



ROYAL INSTITUTE
OF TECHNOLOGY

**RESILIENCE THINKING FOR
COMMON POOL RESOURCE
MANAGEMENT - AVOIDING
DROUGHT INDUCED DISASTER
THREATS IN INDIAN RAJASTHAN**

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Erika Svensson

Programme Officer

MFS Programme, KTH International Relations Office

This work is dedicated to the people that understand the necessity for mankind to change the way our activities are deterring the planet ecosystems.

When we seek the “good way” to perform our actions should it be the way that promises more return in a certain future or is it the way that allows us to keep on doing the things we do?

It is the people that can see through this question whom I would like this work to return to.

Nicolas Sultanem

FOREWORD

The state of Rajasthan in India is one of the lowest rainfall areas in the world and the most drought-prone area in the country yet local communities have thrived for generations in the harsh drought-like conditions. For them water is the most precious resource and they have developed infrastructure for harvesting every drop of rain that falls in the locality, storing and using it with great caution. In fact, the socio-ecological system in the area can be described as drought-resilient. However, in modern times, the traditional knowledge and technologies based on rainwater harvesting and water conservation started getting replaced by the technologies that promote unsustainable, unplanned use of the scarce water resources which are leading to water scarcity, in turn triggering drought and environmental degradation. Impact of global climate change is further deepening the crisis. In such a context, rejuvenation of the traditional knowledge and technologies and strengthening of institutional frameworks that support rainwater harvesting and wise water management is essential. The situation in Rajasthan today is mirrored in many other areas of the country and elsewhere in the semi-arid and arid zones of the world.

In this light, this is a very timely study which attempts to identify the components of the socio-ecological system (SES) in terms of drought resilience and develop a model of resilient SES. The study not only helps explore the uniqueness of Rajasthan's water governance but also puts forward recommendations for enabling strategic adaptive planning towards creation of similar SES in other areas in India and elsewhere in the world where similar circumstances prevail.



NANDITA SINGH

SUMMARY

Our impact on the planet is straining the ecosystem in a way where large scale environmental changes threaten to destabilize our communities. Desertification, drought, land degradation, freshwater scarcity and climate change are all examples of these environmental changes. This study deals with the destabilizing effect of drought on the livelihood of communities leading to outmigration and a destabilized population density distribution. Rajasthan state in India is an area of the world where communities have been facing the necessity of alleviating drought impacts for generations. The purpose of this work is to synthesize from Rajasthan a Socio-Ecological System that can provide for long term droughts mitigation needs to counter outmigration patterns.

Three fields of expertise were combined to come out with the framework for this study. Sustainable Development Goals provided a target to reach in community development that would provide the people with what they seek without them needing to leave their locality. Resilience Thinking helped provide a planning approach that can built up resilience, adaptability and transformability of socio-ecological systems in times of need. Integrated Water Resources Management frameworks helped think of water resources governance in an integrated way.

Using all three fields described, an initial assessment for defining a theoretically resilient system in Rajasthan was performed. With the defined system at hand, a field investigation was performed to assess the communities where the components of this system have been striving. The field investigation covered the infrastructure constructed at community level to harvest rainwater and recharge local aquifers. It also targets collecting feedbacks and opinions of stakeholders involved. Governmental supply and institutional model also had its part. Water governance in the state was completely different one hundred years ago and a lot of traditional lore that had been forgotten has recently been revived by the help of grass-root organizations. The field investigation also covered the works performed by these organizations and their impact on the communities they take part of.

After the baseline assessment and the field investigation were performed a final resilient Socio Ecological System model was established for support in planning needs. The findings summarized in this model were used to advise for building resilience in another area of Rajasthan where similar implementations are needed. If developed with further research and quantification of parameters this model can be used to build the resilience of other areas of the world that have similar conditions to the ones in Rajasthan.

SUMMARY IN SWEDISH

Vår klimatpåverkan anstränger ekosystemen på ett sätt som gör att stora miljöförändringar hotar att destabilisera våra samhällen. Ökenspridning, torka, förvittring, färskvattenbrist och klimatpåverkan är alla exempel på dessa miljöförändringar. Denna studie behandlar den destabiliserande effekten som torka har på samhällen. Torkan leder till emigration och en destabiliserad befolkning. Delstaten Rajasthan i Indien är ett område där samhällena i generationer har behövt förmildra effekterna av torka. Följaktligen är syftet av denna studie att med data från Rajasthan skapa ett socioekologiskt system som kan förmildra effekterna av torka. Således kan emigration orsakat av torka motverkas.

Tre ämnesområden kombinerades och utgjorde ramen för studien. Målen för hållbar utveckling utgjorde ramar för att nå samhällsutveckling inom samhällena som tillät invånare att nå deras önskemål utan att flytta. Resiliens-perspektivet var användbart för att ta fram en planeringsmetod som kan bidra till resiliens, anpassningsbarhet och föränderlighet av socioekonomiska system vid behov. Integrerad vattenresurs-hantering var användbart för att utveckla resursförvaltning.

Genom att använda de tre nämnda teorierna och målen kunde en initial bedömning för att definiera ett teoretiskt resilient system i Rajasthan göras. Efter att systemet definierats så genomfördes fältundersökningar för att utvärdera samhällena berörda av komponenterna av detta system. Fältundersökningarna omfattade infrastrukturen byggd på en samhällsnivå för att samla in regnvatten och tillföra vatten till lokala akviferer. Dessutom samlades åsikter och respons in från berörda parter. Tillförsel från myndigheter och institutionella modeller bedömdes också. För hundra år sedan var vattenhanteringen i delstaten helt annorlunda och mycket av de traditionella kunskaperna gällande detta har fallit i glömska fram till att kunskaperna nyligen återupplivats av gräsrots-organisationer. Fältundersökningen täckte också arbeten utförda av dessa organisationer och deras effekt på samhällen de verkade i.

Efter att grundutvärderingarna och fältundersökningarna genomförts så konstruerades en slutgiltig resilient socioekonomisk modell för att stödja planeringsarbeten. Slutsatserna sammanfattade i denna modell användes för att ge förslag på hur man kan utveckla resiliens i ett annat område i Rajasthan, där liknande behov finns. Om modellen utvecklas vidare med hjälp av mer forskning och kvantifiering av parametrarna i modellen kan modellen sedan användas för att utveckla resiliens i andra områden i världen med behov liknande de som finns i Rajasthan.

सारांश

ग्रह पर हमारा प्रभाव पारिस्थितिक तंत्र पर इस प्रकार से दबाव बना रहा है कि बड़े पैमाने पर पर्यावरण परिवर्तन हमारे समुदायों को अस्थिर करने की चेष्टा कर रहे हैं। मरुस्थलीकरण, सूखा, भूमि क्षरण, मीठे पानी की कमी और जलवायु परिवर्तन ये सभी पर्यावरण परिवर्तन के उदाहरण हैं। इस अध्ययन का विषय है यह जानना कि सूखे के कारण समुदायों की आजीविका किस प्रकार प्रभावित होती है। राजस्थान राज्य भारत में दुनिया का एक ऐसा क्षेत्र है जहां समुदाय पीढ़ियों से सूखे के प्रभावों को समाप्त करने का प्रयास करते रहे हैं। इस अध्ययन का उद्देश्य राजस्थान के उदाहरण से एक ऐसे सामाजिक-पारिस्थितिक तंत्र प्रणाली की रचना करना है जिसके द्वारा कि लंबे समय तक सूखे के शमन प्रवास पैटर्न का मुकाबला किया जा सके।

तीन विशेष क्षेत्रों को संयुक्त कर इस अध्ययन के लिए ढांचा बनाया गया है। संपोषित विकास लक्ष्य समुदाय के लिए स्थान छोड़े बिना विकास संभव बनाता है। समुत्थानशक्ति पर आधारित चिन्तन एक नियोजन दृष्टिकोण है जिससे समुत्थानशक्ति, अनुकूलनशीलता और जरूरत के समय में सामाजिक-पारिस्थितिकी प्रणालियों के परिवर्तन संभव हो सकते हैं। एकीकृत जल संसाधन प्रबंधन दृष्टिकोण जल संसाधनों के शासन में एक एकीकृत रास्ते से मदद कर सकते हैं।

पहले बताये गये सभी तीन क्षेत्रों का उपयोग राजस्थान में सैद्धांतिक रूप से समुत्थानशक्ति प्रणाली को परिभाषित करने के लिए किया गया। इस परिभाषित प्रणाली के द्वारा एक क्षेत्र जांच कर समुदायों में इस प्रणाली के घटकों अध्ययन किया गया है। इस अध्ययन में वर्षाजल संचयन एवं स्थानीय जलवाही स्तर को रिचार्ज करने हेतु समुदाय के स्तर पर बने बुनियादी ढांचे पर जोर दिया गया है। इसमें संबंधित शामिल हितधारकों की राय भी एकत्रित है। सरकारी आपूर्ति और संस्थागत मॉडल भी इसका हिस्सा है। एक सौ साल पहले राज्य में जल प्रशासन पूरी तरह से भिन्न था और पहले की भूली हुई पारंपरिक विद्या को हाल ही में जमीनी संगठनों की मदद से पुनर्जीवित किया गया है। इस अध्ययन में संगठनों और समुदायों के द्वारा प्रदर्शन किया काम शामिल हैं।

आधारभूत आकलन और क्षेत्र जांच के बाद अंत में एक समुत्थानशक्ति पर आधारित सामाजिक-पारिस्थितिक तंत्र की प्रणाली का मॉडल स्थापित किया गया है जिससे योजना बनाने में सहायता मिले। इस अध्ययन के निष्कर्षों पर आधारित मॉडल का उपयोग राजस्थान के अन्य क्षेत्रों में समुत्थानशक्ति निर्माण हेतु सलाह देने के लिए किया गया है, जहां इसी तरह के कार्यान्वयन की जरूरत है। अनुसंधान और मापदंडों के साथ विकसित इस अध्ययन के निष्कर्षों का उपयोग दुनिया के अन्य क्षेत्रों में समुत्थानशक्ति निर्माण हेतु किया जा सकता है, जहां राजस्थान की तरह ही स्थिति है।

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ABBREVIATIONS

Common Pool Resource	CPR
Corporate Social Responsibility	CSR
Geological Survey of Indian	GSI
Gram Vikas Mandal Navyuvak Laporla	GVNML
Gross National Product	GNP
Indian Oil Corporation Limited	IOCL
Integrated Water Resources Management	IWRM
Millennium Development Goals	MDGs
Non-Governmental Organization	NGO
Public Private Partnership	PPP
Rajasthan State Mines & Minerals	RSMM
Socio-ecological systems	SES
Sustainable Development Goals	SDGs
Tarun Bharat Sangh	TBS
United Nations	UN
Water, Sanitation and Hygiene	WASH

ABSTRACT

Drought related problems are a major stress source on the livelihood of communities in several areas of the world. Due to inefficient water resources management people leave their traditional habitat in search for security in larger agglomerations. This creates a big stress on the carrying capacity of urban centers and leaves deserted rural areas incapacitated. Setting Sustainable Development Goals as targets to reach, using Resilience Thinking to provide for resilience, adaptability and transformability, and planning for Integrated Water Resources Management can be a solution to reduce this outmigration.

Rajasthan is a state in India where communities have been surviving with very little available water for ages. Contemporaneous implementations in parts of Rajasthan fulfill the framework set for this study. After identifying a promising SES in terms of drought resilience a field investigation was conducted for adequate assessment and model of resilient SES was reverse engineered from the findings. Reading thru this document one can explore the uniqueness of Rajasthan water governance from pasts long gone and to the current date. In the end of the study strategic adaptive planning recommendations can be found for creating a similar SES.

Key Words: Resilience Thinking, Common Pool Resources, Rajasthan Drought, Drought Alleviation, Sustainable Governance, Water Resources Management, Traditional Water Structures

INTRODUCTION

Drought prone areas in Asia are succumbing to an ever increasing water stress and its associated disasters such as landslides, river bank erosions or seasonal floods originating from several factors (UN ISDR, 2008). In the description of our world today the UN general assembly lists desertification, drought, land degradation, freshwater scarcity as well as climate change as part of the major challenges facing humanity (UN General Assembly, 2015). Apart from global warming and precipitation pattern changes, the factors leading to water stresses also include bad management, over extraction and diversion of water resources to large urban agglomerations usually coupled with uncoordinated land use and other natural resources extraction practices. To survive this unprecedented intensity of events adaptation models involving all relevant actors need to be developed (Swedish FAO, 2015).

The water governance system in the Indian state of Rajasthan deals with a major example of this scenario. By taking a closer look into the survival conditions of the population in several districts of the state, one notices the remarkable alleviation measures undertaken to minimize the water stress impacts. A combination of indigenous knowledge implementations with fostered active community participation has allowed the population of Rajasthan to avoid a complete desertification of drought affected towns (SAARC, 2009). State government intervention on the other hand has been administering pain relief solutions to ease the current condition by reducing vulnerability. However successful this has proved to date, an elaborate adaptive strategy based on clear expectations of a foreseeable future is still needed to prevent a collapse.

Adaptive governance thinking provides a perspective to governance that incorporates the cross scale interactions between SES components (Folke, 2006). Accordingly, interactions of different organizational levels in a governance system can be programmed in a malleable way that provides for adaptability to factor changes. A resilience assessment provides a way to identify feedback and response interchanges of the different components in an SES (Resilience Alliance, 2010). It also provides a structured framework for planning development in a way that meets adaptive governance. Water governance impacts most aspects of sustainable development of a community (UN General Assembly, 2015). IWRM frameworks have proved most adequate in meeting water governance requirements (Moriarty, et al., 2004). Using an IWRM framework to establish a model of adaptive governance; drawing from a Resilience Thinking approach; for fulfill the SDGs set by the UN would be combining the state of the art perspectives in the field of water governance.

The focus on the Rajasthan region of north western India originally drew from the fact that a complex set of inter-related occurrences have led to drought patterns in the area (SAARC, 2009). In the Rajasthan case, one is prone to consider the threshold above which the community-scale interventions and pain relief mitigations will no longer suffice. In the event of these established governance systems falling apart, resulting famine and desertion could lead to ugly losses of life and formation of ghostly rural areas. Synthesizing an SES in Rajasthan with drought resilient characteristics that meet IWRM guidelines is very promising. Reusing what is found to build-up adaptive governance for other similar SES within Rajasthan also seems to be very feasible.

Aim and Objectives

The aim of this study is to investigate if a resilience thinking approach to planning for water resources governance in water stressed areas like Rajasthan can counter drought induced deterioration of life leading to outmigration and accordingly provide a planning strategy for the future. The overarching research question under investigation is: “Can resilience thinking applied to strategic planning help preserve the valued components of the SES of Rajasthan communities as they have been preserved to date, all the while providing for long term resilience and avoiding population outmigration?”

Having introduced the topic as stated in the research question draws from a combination of both observations and experience that have contributed in defining the fields of interest of this study and accordingly shaped the approach. Several objectives need to be achieved for fulfilling this aim.

The first objective is to isolate and define an SES which has displayed a rigorous resilience to water-related stresses within Rajasthan. The second objective is to demonstrate that the extrapolated effect of water-stress alleviation implementations in this isolated system has contributed to countering outmigration. The third objective is to identify contexts and locations within Rajasthan where similar interventions are needed and can be performed. The fourth objective is to formulate a participatory comprehensive strategic planning for the area based on resilience thinking to be adequately communicated along the institutional levels.

The overarching research question can hence be dissected into more targeted research questions to investigate:

- Which SES has displayed the most rigorous resilience to water stresses in Rajasthan?
- Has the impact of water governance related implementations in the resilient SES reached beyond simple natural resources management and contributed in countering outmigration?
- Which other communities in Rajasthan are in need of similar implementations?
- What according to the findings is the adequate strategy for water governance in Rajasthan and where does it need to be communicated?

THEORETICAL BACKGROUND

The combined use of the SDGs, resilience thinking and IWRM undertaken during this study calls for a recollection of the major incidences and events that lead to the creation of these notions.

Sustainable Development

Throughout the 20th century development has been the main driving force that shaped human life (Sachs, 2000). Under this broad line a paper on development by W. Sachs lists the chronology of a shapeshifting concept with the main changes it has undergone. Events of modern history culminated in the beginning of the past century to the establishment of the “anti-colonialism” heralded by the US big brother being a post-colonialist experience itself. Development can be considered to have started manifesting in the form of “rising to the level of an upheld image”. The west needed a solution to fill the post world war two gaps after the lost hegemony of colonialist powers over the global South. Development was hence a sort of umbrella in the 1950s under which ex-colonized countries were allowed out of an authoritarian colonialism framework into independent governance as long as they stay within the set economic framework (Rist, 1997). On the 20th of January 1949 newly elected United States president Truman inaugurated his mandate with the following speech:

“...we must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of **underdeveloped areas...**” (Truman, 1949)

Marking the dawn of the development age at a time where colonial age was ending with countries acquiring their independences and delimiting the split between the global North and the global South. Level of civilization became linked to economic performance and real per capita income where developing countries are those with lower income than advanced countries with higher incomes (Samuelson & Nordhaus, 1985). This induced a race between countries for increasing GNP in order to sit at a higher step on this new measure of excellence. GNP becomes a tool of comparison advertised at a global level. Indeed self-enrichment to the image of the rich global North was a catalyst to any action taken by the global South. With the main precursor of previously colonized countries to stand up to the image of their previous colonizers, to join the race and embraced development as a means of restoring self-respect and pride (Sachs, 2000). The west also de-facto embraced development for its suitability as a means of ensuring global economic stability in the new market led economy.

Increasing production was not the adequate action to take as has been later proved. GNP growth failed to benefit the majority. Not only was the gap between rich and poor still there but it was increasing. The poor suffered from misdistribution and sank into deeper poverty particularly in developing countries (UNDP, 1998). A redefinition of Development was needed. World Bank president Robert McNamara called to strive for eradicating “absolute poverty” (McNamara, 1973). This set new “catching-up” criteria to reach which replaced GNP, including child mortality, nutrition and literacy (McNamara, 1973). The concept of development hence evolved from linear GNP growth to include emphasis on literacy, health and participation. Human Development Index got to become the new grading ladder. Linear hierarchy and preset targets presumed to be adequate was still part of the concept. Again, the “father's image” of developed nations was the target to reach. During the same period, the global South marginalized on international politics level, had several attempts at creating a “Third World” pole to outweigh the established bi-polarity (Sachs, 2000). This culminated in the Oil crisis led by OPEC which collapsed in the 1980's, as well as the creation of the South Commission. And still, all these events did not drive development into a scheme that closes the gap between the “Rich” global North and the “Poor” global South until environmental concerns arose.

