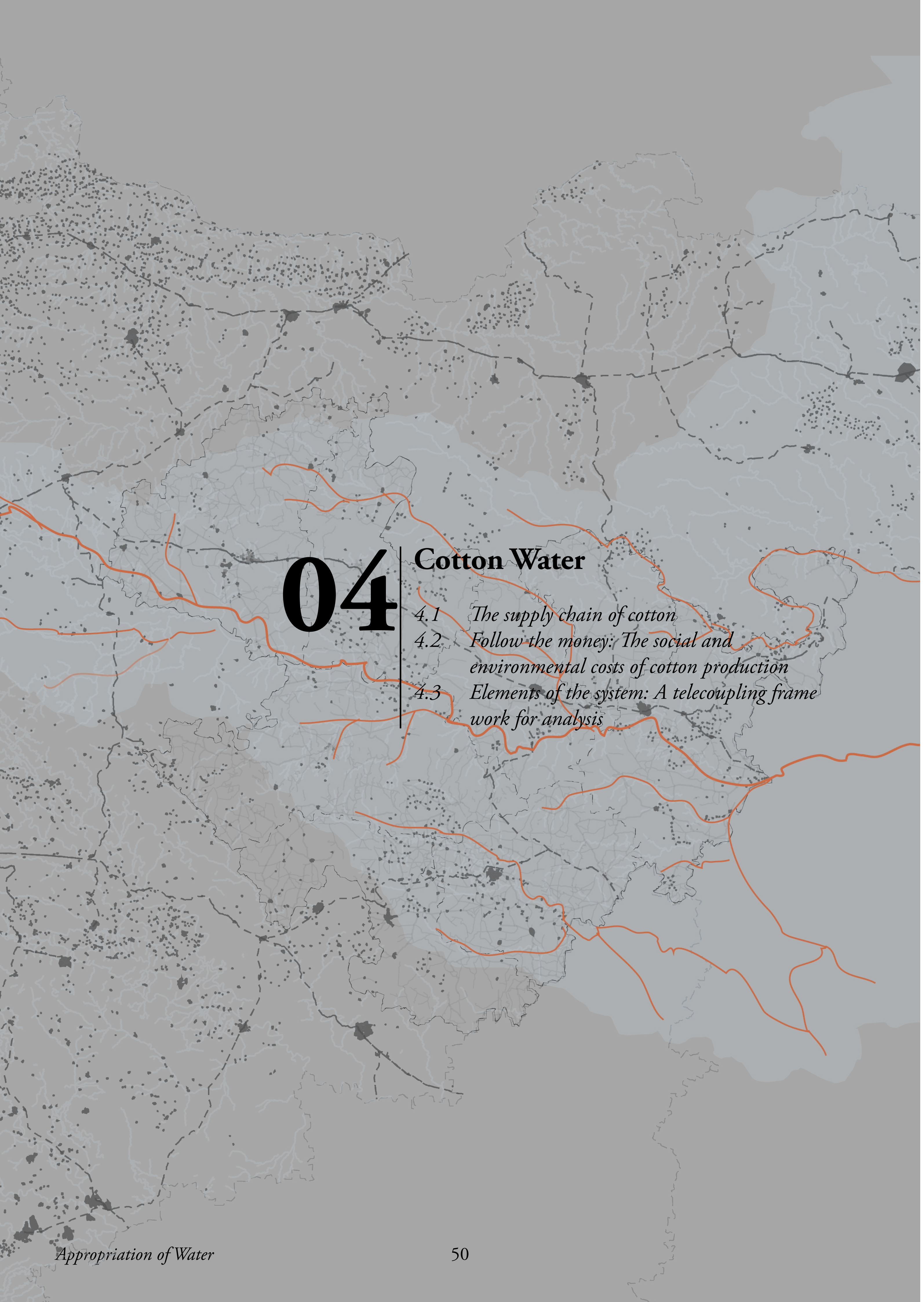


Fig 3.11 Scales
Source: by author

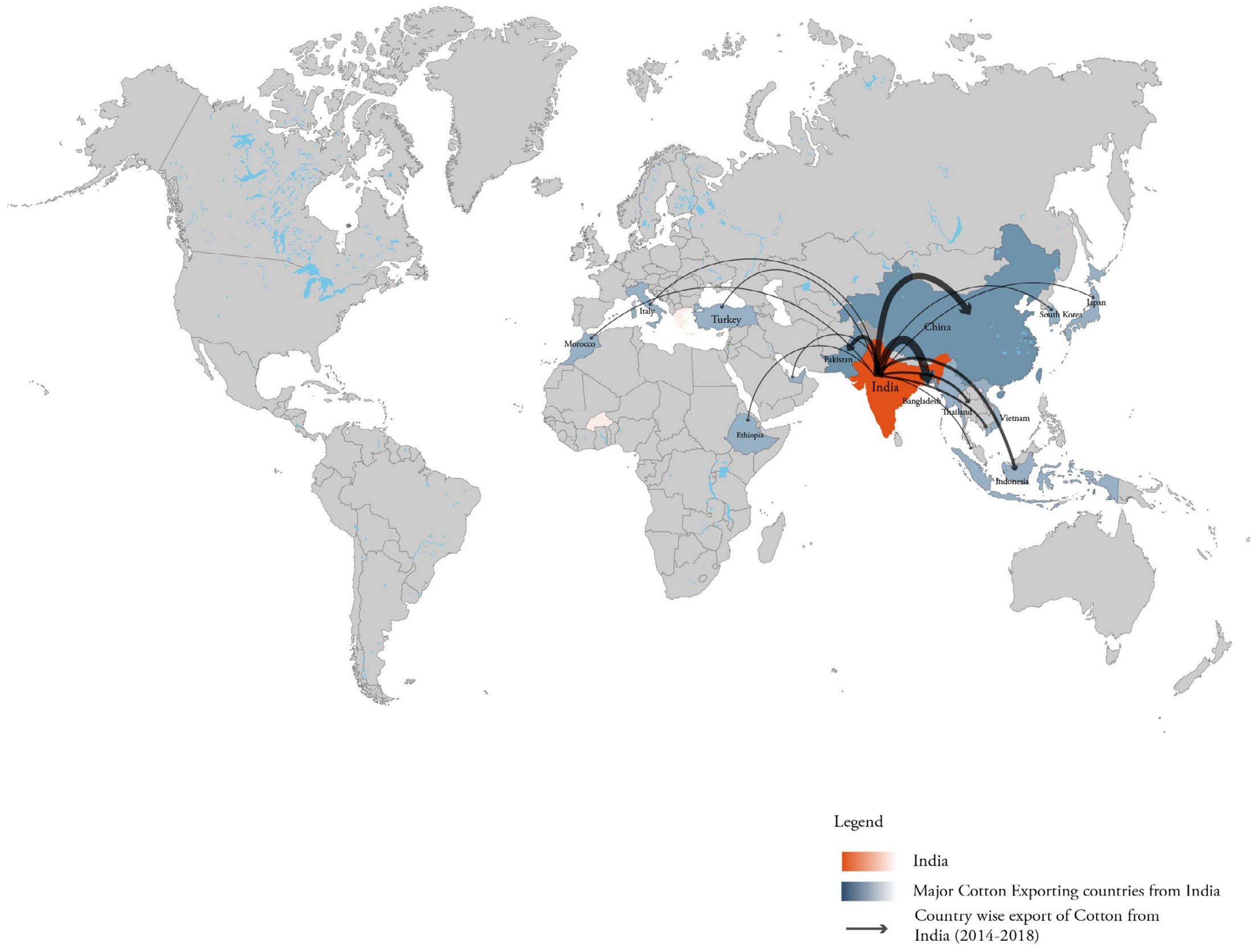


04 Cotton Water

4.1 The Supply chain of cotton

Export of cotton from India

India exports about 5.2 million bales of Cotton every year and is expected to increase by 20%. India mainly exports its cotton to neighbouring countries, Bangladesh, China and Pakistan. Asian suppliers generate the highest portion of worldwide cotton exports at almost two-thirds (64.5%) of the global total of which India is the biggest producer. Indian cotton exports are at $8.1 million dollars and accounted to about 13.7% of global exports (//https//www.worldexports.com, 2018).

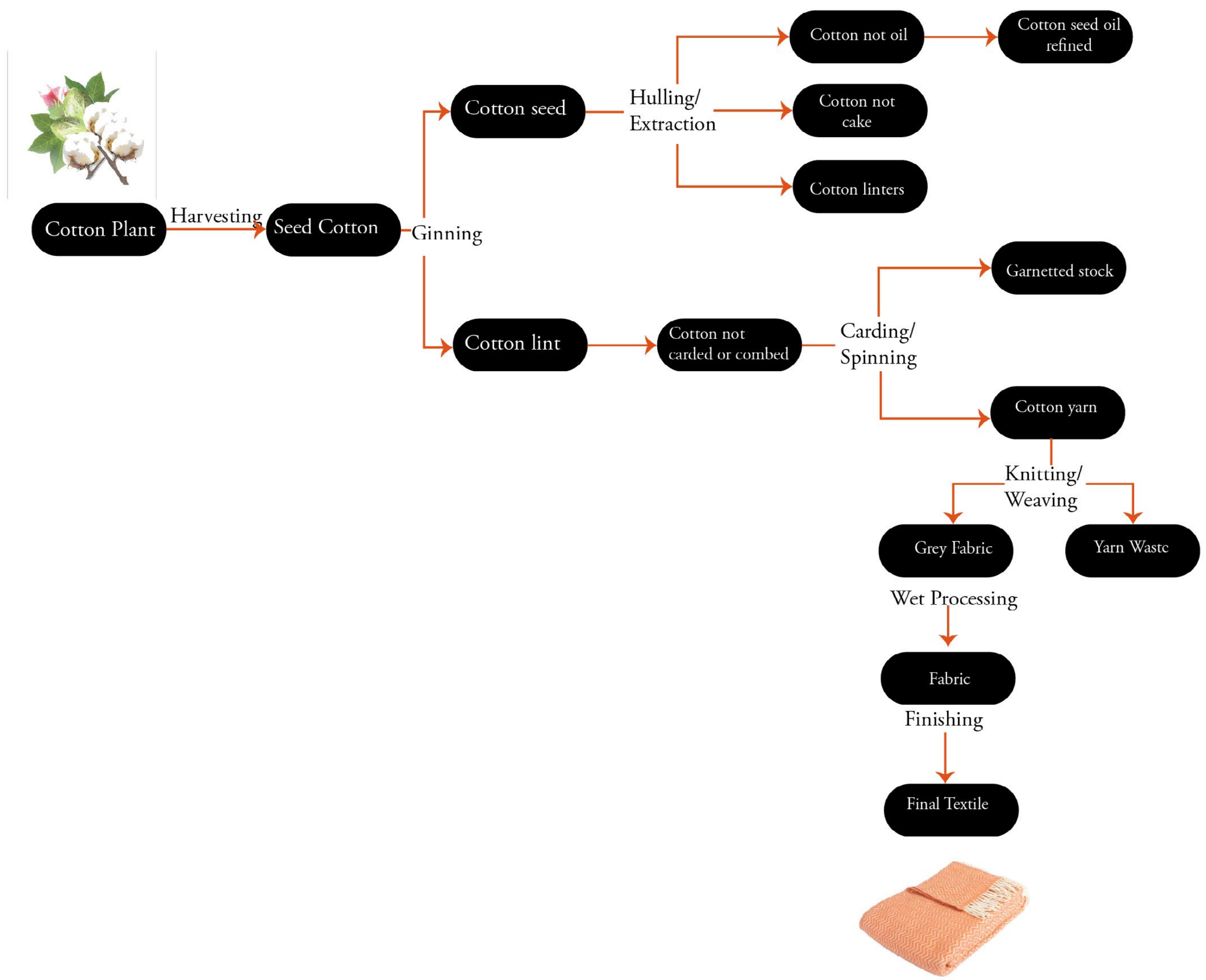


Source : http://sff.arts.ac.uk, https://www.statista.com, Ministry of Textiles, Govt of India.

Fig 4.1 Countries that India exports cotton
Source: Map by author

Product tree of cotton

Cotton product tree shows process of material flow from the cotton plant to finished products like textile which is again used to produce clothing. To be able to analyse the supply chain, the product tree of cotton till textile is only considered in this study. From the cotton plant which is harvested the main two forms of cotton obtained are cotton seed and cotton lint. Cotton seed goes on to produce seed oil etc, and the lint is used to produce yarn which forms into fabric. Throughout the harvesting and supply chain there is exploitation of water resources as blue, green and grey water as explained in the previous chapter.



Source : Chapagain, Hoekstra et. al, 2006

Fig 4.2 Product tree of Cotton
Source: Map by author

Trade of textile and textile products from EU

Considering how EU is the biggest contributor to the cotton water footprint in India, it is important to understand the elements of the system involved. As seen clearly from fig 5.1, India does not directly export raw cotton to EU but rather goes through the chain of export of raw cotton to countries like Bangladesh, China and Pakistan where the cotton lint is processed into yarn and textiles. This is them imported by the EU in the form of textile and textile products. The EU then processed them into various forms of textiles as well as clothing and re-exports it to other countries mainly the U.S. Therefore, the flow of water from India to the EU is a multi fold process.

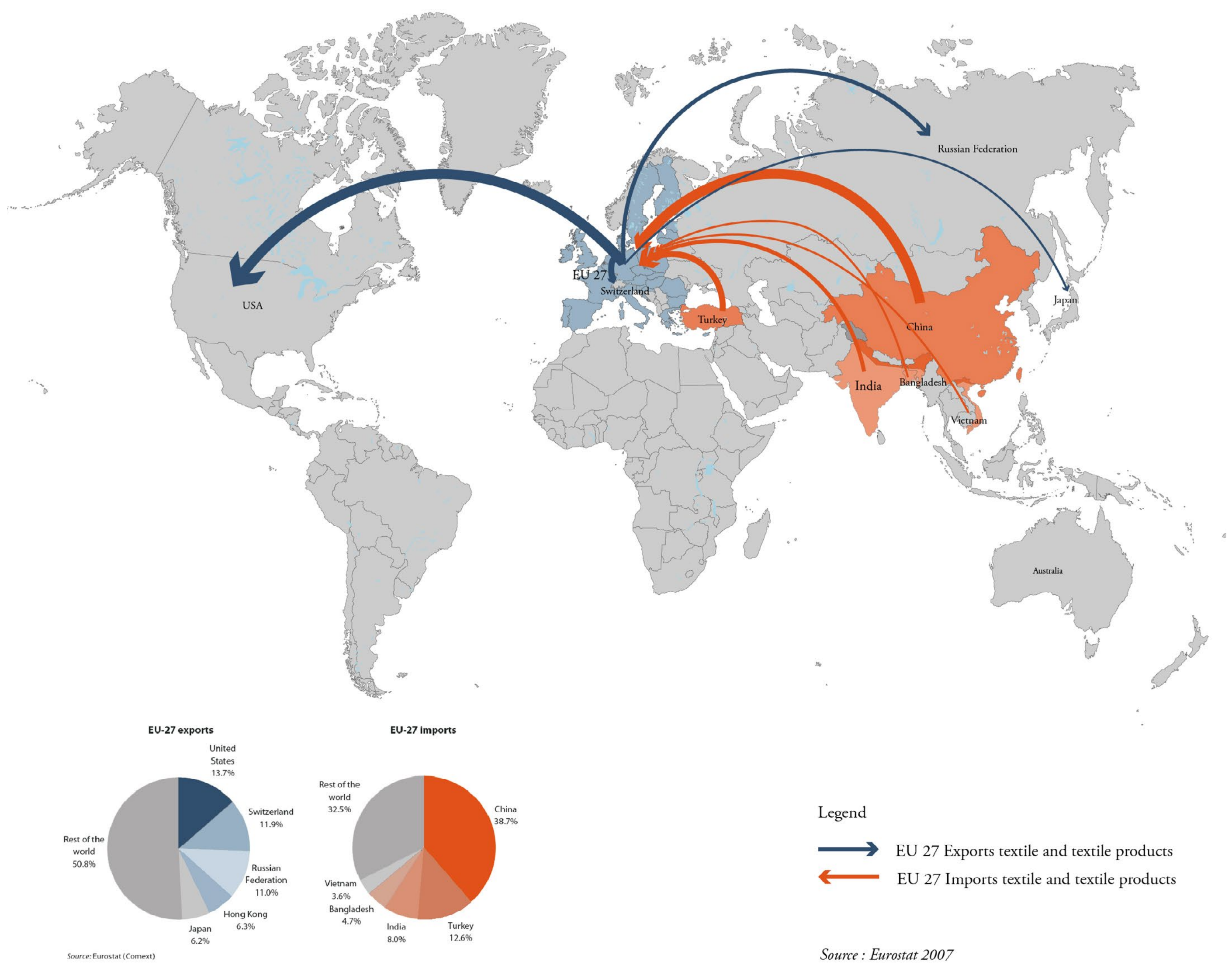


Fig 4.3 Export and Import of textile and textile products from EU 27
Source: Map by author

4.2 Follow the money - Economic impacts

The social and environmental costs of cotton production

Cultivation of conventional cotton India has a lot of negative externalities most of which is related to the water use, water pollution and income of farmers. The highest is in the water use(35%), most of which is related to the irrigation requirement s of cotton crop. With decrease in water availability due to increased production over the years has resulted in water scarcity, which in turn increases the cost of production. Therefore water use becomes the highest environmental cost in cotton cultivation. The second is related to water pollution (17%). Most farmers in India use N and P synthetic fertilizers. As the yield becomes lower due to rainfall variations and other climatic factors, the fertilizer use as well as costs also increase to keep up the production. The fertilizers result in subsequent runoff into the surface water as well as ground water, which negatively impacts the quality of water available for drinking and marine life. The third highest cost is related to the income of framers (12%).Most of the farmers do not own the land and are hence underpaid by the landowners or traders. As the crop yield decreases, this also decreases the income from the fields which prompt them to take heavy interest loans from banks and loan sharks which also puts pressure on the farmers (True price of Cotton from India, 2016).

Cotton cultivation in India uses 1,800 m3/ ha of water on an average. But the availability of water is seasonal and dependent on rains. So, there is about 8-10 months when many regions experience water shortages. It also varies from regions with some regions needing more water for irrigation than rain fed regions. But many places still depend heavily on the monsoon for their yields. Due to climate variations,recently the yields have decreased in many places due to rainfall deficits.

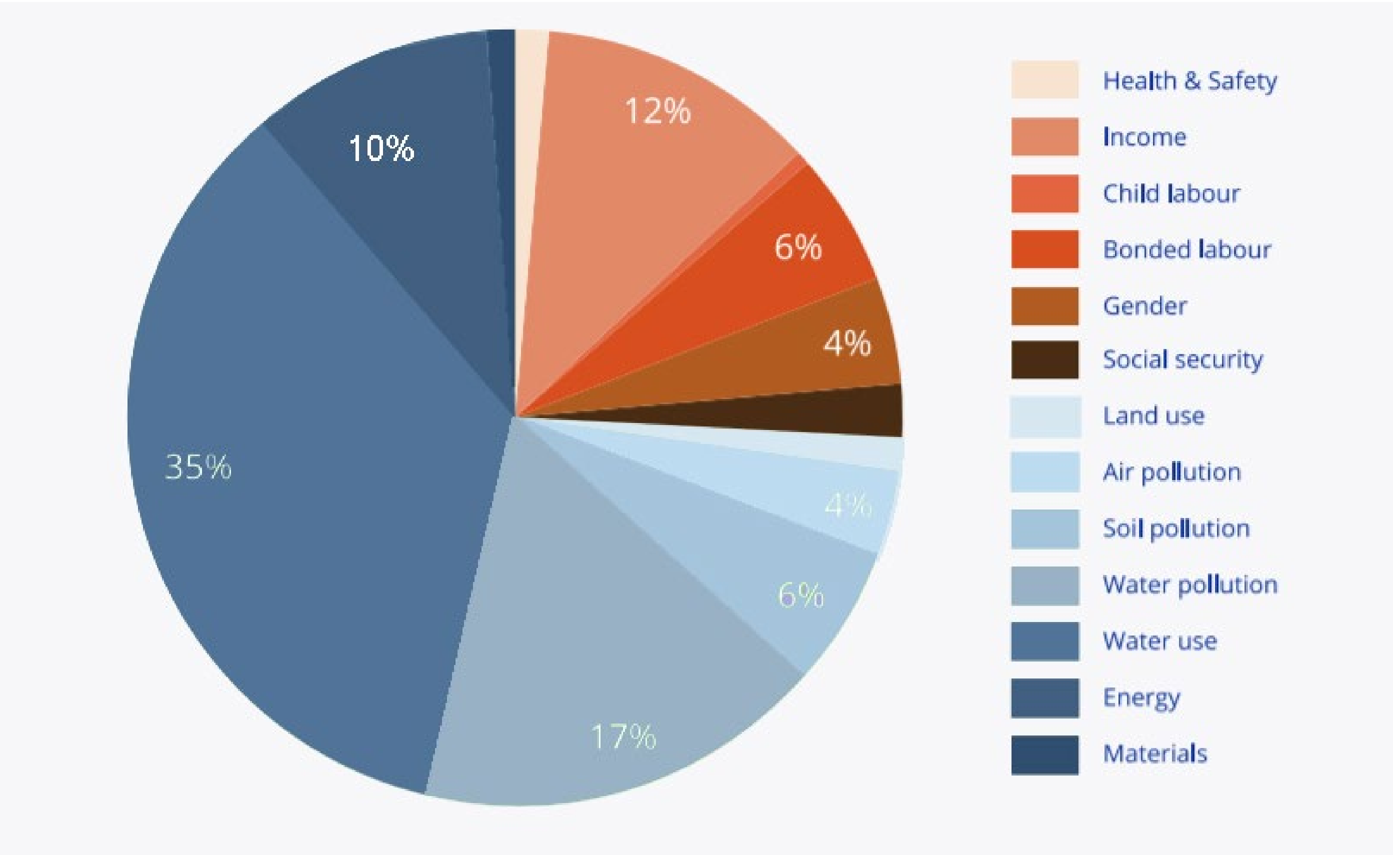


Fig 4.4 Share of each externalities in the total external costs of cultivation
Source: https://trueprice.org/the-true-price-of-cotton-from-india/

True price of Cotton

In the cotton production in India the major costs are due to to environmental costs almost 74% and out of this the major share is the water costs. 34%. Organic or certified cotton is much more profitable that way than conventional cotton as the environmental costs will be significantly lower, however the yields will be much less. The total external costs in the cultivation is cotton is €3.65/kg for seed cotton. By adding the external costs as well, the true price will be at €4.20/kg for seed cotton. Interventions to save water can significant impacts and can reduce the costs by over 50% (retrieved from http//www.trueprice.org).

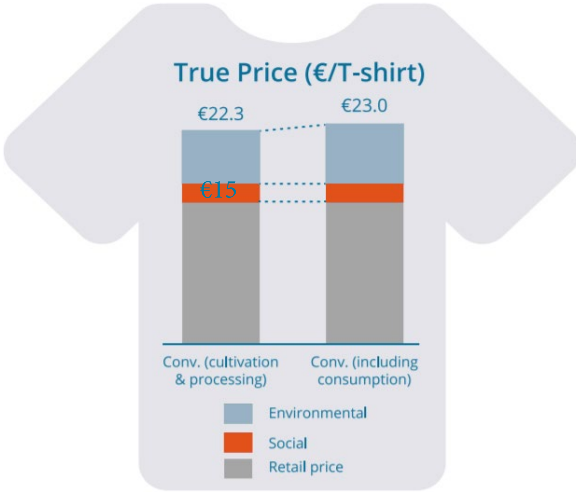
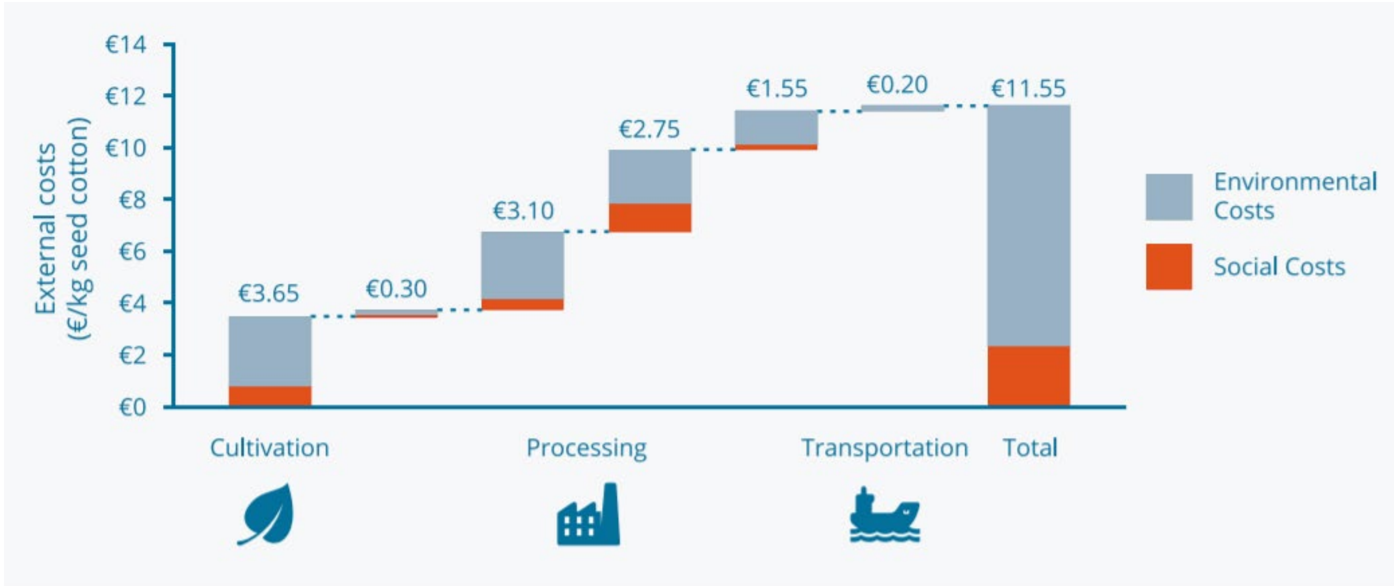


Fig 4.5 True price of Cotton T-shirt
Source: https://trueprice.org/the-true-price-of-cotton-from-india/



At present, the EU price for a cotton T- shirt does not include the water costs. If we add additional environmental costs, the price increases by €8 for one T-shirt.

Fig 4.6 Division of external costs over the cotton supply chain
Source: https://trueprice.org/the-true-price-of-cotton-from-india/

Fig 4.7 The two ends of the spectrum
Source: Image 1: Wall street journal(https://www.wsj.com/articles/retailers-push-early-start-to-black-friday-sales-1479992401)
Image 2: Livemint.com

4.3 Elements of the System

Telecoupling framework for analysis

The elements of the system are defined using the telecoupling framework. This forms the basis of further analysis and classifications. The three main elements are the sending system which is India, the receiving system which is EU and the spillover system, the countries that trade and transport cotton from India to EU. The agent here is 'cotton'. The flows can be defined as the metabolic processes involved in the production of raw cotton and the export of this from India to outside countries and the subsequent virtual water trade associated with this.

The two end of the spectrum will be analysed in order to understand the functioning of the current system and the subsequent reconfiguration in order to achieve a more balanced and just form of supply chain of cotton and a sustainable water footprint in the water scarce regions of the sending system. In order to have a clear picture of the spatial impacts associated the sending system will be analysed in depth over scales and in detail.

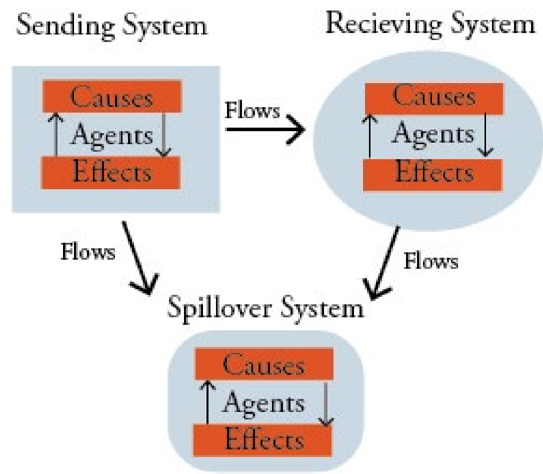


Fig 4.8 Telecoupling framework
Source: by author based on Liu et al., 2013

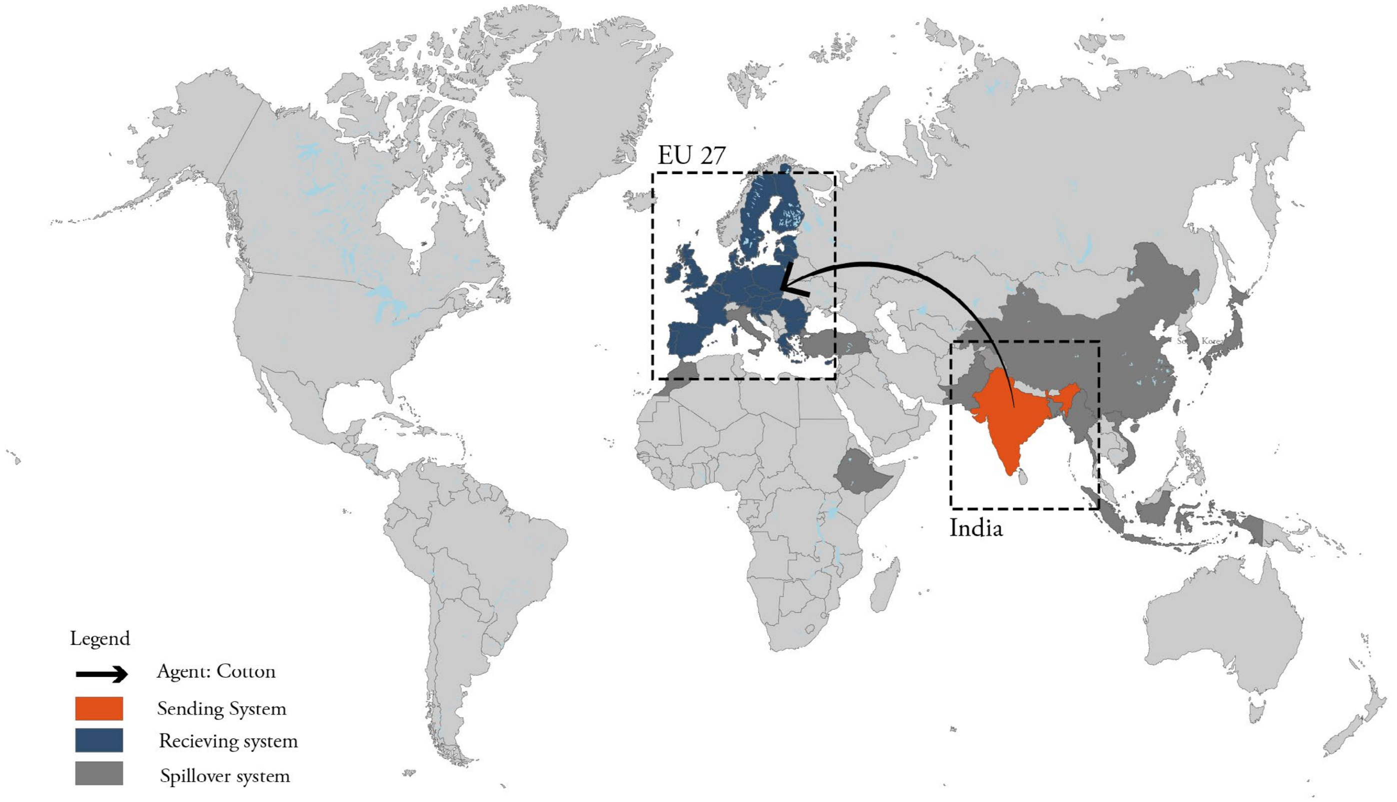
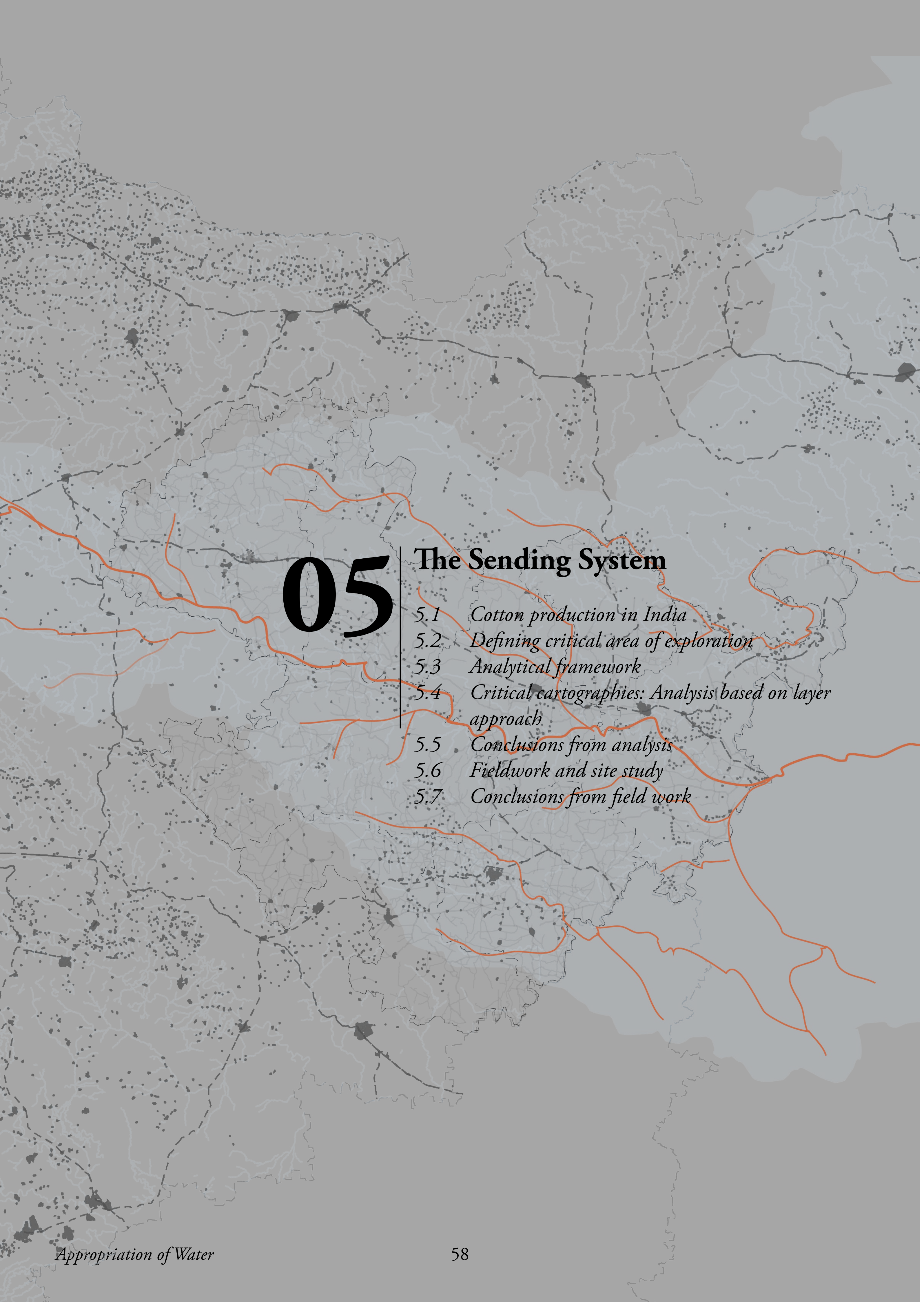


Fig 4.9 Sending and receiving system
Source: by author



05 The Sending System

5.1 Cotton production in India

Cotton belt: Western and Central India

In India, the major cotton producing areas are classified into three regions, north, central and south. The central zone comprising of Gujarat, Maharashtra and Madhya Pradesh together produces more than 50% of the total cotton. However, most of this region is dependent on rains for water availability. However, due to extreme droughts and water scarcity most of the central zone now requires to be irrigated using surface water sources for the production of cotton. This puts extreme pressure on the availability of water resources in the areas for consumption and daily use.

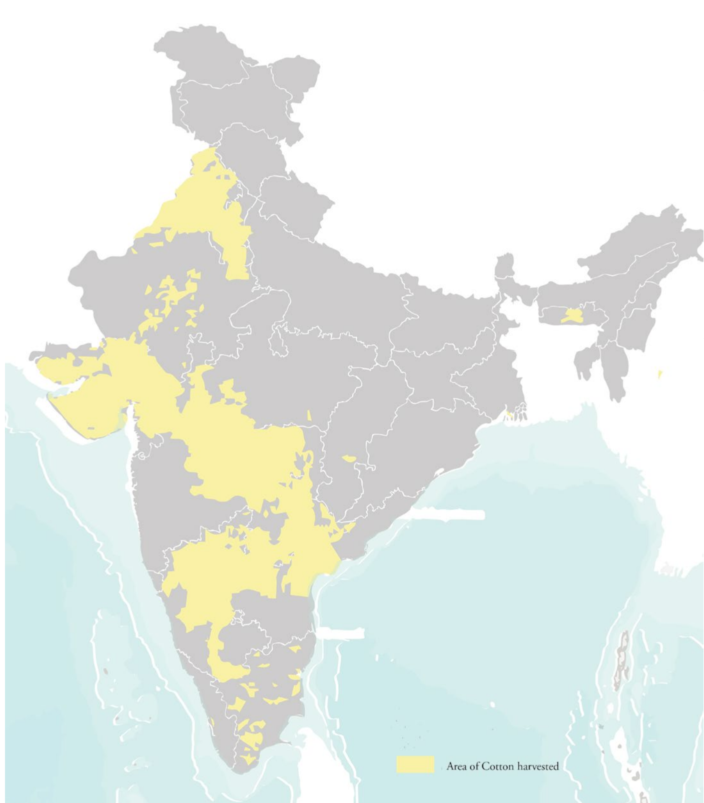


Fig 5.1 Cotton producing areas in India
Source: Pahloe et, al. 2015

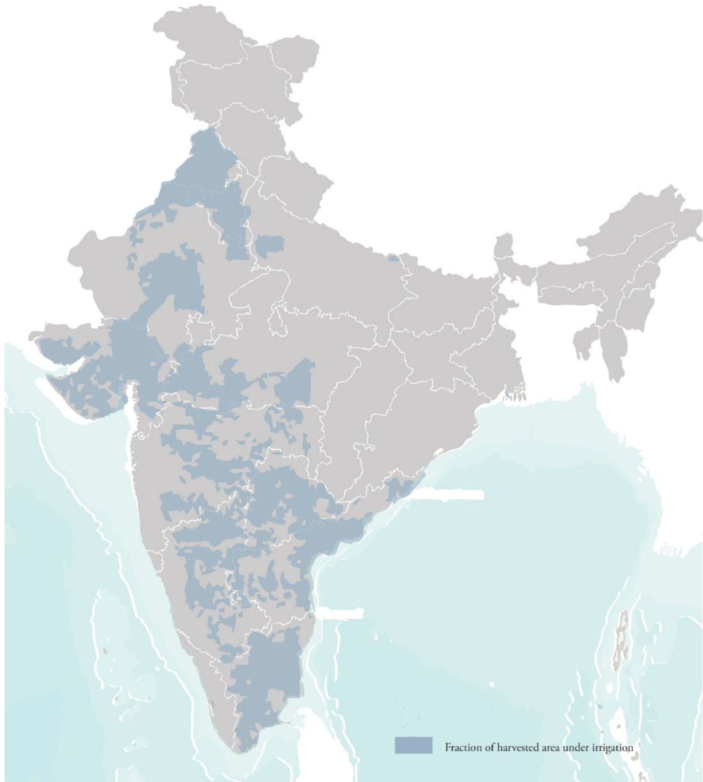


Fig 5.2 Areas under irrigation for cotton in India
Source: Pahloe et, al. 2015

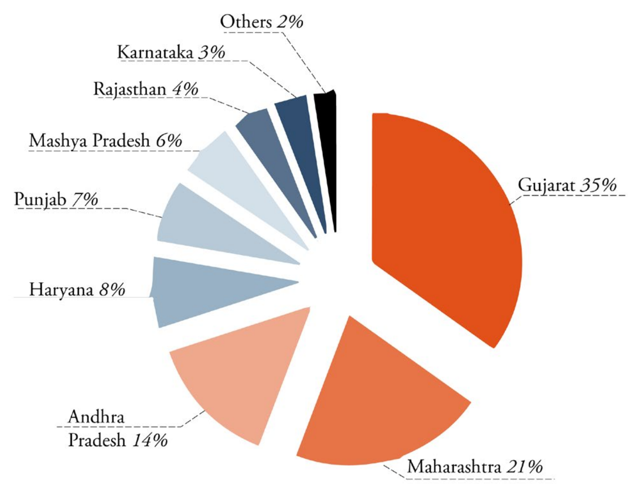


Fig 5.3 Percentage distribution of production in various states
Source: Ministry of agriculture, GOI

Socio-environmental effects

Fig 5.4 shows the areas experiencing extreme to severe drought conditions in India (South Asia drought monitor). From the image it can be clearly seen that the central India experiences the most severe drought conditions. It can be assumed that these areas will therefore have lower agriculture yields. Looking at the areas with high farmer suicides, we can see that Maharashtra has the highest number. Therefore, it can be concluded that the Maharashtra belt experiences the worst effects of extreme weather conditions and has the highest environmental and social impacts.

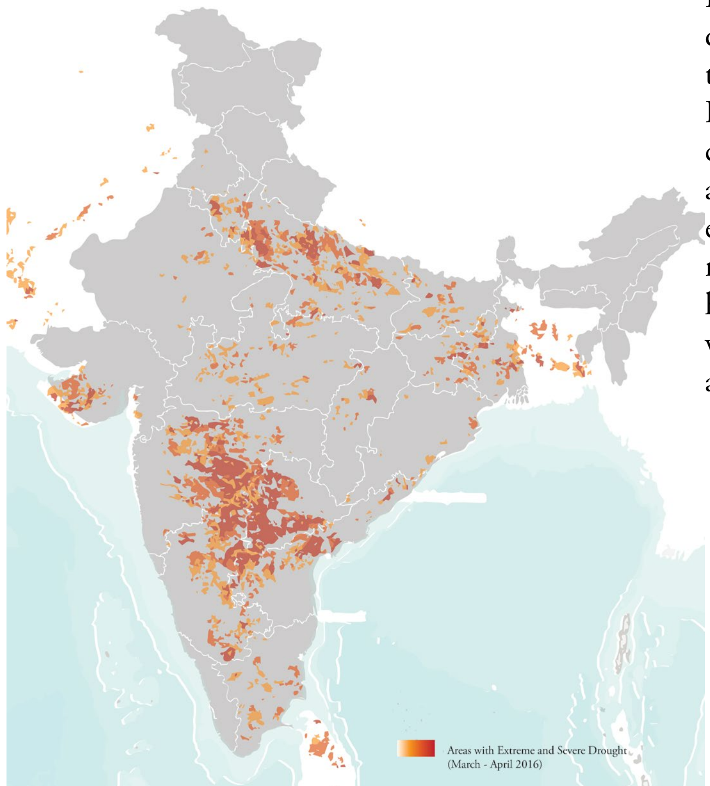


Fig 5.4 Areas with extreme to severe drought
Source: South Asia drought monitor

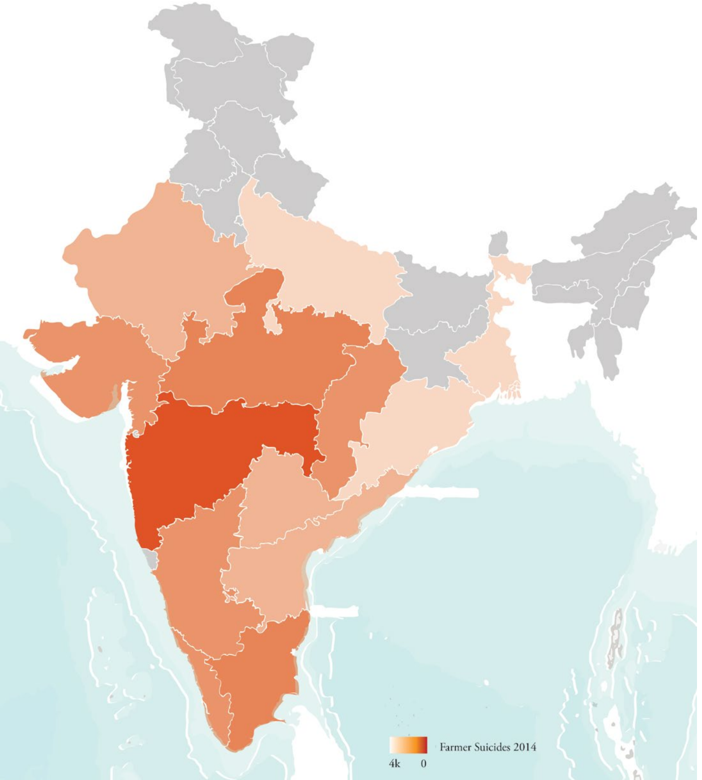


Fig 5.5 Farmer Suicides according to state
Source: http://www.ncrb.gov.in

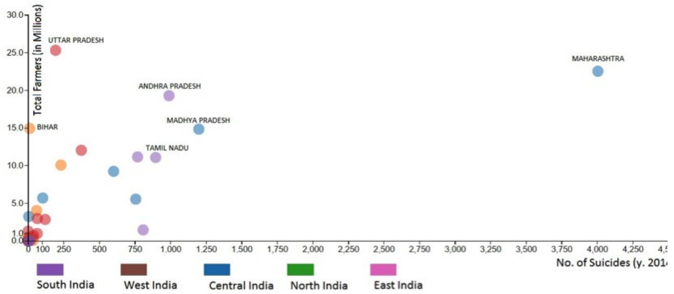


Fig 5.6 Farmer Suicides
Source: http://www.ncrb.gov.in

Conclusion by overlaying the layers to define the area of interest

By combining the social, environmental and spatial impacts, environmental : extreme drought and scarcity, spatial : highest cotton production under irrigation, we can see that the Maharashtra has the highest effects of water issues in relation to cotton production. In addition to these the area has also seen an increased incidents of cotton farmers suicides. This makes this region a vulnerable case for extreme pressures. As a result, the Maharashtra state forms an interesting and relevant case to look at more in depth for this thesis to really understand the perspective from the sending system.

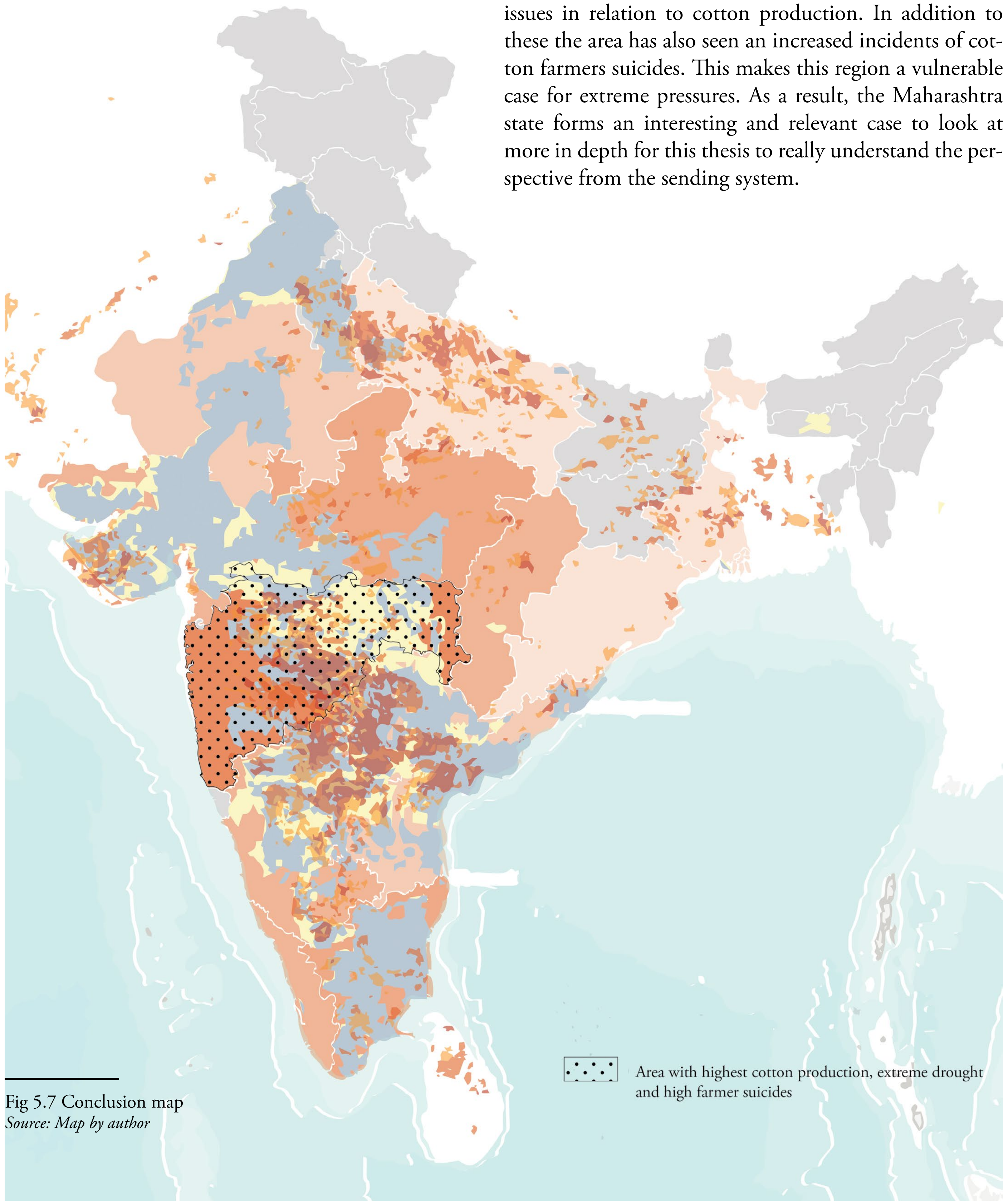


Fig 5.7 Conclusion map
Source: Map by author

5.2 Defining critical area of exploration

Administrative units of Maharashtra state

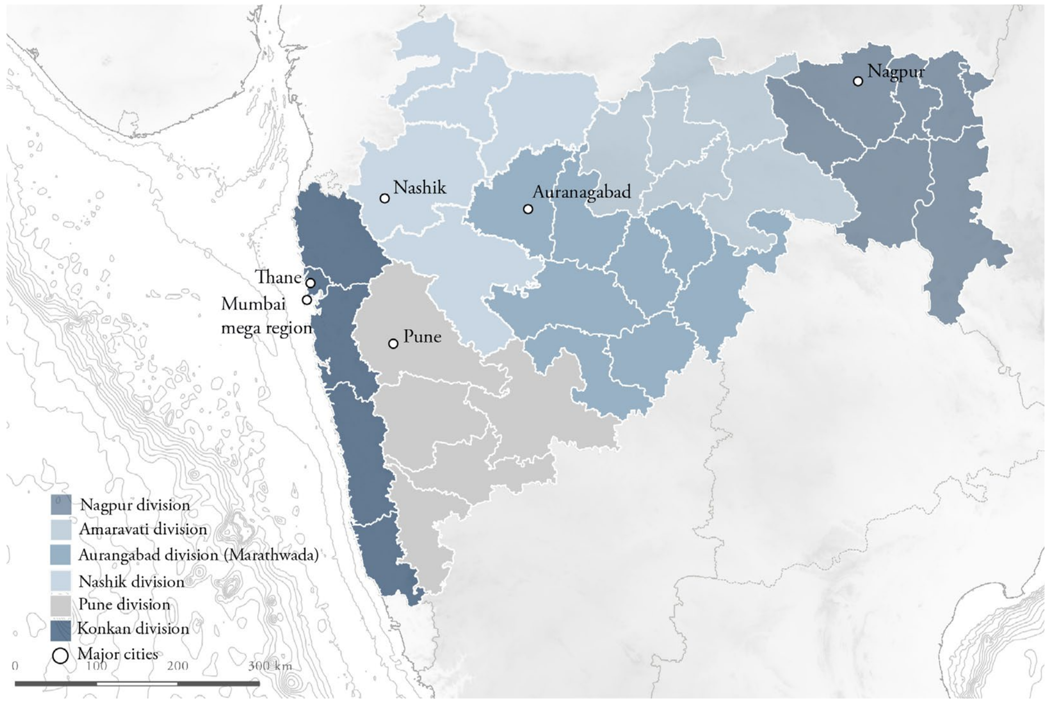
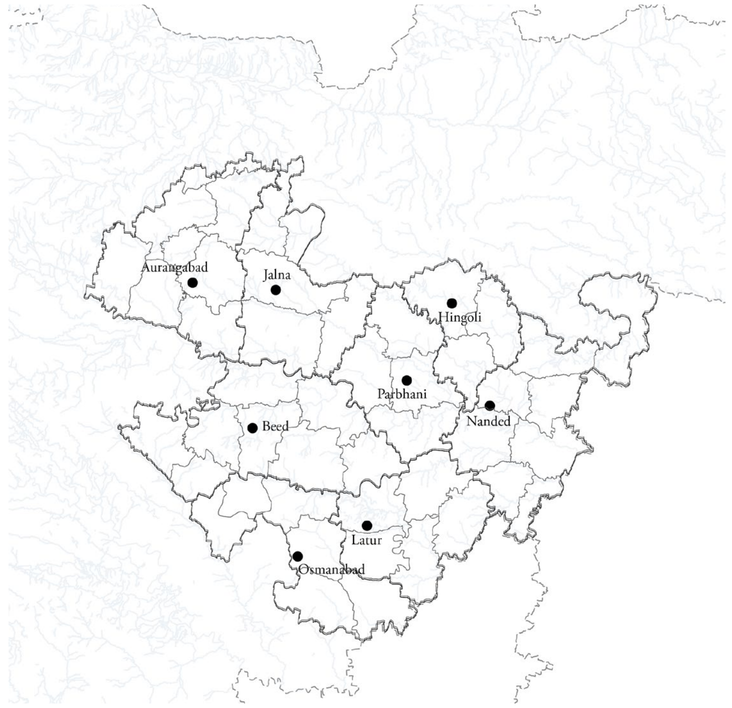


Fig 5.8 Administrative Structure of India
Source: www.google.com

Marathwada region within Maharashtra state

Maharashtra is the third largest state in India, with a population of 114.2 million people (2012) of which more than 52 million inhabitants live in rural areas. It occupies approximately 9.4% of the total area of India. Bounded by Arabian Sea to the west, and neighbouring states of Gujarat, Madhya Pradesh, Andhra Pradesh and Telangana, it is mostly landlocked with one side coast. The state is divided in six main regions (Konkan, Pune, Nashik, Amravati, Aurangabad and Nagpur), 33 Districts, 326 Talukas (Tehsils), and 42,778 villages, of which approximately 7,000 are located in areas of irrigation schemes (krishi-maharashtra.gov.in). These are further divided into districts and sub-districts or talukas. Each taluka contains several municipalities or in the case of rural areas village panchayats.