A realization of the time and space constraint to linear growth due to the fact that our planet can only hold and provide so much resources struck the linear development concept. The stability of the planetary ecosystem is threatened by the overburden imposed from extraction of non-renewable resources and emission of contaminants. The sustainability concept got added atop human development. Sustainable Development defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WECD, 1987) “development that lasts” (World Bank, 1992). Along the same time, shifts in world economics led to closure of the Development Age and entering into the Globalization Age.

With globalization the previous agent, object and scale of development disappear (Sachs, 2000). The permeability of Westphalian modelled nation-states to new players like multinational corporations and other big cross market movements dethrones the state from being the agent driver for development. The previously demarcated container space under the nation state object of the development grading is now dissolved by trans-border flows of capital, human resources and information. The scale of one state development in comparison to other states became obsolete and irrelevant in a globalized world valuing connectivity and flows instead of the previous linear road to progress.

The UN issued in 2000 a list of seven MDGs to be reached by 2015. These were primarily concerned with eradicating poverty and hunger, achieving universal primary education, promoting gender equality, reducing child mortality, improving maternal health, fighting common diseases, ensuring environmental sustainability and developing a global partnership for development (UN General Assembly, 2000). That was the result of elaborate studies and the MDGs were almost unanimously approved by all the world nations. An immense mobilization and loads of assessments and re-evaluations followed with a combination of positive and negative feedbacks as to the progress and achievements.

Table 1. Sustainable Development Targets set by (UN General Assembly, 2015) directly (WASH related goals are in bold).

Goal 1.	End poverty in all its forms everywhere
Goal 2.	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3.	Ensure healthy lives and promote well-being for all at all ages
Goal 4.	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5.	Achieve gender equality and empower all women and girls
Goal 6.	Ensure availability and sustainable management of water and sanitation for all
Goal 7.	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8.	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9.	Build resilient infrastructure , promote inclusive and sustainable industrialization and foster innovation
Goal 10.	Reduce inequality within and among countries
Goal 11.	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12.	Ensure sustainable consumption and production patterns
Goal 13.	Take urgent action to combat climate change and its impacts
Goal 14.	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15.	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16.	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17.	Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

In the World Summit on Social Development held in New York 2005 as a follow up to the Millennium Summit sustainable goals were defined with three pillars being economic development, social development and environmental protection (UN General Assembly, 2005). At the deadline set by the millennium declaration, the 2030 Agenda for Sustainable Development with its 17 SDGs (Table 1) for transforming our world was formulated building upon the MDGs with five Areas of critical importance: People, Planet, Prosperity, Peace, and Partnership. The majority of these listed targets are related to WASH issues.

“This Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. We recognize that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development... The 17 Sustainable Development Goals (SDGs) and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda.” (UN General Assembly, 2015, p. 1)

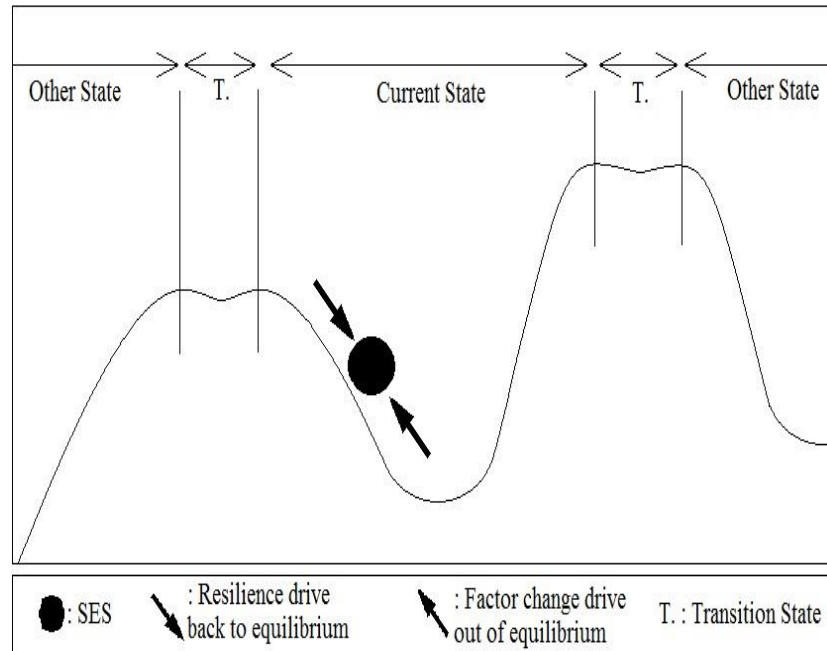


Figure 1. Ball in a basin model for SES state change

Resilience Thinking

The essence of resilience thinking revolves around the definition of the term resilience itself. The origin of socio-ecological resilience comes from ecology when Holing shifted perspectives away from quantitative approach of stable predictable growth to define ecological state (Folke, 2006; Wilkinson, 2012). Fridolin Simon Brand recollected and classified ten different usages of the term resilience. According to Brand, resilience has had three identifiable usage categories, used as a “descriptive concept” or a “normative concept” as well as a “hybrid context” bridging the two (Brand & Jax, 2007).

“Resilience Thinking” is the approach to SES in planning from a resilience perspective integrating “Resilience”, “Adaptability” and “Transformability” (Folke, et al., 2010). Resilience has been defined by Adger in 2005 as: “The capacity of a social-ecological system to absorb recurrent disturbances (...) so as to retain essential structures, processes and feedbacks” (Brand & Jax, 2007, p. 5) best visualized in the ball in a basin model (Fig. 1).

The relevance of this framework to planning is based on two predecessor hypothetical assumptions. The first assumption is that human settlements and societal units are themselves complex adaptive systems where ecology and society are intertwined and cannot be separated. This justifies the need for planners to approach their work from the viewpoint of “human-nature” relations (Wilkinson, 2012). The second is that an approach incorporating system resilience is needed in societal planning to ensure long term sustainability; in contrast with the traditional linear stable growth socio-economical models (Walker & Salt, 2006).

Another core aspect of relevance in Resilience Thinking is the potential for identification of disturbances. In this context resilience comes in contrast to sustainable management approaches focusing on efficiency increase at local level that are failing us by creating secondary effects that backfire of the system (Walker & Salt, 2006). Two core conceptual approaches exist for resilience, “Specified Resilience” and “General

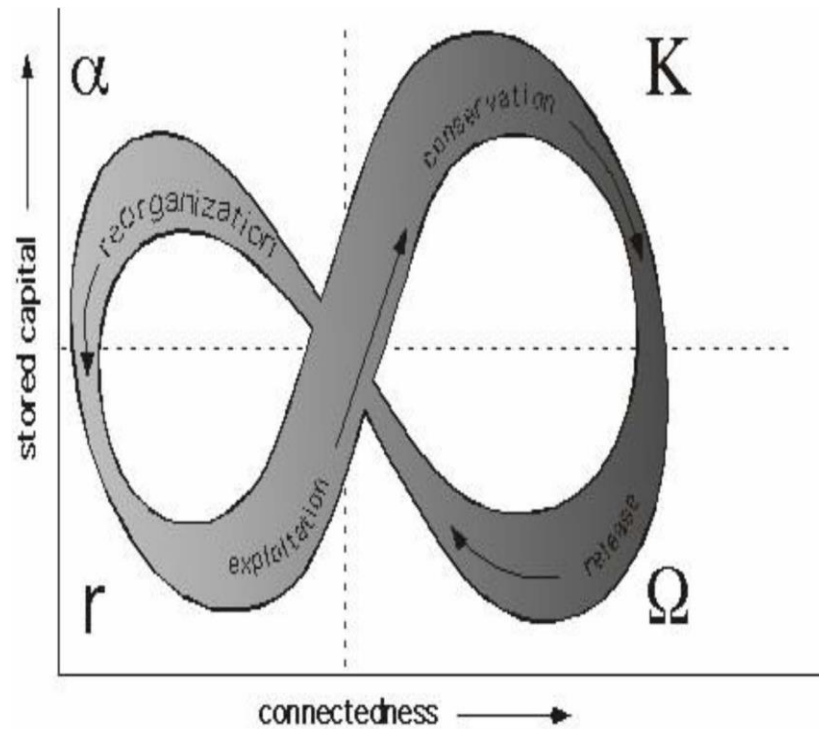


Figure 2. SES Adaptive Cycle Model (Wilkinson, 2012)©

Resilience”. Although both concepts deal with adaptive systems, Specified Resilience assessments are performed in relation to disturbances created by specific perturbation events. In other terms one can ask the questions assessing the: Resilience of what? To what? General Resilience assessments on the other hand are performed with regard to all kinds of foreseeable disturbances including novel ones (Folke, et al., 2010).

The Adaptive Renewal Cycle model (Fig. 2) of adaptive system analysis and its relative Panarchy dynamic (Fig. 3) across nested cycles is also a core concept of resilience thinking. Four general adaptive phases have been isolated by observation of ecosystem dynamics (Folke, 2006). These have been labelled exploitation (r), conservation (K), release (ω) and re-organisation (α) phases. They occur in a looping sequence where the system is consumed to near exhaustion in the fore-loop ($r+K$) then it drops into a regenerative back-loop ($\omega+\alpha$) for reestablishment.

The Panarchy model stipulates that multiple scales of one system interact and affect each other by direct regime shifts at smaller scales resulting from phase changes at higher scales or by indirect induction of revolt and remembrance trigger mechanisms that induce cross scale phase changes (Folke, 2006). On a revolt channel a system at release influences a larger scale system into conservation. Similarly, on a remember channel a system at conservation induces a smaller scale system into re-organisation.

“Resilience Thinking” has not however been free from criticism. A major critique of the concept is that it is more suited to deal with adaptability and preservation than it is with transformability. In a paper about the matter, Per Olsson brings up the claim by Smith and Sterling that functions of SESs should not be resilient because if socio-political

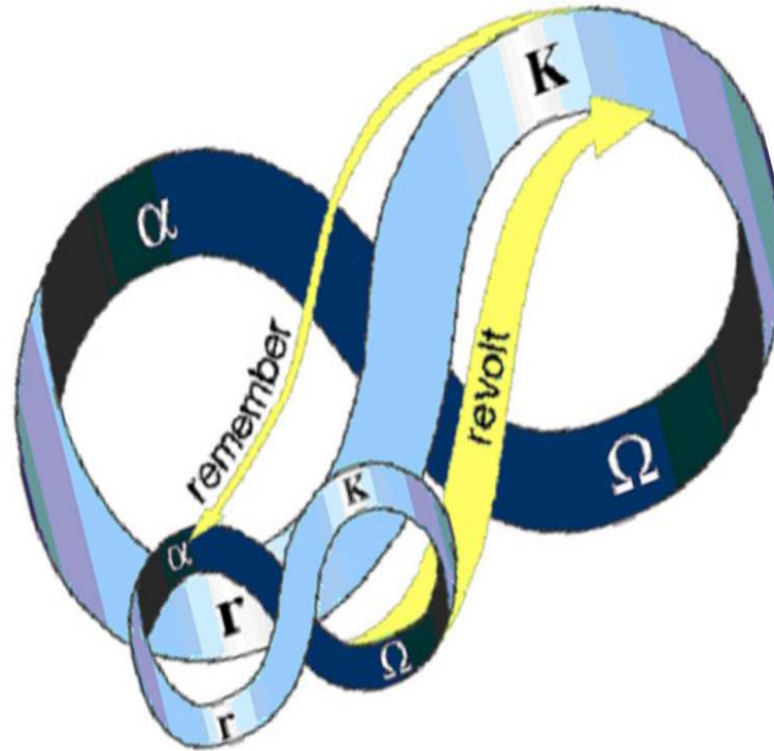


Figure 3. Panarchy Cross-Scale Interaction Pathways (Resilience Alliance, 2010)©

structures are provided adaptive resilience it can have a negative impact on ecosystem structures transformative resilience needs (Olsson, et al., 2014). This brings up an additional point on which resilience thinking is criticized. Power and the subjective bias of resilience in favour of the point of view of the individuals in power getting to decide what important aspects are to be preserved.

From a theoretical perspective, the backbone supporting the emergence of resilience thinking has been the role it can play in developing adaptive forms of governance. Conscience that the ecosystem capacity to regenerate and maintain itself is essential to our societal well-being takes its roots from ecology back in the late 60's in the works of C.S. Holling (Folke, 2006). Developments in the field have since been diverse. The Beijer institute instated resilience as an essential approach to multidisciplinary studies. In cooperation with the University of Florida, host of Holling, they created the Resilience Network, later Resilience Alliance (Folke, 2006). The workbook for practitioners was published by the Alliance as a tool contributing to its aim in establishing Resilience as an overarching framework in planning.

Water Governance

Governance is the way society organizes itself to carry on different tasks. This takes care of establishing rules we can depend on to coordinate our actions towards specific common goals (e.g. written constitutions, codes, laws). It also takes care of implementing actions under these rules on a routine basis leading to achievement of the intended goals. In order to preserve its form and evolve, it also covers developing interaction

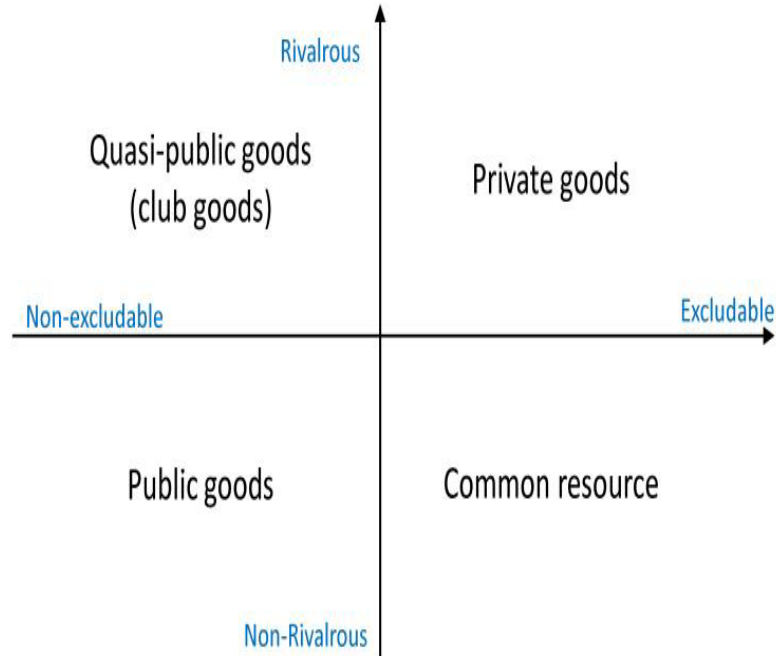


Figure 4. Social Goods Categorization Compass (Samuelson, 1954)

processes and institutions that are empowered to do the above as well as to resolve conflicts that might arise. In sum, governance is “a neutral concept comprising the complex mechanisms, processes, institutions through which citizens & groups articulate their interests, exercise their legal rights and obligations and mediate their differences” (Singh, 2015).

Water as a resource classifies as common-pool (Fig. 4) according to the theory of public economics (Samuelson, 1954). This is due to two main reasons. One reason is the "rival consumption" fact that it is an extractable resource. Due to availability limits, consumption of this resource by one individual has an indirect rivaling effect on the consumption of others. Congestion of water extraction leads to both diminishing the resource availability and increasing its cost or even to the complete destruction of the resource. Another reason is the “non-excludability” fact that it is impossible or highly costly to exclude people in a community from consuming water. Water is also an inelastic tangible good since its needs based demand is very slightly affected by availability of supply.

Due to the large availability of water resources the rivaling effect had not been a challenge in the past. Water could have hence been considered as a Public Goods. The traditional concepts are that public goods should be provided mainly by the government. This has many deficiencies which require exploring new ways to provide public goods to suit the situation. The free rider problem faced in public goods governance is a situation where the participants do not need to pay any costs or pay less than their fair share of the cost of a common resource and enjoy it as much as the one paying (Olson, 1965). This unfair cost sharing hinders the sustainability and permanent public good supply. With the establishment of market based economy, the private sector has become powerful. PPPs are forms of joint ventures between a government entity and one or several private sectors aimed at the

Table 2. Design Principles of Long Enduring CPR Institutions – Excerpts from (Ostrom, 1990)

Principle 1	Clearly Defined Boundaries
Principle 2	Congruence between appropriation and provision rules as well as local conditions
Principle 3	Collective Choice Arrangements
Principle 4	Monitoring
Principle 5	Graduated Sanctions
Principle 6	Conflict Resolution Mechanisms
Principle 7	Minimal Recognition of Rights to Organize
Principle 8	Nested Enterprises (In case of large CPRs)

construction and or operation of the arrangements needed for public goods provision.

However as the extractability factor leading to rivalry in consumption comes into picture what could have been perceived as a public good now needs to be treated as a CPR. Tragedy of the commons is a major problem faced in CPRs management. It is a situation in which individuals act independently with a rationality exclusively driven by their direct self-interest, and their behaviors are not in line with the collective long-term interests (Hardin, 1968). It is possible for this to take place because of the non-excludability of the resource. At congestion this situation will result in depletion of the common pool. Tragedy of the commons problem is also a collective action free rider problem. If everybody was involved in the "free rider" there will not be any common interests. If some people take care of common goods while others are "free riders" it will disrupt supply from reaching optimal and sustainable levels.

Ownership of the water resources is hence a problematic issue to be prioritized for adequate governance. In her observations on CPR management around the world Nobel Prize laureate Elinor Ostrom defines eight design principles (Table 2) for enduring CPR governance institutions (Ostrom, 1990). The IWRM framework formulated by the Global Water Partnership (GWP) has emerged as an integrated management framework for the management of water resources which meets Ostrom's design principles. It focuses on the three major aims for sustainability set in the world summit for social development covering social equity, economic efficiency and ecological sustainability (UN General Assembly, 2005). It incorporates all market sectors, societal groups, application needs and the different time frames (Moriarty, et al., 2004). Formulated at the International Conference on Water and the Environment in Dublin 1992, the Dublin principles as interpreted by GWP (Table 3) serve as a general guide to IWRM (GWP, 2000).

Table 3: GWP recollection of the Dublin Principles for (GWP, 2000)

Principle 1	Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
Principle 2	Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.
Principle 3	Women play a central part in the provision, management and safeguarding of water.
Principle 4	Water has an economic value in all its competing uses and should be recognized as an economic good.