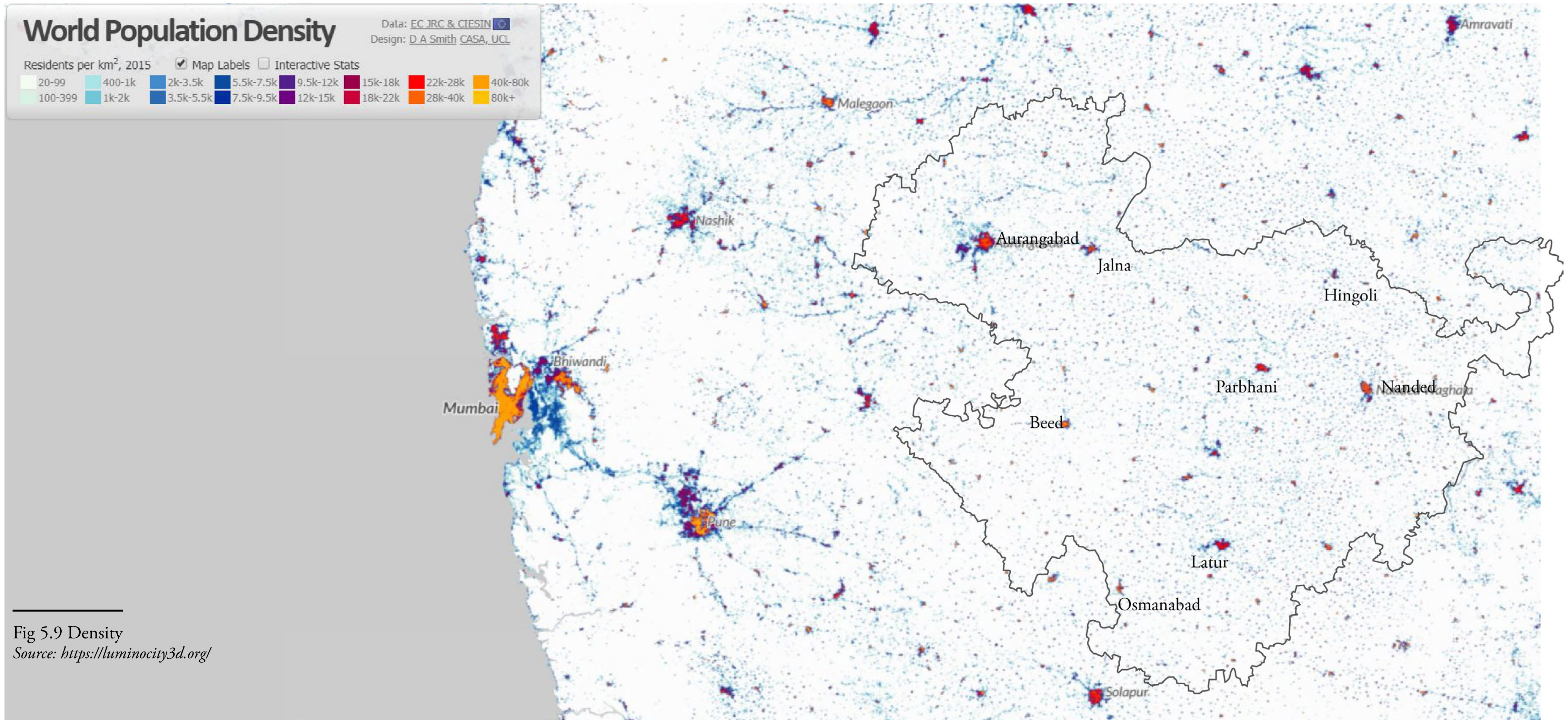


Fig 5.9 Density
Source: https://luminocity3d.org/

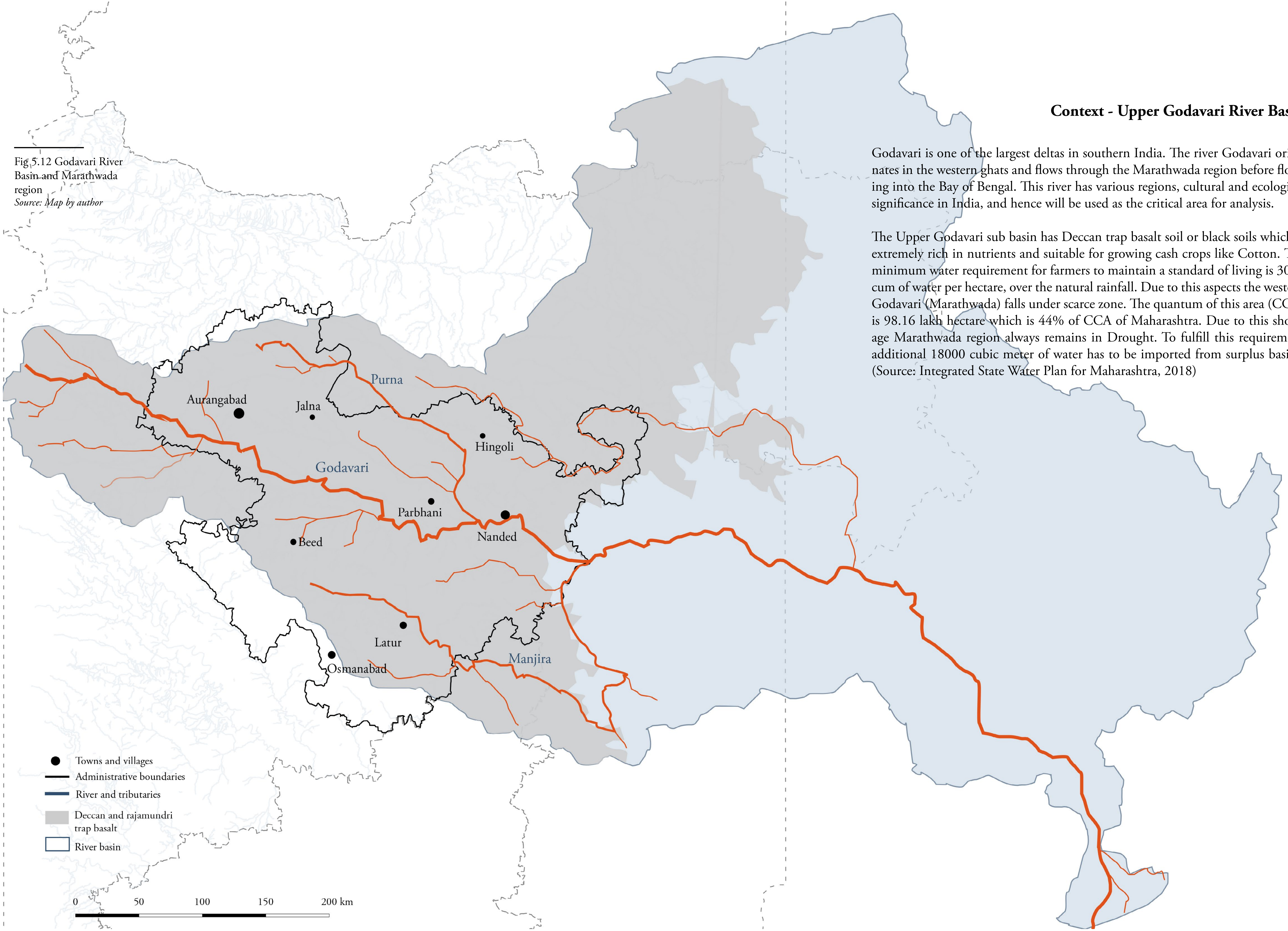
By assessing the areas with highest production of cotton but at the same time some of the lowest yields as well the areas experiencing the most scarcity and ground water depletion, the region of Marathwada is chosen for further analysis as a case area. Marathwada is located in central Maharashtra state of India. The area is defined as the critical area by looking at the yield and production of cotton combined with high levels of groundwater depletion and water scarcity. The region has also been suffering from severe rainfall shortages and due to this several farmer suicides.

Marathwada is situated in the east-central part of Maharashtra (fig 5.16). It is divided into 8 districts, namely Hingoli, Parbhani, Beed, Latur, Nanded, Aurangabad, Osmanabad and Jalna and further into subdistrict called talukas. The area of Marathwada has a population of 19million people.

Fig 5.10 Project area, Marathwada, Maharashtra
Source: Map by author

Fig 5.11 Production landscapes
Source: Photograph by author

Fig 5.12 Godavari River Basin and Marathwada region
Source: Map by author



Context - Upper Godavari River Basin

Godavari is one of the largest deltas in southern India. The river Godavari originates in the western ghats and flows through the Marathwada region before flowing into the Bay of Bengal. This river has various regions, cultural and ecological significance in India, and hence will be used as the critical area for analysis.

The Upper Godavari sub basin has Deccan trap basalt soil or black soils which is extremely rich in nutrients and suitable for growing cash crops like Cotton. The minimum water requirement for farmers to maintain a standard of living is 3000 cum of water per hectare, over the natural rainfall. Due to this aspects the western Godavari (Marathwada) falls under scarce zone. The quantum of this area (CCA) is 98.16 lakh hectare which is 44% of CCA of Maharashtra. Due to this shortage Marathwada region always remains in Drought. To fulfill this requirement additional 18000 cubic meter of water has to be imported from surplus basins. (Source: Integrated State Water Plan for Maharashtra, 2018)

5.3 Analytical framework

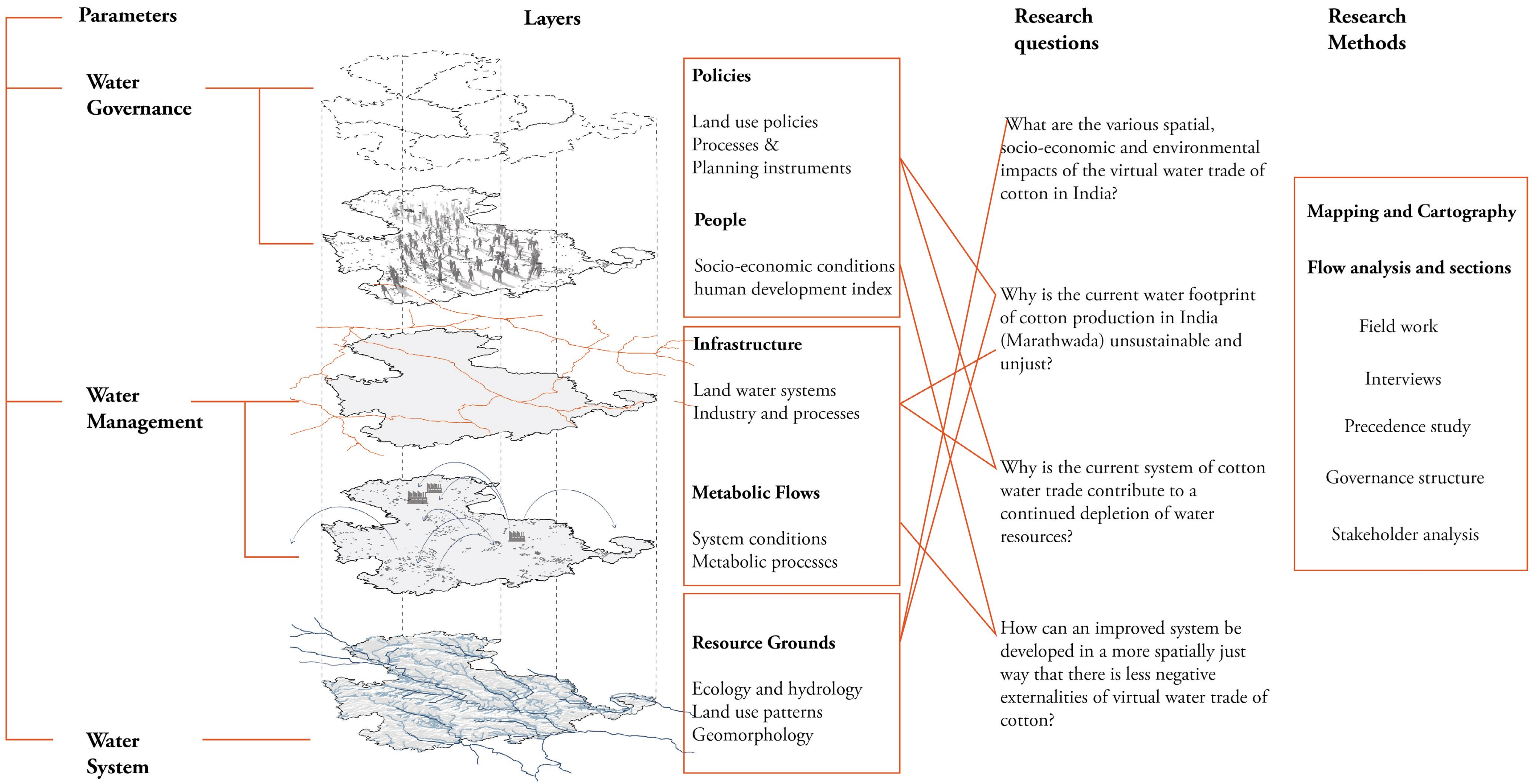


Fig 5.13 Layer Approach for analysis
Source: by author

5.4 Critical cartographies: Analysis

Resource grounds

Watershed and hydrology

Marathwada has a semi-arid climate with an average precipitation between 800-900mm/a. The climate is monsoon driven and Marathwada receives its main rain showers during June-September. Due to its inland location and erratic rainfall pattern, Marathwada is a drought-prone region. Marathwada comprises an area of 64,798 km2 and the height above sea mean level lays between 300-650metres (Shodhganga, 1995). The morphology is determined by fluvial processes, as Marathwada is part of the Godavari river basin. The interior of the basin is a plateau and has a general slope eastwards (WRIS, 2016b).

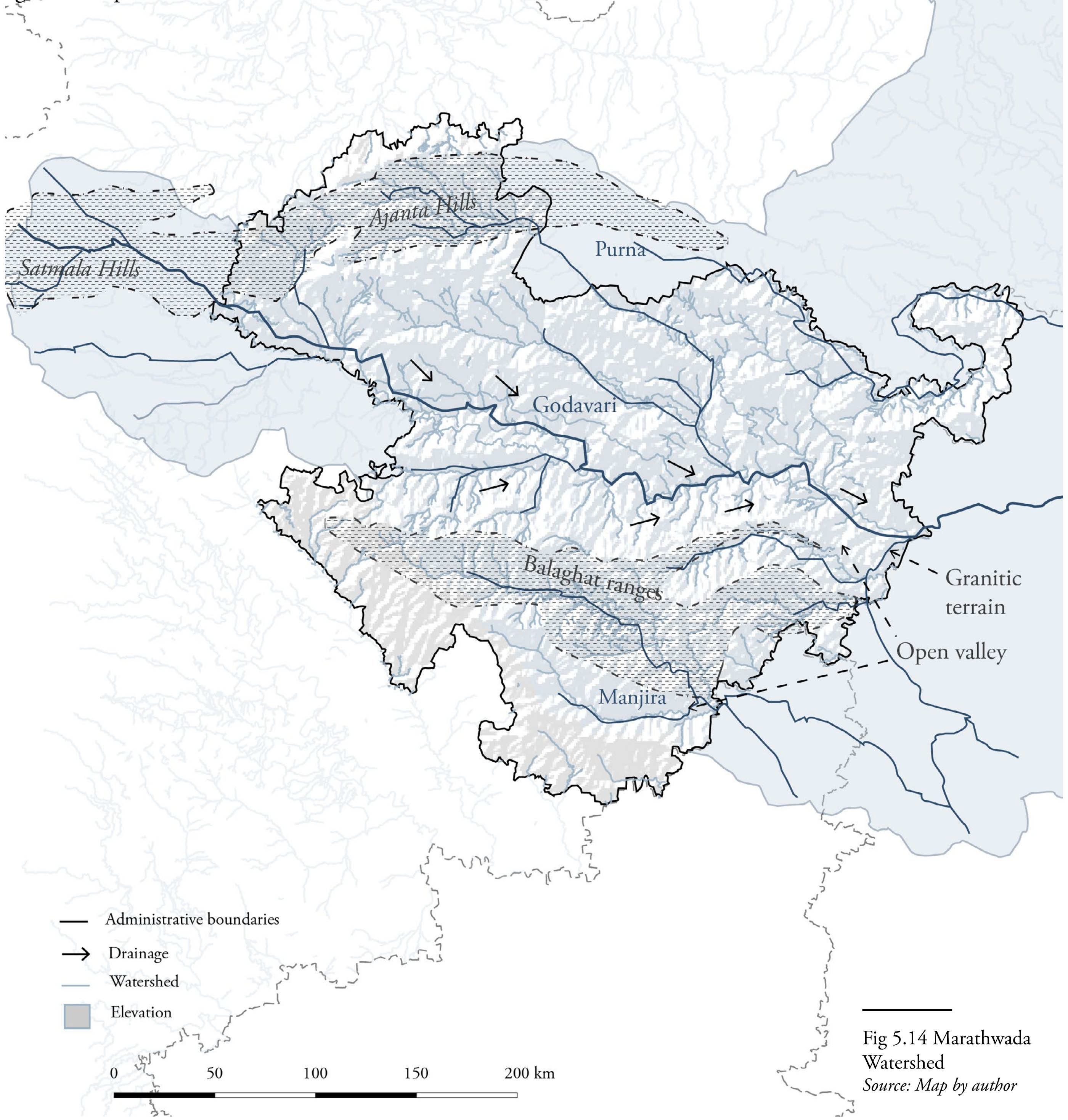
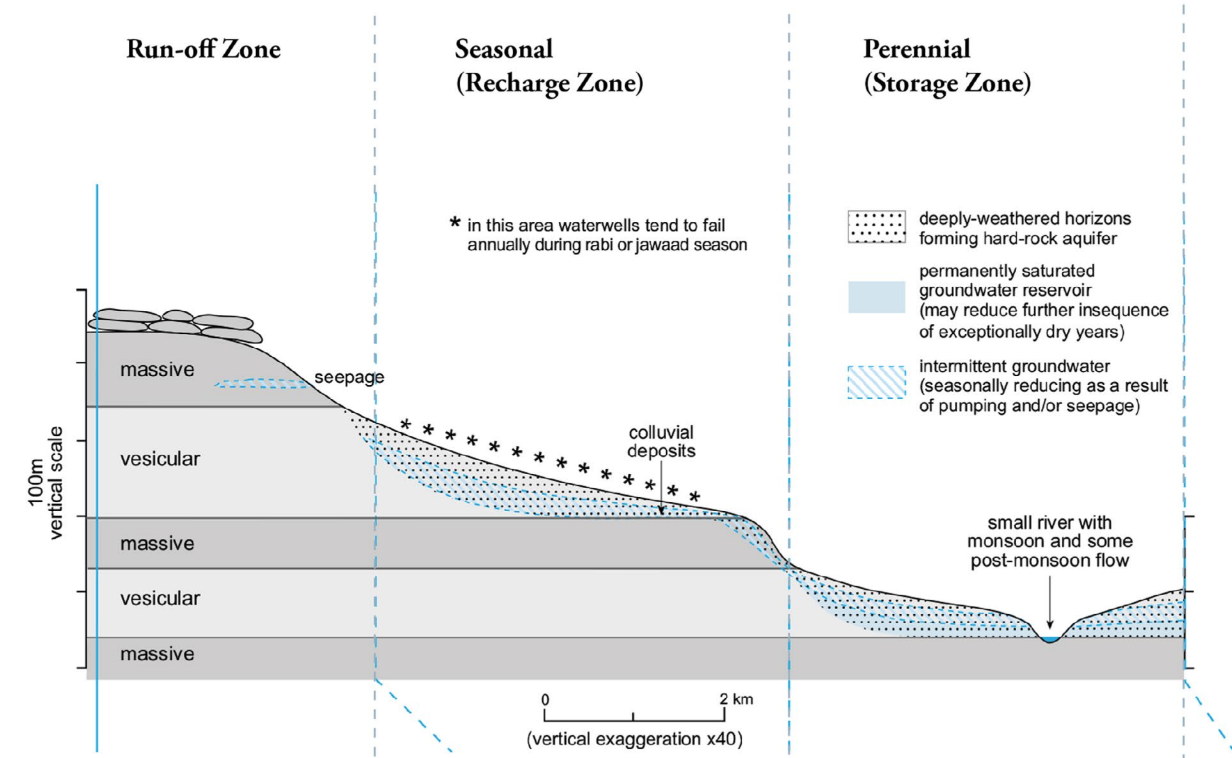


Fig 5.14 Marathwada Watershed
Source: Map by author

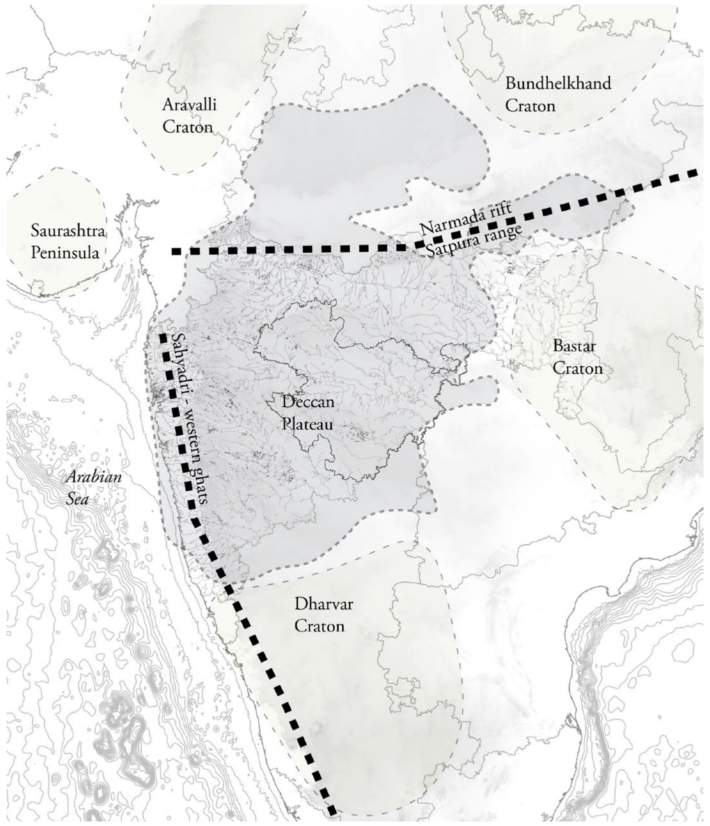
Typical hydrological cross-section of Deccan trap basalt micro watershed



	Run-off Zone	Seasonal (Recharge Zone)	Perennial (Storage Zone)
Ground water resource potential	Extremely limited	Limited storage and irrigation capacity	Modest storage and good irrigation capacity
Village water supply	Insufficient	Potential for improvement	Suficient Ground water availability , but mostly for irrigation
Socio-economic status	Small villages with insufficient water	Larger villages with Kharif cropping. Seasonal migration for work	Densely populated villages Conlficts between water for irrigation and drinking water supply

Fig 5.15 Hydrological section
Source: Foster,S. et al., 2007 (World Bank Report)

Geomorphology and hydrological characteristics



The geomorphological structure of central India. Marathwada falls in the Deccan plateau region which has largely 'black soil'. It is landlocked on both sides by the Sahyadri-Western Ghats mountain range and the Narmada rift - Satpura Range.

Fig 5.16 Geomorphology of India
Source: Wescoat J.L, 2018

The main soil types in the Marathwada region are Chromic vertisols (clay [light]) along with Vertic Cambisols (clay [light]) and Lithosols (loam) (Fischer et al., 2008). Vertisols, also known as "black cotton soils", which covers most of Marathwada. This black soil is very god for growing cotton even in dry conditions. This type of soil can hold up to 250mm of water content. However with decreasing water content due to erratic rains the soil starts cracking and can no longer withhold much water. The infiltration rates therefore starts to drastically decrease after this threshold (Virmani et al., 1982).

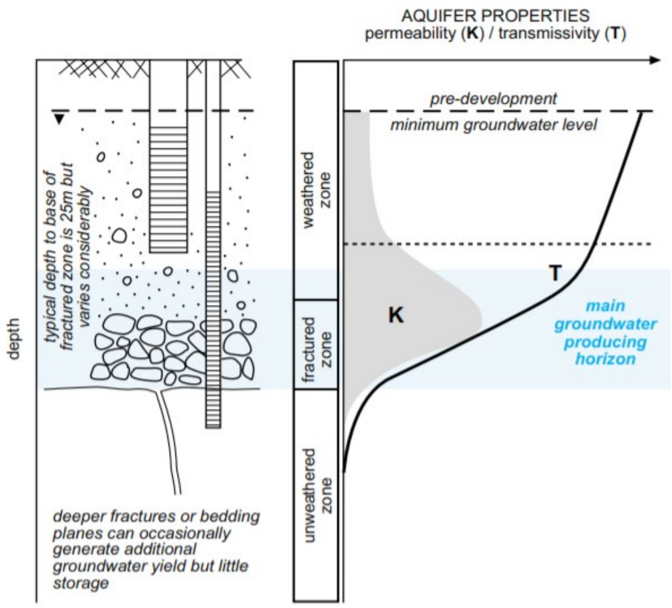


Fig 5.17 Hydraulic characteristics of the weathered Deccan Traps Basalt Aquifer
Source: Foster,S. et al., 2007 (World Bank Report)

Soil typology

The main soil typology seen in Marathwada is clayey and loamy soil which is very fertile. This makes this region ideal for agriculture. The special type of black cotton soil formed by the volcanic ashes makes it suitable for growing cotton due to its high water retention capacity.

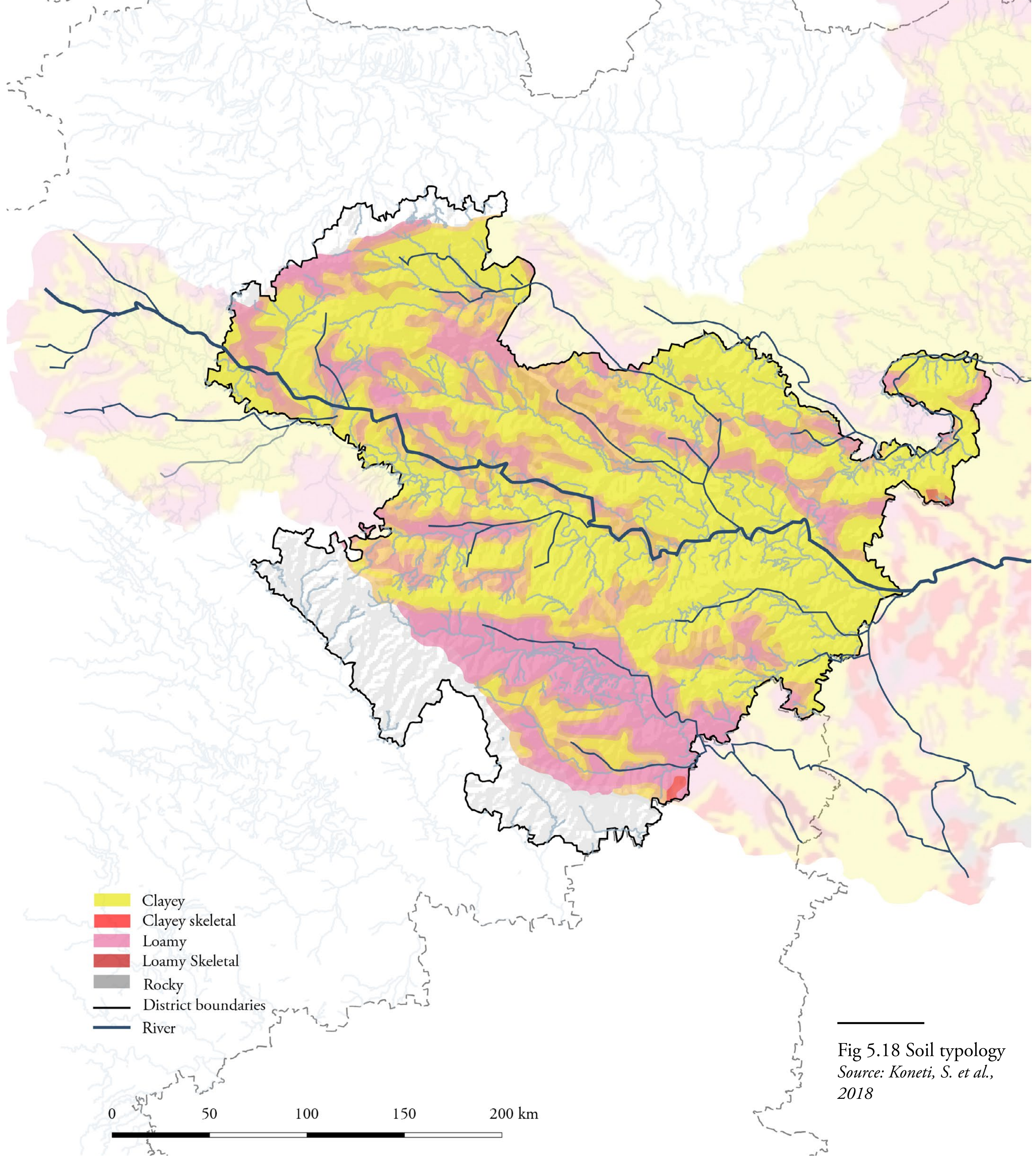


Fig 5.18 Soil typology
Source: Koneti, S. et al., 2018

Built and Unbuilt

The built fabric is sparse with most settlements and villages along the river. The fabric shows the dependency of the built areas to the river structure. It is also dense with most fabric close together with multiple center, forming a polycentric sparse development. the region also shows large open areas mostly rural hinterlands used for agriculture.

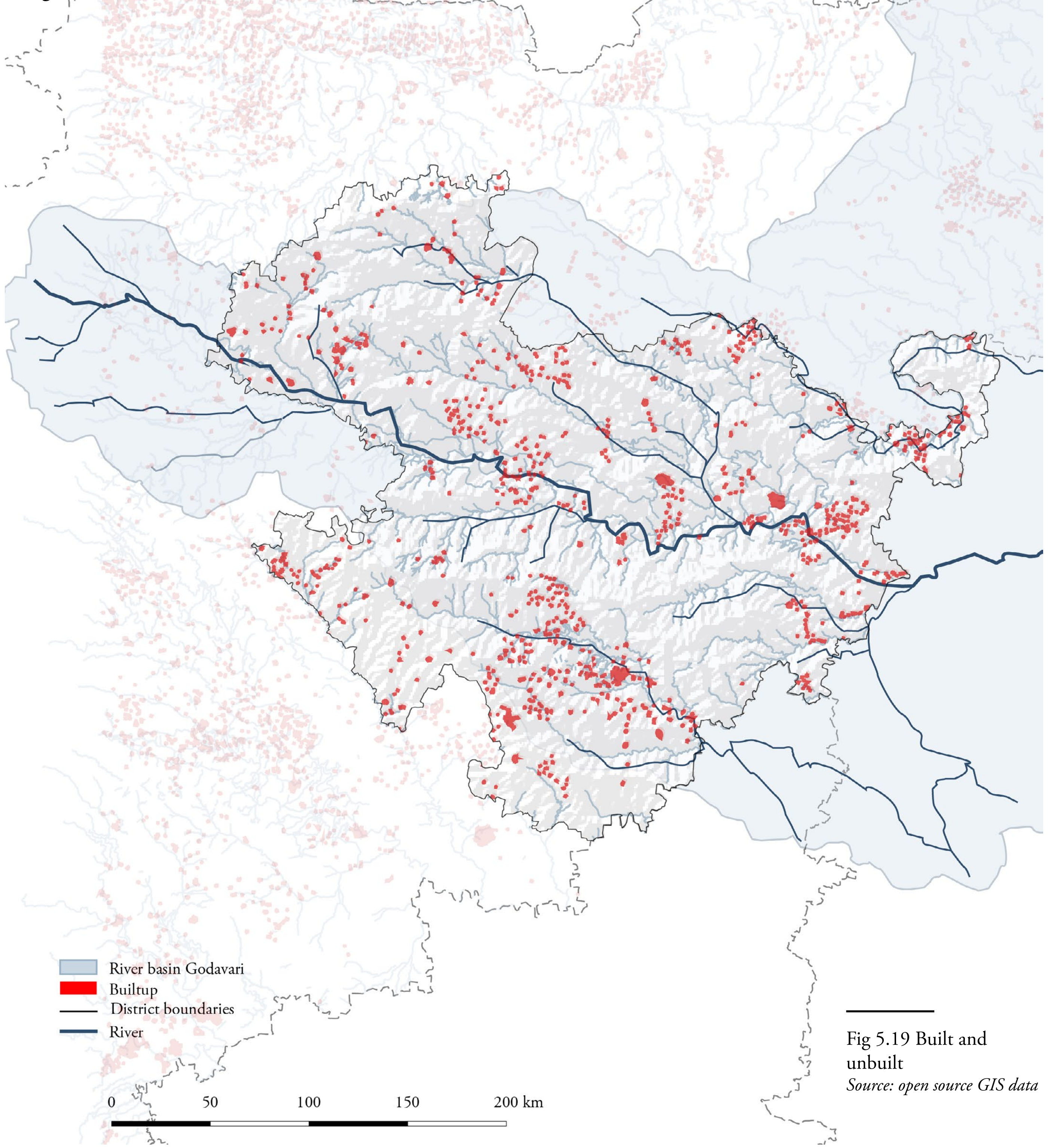


Fig 5.19 Built and unbuilt
Source: open source GIS data

Agriculture areas

The figure shows the large scale agriculture areas or production landscapes also centered within close proximity tot he river structure. The agriculture landscape covers more than 70% of the total area and almost all of the open space or unbuilt areas.

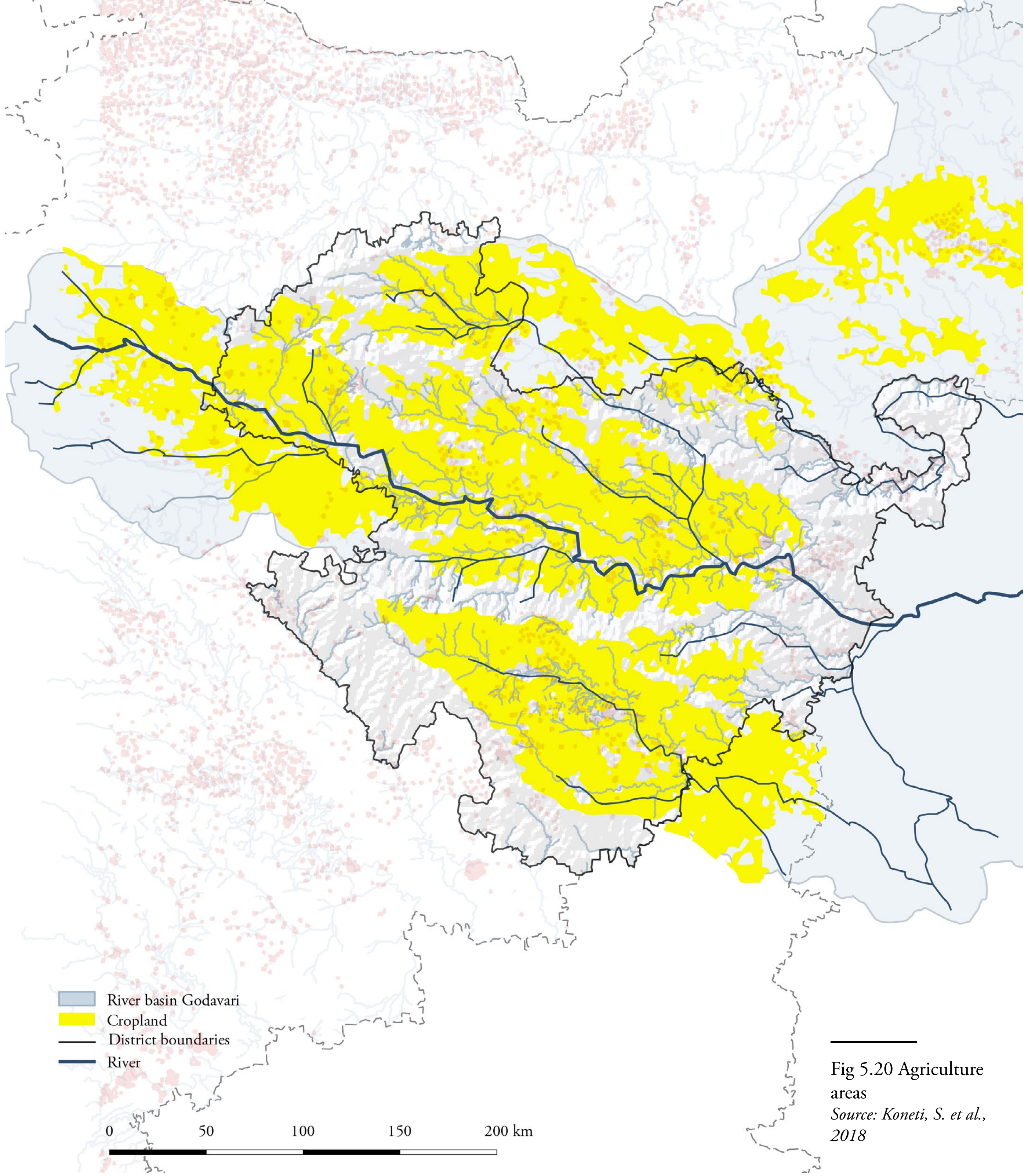


Fig 5.20 Agriculture areas
Source: Koneti, S. et al., 2018

Land Use and Land Cover (LULC)

Agriculture forms the backbone of the community with almost 75% of the total population dependent on farming activities for their livelihood. (Census, 2010-11).

The farmers grow most of their crops in Kharif and Rabi season. The main crops that are grown are cotton (32%), soybean (27%), jowar (23%) and sugarcane (8%), and these numbers are from the year 2013-14 (Sood, 2013). Around sixty percent of the farmers are smallholders (< 4 ha landowners). The land under cultivation and fallow land comprises 83,5% of the whole area (Koneti, S. et al., 2018).

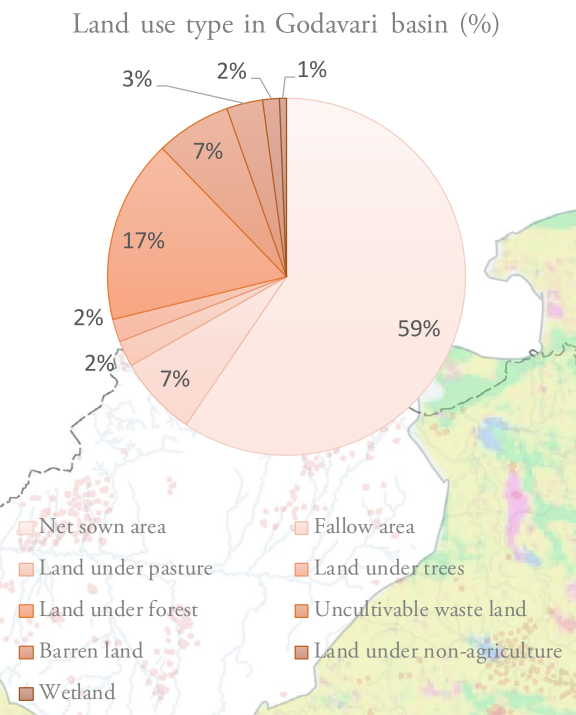


Fig 5.21 Land use type
Source: Koneti, S. et al., 2018

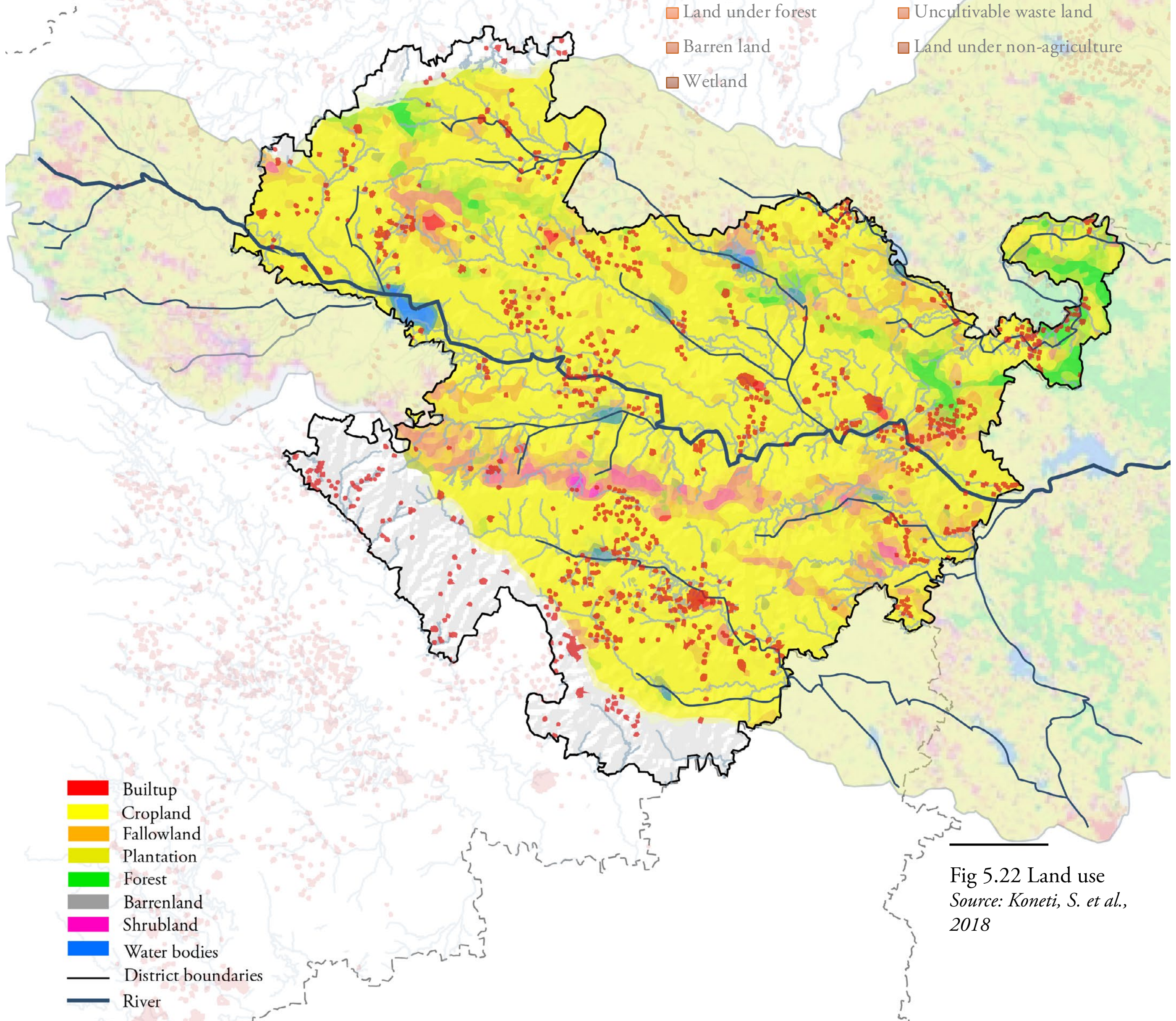
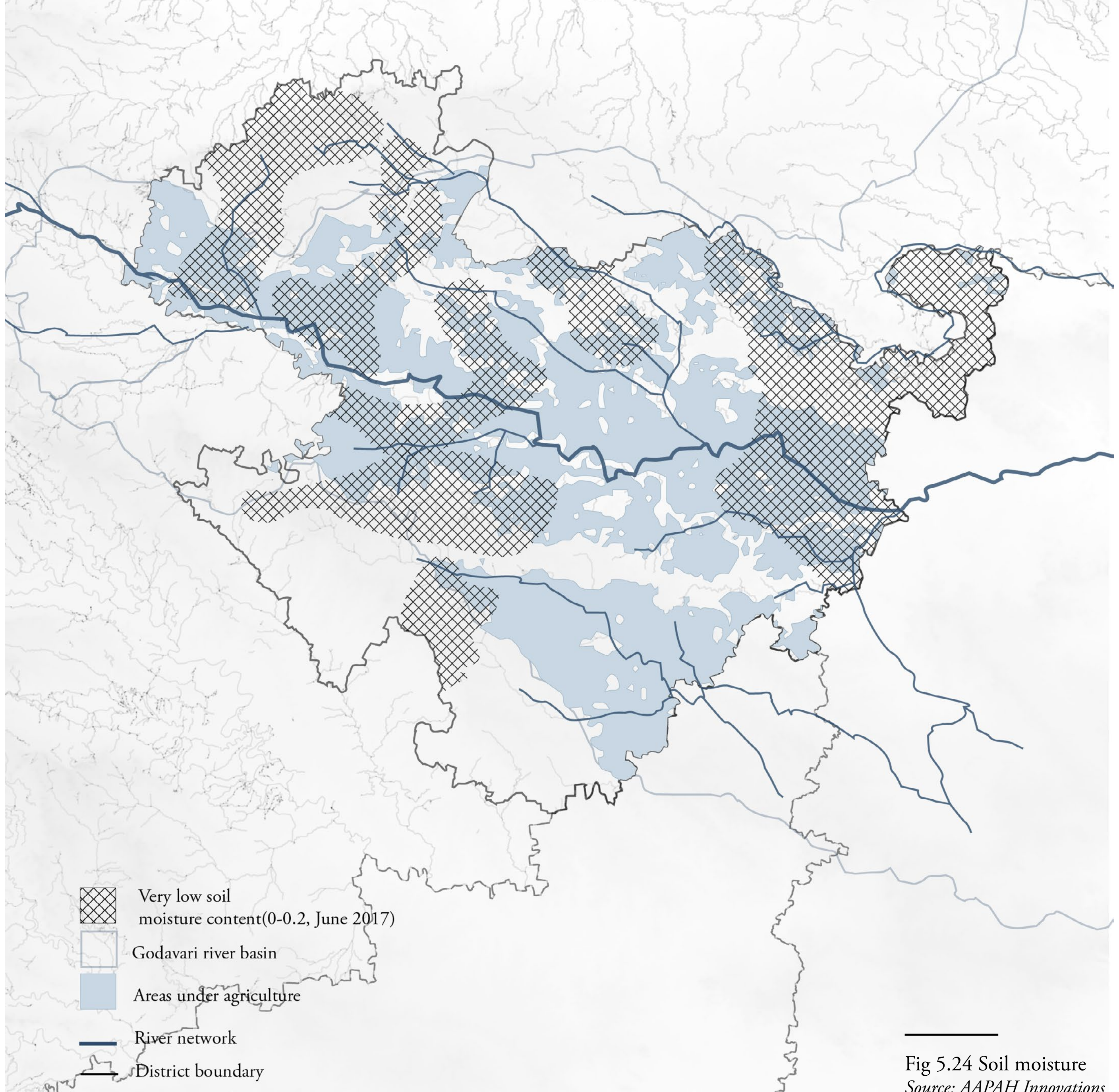


Fig 5.22 Land use
Source: Koneti, S. et al., 2018

Fig 5.23 Farm areas
Source: www.flickr.com

Soil moisture content

The map shows the areas with extremely low soil Moisture (June 2017) as well as the areas under agriculture production. It is visible that a majority of agricultural areas are facing low soil moisture content. This means that those regions also experience a low water retention capacity. With continued decrease of soil moisture content, the soil is unable to hold water for the crops to grow. This can also cause lower ground water tables.



Sources: S Koneti et al., (2018), AAPAH Innovations (2017)

Fig 5.24 Soil moisture
Source: AAPAH Innovations (2017)

Artificial recharge

The map shows the areas that have high prioritisation for artificial recharge due to reduced water retention capacity. This gives insight into the areas that require artificial recharge to cope with the decreasing soil moisture contents and lower retention capacities of water. It is interesting to note that according to the data, most of the region falls under high and moderate priority for water recharge.

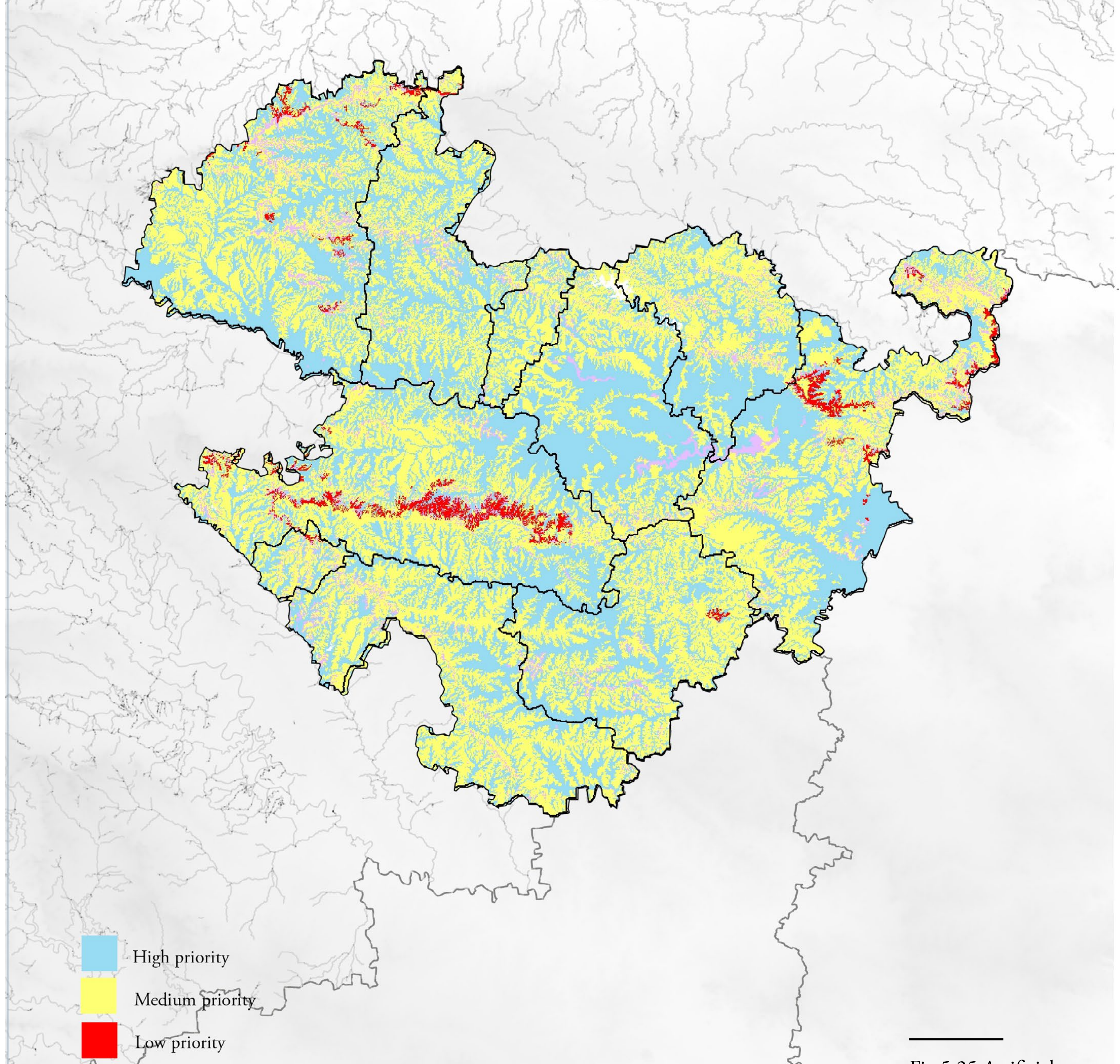


Fig 5.25 Artificial water recharge
Source: GW Prospect map, Government of Maharashtra

Fig 5.26 Karodi National highway connecting Aurangabad as part of industrial corridor
Source: https://timesofindia.indiatimes.com/

Mobility infrastructure

The road infrastructure is radial concentrated mostly within the town areas and sparsely connecting the villages and rural agriculture lands. The rail network is present connecting the major town areas in the region. Most of the villages are far away from the rail infrastructure and is only accessible via road.

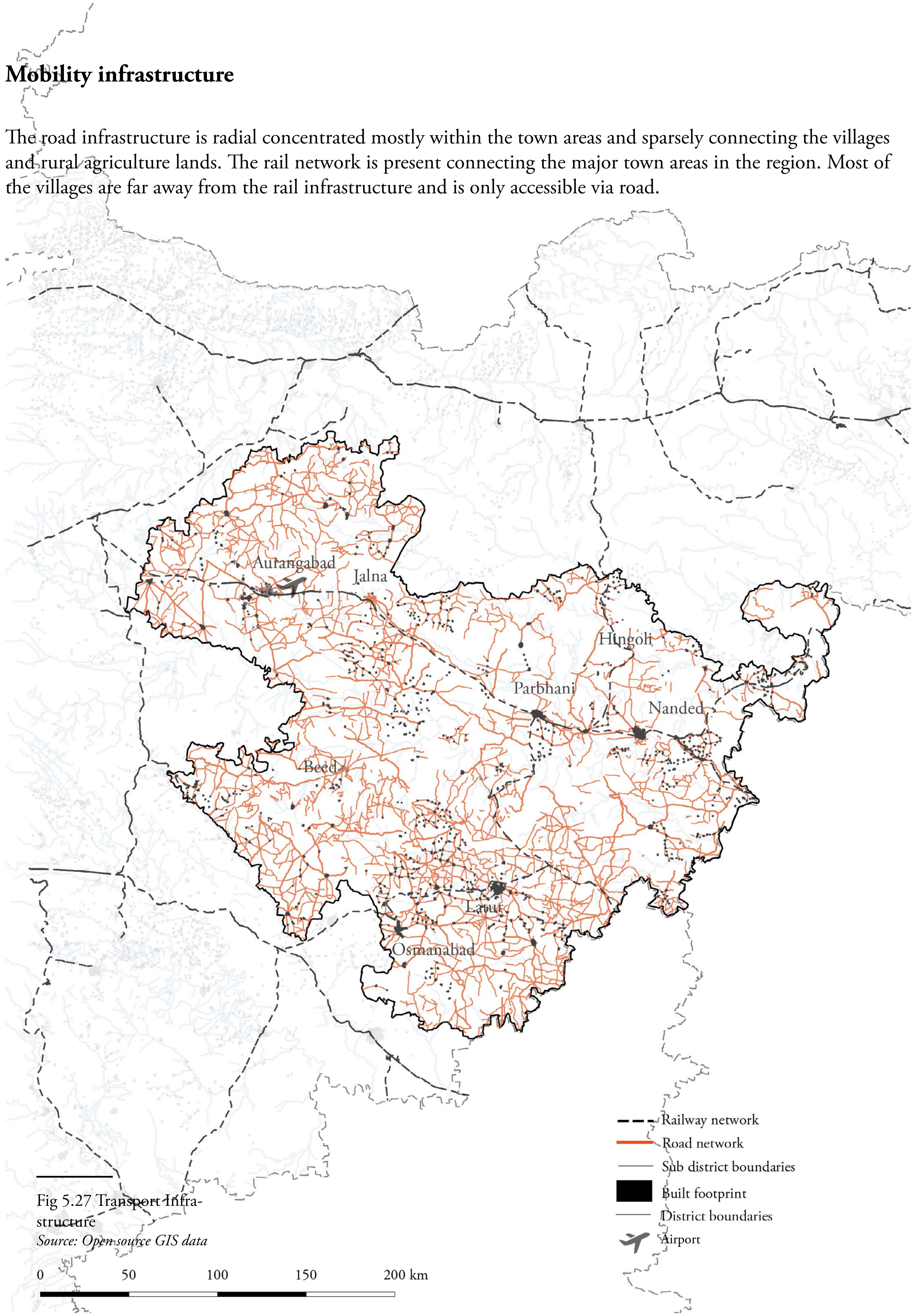


Fig 5.27 Transport Infrastructure
Source: Open source GIS data

Fig 5.28 Jayakwadi Dam
Source: www.flickr.com

Irrigation and hydro-power infrastructure

The Godavari river does not have large surface water bodies in Marathwada apart from Manjira tributary. To increase the water availability for irrigation purposes, several large scale dams were constructed in the region between 1960-2000. However, the amount of water available to the farmers is very low. There is controversy as most of the water is to sustain the industry mostly the cotton and sugarcane mills and ginning units which require large amounts of water as sugarcane and cotton are the major cash crops in the region and has political lobbying to sustain the industry. Therefore they are highly politicised crops.

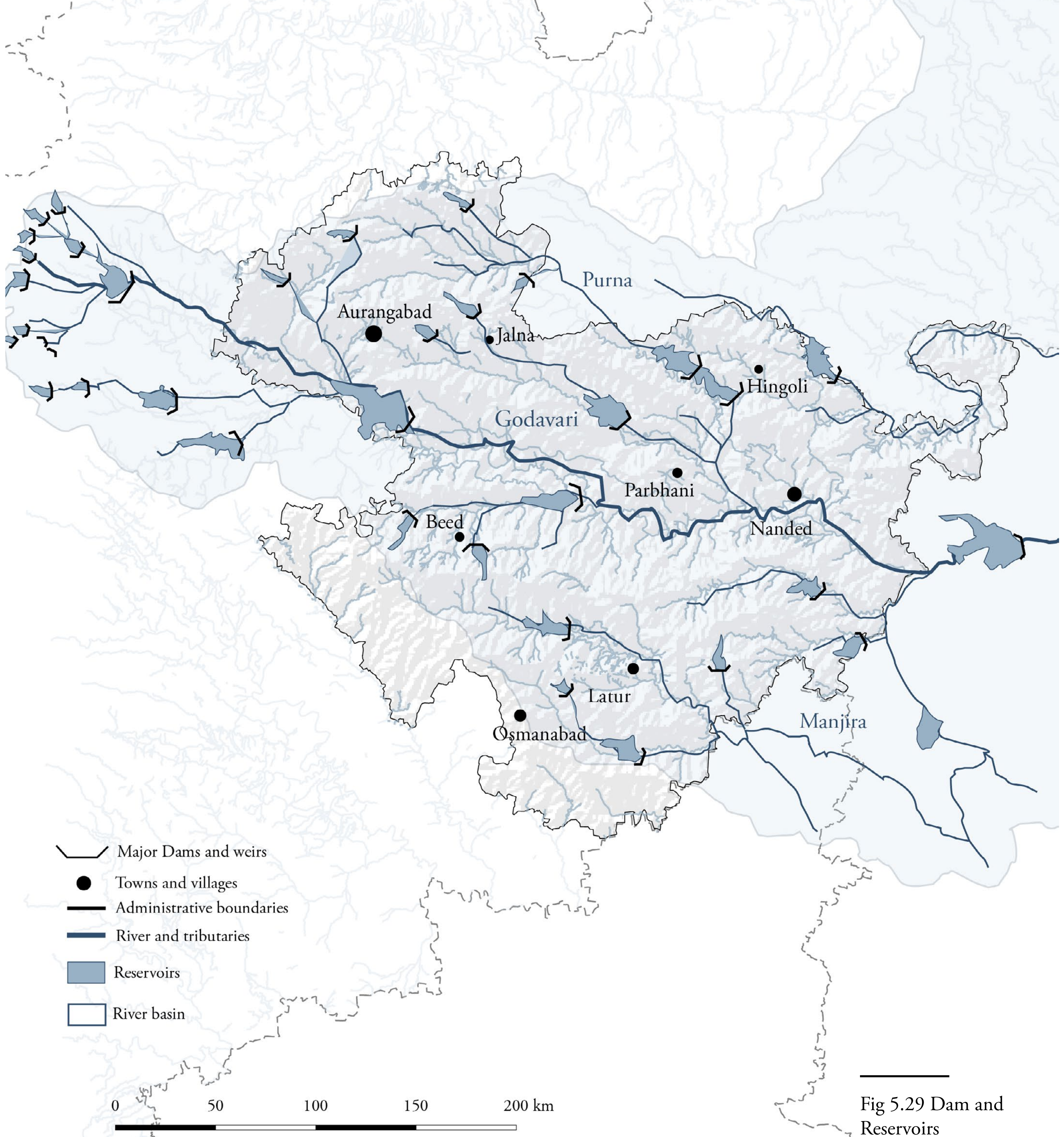


Fig 5.29 Dam and Reservoirs
Source: by author based on Reddy & Poulomi (2012)

Percentage of net sown area per district

Cotton crop has made a tremendous stride in growth of production from 3.83% to 11.34% while the cereals have shown poor performance. Above table shows several features of agricultural development in Maharashtra after liberalization for the period II. It reveals that cropping pattern went in favour of cash crops namely cotton and sugarcane. Therefore the Maharashtra state is experiencing the inflation of food grains since 2002 onwards.

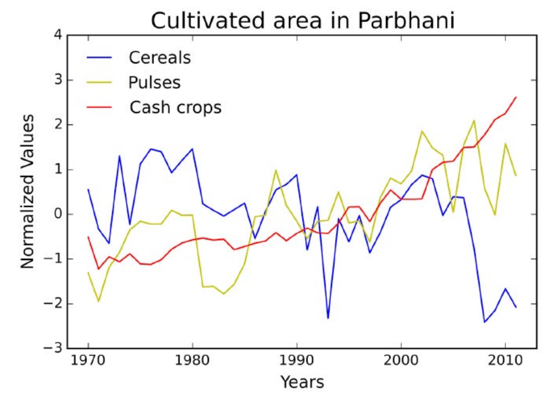


Fig 5.30 Cultivated area in Parbhani
Source: Master thesis, Nadja den Besten (2016)

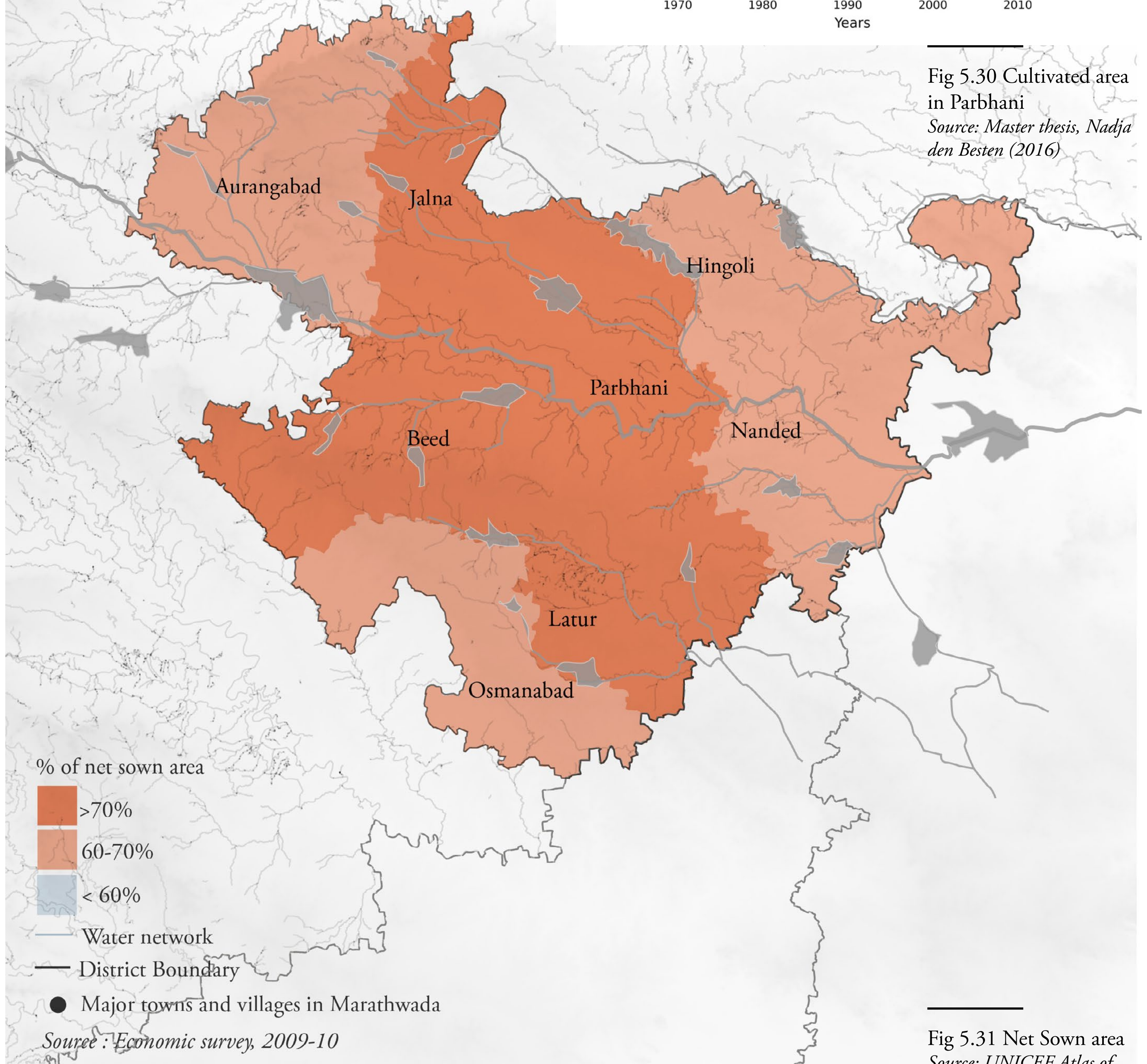


Fig 5.31 Net Sown area
Source: UNICEF Atlas of Social Indicators (2018)

Fig 5.32 Harvesting of cotton
Source: by author

Fig 5.33 Farm ponds
Source: by author

Percentage of area under irrigation per district

Only a mere eleven percent of the total cultivated area is under irrigation in Marathwada (DAC, 2010-2011). Most of the agriculture is rain fed and is dependent entirely on seasonal availability of rainfall. Even though there are many irrigation infrastructure in the region in the form of irrigation dams, reservoirs etc, most of the are is not under irrigation. In the map shown below, you can see the percentage of gross irrigated area as below 20% in 7 out of 8 districts (economic survey, 2009-10).

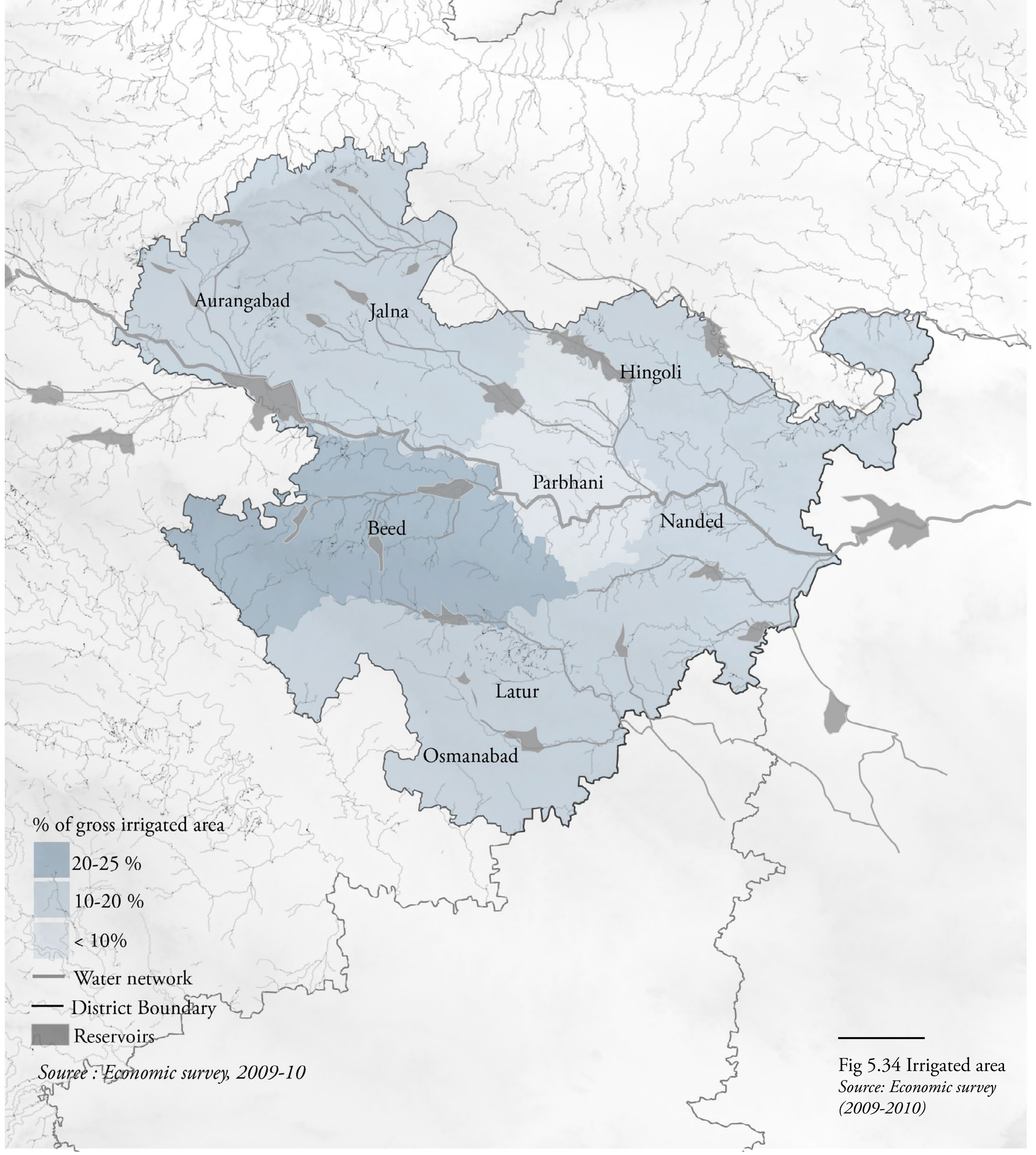


Fig 5.34 Irrigated area
Source: Economic survey (2009-2010)

Cotton manufacturing and ginning units

The map below shows existing cotton manufacturing and ginning mills in the region. Most of them are concentrated in the town of Aurangabad which is the closest for export and transportation purposes. The water for the industries mainly come from the many irrigation reservoirs present in the region. This shows the disproportionate distribution of water resource allocation for agriculture and industries.

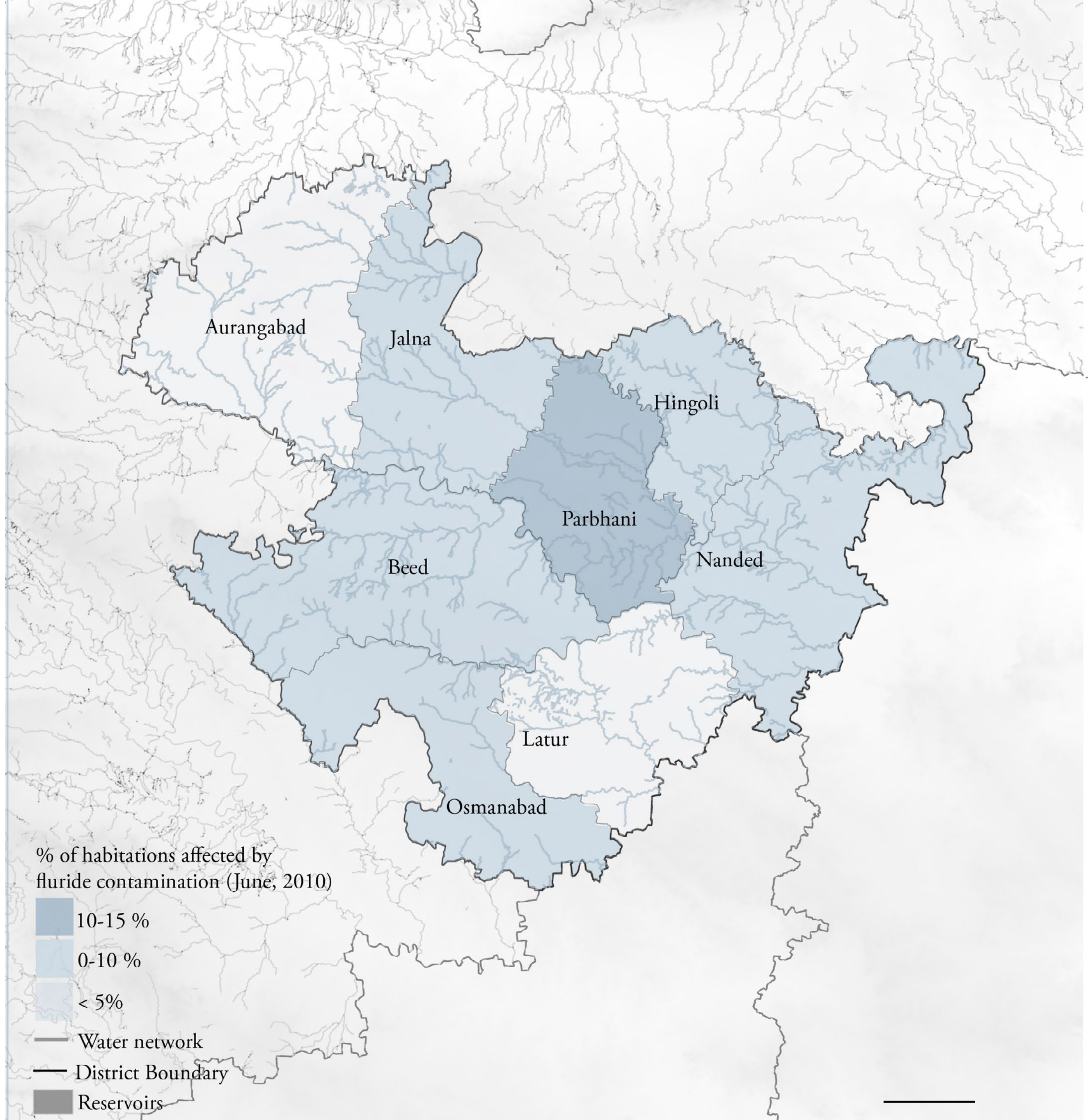
Fig 5.35 Cotton Mills
Source: Google earth data

Fig 5.36 Private pipelines filling water from reservoirs
Source: www.gettyimages.com

Metabolic Processes

Fluride contamination

The map below shows the percentage of habitations(or neighborhoods) affected by fluoride contamination in water. Fluoride contamination is associated with chemical or fertilizer elements in water bodies. This can cause health problems especially in children. Almost all of the districts have at least 10-15 % percentage of neighborhoods contaminated with fluoride.

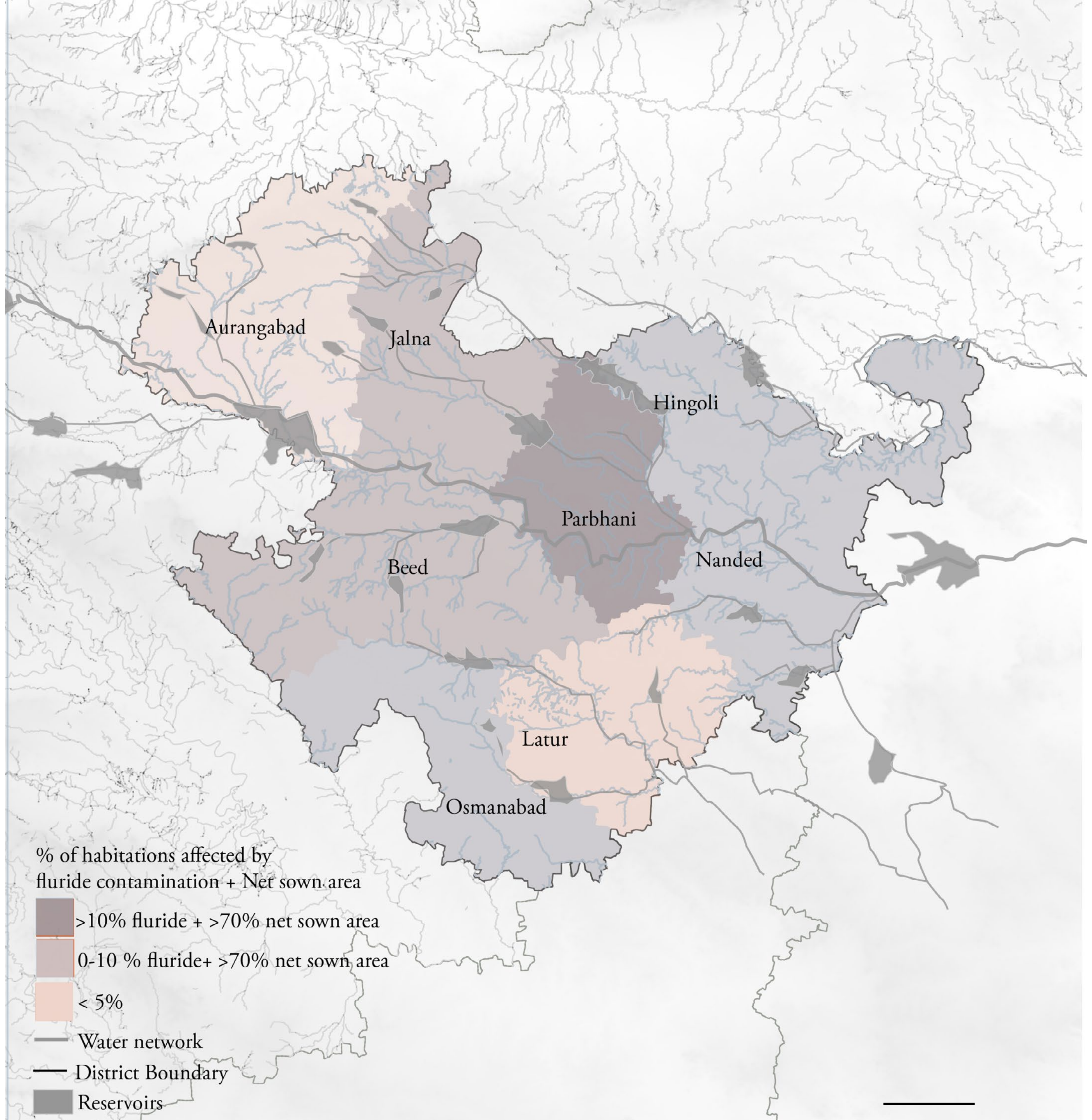


Source : Unicef Atlas of Social indicators, Maharashtra

Fig 5.37 Fluride Contamination
Source: UNICEF Atlas of Social Indicators (2018)

Fluride contamination and agriculture production

This map shows the comparison between neighborhoods that are associated with fluride contamination and the net sown area in each district. It is observed that the contamination is more in areas with a higher percentage of net sown area. This shows the link between the use of chemicals and fertilizers for agriculture and their impacts on the local water resources.



Source : Unicef Atlas of Social indicators, Maharashtra

Fig 5.38 Contamination and agriculture
Source: UNICEF Atlas of Social Indicators (2018)

District wise percentage of households with drinking water facilities

The below representation shows the percentage of households having drinking water facilities with respect to the districts. Only Aurangabad district has a 50-60% households with drinking water facilities. This could be related to the fact that Aurangabad is a major city and has a large urban population. However, it is still a low percentage compared to other urban areas. The rest of the districts mostly consisting of villages, fair even poorly with as low as less than 40% in Parbhani, Latur and Osmanabad. This means that a large population is dependent on external water supply through tankers etc for their daily water use.

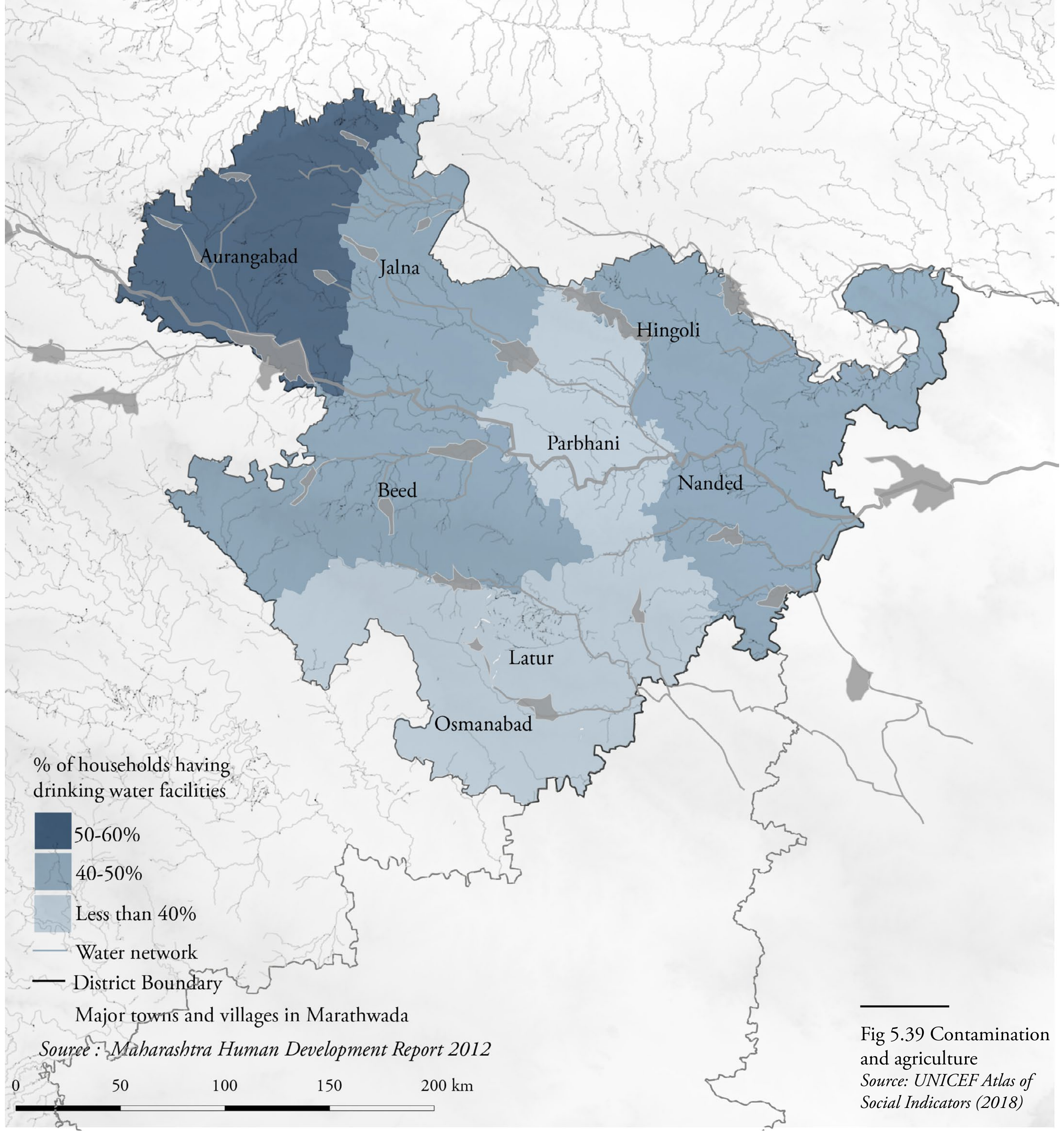
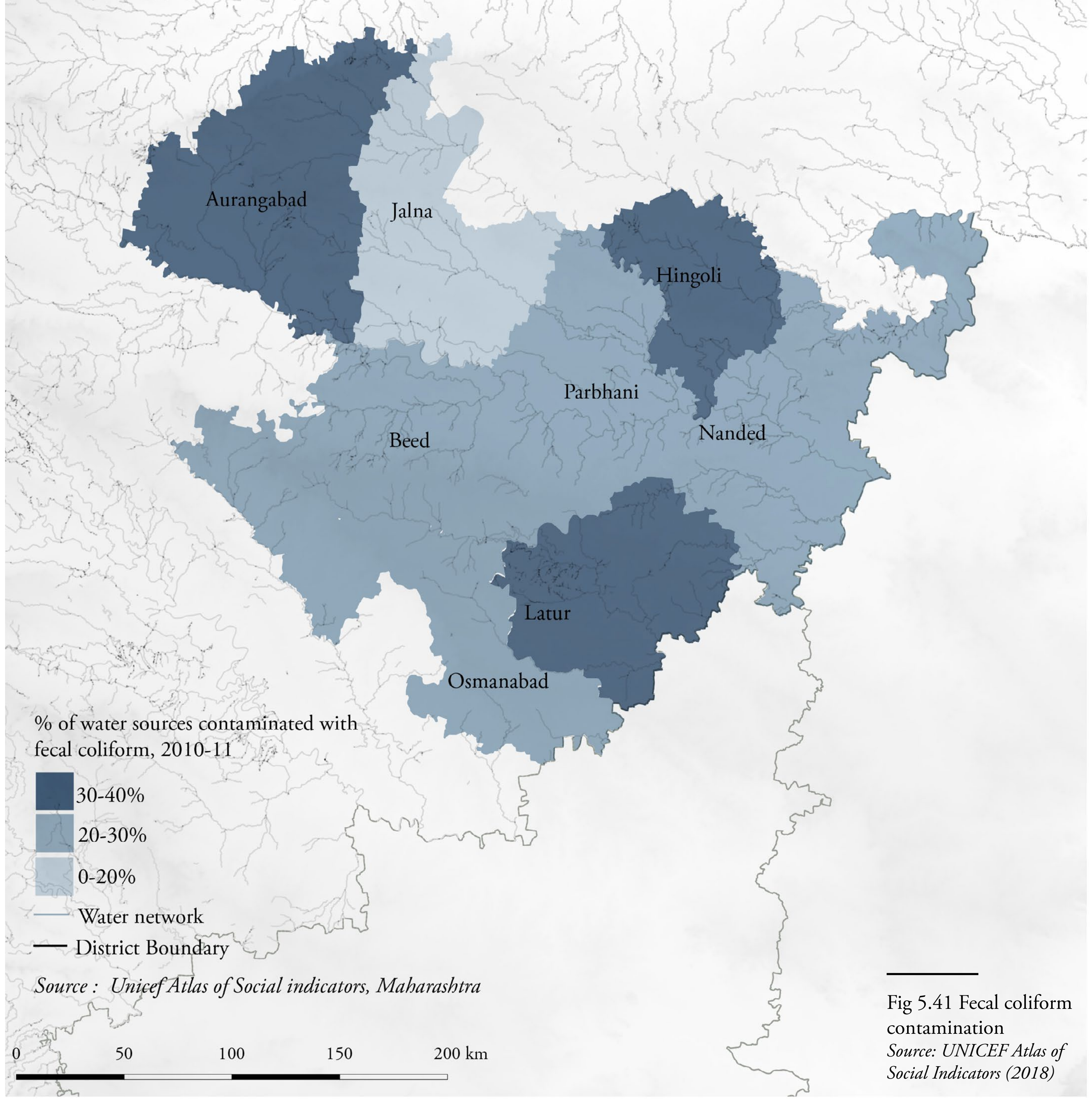


Fig 5.39 Contamination and agriculture
Source: UNICEF Atlas of Social Indicators (2018)

Fig 5.40 Water being brought via trains to Latur from 300 km away
Source: Photo by Harsha Vadlmani https://www.sriharsha.in/marathwada-drought/#1

District wise percentage of households contaminated with fecal coliform

The map below shows the percentage of water sources contaminated with fecal coliform. Fecal coliform is generated mostly from the presence of human excreta in water bodies and this is due to the lack of proper sanitation and water treatment facilities. The presence of fecal coliform can also cause many infectious diseases and affect the health and well being of people. The data shows as high as 30-40% contamination in Aurangabad, Hingoli and Latur.

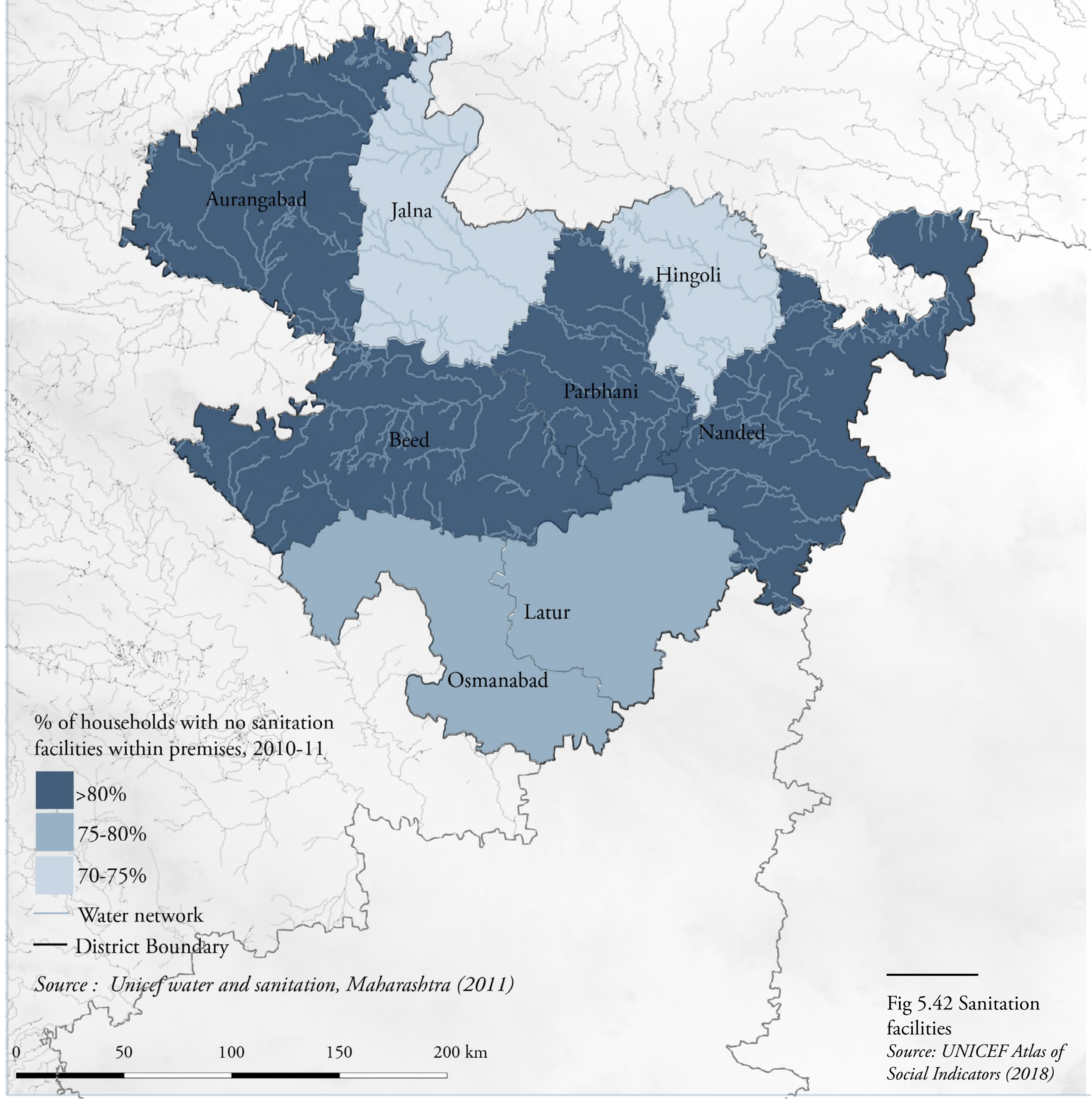


Source : Unicef Atlas of Social indicators, Maharashtra

Fig 5.41 Fecal coliform contamination
Source: UNICEF Atlas of Social Indicators (2018)

District wise percentage of households with no sanitation facilities

Comparing to the presence of contamination with fecal coliform to the percentage of sanitation facilities, we can see that there is a clear co-relation. A staggering 80% of households have no sanitation facilities in 4 out of 8 districts in the region. This points at a lack of sewage and sanitation infrastructure in these areas. The grey and black water from households therefore gets directly dumped into the river systems , polluting the water sources.

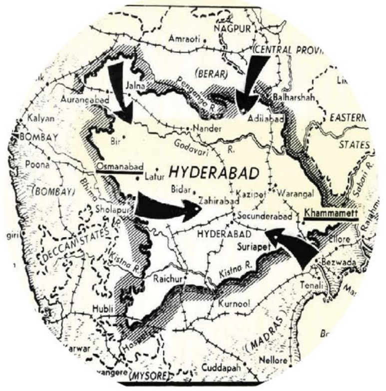


Source : Unicef water and sanitation, Maharashtra (2011)

Fig 5.42 Sanitation facilities
Source: UNICEF Atlas of Social Indicators (2018)

Land-use policies

Major land use policies and planning instruments in Marathwada region (1858 - 2019)



Marathwada was part of hyderbad Nizam rule

Hyderbad Deccan under Nizam rule
1724-1948

British Raj
1858 - 1947

Colonial Era
1858 - 1947

1947
Indian Independence

1948 - Operation Polo
It was a military operation in which the Indian Armed Forces invaded the Nizam-ruled princely state, annexing it into the Indian Union.

Post Colonial Era
1947 - present

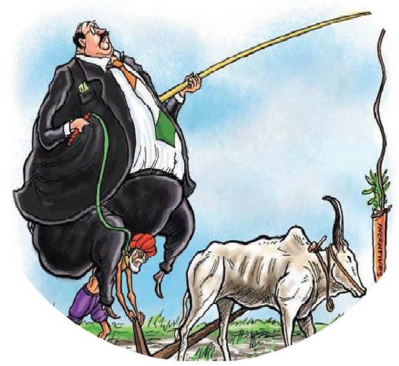
Maharashtra state
1960

The Green Revolution in India refers to a period when Indian agriculture was converted into an industrial system due to the adoption of modern methods and technology such as the use of high yielding variety (HYV) seeds, tractors, irrigation facilities, pesticides, and fertilizers.

Green Revolution
1965

Agricultural Prosperity
Infrastructural developments

1991
Liberalisation
During the first twenty two years (1991-2012) of new economic policy and its impact on the transformation traditional agriculture was by and large spread over the Maharashtra.Change in cropping patern from pulses, cereals and vegetables to cash crops such as cotton, sugracane and soyabean.



The introduction of HYV (High yielding variety) and GM (Genetically Modified) seeds increased the use of insecticides and pesticides. By adopting more and more foreign practices, the farmers in Marathwada (and throughout India) became increasingly dependent on external inputs.

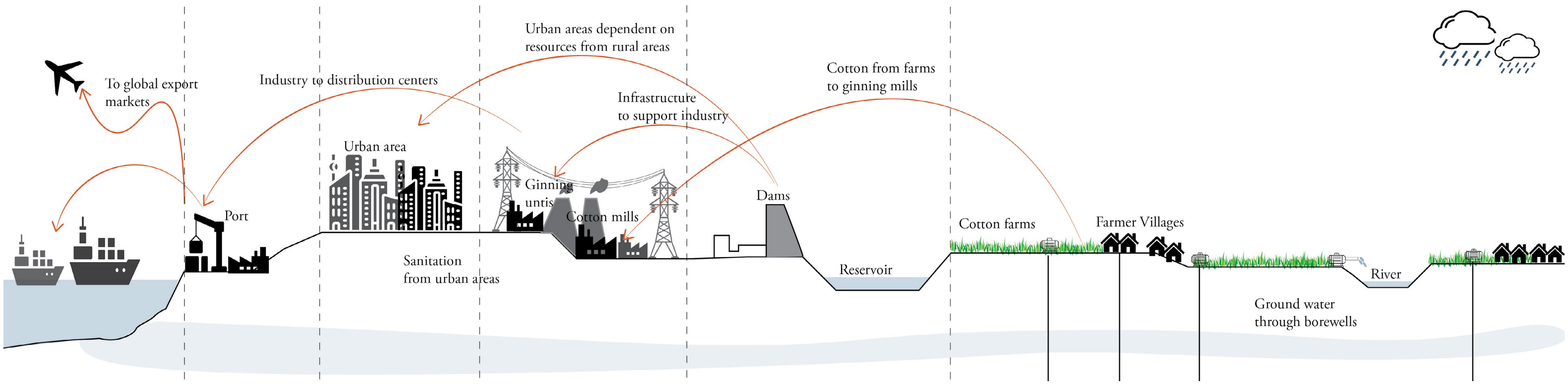
GMO Cotton(BT Cotton)
2006

2014-2015
Consecutive droughts
The consecutive drought oupled with bad agricultural practices led to lower yields resulting in large debts for farmers and subsequently farmer suicides.

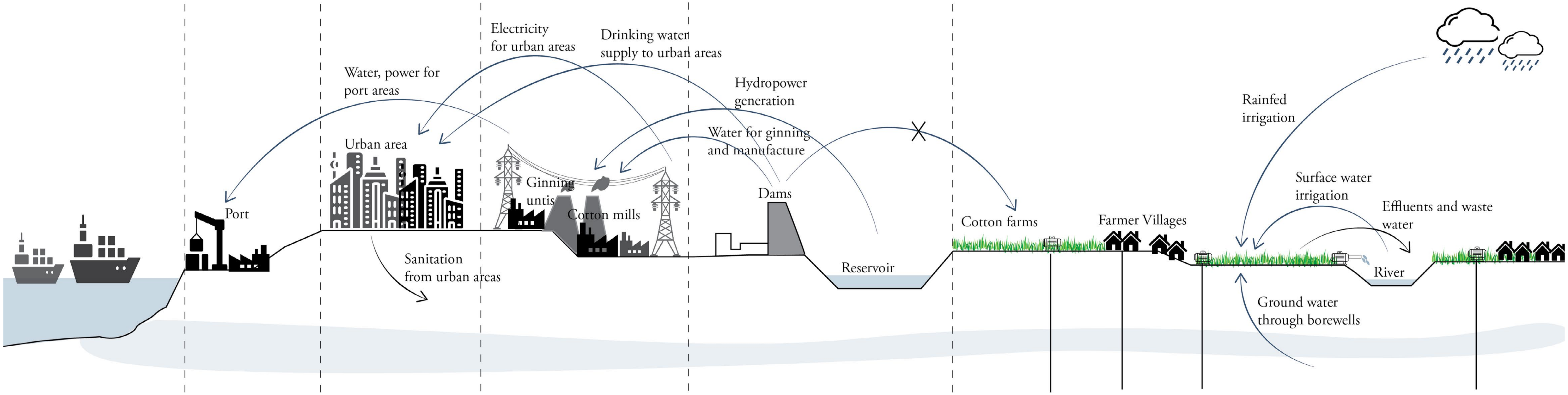
2014 -2019
Crisis

Resource flows

Resource flows: Cotton



Resource flows: Water



Export industry

The export market controls the industry and production

Districbution

Urban area

Urban sprwal and migration to the cities

Industry

The industry or warehouses result in large scale environ-mental degradation

Infrastructure

The infrastructure investments caters to the industry and export markets

Extraction grounds

The rural hinterlands of agriculture production as places for resource extraction without social policy and infrastructure support becomes *neglected scoieties* with low social-economic growth and environmentally vulnerable

5.5 Conclusion from analysis

The main conclusions are as follows:

There is a conscious policy choices to favor the market driven demand based agriculture that resulted in the shift in cropping pattern from pulses, cereals and food grains to cash crops after 1991. The change in cropping pattern has adverse effects on the economy, environment as well as resulted in ground water depletion and inflation of food for local demand. The infrastructural developments such as dams hugely favour large scale cotton and sugarcane mills and not farmers or household use. Coupled with a lack of good social infrastructure , the farmers are incapable of making informed choices and have no access to better their lives. This has resulted in the farming communities and the hinterlands as mere extraction grounds for resources to be taken to the cities for export markets. As a result there is a socio-economic decline amongst the farming communities. Therefore, there needs to be policies for empowerment of the farmer communities and local people through improvements in social infrastructure, which can result in overall water resilience.

Fig 5.43 Women protesting against farmer distress
Source: Photo by : Jaideep Hardikar (PARI)

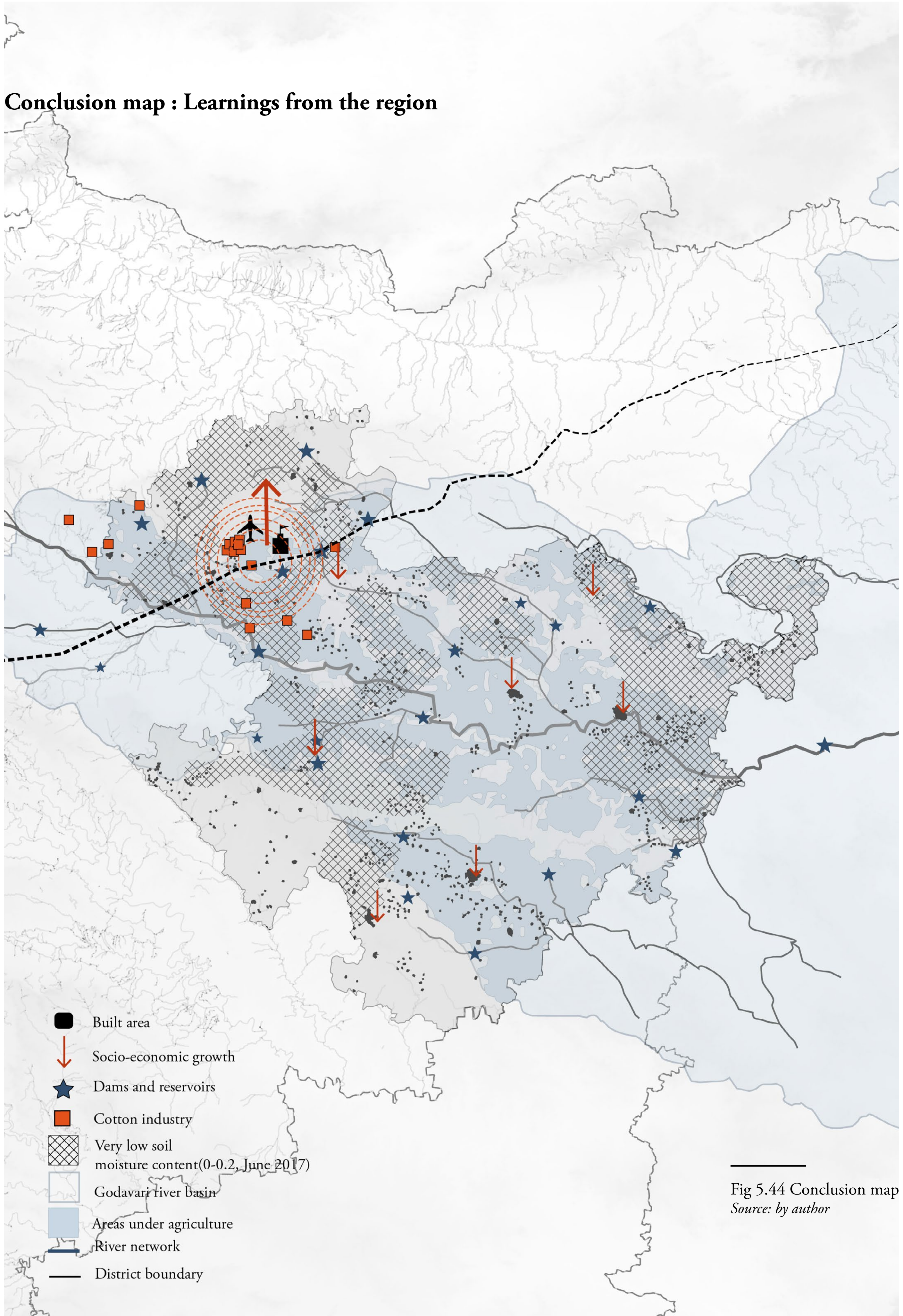


Fig 5.44 Conclusion map
Source: by author

5.6 Fieldwork and site study

Field Work : Site visits

The fieldwork was conducted over a span of two weeks from 21st January 2020 to 4th February 2020 in collaboration with the local NGO, SOPPECOM, Pune. An extensive fieldwork and interviews were carried out in the upper Godavari basin in Marathwada region, Central India. The fieldwork involved visiting the cotton producing and manufacturing villages in proximity such as Gangapur, Aurangabad, Beed and Parli in the state of Maharashtra, India and interacting with various stakeholders in the region. The outcomes from the fieldwork proved to be an inevitable part for the research and framing the vision and strategies for the region.

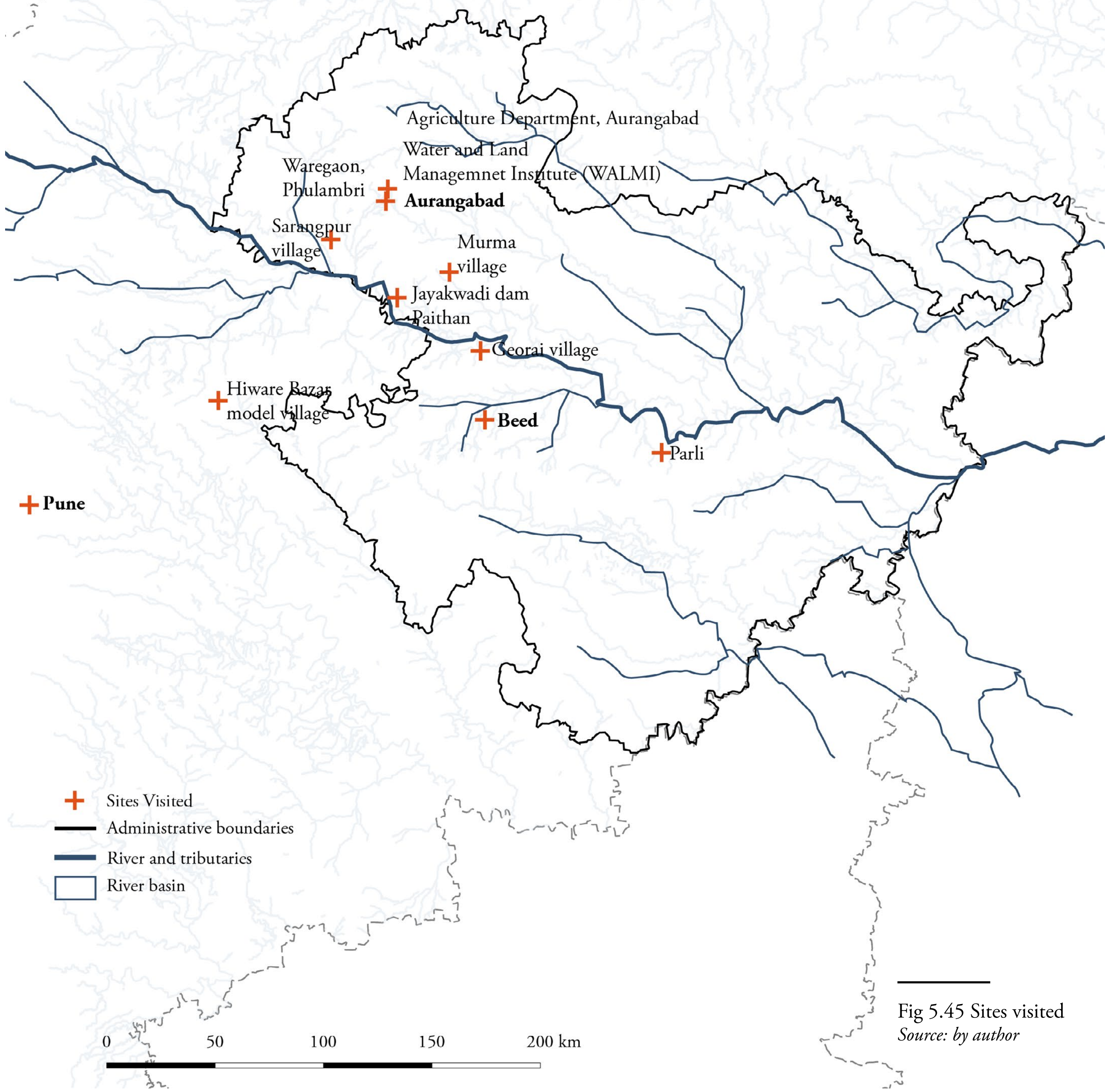


Fig 5.45 Sites visited
Source: by author

Fig 5.46 Cotton plucking before harvest
Source: by author

Life-cycle of Cotton in Marathwada

The below diagram explains the life-cycle of cotton in Marathwada region from seeds to planting to harvesting to processing and manufacturing into raw cotton and by products. The process involves farmers, labourers, industry, traders and exporters. The longest time period is during the growth cycle and this is also the most water intensive part of the process. There is also a lot of investments which is needed in these stage in terms of fertilisers and pesticides, tractors and equipments for plowing and harvesting etc. This also a labour intensive process which requires extra attention and care. At the industry the seed is separated using machines and the cotton is processed for exports. The seed is then refined to cooking oil and the by-product is sold as fodder for cattle both of which are locally sold.

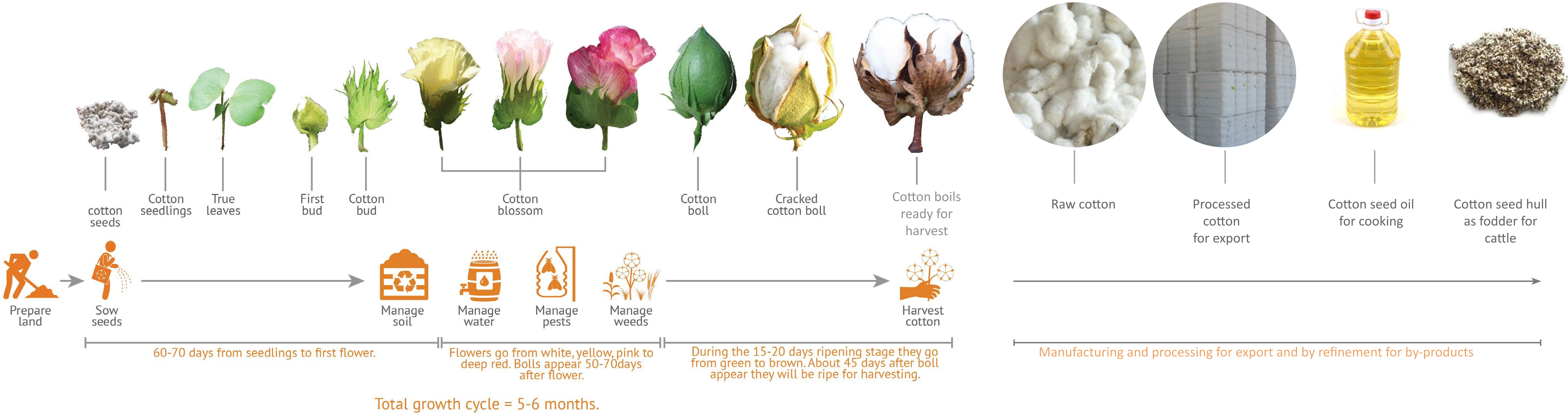


Fig 5.47 Cotton life cycle
Source: by author based on Field-to-fibre. Retrieved from http://aboutorganiccotton.org/

Fig 5.48 Farm laborer spraying chemicals for higher yield
Source: by author

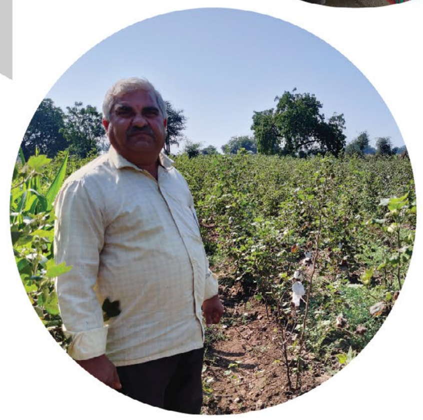
Interviews with stakeholders from the region

Cotton Farmers

" There is no water from the top or from the ground".

"There is not enough water to drink. Once in 4 days, a government tanker gives us 200L for the whole family. If needed more, we need to buy from private tankers".

"The profits I make, I need to pay for pesticides, for water, for labourers. I want to shift to fruits but its a risk I cannot take alone".



NGOs

"Scarcity prompts the farmer to overuse the water, and a tendency to maximize profits. There needs to be assured water that ensures equity. We have calculated the water for livelihood as 5000 cubic meters per year to sustain."

Academicians (WALMI, Water and Land MAnagemnet institute, Aurangabad)

"Marthwada is a rain shadow area, so there is uneven and unpredictability in rains. Irrigation practice is not there historically".

Goverment bodies (ATMA. Agriculture Technology managemnet agency)

" The problem lies in uneven rainfall. If there is good rains, there will be water. We cannot control that".

"We cannot be responsible for maintenance and implementations, that is the job of irrigation department".

Fig 5.49 Interviews with stakeholders from the region
Source: by author

Cotton indsutry

"We get raw cotton from farmers and traders. The rates are dependent on the international markets, Around Rs 110 for 1 kg of cotton."
"It is sold to local markets in India and international markets mainly China."

Farmers who shifted from cotton to papaya

"I switched to horticulture two years back. I grow ingenious variety papaya, and it requires only less water. We grow as a group of 50 acres, and that is more profitable. I had Rs 3 lakhs profit last season."

"With initial investment help and as a collective group, it is possible to shift from cotton".