Table 4: Steps for reverse engineered definition of the resilient system

Step 1	Find an SES that seems resilient to water stresses
Step 2	Validate the fact that this SES is really resilient
Step 3	Identify the extrapolated impacts that this resilience encouraged in the community
Step 4	Make sure that reducing outmigration is one of these impacts
Step 5	Find out other systems that are suffering from both droughts and outmigration
Step 6	Formulate a path for the other systems to govern themselves in a way where they develop the components that lead to the successful resilience of the first ones
Step 7	Make sure that these formulations can really deliver their intended purpose.

Achieving sustainable WASH is preliminary to fulfilling most of the 2030 SDGs. Using the IWRM framework to establish a model of Adaptive Governance drawn from a Resilience Thinking approach and which can fulfill the SDGs set by the UN would be combining the state of the art perspectives in the field of water governance.

METHODOLOGY AND DATA COLLECTION

To answer the research questions that were established previously, predefined systematic procedures were used in combination with other improvised methods depending on the needs faced during the investigation. While this might seem rather straight forward, the tricky part of this work was to identify the real combination of interacting components and factors that gave the resilience to the SES. Especially that the approach to the analysis is not coming from a point where resilient SESs are specifically known and their resilience was planned for and preconceived. A reverse engineered definition of the resilience system needed to be performed (Table 4).

Two Major Phases in the Resilience Assessment

The workbook published by the Resilience Alliance titled: Assessing Resilience in Social-Ecological Systems – Workbook for Practitioners forms a base for performing the Resilience Assessment. This document provides structured steps for conducting a resilience assessment as well as a basis for planning using resilience thinking. In the first phase of the study, a baseline assessment was formulated drawing from review of relevant literature. Covering cases of drought mitigation and related topics in Rajasthan allowed for understanding adaptive capabilities of SESs in this area. In the second phase of the study and after getting the inputs from the field investigations the second and final resilience assessment was formulated.

The Baseline Assessment

The baseline assessment was split into two main sections. At start the SES that needs to be taken into consideration was defined and its spatial and temporal frameworks were set. Then the dynamics that govern the SES within its own adaptive cycles and the Panarchy of nested systems it is part of was described.

Defining the SES

In the baseline assessment primordial definitions of the Resilience SES were set in order to define the system as well to delimit the framework of the study. The most important aspects that needed to be taken care

of while defining the system where: defining the focal scale boundaries; pin-pointing the main worrying issues; identifying the main components that need to be resilient; defining the stress factors that resilience needs to be built against; Identifying the hierarchy of interactions that our SES belongs to when looking at the smaller and larger scale systems.

To set clear boundaries within which to perform the study is an important step. However, due to the broad coverage spectrum of the topic, setting clear-cut limits to the focal system was premature at this stage of the works. In general terms, the system under scope at this stage was “the complex system ensuring that populations in the villages and towns of Rajasthan are equipped with drought fighting mechanisms allowing them to keep on living in their locality”. The system boundaries were hence formulated to fit all and every component that ensures this.

After setting the system boundaries, it was imperative to clearly define the problematic issues that the SES needed to be resilient against. The study is mainly interested in countering outmigration of the populations from their habitat, but the reasons leading to outmigration are not only related to water stresses. A paper on the shift from urban-rural to global dependencies in our contemporaneous knowledge based economy (Westlund & Yuheng, 2014); co-authored by Hans Westlund from regional planning at the Royal Institute of Technology and Yuheng Li from the Resources Science and Technology College at the Beijing Normal University; provided the clues needed to identify these reasons. Putting these into Rajasthani Indian context defined the problematic issues leading to outmigration in our SES.

After both the system was delimited and the problems faced defined, finding the valuable components of the SES that need to be resilient was the next stage. In other terms, answering the specific question: “Resilience of What?” was needed. While the reasons leading to outmigration were defined, some components of the SES are able to counter these reasons by providing an added value leading to people staying. These components were identified by considering the integrated usage of water and Land resources in the SES focus scale. The pathways leading to the most valued ecosystem services provided by these natural resources specifically represented what needs to be preserved in our SES.

The main factors stressing the system out of equilibrium needed to be identified next. While drought is the major problem subject to investigation, the understanding of drought itself varies according to the point of view of the observer (SAARC, 2009). Drought is not a quantifiable value but rather a description of the SES condition. For example the threshold of lack of water availability that is considered a drought event in a Swedish rural context due to disruption of agriculture and fresh water supply can be a very good level of water availability in most of Rajasthan. What drought technically represents in the context of the SES boundaries set hence needed to be evaluated and its impact on the valued components identified also needed to be understood. All the disturbances that have been in the past or are currently stressing the valued SES components into drought were assessed and categorized. Possible unforeseen future disturbances were also accounted for.

Finally, this whole SES defined needed to be put in context of both the bigger systems it is part of as well as the smaller systems it comprises. First we needed to identify the smaller- and larger-scale systems on the focus scale ladder. Our SES being part of Rajasthan which is part of India was a direct precursor for adopting those two administrative

boundaries as larger-scale system delimitations. The hydrologic catchment delineation that our system completely falls inside was also another clear upper-scale system. The smaller-scale systems were a bit more problematic since the SES boundaries were not geographically defined within one specific administrative or landscape boundary. These were hence all and every relevant smaller-scale system that can be analyzed in relative isolation from our SES while still making part of it. A timeline of the most notable and relevant phases this hierarchy of scales has gone thru was then set-up.

Understanding the SES dynamics

After defining the system it was possible to move onto the second phase of the baseline assessment to explore the change dynamics of the system that define the different stages it can go thru. Performing a cross-scale systems analysis afterwards allowed us to understand the interaction pathways and feedbacks between the different scales. This is necessary in order to establish the stresses and changes induced on our SES resulting from changes at different focus scales.

Establishing the adaptive cycle model of our SES was most helpful in defining the hypothetical state-change inducing parameters. It also in turn allowed identifying which resources necessary for the SES to be able to rejuvenate itself. After this was set, a look into the historic timeline; previously established when defining the system; allowed categorizing the different phases of the adaptive cycle that the SES has already been thru. This further allowed identifying potentially desirable and undesirable aspects of each state. It also allowed exploring the transitional phases from one state to the other as well as their intensity, hence providing a predictive transitional phase description for every state change identified. Accordingly it was possible to quantify the thresholds at which these transitional phases were decoupled and to identify which of these thresholds is the most threatening in terms of unwanted state changes.

After the adaptive cycle of the SES under focus was established, the Panarchy interaction patterns between the cross-scale systems states needed to be analyzed. It was imperative to first define the different stages of the adaptive cycles of each of these cross-scale systems. This made it possible to define which stage of their cycle each cross-scale system is currently going thru. It was also necessary to define the influence pathways of the remembrance induced from upper-scale system conservation stage on the SES as well as the revolt and learning induced from the lower-scale systems release stages. It is important to assess if these interchange pathways have been functioning or if they have been obstructed for some specific reason. Induced changes on cross-scale systems can encourage sought-after stage changes at our SES scale. The thresholds of relevant variables associated with the positive sought-after induced changes as well as the negative unwanted induced changes were then defined for further use.

The Final Assessment

The final assessment builds upon the baseline assessment by including the findings from the field investigation performed. The baseline assessment only partially covered the steps associated with a Resilience assessment and only drew from literature reviews. The final assessment featured a re-evaluation of the literature data after including the empirical findings on the ground. In addition to that, two steps in the resilience assessment were completely missing from the baseline

assessment. One of these steps is to define the governance system associated with the SES object of the assessment. The other step is to synthesize the findings of the assessment in order to formulate a resilience thinking based stewardship model that can be applied in similar SES so that they build up their own resilience.

In order to validate or disprove the hypothetical SES described in the baseline assessment, all the data used in defining the SES and its interactions needed to be verified. What this meant in practical terms is that every single component of both the social and the ecological systems needed to be experienced on the ground. The field study was hence split into three distinct processes: site investigations where infrastructure and ecology were the two main topics of interest; surveying the living conditions of the population both now and in the past; as well as collecting inputs from stakeholders about their different perspectives on the situation. These three processes of the field investigation are further elaborated upon in the following sections. The synthesis of the findings allowed to modify the baseline assessment findings and to come out with the final system definition and interaction patterns.

After the SES at hand was successfully defined it was time to explain the actual governance system that allows it to be maintained. This step had been omitted from the baseline assessment on purpose although it could have also been hypothetically performed. The idea was to try to approach the field with the least prejudice possible. That was in order to escape the possible misleading data resulting from power struggles, associated with politics, the media, advertisement and all similar sorts of misleading representations of reality. In other terms it was considered that, if all the literature talks about a specific institution that guarantees the subsistence of the system at a specific stage, it does not mean that this institution is the sole guarantor of this equilibrium nor the most valuable player but only means that there is a very strong reason for it to pose as such. Accordingly and in order to conduct a just and impartial assessment of the governance system, identifying governance institutions was kept until after the field investigation process was completed. A real list was then established enumerating the governance institutions that play a role whether be it enhancing or constraining the flexibility and adaptability of the SES with regard to the issues under focus. In the same way, social networks between stakeholders and how the communication process between them facilitates or hinders the role played by the governance institutions was adequately mapped.

After the whole resilience assessment is completely conducted, the SES at hand can now be expressed in the form of a series of modelled diagrams that summarize its different aspects. Drawing answers from the previous findings in the different assessment steps, a model presenting the SES in terms of both slow changing and fast changing components of two separate types social and ecological was utilized. In addition this model enlists the interaction pathways between changes in the external control components and the SES components, their social and ecological impacts, the ecosystem services provided, the stakeholders at play, as well as the governance institutions responses and their concurrent impacting change on the SES back again summarizing all interactions and responses. Based on this model at hand with conjunction of the data from the model for identifying areas where a similar resilience can be built (elaborated upon in the following sections) it will be possible to formulate a resilience based stewardship strategy.

Literature Surveys and Data Sources

The literature survey part of this study did not only consist of acquiring background data and state of the art knowledge. For most of the baseline assessment conducted surveying and synthesizing the literature formed the main source of the data to perform the works. The literature surveyed for this purpose needed to cover every aspect of the SES assessed across the different focus scales and timeframes.

Daily Life around Water in Rajasthan

To understand daily life in Rajasthan and its connection with the way water resources are governed was a rather complex task. The big picture that was initially formulated by relying on personal feedbacks received from other people as well as from the mass media. As these are not the most accurate sources to rely upon and due to the need to form the complete picture before conducting my field study, published literature of different backgrounds needed to be collected and reviewed.

General comprehensive sources in encyclopedia format about India and further narrowed down to Rajasthan served this purpose. This ranged as much as possible from past the Indian monarchic and colonial eras up to the present post-independence and democratic federation era. Two main sources were most valuable. The first is a pocket format atlas issued by the Swedish Institute for International Politics published by country (Daleke, 2010) titled “Lander I Fickformat nr 816 INDIEN”. The second is another atlas titled “Cultural Atlas of India” by Gordon Johnson.

Other publication on Indian wide scale also provided the background needed before tackling Rajasthan specifics. The government of India National Water Policy (Indian Gov. MWR, 2012) as well as an appraisal of the different Environmental Legislations of India (Indian Gov., 2010) gave way for the institutional expectations. A technical focus paper by the Global Water Partnership tackling water security in India featured a critical evaluation of the changing reality of Water Governance in India (GWP, 2013). An article on land tenure principles by Nandita Singh gave insight on the tribal situation in India (Singh, 1999). A review on private sector participation in India’s Water Sector issued by the water sanitation program of the World Bank provided the perspective from the private sector point of view (World Bank WSP, 2011). An article by Anil Agarwal on participatory democracy in India provided an overview of the role of the private sector in governance at grass-root level (Agarwal & Narain, 2000).

When it came to Rajasthan itself, most of the literature of interest became specifically centered on water resources conditions and techniques. The report on indigenous knowledge of the Rajasthan communities published by the SAARC (SAARC, 2009) was most valuable to create an inventory of the structures constructed throughout the ages as well as the living patterns of the communities that erected them. A governmental report from the Ministry of Water Resources concerning planning of water resources in Rajasthan (Indian Gov. MWR, 2014) provided the government institutional perspective on water resources availability and usage possibilities. A review by M.S. Rathore from the Institute of Development Studies in Jaipur on the groundwater exploration and augmentation in Rajasthan (Rathore, 2005) helped verify the data collected from the governmental sources as well as it gave researchers perspective into the matter. A paper by the International Water Management Institute on Rajasthan’s potential for

water harvesting and conservation (Narain, et al., 2005) helped shed the light on the practices performed in this regard and the prospects for additional interventions.

Finally a big portion of the most representative information on rural life of Rajasthan in the literature came from extensively available publications made by the grass root NGOs themselves or one that were made directly about them and their works. The comprehensive report made by TBS on their own works (Sisodia, 2009), an unpublished paper written by their leading figure Rajendra Singh of his experience (Singh, 2010), a UN publication about the Johad structures (Samantaray, 1998), as well as an evaluation commissioned by SIDA (Kumar & Kandpal, 2003) which was a major contributor to the organization in terms of donations, all gave a good perspective of the conditions throughout the last 35 years in their areas of action mainly the Alwar district back then. The ISDR report covering SEEDS works in the Barmer district (UN ISDR, 2008) was very representative of this area. Annual reports by GVNML (GVNML, 2009; GVNML, 2010), as well as a report about the Chauka System made by the UNICEF (UNICEF, 2001) gave a good idea of the way things go in the Jaipur and Tonk Districts where they largely operate. A feasibility study for a trial of establishing a cooperative NGO under the name “Kadesha Pastureland” in the Udaipur district (Sharma, 2014) gave insight about the specificities of that area.

Quantitative Data Collection

Publications by the different Indian governmental sources provided quantified values for most of the socio-political and ecological data required. The yearly publications by the directorate of economics and statistics covered most of: household data and derived development markers, administrative and political data, financial and socio economic data, agriculture figures and industry data. Two population surveys conducted by the Indian government in years 2001 and 2011 provided most of the data required. Publications by the GSI provided data on land cover and land use, surface geology, soils and minerals, district resources. Publications by the Indian Central Groundwater Board which used to be part of the ministry of Water Resources provided for: Groundwater data, surface water data, extraction well locations, usage volumetric estimates and annual precipitation patterns. Annual report publications and a strategic plan by the Indian Ministry of Mines provided figures and future prospects data of the mining industry which is a large portion of Rajasthan economy.

Surface elevation data was retrieved from ASTER GDEM quadrangle datasets, a joint program between the Japanese Ministry of Economics, Trade and Industry and the United States National Aeronautics and Space Administration. ASTER stands for “Advance Space-borne Thermal Reflection Radiometer” and the quadrangle tiles have a 1° by 1° spatial coverage with 16bits resolution and a vertical precision of 20m with a 95% confidence (METI & NASA, 2009). The United States Geological Survey databases provided a comparative to assess the ASTER data reliability (METI & NASA, 2009) as well as hydrological basin and stream delineation data based on Shuttle Elevation Derivatives at multiple Scales (Lehner, et al., 2006) for comparison with the results from the sub-catchment definition and micro-stream delineation performed as part of this study. Land Cover data was compared to the Global Land Cover Data which is a global database of classified land covers coordinated by the International Steering Committee for Global Mapping (Ryutaro, et al., 2014). Additional

Rajasthan specific monthly rainfall data was retrieved from the UN Database which is collected in collaboration with local municipalities and NGOs.

Analysis for Community Scale Structures

Apart from simply relying on published data sources, data was also retrieved by both modelling and comparison to check for reliability. Locations where a network of rainwater harvesting structures is constructed at community level call for an assessment from a watershed perspective. For this purpose sub-catchments and micro-streams delineation was performed using the ASTER GDEM data and impregnating with the actual streams and rivers taken from the GSI topo sheets. The process was done following the method elaborated for specific use with the Hydro Tools extension of the ESRI ArcMap software (Djokic, 2008).

Field Study Methodology

After establishing the baseline resilience assessment and hence setting the boundaries of the relatively resilient SES and its components, it was possible to identify the most relevant locations to target in the field visit as well as to define the information needed to be retrieved. The best case scenario for experiencing the grass-root life and governance in Rajasthan; as a foreigner single handedly performing a comprehensive study restricted within a two months period in the field; was to go along with the local NGOs in their daily activities. The reason to this was a multitude of factors. Most of these active NGOs are already well versed in the research activities going on about them and Rajasthan. They are well equipped to accommodate for the investigation requirements. They also have personnel with intrinsic knowledge and who are eager to share it. Moreover the direct stakes of these NGOs are in line with the direction of the study i.e. drought mitigation for countering outmigration.

During the field investigation it was very important to gather the perspective of the different identified stakeholders and to figure out the social networks between them. Contact with the local populations allowed for an elaborate formulation of ideas concerning their own way of life and needs. Interviews with local authorities and community representatives were undertaken to figure out the role that the government plays in the water resources management. The NGOs themselves are big players in the governance system in place. The opinion of key personnel in these organizations was gathered along the stay with them through profound discussions and re-evaluation of the SES. After all of these feedbacks were gathered, getting the opinion from a team of Indian scientists and researchers provided the local experts insight on the matter.

General Investigation Process

It was hence decided to spend twenty days of time along with TBS, another twenty days along with GVNML and ten days based in the state capital of Jaipur. A final period of two weeks was spent in the city of Patna in the State of Bihar where local supervisor Dr. Ashok Ghosh takes office in the A.N. College. The visit to Patna allowed for enriching the study with prolonged feedback from an academic perspective within India. It also allowed me to compare practices in Rajasthan to practices in Bihar which features extreme contrasts in terms of climate, water resources availability, and population density. The sharp differences in governance structure between the urban and the rural contexts in India

called for a split of the investigation into two distinct sections, notably one investigation about Rural Water Conditions and another about Urban Water Conditions.

Rural Water Conditions

In the first part of the rural field investigation conducted along with TBS I got the chance to experience both the water infrastructure they implemented in Alwar as well as the community development works they have been conducting. In their Aravaly Hills area of Rajasthan, TBS has been constructing a collection of structures revived from old lore including: Johads, Anicuts, Check Dams, and Bund Earth Embankments. Visiting these structures and assessing them from a watershed perspective allowed verifying the role they play in the SES.

Analysis from a social perspective in the villages and agglomerations directly affected by these structures was possible because of the flawless relationship between TBS and the communities with which it is working. On a daily basis I was able to sample out all societal strata and age groups, gathering pointer on consumption habits in the past and the present. The methods used for this latter process are dissected in the “Population Surveys” section that follows later.