Major challenges and problems

Some of the challenges experienced in the region are as follows:

— Lack of awareness regarding water conservation
— Lack of manpower in agencies(governmental/non-governmental) to create awareness
— Lack of scientific research on sustainable practices at local scale
— Lack of systems and policies for equitable distribution of water
— Lack of maintenance of existing systems leading to losses
— Lapse in governance systems and corruption
— Lengthy, complicated and inaccessible bureaucratic process
— Lack of coordination between different governmental agencies as well as citizens
— Lack of initial investment for sustainable alternatives
— Water subsidies and other policies are disproportionately benefiting the larger farmers
— Improper implementation and lack of monitoring
— Lack of compensation from international markets
— Large number of people shifting from farming
— Migration to urban areas due to lack of profitability in agriculture sector

Fig 5.50 Farmer based on land holding
Source: by author

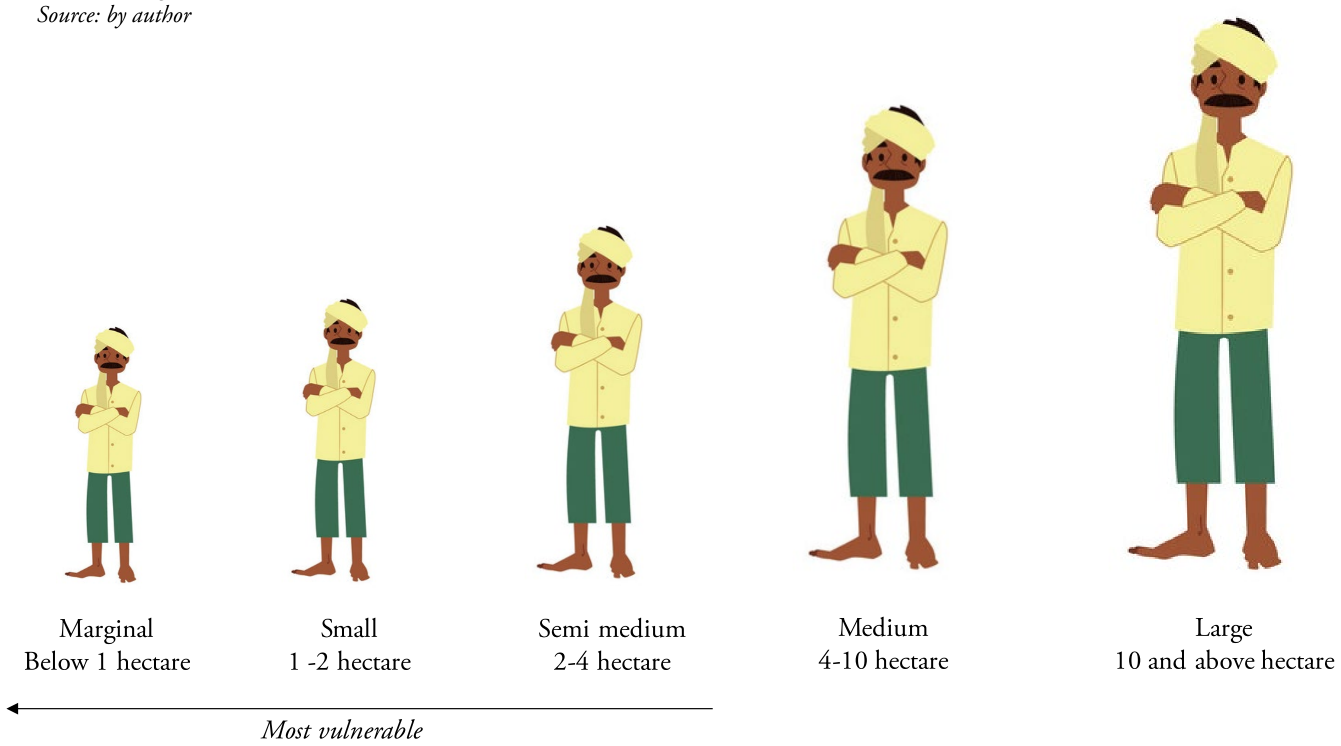


Fig 5.51 Cotton stored in farmer's house before selling
Source: by author

Fig 5.52 Cotton for processing at the mills
Source: by author

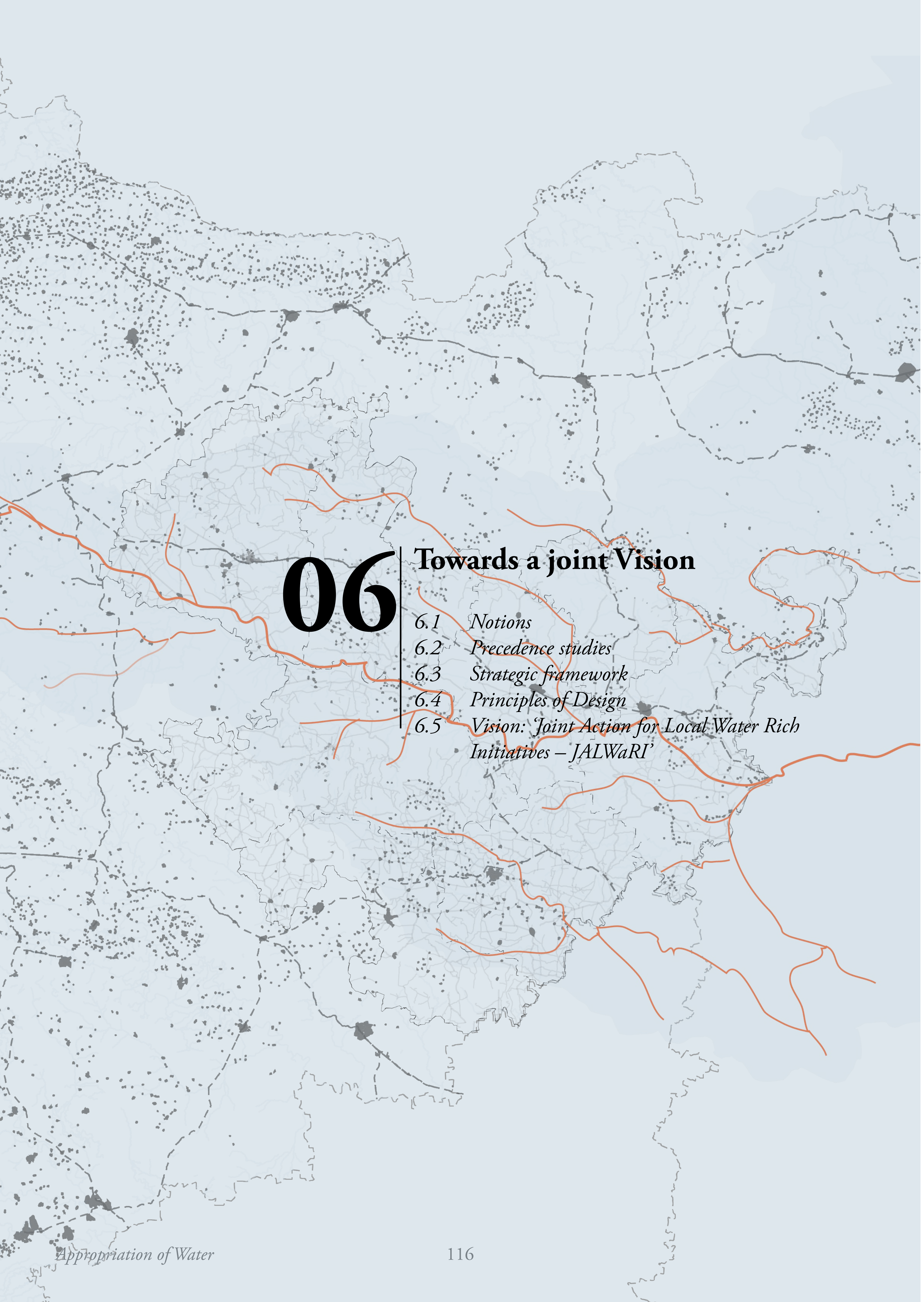
5.7 Conclusions from fieldwork

Local water scarcity and socio-economic decline

From the fieldwork, the main inference was that there is many factors that contribute to the local water scarcity issues but all are interlinked to the massive cotton production aimed at export markets. The farmers are unable to utilize the irrigation facilities and are dependent entirely on chance for good season and this also leads to a scarcity mentality when it comes to rain water harvesting. With a lack of accountability from people in power, to a lack of financial means to alleviate from poverty and a lack of necessary tools and awareness, results in an overall lack of water.

Lack of Accountability + **Lack of Finance** + **Lack of Awareness** → **Water Crisis**

Fig 5.53 Conclusions from fieldwork
Source: by author



06 Towards a joint Vision

6.1 Notions

In this chapter, the notions that are form the basis of conceptualisation of vision and strategies will be discussed. These notions are based on some of the theories as explained in some key literature regarding the broader concept of resource management and water governance. These notions can be divided into three main categories which will form the basis of the strategic framework. The three categories are; (1) organisational styles, (2) organizational structure and (3) integration of scales. Through these categories the key notions behind a changing water governance policies and management will be elaborated.

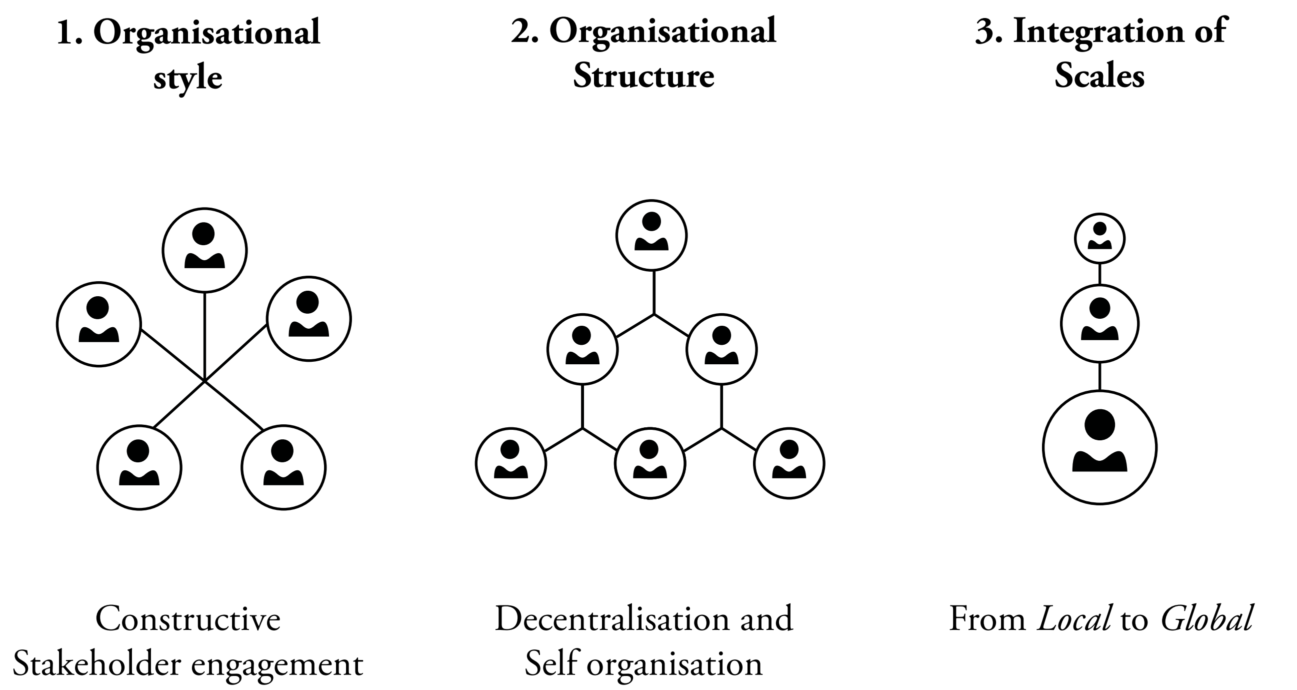


Fig 6.1 Notions
Source: by author

1. Organisational style : Constructive stakeholder engagement

The first notion is regarding the organisational style that is used to explain the current form of organisation as seen in the region of Marathwada. This helps in understanding the present situation and it contributes to the persistent systemic failure in terms of water resource management. The main concept that can be used to explain is "The tragedy of the commons" (Hardin, 1968), Hardin explains the theory behind the very reason of failure or collective is when individualism takes over prioritizing the benefits of a single or certain group of individuals over the others. The use of the commons if below the carrying capacity of the land, only then can all users benefit. Unfortunately, what is seen in the case of Marathwada is that, there is a monopoly by large farmers and cooperation's that use the resources, in this case water, for making individual profits thereby leading to scarcity of water overall. However, the cost of the degradation is incurred by all. Eventually the land will be unable to cope with the continuing activity and thus will lead to a complete system collapse as seen in the region.

The reasoning behind can be explained by using the cultural theory (Gyawali, 1999) that explains the institutional forces behind the water conflicts and problems in terms of allocation. It can be argued that there is a conflicting organisational styles which are behind the large infrastructure and single mission policies of hydropower and irrigation dams seen in the region which overlooks social empowerment that is necessary for the development of the region. Gyawali points out that a constructive engagement among different user groups and perspectives such as the state, market and civil society can only be the solution to the water problems in the region (Gyawali, 1999) .

2. Organisational Structure: Decentralisation and Self organisation

The existing organisational structure of irrigation management in the region of Marathwada can be explained as heavily state dominated with large investments on infrastructure which is often backed by private entities and foreign governments and a minimal revenue generation that is perpetuated and nourished by a corrupt political structure often leading to "rent seeking"(Mollinga & Tucker, 2010). There is a dire need for reform in the irrigation sector from various ideological backgrounds. The underlying theme is to move towards Decentralisation of irrigation management and monitoring or the devolution of power of water resource management to the everyday users like the farmer communities (Suhardiman & Mollinga, 2017).

Elinor Ostrom argues that local communities have effective ways of self organisation and self-governance capacities (Ostrom, 1990). This can be an effective method to avoid the "The tragedy of the Commons" and the degradation of natural resources. Therefore, the alternative strategy should be aimed at improving the self-organising capacity of local communities through various governmental interventions so as to develop a more efficient resource management regimes (Pahl-Wostl, 2002). Pahl-Wost describes this as a polycentric approach to governance and policy making that enhance systemic sustainability (Pahl-Wostl, 2002).

3. Integration of Scales: From *Local* to *Global*

As established in the first chapter, there is a global dimension to water problems that goes beyond borders and limits of the river basin. While formulating solutions for local water scarcity, it is also important to keep in mind the (sub)continental or even the global factors. Therefore, the governance approach should comprise of institutional arrangements that goes beyond the extent of the river basin (Hoekstra, 2011). This is only possible through the integration of scales in water resource management as well as governance policy discourses (Pahl-Wostl, 2002). This can be explained through multiscale perspective in the allocation of water.

At the local scale; this will mean having a vision and implementation strategy that focuses on self organisation and governance capacity of local communities (Chapter 6).
At the regional scale; it is about equitable allocation of water amongst different user groups and establishing synergies amongst them to achieve a sustainable and circular water system (Chapter 9).
At the state or transnational scale; it is about creating Institutions for collective actions for allocation and use based on availability of water in river basins.
At the Global scale; it is about Institutional arrangements for compensation, management, allocation based on virtual water transfers (Chapter 9).

This chapter will focus on the local scale and the vision for a decentralised system of water resource management and governance whilst look at a systemic way of integrating the different scales.

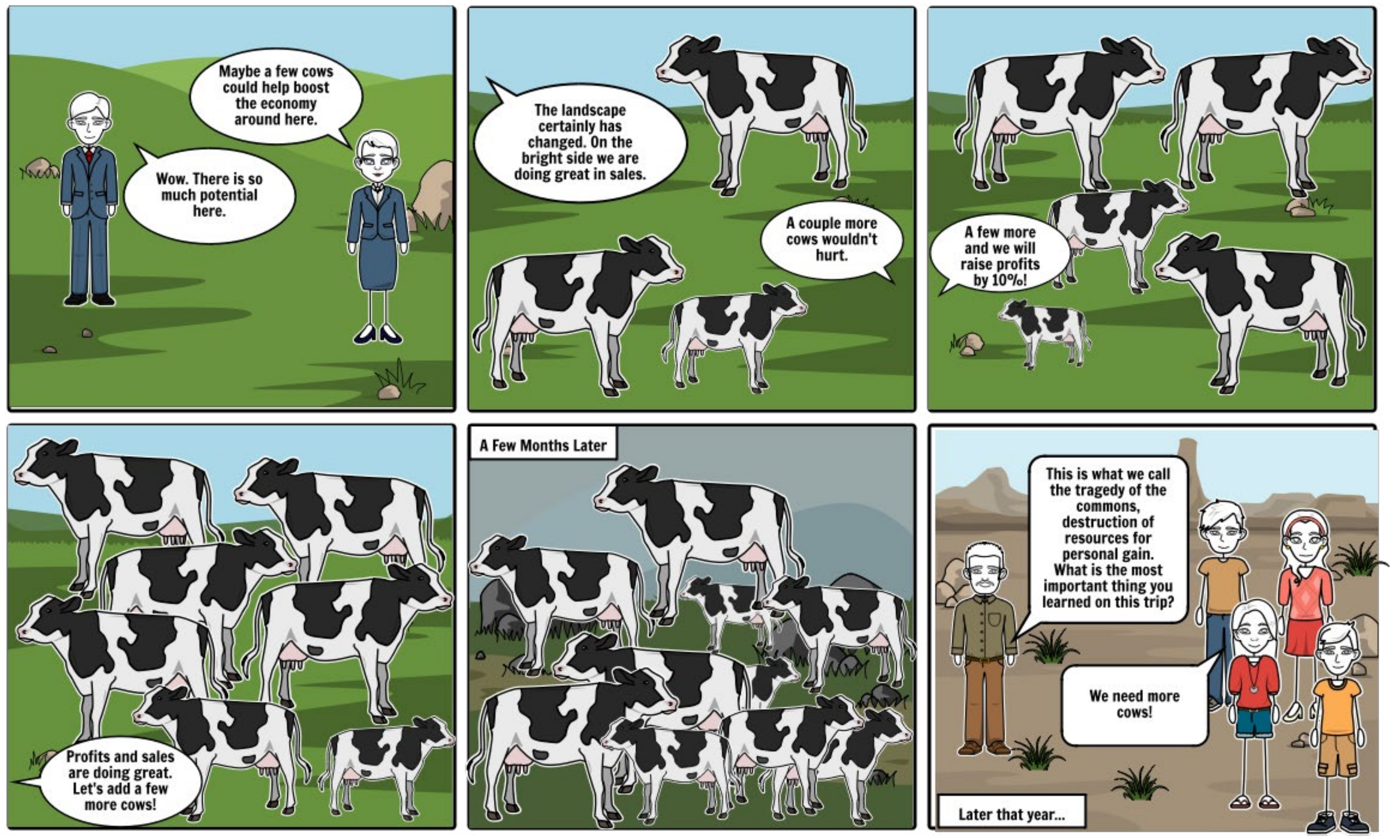


Fig 6.2 'Tragedy of the commons'
Source: https://sheilasingapore.wordpress.com/

6.2 Precedence studies

The following are some of the precedent studies that were used as references in understanding and formulating the vision and strategic framework. The examples are; (a) water management systems in Israel, (b) Self help groups from India, (c) Water Framework Directive, European Union and (d) Water boards from Netherlands.

(a) Israel has one of the best examples of improving water use efficiency for agricultural purposes. They are also a big exporter of water intensive crops. Almost 86% of waste water is recycled for the use of agriculture by 2015. The approach of Israel is good example of combing efforts of large scale recycling of waste water, micro irrigation technology and desalination of sea water has resulted in becoming a pioneer in water management technologies.

(b) Kudumbashree (translated to 'prosperity of family') is a local self help group initiative started by the government of Kerala state in India. Started in 1998, as a participatory program for poverty alleviation and women empowerment, the program aims at creating local self organised communities. They work through a 3 tiered system of community network run by women. The program aims at socio-economic empowerment by providing opportunities. This has been a success and has been adapted by several other states.

Fig 6.3 Water treatment and recycling
Source: https://www.plazilla.com

Fig 6.4 Kudumbashree model, Kerala,India
Source: https://www.azhimukham.com/

Fig 6.5 Water framework Directive
Source: https://ec.europa.eu/

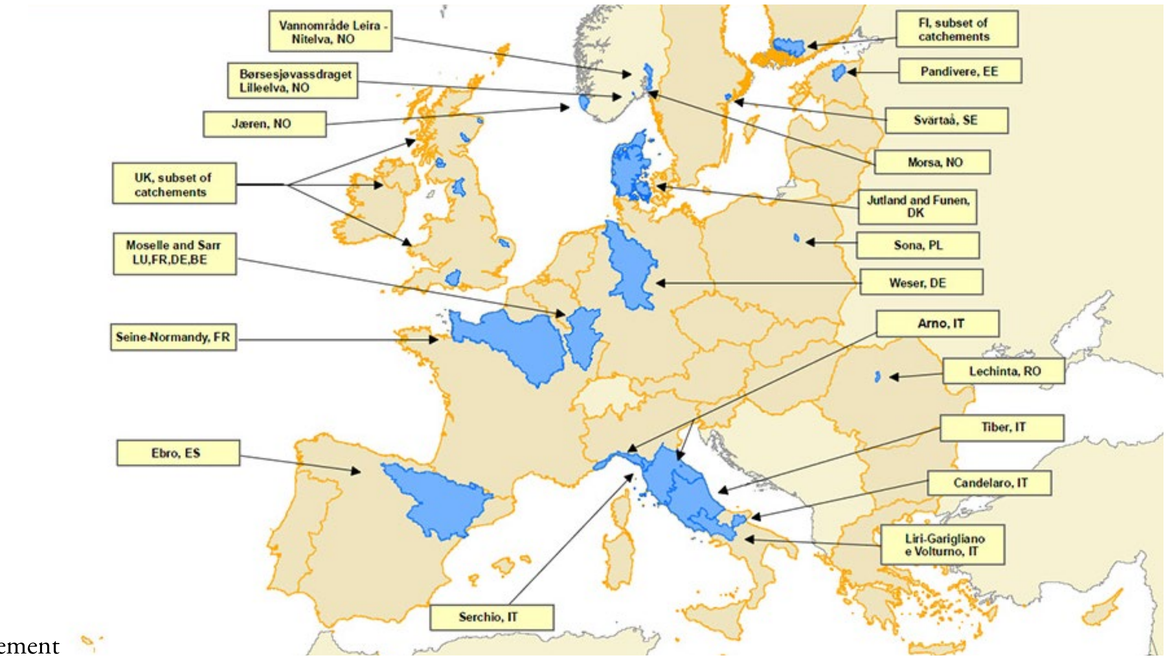


Fig 6.6 Water Management in the Netherlands
Source: https://issuu.com/

(c) The Water Framework Directive (WFD) was adopted in 2000 by the European Union as an integrated river basin management for Europe. This was a single system of water management looking at the geographical and hydrological units rather than administrative or political boundaries. The plan traversed national frontiers and meant coordination from different nations with which the river basin falls to work together.

(d) The Netherlands have developed an impeccable standard of water management and flood protection in the country. This is jointly done through the 21 'waterschappen' (district water boards) and the 'rijkswaterstaat' (national water board). Together they are responsible for ensuring sufficient water supply and protecting from floods. The rijkswaterstaat is responsible for maintaining the larger rivers and seas while the district water boards are responsible for canals and polder waterways. The water act sets out the responsibilities for the various government bodies involved.

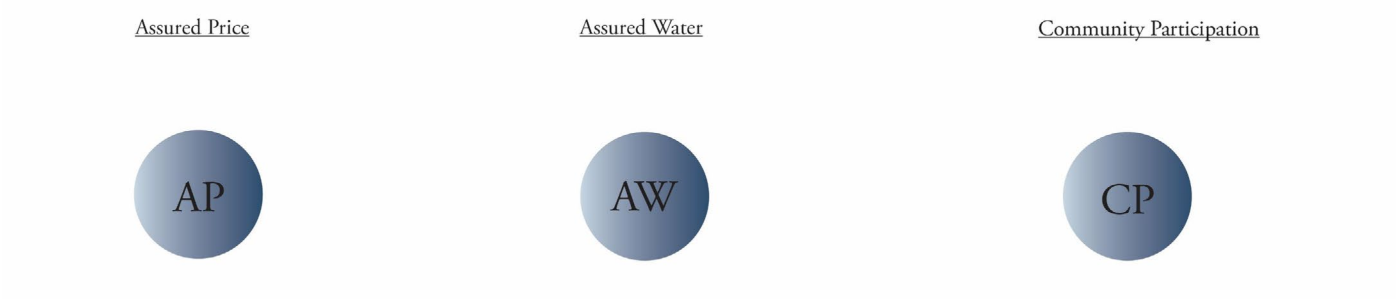
Fig 6.7 Water efficient irrigation, Israel
Source: https://www.lonelyplanet.com/israel/sde-boker

6.3 Strategic framework

Systemic synergies: Integration of local adaptation to global mitigation

The notions based on theoretical understanding and the precedent studies help formulate the strategic framework and towards a vision for water resilient futures. The concept model as shown in the figure below explains the systemic synergies between the sending, receiving and spillover systems in both the current and proposed new systems. From the earlier chapters, it is clear that the current system in unbalanced. In the supply chain of cotton water, the sending system is providing the resources such as the raw material in the agricultural production, the manpower which are the laborers and farmers, as well as monetary value in the form of initial investments and production costs. However, there is not enough compensation on these inputs from the receiving system who is getting the benefits of the products and also saving their resources such as water. The sending system also ends up with the negative externalities from this production chain which is also not shared by the other end of the system.

In the proposed new system, there is sharing of benefits as well as costs that is translated across the supply chain. Through the adopting the concepts of community engagement, decentralisation of resource management systems, and integration across scales, the inputs to the sending system are enhanced resulting in a more sustainable supply chain and thereby creating positive impacts in the socio-economic, spatial and environmental outputs. This is only possible if there is a proper compensation in terms of social and ecological costs of production which take into account the water, raw material and human capital. In addition to this there needs to be a transparent supply chain through water labeling and pricing which can result in global water use efficiency.



Assured Price is defined as the true price guaranteed for a product considering the social and environmental costs of production.

Generation of income through compensation leading to high quality products and transparent supply chain.

Assured Water is defined as the minimum water required for maintaining a comfortable living for farmers, 'water for livelihood' calculated as 5000 cubic meter per year.(based on calculations done by water conflict forum)

Equitable allocation and sustainable use of water resources through institutional reform.

Community participation can be defined as the joint participation formed by farmer coalitions for monetary benefits as well as sharing positive and negative externalities.

Decentralisation and Self organisation of water management and governance

Fig 6.8 Components for local adaptation
Source: Image by author

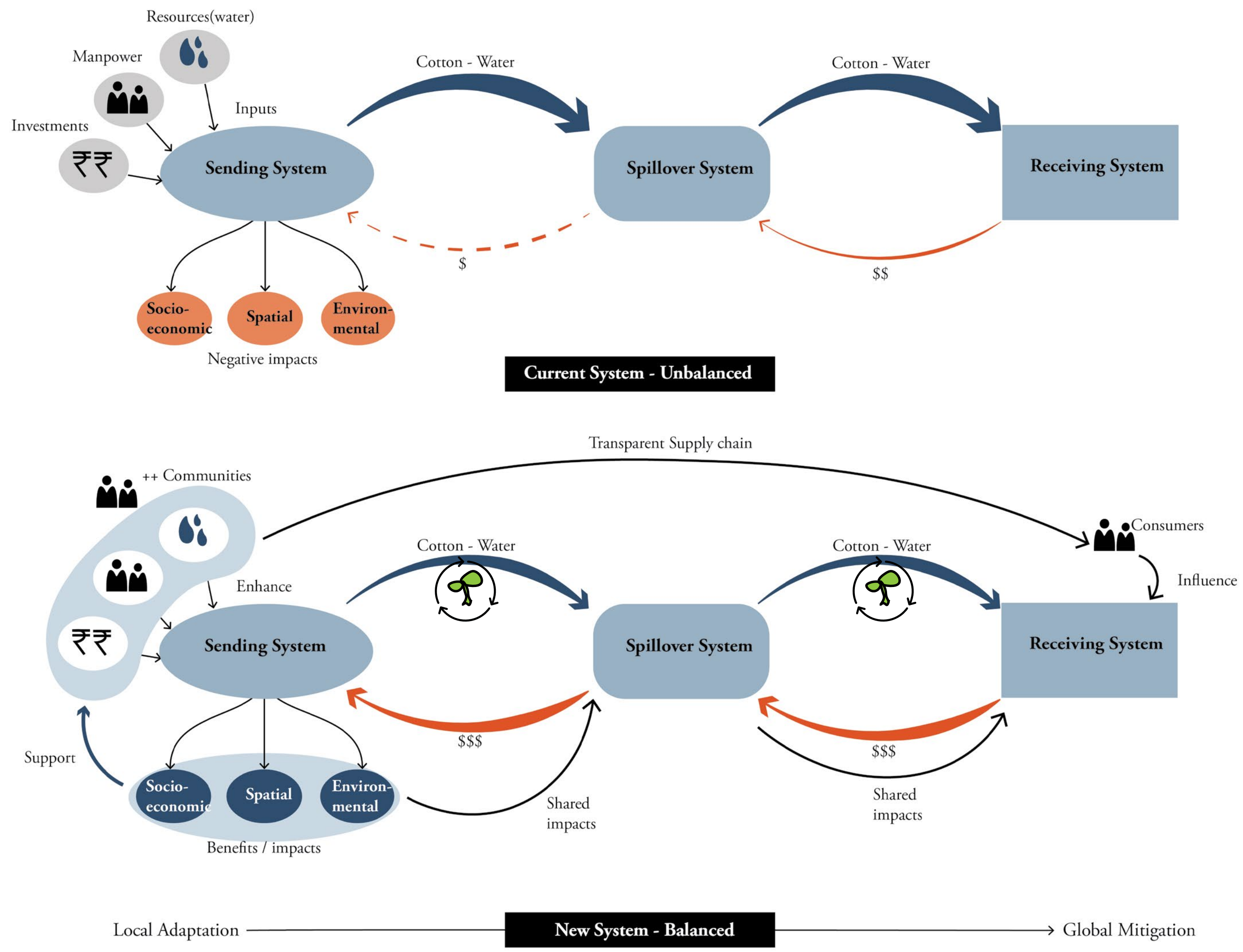


Fig 6.9 Current vs New system
Source: by author

6.4 Principles of Design

Principles for an 'Integrated Water Resource management' (IWRM)

The diagram below shows the systemic relationship in achieving local adaptation and towards an integrated water resource management. The components of adaptation as shown in the earlier section of 'assured water' and 'assured price' become the operational goals or 'what' through community participation, the 'how'. From this six principles of designs formulated which takes into account the two main goals for local adaptation; water resilience and social empowerment. The principles of design are aimed at guiding the strategic actions and the vision(Fig 6.7).

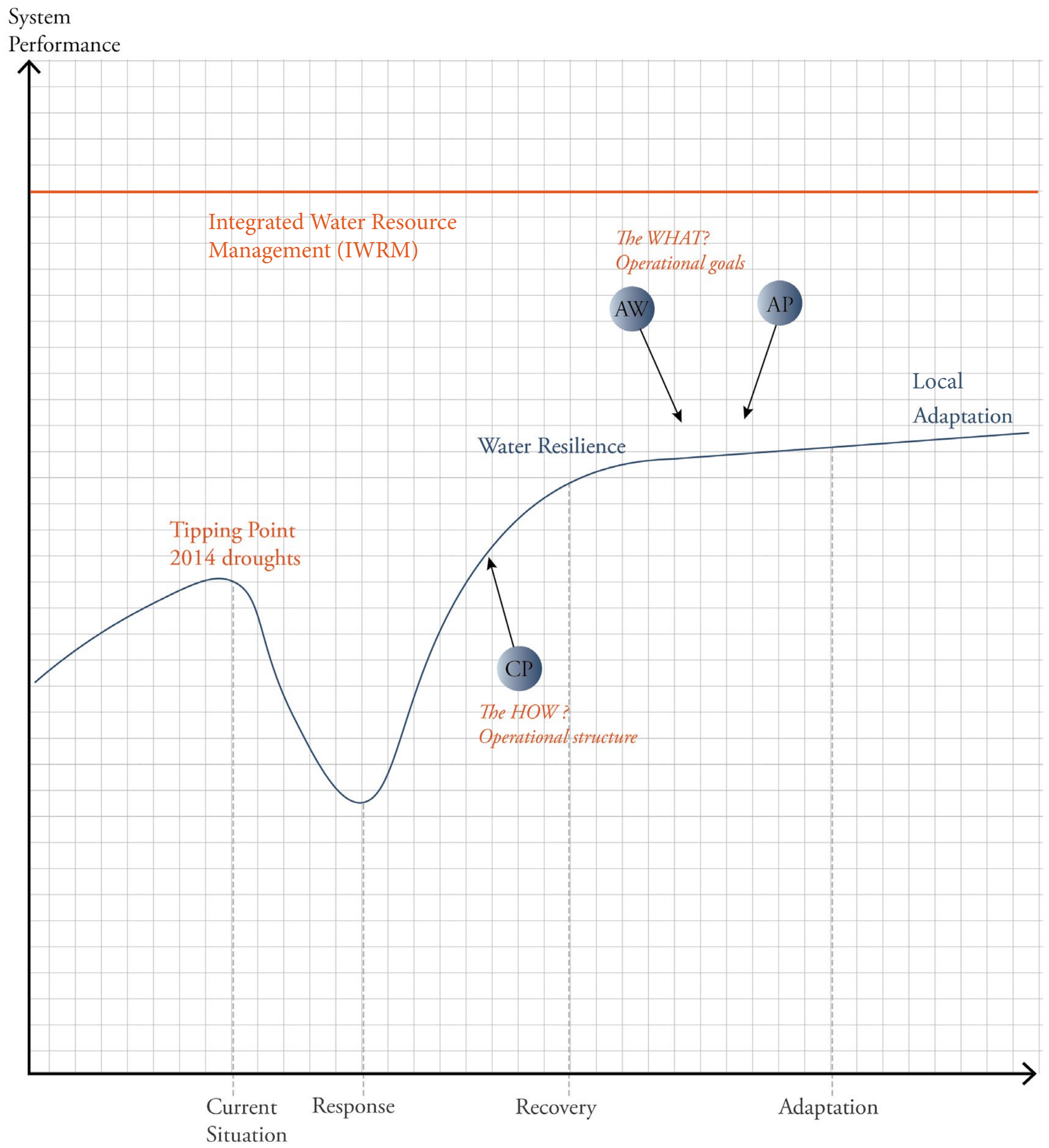


Fig 6.10 System performance over time
Source: by author

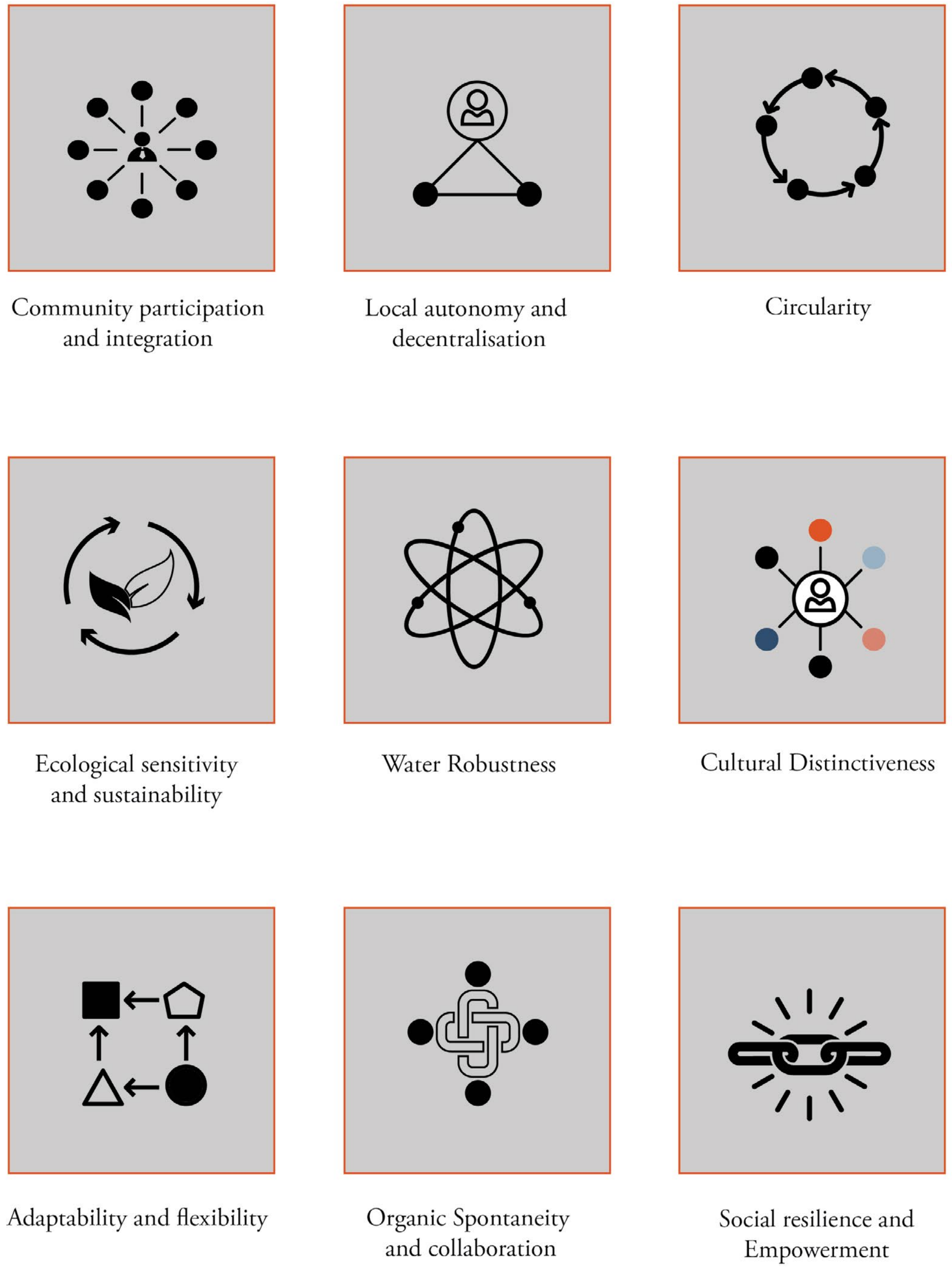


Fig 6.11 Principles of Design
Source: by author

6.5 Vision 2050

Towards vision: Strategic actions for local adaptation

The six principles of design guide specific strategic actions for the local scale that presents the necessary steps towards formulating the vision. The twelve strategic actions from the three parameters of water systems, management and governance is based on the notions of reform in water irrigation and farming practices and to achieve the operational goals as previously elaborated. They form the design rationale in guiding the design process and can be adapted depending on the context. Each form a crucial pillar in forming the vision for future.

The various aspects to introduce decentralisation will imply a changing role and responsibilities of different stakeholder groups and more involvement of the end users leading to more bottom up initiatives. There are also many examples in theory and practice where decentralisation can also have a positive impact on improving the socio-economic conditions. In countries like India, where public administration is not accurately functioning and non-reliable, giving more responsibilities to individuals is argues effective (Pahl-Wostl, 2002). But this has to be accompanied by providing opportunities that can nurture and empower citizens to take up and effectively undertake these responsibilities. This also requires social and institutional reforms and has to be in adherence to the existing cultural nuances.

The strategic actions are to the essential tools to achieve decentralisation in the water resource management. They give the power to the local community to carry out implementation and monitoring and gives them the necessary tools to achieve this. Further, the strategic actions are based on integrated water resource management principles thereby combining actions for water resilience together with sustainability of systems, social infrastructure development, empowering rural communities, socio-economic development and enhancing ecological systems. They are also aimed at creating farming practices that take into consideration increasing water efficiency.

The twelve strategic actions are; (1)farmer coalitions, (2)Micro financing options through self help groups, (3)farm ponds, (4)drip irrigation(or micro irrigation), (5)inter-cropping, (6)decentralised water treatment systems, (7) Water recycling through landscape integration, (8)Horticulture, (9)Zero Budget Natural Farming (ZBNF), (10) Cattle and poultry farming for additional income generation, (11)Enhancing ecological systems and promoting agro-tourism and (12)social infrastructure development and community empowerment programs.

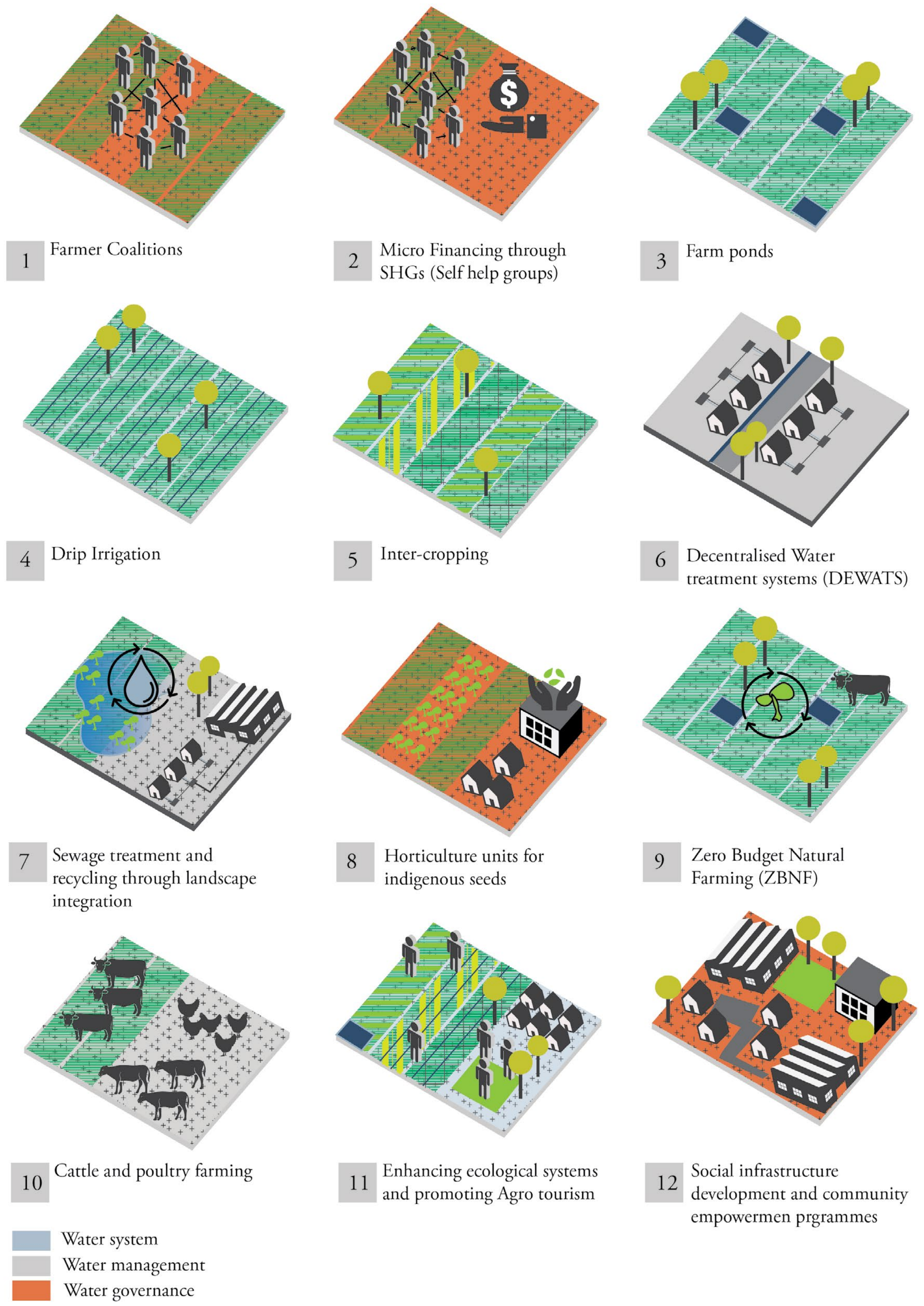


Fig 6.12 Strategies
Source: by author

Vision 2050: *'Joint Action for Local Water Rich Initiatives – JALWaRI'*

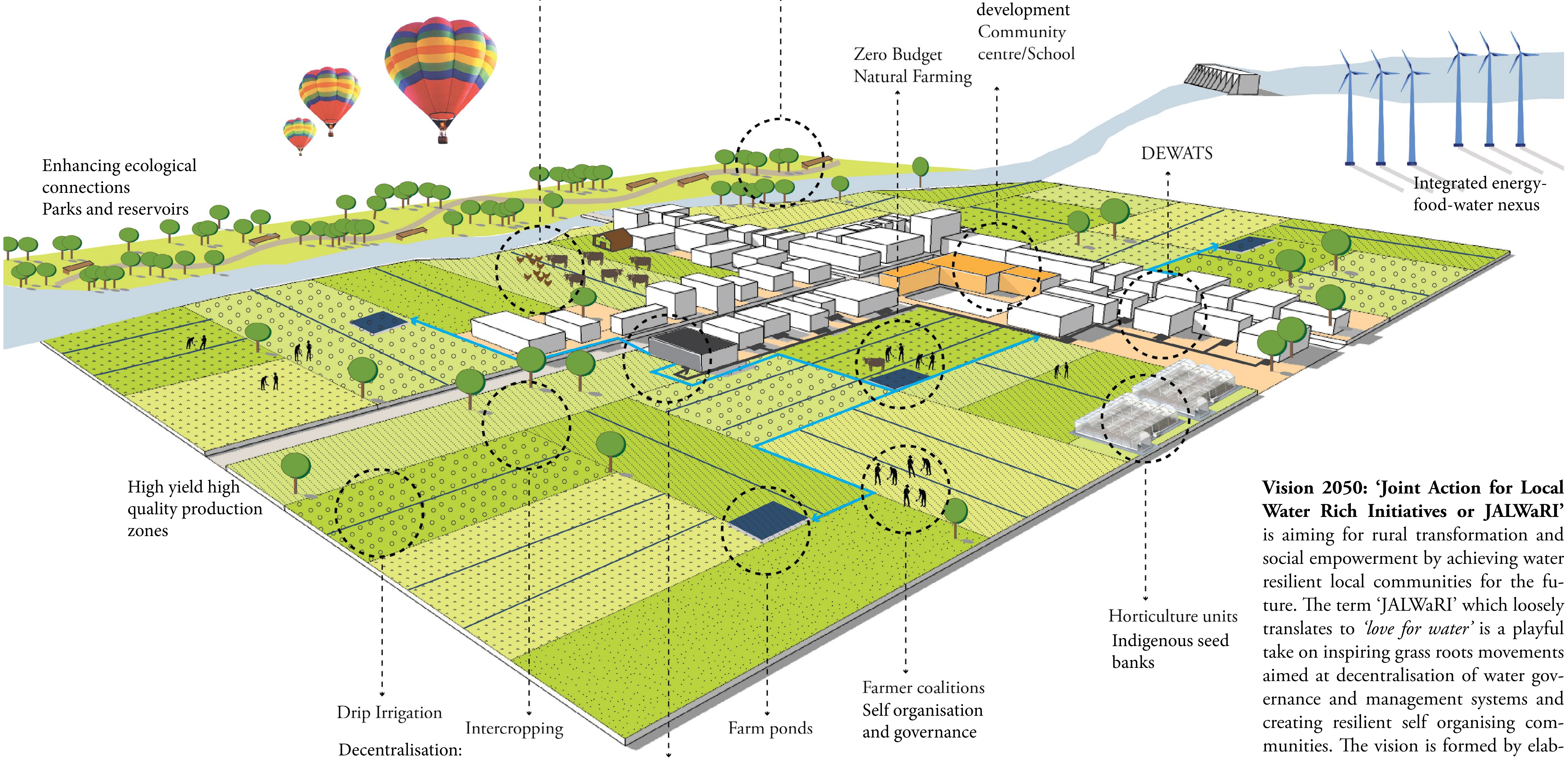


Fig 5.13 Vision 2050
Source: by author

Vision 2050: 'Joint Action for Local Water Rich Initiatives or JALWaRI' is aiming for rural transformation and social empowerment by achieving water resilient local communities for the future. The term 'JALWaRI' which loosely translates to *'love for water'* is a playful take on inspiring grass roots movements aimed at decentralisation of water governance and management systems and creating resilient self organising communities. The vision is formed by elaborating on the principle of design and the strategic actions for local adaptation. The vision aims at imaging a self sufficient and sustainable farming communities for future generations to safeguard and nurture the cultural heritage of rural areas.

07 Research by Design

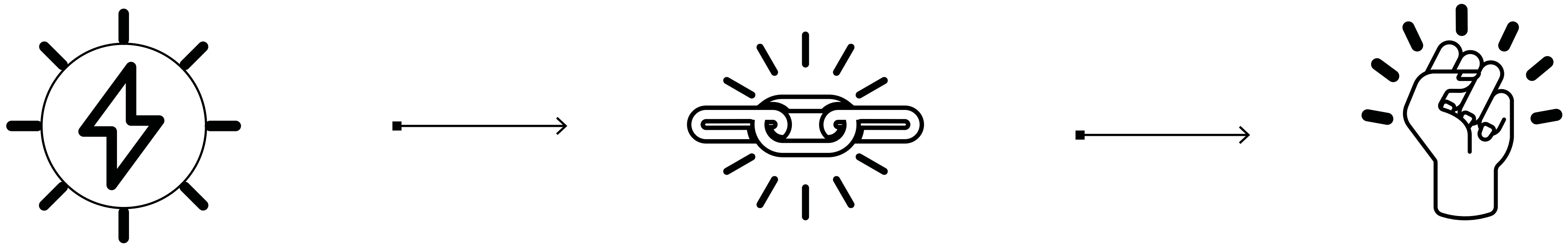
Fig 7.1 Cotton balls before harvest
Source: by author

7.1 Design phasing of evolutionary strategies for change

Energise
Short term goals and actions
(+5years)

Enhance
Medium term goals and actions
(+10 years)

Empower
Long term goals and actions
(+15 years)



	Energise Short term goals and actions	**Enhance** Medium term goals and actions	**Empower** Long term goals and actions
Operational Goals	- Awareness and Capacity building - Creating community participation and self organisation - Leveraging existing institutional structure and cultural links	- Sustainable irrigation and farming practices through decentralised water resource management - Circularity in water cycles and recycling of water for irrigation through synergy between user groups - Generating additional income through empowering women and vulnerable communities	- Ecological restoration and landscape integration - Social infrastructure development and community empowerment - Integrated water resource management towards evolutionary resilience

7.2 Test Case 01: Sarangpur Village, Ganagpur

Context

Sarangpur is situated 25km away from district headquarter and major city Aurangabad. Dahegaon is the gram panchayat of Sarangpur village along with 2 other villages. The total geographical area of village is 187.21 hectares. Sarangpur has a total population of 564 peoples. There are about 117 houses in Sarangpur village.

Cotton is mostly grown here along with other crops like, split pigeon peas(toor Dal), split chickpeas (Chana Dal), Red Lentils (masoor Dal), millet (bajra) ,Sorghum (jowari). Sugarcane is not grown due to non-availability of water. Mostly rain-fed irrigation is practiced as many bore wells in the village does not yield any water (based on field work and interviews).

Sarangpur village has lower literacy rate compared to Maharashtra state average. In 2011, literacy rate of Sarangpur village was 71.19 % compared to 82.34 % of Maharashtra. In Sarangpur male literacy stands at 86.23 % while female literacy rate was 55.17 %. Sarangpur village of Aurangabad has substantial population of schedule caste. Schedule caste (SC) constitutes 25.89 % while schedule tribe (ST) were 4.43 % of total population in Sarangpur village.

Fig 7.3 Site conditions
Source: by author

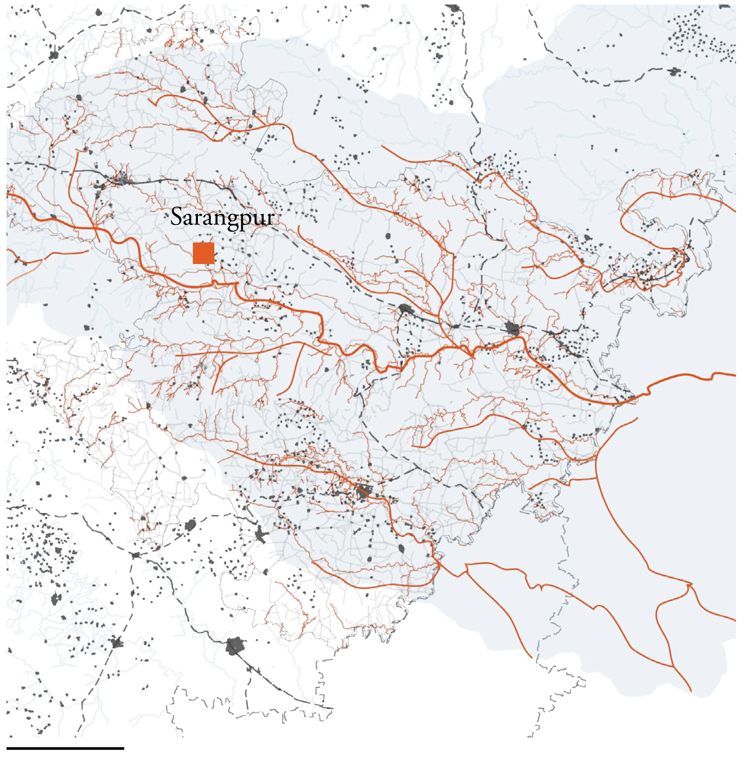


Fig 7.2 Site location
Source: by author

Fig 7.4 Site conditions
Source: by author

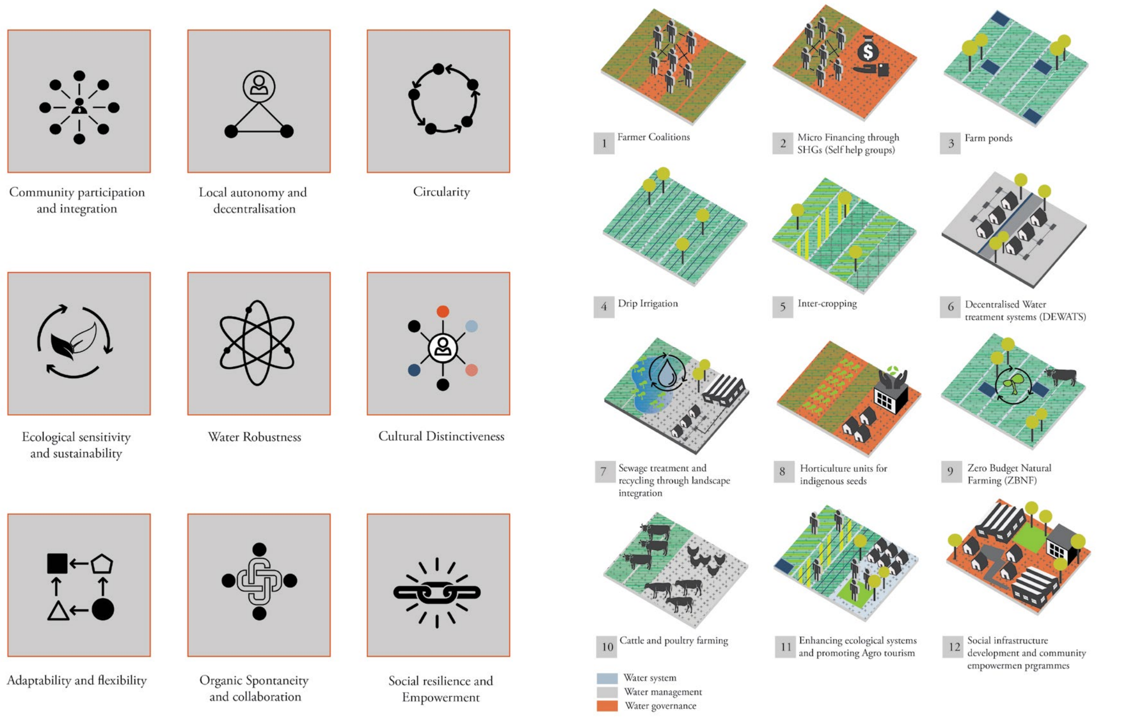


Fig 7.5 Principles and Strategies
Source: by author

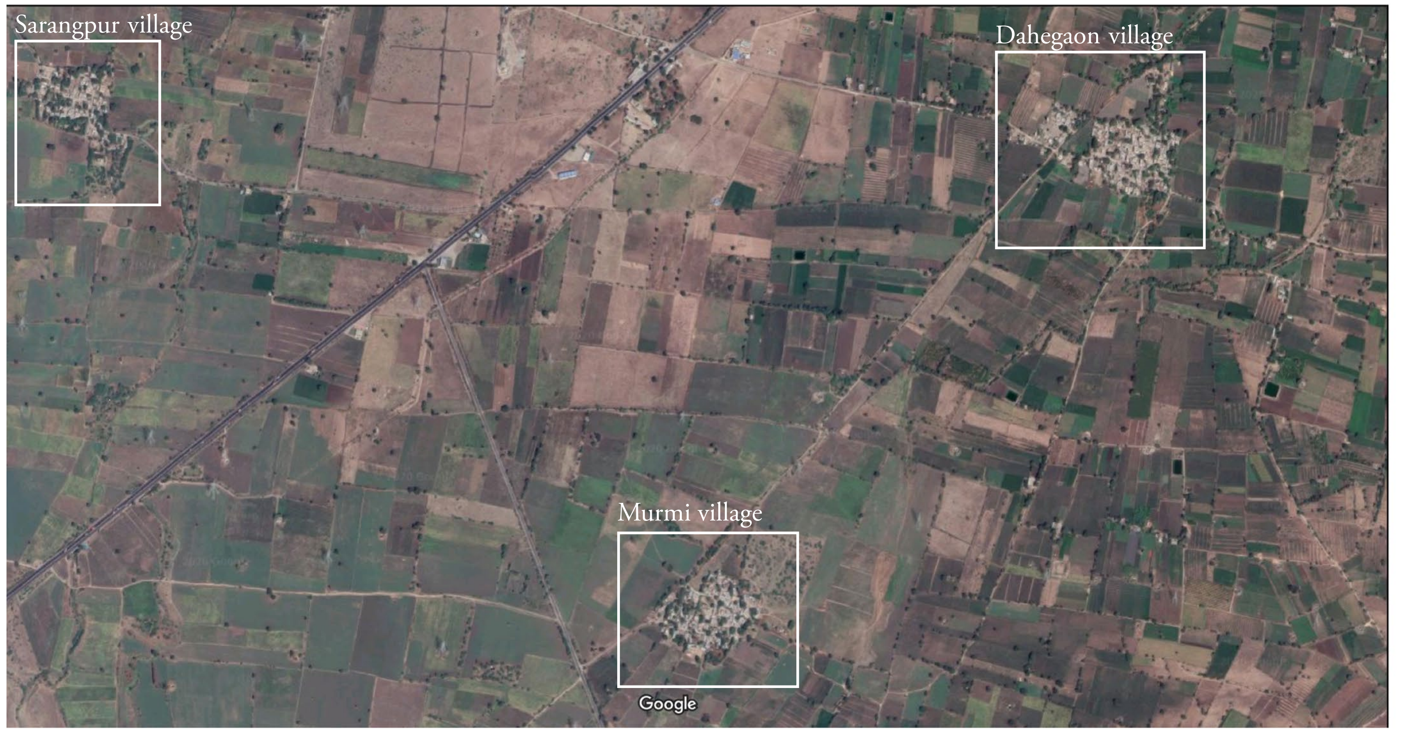


Fig 7.6 Context
Source: Google maps

Energise
Short term goals and actions

- Awareness and capacity building
- Creating community participation and self organisation
- Leveraging existing institutional structure and cultural links

1. Initiate village *JALWaRI* unit integrated with the formalised local self governance system at the village level or *Village panchayat*
2. Training and Vocational centres for capacity building and entrepreneurship programmes for women
3. Micro credit systems through *JALWaRI* unit

Fig 7.7 Phase I
Source: by author

Enhance
Medium term goals and actions

- Sustainable irrigation and farming practices through decentralised water resource management

- Circularity in water cycles and recycling of water for irrigation through synergy between user groups

- Generating additional income through empowering women and vulnerable communities

4a Sustainable irrigation and farming practices

4a Zero Budget Natural Farming(ZBNF)

4b Farm ponds

4c Intercropping and indegenious farming

4d Drip Irrigation

4e Crop rotations

5 Circularity in water systems

5a Decentralised water treatment systems(DEWATS)

5b Recycling of treated water for irrigation

6 Ensuring adaptability and flexibility

6a Poultry and cattle farming

6b Horticulture and indeginous seed banks

Grey water

Treated water

Fig 7.8 Phase II
Source: by author

Empower
Long term goals and actions

- Ecological restoration and landscape integration

- Social infrastructure development and community empowerment

- Integrated water resource management towards evolutionary resilience

7 Social infrastructure development

7a Community centre, daycare and school

7b Women entreprenuer centre and vocational training

7c Public parks and roads

7d Future housing expansion area

8 Community empowerment

8a Promoting agrotourism as a source of income generations

8b Vegetable and fruits market/ arts and crafts shops

8c Recreational areas and natural reservoirs

100 M

Grey water

Treated water

Fig 7.9 Phase III
Source: by author

Systemic section showing circular water cycles

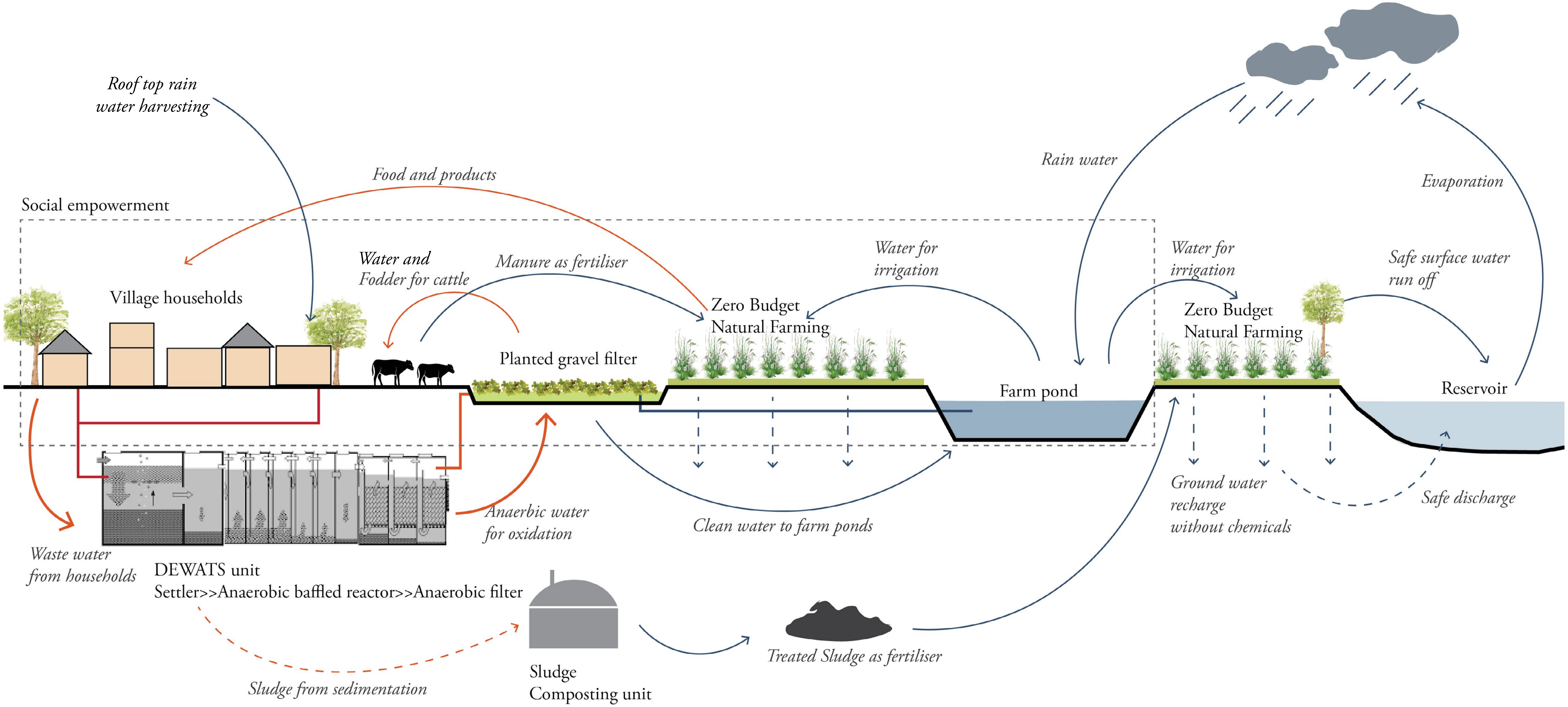


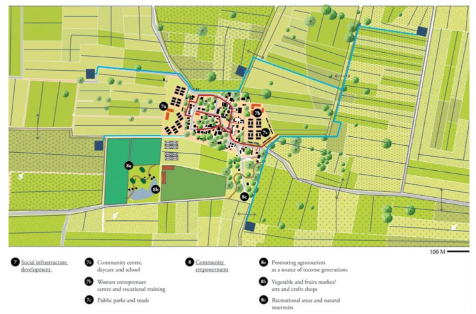
Fig 7.10 Systemic section
Source: Author

Systemic Scale Vision

Self organisation and governance of water resource management as a means
to a more robust local water system, social infrastructure development and community empowerment

Design phasing for evolutionary strategies for change

Energise (short term actions) 5 years - 2025	→	Enhance (medium term actions) 10 years - 2030	→	Empower (long term actions) 15 years - 2035



Stakeholders for each phasing

Energise:
- Small and Marginal farmers
- Large farmers
- Research Institutions
- NGOs

- State government
- Gram panchayats
- Taluka bodies / Tehsildars
- Maharashtra Water Resources Regulatory Authority (MWRRA)

- Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA)

Enhance:
- Small and Marginal farmers
- Large farmers
- Research Institutions
- NGOs

- State government
- Gram panchayats
- Taluka bodies / Tehsildars
- Maharashtra Water Resources Regulatory Authority (MWRRA)
- National Government
- International Organisations

- Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA)
- Cotton traders
- Cotton and textile industry

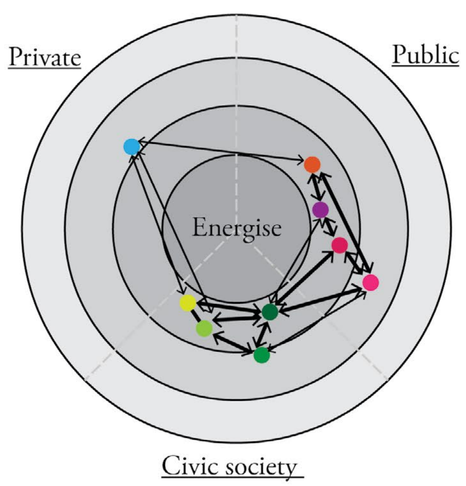
Empower:
- Small and Marginal farmers
- Large farmers
- Research Institutions
- NGOs
- Consumers

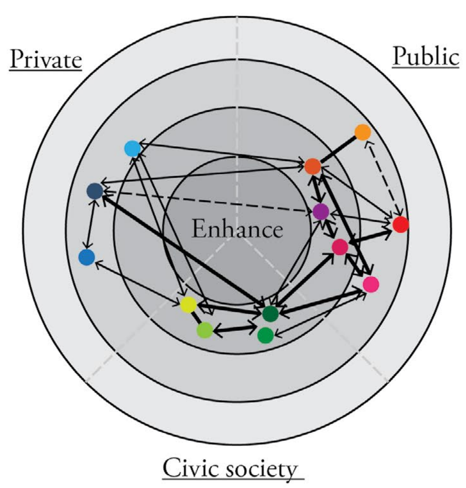
- State government
- Gram panchayats
- Taluka bodies / Tehsildars
- Maharashtra Water Resources Regulatory Authority (MWRRA)
- National Government
- International Organisations

- Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA)
- Cotton traders
- Cotton and textile industry
- Textile brands
- Sustainable initiatives

Proposed Stakeholders Engagement

Type of relationship
- ⟷ Strong
- ⟷ Ad-hoc
- ⇠⇢ Indirect





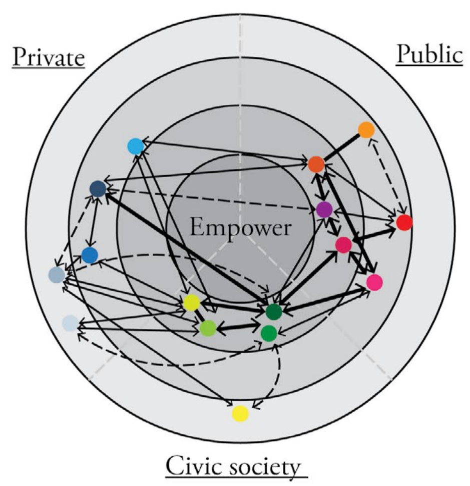


Fig 7.11 Actors vs Actions
Source: Author

Fig 7.12 Future impression of Sarangpur
Source: Author

7.1 Test Case 02 : Shendra Kamnagar

Context

After 1960, Maharashtra Industrial Development Corporation (MIDC) began acquiring land and setting up industrial estates. The Shendra industrial corridor was established next to Aurnagabad- Jalna highway in 1990.

Shendra Industrial Area has total area of 902 hectares. Of which 750.55 hectares is the village area. The Shendra Kamangar village has population of 2987 people (2018).

Mostly has marginal workers and agricultural laborers.

Shendra is located 17 km from Aurangabad. It is 8.0 km from Aurangabad airport. The Aurangabad railway station is 19.0 km away. The Shendra Industrial Area is just a 15 mins drive from the city. Shendar ahas many prominent industries such as Audi India, Škoda Auto, Volkswagen, Siemens etc.

Shendra Kamangar village has lower literacy rate compared to Maharashtra. The village is administered by village council headed by 'sarpanch' (village chief).

Fig 7.14 Site conditions
Source: by author

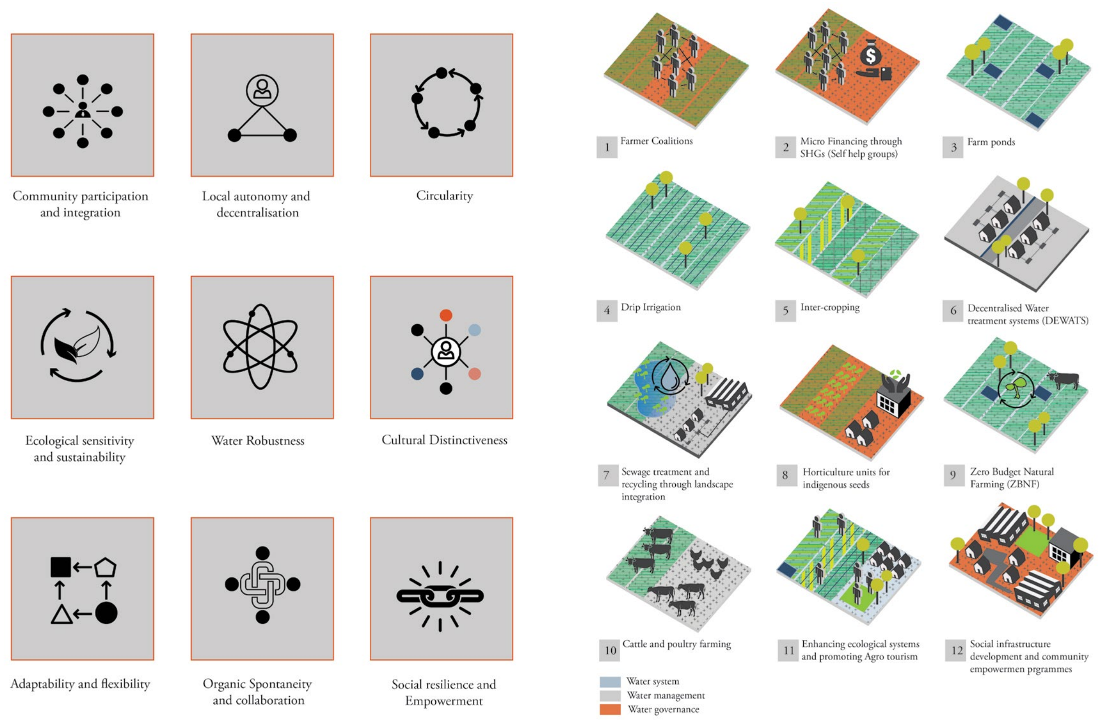


Fig 7.16 Principles and Strategies
Source: by author

Fig 7.13 Site location
Source: by author

Fig 7.15 Site conditions
Source: by author

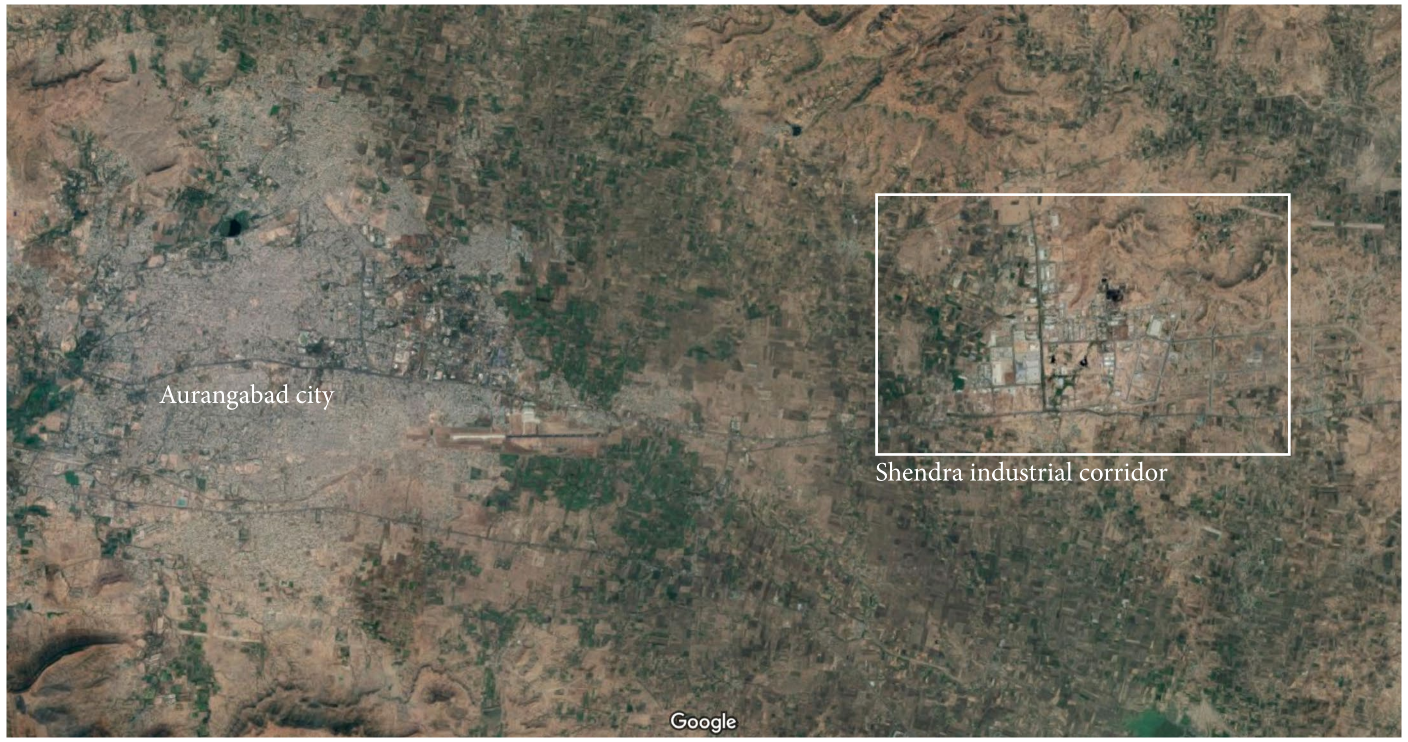


Fig 7.17 Context
Source: Google maps

Energise
Short term goals and actions

- Awareness and capacity building

- Creating community participation and self organisation

- Leveraging existing institutional structure and cultural links

Fig 7.18 Phase I
Source: by author

Enhance
Medium term goals and actions

- Sustainable irrigation and farming practices through decentralised water resource management

- Circularity in water cycles and recycling of water for irrigation through synergy between user groups

- Generating additional income through empowering women and vulnerable communities

100 M

4a Sustainable irrigation and farming practices

4a Zero Budget Natural Farming(ZBNF)

4b Farm ponds

4c Intercropping and indegenious farming

4d Drip Irrigation

4e Crop rotations

5 Circularity in water systems

5a Landscape integration : Artificial wetland for water treatment

5b Recycling of treated water for irrigation and industrial use &vice versa

6 Ensuring adaptability and flexibility

6a Aquaculture and integrated farming

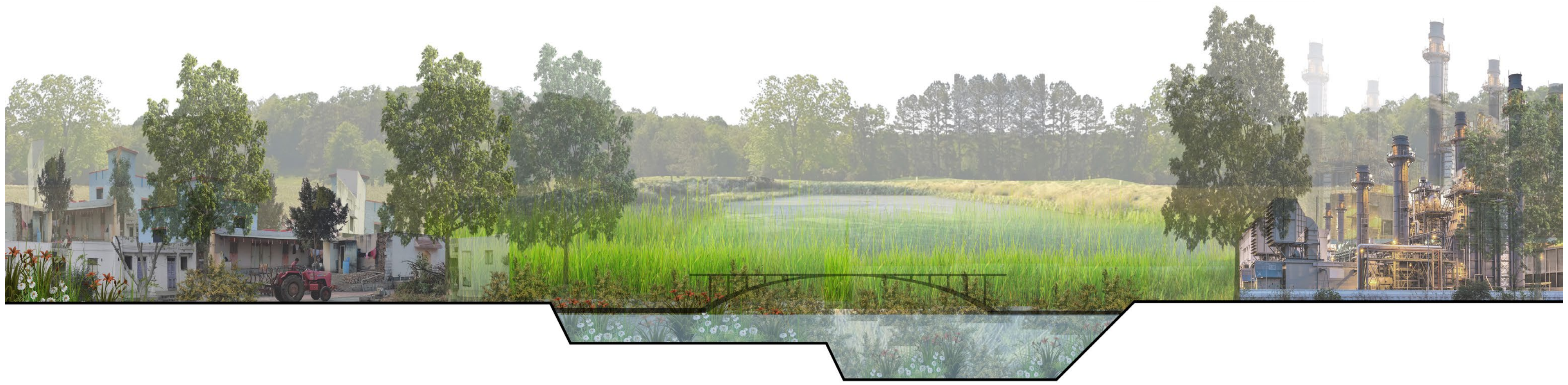
6b Horticulture and green houses

6c Community run Recycling and waste treatment plants

Grey water

Treated water

Fig 7.19 Phase II
Source: by author



Empower
Long term goals and actions

- Ecological restoration and landscape integration

- Social infrastructure development and community empowerment

- Integrated water resource management towards evolutionary resilience

100 M

Grey water

Treated water

7 Social infrastructure development

7a Community centre, daycare and school

7b Women entreprenuer centre and vocational training

7c Public parks and roads

7d Future housing expansion area

8 Agrotourism and Landscape integration

8a Tourist attractions and convention centres

8b Learning and awareness centres

8c Recreational areas and natural reservoirs

Fig 7.20 Phase III
Source: by author

Systemic section showing circular water cycles

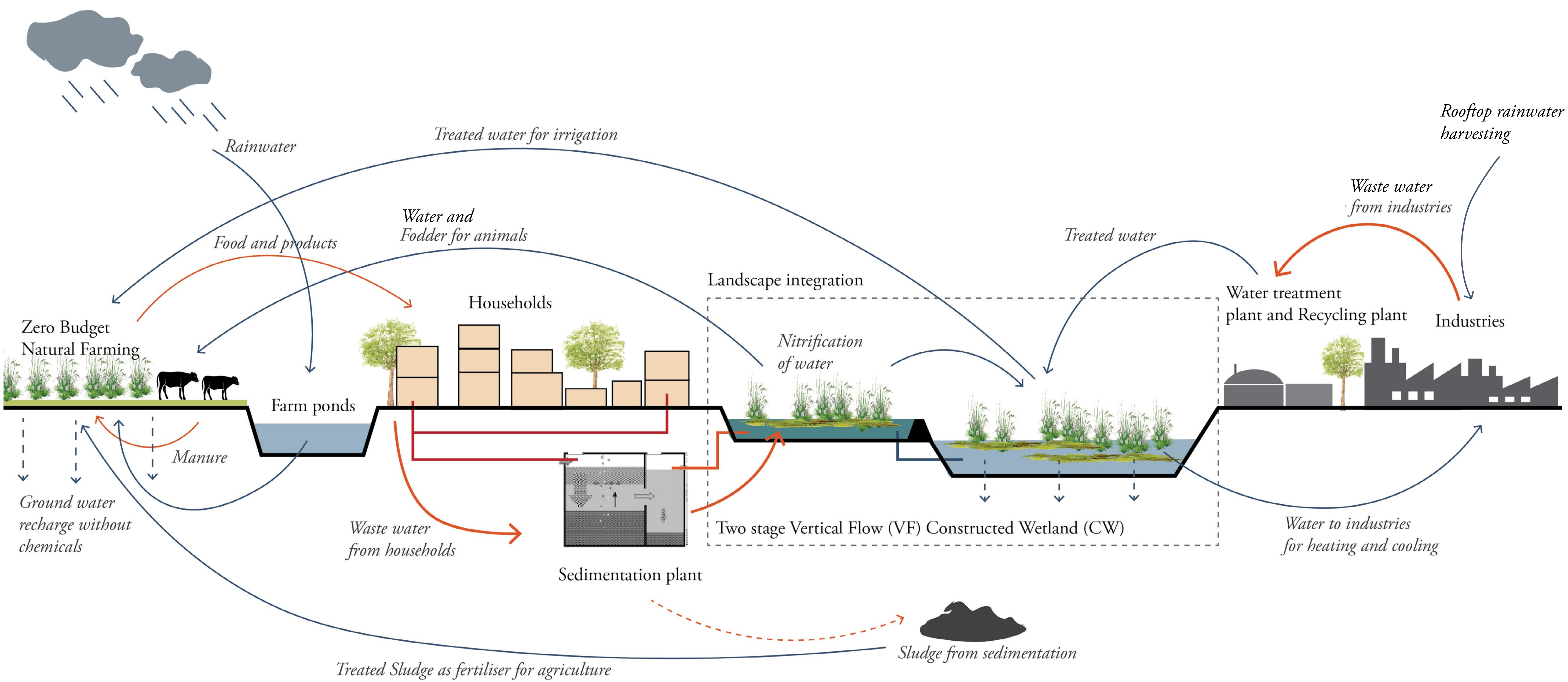


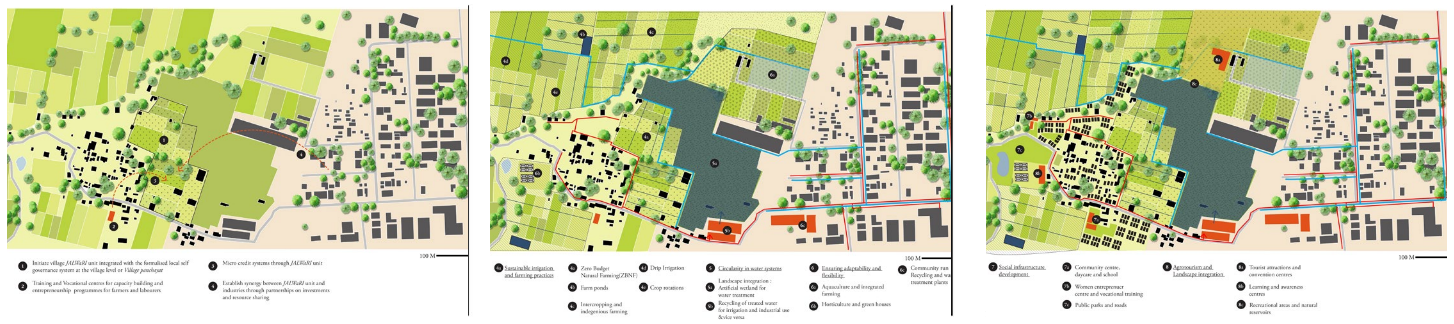
Fig 7.21 Systemic section
Source: Author

Systemic Scale Vision

Self organisation and governance of water resource management as a means
to a more robust local water system, active integration with local industry and sustainable developement

Design phasing for evolutionary strategies for change

Energise (short term actions) 5 years - 2025 → Enhance (medium term actions) 10 years - 2030 → Empower (long term actions) 15 years - 2035



Stakeholders for each phasing

Energise	Enhance	Empower
Small and Marginal farmers Large farmers Research Institutions NGOs	Small and Marginal farmers Large farmers Research Institutions NGOs	Small and Marginal farmers Large farmers Research Institutions NGOs Consumers
State government Gram panchayats Taluka bodies / Tehsildars Maharashtra Water Resources Regulatory Authority (MWRRA)	State government Gram panchayats Taluka bodies / Tehsildars Maharashtra Water Resources Regulatory Authority (MWRRA) National Government International Organisations	State government Gram panchayats Taluka bodies / Tehsildars Maharashtra Water Resources Regulatory Authority (MWRRA) National Government International Organisations Tourism department
Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA) Local Industries	Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA) Cotton traders Cotton and textile industry Local Industries	Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA) Cotton traders Cotton and textile industry Textile brands Sustainable initiatives Local Industries

Proposed Stakeholders Engagement

Type of relationship
- Strong
- Ad-hoc
- Indirect

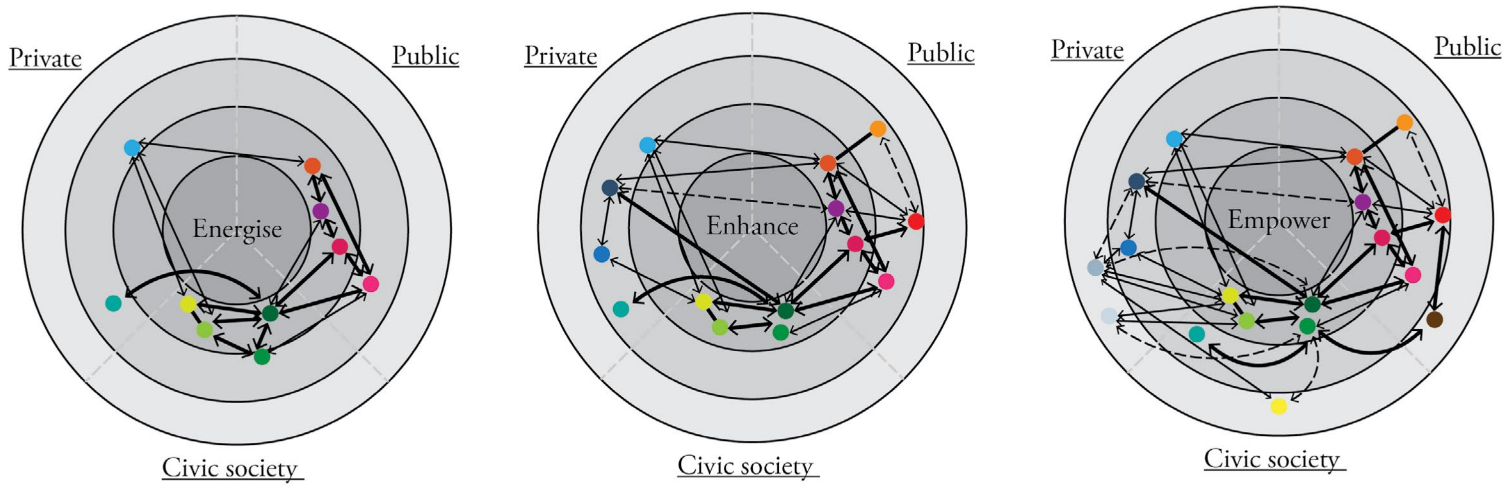


Fig 7.22 Actors vs Actions
Source: Author

Fig 7.23 Future impression of Shendra industrial area
Source: Author

08 Water Governance Policy framework

8.1 Stakeholder engagement

Market centric system to human centric system

The current system is a market centric system with the policy instruments, infrastructure facilities all favoring the industry which is in turn favoring the textile brands based on Global markets. There is no correlation between the consumer and the farmer who produces the commodity nor is there any instrument to support and cater their needs. Therefor the farmer become neglected communities and the consumers are unaware. The proposed framework for stakeholder engagement will look toward reorganise the current relationship to a human centric system.

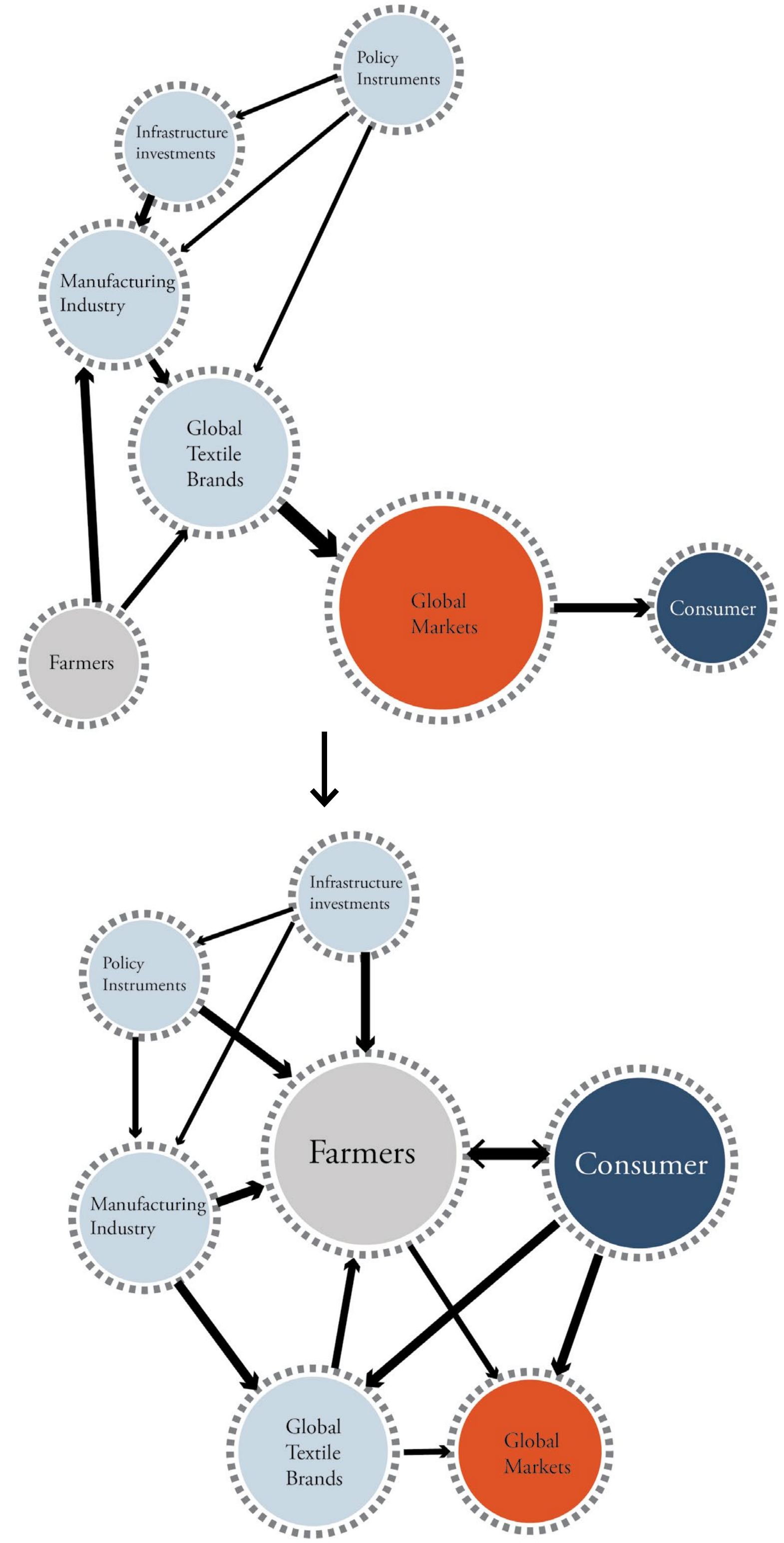


Fig 8.1 System change
Source: Author

Stakeholder relationships: existing vs proposed

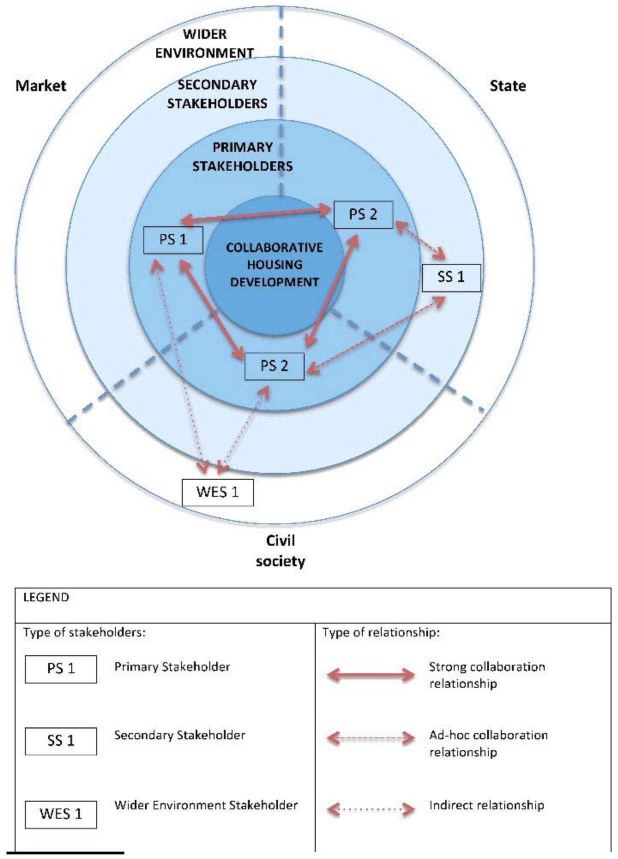
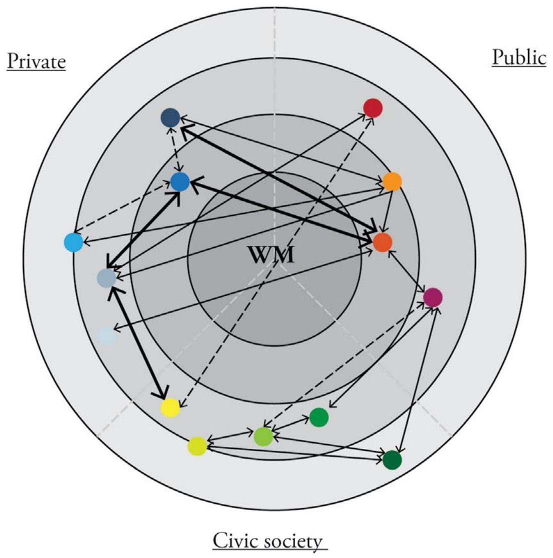


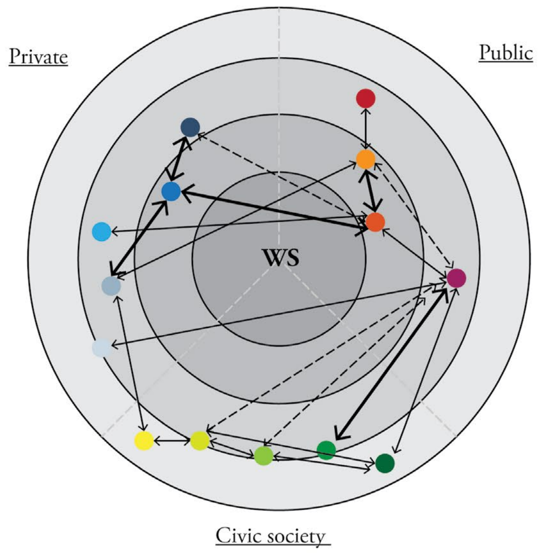
Fig 8.2 Stakeholder moel
Source: Czischke, 2007

The stakeholder relationship and engagement is explained using the model based on the Czischke's model on social housing provision in the European union (Czischke, 2007). The model places the stakeholders from primary to secondary to wider environment based on their power vs interest in the given topic of analysis. The existing relationship is elaborated by the author for the three themes, water system, water governance and water management. The diagram clearly depicts that the in all the three themes, the state is dominating with the highest power vs interest. They also have a direct relationship with the market in this case the cotton traders, manufacturing industries as well as textile industries. Hence, the current situation can be defined as more hierarchical and capitalistic.

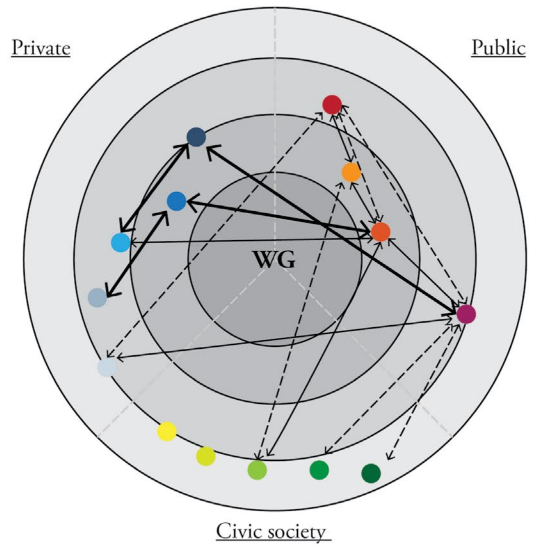
In the proposed stakeholder model, the civic society is envisaged as the primary stakeholder with most power to the farmers in close proximity with the NGOs and research organisations. They have direct relationship with each other as well as with the local governing bodies such as the village council and municipalities. There is also a proposed indirect relationship between the consumers and the farmers. This is aimed at increasing the transparency in the supply chain. They are also closely functioning with the state and governmental bodies as well as private entities. Therefore, the proposed model takes a more collaborative approach to stakeholder engagement and planning.



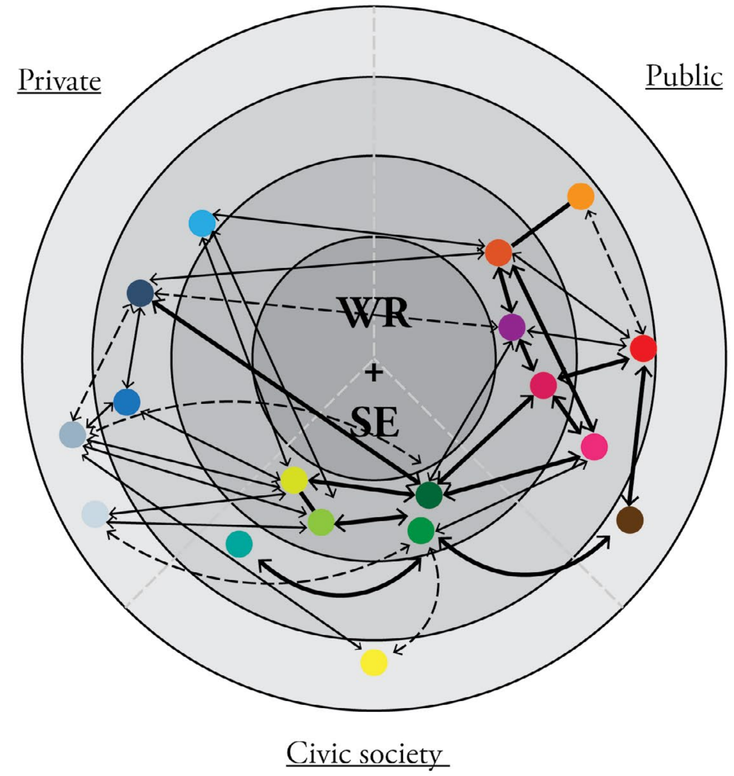
Water Management



Water System



Water Governance



Water Resilience + Social empowerment

- Small and Marginal farmers
- Large farmers
- Research Institutions
- NGOs
- Consumers

- State government
- Gram panchayats
- Taluka bodies / Tehsildars
- Maharashtra Water Resources Regulatory Authority (MWRRA)
- National Government
- International Organisations
- Tourism department

- Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA)
- Cotton traders
- Cotton and textile industry
- Textile brands
- Sustainable initiatives
- Local Industries

Type of relationship
- Strong
- Ad-hoc
- Indirect

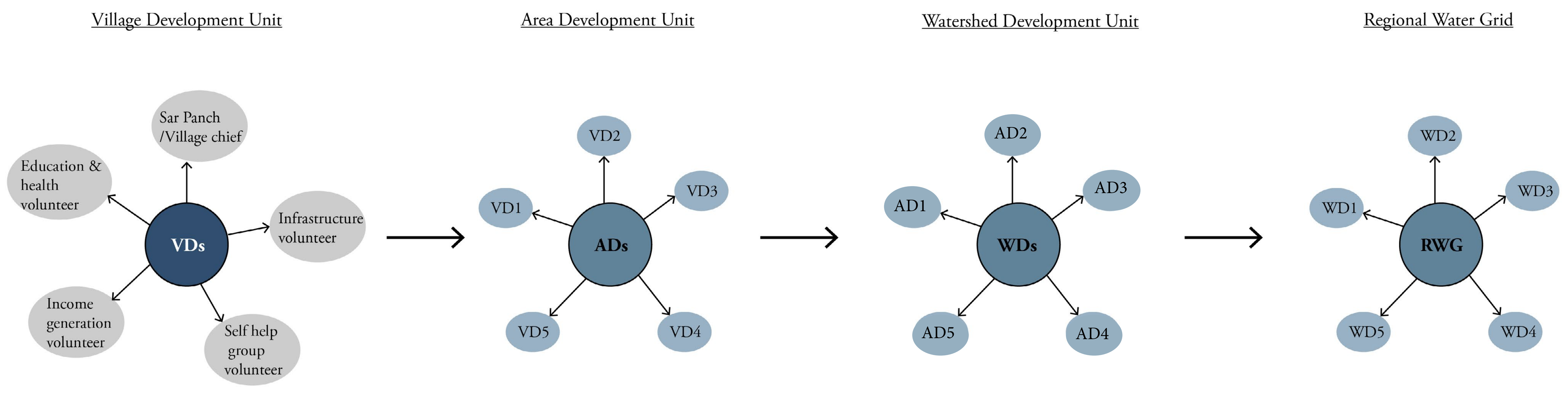
Leveraging existing socio-cultural structure and systems

The gram panchayat (transl. 'village council') is one of the lowest level of democratic form of government existing in rural India. It is the only grass-roots level kind of formal self governance system which is completely local. The village council is headed by a democratically elected village chieftain known as 'sar panch' by the members of the village for a term of 5 years. He is the decision maker in all matters regarding the village and governs with a village level constitutional body of 5 other elected representatives. They form the point of contact between the governmental organisations and the people.

By using this existing socio-cultural organisation to be part of a decentralised water system will be the most efficient method of establishing self-organisational structure at the village level. Further, the existing cultural norms and traditions as followed through the village council will add as an additional asset in planning and implementation processes.

Fig 8.3 Gram panchayat
Source: Photo by Shaji Kannur

8.2 A new model: 'Participatory water governance'



1 Member from each household in a group of 40-60 families

5 Office bearers democratically elected through the village council for a 5 year term

Representatives from each *Village unit* working with the municipality or tehsil

Office bearers democratically elected will form the general body

Representatives from each *Area unit* within the respective watersheds

Executive committe of elected representatives of ADs democratically elected for 5 year term

Representatives from each *Watershed unit* within the Marathwada/Upper Godavari region

Regional water grid with elected representatives to work closely with Maharashtra Water Resources Regulation Authority

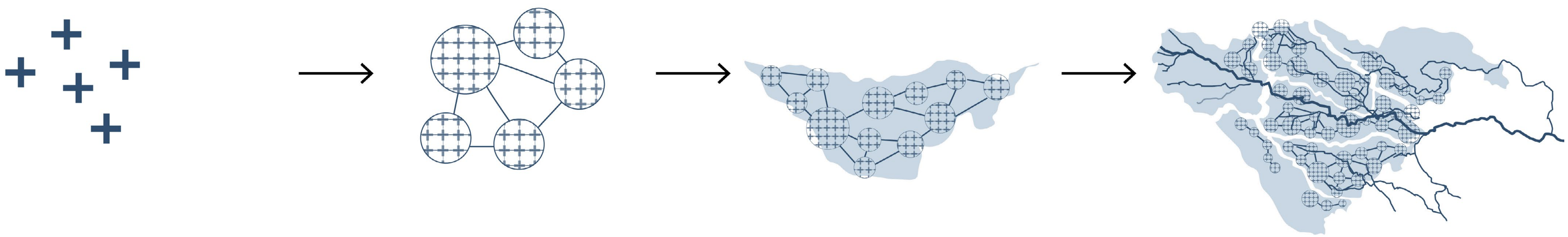


Fig 8.4 Water governance model
Source: by author

8.3 Regional Water Grid

Spatial representation of a new model of water governance

The term 'regional water grid' represents the alliances at various levels integrated to form a paradigm shift in the current water governance system to a new form of participatory water governance. The term 'water grid' is borrowed from a policy that aimed at decentralizing water infrastructure but was never fulfilled. The regional water grid is a collective approach of self organisation and decentralisation of water management systems at the local scale (villages) and then multiplying the similar concept to form several area, watershed and regional coalitions. One of the important aspects is the module at the sub regional scale representative of a water shed boundaries and not the administrative boundaries. This ensures an equitable allocation and distribution of water resources based on the characteristics of the watershed and gives a better organisation when it comes to water governance and management. It is important to uphold the democratic nature of organisation but from a top down bottom up perspective. The spatial representation showcases the transformation of the region based on these principles.

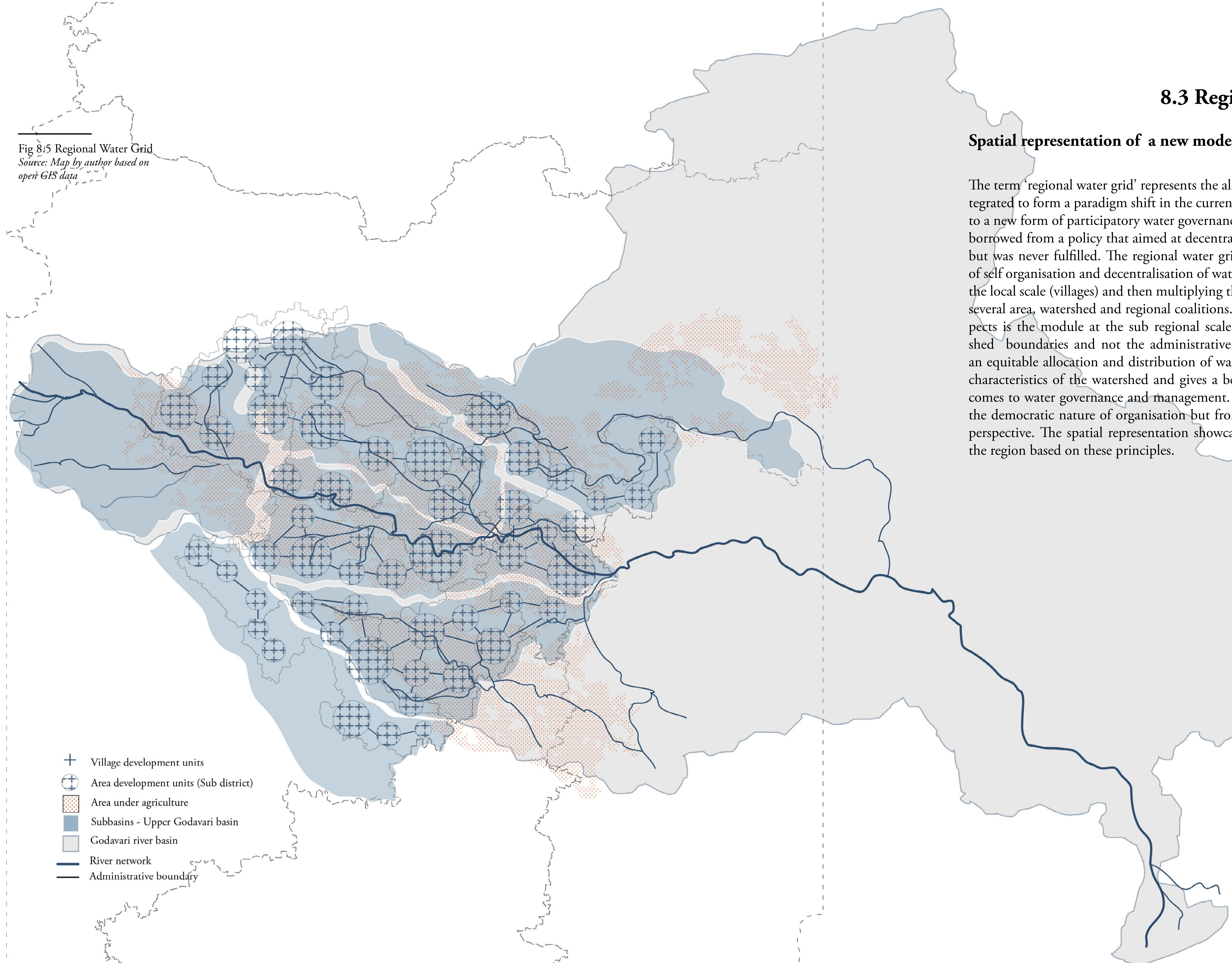


Fig 8.5 Regional Water Grid
Source: Map by author based on open GIS data

8.4 Policy implementation framework

The proposed framework gives a clear picture of carrying out the planning and implementation processes in order to successfully implement the system of participatory water governance. The pathways follows the steps from initiation by the state government to providing incentives for adopting the proposed vision by villages. This is to positively nudge in forming the village development units and creating a formalised form of self organisation for water resource management. The steps then follow from the analysis, frameworks for implementations, target identification and strategies for adoption. The final step is towards collaborative planning at the different scales from municipal to watershed to regional.