Also with TBS the district of Karoli where works have recently intensified was visited. This allowed to put the finger on how the whole process goes from identifying the “poorest of the poor” in need of support, to decision making thru Gram Sabha Meeting upon which structures need to be constructed and at which locations, as well as the whole process to secure the project financing from both the villagers side and the external funding sources.

In the second part of the rural field investigation conducted along with GVNML, I was also able to assess both the infrastructural and socio-ecological aspects of the areas they have performed their most extensive works in, notably the Jaipur and Tonk districts. The structures implemented by GVNML are different in nature than the ones done by TBS due the differences in landscape they handle but still serve the same purposes. In the majority flat areas where GVNML operates the traditional lore has favored structures such as farm and village ponds, water canals and open step wells. Alongside their contribution in reviving these traditional structures GVNML has also developed new concepts such as the Chauka System and introduced impermeable farm ponds.

Also with GVNML a close look was taken into a wide scale CSR driven community development project centered on water needs which they have been taking part of during several stages with the IOCL. The complete investigation of twenty villages in need of support along the areas where Indian Oil have running pipelines was also performed by GVNML. Following up on these works allowed to understand the governance part played by of the private sector entities of the social mesh in rural Rajasthan.

Urban Water Conditions

Investigating Urban Water Governance was a whole different story. A part of the works covered infrastructure site visits to big dam constructions that allowed for reservoir collection of water before further redistribution. A visit was conducted to the Bisalpur dam which was recently constructed in the Tonk district. I even had the chance to visit a pumping station and adjacent water tank under construction in the outskirts of the city of Jaipur. Ancient systems were also part of the

Table 5: Areas of interest for development at community level in Rajasthan

1	Fighting Poverty	2	Gender Equity
3	Industry and Technology	4	Food Security
5	Sanitation	6	Agriculture Support
7	Job Security	8	Water Security
9	Cooperation	10	Environment Protection
11	Strong Governance	12	Health and Medication
13	Education		

investigation when it comes to water resources provision for big human agglomerations and centers of power.

Visits to a government founded non-government operated NGO called Aravali with which I got introduced to the different support schemes implemented by the government. By interacting with the urban population I was also able to get their feedback concerning the availability and quality of the water supply in the cities. In the city of Jaisalmer in the western-most part of the state I was able to meet a young entrepreneur who subcontracts fresh water well drilling contracts directly from the public health department.

Population Surveys

Workshops of participatory planning helped involve the local population in the study by providing their opinion and concerns. This also helps the study reinforce or de-prioritize components of the SES which would have theoretically been given misrepresented value and weight. A detailed questionnaire was run on heads of households covering family unit size and conditions, consumption and dietary patterns, agricultural activities, water consumption patterns, as well as general life satisfaction in terms of health, education and opportunities. These questionnaires were performed in the presence of all the other family members who were possibly gathered making sure they understand and take part of the discussion but keeping the final answer to the individual identified as the head of the household. The gathering attendees commonly expanded beyond the single hosting household into a collection of the vicinity, and kin connected households within the locality.

In the end of the session all of the attendees were requested to fill up a personal voting in which they were asked to prioritize areas of development from a provided list. The list was taken directly from the seventeen SDGs (Table 5). Priority was asked to be given to the most important things needed in order for the individual voting to choose to live in the locality without needing to migrate to the big cities and other places. These surveys needed to incorporate the perspective of all the different components of the society. Since the Indian society is highly stratified in many different ways it was mandatory to get an uninfluenced feedback from the different categories within this stratification. This meant the necessity to retrieve the real personal opinion which for several individuals could not be freely expressed in the presence of others higher on the authority chain. The three main characteristics of social stratification that were dealt with were: gender differences; age differences; and cast differences.

Factoring-out Gender Differences

In the case of gender representation, Indian society is a patriarchal society where the male is the traditional authority figure, although some exceptions do arise and are socially accepted. To gather the unrestrained

and uninfluenced opinion of the woman in such a context necessitated performing workshops with exclusive woman attendance. While this task did not prove very problematic to achieve, the vague almost inactive presence of a usually youngster male was always featured amongst the attendees. The exclusive woman gatherings also featured a more relaxed and stress-free interaction between the different age groups and different society casts than the regular gatherings. In other circumstances where exclusive woman gatherings were not possibly manageable, a follow-up visit with a repeated input collection was performed in order to identify changes between the two feedbacks and factor out inconsistencies.

Factoring-out Age Differences

The other criterion that needed to be incorporated was the different opinions pertaining to different age groups in the society. Here also the Indian culture features a clear cut seniority authority where the thoughts and behavior of younger individuals is usually expected to manifest within the guidelines set by the older ones irrespective of age or maturity. Accordingly in front of an outsider entity, a young brother would usually simply second the opinion of his eldest brother even at mature age, a son and daughter would usually abide by the opinion of their parents even after they themselves have become parents. In general any younger individual in society is expected to show respect to an elder in public life, and that is manifested in an apparent radically subdued communication fashion. To factor out this restrictive influence, exclusive youth groups were investigated especially in school environments where reducing elderly authority influence was easier. Youngsters were also encouraged to provide their own answers when in the presence of elder individuals who expressly instructed them to second theirs.

Factoring-out Cast differences

The Indian society especially in Rajasthan is still to date highly influenced by the cast system even after all the trials to erase the boundaries between casts that have been implemented since the independence. Especially in rural areas and similarly amongst the majority Hindu population as amongst other religions, cast dictates several aspects of life. These range from dietary and hygiene habits to profession and marital restrictions. Interaction between different casts is governed by an ancient well established hierarchy which in different aspects restricts the freedom of people in society be it upper cast, lower and untouchable casts, or anything in-between. To factor out the influence of the cast differences on the survey results a two-step process was needed. First the workshops and meetings were conducted with an audience incorporating both the majority as well as the minority casts within the locality. Afterwards the different casts were separated and their independent feedback was inquired anew in order to recognize unspoken politics.

Government Role

Besides the big infrastructural developments, the para-national support schemes, or the different departments pertaining to the different state ministries involved, the government is implicated at the local community level of water governance via a different political institution. The Panchayat Raj institutional tree branches down from Panchayat Samities to Gram Panchayats headed by the Panchayat Sarpanj. This institutional tree is completely split from the different ministry departments and acts

almost completely independently. The Gram Panchayat members are elected by the local Gram Sabha assembly which is technically constituted from every individual in the locality who is above eighteen years old. The local panchayat bodies are vested with an executive power and a yearly budget from the local government to perform the developments they see fit in their locality. In order to gather the feedback from these institutions interview meetings were performed with three different Panchayat Sarpanjs. Moreover a Gram Sabha meeting was attended where decision making was happening concerning the location and proprietary arrangements related to a water harvesting structure planned to be implemented.

NGOs Perspective

The perspective of the different NGOs involved in the water governance was collected thru a series of formal as well as informal targeted conversations all along my journey with them. In order to adequately represent the position of the NGO it is essential to investigate all of the contributors to the identity it displays and role it plays on the ground. However the most sought after feedback was the one pertaining to the individuals on the highest positions in the organizational structures. This is due to the fact that these organizations function in a way where the individuals with the highest positions directly instruct actions to others down the ladder. The lower positions although filled by highly motivated and self-implicated individuals, have very little to no impact at all when it comes to the decision making process in the hierarchy. The two main NGO investigated were TBS and GVNML. At a different scale Aravali the government initiated NGO was also probed. The feedback gathered from these organizations was mainly intended to understand their exact role as an irrevocable stakeholder in the SES. Hence investigation areas covered their beginnings, motives, extent of works, programs and agenda items, interaction with other stakeholders, financing schemes, vision for the future, adversaries and opinion about antagonist views.

Experts Knowledge

At the end of the field work a presentation of the study as well as the general findings of the field investigation in Rajasthan was done in front of an audience of academic individuals at the A.N. College University in the city of Patna. These consisted of researchers and professors in fields ranging from Land and Water resources, to geography and social sciences and pertaining to both the university itself and other institutions outside. The audience was afterwards asked to weigh the same topics of interest to development that were used during the population surveys in order of importance. A Delphi method based reassessment gave them the opportunity to rectify the initial weigh they gave after informing them of the voting results from the population surveys. The feedback received from these experts was valuable from both the professional background and the fact that being from a different state in India makes for a dissociated objective opinion that still fall within and Indian context.

In Patna I also got the chance to meet professionals that have followed up on the local Ahar & Pine traditional water harvesting and irrigation system. This system has been going thru a declining usage phase and its absence has created threats to the agricultural practices and even to the overall water resources abundance in Patna. Understanding the factors that have led to the downfall of this system provided important

comparative insight to understand the Rajasthan SES requirements in terms of preservation of erected structures.

Other Stakeholders

The private sector plays a certain role at community scale and has a certain influence. Private sector stakeholders that were investigated were both directly and indirectly involved in the water governance. A major involvement was perceived in the mining sector. The high ecological impact from mining activities combined with their high contribution to the Rajasthan economy makes the mining sector a major external stakeholder in the SES at hand. Interviews were performed with personnel from the RSMM a private organization owned by the government which manages the biggest mines in the state. Their feedback was most valuable in terms of explaining the different procedures they undergo in regard to Environmental Impact Assessments and further compensation required in the form of water treatment facilities and CSR expenditures.

Another external stakeholder in the SES at hand which does not necessarily have a direct impact on the water resources themselves is the IOCL. Their large involvement thru CSR projects such as the one with GVNML makes them a vital source of financing to the villages where they have interests. In most of these villages, the government expenditures have categorically been replaced by the CSR funding as the sole source of financing to water resources related developments. Interviews with IOCL personnel directing this CSR project gave an insight on the role of this other government owned private entity in regard to water resources governance.

Formulating and Communicating the Strategic Development Program

The adequate picture of the resilient SES being formulated, an adaptive management stewardship can be conceived. A work by Cathy Wilkinson in 2011 on the insights and issues of socio-ecological resilience for planning theory is especially developed around the specificities of the Translation task of Planning Theory (Wilkinson, 2012). Inference can be derived from this work in regard to non-resilient conceptualizations of governance in urban settings which in our case directly affects the integrity of the SES. A work by Walker and Meyers featuring databased thresholds of ES and SES can be relied upon as support for threshold identification (Walker & Meyers, 2004).

In addition to that, the resilience assessment notebook features a tabulated list of criteria and comparative characteristics that make up for adaptive governance instead of the conventional forms of governance (Resilience Alliance, 2010). Insight from this list will be taken into consideration in the formulation of the development program. Guidance was also taken from literature about strategic environmental assessments with integrated resilience thinking as advised in a discussion paper by Roel Slootweg & Mike Jones (Slootweg & Jones, 2011).

RESULTS AND FINDINGS

If any resilience was built in any of the SESs of Rajasthan it mostly came from preserved prescriptions inherited in the lore from generation to the other. This knowledge was basically the result of trial and error observations by which actions that helped and other that did not were identified. After putting Rajasthan in the context of study, defining the

SES and processing results from the field findings in the field the final resilience assessment recapitulates the resilient SES for use in the model.

Rajasthan Context of Study

To situate the context within which SESs function in Rajasthan it is necessary to go thru a description of the broad-lines along which community life in Rajasthan is defined nowadays. For this a comparative of Rajasthan figure to Indian figures serves to place it in a larger scale context while reviewing the household figures defines the picture at smaller scale. The works of NGOs at community also make up for a big part of the study.

Rajasthan in India

The historical land of the Rajaputana city states draws its boundaries today within Indian Territory between latitudes E69°30'-E78°17' and longitudes N23°3'-N30°12' (Plate 1) and shares the Thar Desert as a border with neighboring Pakistan (DPDES, 2015). Covering an area of 342,239 km², Rajasthan accounts for 10.41% of total Indian land (DPDES, 2013a). The vast extent of this land is not reflected in its other associated welfare figures. The population density in the state (Plate 2) is contextually low at 200 persons per Km² while India as a whole stands at 368 persons per Km². Both these values are still very high when compared to other countries such as Sweden at 24 persons per Km² or the United States at 35 persons per Km² and even China at 145 persons per Km² (World Bank, 2016). Population growth in the state between years 2001-2011 was at 21.3% with 12,041,249 more people which was higher than the general population growth over the whole of India at 17% during the same decade. This increase was not at the same rate for both Rural and Urban areas where it was at 19% and 29% respectively (DPDES, 2015).

On the administrative level the highest institution in Rajasthan under the Indian National Government is the Rajasthan Government. The state is split into 7 divisions covering a total of 33 districts (Plate 3) which are in turn split down into 188 subdivisions (DES, 2011). Another administrative structure also splits the districts into 249 Panchayat Samiti blocks or administrative regrouping units. These Panchayat Samiti units regroup the 9166 Gram Panchayat sub units which each represents a group of neighboring villages with varying sizes according to population (DES, 2011). The state counts 297 Towns with only 184 of those having municipalities while all the others adhere to the panchayat system, 15 Urban Agglomerations and up to 44,672 villages (DPDES, 2013a; DPDES, 2015) 7,455 of which were not yet connected with a road (Plate 4) in 2012 (DPDES, 2013a). Out of the 68,548,437 Rajasthani inhabitants, around 25% live in urban agglomerations while the remaining 75% are still in areas considered rural. This is far less than the average planetary distribution of urban v/s rural dwellers which reached more than 50% of the world population living in urban areas since 2010 (USAID, 2013).

Household Figures in Rajasthan

The number of households in the Rajasthan state is 12,711,146 with an average size of 5.3 persons per household. The average household size has been in decline in comparison with previous years as it was at 6.06 in 2000 and more at 7.2 in 1980 (DPDES, 2015). Literacy rates in terms of basic ability to read and write have increased from 60.4% in 2001 to 66.1% (Fig. 5) in 2011 with coverage of subsidized governmental primary education reaching up to 1.58 establishments for every 1000

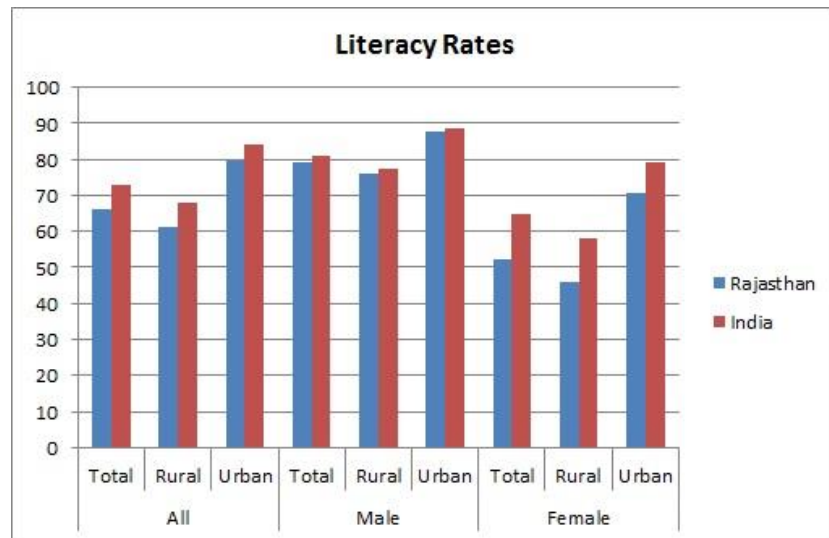


Figure 5. Literacy Rates in Rajasthan by Sex (DPDES, 2013a)

inhabitant (DPDES, 2013a). In the 2011 population census 29,886,000 people (43.5% of total population) were reported as workers in Rajasthan while 38,662,000 were non-workers (DPDES, 2013a). That was an increase as compared to the 2001 census reports of 23,765,000 workers (42% of the 56.4 million inhabitants back then) versus 32,740,000 non workers (DES, 2011). These workers are divided into four main categories (Fig. 6) with cultivators (own fields) accounting for 44.5%, agricultural laborers 17.5%, household based industry workers 2.5%. All types of work accounting for other forms of employment, self-employment, free jobs and governmental jobs get only 35.5% of the workers with half of them held by urban dwellers (DPDES, 2013a). The gender distribution of works is also highly uneven with only 38.7% of jobs being held by women and 49.8% of those being marginal jobs. A big portion of the population (up to 12,221,000 people) in Rajasthan belongs to the scheduled casts and another as big portion (up to 9,238,000 people) belongs to the scheduled tribes (Plate 5) who mainly live in the rural areas and are protected by constitutional reservation policies.

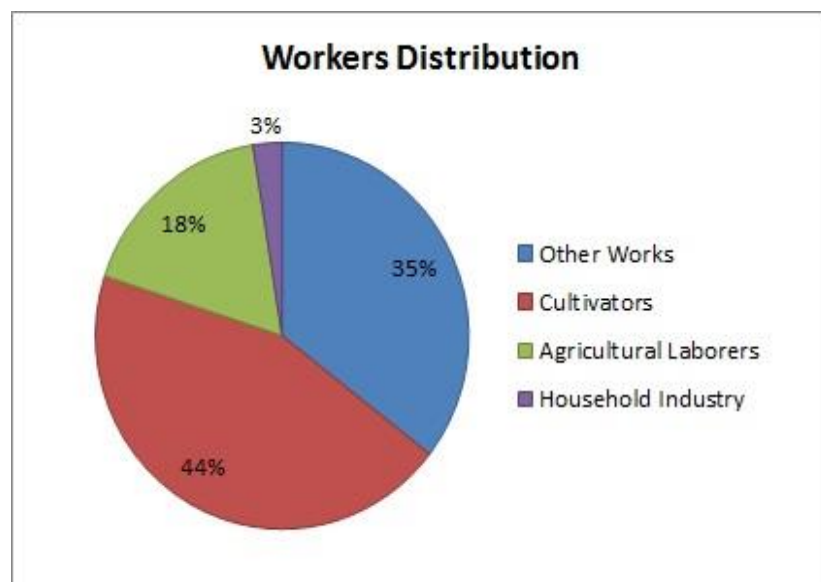


Figure 6. Rajasthan Workers Distribution by Trade (DPDES, 2013a)

Only 67% of these households use public electricity supply as their main power source which is available at a 665 KWh per capita supply capacity (DES, 2012), while up to 30.9% rely on Kerosene. These numbers are not the same between urban and rural areas with 93.99% of urban areas enjoying electrical supply while only 58.3% of rural areas do. Drinking water sources (Plate 6) in the state are diverse. While only 40.6% of the total households are connected to public tap water supply, one fifth of these connections deliver untreated water (DPDES, 2015). Here again the urban households enjoy an 82.6% connection rate to the network with only 9.5% of those from untreated sources while the rural areas are marginalized at only 26.9% of the households connected to up to 33% supplied untreated water. Other household water supply sources in the state include Hand Pumps at 25.3%, Tube Wells at 12.2%, Open Wells at 10.8% and common Ponds and Tanks at 5.9% mainly supplying the rural areas (DPDES, 2015). Basic sanitation figures are rather low with as little as 35% of households having in-house latrine facilities all over the state while all the remaining 65% still practice open defecation and little use public latrines. Even amongst the households with in-house facilities which are mainly urban at 82% coverage while rural is only 19.6%, only 20.5% are connected to a piped sewer system while all the others discharge in sump pits and pit latrines (DPDES, 2015).