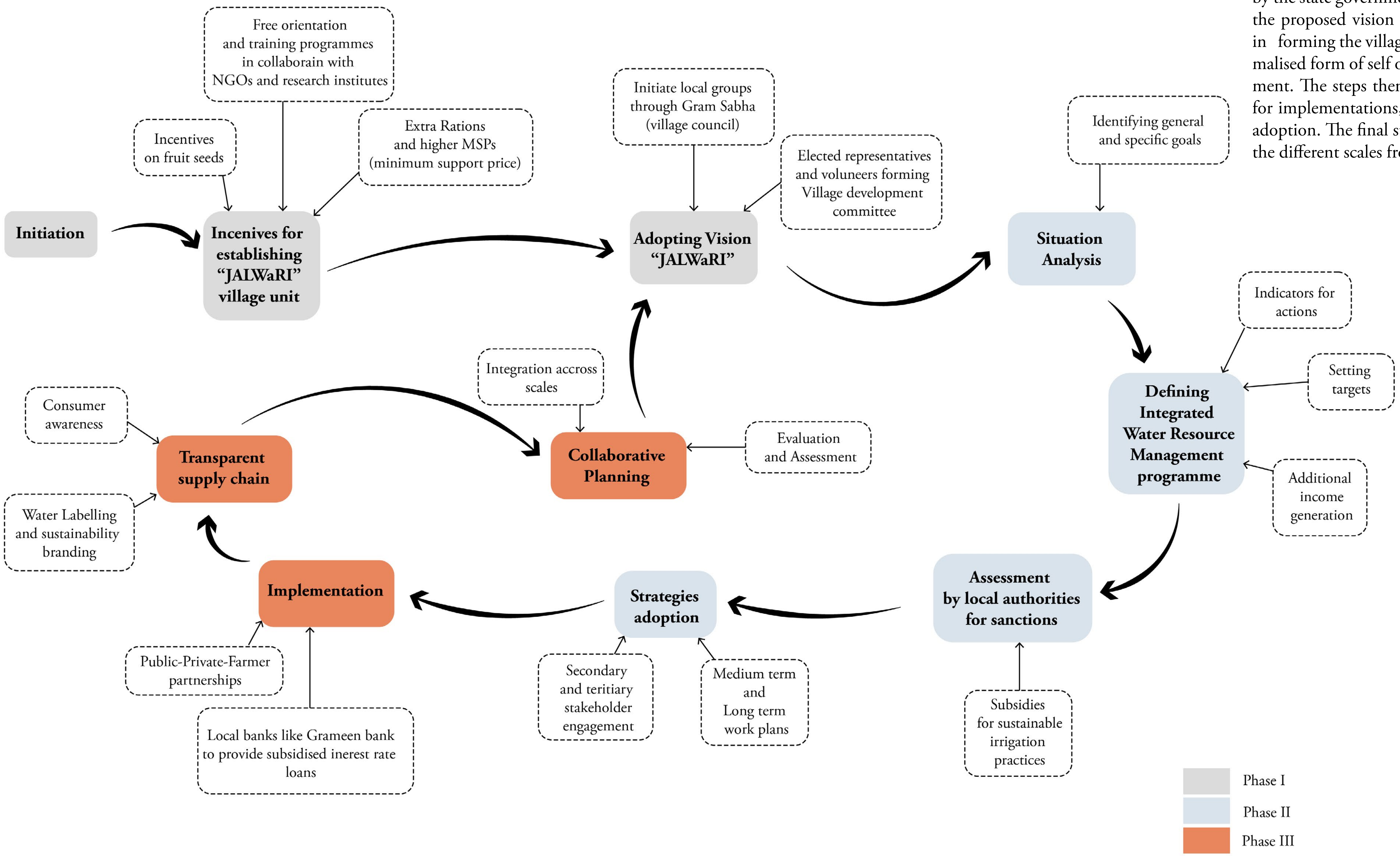
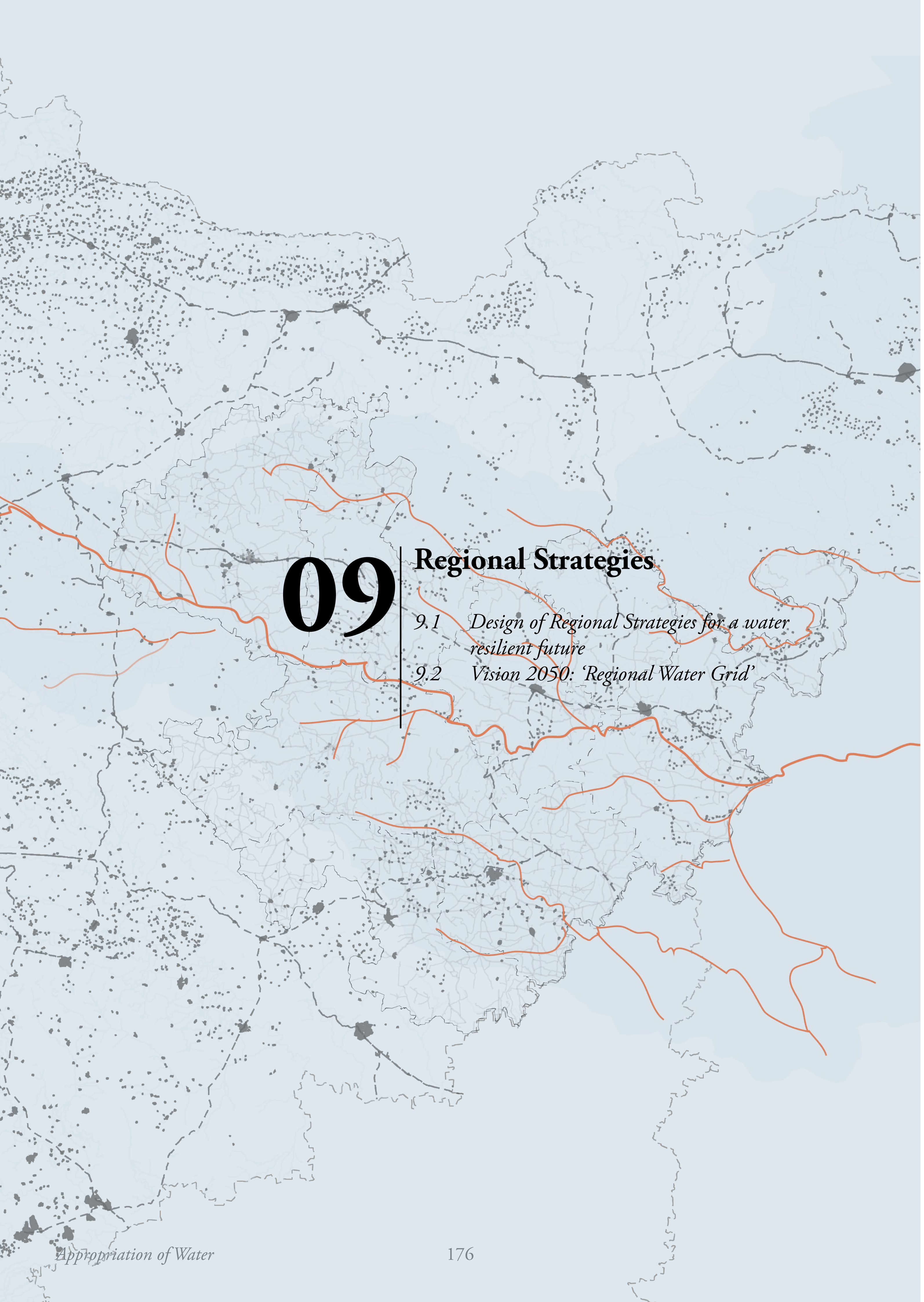


Fig 8.6 Implementation framework
Source: by author



09 Regional Strategies

9.1 Design of regional strategies for a water resilient future

An integrated and collective approach

The regional strategies are developed by translating the inferences from the micro scale analysis (test cases) to than macro level-of region. The six strategies for change is aimed at creating an integrated framework of water resilience, ecologically sustainability and social empowerment. These are the spatially represented to understand the systemic changes in creating a new water grid model of interconnected network of sub-basins and different user groups.

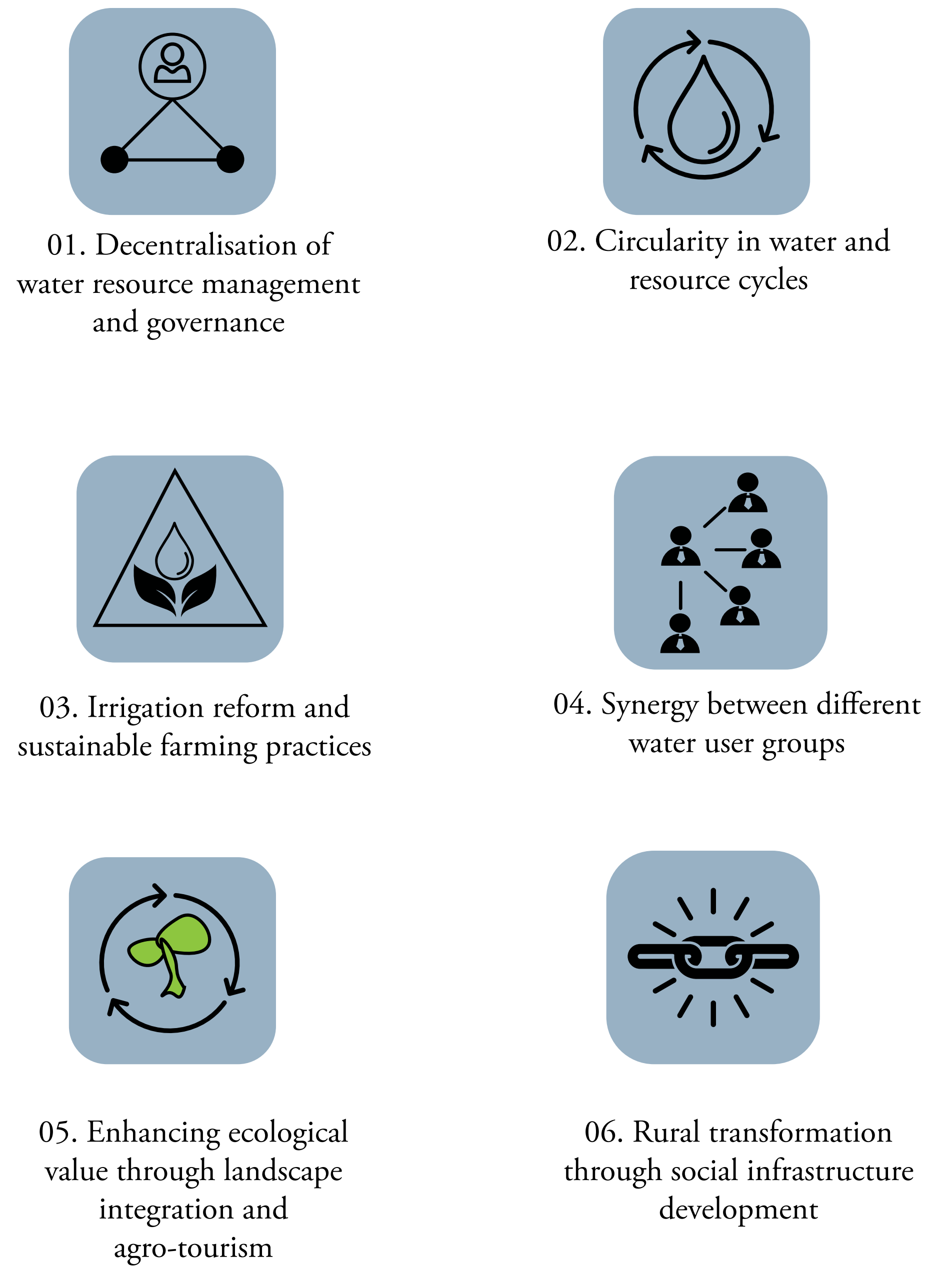


Fig 9.1 Regional Strategies
Source: by author

01. *Decentralisation* of water resource management and governance

The first strategy is aimed at creating a decentralised system of water resource management through the participatory governance structure as elaborated in the previous chapter (Fig 8.4). This will lead to an integration in planning instruments, infrastructure, policies and jurisdiction of water governance bodies. As well as a top down bottom up form of water infrastructure and governance framework realised through the multiplicity of self organising local coalitions across the region.

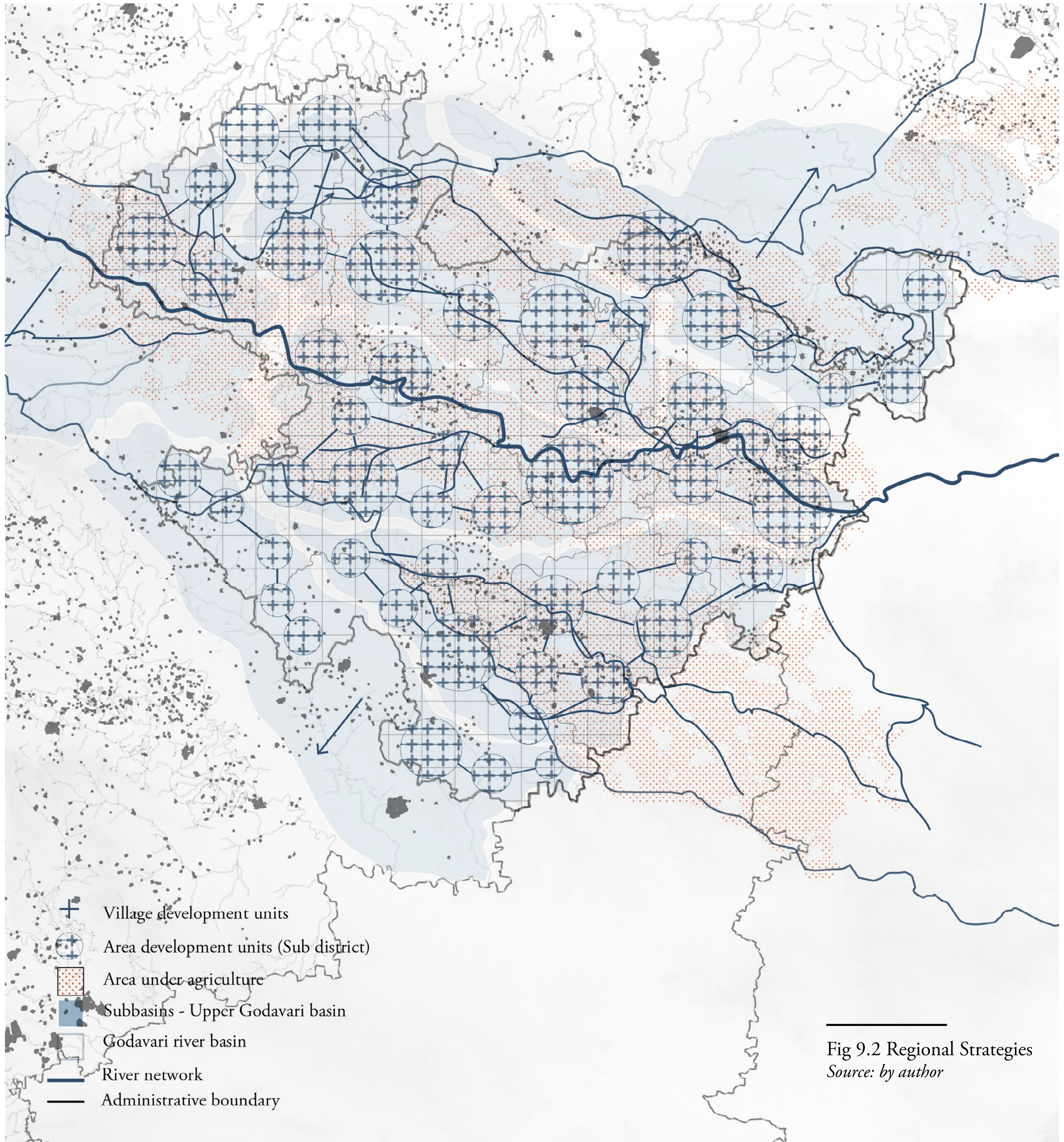


Fig 9.2 Regional Strategies
Source: by author

02. *Circularity* in water and resource cycles

This strategy is aimed at creating a circular water cycle to enhance ecological sensitivity and sustainability. The circularity is achieved at the local level through treatment of water from households in rural and urban areas through small scale practices such as decenralised water treatment systems and constructed wetlands as well as large scale practices of treatment for industrial areas. This water is recycled and used for agricultural purposes. This will also result in ground water recharge and clean water discharge in open water systems.

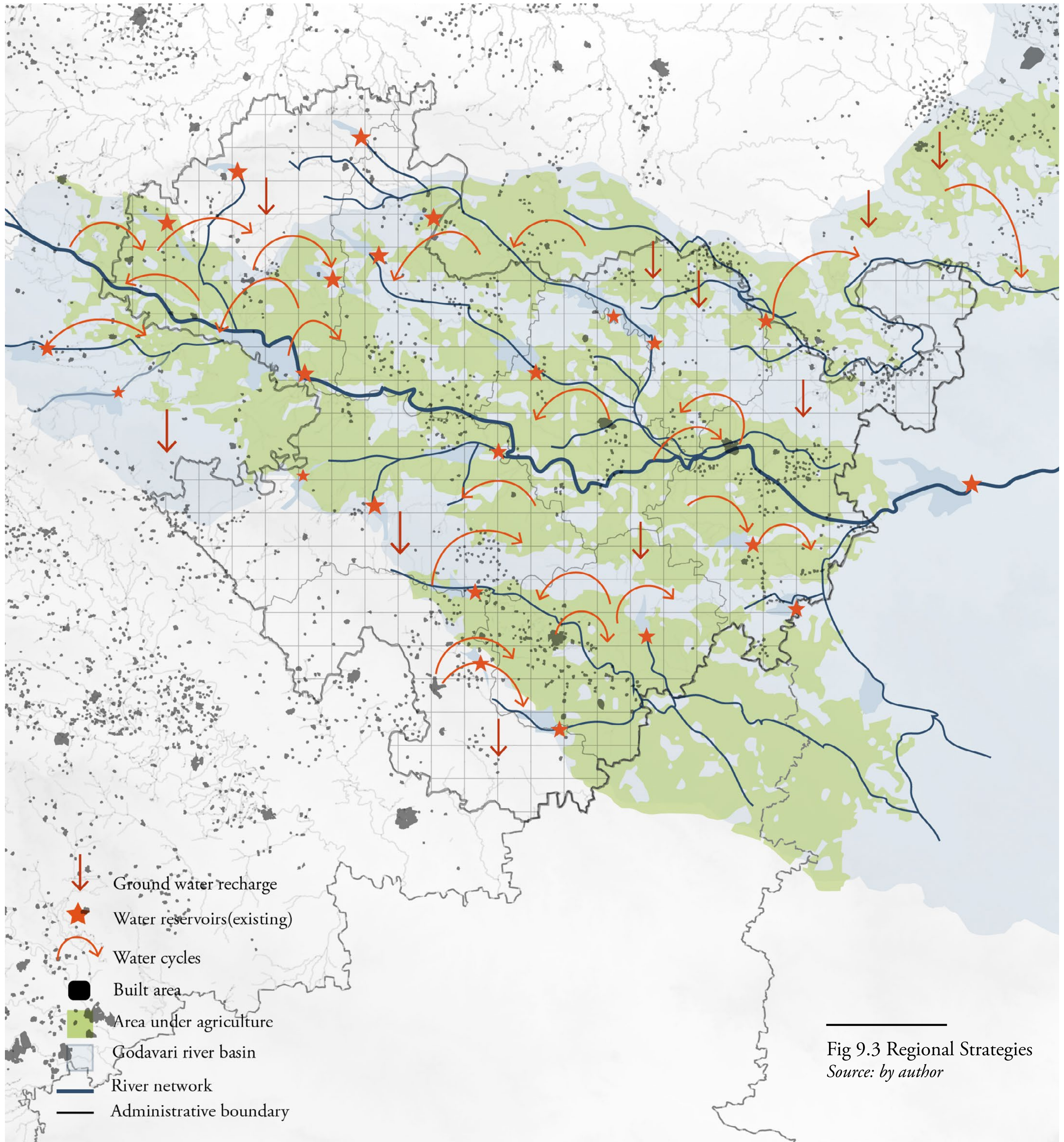


Fig 9.3 Regional Strategies
Source: by author

03. *Irrigation reform* and *sustainable farming* practices

Irrigation reform and sustainable practices is aimed at creating a system of micro irrigation throughout the region which will lead to water use efficiency, that is reducing the amount of water required for production as well as natural farming practices which were developed in the region. This will reduce the dependency on rain water for irrigation thereby reducing the negative externalities caused by a bad season. The irrigation reform will also result in investments in decentralised system as proposed to the large scale irrigation dams as seen now.

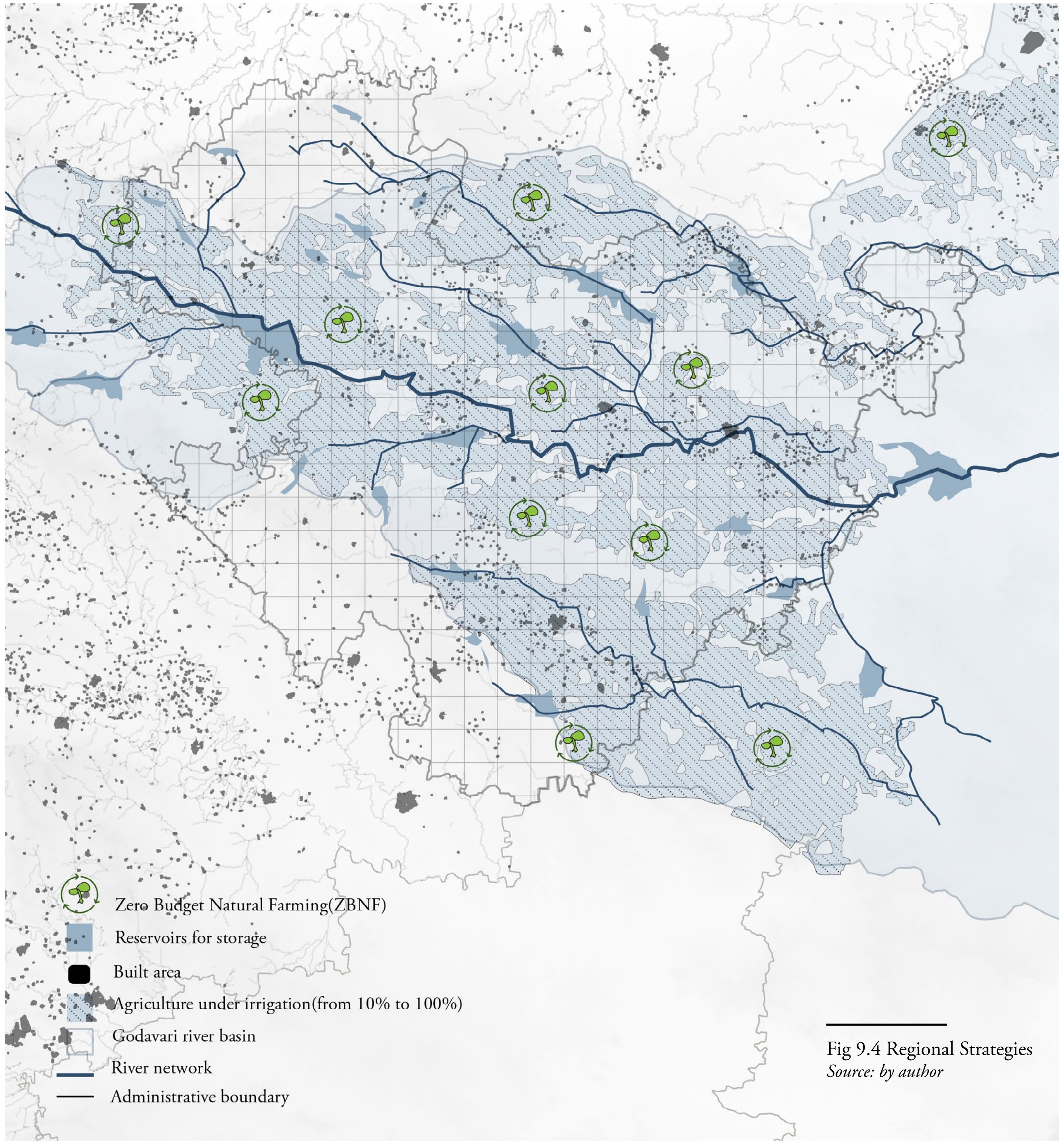


Fig 9.4 Regional Strategies
Source: by author

04. Synergy between different *water user groups*

This strategy is aimed at creating a synergy between different user groups of water resource such as agriculture, industrial and domestic. It is to create an equitable allocation and distribution of water resources by increasing resource sharing and partnering in investment. This will lead to an integrated water resource management system which will inform policy and practices that are aimed at creating water resilience for the region.

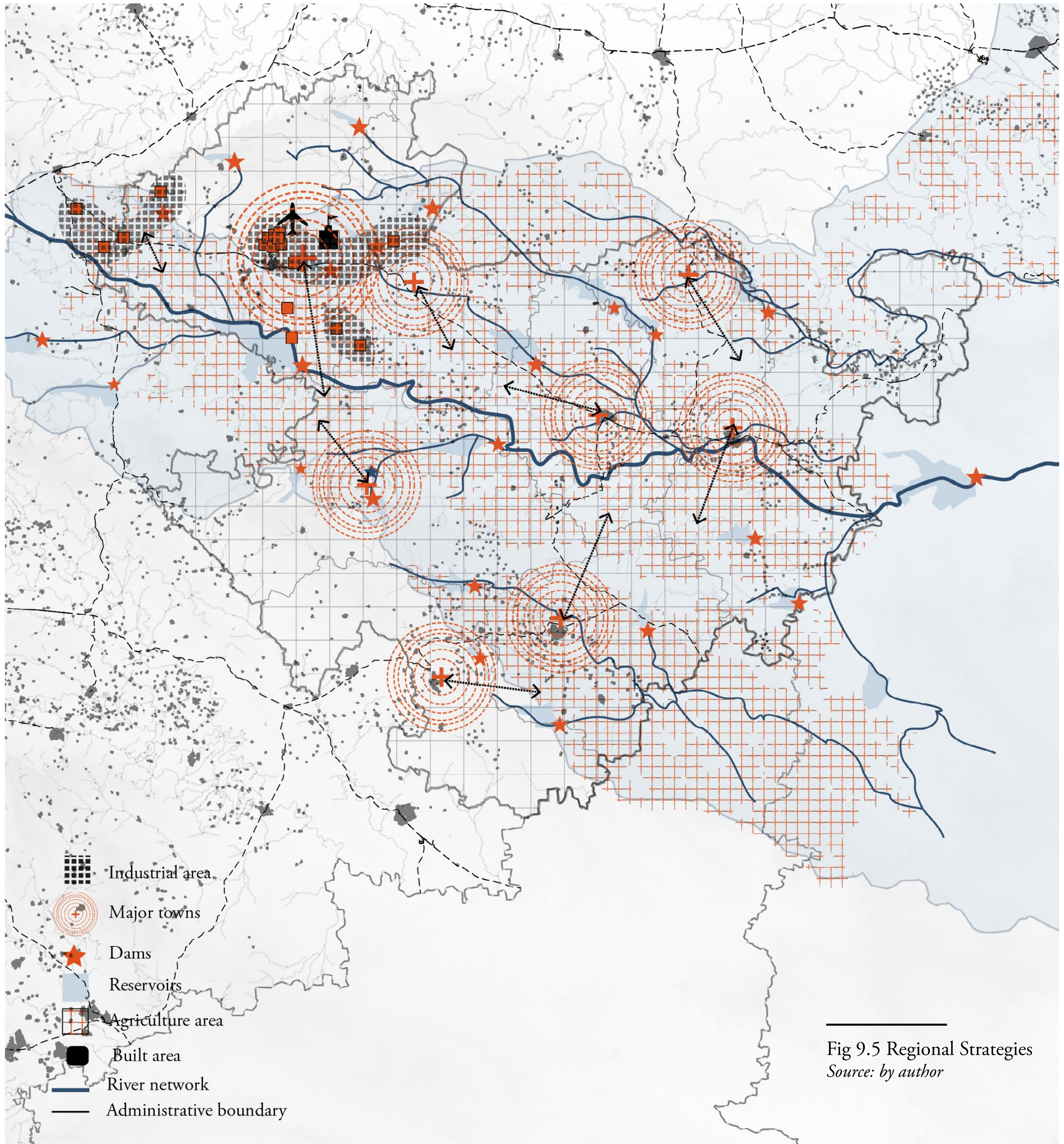


Fig 9.5 Regional Strategies
Source: by author

05. Enhancing ecological value through *landscape integration* and *agro-tourism*

This strategy is aimed at enhancing the ecological value through landscape integration and promoting agro-tourism in the region. The ecologically sensitive zones are identified and will be restored through sustainable measures. National parks, recreational zones and natural reservoirs are developed on existing and new aquifer locations which can become attractions for people. This will also lead to socio-economic development of the region through enhancing ecosystem services.

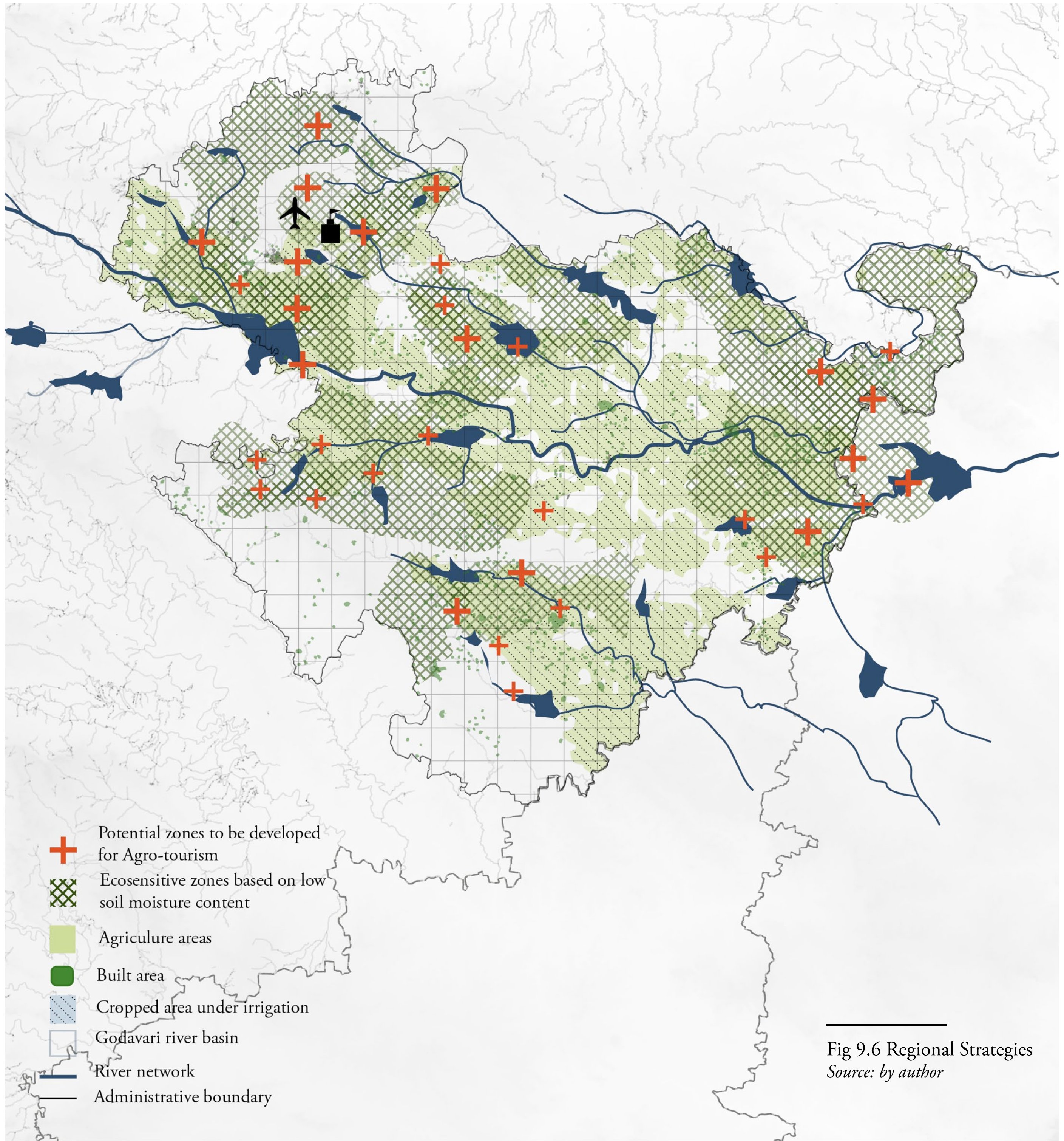


Fig 9.6 Regional Strategies
Source: by author

06. Rural transformation through *social infrastructure development*

Most rural areas in India are neglected in terms of social infrastructural developments compared to the urban areas. This strategy is aimed at creating investments in social infrastructure in rural areas through collaborative planning and community participation. This would involve development of community centers, schools and educational institutions, public health centers, as well as public and freight transport infratdrcuture, resulting in a complete rural transformation

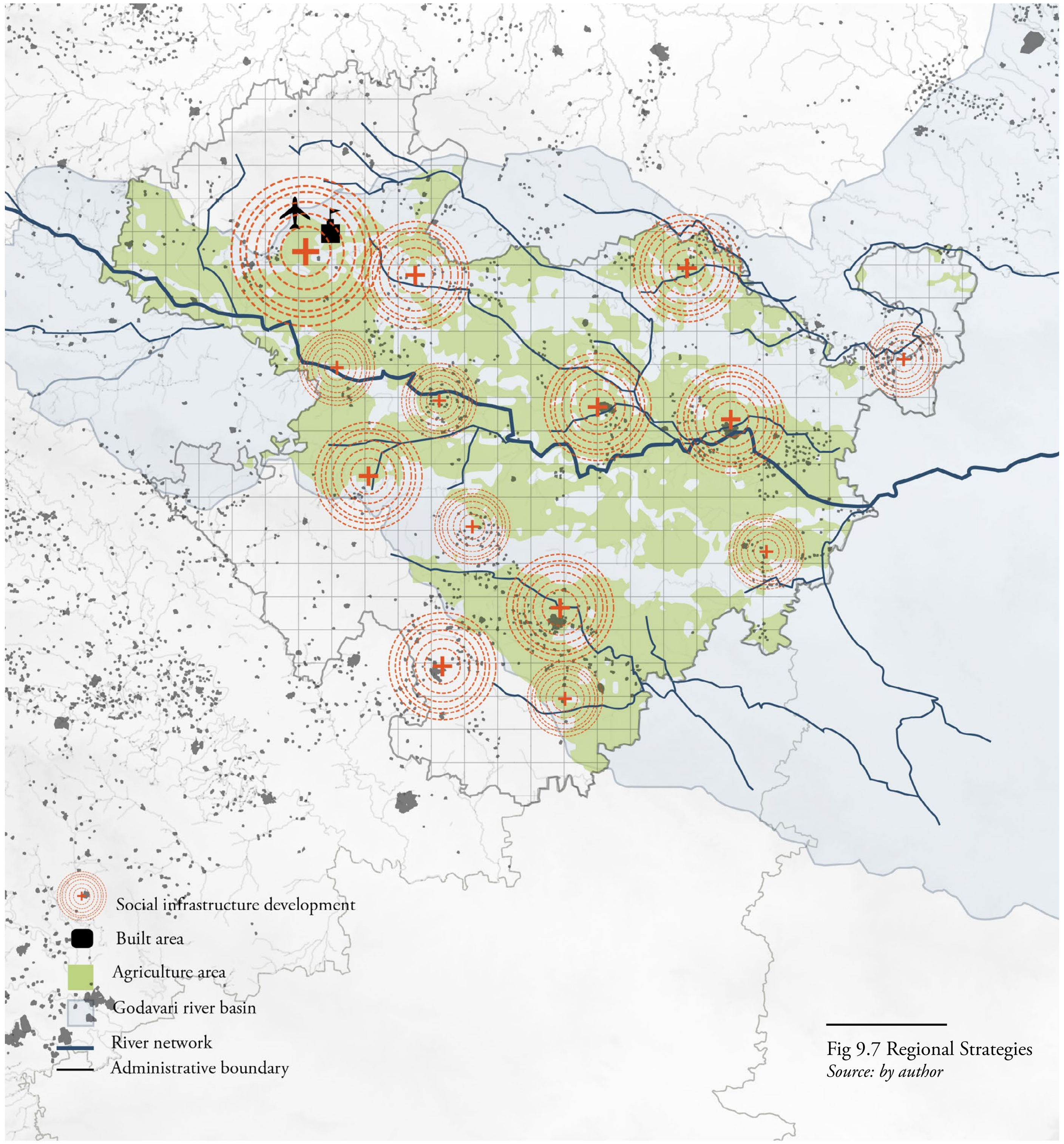


Fig 9.7 Regional Strategies
Source: by author

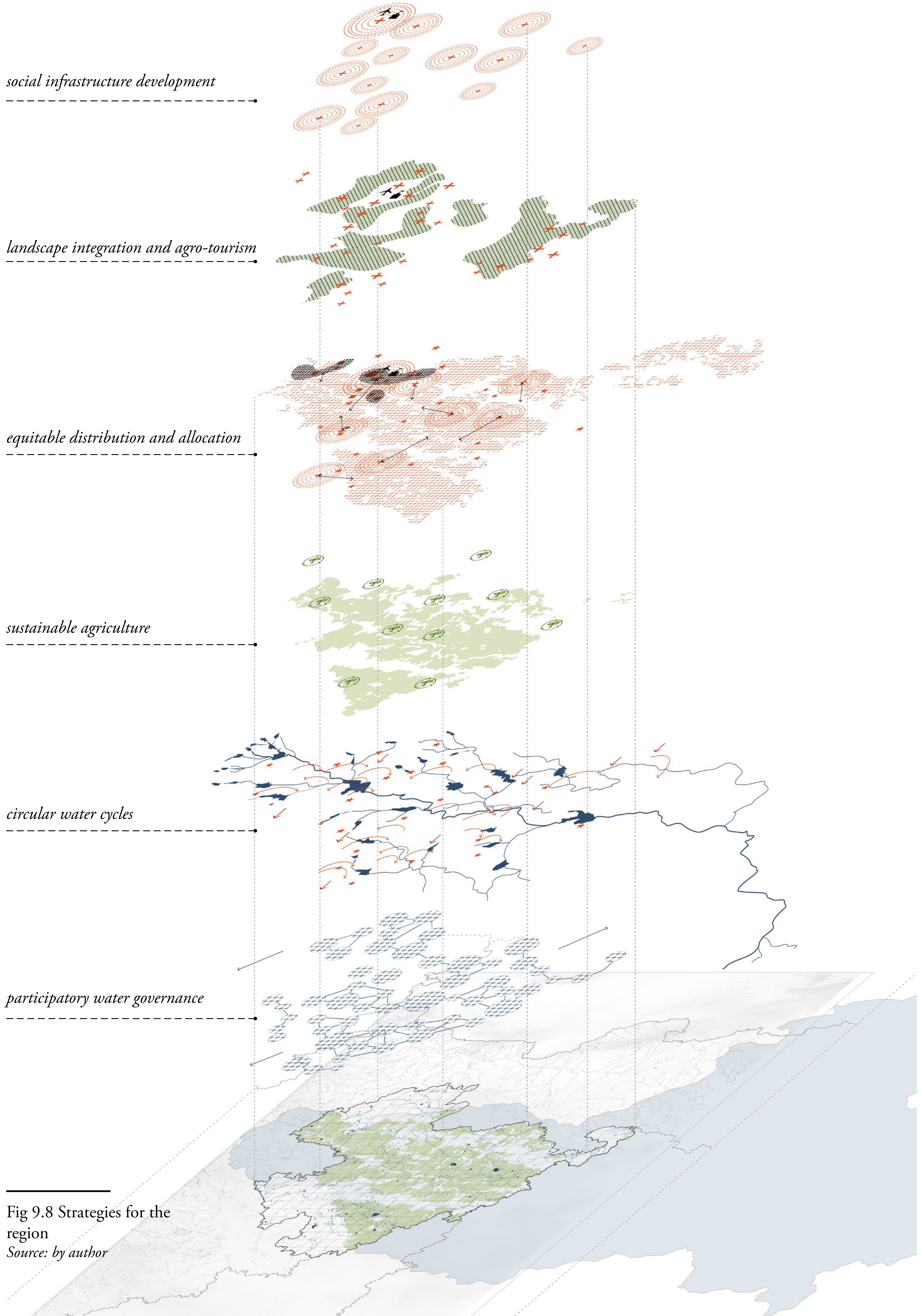


Fig 9.8 Strategies for the region
Source: by author

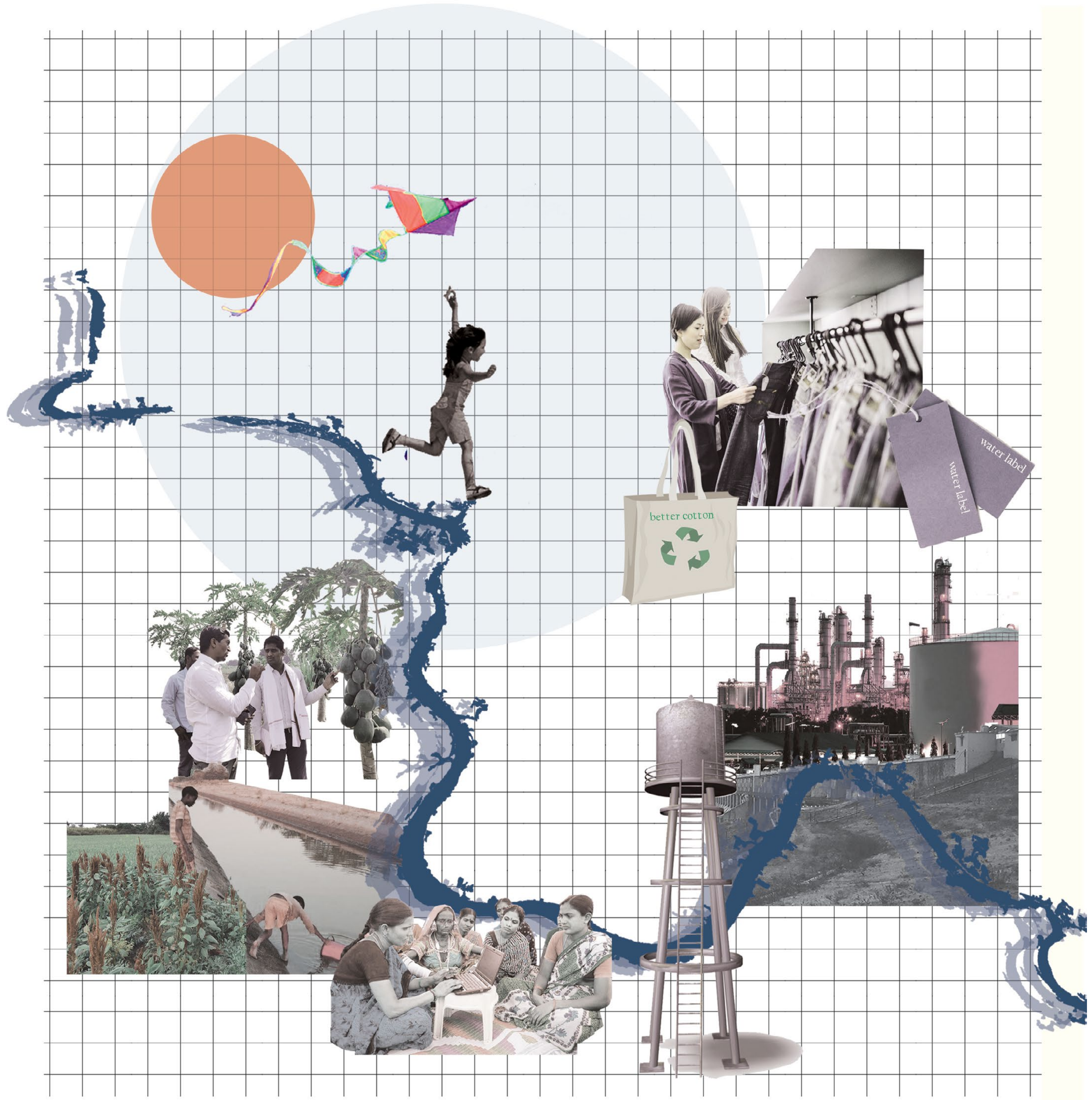


Fig 9.9 Towards water resilience
Source: by author

10 Beyond the region

10.1 From *local* to *global*

Conclusions from the local and regional strategies towards an integrated approach across scales

Throughout the thesis it was proven that the water problems of scarcity and stress extend beyond the borders of the region. The previous chapters defined a vision for local adaptation and regional strategies for evolutionary change. Further, it was also discussed an effective stakeholder engagement strategy and a new model of participatory water governance structure. However, this still needs to be translated to scales that go beyond the region. State, trans-national and global policy reforms that can contribute to an equitable allocation and compensation for the water resources is a key factor in developing a sustainable model of water resource management. This means that there needs to be definition of policy actions that are national and global which can lead to accountable and transparent supply chain systems.

Therefore, this chapter will focus on the scales beyond the region and to provide insight into the policy actions which are necessary to achieve an integrated multi-scale approach to tackling local water scarcity issues. There is an urge for institutional arrangements that spans across scales to effectively implement solutions for water resilience at the local level (Hoekstra, 2011). Thus local adaptation and global mitigation are not mutually exclusive concepts but rather has to work in an integrated systemic arrangement where one can compliment the other.

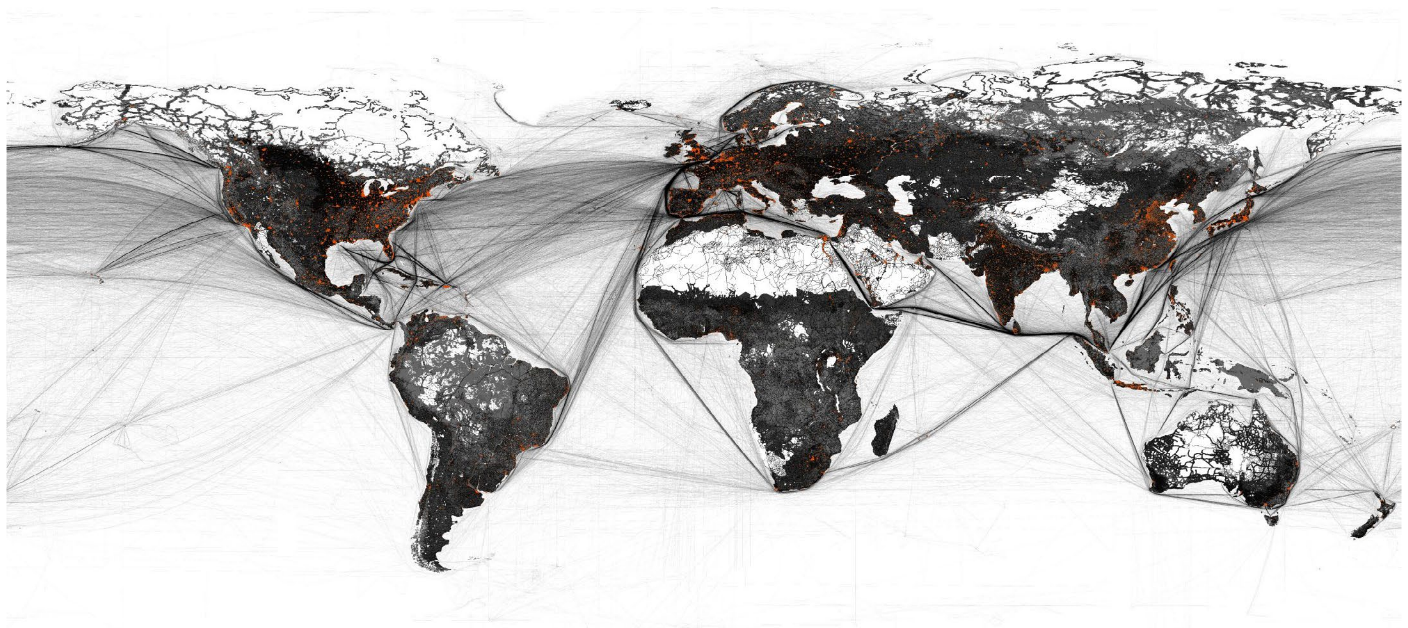


Fig 10.1 The Planetary Thünen Town
Source: Katsikis(2019)
https://technosphere-magazine.hkw.de/

10.2 A 'Global Traceability Framework'

Towards global policy change in receiving systems

There is a need to look at institutional arrangements at the (trans) national and global level that takes into account a fair and just system of virtual water transfers and leads to an equitable allocation of water based on the conditions of the sending, spill over and receiving systems. The following is aimed at achieving a sustainable and balanced systems of production and consumption. According to Hoekstra (2011), the four major issues of efficiency, equity, sustainability and security of water supply at the global scale (Hoekstra, 2011). The following are a few recommendations of institutional arrangements based on the paper by Hoekstra (2011) that is required to achieve an accountable global transparency framework for water intensive products and virtual water transfers.

1) Global Water use efficiency

This can be defined as minimizing the amount of water required to produce the same volume of products and services by increasing the efficiency in use and management (Hoekstra, 2011). This can be achieved at various scales and levels of management from local to global.

2) Water Pricing and taxing

This can be defined as the true price of products imported based on the environmental and social costs such as investment costs, operational and maintenance costs, social costs such as labour costs, pollution taxes etc.

3) Water scarcity rent

This can be defined as the minimum required amount to be paid by receiving and spill over systems when importing water intensive products from water scarce regions. This will include all water using sectors such as agriculture and industrial.

4) Water labeling of Water intensive products

This is defined as the label to be developed for each product depending on the amount of water used while production, manufacture and distribution to be made aware to the consumers.

5) Maximum allowable water footprint (import/export)

This refers to the maximum allowable limit for each country based on their domestic water uses and availability to import water intensive products from other countries. For example, a country like Netherlands with high water availability will have lower allowable water footprint allowed to import water intensive products from a water scarce region.

Fig 10.2 Global policies
Source: by author based on Hoekstra 2011

Global Traceability Framework (GTF)

A balanced system of global water transfers

The global traceability framework is aimed at global policy changes that can lead to a more transparent and sustainable water footprint in supply chains. This is aimed at integrating local adaptation strategies through water use efficiency and water labeling from the sending systems and water pricing, scarcity rents, water taxes and limiting externalizing water footprints from receiving systems. Through this there is a direct and transparent functioning of supply between consumers and producers at both ends.

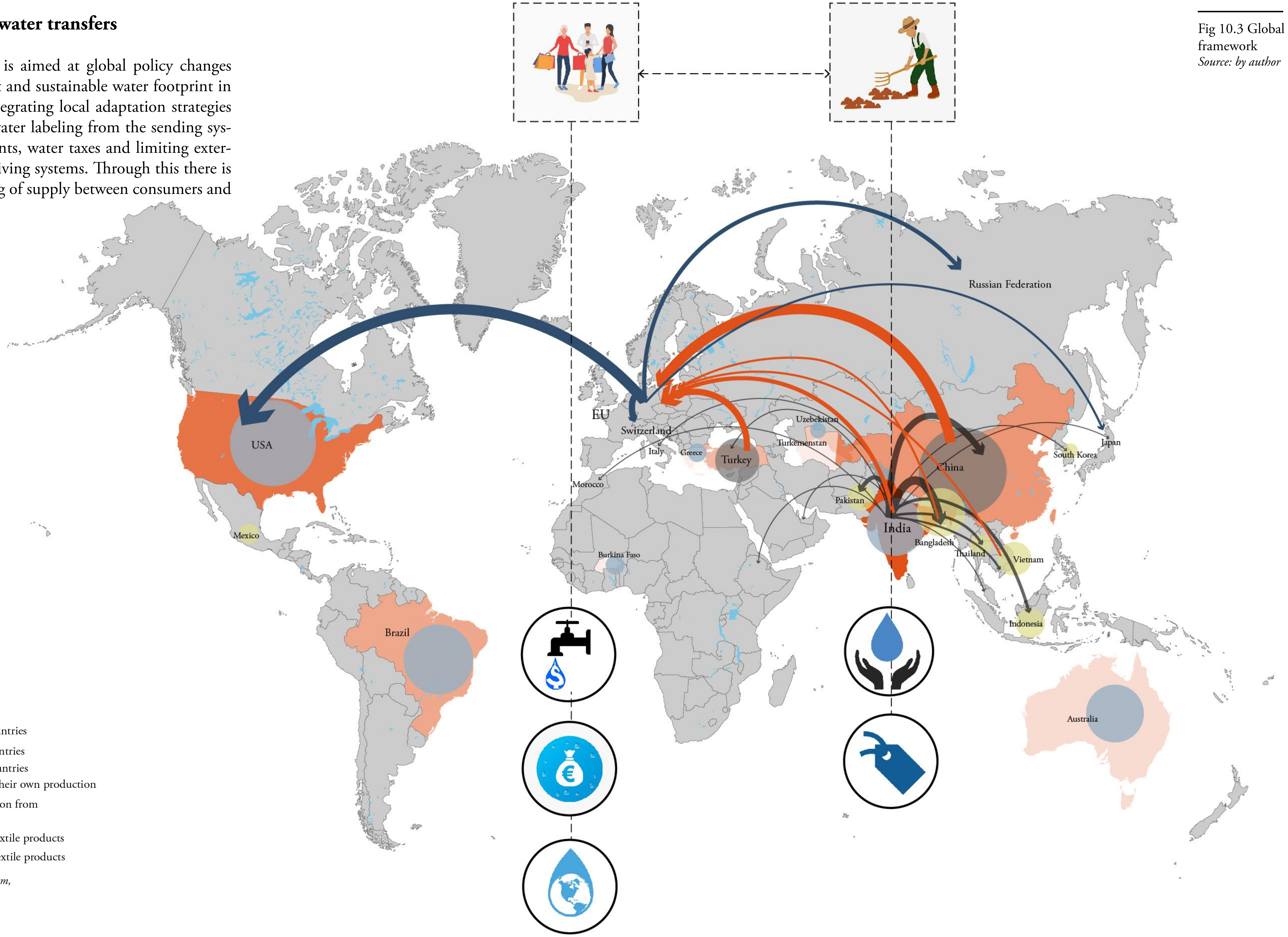


Fig 10.3 Global traceability framework
Source: by author

Legend

- Major Cotton producing countries
- Major Cotton exporting countries
- Major Cotton importing countries
- Countires that supplement their own production
- Country wise export of Cotton from India (2014-2018)
- EU 27 Exports textile and textile products
- EU 27 Imports textile and textile products

Source : Eurostat 2007, https://www.statista.com, Ministry of Textiles, Govt of India.

10.3 Roadmap for integration

Towards achieving an integrated local adaptation to global mitigation

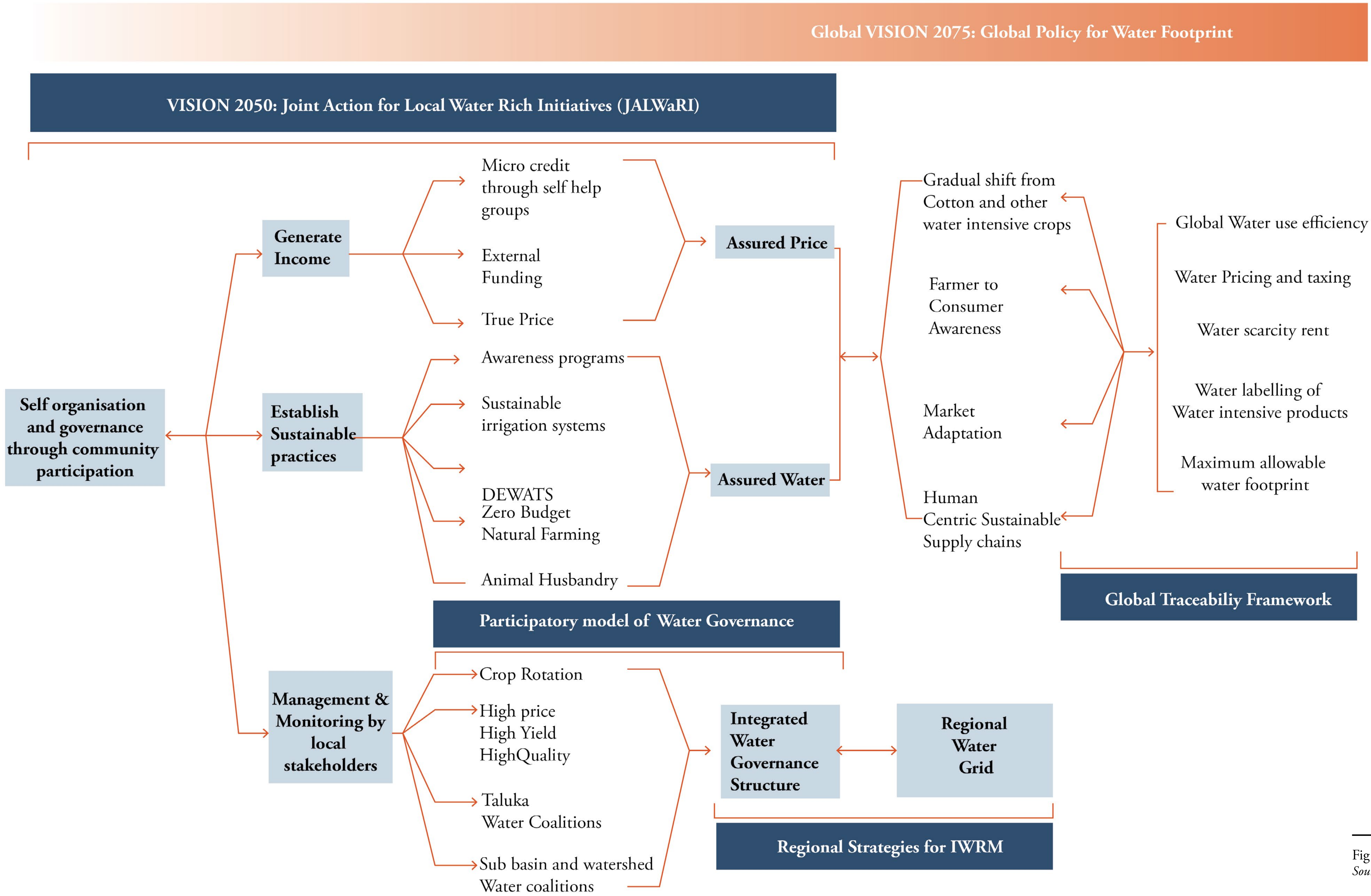


Fig 10.3 Global policies
Source: by author

11 Conclusion

11.1 Scenarios for future: Planning for uncertainties

Towards formulating an adaptive framework for decision making

The previous chapters showcased the vision and strategic interventions proposed for achieving a water resilient future for the region of Marathwada and creating a more sustainable and transparent supply chain in cotton production and consumption. However there are many uncertainties that can occur in the future that will affect in the implementation of these strategies. By imaging different future scenarios of possibilities, it can be ensured that an adaptive system can be achieved irrespective of what the future may hold.

Bohensky et al., defines scenario planning as 'a set of plausible not probable narratives' that has the ability to depict alternative pathways that can help predict the future changes (Bohensky, Reyers, & Van Jaarsveld, 2006). This thesis looks at the two axis based on the two systems that are at either ends of supply chain. The vertical axis looks at the degree of decentralisation based on the sending system. The horizontal axis looks at the extent of compensation from the receiving system. This gives rise to the four scenarios as explained below namely; (1)harmony, (2) indifference, (3)dependency and (4)despair. These scenarios then help formulate the policy actions and simplify the complexities in the outcomes.

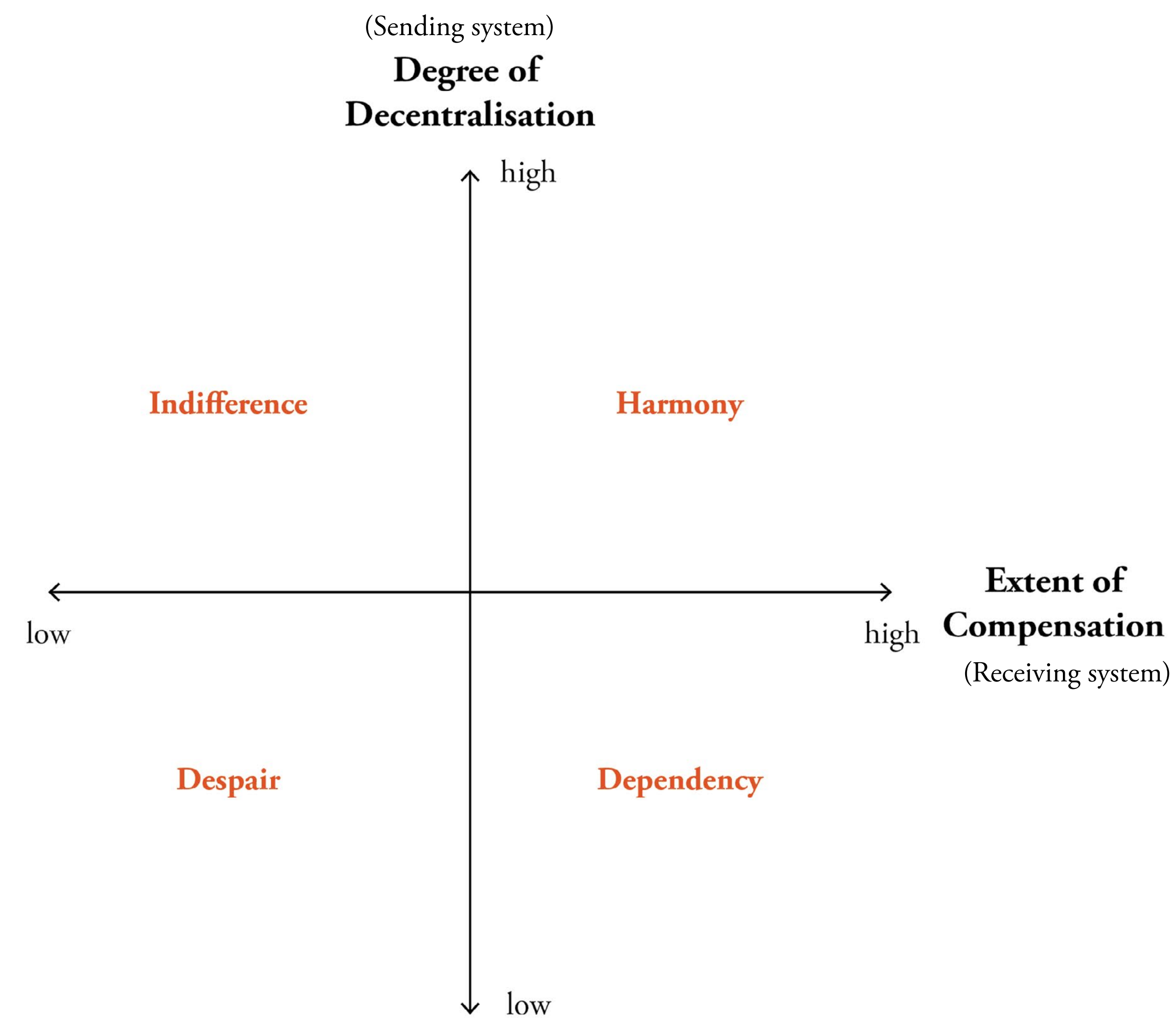
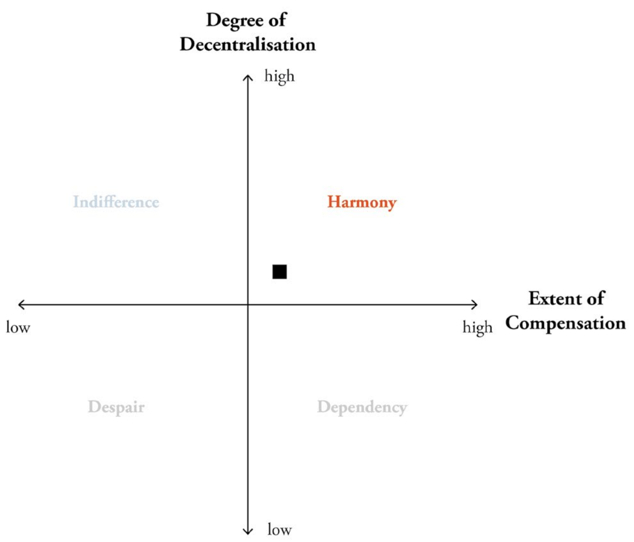


Fig 11.1 Four scenarios
Source: by author based on the Dutch climate scenarios



Scenario I: Harmony

The first scenario is referred as 'harmony', when the both the degree of decentralisation and the extent of compensation is high.

This scenario depicts a future when there is a high amount of self organisation of the local communities at the sending system. This will lead to a decentralisation in water management and irrigation systems, and an active collectivism in community participation. The characteristics of the sending system will include, a better organised farming communities leading to micro credit systems and increased investments in sustainable production practices. There will be more natural production leading to high yields of high quality natural cotton and other products. The local communities would engage more in other forms of income generation and would be capable of investing in social infrastructure development. There would be an integration on scales of participatory water governance leading to an improved water systems and equitable distribution of water resources.

On the receiving system, there is a high compensation in terms of social and environmental costs and this will lead to a more sustainable and transparent supply chain. The consumers are more aware of the products that they purchase and there is a heightened consciousness regarding the sustainability of water footprint leading to a global market shift that will influence a global policy change in the traceability.

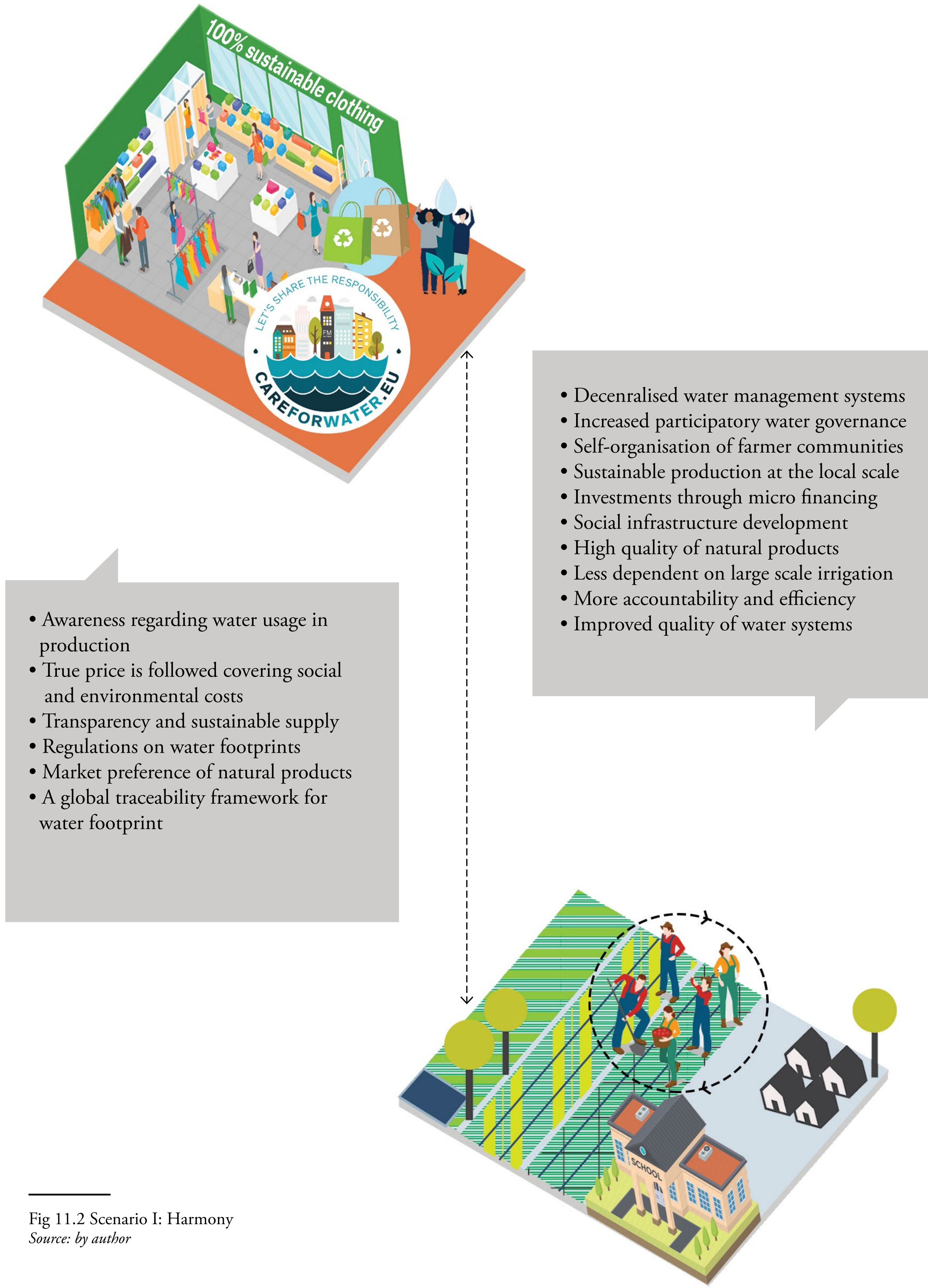
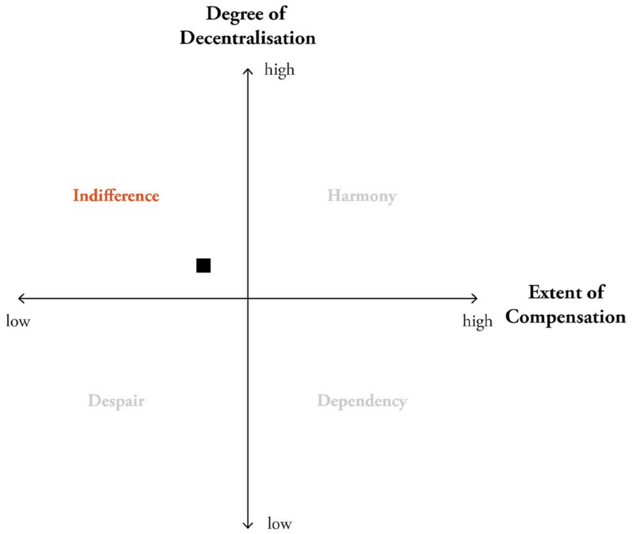


Fig 11.2 Scenario I: Harmony
Source: by author

Fig 11.3 Scenario I: Harmony
Source: by author



Scenario II: Indifference

The second scenario is called 'indifference', when the degree of decentralisation is high however the extent of compensation is low.

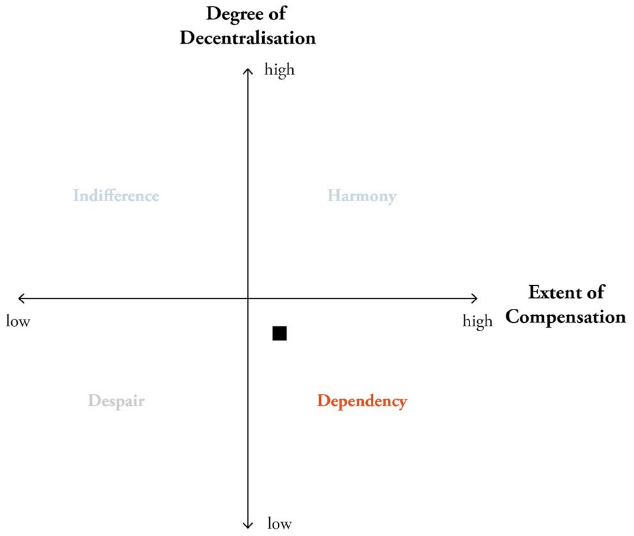
This scenario depicts a future when there is a high amount of self organisation of the local communities at the sending system. This will lead to a decentralisation in water management and irrigation systems, and an active collectivism in community participation. The characteristics of the sending system will include, a better organised farming communities leading to micro credit systems and increased investments in sustainable production practices. The local communities would engage more in other forms of income generation to supplement.

On the receiving system, there is low compensation in terms of social and environmental costs. There is a lack of awareness regarding the water footprint of products from water-scarce regions. This would mean that there is still a high value for cheap water intensive products. Global policies are ineffective and inefficient in the moving towards a balanced system.

In this scenario, there are local level smaller initiatives but large scale systemic problems are still persistent. Without the compensation, it would take longer for local communities to make significant change and will take a much longer time to achieve water resilience.

Fig 11.4 Scenario II: Indifference
Source: by author

Fig 11.5 Scenario II: Indifference
Source: by author



Scenario III: Dependency

The third scenario is called 'dependency', when the degree of decentralisation is low however, the extent of compensation is high.

This scenario depicts a future when there is a low amount of self organisation of the local communities at the sending system. This will lead to a more state led infrastructure development for water management and governance. More funding will need to be allocated in the form of financial aid and subsidy as the farmers. The lack of participation and collectivism would also result in lower social developments. This will force farmers to sell their lands for other infrastructure developments and will need to adapt to other job possibilities.

On the receiving system, there is a high compensation in terms of social and environmental costs and this will lead to a more sustainable and transparent supply chain. The consumers are more aware of the products that they purchase and there is a heightened consciousness regarding the sustainability of water footprint leading to a global market shift that will influence a global policy change in the traceability.

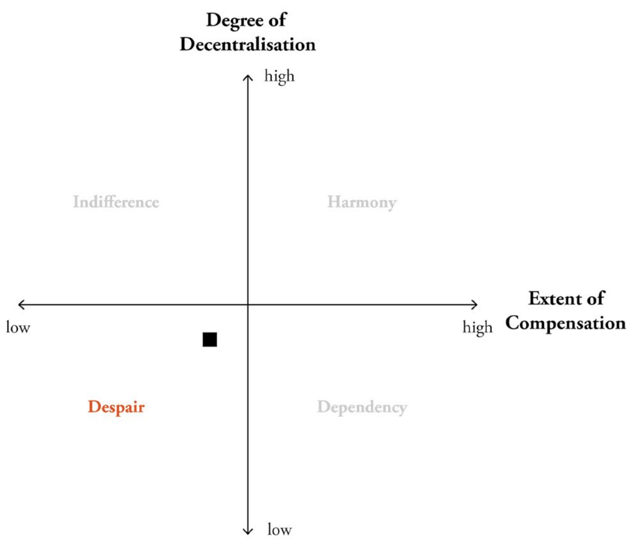
This scenario would result in the sending systems being dependent on external help for survival and maintaining production. There is more financial aid and supplements. This can result in short term improvements on the infrastructure facilities for agriculture production.

- Low self organisation
- Dependent on large scale infrastructure
- Dependent financial aid and external funding
- Lack of collective and participation
- Lower social infrastructure developments
- Lower quality of life

- Awareness regarding water usage in production
- True price is followed covering social and environmental costs
- Transparency and sustainable supply
- Regulations on water footprints
- Market preference of natural products
- A global traceability framework for water footprint

Fig 11.6 Scenario III: Dependency
Source: by author

Fig 11.7 Scenario III: Dependency
Source: by author



Scenario IV: Despair

The fourth scenario is called 'despair', when the degree of decentralisation and the extent of compensation is both low.

This scenario depicts a future when there is a low amount of self organisation of the local communities at the sending system. This will lead to a more state led infrastructure development for water management and governance. The farmers are not able to cope with increasing water scarcity and depletion of water resources and would be increasingly dependent on external help from governments. The lack of participation and collectivism would also result in lower social developments. This will force farmers to sell their lands and migrate to cities in search of menial jobs and can lead to urban poverty.

On the receiving system, there is low compensation in terms of social and environmental costs. There is a lack of awareness regarding the water footprint of products from water-scarce regions. This would mean that there is still a high value for cheap water intensive products. Global policies are ineffective and inefficient in the moving towards a balanced system.

This scenario will lead to a collapse of the rural economies that are dependent on the agriculture systems. There is persistent water scarcity experienced at producing regions. This would lead to shortages and crisis for products and can result in inflation and a global crisis in the future.

- Low self organisation
- Dependent on large scale infrastructure
- Dependent financial aid and subsidies
- Lack of collective and participation
- Lower social infrastructure developments
- Lower quality of life
- Increased negative externalities

- Lack of awareness on water footprint
- True price is not considered
- Non transparent supply chains
- Cheap and low quality of products
- No regulations on water footprints
- Lack of global policy change
- Unsustainable use of resources

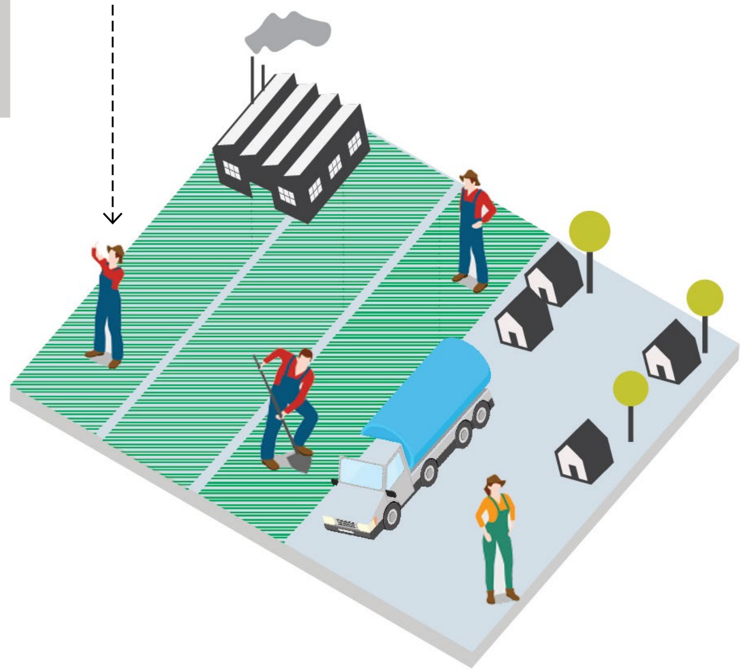


Fig 11.8 Scenario IV: Despair
Source: by author

Fig 11.9 Scenario IV: Despair
Source: by author

11.2 Dynamic Adaptive Policy Pathways (DAPP)

Formulating actions based on the four scenarios

The local catalysts are policy actions that are the local scale which focuses on decentralisation and self organisation in moving towards an integrated water resource management for the local farming communities and subsequently lead to socio-economic development of the region. Whereas the non-local catalysts can be defined as the policy actions that are from a regional, national and global perspective that can contribute towards a systemic change in the way globalisation of water is conducted and work towards a more balanced system. These actions are informed based on the four scenarios explained in the previous section.

The two sets of catalysts are not mutually exclusive but rather they work together for an integrated cross border solution to the core issue of globalisation of water. The importance of each scale in tackling the issue was elaborated earlier (section 6.1, chapter 6). Each action however comes with an adaptation tipping point (ATP) based on their applicability as explained in the next section. Then they have to be supplemented by a new action to continue the pathway. Hence each policy action can perform to kickstart the other actions in multiple pathways.

In the paper, 'Possible futures, preferable futures', there are four scenarios of futures elaborated (Hancock & Bezold, 1994). The four futures are namely, the possible – what may happen, plausible – what could happen, probable – what will most likely happen and preferable – what we want to have happen. The adaptive pathways provide an insight into these future scenarios and helping policy makers navigate more towards the preferable future. However, this is subjected to change and needs to be adapted based on a stakeholder engagement in practice. However, here the pathways for future scenarios are elaborated from a theoretical perspective based on the author's own explanations from stakeholder analyses. The various shortcoming and pitfalls are imagined in a realistic way as possible based on the scenarios considered. The limitations are explained in the reflections (chapter 11).

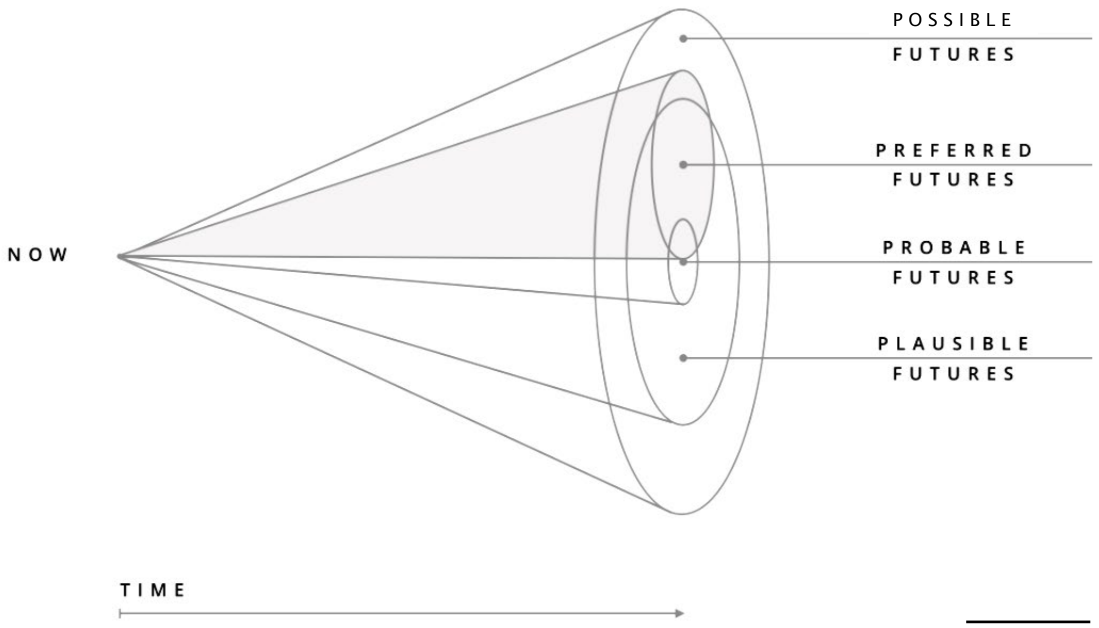


Fig 11.10 'Possible futures, preferable futures'
Source: Joseph Voros based on Hancock & Bezold, 1994

Evaluation of actions based on qualitative assessment on applicability

The qualitative assessment is an important step to understand which scenarios are possible, plausible, probable and preferable from the perspective of a policy maker. The assessment gives insight into the impacts and time frame for each actions and the costs incurred to make it happen. It gives a clear picture of which actions have high applicability based on their costs and impacts and can be used as catalyst to initiate the other actions.

Scenarios	Actions	Impact (+/-) Water Conservation	Nature & Ecology	Society	Sell by Date	Costs	Applicability
1/2	'Joint Action for Local Water Rich Initiatives' (JALWaRI)	+++	+++	+++	>2100	Low	+++
1/2	'Regional Water Grid' based on participatory water governance	+++	++	+++	>2100	Medium	+++
3/4	Water transfers and re-allocation during drought conditions	+	+	++	2030-40	High	+
3/4	Increasing yield by using drought resistant seeds and chemicals	– –	– – –	++	2050-60	High	+
3/4	State led (large scale) infrastructure development for irrigation	++	–	++	2070-80	High	+
3/4	Subsidies and aid from NGOs and international organisations	++	+	++	2050-60	Moderate	++
1/3	Global traceability framework for sustainable water footprint	+++	+++	+++	>2100	High	++
1/3	Market shift towards mixed cotton and cotton substitutes	0	+/–	+	2080-90	Moderate	++

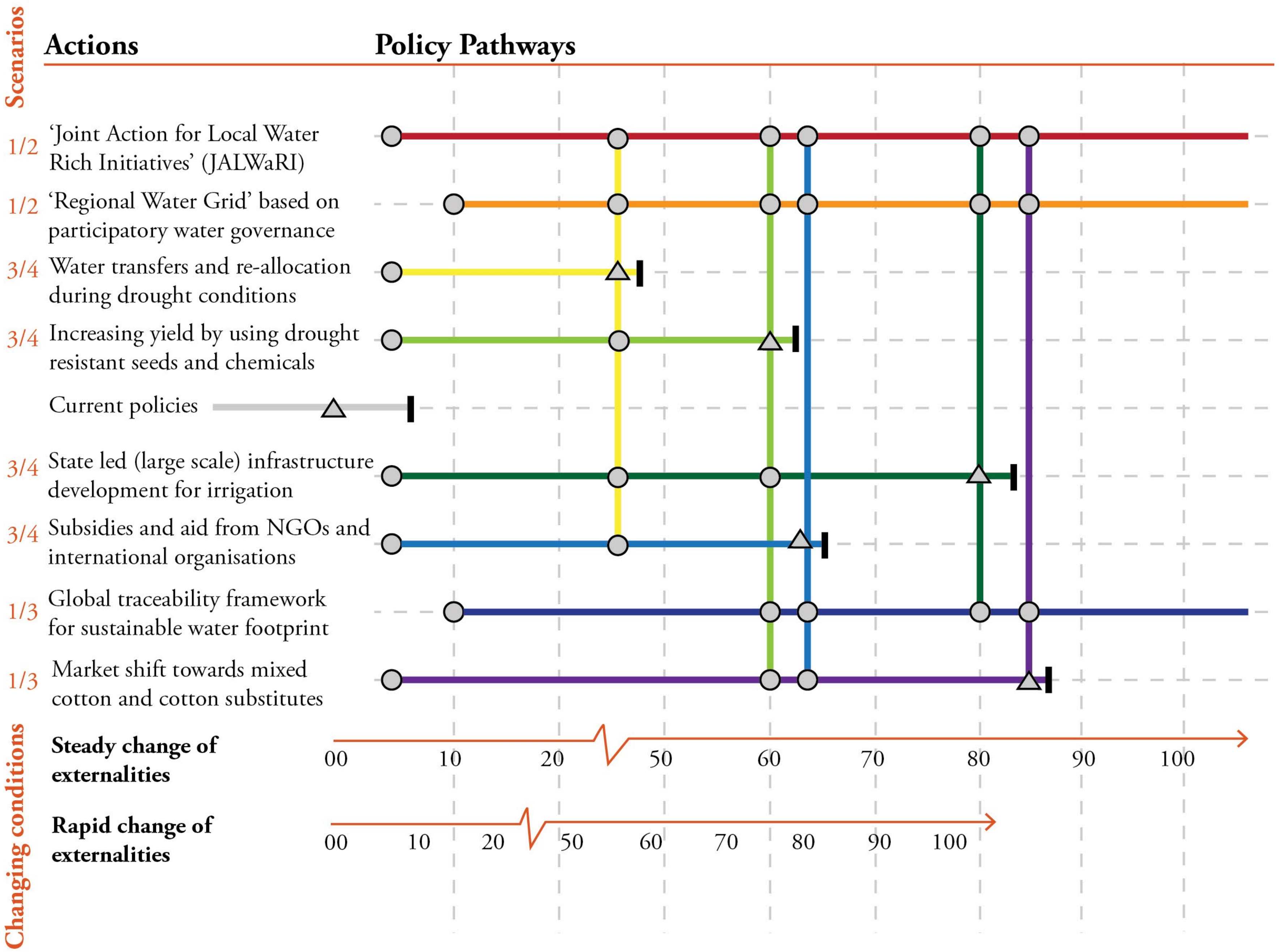
Legend

0 No impact
\+ Minor Positive impact
++ Moderate Positive impact
+++ Large Positive impact

+/– Positive or Negative impacts
– Minor Negative impact
– – Moderate Negative impact
– – – Large Negative impact

\+ High applicability
++ Moderate applicability
+++ Low applicability

Fig 11.11 Assessment of actions
Source: by author based on Haasnoot et al., 2013

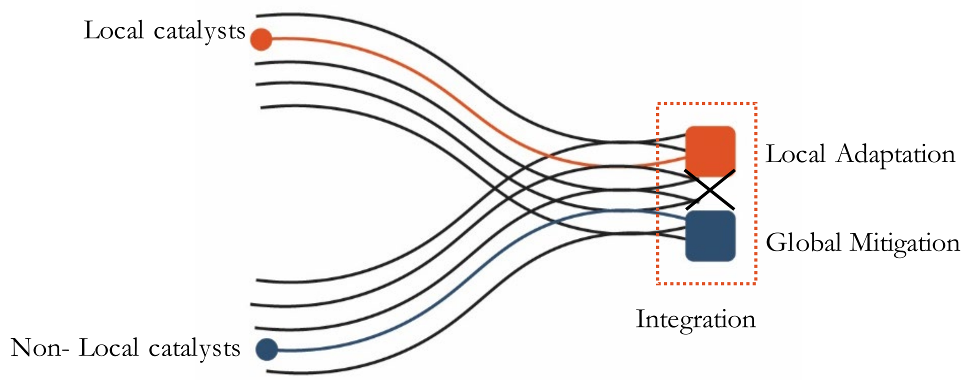


Legend

- Transfer station to a new policy action
- Adaptation tipping point
- Policy action effective
- Decision mode

Externalities (steady/rapid)

Climate change
Production and consumption
Economic growth
Technological advancements



Dynamic Adaptive Policy Pathways

The 'Dynamic Policy Adaptation Pathways' (DAPP) (Haasnoot et al., 2013) is used as a method to envision the different pathways that are possible dependent on the different policy actions of the local and non-local catalysts. This method gives an important insight into the various possible futures that can help achieve the set goals and vision. The pathways also help in setting up short term and long term targets and milestones that can used to effectively guide the process of change.

The diagram (fig 11.12) shows the interpretation of adaptation pathways based on the author's own explanations from the stakeholder analysis carried out as well as the future scenarios explored (chapter 7). The various policy actions are based on the different scenario criteria discussed in the previous sections. The exercise proved as an effective tool to plan for contingencies in case of a proposed action is not taking place or delayed. This gives a realistic picture to the policy makers of the various options that they have but most importantly showcases the routes that are the most preferable.

The explanations on the start of policy and adaptation tipping points are based on the qualitative assessment done for applicability looking at the impacts v/s the costs of each action. Therefore, the actions with high applicability and lower time frame are used as start actions and the actions with low applicability and high time frame are used to determine tipping points. At this a decision mode is reached to continue with a different action.

Fig 11.12 DAPP
Source: by author based on Haasnoot et al., 2013

Pathways		Score card: Costs	Impacts (+/-): Water Conservation	Nature & Ecology	Society
1	red	Low	+++	+++	+++
2	orange	Moderate	+++	+++	+++
3	yellow, red	Moderate	++	++	+
4	yellow, orange	Moderately high	++	++	+
5	yellow, light green	Moderately high	0	– –	–
6	yellow, dark green	Very high	+	– –	–
7	yellow, light blue	Moderately high	+	+	–
8	light green, red	Moderate	++	+	+
9	light green, orange	Moderately high	++	+	+
10	light green, dark green	Very high	+	– – –	0
11	light green, dark blue	Very high	++	+	+
12	light green, purple	Moderately high	+	+	+
13	dark green, red	High	++	+	+
14	dark green, orange	High	++	+	+
15	dark green, dark blue	Very high	++	+	+
16	light blue, red	Moderate	++	+	++
17	light blue, orange	Moderately high	+	+	++
18	light blue, dark blue	High	++	+	+
19	light blue, purple	Moderately high	+	0	0
20	dark blue	High	+++	+++	+++
21	purple, dark blue	Moderately high	++	++	++
22	purple, red	Moderate	++	+	+
23	purple, orange	Moderate	++	+	+

Legend

0	No impact	+ / –	Positive or Negative impacts
+	Minor Positive impact	–	Minor Negative impact
++	Moderate Positive impact	– –	Moderate Negative impact
+++	Large Positive impact	– – –	Large Negative impact

Qualitative evaluation of pathways

By using the DAPP method, different policy pathways are achieved based on the adaptation tipping points or sell by dates and the probability of different plausible actions that can follow to continue on. This gives a clear understanding of which actions are preferable over the others. By assessing each pathways for the costs and benefits(the impacts created on water, nature and society), it is easily translatable to decision makers to choose and adapt accordingly. The evaluation of the different pathways showcases which actions have a higher costs but more negative impacts and which actions are beneficial as well as low on investment. This also allows the actions to be carried out irrespective of the different future scenarios and their uncertainties.

From the fig 11.13, it is clear that pathways 1 and 2 has lower capital requirement but has higher positive impacts. Whereas pathways 20 has high positive impacts but costs higher. Whereas pathways 3,4 and 21 gives a possibility where the costs are not high but has considerably good positive impacts.

In the end which pathway is preferred is dependent on the decision makers and has to be subjected to stakeholder analysis for a more accurate depiction of possibilities.

Fig 11.13 Evaluation of pathways
Source: by author based on Haasnoot et al., 2013

11.3 Outcomes of research questions

To what extent can the impacts of 'globalisation of water' be minimized in order to achieve a more just and sustainable water footprint in cotton supply chains?

The main research question sought to answer the ways to minimize the impacts of globalisation of water and find effective methods to reduce water footprint in supply chains. To understand and comprehend the key issue of globalised water, several sub issues need to be looked at. The sub research questions sought to look at the various aspects of the core problem of globalisation of water to form a complete overview.

a) What is the link between virtual water trade and water scarcity in India?

To answer this question, it is important to define and understand the extent of the impacts and the reason for causing these impacts. This can provide guidance to then effectively minimizing the negative impacts. In this thesis, the impacts are refer to as socio-economic, spatial and environmental problems related to virtual water trade. Chapters 1 and 2 is dedicated to understanding the meaning of these impacts and their affect on local scale. The concepts of planetary urbanization and territorial metabolism were used as main theoretical notions to frame the research.

What are the various spatial, socio-economic and environmental impacts of the virtual water trade in India?

There is a clear link between virtual water trade and water scarcity in India. This is explained over the analysis done at the national and regional scale. It is concluded in the analysis chapter that the water scarcity issues in Marathwada was perpetuated by many global factors. The change in cropping pattern due to the liberalization policies of 1990s and the opening of free market, led to the farmers shifting from pulses, grains and cereals to more water intensive crops like cotton, sugarcane etc. This shift was mainly aimed at export markets. There is clear evidence correlating the liberalization to the excessive production of water intensive crops and the subsequent ground water depletion and subsequent droughts in the region.

Why is the current system of cotton production in India (Marathwada) unsustainable and unjust?

The unsustainable supply chain of "cheap cotton" due to improper compensation also played a vital role in creating an unjust system of production that was degrading the environment and ecology and creating many negative externalities. In order to understand how these impacts are caused and what are the underlying factors that contributed to the issues at the local scale, it is important to look from a global perspective. By using the telecoupling framework, it was possible to define clearly the relationships between a coupled natural and human system in the supply chain of cotton. This proved to be an important factor to answer the research question and to simplify the complexities better.

How can an improved system be developed in a more just way that there is fewer negative externalities of virtual water trade and create more spatially just system?

Integrated Water Resource Management (IWRM)
Integrated Water resource management was found as a key aspect in trying to understand the ways to minimize the impacts of cotton water trade. This concept formed the base to develop the vision and strategies for local adaptation. One of the important conclusions was that, the effects of water scarcity on society, economy and ecology was more heightened due to a lack of social infrastructure development. Therefore, any method of trying to minimize the impact has to look at the problem related to water has to be integrated to societal development.

How can a design of a new system contribute towards water resilience and empowerment of local communities?

Self organisation and participation
As mentioned earlier, water resource management without social development will not be effective in achieving a resilient system. In countries like India, where there is lack of institutional accountability in management and governance systems, it is important to go for a more decentralised system. Therefore, the principle of self organisation and governance was used as a tool to achieve social empowerment. This is done by leveraging existing socio-cultural norms and practices as well as existing institutional arrangements.

How can a sustainable supply chain of cotton be developed that integrates multiple scales?

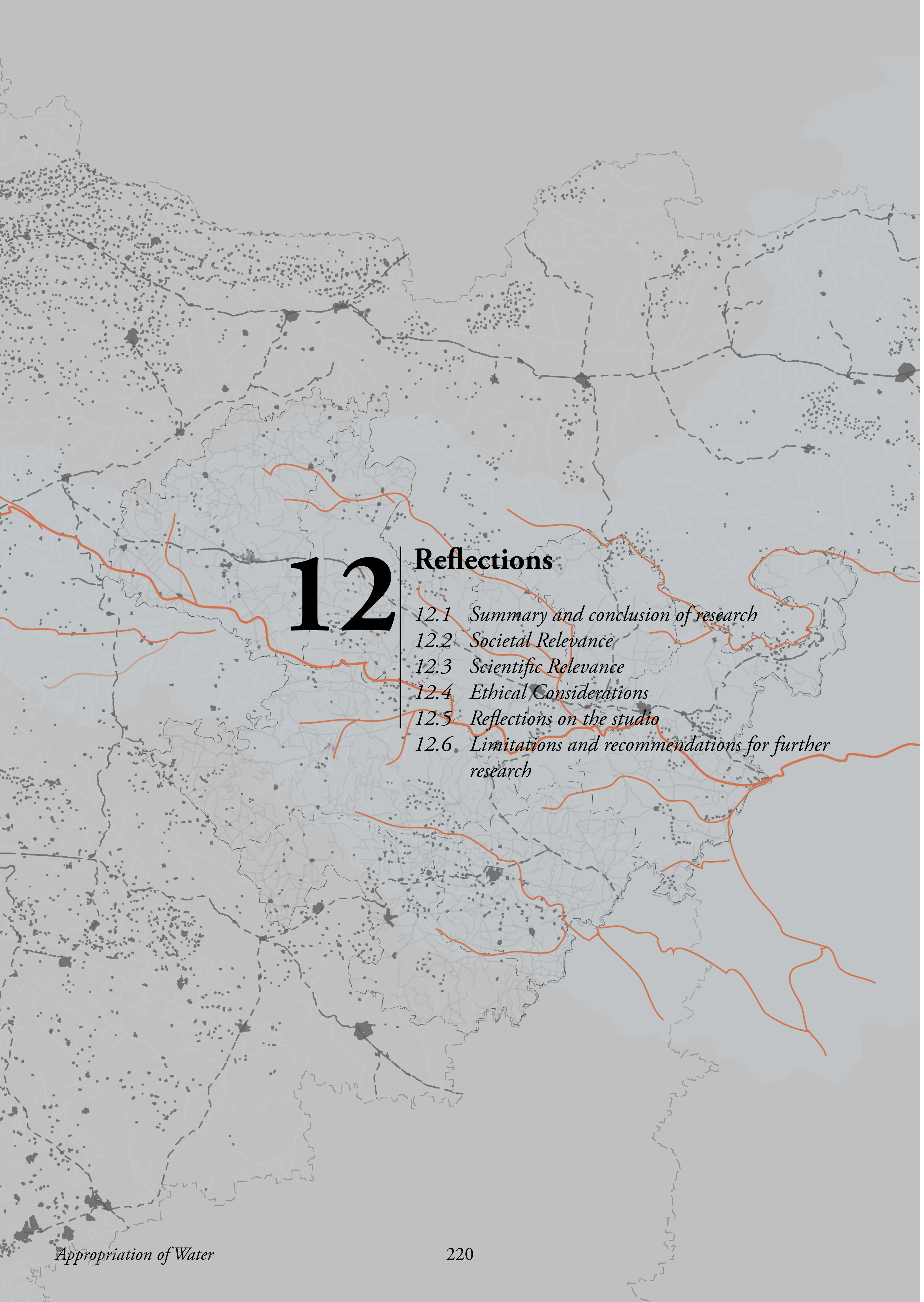
Integration of scales
Another important aspect while answering the research questions, is the integration of scale. Local water scarcity has a global dimension and thus the local adaptation methods have to be in alignment to global mitigation methods that can support each other. Therefore, and integration of scales is seen throughout the design strategies, as well as the policy framework.

Transparency in supply chains
With the integration in scales in terms of water management, its is also evident that the current system is imbalanced due to the fact that there is no transparency in the supply chain of cotton. The consumers on the receiving end, are in a position of power where they can influence the global markets which can in turn influence policies for production areas. Hence, a transparent supply chain is key in creating a more sustainable supply chain of cotton virtual water trade.

How can futures scenarios be envisioned that can guide policy makers to make effective choices?

Adaptation Pathways
In order to understand the extent of the realising the various goals and proposals elaborated in the project, it is essential to evaluate and imagine different possible pathways in which future scenarios can unfold. This is explained using the Dynamic Adaptation policy pathways (DAPP) method to successfully showcase the different possible, probable and preferable future which can effectively guide policy makers and stakeholders. The actions are informed based on the four possibilities of scenarios explained in the previous sections. This is a key aspect in answering the research question and justifying and evaluating the various methods adopted throughout the project. The pathways therefore provide a realistic insight into the possibilities of implementation and planning frameworks required to effectively move towards a sustainable and just system of supply chain management of cotton water. They provide guidance for decision makers to understand the adaptiveness of each action.

The above explained concepts together help understand the ways to minimise the impacts of 'globalisation of water' and achieve a more just and sustainable water footprint in cotton supply chains. This answers the main research question of this thesis.



12 Reflections

12.1 Summary and conclusion of the research

This thesis analysed the phenomenon of 'globalisation of water' (Hoekstra & Hung, 2005) and it's consequences on local water scarcity issues of Marathwada. The trade of water through exporting cotton from the region has led to virtual water flows between the places of production in Marathwada and areas of consumption that lay far beyond the administrative and political boundaries. The region experiences acute water shortage and has several socio-economic, environmental and spatial problems related to the production of cotton. By trading this water intensive crop to other countries such as the EU, they end up externalizing their water footprint and adding to the problems persistent in the areas of production. Therefore, this thesis sought to understand the extent of these impacts, by looking at the metabolic flows that goes beyond the limits of the city or 'urban'. The thesis investigated the extent of the impacts of virtual water trade in water scarce regions of Marathwada, India, formulated through the concept of territorial metabolism and planetary urbanisation. These concepts help look beyond the local issues as merely being affected by local factors, but as a part of a larger chain of metabolic processes. The thesis also looked at telecoupling framework as an approach to analyse and define the elements of the system that constitutes it, in order to achieve a sustainable water footprint in cotton supply chain.

Furthermore, to answer the research questions, as to how to move towards a sustainable water footprint in water scarce regions, it was important to look at various points of the system and providing interventions at each point. At the sending system or the areas of production, it was about effective water resource management and implementing strategies for renewal, preservation and adaptation. This was done through socio-ecological and landscape interventions through collaborations at the local scale, elaborated in the vision chapter. At the receiving end, or the consumption areas, it was important to intervene through the practices of consumption such as traceability of products and their water footprint, taking environmental and social costs into consideration.

Therefore, the project successfully establishes a clear understanding of the interrelationship between water footprint of various products and water scarcity issues and formulates a strategy for implementation by integrating 'local adaptation to global mitigation'. Through the concept of adaptation through scales, tested using dynamic policy adaptation pathways, the project formulates a clear strategy and policy solutions for a water resilient future, considering different actors and future scenarios.

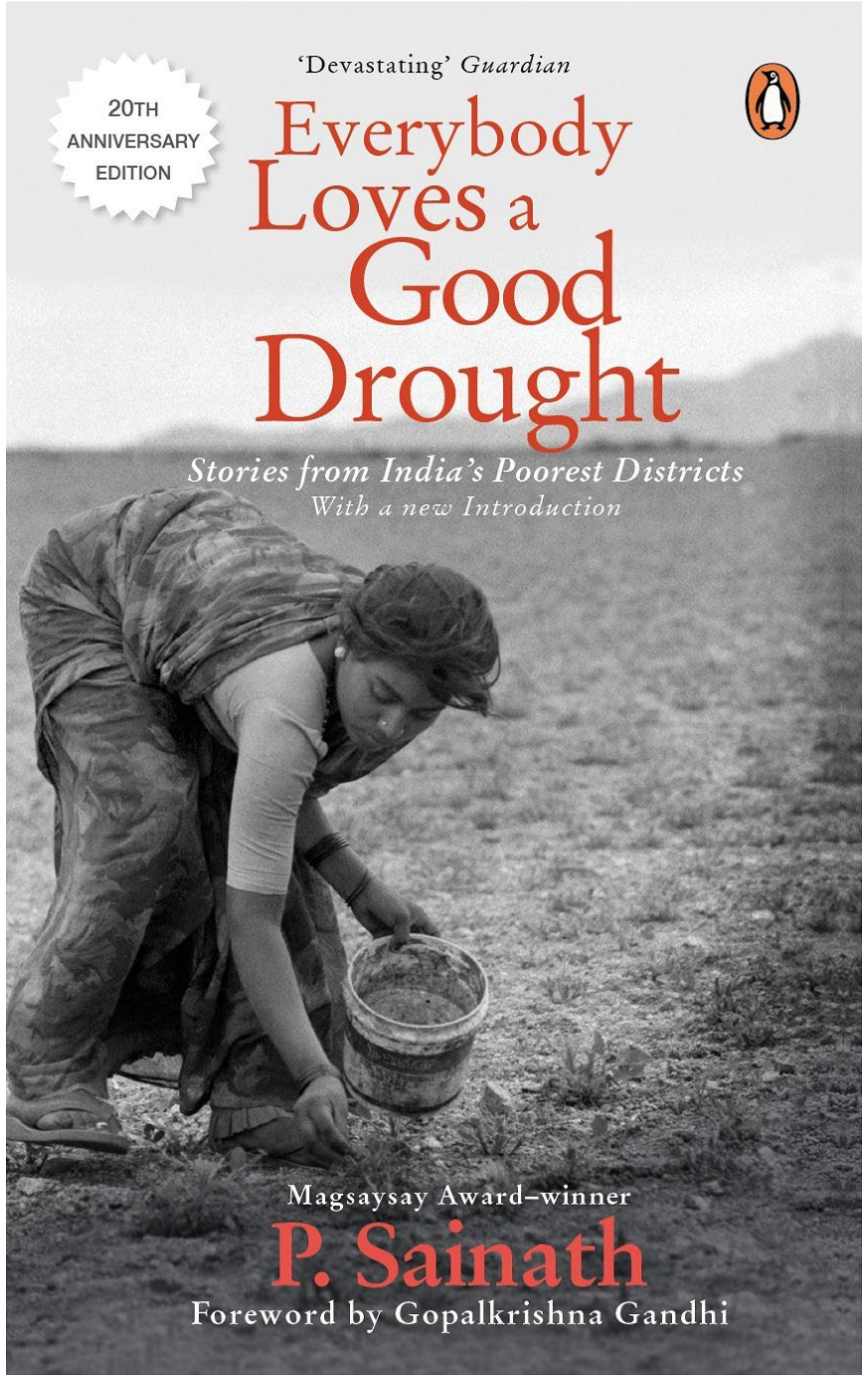


Fig 12.1 Stories on water scarcity issues of rural India by P Sainath, an award winning journalist
Source: public domain

12.2 Societal Relevance

Several countries have externalised their water footprints significantly by importing water intensive products. One of the major impacts of this phenomena is observed in the depletion of Aral Sea in Uzbekistan. The environmental degradation adversely affecting the ecosystems, and thereby leading to many negative externalities on society. The Aral Sea is a devastating example of a complete ecosystem collapse. As the sea dried up over the years due to continued drenching of water from the sea to irrigate the countries cotton production and export. This also led to socio-economic issues as the collapse of the fishing as well as extreme pollution leading to cancerous diseases among the population from the toxic dust from pesticides such as DDT used in cotton production (Article in national geographic online magazine, 2015).

Similar to this, in a developing country like India, the socio-economic impacts related to local water resource depletion are immense. In central India, one of the major cotton belts of the region, the allocation and use of water for agricultural purposes and production of water intensive crops has resulted in severe droughts leading to an unprecedented agrarian crisis, with many farmers committing suicides. The region is one of the biggest producers of cotton in India with almost 50% of the state of Maharashtra's cotton being produced here (Cotton Association of India, 2017). The latest statistics show over 7,700 farmers committed suicides in the last years, with a staggering average of over 6 farmers committing suicides per day. These suicides are attributed to debts caused by poor yield as a result of unavailability of enough rain, extreme drought, ground water depletion and water stress. The situation is perpetuated by the liberalization that took place in 1991 and therefore is very much geo-political and interlinked with socio-cultural elements. In Marathwada, sugarcane and cotton are political crops used to win elections and any decision making in the allocation of water resources on issues of water stress is as much as spatial and environmental as it is political.

With an increasing globalised world and the presence of more uncertainties perpetuated by climate change, population growth and an increased food need, we are looking at a situation where many countries like India are facing crisis. This is already visible with water conflicts in many parts of the country, large scale farmer protests, rampant food shortages and inflation. But it is not just the areas of production that will be affected, as the ripples will be felt across scales. It is important as a society we understand the gravity of the situation and our part in contributing to the crisis. It is inevitable that we will have to adapt to a future society where water and food crisis is more common, and this cannot be possible without changing the way we currently live.

12.3 Scientific Relevance

It is interesting to note that problems of water scarcity are viewed as local water management issue. However, the concept of 'globalisation of water' (Hoekstra & Hung, 2005) sheds light to the fact that water scarcity is very much related to the trade of several products across countries and crossing borders. The solution to the local water problems cannot be solved by just intervening where they occur, but more often, the local water depletion, water pollution and water stress are closely linked to the national or even the global economy (Hoekstra & Mekonnen, 2012). According to the study by Hoekstra et al., shows the way in which many countries like the Netherlands rely on foreign water resources to meet their domestic demands of food and clothing products and illustrate the extent of global dimension of water consumption with significant impacts on pollution elsewhere (Hoekstra & Mekonnen, 2012). It is therefore important to look at the issue of freshwater availability from a global perspective, or 'global water use efficiency' (Hoekstra & Mekonnen, 2012).

It is evident that there is a clear correlation between the impacts through the underlying concept of Globalisation of water. There is a clear knowledge gap in the understanding of the interdependencies between socio-economic, spatial and environmental factors of the virtual water trade. The first step is to recognize the overarching problem and to look at the impacts as an interrelated system. Secondly, it is also important to look at spatial planning and metabolism as a way to create a framework of analysis. This is crucial, as only then, we can look beyond the local issues as merely being affected by local factors, but as a part of a larger chain of metabolic processes. It is important to understand the link between water scarcity of these regions in association to virtual water trade and as a result leading to spatial impacts, such as infrastructure, the operational landscapes, the land use policies and planning. How has these landscapes impacted in the continued ground water depletion and as a result a reduced crop yield and pollution of major fresh water sources? The links between these in the increased number of farmer suicides and how can they be tackled? This requires looking at the problem and the rippled effects of globalised water on achieving spatial justice locally.

To formulate a framework for understanding the metabolic processes related to virtual water flows, the theories related to the concept of urban metabolism and their evolution need to be assessed. Further it is essential to look for a framework to be able to analyse these metabolic processes to understand the problematisation and give it a spatial dimension. Therefore, the scientific relevance of the thesis is addressed in three ways, (a)by understanding the problem, (b)the theories to frame the problem precisely and (c)a possible approach to analyse the problem. It is essential to move towards some radical steps in order to create a just way of production and consumption, in order to minimize continued depletion and to create accountability. All of this together, will help re-organise the chain in a more just way and create a sustainable water footprint in water scarce regions of India, which is not only ideal but most essential.

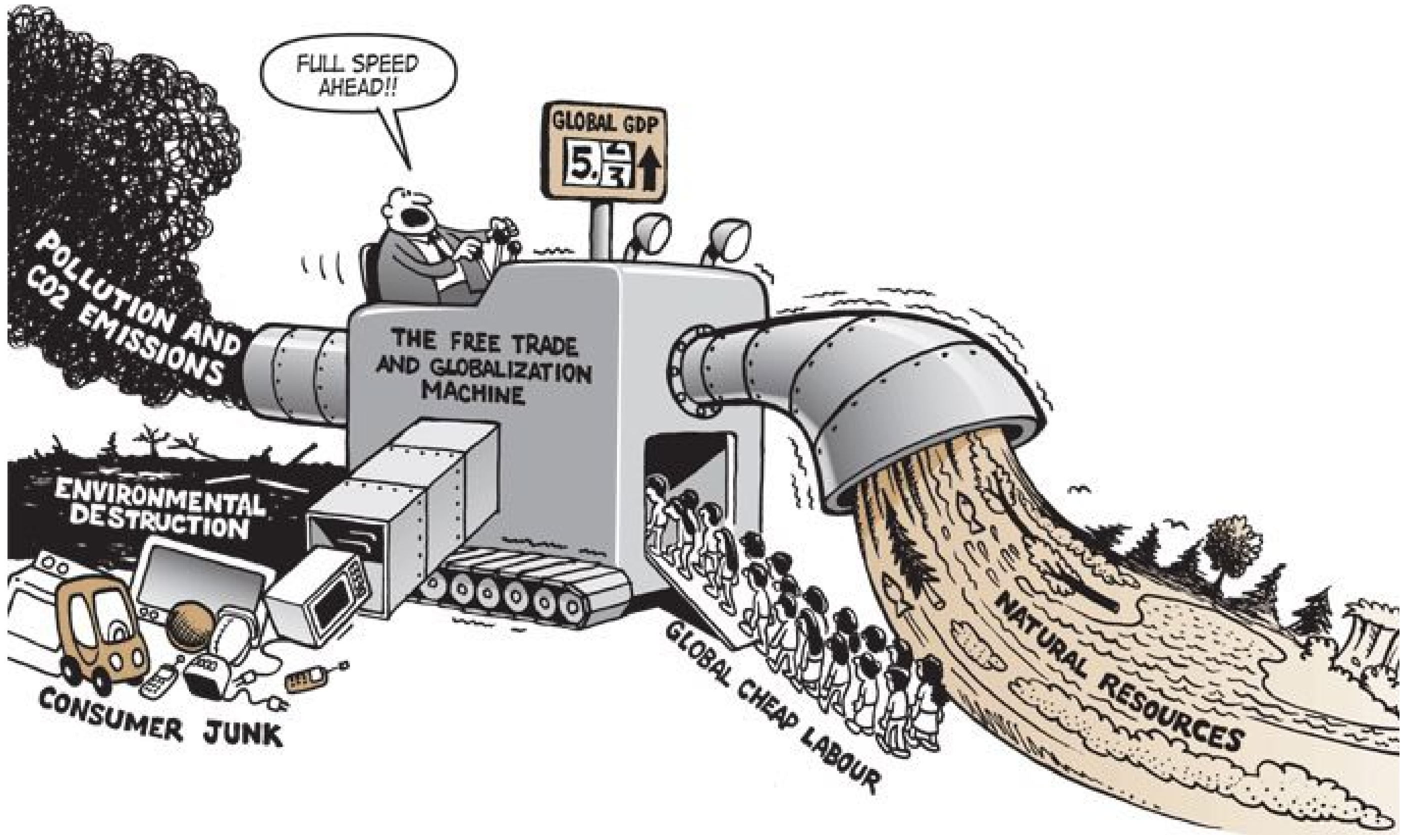


Fig 12.2 Cartoon by Tony Biddle
Source: all right reserved by http://howtosavetheworld.ca/2013/07/15/links-of-the-month-july-15-2013/

Fig 12.3 Children at Murmi village, Marathwada
Source: Photo by : author

12.4 Ethical Considerations

There are several ethical considerations to be considered while analysing the problem and designing a subsequent framework for change. The main ethical consideration is to understand the intricacies of culture and people in providing voice towards analysis and planning. For years, cotton farming has been the livelihood of several small holder farmers in India. To radically analyses or reduce the production would mean a significant change in the lifestyle and sources of income for these farmers. It would also result in serious alterations in the cotton industry, especially the migrant laborers and daily wage workers who are involved with the production and processing of cotton. This brings a serious ethical dilemma if such a measure is to be taken, will the society be able to cope with it. But at the same time, without doing any changes would only mean that the lives of the farmers will continue to suffer and will soon reach a point of no return. Subsequently, while considering the ecosystem services as main drivers for the project, there is a possibility that economic stability is affected and hence could have impact on the society. There is also dilemma regarding the ways in which environmental factors play a role, such as the rich biodiversity and the use of that as a means to address human needs. There are also several ethical consideration related to the socio political issues such as farmer suicides and the influence of case systems in contributing to vulnerabilities.