NGOs Participatory Works

A massive amount of participatory work at community level is performed by the different NGOs in the state. Leads to high chances of success in identifying a resilient SES in Rajasthan can be traced down to these participatory forms of governance. Works by UN organizations like the International Strategy for Disaster Reduction (ISDR) for instance. Coverage of specific cases in disaster mitigation in Rajasthan successfully handled by SEEDS a local NGO (SAARC, 2009). European Union funded works as part of EU commitment to sharing knowledge outside its borders are also frequent. All of that puts NGO work in Rajasthan at the center of this study.

Works by local organizations TBS and GVNML (Plate 7) are getting well renowned on both the Indian and cross border scales. Apart from their work on community empowerment and enabling strategies, the structures constructed and land-use modifications created by these organizations have proved reliable in rejuvenating natural water resource cycles and ecosystem services that were previously lost in the area. TBS mainly operates in the Aravali Hills dominated landscape of southern Alwar district where slope adapted water harvesting structures like Johads (Fig. 7) are implemented (Plate 8; Plate 9). GVNML on the other hand works in areas that are less inclined and use structures like Chaukas (Fig. 8) and managed ponds (Fig. 9). While they mainly take pride of following Ghandian models and Anupam Mishra teachings, the way these NGOs operate perfectly fits IWRM models as well as the Nobel Prize laureate Elinor Ostrom perspectives on stable local CPR management institutions.



Figure 7. Typical Johad Structure



Figure 8. Newly Constructed Chauka System



Figure 9. Village Grazing Pond

The Baseline Resilience Assessment

The baseline Resilience assessment conducted allowed drawing the big picture concerning the most resilient SES in terms of drought mitigation leading to outmigration reduction in the context of Rajasthan. The SES was first delimited and defined then its interactive dynamics were identified.

Preliminary System Definition

The general description of the spatial and temporal boundaries of the system, the main issues it is facing, its valued components, the stresses impacting it, as well as the larger and smaller scale systems it is nested in define our SES.

System Boundaries

Presenting the topic in the way it was done would have generally promoted adopting a focal scale delimiting each cloistered agglomeration in Rajasthan within its own geographical jurisdiction and performing an independent study for each in isolation. Due to the fact that impacts of the human population nowadays acutely alter the planetary ecosystems no real isolated settlement exists anymore. Ensuring resilience of the community-scale SES goes through providing for the impacts incurred to this system by others. The diverse nature of the Indian social fabric as well as the vast area of the Rajasthan state makes it so that the localities feature tremendous socioecological differences. Accordingly what applies to one locality would not apply to another. It is hence imperative to account for a holistic perspective where the spatial focal scale is wide enough for several localities to be incorporated as interacting subcomponents but small enough to be manageable as a unit (Fig. 10). From a temporal perspective the yearly hydrological cycle governs a large aspect of water resources availability while from a socio-political perspective Rajasthan being an Indian state ever since the federation was established defines its main condition. We will nonetheless refrain from adopting a temporal focus scale at the moment until further stages in the assessment allow it.

Administrative jurisdictions usually specifically fulfill the role of having units at manageable scales. Strategic planning can be performed in a way where national level governing institutions branch down to specific support institutions at provincial level which in turn branch down to district and community level management groups. In the highly decentralized Indian model, the latest National Water Policy act issued in 2012 by the National Water Council clearly states that on national level the National Water Board needs to prepare an action plan to meet policy directives which State Water Policies will need to fit into (Indian Gov. MWR, 2012). These intend for State Government Departments to develop and manage water resources following an IWRM fashion where basins and sub-basins are the base district level planning unit. It also requests Appropriate Institutional Arrangements on river basins for monitoring and data collection (Indian Gov. MWR, 2012). At community level, projects are required to be managed by the local rural population or the urban local bodies in a participatory approach and PPPs are encouraged. The Rajasthan Water Supply & Sewerage Management Board is the state level institution responsible for water management within Rajasthan borders (PHED, 2015).

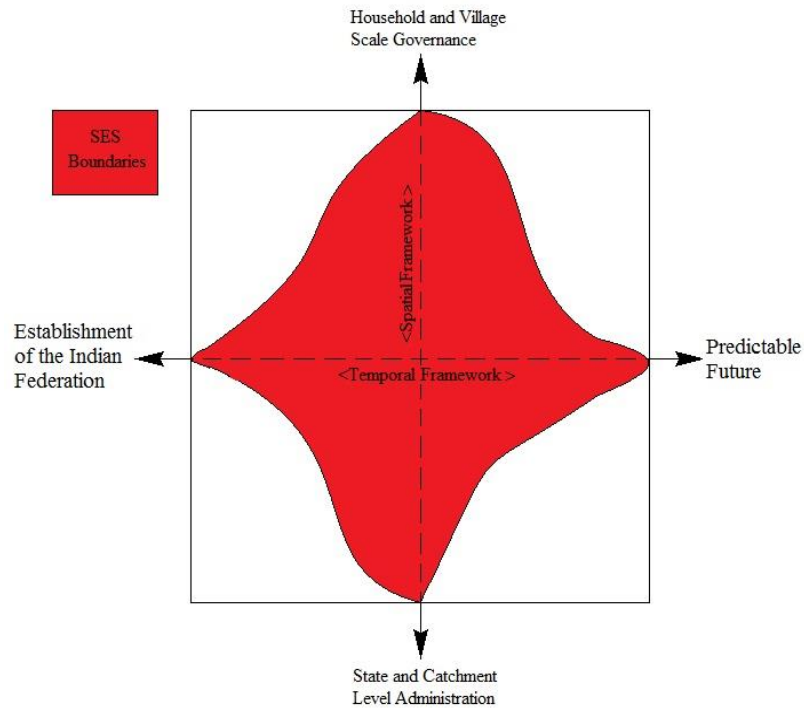


Figure 10. Preliminary SES Boundaries Compass

The State topography dissects the landscape into eight distinct river basins (Indian Gov. MWR, 2014). Two of these are only perennial rivers and also receive water from other states. The complex SES governing the interactions and feedbacks amongst these units will delimit the focal scale of our focus system to start with.

Main Issues

In an overpopulated country soon to be the most populated worldwide, disproportional distributions of population density cannot be ignored and constitutes a major issue for strategic planning. As previously explained, being the largest state in terms of area Rajasthan alone accounts for 10.4% of Indian Territory (DPDES, 2013a). However, demographically speaking Rajasthan population represents only 5.66% of the 1,210.570 Million Indian population census of 2011 (DPDES, 2015). To top it up outmigration patterns are a marking element in Rajasthan. In gross figures, 73 agglomerations in Rajasthan enjoyed the statutory title of town in 2011 but did not have the population requirements to be counted as such in the population census results (DPDES, 2015). Out of the villages censused, 1600 were completely deserted in 2001 (DPDES, 2015). These outmigration patterns have been established where rural dwellers head out of their localities towards the big cities in the state and further to the bigger national metropolitan cities like Delhi or Mumbai. These outmigration patterns originate from a multitude of factors raging from education and work opportunities to quality of life and services provided in the urban areas that do not exist in the rural areas.

Table 6: Issues of concern in the SES

Concerns	Issue Definition	Valued attribute in the SES
Main Issue	Countering outmigration and population density disproportion	Providing the benefits sought after in the urban centers
Sub Issue 1	Water resources potential	Allowing for cycle long sustenance of community water needs
Sub Issue 2	Agricultural Capabilities	Securing for internal food supply at community level
Sub Issue 3	Water, Sanitation and Hygiene	Management of water usage in a form where effluents do not disturb the SES

Outmigration and Population Density Disproportionality are hence the main topic of concern for our SES under study. Most of the reasons leading to the pronounced patterns of outmigration are also drought induced. Several subtopics (Table 6) facing water stress lead to increased stresses on the main topic and hence also ought to be tackled as topics of concern. These are dissected down into three categories of issues: Water Resources Potential, Agricultural Capabilities, as well as WASH.

The water resources potential of the state compared to global Indian resources is no less dysmorphic than the population distribution data. Rajasthan is the driest Indian state holding only 1.15% of the total fresh water resources of the country (DPDES, 2013b).

The climate is predominantly harsh with up 60% of the state area classified as arid and up to 75% semi-arid. Only 9.53% of the state is categorized as forested areas out of which only 25.3% of are covered by trees. Rainfall patterns have been noticing slight increases to the normal values. When state averaged yearly rainfall was 575.1mm, higher values of 757.2mm and 642mm were measured in 2011 and 2012 respectively. These increases were mainly due to flash flood events and did not efficiently contribute to fresh water availability. Groundwater being the main reliance source for uptake also faces a multitude of issues that need to be elaborated upon.

Agriculture is the main economic activity in the region and vital to the livelihood of 18.559 Million workers and their family dependents. The total net area of land where seeds were sown and yielded crops at least once in 2012 was 180,340 Km² but only 49.3% of this land was irrigated (DPDES, 2013b). Systematic agriculture with several harvests only accounts for an additional equivalent 35% of total agricultural land raising the gross agricultural sown land to 245,050 Km². In a world economy pushing towards green ecofriendly local procurement of food for reduction of transportation such conditions ought to be considered as an issue to be tackled.

These issues combined revolve around the big issue of context of this study; the obvious fact that WASH management in Rajasthan is highly problematic and that this condition is only getting tougher. At the forefront of its struggle the Rajasthan population is directly affected by the water scarcity and bad quality in their water consumption patterns. At a secondary impact level WASH problems engender: a reduced quality of health and sanitation, social and gender inequalities nurtured by the required additional efforts to procure water, as well as increases famine and poverty burdens due to inability of producing crops and raise cattle.

Table 7: SES valued components and stakeholders in terms from Land and Water resources perspective

Water Resources		Stakeholders		Landuse	
Usages	Reliance	Direct Use	Reliance	Usages	
Food and Beverage, Agriculture, Sanitation and Hygiene, Cattle Herding, Heat Mitigation, Entertainment, Habitat and Procreation, Nutrient Source	High	Agrarian Population	High	Housing, Agriculture, Entertainment, Natural Habitat, Cattle Herding, Storage, Pride and Tradition	
	High	Local Residents	Low		
	Low	Government Institutions	Low		
	High	Local Fauna	High		
	High	Local Flora	High		
	Optional	NGOs	Optional		
Usages	Reliance	Indirect Use	Reliance	Usages	
Energy production, Industry Needs, Retail, Fishing, Host to other resources	Low	Mining Sector	High	Resource Uptake, Factories, Energy Stations, Research Facilities	
	Optional	Energy Sector	Optional		
	High	Fisheries	Low		
	High	Bottling and Beverages	Low		
	Optional	Other Profit Making	Optional		
	Low	Government Institutions	Low		

Valued Components

It is imperative to determine what exactly in the panoply of factors that need to be preserved in order to reduce the stresses on the main topics of concern identified. What are the important aspects of the SES components which lie at the core of defining its identity? What part of this identity is to be safeguarded and what is flexible to let go of? Which of these assets are valued today and which others that today are redundant will be valued in a time of high stress and need for change? To answer these questions it is imperative to define the core natural resources that the SES at hand relies upon. Identifying these resources and the potential uses attributed to them (Table 7) indirectly leads to defining the valued components of the SES and its relative dependence on each one of them. Building-up the resilience of the SES hence goes thru providing for the resilience of its most valued subcomponents.

From a quasi-ecological perspective it is most logical to begin with fresh water itself as a naturally regenerated resource through the well-known water cycle. Preserving the functionality at the different stages of this cycle is vital for the regeneration of this resource. Conditions hence need to provide for adequate precipitations through rain and snow. Adequate drainage of run-off into streams of rivers and lakes is mandatory. Top soil drenching and moisture retention is a must for all Fauna and Flora. Groundwater infiltration with aquifer recharge and saturation level sustenance is also a major necessity. The current and projected near future human technology is limited when it comes to control over the evapotranspiration and precipitation parts of the cycle. This in turn limits our strategic planning possibilities to mere reactive adaptation to changes in these latter parts of the cycle. In opposition to that we can play a very active role when it comes to all of the other parts of the cycle.

Another resource of major importance to the Rajasthan communities and one of the most important to be preserved is the land itself (Singh, 1999). The existential value generated from the attachment to the territories of their ancestors is beyond financial quantifications and runs

deep in the ethno-religious mesh that binds the society together. Land use patterns and associated strategies and exploitation rights directly relates to the agricultural capabilities of the territory. It is essential to preserve and enforce the return value from this component in order to provide for both nutrition and financial needs. There is no sustainability without a nexus approach to planning altogether linking sustainable development, land use, energy and agriculture. The National Water Policy act of 2012 mentions IWRM but does not specifically extend into any Integrated Land, Water and Energy Resources Management (ILWERM) perspective. Such an integrated nexus is not really established neither in the planning approaches of the Rajasthan State nor in institutional infrastructure implement in the field.

In terms of ownership and rights of tenure all water resources in the Rajasthan state as well as the water imported from other states are constitutionally expected to be directly owned by the state government (Kumar & Kandpal, 2003; GWP, 2013). This is not technically the case. In the National Water Policy water resources are classified as CPRs held by the state under public trust doctrine (Indian Gov. MWR, 2012). Local scale water related structures ownership however still falls under the land tenure and ownership right. All executed structures on personal land including dug wells as well as the groundwater itself are considered private property (Kumar & Kandpal, 2003). This creates opportunities for inequitable use of water resources that can inhibit a tragedy of the commons scenario. This component of the nexus linking land tenure and water governance in a way that insures adequate extraction and distribution of water resources needs to be created and provided with resilient characteristics.

Disturbance Sources

This study is directly concerned with drought induced impacts on life in Rajasthan localities. Resilience of communities in the area when it comes to stress incurred by lack of water resources is the main focus topic and defense line to be assessed. However as previously explained, drought by itself is the result of a series of complex mechanisms leading to lack of water as a final result. Accordingly the resilience assessed cannot be considered a specific resilience with one singular changing factor but rather needs to account for all the factors that lead to a drought event. The following describes the main points (Table 8) creating the largest impacts leading to drought which need to be mitigated.

A major stressing issue contributing to drought is climatic variations that incur water scarcity and water cycle pattern changes. An ever changing global climate strained by human activities with a blurred feedback response mechanism linking point sources to impacted areas is a set reality to deal with in any planning process to be performed nowadays. In areas of water stress this translates into a need for insuring a vital supply of water throughout the climate fluctuations both yearly based and periodically projected. Any development in such areas is constrained by the overall usable water inflow outflow balance as the main restrictive criterion. Broad estimates regarding climate change impacts have been developed to link aspects like estimated rise of sea level in relation to CO₂ emissions levels. These impacts are not a completely charted territory yet and future projections remain estimates as do their impact of human life. It is notable to say that climate change incurred variations are not a compulsory stress. Rainfall patterns in Rajasthan have for instance perceived an increase in average yearly precipitations as discussed earlier. Temperature level variations did not follow the same

Table 8: Disturbance sources at SES scale

Disturbance	Type	Frequency	Recovery Time	Component Affected	Aspect Affected	Magnitude	Pattern Change
Climate Change	Press	Continuous	Eons	Water Res.	Water Cycle	Manageable	Increased
Diversion of Water	Pulse	Periodical	Seasonal	Water Res. / Landuse	Amounts / Distribution	Severe	None
Inability to Hold Water Upstream	Pulse	Periodical	Seasonal	Water Res. / Landuse	Storage Amounts	High	Decreased
Social Idleness	Press	Continuous	Generations	Water Res. / Landuse	Storage Amounts	High	Decreased
Over Exploitations	Press	Continuous	Generations	Water Resources	Amounts / Quality	Severe	Increased
Lack of Awareness	Press	Continuous	Generations	Water Res. / Landuse	Amounts / Storage	High	Decreased
Inequitable Distribution	Press	Continuous	Generations	Water Resources	Quality / Distribution	Low	None
Population Increase	Press	Continuous	Generations	Water Res. / Landuse	Amounts / Distribution	Medium	Increased

pattern. Estimates of variations in global climatic conditions can be linked to variations in the water cycle and hence to availability of freshwater in a specific geographical context. The Global Climate Models are the source from which the pressure caused by climate change will be quantified.

Diversion of water is also a major stress source on water resources that incurs droughts. That could be in the form of direct infrastructural developments like dams and artificial lakes. Another indirect diversion originates from large impervious urban land coverages as well as obstructing structures such as road that deter the water to change its natural path. This problem is available in Rajasthan just like in many other areas of the world. It is most of the time due to the combined result of a non-integrated or absent planning process with prioritization of conflicting development project. A big problem that was faced in the Alwar region for instance was the excessive open-pit sandstone quarrying in random areas chosen solely for their economical profitability. These quarries became the drainage point for run-off water collected by the watersheds. These heavy metal contaminated water bodies deterred further circulation of the water in the natural environment and concurrently led to drought of water channels and river branches downstream. These conditions are a huge stress on the environment and water resources. It can lead to unfixable damages on a timely and capabilities equivalent scale.

Another contributor to local droughts in a specific geographical area is the inability to hold the water it receives. This can be seen in both surface water bodies drying out as well as groundwater retention failure. At origin natural water runway thru the landscape are unconditioned by any regard based on human settlements. Throughout history human have settled in locations where water was either in abundant availability sufficient enough to sustain the community or in locations where adequate management of the resource was capable of fulfilling that. While we grow in numbers however, our resources do not grow with us. What was naturally capable of sustaining a community of 100 does not necessarily extrapolate to sustain a community of 1000 without our intervention. Even with manmade interventions for water collection

such as the multitude of step wells constructed throughout Rajasthan, failure to preserve adequate flow into the structures and adequate maintenance to upkeep their retention capabilities lead to their malfunctioning and largely hinders the communities relying upon them.