Finally any objective decision making is inherently influenced by political choices, of the designer as well as of the decision maker. Hence the personal biases of the designer is inevitable in the design and framework. The policies outcomes that are favored is based on the political and personal choices and may be subjective. This is something that is impossible to escape while conducting an academic research. The proposal of various infrastructure projects also has serious environmental as well as human rights consideration, as often these projects are in places of informal settlements and require rehabilitation efforts, which always brings the question, 'Who does the land ultimately belong to? Who has the right and who decides?

12.5 Reflections on the studio : Urban metabolism

This project is part of the larger studio group 'urban metabolism' which deals with the understanding of the metabolism of urban environments and its relationships to infrastructure, nature and ecology . Urban metabolism investigates the performance of infrastructures, environmental technology and systems in relation to spatial quality, environmental sustainability, livability and the social wellbeing of future cities. This research project is an example of the fact that the extent of urbanisation and globalisation goes beyond the limits of the city itself and how various systems influence each other. The concept of 'planetary urbanisation' and 'territorial metabolism' talks about this idea of a connected world and the interlinking of the problems we face as a planet. With the aim of to foster research at the different levels of planning, from local to global, this project is an example at the understanding the issue of urbanisation and spatial planning from a larger perspective. It is important to understand that the consumption of certain products such as the food we eat, the clothes we wear and so on comes from different parts of the world. By understanding the synergies of the system that constitutes this connection, we can change the system to function in a better, more sustainable and more just way, which I believe are also the core principles of urban metabolism studio.

12.6 Limitations and recommendations for further research

There were many challenges encountered during the process of carrying out the research. To begin with, the main challenge was data collection and finding relevant information online. Since the chosen context is in India, and due to the lack of many documented data or non-availability of open data, the first part of thesis was time consuming and challenging. There were also challenges in doing the field work and traveling to Marathwada had several considerations of safety, expenses, logistics and language restrictions, but none the less a very stimulating and worthwhile experience.

While formulating my framework and design on the policies, planning instruments and practices in such contested realities, the key aspect to overcome social vulnerabilities and to create evolutionary resilience is through collaborations involving multiple actors across scales. The proposed vision termed, 'Joint Actions for Local Water Rich Initiatives (JALWaRI), is aimed to create a decentralised, sustainable and equitable systems of water management and governance. Through this approach, the aim is to achieve rural transformation and social empowerment of farmer communities through self-organization and capacity building by shifting power. The implementation of water governance model is then tested using Dynamic Adaptive Policy Pathways that facilitates various scenarios for future. While designing the framework and policies for the region, it is ideal to have achieved the right balance through discussion and debate between the stakeholders. Hence the current pathways are not completely objective as it lacks the stakeholder and citizen engagement. Therefore, this would be interesting to test the results further using forms of participatory methods.

It would also be interesting to expand the research to other regions and products using the same framework. It is different how various regions face different impacts to the same issues perpetuated by planetary urbanisation. Therefore, more research can be done focusing on narratives from the receiving and spill over systems, which was not explored in this research. The cotton chain was used as an exemplary product chain. There are many similar water intensive products from various regions that may have similar consequences over multiple scales and would then give possibilities for comparisons for further research.

This thesis also did not focus on various external issues that may be associated with agricultural productions such as mass migrations from rural to urban areas, the influence of technology in innovation etc. This is beyond the scope of the project and requires further research. There is also the dichotomy between urban and rural areas and the influence on urban water availability , energy production and consumption, urban poverty etc that are beyond the scope of this thesis and requires further study.

Fig 12.4 Fieldwork
Source: Photo by : Anitha P

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All image references are below the images.

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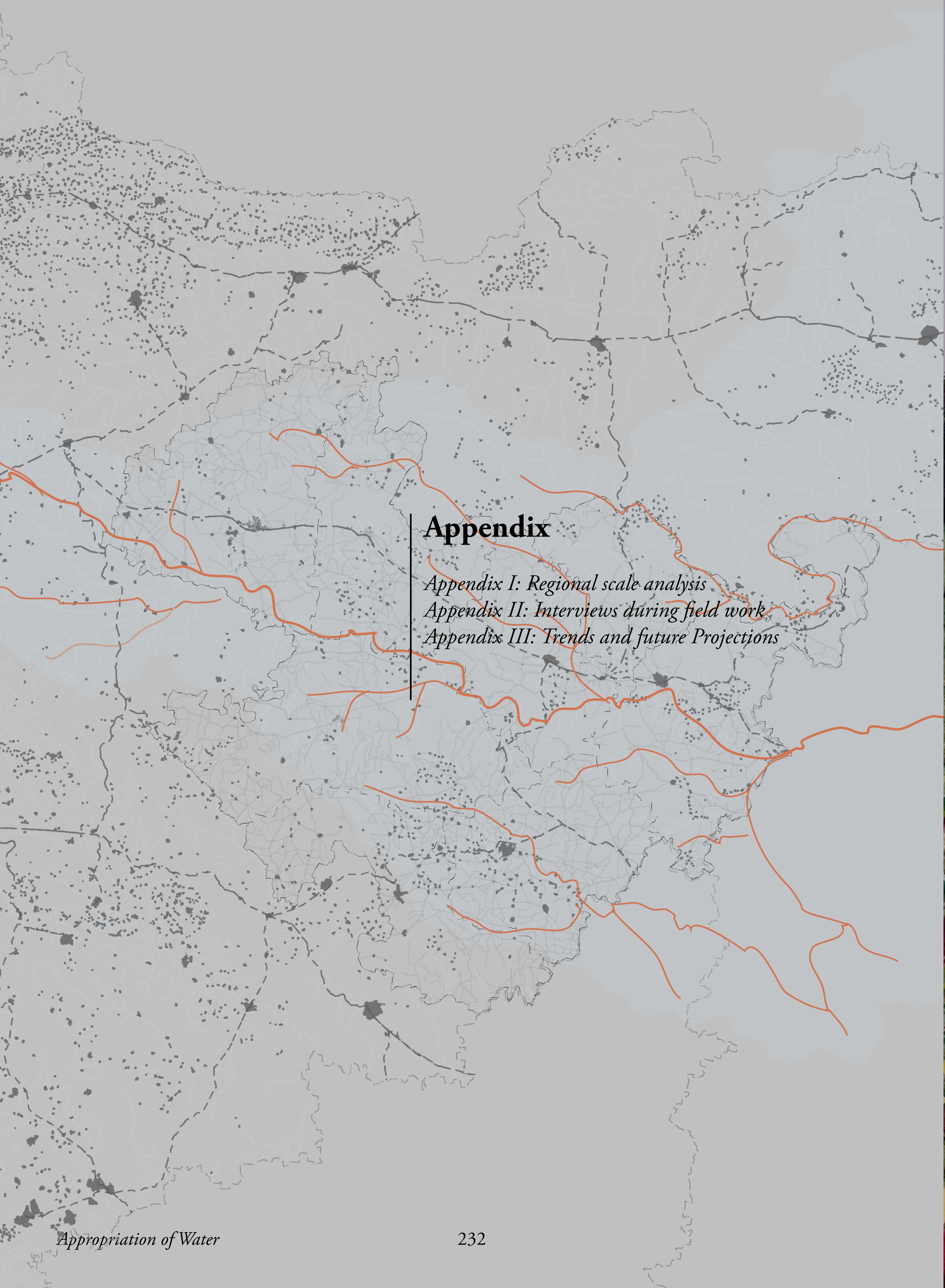

Appendix

Appendix I: Regional scale analysis
Appendix II: Interviews during field work
Appendix III: Trends and future Projections

Fig A.1 Agriculture fields
Source: Photo by author

I Regional scale analysis

Cotton production and yield

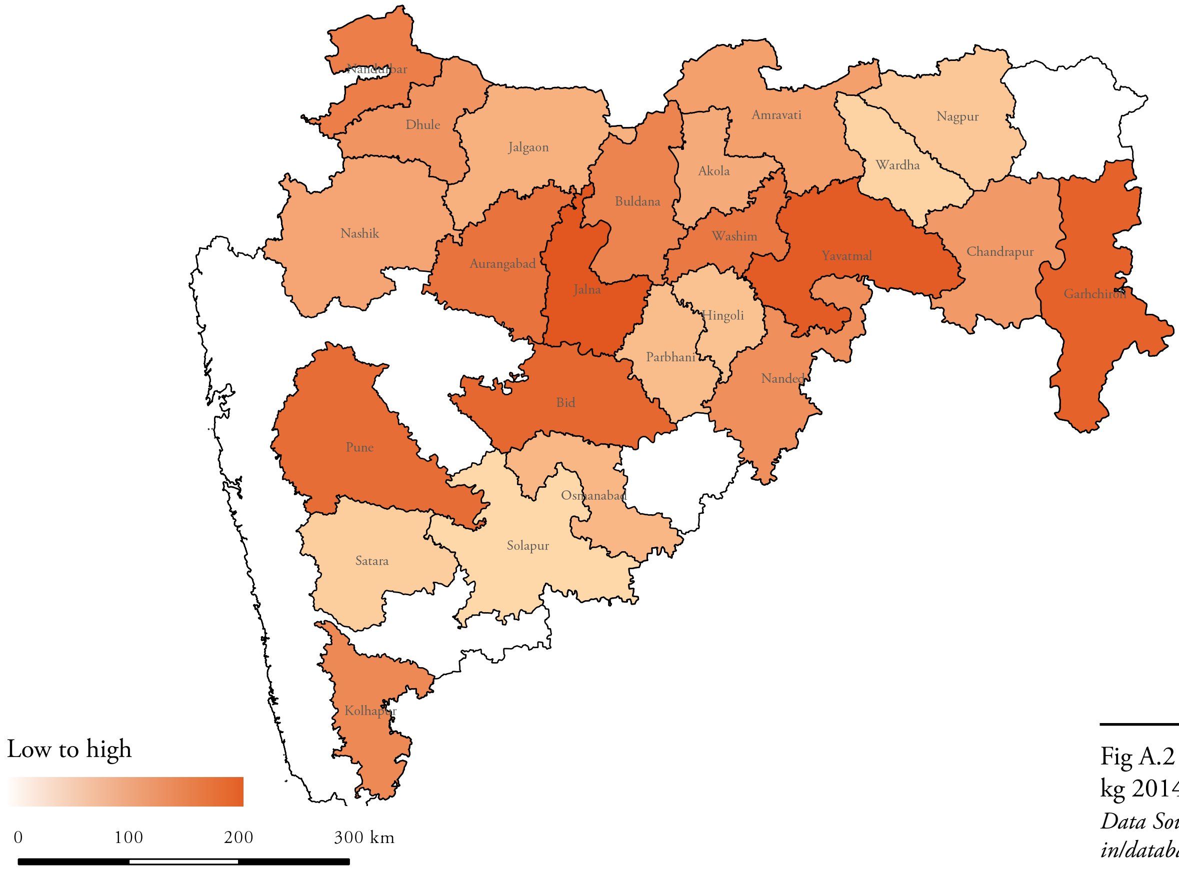

Fig A.2 Cotton production in kg 2014
Data Source: http://www.cicr.org.in/database

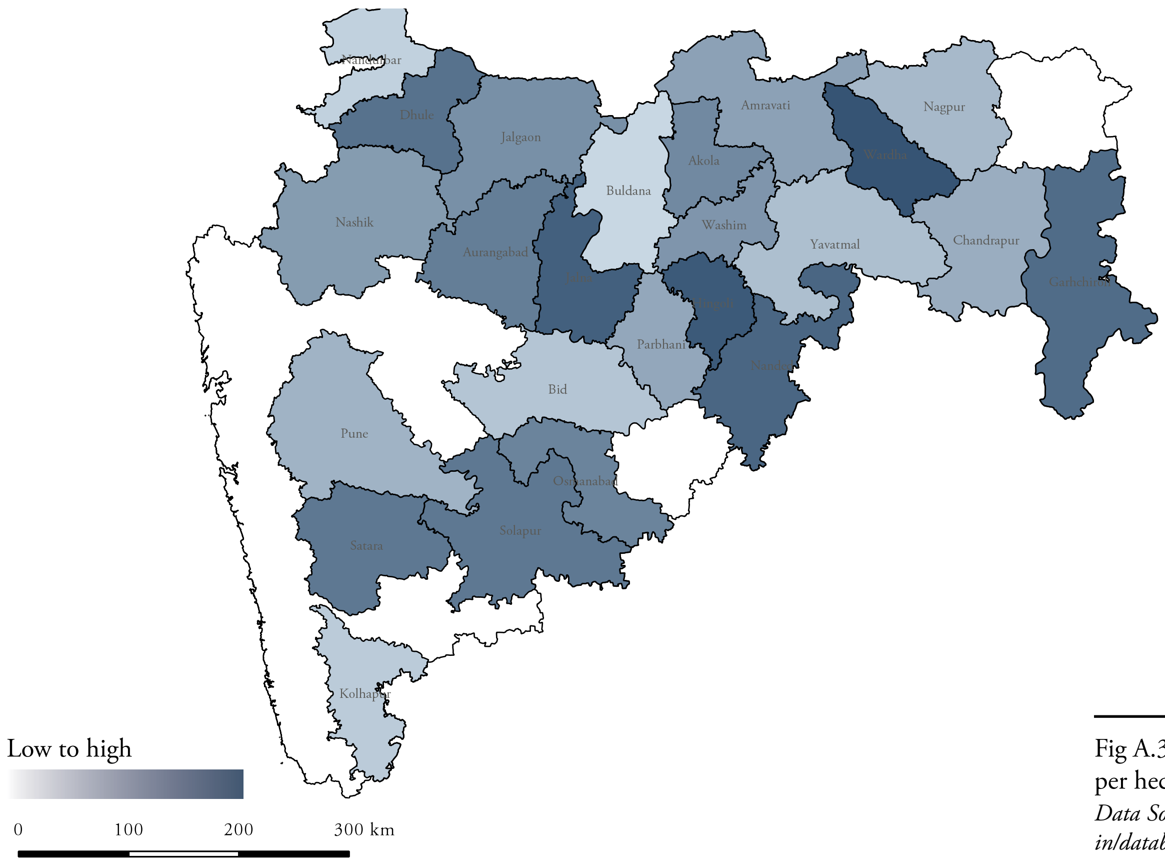

Fig A.3 Cotton yeield in kg per hectare 2014
Data Source: http://www.cicr.org.in/database

Agro climatic zones

The topography of Maharashtra can be seen as the topmost elevation in the Western ghat mountains and then sloping to the Arabian Sea. The land between the mountains and the sea forms the coastal areas. The eastern side of the mountains contain large Deccan plateau and the climate is more drier. The entire state is divided into nine agro-climatic zones based on the agriculture possibilities.

The western coastal plains have high rainfall and often has flooding issues during monsoon. It is followed by ghat mountain range with high biodiversity and then transition zones, and drought prone zones. The very eastern zones again have moderate to high rainfall (annual rainfall 3000mm). The major agriculture areas are rain-fed with southwest monsoon season in June-September.

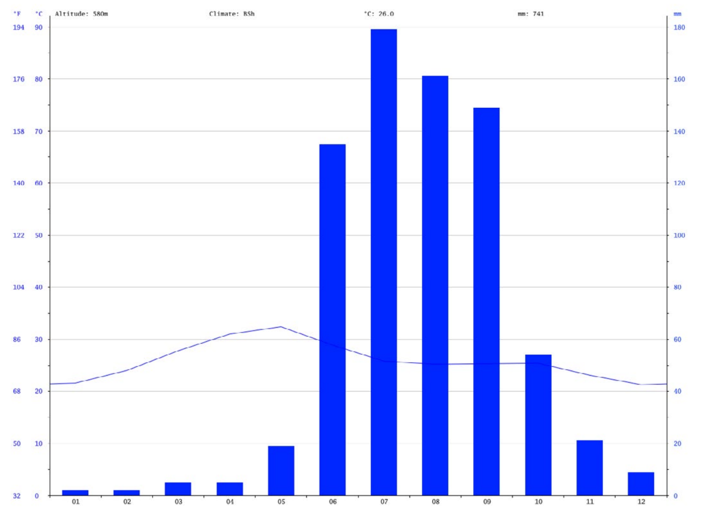

Fig A.4 Average rainfall of Aurnagabad city
Source: https://en.climate-data.org/

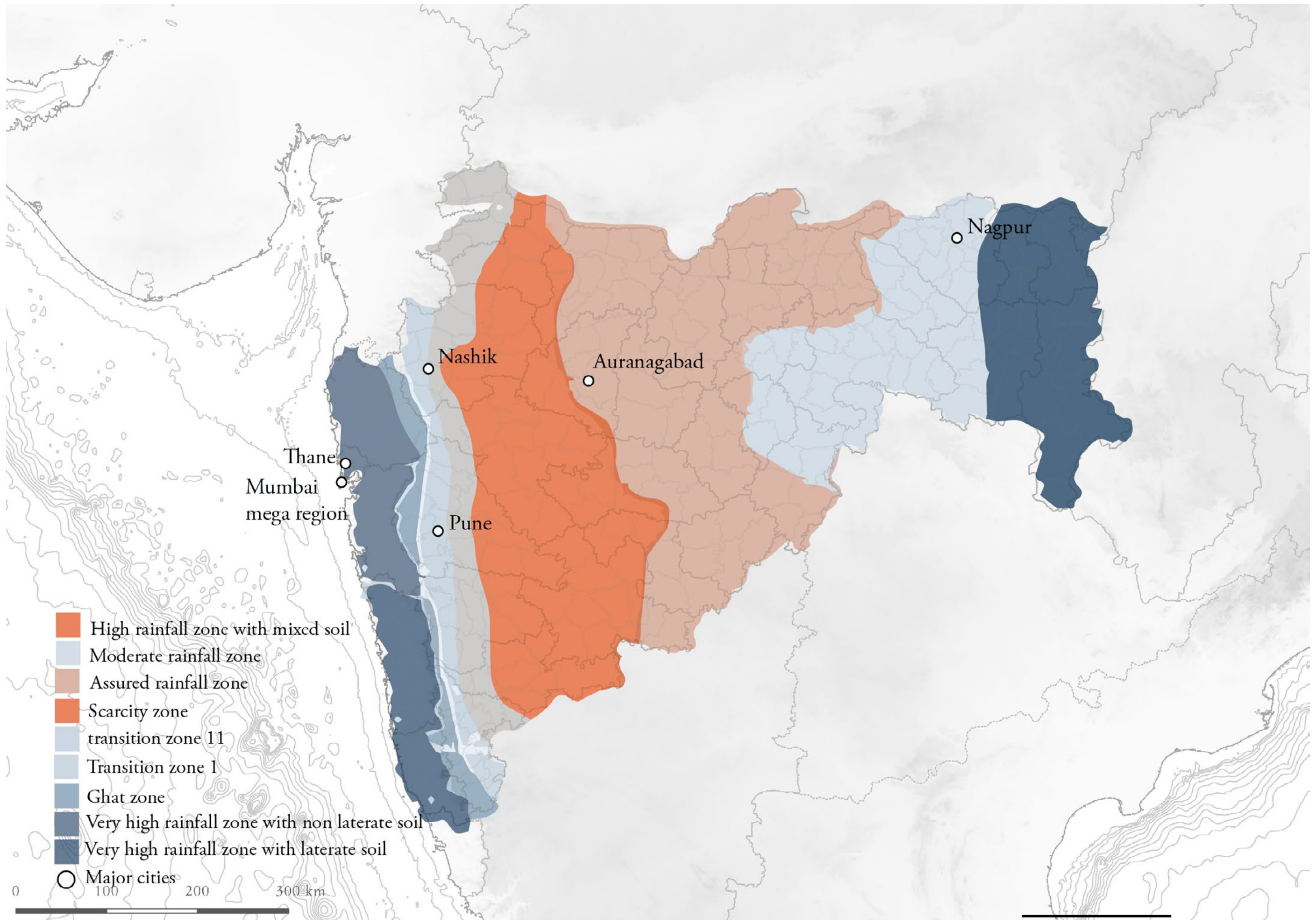

Fig A.5 Agro-climatic Zones
Source: https:// krishi.maharashtra.gov.in/

Per capita Income

Cotton is mainly grown in the Central and Eastern regions of Maharashtra with an average yield of 5.5 quintals of lint per hectare(2012-26). However the amount of yield varies considerably between the districts, for example some of the larger cotton areas but with lower yield is Beed with 1.6 quintals of lint per hectare but Amaravati has 4.7. This has to do with the seasonal rainfall patterns and the availability of water resources in the area.

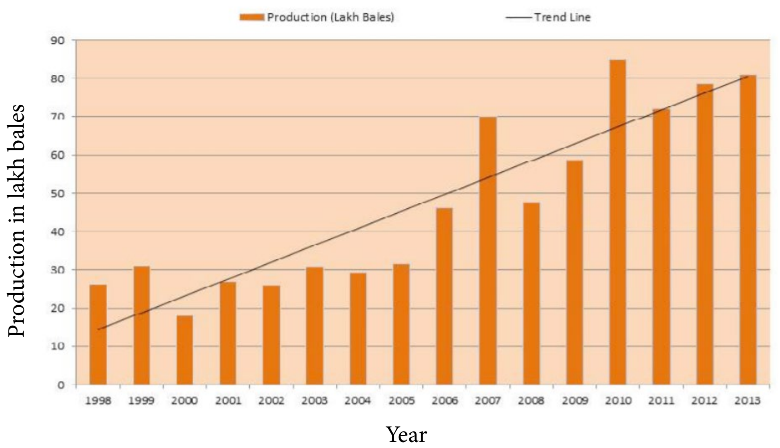

Fig A.6 Production of cotton in Maharashtra state from 1998-2014
Source: Kulkarni et al., 2017

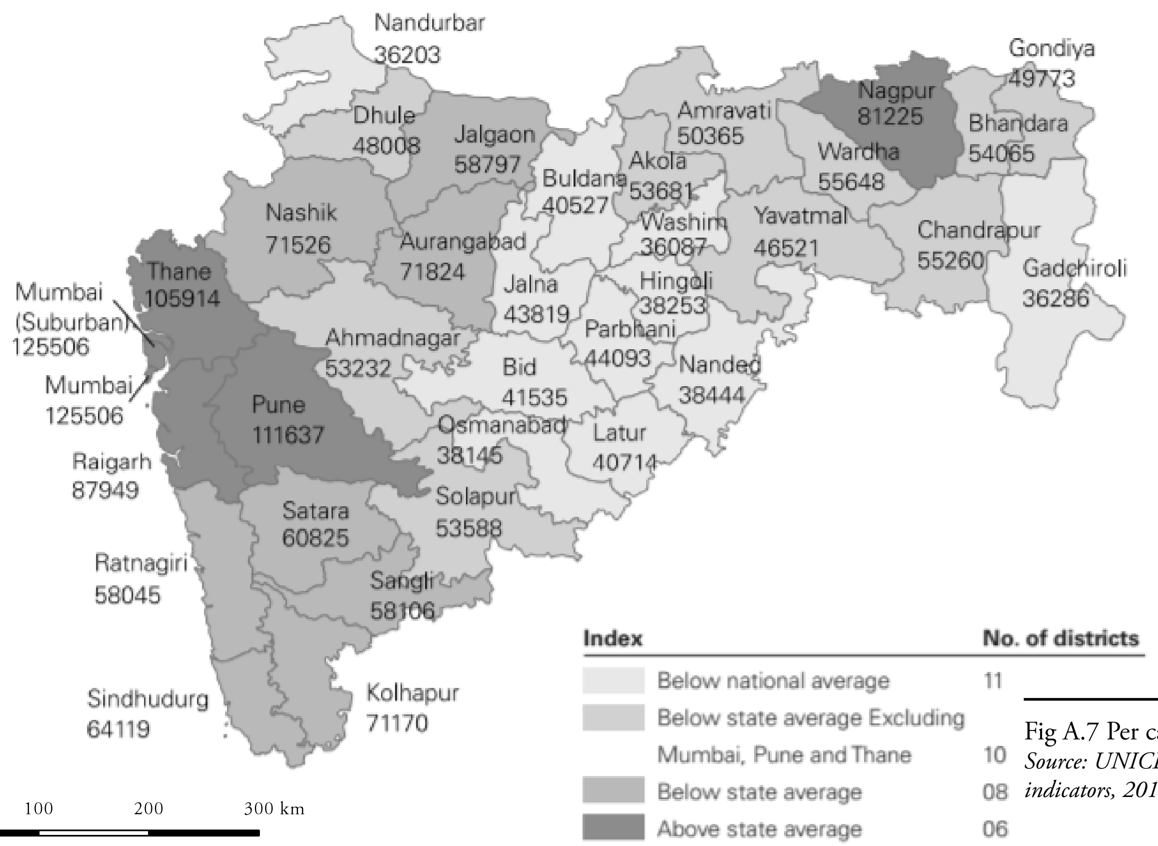

Fig A.7 Per capita income
Source: UNICEF Atlas of social indicators, 2018

Environmental depletion

The map 5.14 shows the villages that are experiencing Water scarcity in different time durations. The most villages experiencing scarcity are located in the central Maharashtra region with agro-climatic zones of scarcity and assured rainfall. The Marathwada division experiences the most number of villages with scarcity.

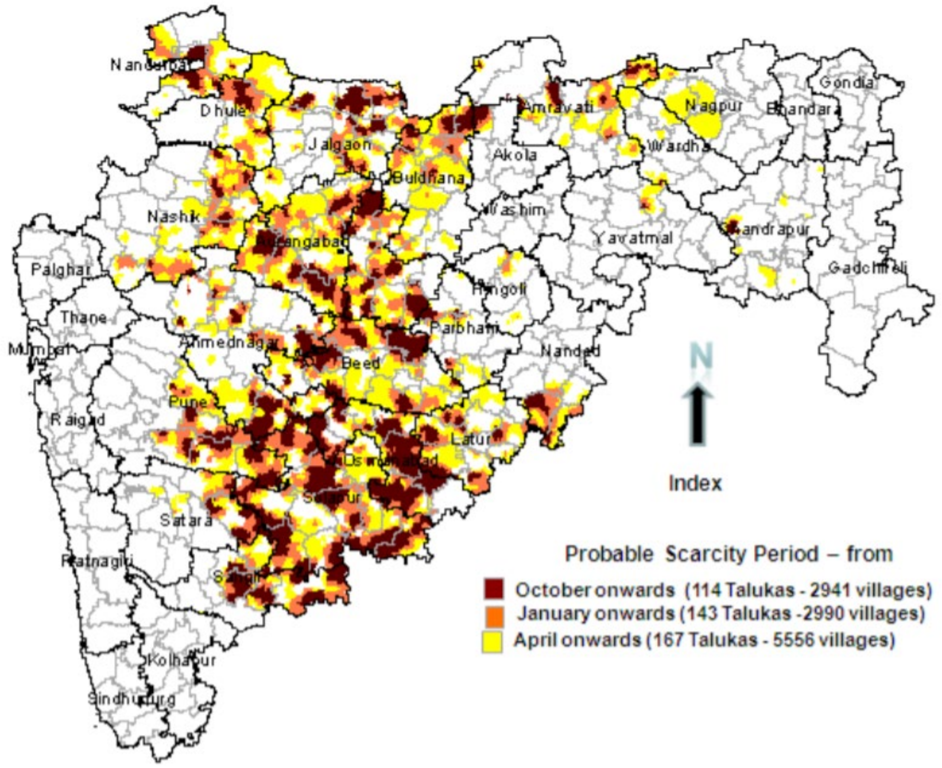

Fig A.8 Water scarcity
Source: Water scarcity report, 2018-19

According to the water scarcity report by the water resources department of Maharashtra, the fig 5.15 shows depletion in groundwater levels observed in September 2019 compared to the last 5 years of average ground water levels. This is also predominately in the Marathwada region of central Maharashtra.

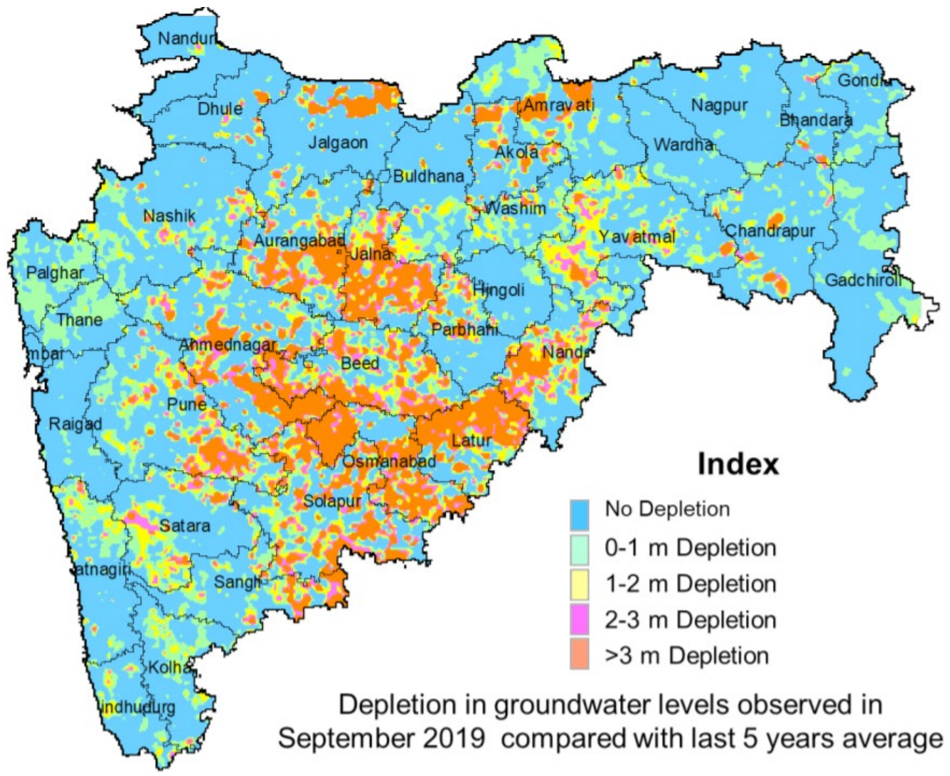

Fig A.9 Ground water Depletion
Source: Water scarcity report, 2018-19

II Interviews during field work

Interview and discussion with Stakeholders: January 2020, Marathwada, India

01 Cotton Farmers

Place: Sarangpur, Gangapur, Maharashtra,India
Name: Balasaheb Chape(42), Ramchandra Chape(35), Ravindra Parthi (40) and Kaduchape (70)
Occupation: Small holder Farmers (5 acres)

" The situation is bad if there is no rains. After 2012 droughts, our wells have gone dry. There is no water in the ground".

"The irrigation is rain-fed. We make a profit of Rs15000 per acre per year if the rains are good".

"There is not enough water to drink. Once in 4 days, a government tanker gives us 200L for the whole family. If needed more, we need to buy from private tankers".

Place: Murmi, Gangapur, Maharashtra,India
Name: Anna Sahab Parde(40)
Occupation: Small holder Farmer (3-4 acres)

"70% of the land is cultivated cotton. I have two bore wells in my land but both gives no water. We also get water from government every 4 days."

"30 years ago there was a lot of water in the land, the land used to hold water."

"In summers when there is no water, the whole family workers in factories."

"Traders come only for cotton, other crops are not profitable as much."

Interview and discussion with Stakeholders: January 2020, Marathwada, India

01 Cotton Farmers

Place: Beed, Maharashtra,India
Name: Vijay Deshmukh (52)
Occupation: Marginal farmer(18 acres)

" There is no water from the top or from the ground".

"I am unable to invest in farm ponds or drip irrigation, as I do not have money to raise the intital investment. The government subsidies are given as reimbursement but we have to put up the initial investments. And it takes 4-5 years to get the reimbursement which is a long and tiring process".

"The profits I make, I need to pay for pesticides, for water, for labourers. I want to shift to fruits but its a risk I cannot take alone".

Place: Sarangpur, Gangapur, Maharashtra,India
Name: Lakshmi Chape(30)
Occupation: Small holder Farmer (3-4 acres)

" I work in our farm and during summer we go to the factory to work".

"I have two kids, they go to the school in the nearest town. After this, the will go to Aurangabad city for college and jobs. I don't want them to stay in farming, that we will take care."

Interview and discussion with Stakeholders: January 2020, Marathwada, India

02 Government officials

Place: Aurangabad, India
Name: Prakash B Avhale Patil
Occupation: Deputy Project Director, ATMA(Agricultural Technology Management Agency), Govt of Maharashtra

" The problem lies in uneven rainfall. If there is good rains, there will be water. We cannot control that".

"We don't check if people take water illegally. Rather than going to waste, it is better people use it".

"There is a lot of awareness programs for farmers, the funding is also good."

"We cannot be responsible for maintenance and implementations, that is the job of irrigation department".

Place: Jayakwadi, Paithan, Maharashtra, India
Name: Ashok Chauhan
Occupation: Deputy Chief Engineer, Jayakwadi Dam, Irrigation department

"Jayakwadi is a multipurpose dam and gives water for domestic use, hydro power and industrial use in Jalna, Beed and Aurangabad".

"However the water for irrigation is not utilized properly due to open and damaged pipelines."

"The availability of water is also dependent on rains in catchment area, dams on the upstream and so on."

"There is a lack of manpower, maintenance and water use in the irrigation department, due to which the water is not used effectively'.

Interview and discussion with Stakeholders: January 2020, Marathwada, India

03 Civic society and organisations

Place: Aurangabad, India
Name: Jayajirao Suryavanshi
Occupation: Farmer and Activist, Annadatha Kshethkari Sangatna (Farmers Collective)

" There is no monitoring of the water use, hence the industry is getting most of the water than farmers".

"Farmers go for water intensive crops like cotton and sugarcane as they are risk-less crops, they have assured MSPs(Minimum support price), lobbying by traders and export markets".

"There is policy failures in terns if giving subsidies, night irrigation and they are not efficient".

"They (govt) are killing the rivers by silting and river deepening. There is no vision. and soon farming will become defunct".

Place: Pune, India
Name: K J Joy (Dir. SOPPECOM), Sarita Bhagat, Neha Bhadbhade (Research associates), Hari Nage (MCCI, Pune)
Occupation: SOPPECOM, NGO

"Scarcity prompts the farmer to overuse the water, and a tendency to maximize profits. There needs to be assured water that ensures equity. We have calculated the water for livelihood as 5000 cubic meters per year to sustain."

"The schemes fail at implementation level due to a lack of awareness and strict monitoring."

"There needs to a design of cropping pattern and policies for pricing and water budgeting".

"A social understanding and awareness is required to make a collective choice."

Interview and discussion with Stakeholders: January 2020, Marathwada, India

04 Cotton Industry and labourers

Place: Beed, India
Name: Kishorie Industries
Occupation: Cotton ginning and refining Industry

" We have to add water to maintain the moisture level of up to 12%, that is the major use of water in ginning".

"We get raw cotton from farmers and traders. The rates are dependent on the international markets, Around Rs 110 for 1 kg of cotton."

"It is sold to local markets in India and international markets mainly China."

Place: Parli, Maharashtra, India
Name: Group of labourers
Occupation: Daily wage farm labourers

"We get around Rs 150 -200 per day for sowing and Rs 7 per kg for plucking cotton flowers".

"Cotton requires about 5 rotations of water. After cotton season, we work as labourers in factories etc".

"There is toilets but no water. The hospitals and schools are far away, so we don't go. Most of us dropped out of school after class 9th or 10th."

Interview and discussion with Stakeholders: January 2020, Marathwada, India

05 Researchers and scientists

Place: Aurangabad, India
Name: Dr. Harshada P Deshmukh
Occupation: Phd in Soil Science, Assistant Professor, WALMI (water and Land Management Institute, Aurnagabad), Faculty of Agriculture,

"If you manage the water requirement and irrigate only crop root zone, then water can be saved. You must use only drip irrigation instead of flood."

"The clay type soil is best for cotton and has high retention capacity. Depending on the soil type, you can decide the interval also. So excessive irrigation causes stratification. However, there is no awareness amongst farmers."

"Night irrigation is not allowed physiologically, but farmers only get water then, so they also have to worry a lot."

Place: Aurangabad, India
Name: Dr. G R Jekale
Occupation: Assistant Professor, Faculty of Agriculture, WALMI (water and Land Managemnet Institute, Aurnagabad)

"It is always not the case that you need more water to have more yield."

"Marathwada is a rain shadow area, so there is uneven and unpredictability in rains. Irrigation practice is not there historically".

"We have field workers to create awareness amongst farmers, and the farmers are keen to learn. But policies are not always favoring them"

06 Farmers shifted from cotton to other crops: January 2020, Marathwada, India

Place: Hiware Bazar, India
Name: Dhangane (64)
Occupation: Farmer from Hiwere Bazar using sustainable water practices.

"I had water in my well even though there was no rains last year. I have never used even an ounce of bore well water(groundwater extraction) for irrigation."

"I have discarded crops that are water intensive like cotton and sugarcane. I only grow crops required for food and for cattle fodder like Maize, millets, cereals and pulses. I also have dairy business from my cows. These can give us profits."

"Now I have surplus water for household use and irrigation".

Place: Parli, Maharashtra, India
Name: Bharath Natha Bhandge
Occupation: Shifted from cotton to papaya

"I switched to horticulture two years back. I grow ingenious variety papaya, and it requires only less water. We grow as a group of 50 acres, and that is more profitable. I had Rs 3 lakhs profit last season."

"I was supported by Global Parli (NGO) for the intimal investment. Now I have applied for other government schemes for climate resilient agriculture."

"With initial investment help and as a collective group, it is possible to shift from cotton".

III Trends and future projections

DMIC (Delhi Mumbai Industrial Corridor)

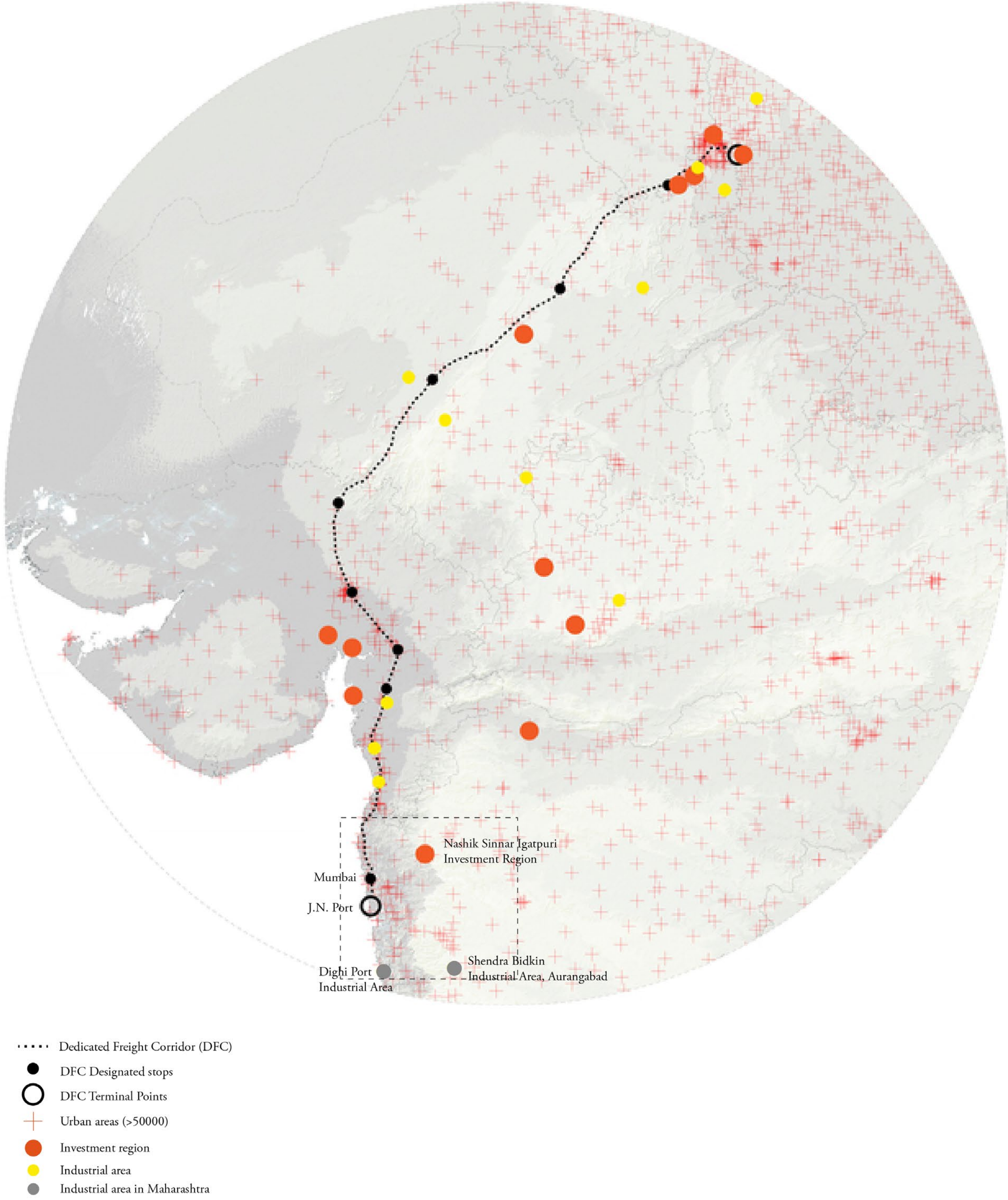

Fig A.10 Projections
Source: by author

Mumbai Nagpur high speed network

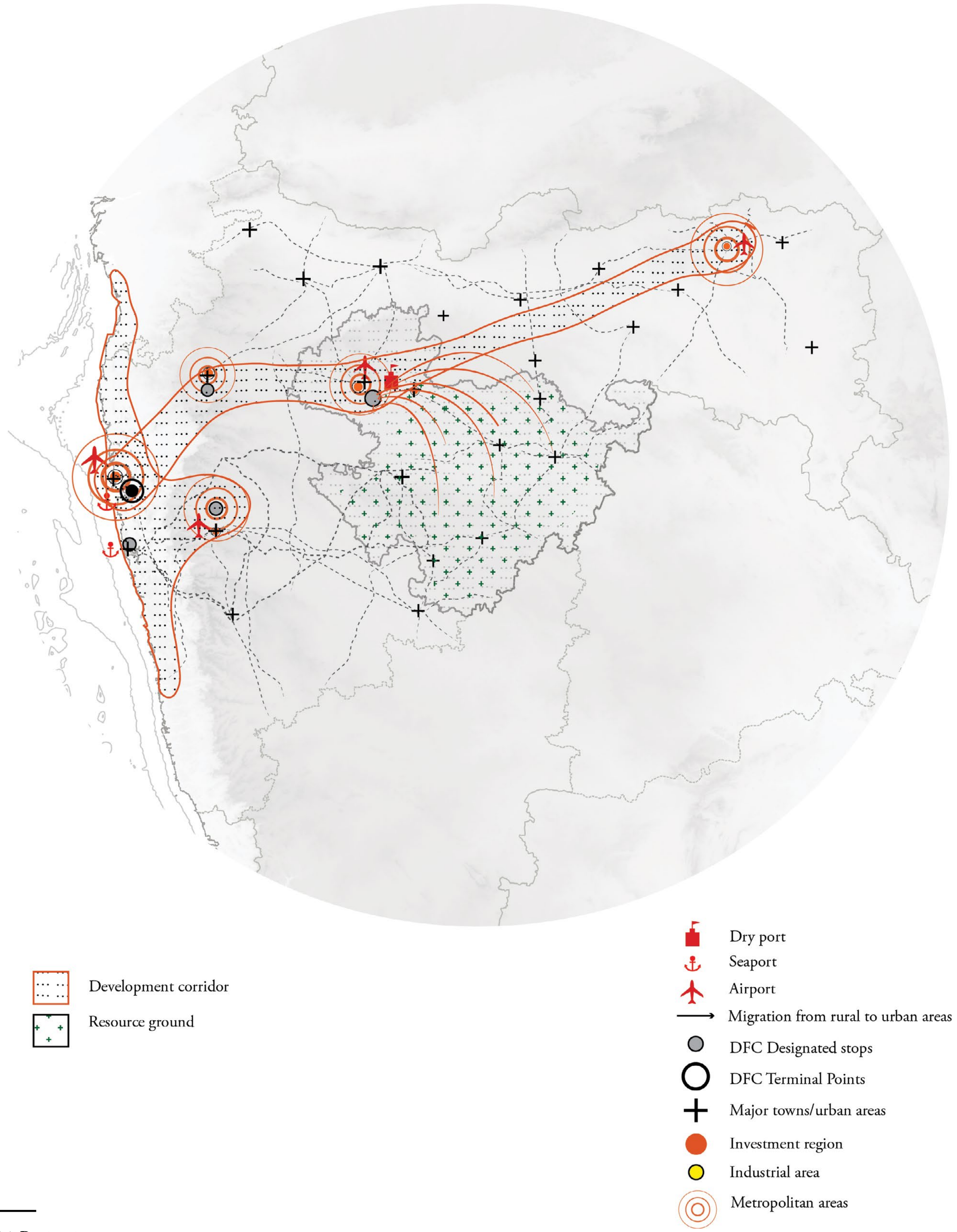

Fig A.11 Projections
Source: by author

Freight transport facilities (present)

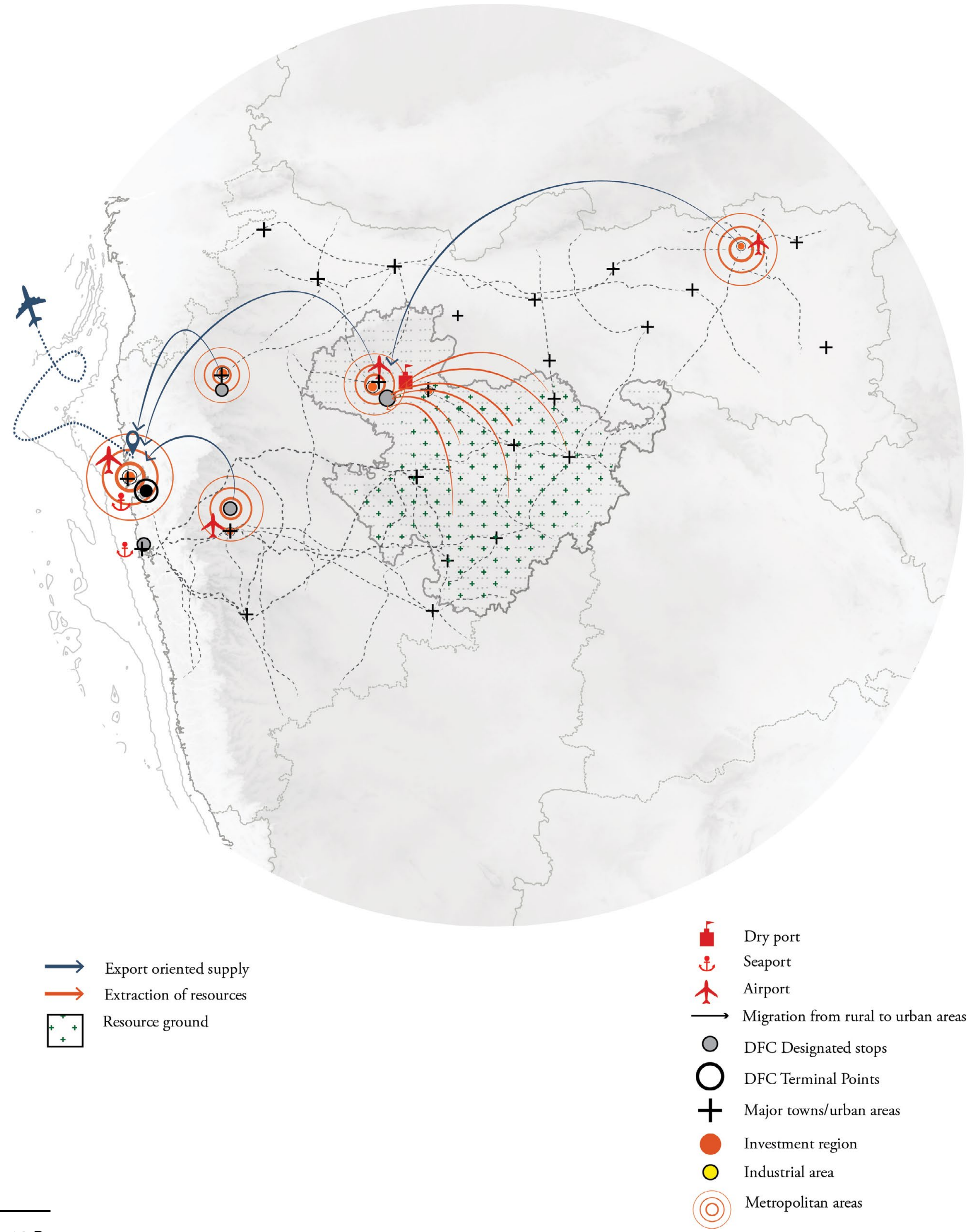

Fig A.12 Projections
Source: by author

Migration from rural to urban areas

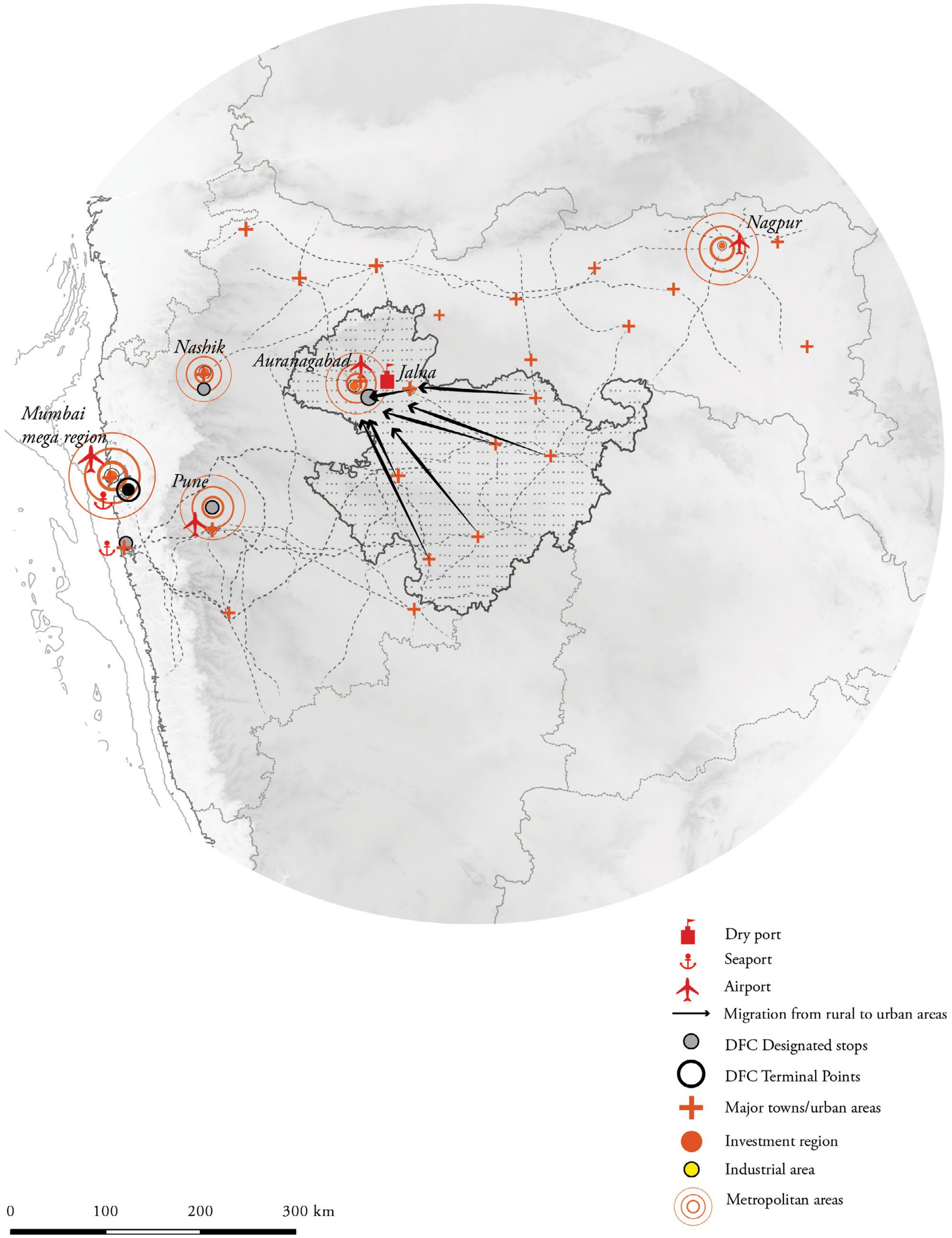

Fig A.13 Projections
Source: by author

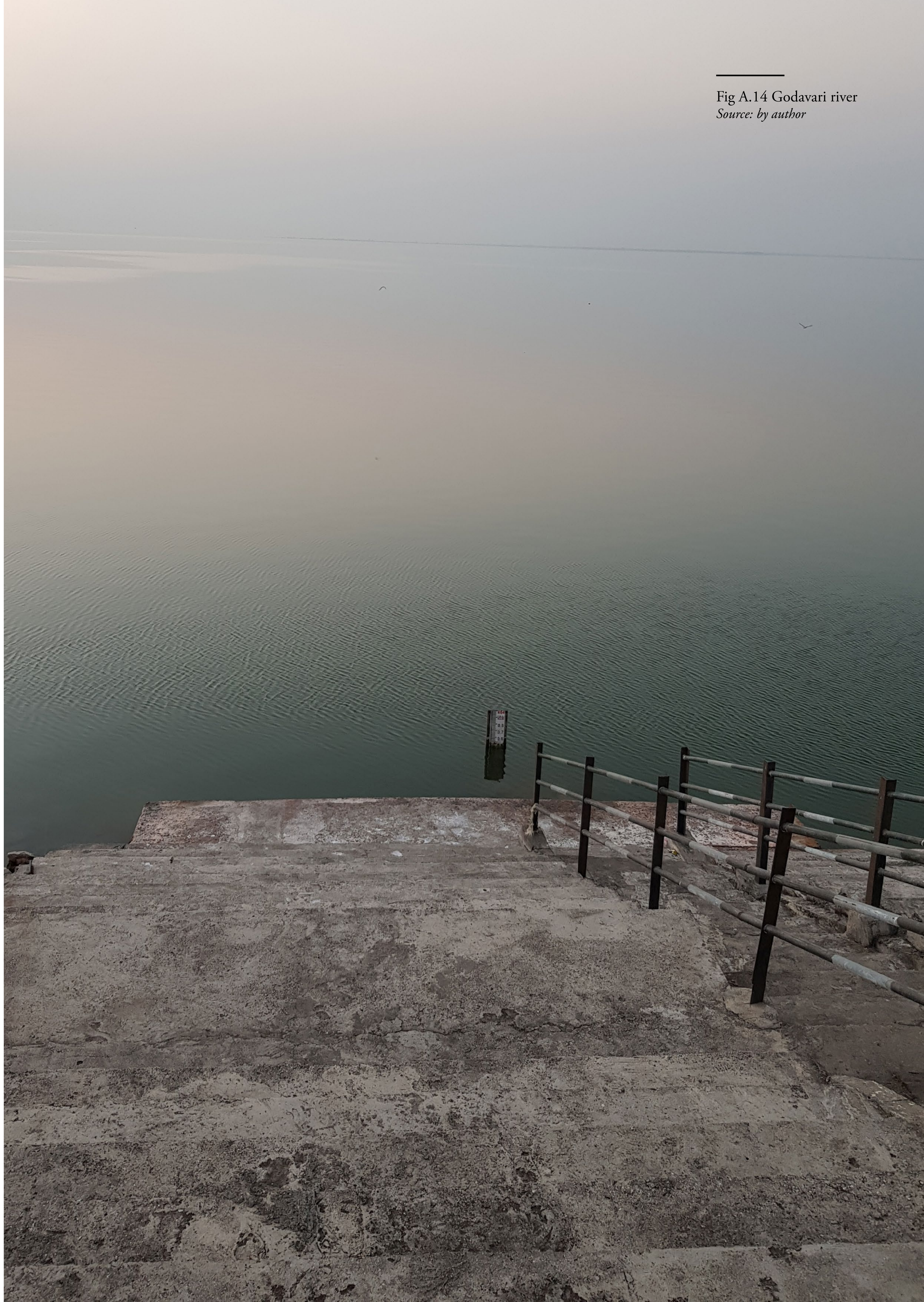

Fig A.14 Godavari river
Source: by author

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June 2020