On the same line of stresses idleness of mankind and a comfort taking in a seemingly status-quo of water supply is a major burden source. Opportunities exist where we can tweak the landscape to our advantage to make it possible for larger amounts of water to be retained for further use. These tweaks do not necessarily have to be massive radical interventions like the construction of a dam or the diversion of river flows which have multiple destructive effects. Simple small rainwater collection mechanism implemented at strategic watershed locations can for example provide for this purpose without damaging the ecosystem. Ancestral practices and knowledge has been of ample help in this field for Rajasthan communities throughout history. People today only need to keep on doing what has been done thru out history in order to gather the benefits. This has not been the case for the last half a century where people have amply relied on industrial method for water procurement by mainly pumping the groundwater. This evolved into a social amnesia where the ancestral ways were forgotten and the inherited structures were kept without maintenance leading to water resources preservation becoming dysfunctional.

Over-exploitation of the water resources is also a major source of stress with devastating results on both human life and the ecosystem. The location of the state capital city of Jaipur was for instance specifically chosen because of the basin forming underground geological and topographical shapes that provided high groundwater collection. The planning for the city was a first of its kind in India when in the late 1720s water safety plans accounted for a city population of 150,000 inhabitants. Later with the advent of technology in the 1850s damming and pumping of the Amanishah Nala provided the source of water for the ever growing population. The over extraction caused drought and silting of the dam largely reducing capacity. In the 1903 the Ramgarh dam was constructed for agriculture and in 1935 to transported water to the city from a now 30 Km distant source. Overlapping stresses of population increase and bad governance and distribution problems ended up breaking the symmetry in the city plans and overexploiting all three sources; the groundwater, first and second dams.

Unawareness and lack of knowledge also contribute to a huge stress on the system when it comes to water resources exploitation. What can be an opportunity in the hands of aware and sharp minded individuals can be the doom of others less conscious. A small but very representative case of that can be seen in the more arid western parts of the state. In Dalit marginalized communities living in a sandy desert landscape it is usually the children task to collect water for the household. These children daily spend their time walking to locations where underground water is available at shallow depth. When there they bare-handedly dig up holes that can reach their own size where water can be accessed. They then use their hands again to fill up their containers in an everlasting slow routine. While the spectacle can be amusing to an explorer eye observing such a phenomenon for the first time, it is imperative to question the scenario at hand. Looking at the filled part of the glass, it is astonishing to find children who are natural at finding underground hidden water this way. It is hard however to weight which exactly is the worst part of the story, be it child labor, traveling to fetch

water, filling a bucket of water by hand, spending the day under a burning sun or the ridiculous amounts of water extracted compared to the man hour time resources spent. But the most certain downturn of the story is that these children will not be receiving any education while growing-up in such conditions and will become parents raising future generations in the same way they were raised. A big emphasis hence needs to be given to education for the mitigation of the stresses incurred by lack of knowledge.

Inequitable social structure and societal practices also play a major role in impacting the water governance. The Caste system has governed Indian life for several generations and is deeply impregnated in the minds. Members of different casts fail to have a shared equitable daily life. Extreme negative manifestations of this phenomenon where blood has been shed and big humiliations incurred are put aside for the purpose of this report. Nonetheless the Caste system governs everyday life especially in rural areas. People of higher casts do not share food prepared by lower cast and do not drink from the same water they drink from either. The concept comes from contamination fears justified by religious interpretations of the Hindu scriptures and reinforced by a rather alchemistic model of contamination spreading. While the Indian government is implementing a reservation scheme to protect against Caste discrimination, Indian society is far from letting go of their traditions and life has only to revolve around it. In terms of water governance this translates into the need to incorporate Caste based needs into the system where for example two wells are needed to supply a village with water. One to be used by the upper Castes and the other is kept for the lower Caste use.

Manifold Frames

The SES under focus is already elaborately multi-scaled. However expanding and retracting the system in time, space and other variables is always possible. The system boundaries were set to a focal scale wide enough for multiple localities to be incorporated as interacting subcomponents but small enough to be manageable as a unit. The many geographically neighboring unit systems accordingly defined, also interact with their respective neighbor other along all their SES components and variable changes creating a larger-scale system. Our SES is also the product of subcomponents made up of a collection of smaller-scale focus systems with internal feedback and responses creating an interactive network in current equilibrium that changes and adapts according to conditions. The feedbacks and responses interaction impacting the main issue of concern in our SES that can be attributed to those larger-scale and smaller-scale focus systems is of major relevance to its resilience.

Form an administrative perspective the state is broken down into districts split down into Taluks where Panchayat blocs are broken down into Gram Panchayat. The hierarchy of this institutional hierarchy hence defines the Rajasthan state boundaries as the boundary of the larger scale-focus system. Our SES is not however specially bound at district level. Looking into the hydrological boundaries chosen, the Rajasthan river basins are broken down into sub-basins of sizes nearly matching those of the Taluk units. As set by the National Water Council local scale governance is performed at community level which is relative to the Gram Panchayat extent of jurisdiction. River sub-basins scale allows for a holistic catchment management while community level governance has a narrow focus in hydrological terms.

The Larger-scale systems cover both the geographical extent of the Rajasthan state in terms of land resources and the hydrological catchments of the river basins in terms of water resources. In contemporaneous times a democratic governance model ensures the socio-political stability of this system within the Indian federation. The political agenda decided on state level is directly forwarded for adoption at district and sub-district Taluk levels. This means that any change of parameters that affects land and water resources use at state level will have a direct impact on the issues of concern at our SES level. A decision taken at state level to allow for permanent residential constructions on agricultural land will directly become a given at the SES scale and create a distortion pulse negatively affecting the agricultural capability issue of concern. The same goes for the social perspective where changes in the social fabric that happen on a state wide level get directly reflected on issue of concern at SES scale. From an ecological perspective the larger-scale focus river basin catchments are a natural parent of our SES focus scale sub-catchments. Changes in planning for water resources at river basin catchment level hence directly stresses the SES scale topics of concern. A dam construction for instance where a section of the river catchment area is obstructed for redistribution of the water into other areas deters the water inflow amounts into the SES scale sub-catchments downstream. This impacted water resource availability directly impacts the general ecological conditions in the SES.

Examples to these induced stresses due to interaction with changes in the socio-ecological parameters of the larger-scale focus can be tracked all along the focus timeframe. A major historic event with political regard can be traced to the land reform conducted during M.P. Indira Ghandi office time. Amongst other things huge land owned by previous monarchs was redistributed along the agrarian and tribal populations during this reform. When tracing social changes at the larger scale one finds that the Indian population is increasingly globalizing and requiring previously alien living standards, with higher average water consumption per capita. With this being the general scenario at state level, what it translates into at the SES scale is an increase in demand on water and sanitation requirements and hence an increased stress on water resources potential. Changes at river catchment scale water resources management can also be seen. The recently constructed Biselpur dam has set a marking time point in this regards. Also decisions at state level to import channeled water from different states such as in the case of the Indira Ghandi Canal increase the water resources at SES scale sub-catchment level. The construction of this canal also has marked an important point in the timeline where ecological conditions at SES scale have changed.

The smaller scale systems cover all systems nested within our SES at focus. Many of those are of major relevance due to their impacts on the issues of concern. Looking deeper into what makes up for a Rajasthani community from a pure social perspective it becomes obvious that the family unit is an important smaller-scale system especially from a rural life perspective. Not specifically the regular mother father and offspring family unit. When it comes to Indian society it is rather the extended family living under the same roof and sharing the same conditions. The man in the family are usually expected to fill up the provider's role mostly directed outside the household with income generating purposes for sustenance. The woman are more expected to keep up with all

necessary household care and perform the labor work be it food preparing, fetching water, irrigating the family fields, washing and cleaning, as well as raising the kids. The children are usually expected to attend some form of education but help with the daily family activities and requirements to a large extent. A hierarchy amongst ages does exist where senior members dictate the activities required to be performed by the younger individuals.

Interaction between these family units at our SES scale mainly occurs in the economic sector with agriculture at the center of the practices. The biggest portions of land in our SES previously used to be owned by families of higher Caste status and lower Caste laborers in their field work for them. After this has stopped being the case the land management shifted from a central one model governed by the interests of only one of the families composing the SES to an equalitarian model where each family is meant to be represented similarly. This change in subcomponents conditions incurred a radical change in the SES agriculture capability issues of concern. The water collection activity is also an occurrence of interaction between people from households pertaining to different casts in daily life. The water collection activity is hence a main precursor for social exchange. When previously higher cast rule unilaterally decided upon management of the water resource at SES scale they now need to sit down with individuals from other families pertaining to different casts for decision making. The different standards that different casts has concerning water and sanitation is now needed to be shared in order influence the others to adopt and lobby a common resource management decision. This pattern change at smaller-scale focus hence impacts our SES scale water & sanitation issue of concern.

Another smaller-scale system with impact on our SES is micro-catchments that make up for a bigger sub-river basin catchment. Similarly as to the case of river to sub-river catchments there is a direct relationship between the sub-catchments and the micro catchments. Any change in the parameters of micro-catchments directly stress issues of concern at our SES scale sub-catchments. A change in the outflow at surface drainage point of a micro catchment due to direct uptake or permanent storage reduces the total available water in the catchment and hence contributes a stressing factor to the whole Water Resource Potential issue in our SES. Failure of groundwater recharge or obstruction of groundwater flows in micro-catchments at the smaller-scale systems also stresses the balance of the water cycle at river sub-catchment creating a stress on Water Resources Potential. A major event that has contributed in straining the groundwater aquifers capacities which originates at smaller-scale systems was the shift to pump use with the advent of industrialization and technology. Ever since pumping the groundwater has been freely performed at single household scale, the stress it is incurring on the whole groundwater potential of the SES is enormous. Change in the level of governance right associated with groundwater extraction need to be made. The geographic extent of the micro-catchments at hand is yet to be set to a specific water collection area.

System Dynamics

The change patterns that our SES undergoes within one defined state of equilibrium are essential to understand in order to build up long term system resilience. Putting our SES in context of the adaptive cycle model phases helped define this change dynamic. The many different states that the SES has been into in the past and which it can possibly go

into in the future also needed to be defined. This helped identify the changing factors which can reach threshold that break the system resilience and force its adaptive transformation into a different state. Moreover, extrapolating the adaptive cycle onto the different focus scales where our SES is nested helped identifying cascading change interactions pathways between the cross scale systems.

The Resilient SES in an Adaptive Cycle Panarchy

Taking the origin of our system state at the establishment of the Indian Federation one can consider that a reorganization of the conditions prevailing after colonial times was the starting point defining the adaptive cycle of our SES. The revolt against the British colonization was a threshold breaking disturbance with respect to the previous state of the SES. From a socio-political perspective the liberation from the direct influence of the British system created a gap in higher management authority. Rajasthan was to a certain extent not directly ruled by British institutions; it was the role of the established Rajput rulers to maintain stability as long as British interests were preserved. However with the advent of democracy in the federation, influence of the local Rajput was also diminished and replaced with the newfound governance institutions. At local community scale this meant stripping the role of the local rulers with not much attention to details as to how the added value elements it had provided will be provided for institutionally and socially speaking. Moreover, decisions on land use rights and associated resource extraction patterns was previously left by the British colonizers to be decided upon at local community level (MURTY, 2003). After the Indian constitution was established this condition changed into an unprecedented model where nation level directive translated into state level acts that were implied on the management at our local community SES scale. Coping with all of these factors defined the adaptive cycle reorganization (alpha) phase of a new system state which our SES is still to date in.

After embracing this new state and realization of the new factors during the reorganization phase of adaptation came the exploitation (r) phase. In this phase the new fruits that were born during reorganization were mixed with the old remnant seeds from the previous colonial state to shape the identity of this new SES state. Freedom to use this newly acquired land at individual level translated into a possessive attachment and was soon starting to become a tragedy of the commons hazard at community SES scale. Usage patterns when it comes to groundwater and land use were in complete disregard to community benefit and were only concerned with increasing personal returns. The groundwater extraction for example became the main source of water supply at single household level in both rural as well as urban contexts (Rathore, 2005). Although the state resources are meager in this regard no regulation or control over the amounts extracted at SES or larger focus scales were ever implemented. From the top down national perspective a new governance model needed to be established when it comes to resources management. Repetitive trials to manage the water resources for instance led to up to twelve five year plans set by the Ministry of Water Resources in 2012 (GWP, 2013). Agriculture based economy also became the main activity of interest of the newly established owners who now serve their own interest instead of working in the fields of others. With this freedom to use the land as each pleases the government needed to establish agricultural governance models to manage productivity. Incentives in terms of guaranteed purchase prices

and financial support schemes were initiated to help agricultural communities and in the same time to channel their yield of the products required. However development of rural areas in general was not catching up with the trends of global development or the development trends in the neighboring urban agglomerations for what matters. Emerging from a previous monarchic model, the current model of governance can in general be described as advised at national level, prescribed at state level, directed at district level and implemented at community level. All of this emanates from a democratic process where majority vote is the general base to all the allocation along the structure. The increased sense of freedom acquired with the independence from the colonizers and the freedom of movement of the population within the Indian Territory promoted the outmigration patterns from rural to urban areas in search of overall improved living conditions. Alongside internal system factor changes external ones like climate change impacting the availability of water resources also started appearing.

After the SES at hand developed and matured deeper into the described exploitation phase the conservation (K) of state phase has begun. More and more demand on the new state largely originating from population growth patterns and culminating into drought alarming stresses on water resources availability forced the exploitation phase to evolve into the current conservation phase of the system where everything is built-up around maintaining the SES in the state it is in. Here and there around the state adequate participatory governance and collaborative contribution at all levels of the social and management structure was initiated. Notably one can stress on the major role played by NGOs involved in local community management groups and their contribution to fields like education and tutelage, gender equity and social equalities. Initially created for water infrastructure maintenance and resources management, these NGOs either evolved or influenced other ones to cover other fields such as the ones mentioned. Notable success can be seen in the “Chaukas” projects implemented by GVNML (UNICEF, 2001). In these earthen structures impervious land surfaces are scraped in several locations to expose a more porous lower level. The surrounding is slightly dammed to momentarily retain rainwater past the direct infiltration potential. Strategically locating these scrapes makes it so that the groundwater in the locality of the structures is refilled and outflows in a local surface water pond. Another success can be attributed to the works promoted by TBS on the “Johad” structures where minor earthen dam-like obstacles are erected at strategic locations of the watershed to provide for adequate water retention according to the community needs (Samantaray, 1998). A large diversity of such structures exists and can be implemented to improved surface and groundwater conditions (SAARC, 2009). The motivation and organizational structure provided by these community based participatory governance organizations can counter the “laissez faire” stress on the system. A period of civil society campaigning and legal battles spearheaded by the nongovernmental organization Tarun Bhara Sangh (TBS) led to the closing of some mines and re-establishment of the landscape. The water condition started to get better downstream leading to revitalization of the fish population. At that point the local government contracted fishing companies to massively extract the newly available resource! Project which they directly stopped after renewed civil society lead demonstrations. This example shows a completely uncoordinated and unplanned water resource management scheme fueled by conflicts of interests and financial return incentives. It also

shows that the contribution from this community level NGO was vital to preserve the SES at conservation phase by increasing its defense mechanism against threshold breaking external stresses that otherwise would have forced it into collapse and state changes.

The final phase of the adaptive cycle of our SES is the collapse or release (omega) phase where after conservation of state becomes incapable of absorbing stressing disturbances. In the collapse phase the thresholds of the SES to the different stressing factors are put into test. If resilience is not broken the SES remains in its current state looping back into a phase of internal shock absorbance and reorganization. Otherwise the SES will be forced into a completely different state with its own adaptive cycle. The social structure of Indian societies is going through a multitude of changes to fit into a contemporaneous globalized world and its development targets. A long path needs to be crossed for the world to get set on a sustainable development pattern and India accounting for almost one fifth of the global population needs to be at the head of the race. The de-facto infrastructure that has been set for governance and amelioration of the water resources in Rajasthan had been indirectly providing for the SDGs. Several organizations along the hierarchy of grass-root bottom-up and top-down participatory institutions have successfully led community based endeavors in this regard. The way these community level groups have ensured the conservation phase of our SES to date is the key to understanding how to navigate through this release phase. The value they provide for the SES under study is at the base of the mechanisms of survival in many parts of Rajasthan. They are not to be hindered if equilibrium and preservation of system state needs to be sustained. Accordingly their resilience directly makes for the resilience of the SES. Details about how these organizations function will be elaborated upon in the NGO perspective section.

Previous States and Other Future Possibilities

After defining the current state of the resilient SES in terms of its adaptive cycle stages it is possible to list the other states that it has been thru in the past or ones it can predictably reach in the future. The criteria defining the different states are split into two different sections pertaining to aspects over which community conditions are assessed. The first criterion is water resources availability and the general community condition in terms of drought. The second factor is governance structure and the political framework that governs the SES.

In terms of water resources and drought condition Rajasthan has always been an arid area where access to water is a problematic topic. The condition of water resource availability to fulfill living needs in which communities within Rajasthan has lived where not always necessary as tight. Saying so does not imply that water was ever more abundant but rather that the lifestyle demands and resource consumption need was less. Where in the 21st century having continuously running water at accessible proximity is a minimum set standard that nobody accepts living without this has not always been the case. Villages that now cannot do without water pipes were previously relying on wells located in the village center from which people filled their supply of water for the daily usage. This extra labor required to procure the water meant that consumption for personal needs was restrained. Hygiene standards were lower due to less emphasis on washing up after every contaminating activity. Less population earlier in history meant less demand on overall water resources as well as less demand on food even

had similar living standards prevailed. This in turn meant less return requirements from agriculture or animal grazing to meet the consumption demands of the community and hence less imbedded water resources consumption associated. When it comes to ecological aspects, the North Eastern most parts of Rajasthan have reportedly been greener in earlier history. Massive cutting down of trees and incurred desertification is associated with rushed resource extraction from fear of land tenure rights transfer from the Rajput rulers to the Indian Federation after independence. Precipitation patterns slightly change when the land is stripped of vegetation due to the changes in local levels of humidity and temperature leading to decrease in precipitation volumes. This is a general assumption but could be an indicator to previously more ample monsoon volume. Stripping down the landscape from its green cover also increases its exposure and facilitates evapotranspiration losses of water reducing the water availability potentials.

Apart from the different state in terms of drought conditions, a completely different governance structure and available possibilities prevailed during previous phases. Instead of the participatory democratic governance that is now the model in India previous system states have in general revolved around monarchies. In Rajasthan two different monarchy models fought amongst each other for control over the territory and accordingly the SES resources before the British colonial time. The Mogul Empire based in Delhi and Agra in the currently neighboring state of Uttar Pradesh controlled large parts of what now is Rajasthan. These parts were governed under a sultanate model where subordinate Maharajas were allowed control over territory in return to tax payments and contribution in army efforts. The Jaipur city was a major example of these. In the western and southern parts of Rajasthan other independent city states thrived during the same period. The Udaipur city state in the south and the Johdpur city state in the west are two historically prominent ones. These independent city states were commonly at war against the Moghul Empire as well as in between each other. While the title of the supreme ruler in the independent state of the Rajputana were changed from Maharaja into Maharana and Maharani they were all established based on a cast system. It ensured the ascension of the closest blood related Rajput after the death of a monarch. Moreover every job occupation in society was held by the appropriate cast for it and no changes whatsoever were allowed not even for offspring generations. The offspring of agriculture people inherited agricultural jobs and so on. All the lands under these territories technically belonged to the Maharaja and the people lived and worked for the direct profit of the city state. In return the city state was expected to provide the people with planning and means to ensure their sustenance and protection. At local scale this was achieved thru the delegation of the task to local Raj rulers that were given auxiliary control over community scale territories. In these territories assigned Raj contributed to development because of many incentives. The first is the increased return that they need to share with the higher monarch in order to win his favor. The second is the acclamation by their local community that guaranteed its cooperation and support. The third is the show off between the community level rulers themselves which were a constant open security threat to each other and where each took pride in the extravagance of executed structures under their jurisdiction. Impervious surfaces as well as damming and channeling structures did not exist or at least not in the efficiency or the abundance they are

constructed in at our current system focus state. This would have allowed for a more free circulation of water thru the hydrogeological terrain features favoring downstream locations with respect to other off stream locations in terms of water availability. This condition survived all through the British Colonial Age with the small change in the fact that instead of Moghul rulers now the entire Rajputana now reported to assigned British Governors and important development decisions needed their approval.

Future conditions might change along a charted path or in the most unexpected ways. In terms of drought things might get worst in terms of water consumption demand to a point where the resources do not suffice anymore. These are already at an overexploited stage so this scenario is not too far from reality (Rathore, 2005). Changes of state can also occur if climatic conditions change to an extreme radical point where no monsoon happens anymore or precipitation patterns become more spread along the year (Rockström, et al., 2009). Such changes are highly probable and predicted by most environmentalists. Other stresses on water availability may originate from other states not being able to supply Rajasthan the water they currently do. An example of other less perceivable changes that would move the SES into a complete different state in the future would for example be technological advances that allow geoengineering of new ways to modify the water cycle in order to induce increased precipitation at a specific location. All ranges of possibilities can also be imagined in terms of governance model changes. The rejection of monarchies and colonialism lead to the elimination of a system that has been established for centuries in favor of participatory democracies. Similar changes of tastes and values of the human conscience can lead to yet other forms of governance. The basic form can probably be described as the absence of governance or complete anarchy where the SES would have to transform into a continuously adapting one to cope with all expectancies. Other system state can be attributed to changes of state level jurisdiction. Maybe the dissection of the Rajasthan state unit into several smaller states or even the integration of other neighboring territories into Rajasthan can be considered. And what if the whole Westphalian modeled of nation states falls apart? Then a new void in the decision making process will arise and new forms of governance will fill the gaps taking the SES into completely different states.

Factor Changes with Transition Thresholds

The most important part not to miss upon in this system dynamics description is the identification of the thresholds of stresses that the resilient SES can sustain before having to adapt and transform into a new phase. Looking closer at the parameters leading to system state changes described above ones can easily sort out these factors (Table 9) where major parameter changes categorically break thresholds of relevance to our SES main issues of concern throwing it into a different adaptive state.

Some of these variable changes can also break many thresholds ending up in a cascading change event. For instance as explained, change that leads to deforestation which is a change resulting from land use modification impacts agricultural possibilities to probable threshold breaking points. It also incurs a cascaded change that stresses meteorological factors in terms of ambient temperature and local evapotranspiration which can reach threshold breaking points in terms of the general water cycle state of the SES.

Table 9: Factors with potential SES state change thresholds

Personal water consumption for daily intake and hygiene	Household water consumption in food preparation and sanitation
Change in agricultural technology	Required financial returns from natural resources and agriculture
Changes in community capabilities possibilities	Changes in the institutional model within the federation
Amounts of embedded water in food consumed	Radical changes in land cover and land use
Change of the democratic system	Changes in Geopolitics
Radical changes in ambient temperature	Radical changes in precipitation Patterns
Community Size Changes	Changes in land-use directives

Cross Scale Interactions

Changes along the phase of the adaptive cycles of the cross-scale systems will be evaluated for their impact on the SES adaptive cycle phases. It is expected that conservation phase needs in the adaptive cycle of a larger focus scale induce pathways of remembrance on a smaller focus scale system. The remembrance pathways drive the smaller scale system it into a state change and an associated new reorganization phase in its adaptive cycle. On the other hand, it is expected that a smaller scale system collapsing into the release phase after disturbance of conservation will impact a larger scale focus system through a revolt pathway. This revolt pathway usually moves the larger scale system also out of its conservation phase collapsing in turn into its release phase in a form of cascading cross scale chain of collapses.

An example of remembrance pathway that our SES focus scale has induced in smaller scale systems can be seen in the revival of traditional rainwater harvesting practices at micro-catchment smaller scale system level. When our SES focus scale reached the conservation phase of its cycle the need to find new ways to preserve its current state necessitated finding new ways to increase the water resources potential to meet the increasing demand. This activated a social remembrance of the practices that used to be done before the advent of technology and industrialization in order to secure those water needs. Remembering more favorable past states pushed the smaller scale system of local community level into reorganizing itself into the way it used to do things before. Agrarian households and villages were pushed to revive the implementation of these old rainwater harvesting methods in their fields defining a new state of their water resources management.

There also is another example of remembrance pathway in which this time our SES scale was the object of the state change due to conservation needs at the larger-scale focus system. In this case entering a conservation stage at the Rajasthan scale system in terms of post-colonial governance model state induced remembrance pathways at community level. In order to find better ways to sustain the governance model and preventing it from collapsing old wisdom of community level management was revived. As described earlier in previous colonialist and pre-colonialist time community level management emanated from an incentive driven Rajput rulers institution. While the monarchy aspect itself was not wanted, its dissolution led to the downside of losing leadership at community level. Remembrance of the advantage of having



Figure 11. Biselpur Dam and Downstream Water



Figure 12. Exposed Pressurized Water Distribution Pipe

leadership at community level was the main precursor to the creation of the NGOs and their work on community reorganization. This induced a state change in one of the components of our SES that defined a new community scale governance model with the NGOs at its forefront.

Revolt pathways are more straightforward than remembrance pathways. Changes of factor lead to conviction at individual and family scale of the need to get out of the colonialist system state hence falling into a release phase at this scale. The cascading aspect of this phenomenon slowly built up from village level to larger community scales and further. This culminated into a revolt pathway that induced change of factors in our SES community scale adaptive cycle pushing it out of conservation and into release phase. A similar revolt pathway was experienced at the larger Rajasthan scale system due to a collapse at SES scale. In the events that led to the creation of the Aravalli River Parliament stresses on the water resources rejuvenation system that was established at community level lead to a collapse in their acceptance of the way governance was performed. This collapse impacted the larger scale Rajasthan governance system by forcing it into its own collapse and reorganization into a form that incorporates for the adaptive needs of the community scale systems.

Field Investigation Findings

The findings from the field investigation in terms of governance infrastructure implementations as well as stakeholder position or other contributions in context of the Resilience to Drought of our SES are dissected in this section.

Water Management Infrastructure

A major part of the field investigation was concerned with identifying water collection and distribution infrastructures across the state of Rajasthan. A focus was given to assessing governmental large scale infrastructures and distribution schemes. Another point of interest was to understand how securing water at a large scale used to be performed in the past. Water harvesting at community scale with the help of grass root organizations has made its impact on increasing the resilience of the SES to meet the conservation phase requirements. The case of Gopal Pura in Alwar district will be further explained in details.

Contemporaneous Water Supply Infrastructure

Big dams are a major source of water to the water supply network all over the state. The Biselpur Dam (Fig. 11) is located on a strategic point along the Aravari ranges. It was constructed to secure water supply to the state capital city of Jaipur. The district of Tonk and the areas of the district of Jaipur where the water pipe (Fig. 12) reaching the city cross are also supplied by water from this dam. A big problem facing the distribution system is the destruction of the exposed pipe by local villagers for direct intake of water to their fields. This leads to unmonitored losses and disruption of supply due to pressure drops. After the water is pumped from the dam reservoir it is distributed to neighborhood pumping stations and uplifted into suspended water tank reservoirs for further gravity pressure distribution (Fig. 13).

In the city of Jaisalmer far west in the internal drainage areas of the state operations are targeted around the channel of groundwater aquifers known as Saraswati which in Hindu mythology is believed to be a holy underground river running in the area. This water pumping comes to support the shortages in supply from the Indira Gandhi canal (Fig. 14) which connects the western part of Rajasthan to water coming from the neighboring state of Punjab. In general all over the Rajasthan state



Figure 13. Gravity Pressure Distribution Reservoir



Figure 14. Aerial view of the Indira Gandhi Canal (Purushottam Diwakar) ©



Figure 15. Bhandareg water Baori



Figure 16. Hadi Rani Kund Step Well

government supply is provided thru groundwater extraction to support bigger hydrological projects. The condition of groundwater extraction is at overexploitation stage all over the state with the only exceptions of the Mahi and Ghaggar catchments (Indian Gov. MWR, 2014). Outside municipal boundaries this supply only reaches neighborhood distribution points and is not connectable to single household units.

Ancient Water Infrastructure

In addition to the currently functioning structures I was able to visit old forms of constructions for water collection and preservation. Enormous scale traditional water structures are abundantly available all around the state and in the most unexpected places. The Bhandareg water Baori (Fig. 15) presented an example of how structures served security purposes by surrounding water points with huge guarded entrances. The Hadi Rani Kund (Fig. 16) featured the way water structures served embellishment purposes in open step wells both to please the community as well as to show off the power to erect such structures between neighboring local rulers. Other village pond water houses (Fig. 17) that held worship altars in a small construction before giving access to a ramp leading down the pond emphasized the holiness attributed to water.

A five hundred years old catchment dam was investigated in the deserted city of Bhangard (Fig. 18) in southern Alwar which was a Moghul Empire allied city before Rajputana Territories. The watershed fortification of the Amer city (Fig. 19) gave an image of the importance to secure water in the previous capital of the former Amer city-state before the center of power was moved to Jaipur which has now become the capital of the Rajasthan state. Along with the watershed fortification, the Jaigarh catchment fort that was fully equipped with a self-sufficient water collection (Fig. 20) and filtration facility which reportedly used to be able to sustain an army of five thousand men was also part of the water security strategy. More to the south of the Rajasthan state, in the city of Udaipur otherwise known as the city of lakes, another center of power to yet another city state was located in the middle of a series of hills centering a multitude of lakes. Defensive forts were erected on the tops of these hills to protect the central lakes around which the main agglomeration settled and which also supplied neighboring villages.

Community Scale Water Harvesting in Alwar

The district of Alwar in the North-East of Rajasthan is amongst the most densely populated ones. It also lies closest to the capital city of Delhi and at mid distance between it and the state capital of Jaipur. Only the district capital city Alwar is connected by Railway (Plate 10). The sector of Thana Ghazi in the southwestern most part of the district the landscape is dominated by the 700m high Northern Aravali Hills ranges (Plate 11). The land use in this sector is split into two prominent categories. Almost half of the area is considered as barren wasteland and the other half has single cropping agricultural activities (Plate 12). The Sariska national park reserve also makes up for a considerable portion of the sector. No permanent water bodies exist in the sector which drains into three different river catchments and all water streams are perennial (Plate 13). The annual precipitation levels in the sector range from a maximum of 600mm down to lower than 500mm (Plate 14) (MWR CGWB, 2013).



Figure 17. Village Pond Water House



Figure 18. Catchment Dam in Bhangard



Figure 19. Watershed Fortifications in Amer



Figure 20. Rainwater collection in Jaigarh

It was in this district that TBS had first started their works specifically in the village of Gopal Pura. Across the years they have constructed more than a thousand different rainwater harvesting structures all over the Alwar district (Plate 15). Three of their most notable micro-catchment works were assessed during the field investigation. The first is a complex network of interlinked Johads and Anicuts (Plate 16) helping preserve the groundwater in the aquifers of villages Bikampura, Gopal Pura, Gobin Pura and Jaitpur, allegedly enabling the local population to practice multi-cropping all year long. The second is a strategically located cemented earthen Dam (Fig. 21) on the outlet of a big catchment and helped by adjacent check dams. These supposedly channeled groundwater into a series of Anicuts reducing the flow of water in the ground and preventing it from exiting a valley where six villages in the Bhauta locality can use the water all year long. The third is the location where the perennial Ruparel River that had been totally dry for years was rejuvenated. Both the second and third locations were almost completely dry at the time of the investigation.

Taking a closer look at the interconnectivity of the structures constructed for the community neighboring Gopal Pura one can notice an interesting pattern for structures localization. Johad structures located downstream of slightly sloped areas allow for draining water of monsoon rains to be collected. These open reservoirs provide for animal grazing needs and the fact that their bottom is permeable allows for the stagnating water to slowly percolate into the local groundwater aquifers. This local groundwater recharge increases the humidity of agricultural land downstream and can also be pumped during the drier season. To collect the excess rainwater draining thru the fields a series of laterally placed Bands and Anicuts delaying the flow from going downstream. Further downstream where the settlement is located an open Pond collects all the excess water draining from agricultural fields for usage needs and re-percolation into the aquifers underneath the houses. In this area the is completely categorized as Barren Land (Plate 17) the community now has water resources available all year round and are able to produce multiple crops per agricultural season (Fig. 22).

Population Surveys

The population survey results are split into two distinct sections. In the first section feedback from the questionnaires provide a description of the livelihood conditions of households at community level. In the second section results of the voting for priorities in development are dissected.

Questionnaire Results

The questionnaire addressed to the heads of families interviewed was categorically structured into five sections. In the beginning family size and status of members living under the same roof was inquired. Food consumption habits with type and amounts of consumed items came next. Water use needs and source of procurement is the third category. Education and occupation of the different members of the family is the fourth section. The last section was concerning land ownership as well as agricultural and animal herding practices. Answers were collected in a rather convivial fashion where discussion was mainly held around a cup of tea sometimes even food was presented.



Figure 21. Cement Reinforced Earthen Dam in Bhauta



Figure 22. Green Field Crops in Gopal Pura

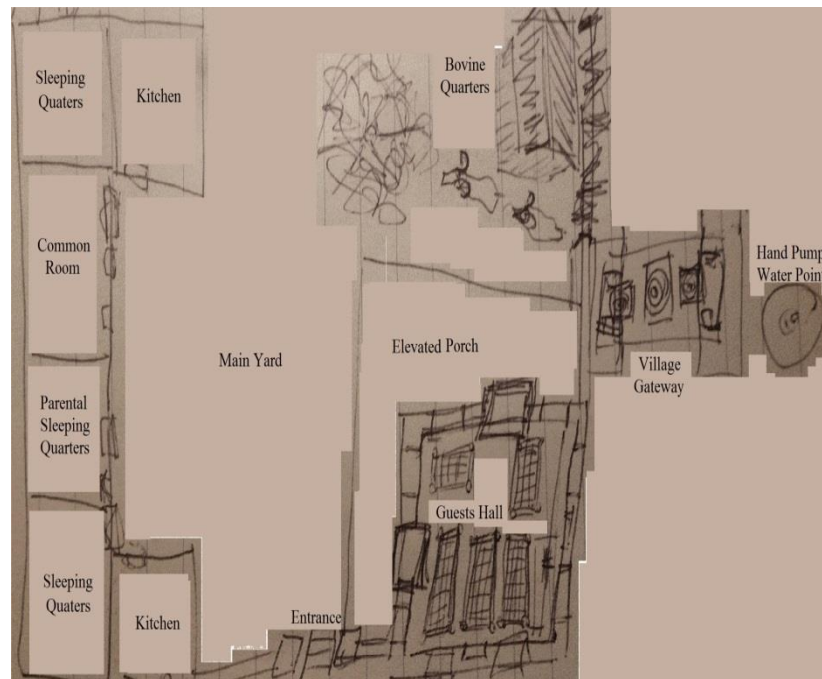


Figure 23. Typical Single House Arrangement in Alwar

All the families investigated were composed of the mother and father having around four children equally split between boys and girls. The couple would have married at young age and settled in the house that used to be the property of the husband parents. The children would in general keep on living in their parental house (Fig. 23) without ever facing the necessity to move out and establish their own house especially for the sons. Married daughters move out to go live at their husband parents place. They are usually replaced by the wives of the sons who in the same timeframe will be marrying and getting their wives home. This maintains the number of individuals that the single household has to sustain in relative equilibrium. The young individuals who reach university level and want to pursue their education need to have their own house in the city where they study. This is usually in proximity of the locality where they live and their largest amount of time would still be spent at the parents place. The third generation offspring are also raised in the house. Some cases where the same roof cannot accommodate for everybody anymore calls for one of the second generation couples to move out and establish on their own. This is usually done in very close proximity of the parental house and sometimes even as a simple extension of the building.

Food consumed by the people in these communities is mainly vegetarian. This is mainly due to the majority Hindu population and the conviction that has developed thru the ages against killing animals. It is not vegan however and all dairy products like milk and butter cheese make up for a respectably large portion of the nutrient sources. The amounts of milk reportedly consumed ranges between families from 3L to 5L drinking milk per day and up to an extravagant 15L per day but which includes preparing derivative products like butter and cottage cheese. The vegetables, pulses and grains which make up for the main bulk of nutrients intake are collected in the fields and acquired at the markets in the neighboring larger agglomeration which accommodate for one. The products from the fields include Wheat, Mustard seeds and oil, Gram and Chickpeas, lentils, and other vegetables and roots. From

the markets nearby the complementary items needed to be purchased are spices, the main bulk of fresh vegetables and roots, rice, and the different types of fruits.

In terms of water needs, the average household unit would consume around 35L of water for drinking and food preparation needs. Personal hygiene consumption needs around 25L per bath per person so around 175L for the whole family. This is not however on a daily basis but around three times a week instead. The procurement of the water is possible via connection to the local government supply that originates from groundwater extraction. The general trend is to not connect due to prices considered to be exorbitantly unaffordable. Instead direct pumping of the groundwater at the house premises is frequent. A lot cannot afford the sunk cost related to having a groundwater extraction borehole at home which could reach 1 Lakh Rupees (roughly 12,500 SEK) even if half the cost was provided by aid organizations or government support schemes. For those transporting water from the closest available open well is a daily necessity performed by all family members but mainly by the woman and children.

In terms of education, the youngsters attend local village schools that usually provide for up to grade seven. The students are separated in age, class level, and gender according the possibilities of accommodation. For further education at higher grade classes the students would need to travel to the school located in the bigger agglomeration nearby which is usually the same as where the markets are available. This is sometimes problematic due to lack of transportation means but most keep on doing it. At the same time where they attend school the children would still help with the daily needs of the household in caring for cattle or up-keeping the house. Further into college education the students would need to attend in the statutory towns that have a local university. Usually the closest town is chosen especially when no big shot education is targeted and when another sibling is already studying in the same town. These educations mainly cover Bachelors of linguistics, arts, social and political sciences and fields that do not necessitate intense technological apparatus. Work opportunities are almost completely unavailable. The main employer being the government everybody seeks a government job for stability and job security. Other minor jobs include working the fields of others but these are not stable jobs. Construction entrepreneurship can be profitable but no stable employer exists. For their sustenance the people mainly rely on work in the field and the contribution of one family member that has succeeded in securing a job in the city. In general everybody wants to leave for the city to get a job and that is what even the well-established parents want for their children.

Land ownership is usually in the name of the man in the household. The rights associated with the agricultural land are rights of occupancy and use. Tenure does not extend to irrevocable ownership and the government has the right to reacquire and redistribute the land at any time. Distribution of the Land amongst the offspring is usually performed during the lifetime of the parent. Inheritance rights after death legally include the daughters but this is rather socially unacceptable and the girls usually let go of their rights to their brothers unless special vital conditions require otherwise. The land inherited has to produce the food needed for eating and more to sell and sustain the financial needs. With the passing generations land inherited is becoming smaller and smaller. Irrigation of the fields when performed is traditionally done

thru open channel flooding irrigation style. Recently drip irrigation by the help of removable sprinkler apparatus has been introduced. The water is procured by pumping groundwater in open field wells with help of electricity or diesel based pumps. On average family heads investigated mentioned that their land on which the whole household relies ranges in size from 3 to 6 ha. The straw for cow and buffalo food is usually procured on the market and excreta regenerated into combustible material. Sheep and goat herding is also practiced in less expressed amounts. Buffalo and cow daily water needs is around 20L for adults and 10L for calves on a daily basis. The average herd of ten animals per household hence necessitates an intake of roughly 200L of water daily.

Notes on Priorities in Development

Drawing from the 2030 SDGs thirteen areas of development within the context of the Rajasthan communities were presented to the different social groups surveyed. The list was composed of the following items:

A total of 131 aware votes were collected in a community of four villages close to the Town of Thana Gazi in Alwar. These villages include Gopal Pura, Govin Pura, Jaitpur and Bikampura. The scale of these villages is such they are home to an approximate total of 50,000 people but are yet not treated as separate unit in statistical data. As previously stated this area has been the starting point for TBS activities and their current headquarters and sanctuary is located almost in center of these villages. A large network of local rainwater harvesting structures has been constructed for this community relying on TBS support. TBS has also been very extensively working at community level in areas of Environmental Awareness, Gender Equity, Agriculture Support, Education and Gender Equity. The voters were asked to prioritize four choices where they on a personal basis would want us (TBS involved) to increase efforts and provide the means for development. The priority needed to draw from what they believe is an obstacle for them in their community leading to their outmigration. The prioritized items also need to be ranked in order of importance and urgency.

The results from the voting (Table 10 & Table 11) are as follows. In general terms Water Security got the highest amount of votes at 24% of the total votes and 76% of the voters ranking it as the most urgent. Next was Environment Protection that got 17% of total votes followed by Food security as well as Health & Medication with 13% of the total votes each. These were not voted the most urgent things to work on. That vote went for Job Security and Education at 6% of votes each. It was surprising to note that Cooperation, Fighting Poverty and most impressively Agriculture Support did not receive any vote in total votes cast.

In terms of gender distribution, the voters were split into 60% woman and 40% man. Their emphasis and priorities were somehow different. The woman emphasized Water Security Environmental Protection and Health & Medication at 24%, 16% and 13% of total votes. Their urgent topics included Gender Equity, Sanitation and Job Security each at 5% of votes following Water Security that got 86%. The man votes on the other hand emphasized the same things as women but Food Security instead replaced Health & Medication with the same distribution of total votes. Water Security and Education were considered the most Urgent by 58% and 17% of the man voters respectively. Industry & Technology Job Security and Environmental Protection followed with 8% of the votes each.

Table 10: Community voting results by percentage of total votes (Red: Intriguing results; Yellow:2nd and 3rd highest ranking results)

Seq	Criteria	Total Votes	Age Groups				Cast Groups		Genders	
			<15	5<x<30	30<x<50	>50	SC+OBC	Regular	Female	Male
1	Fighting Poverty	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	Gender Equity	2%	3%	4%	0%	0%	3%	0%	4%	0%
3	Industry & Technology	5%	14%	0%	6%	0%	5%	8%	6%	4%
4	Food Security	13%	0%	11%	25%	24%	11%	19%	12%	15%
5	Sanitation	4%	0%	4%	3%	12%	4%	4%	2%	7%
6	Agriculture Support	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	Job Security	9%	14%	4%	13%	6%	10%	4%	12%	4%
8	Water Security	24%	19%	26%	25%	24%	24%	23%	24%	24%
9	Cooperation	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	Environment Protection	17%	19%	15%	13%	24%	19%	8%	16%	17%
11	Strong Governance	2%	3%	4%	0%	0%	2%	4%	2%	2%
12	Health & Medication	13%	19%	15%	9%	0%	12%	15%	13%	13%
13	Education	11%	8%	15%	6%	12%	10%	15%	9%	13%

Table 11: Community voting results by percentage of most prioritized criteria (Red: Intriguing results; Yellow:2nd and 3rd highest ranking results)

Seq	Criteria	First Choice	Age Groups				Cast Groups		Genders	
			<15	5<x<30	30<x<50	>50	SC+OBC	Regular	Female	Male
1	Fighting Poverty	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	Gender Equity	3%	0%	8%	0%	0%	4%	0%	5%	0%
3	Industry & Technology	3%	0%	0%	11%	0%	0%	13%	0%	8%
4	Food Security	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	Sanitation	3%	0%	0%	11%	0%	0%	13%	5%	0%
6	Agriculture Support	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	Job Security	6%	25%	0%	0%	0%	8%	0%	5%	8%
8	Water Security	76%	63%	83%	67%	100%	88%	38%	86%	58%
9	Cooperation	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	Environment Protection	3%	0%	0%	11%	0%	0%	13%	0%	8%
11	Strong Governance	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	Health & Medication	0%	0%	0%	0%	0%	0%	0%	0%	0%
13	Education	6%	13%	8%	0%	0%	0%	25%	0%	17%

In terms of age distribution, the voters were divided into four categories for analysis. First the below 15 years old range which accounted for 24% of the voters, the 15 to 30 age range with 36% of the voters, the 30 to 50 age range with 28% of the voters and finally the above 50 years old with 12% of the voters. The youngest category emphasized Water security, Environmental Protection and Health & Medication each getting 19% of total votes. Priority nonetheless went for Job Security and Education after Water security in similarly with total votes and getting 65%, 25% and 13% of votes respectively. The next age range from 15 to 30 years old emphasized more on Education with 15% of total votes but had similar results as for the previous group. For the most urgent to work on Gender Equity popped out alongside education with 8% of the votes after Water Security with 83%. In the next age range of 30 to 50 years old some changes can be seen in voting results. While total votes still emphasize Water Security another item jumps up to the same rank. Food Security gets as many total votes at 25%. It is followed by Job Security and Environmental Protection at 13%. And in the most urgent things to tackle also two new items pop out where Industry and Technology as well as Sanitation are highly prioritized with 11% of the votes each. The older age range above 50% also has Food Security at 24% of total votes equaling those for Water Security and Environmental Protection.

When it comes to cast distribution of the voters, these were split into two sections. Votes performed by individuals from regular casts and votes performed by individuals from Scheduled and Other Backwards casts (SC & OBC). These latter being constitutionally protected in way that are meant to ensure their rise terms of social representation and power grab would be expected to have different priorities than those who are not. The SC & OBC represented 75% of the voter while the other 25% were regular casts. This roughly represents the cast distribution of the population in this area. SC & OBC cast members emphasized Water Security, Environmental Protection and Health & Medication at 24%, 19% and 12% of the total votes respectively. Job Security and Gender Equity came after Water Security in terms of Urgency for 8% and 4% of the voters respectively. For voter from regular casts emphasis was given on Food Security and Education instead of the Environment Protection with 19% and 15% of total votes respectively. Water Security and Health & Medication were still in the scores with 23% and 15% of the votes. In terms of urgency regular cast people votes features mention of Sanitation as well as Industry and Technology at 13% of the votes.

Refined Voting Results

The raw results from the voting that was performed were not usable in the way they got collected. Water Security and Environmental Protection were the most emphasized topics overall. The importance of developments in these areas is not contestable; however the large bulky number they received in the results completely negates the priority of other items. Moreover my presence as an investigating entity was not completely free from prejudice. After all I was accompanied there by individuals from an organization that primordially works with water and the environment and which has contributed to the livelihood of these people for several decades. Pleasing the organization with their voting results was probably a major factor of influence that I needed to work my way around. For these reasons another assessment of the voting results was performed after omitting the Water & Sanitation item when

it was chosen as first priority. In terms of total amounts of votes the omission only translates into a change in the percentage received by Water Security while other items remain unchanged and rank similarly on the ladder with only Water Security drawing back. It is to note that due to the high amount of voter that had chosen Water and Sanitation as a first choice this item does not rank in the three most emphasized items in the total votes of any voter category. In terms of most prioritized fields of development interesting result changes occurred (Table 12).

In terms of gender distribution of voting we can now see that Woman voters think that Environment Protection, Food Security, Sanitation and Health & Medication is very primordial with 52%, 14%, 10% and 10% of votes respectively. Man votes for Water Security on the other hand were split between Environment Protection and Food Security at 25% of voters each. When it comes to age wise distribution of votes, the votes of the youngest under 15 yo category basically went in the favor of Environment Protection which now got prioritized by 50% of the voters. The votes of the next 15 to 30 yo category were split between Sanitation and Food Security getting 17% and 8% of voters respectively. The 30 to 50 yo voters now prioritize Food Security, Environmental Protection and Health & Medication at 22%, 44% and 11% respectively. Finally the priority of the eldest age range of voters which was categorically dominated by Water and Sanitation now got split into Food Security at 75% and Environmental Protection at 25%. In terms of cast distribution of votes, the 88% of SC & OBC casts voters that had prioritized Water and Sanitation now have their votes split between Environmental Protection at 48% and Food Security at 20%. Priority votes of general cast members did not vary a lot but Food Security and Health and medication now each got 13% of the votes.

Table 12: Refined community voting results by most prioritized criteria after omission of water security as first priority (Yellow: Top three ranking results)

Seq	Criteria	First Choice	Age Groups				Cast Groups		Genders	
			<15	5<x<30	30<x<50	>50	SC+OBC	Regular	Female	Male
1	Fighting Poverty	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	Gender Equity	3%	0%	8%	0%	0%	4%	0%	5%	0%
3	Industry & Technology	3%	0%	0%	11%	0%	0%	13%	0%	8%
4	Food Security	18%	0%	8%	22%	75%	20%	13%	14%	25%
5	Sanitation	9%	0%	17%	11%	0%	8%	13%	10%	8%
6	Agriculture Support	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	Job Security	9%	25%	8%	0%	0%	12%	0%	5%	17%
8	Water Security	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	Cooperation	0%	0%	0%	0%	0%	0%	0%	0%	0%
10	Environment Protection	42%	50%	42%	44%	25%	48%	25%	52%	25%
11	Strong Governance	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	Health & Medication	6%	0%	8%	11%	0%	4%	13%	10%	0%
13	Education	9%	25%	8%	0%	0%	4%	25%	5%	17%

Government Role

At community level the government is represented by the Panchayat executive body which is responsible of maintaining all the necessary coordination between the different ministerial departments and institutions as wells as the local population. Their direct authority is restricted by approvals they need to procure themselves for execution of projects at higher levels and to a yearly budget they are given with spending directives from the Gram Panchayat. To better understand their role and position it was necessary to interview some of the Panchayat members. The panchayat gets voted for by the Gram Sabha assembly. A meeting at Gram Sabha level was also attended to understand the decision making process that takes places there.

Panchayat Members Views

The first member interviewed was the Panchayat Sarpanj or head in the village of Bikam Pura. Part of the Miina agricultural cast has recently gotten his mandate of Sarpanj after the latest elections. While his profession is in the village real estate retail and owns a very prominent concrete construction for a house in comparison to other constructions in his village. The previous Sarpanj owned a groceries and sweets shop. This person was interviewed at the TBS sanctuary premises where he insisted to join us. The familiarity and traded flirting between him and TBS personnel was marking. He openly admits to represent a political party for practical as well as financial reasons. He feels that the contribution of TBS to the community is by far higher than that of the government and that people rely on the organization in several aspects of life. When asked about his possibilities to induce a change if needed his answer was rather on week side where not much change can be hoped for and corruption and self-interests where the keys to all things. When asked about his budget spending plans he pin pointed some road repairing projects and other employment guarantee scheme related expenditures. He specifically stated however that the money could be kept unspent without any sanctioning but would not add to the following year budget.

Another Sarpanj was also interviewed in the area where TBS have their major works. The Sarpanj of the Bhauta village had worked at TBS as an employee for several years in the past. For internal disagreements with trends in the organization he has ever since left and opened his own at smaller scale. He argues that the NGO he has established is interested in a continuous support of a specific community to which it dedicates itself in opposition to the way TBS enables a specific community and then moves on to another one. As part of his works as Sarpanj he has managed to invest money in purchasing a public owned movable water cistern which can be filled in wells that have water an then parked at needed locations in the village. This was needed because several wells located in the vicinity of the village have run completely dry after a couple of years with a bad monsoon. He also promoted the renovation works in a village temple and plans to join his village with a concrete road to the newly constructed concrete road that runs adjacent to it. I addition to his works as Sarpanj his organization is still active. Along other thing his most valuable project running at the time of the interview was a remodeled Johad made from reinforced concrete that he claims to be his personal design. After interviewing him in his house he took us to neighboring village where Coca Cola has invested ten million SEK in CSR money for the construction of one of these Johad downstream agricultural lots in order win favors of the population.

A woman Panchayat member was also interviewed. In the village of Laporla the population is too small to have a local Panchayat body. The Panchayat that represents Laporla hence also has other villages under its jurisdiction. Seats in the Panchayat body are reserved for women. The meeting took place at the house of this member during the Holi festivities. I was accompanied by the GVNML organization founder Laxman Singh who was the main center of attraction in the gathering. The conversation mainly took place between him and the husband of the Panchayat member who I later understood had been Sarpanj earlier. Some questions were asked about constructing public toilets in the village. The village also has a big problem where wastewater is accumulating in the middle of the road and where a combination of bureaucracy, budgeting and land ownership rights is preventing any intervention. I tried asking about it but no clear eventual plans to repair were expressed by the man we were talking to. The panchayat member herself was busy preventing the children from eating colored powder and making sure tea is served. The setting was strange to the point that a sort of minstrel troubadour was even called after to recite some fable and throw in jokes and folk songs. That mainly to honor Laxman Singh but it is necessary to clear out the fact that Indian society still has this kind of performers who belong to a specific cast that has this for a job. Festivities and holy days are usually their chance to make money.

The Gram Sabha Meeting

In the village of Rashi Pura in the Kira locality of the Karoli district decision needed to be taken concerning the construction of a Sham Pokhar traditional water harvesting structure. It is composed of a series of pond creating walls where water is accumulated for cattle to drink and where groundwater is recharged to humidify the downstream field and this repeated in chain. The target was to insure water for the irrigation and groundwater recharge of 200 ha of agricultural land benefitting 22 families. The current groundwater level is at a 200 ft depth at the site where it is planned and this intervention is vital to the community. The cost for the construction of the structure itself will range between 7,500 and 10,000€ which would need to be bared by the community taking profit from the structure. TBS would willingly provide funding for up to 70% of the project costs but the land needs to be yielded by its legal owners in favor of the community. The structure would also have to be publically owned and managed by the Gram Sabha (Fig. 24).



Figure 24. Gram Sabha Meeting in Rashi Pura

The Gram Sabha meeting called for in order to have an informative and strategy setting agreement was led by the brother of TBS founder Shaman Singh who is not from this locality. Several members from the village as well as other surrounding villages attended. The total number was around thirty. The seating was in a circular fashion where the elderly were more centrally seated than the younger individuals. No children below 18 were allowed in the gathering but it was obviously an event of interest to them who gathered in proximity in almost a form of secondary meeting. Complete absence of women participants was remarkable. The minutes of the meeting were kept by a person recently recruited by TBS and the whole discussion was recorded for further reference. The attendees were rather deeply involved and the participation in the discussion came from almost everybody. The main figures of authority in the village lead the discussion mainly addressed to the elders. One of the participants was infuriated about giving in his portion of land for the construction of the Pokhar. Several trials to bring him to reason and promises of exchange of his land with another lot elsewhere failed. In an attempt to increase his lobby this person stands up and circles around while making a phone call for others to join. Some elderly were sharing a water pipe that was circulated between all the attendees and seemed to be a center-point of the meeting. One thing was certain in this completely non-formal context, members of the community were sitting together and did take a decision concerning the Pokhar construction and associated governance required. The whole process can definitely be entitled participatory democratic governance with the exception of a complete absence of women.

NGO Perspectives

With the two NGOs that were followed upon a specific pattern has taken place where a specific individual has led a fresh starter community intervention that culminated in large scale acclamation. Around this person then grew a team of active persons at community level some of which became employees in the NGO itself while others went on to other activities outside. Also around the NGOs grew a form of family extended support and interest within the parental proximity of the founders. Several individuals from the founder families are vested with key roles in the organizations. On the larger focus these NGOs needed to provide funding for their activities which was especially hard during their beginnings. Funding partners and aid organizations sometimes had their own specific interest and hence diverted the works of the NGO into specific projects instead of others.

Tarun Bharat Sangh

The Young Indian organization as its name translates into was founded by Rajendra Singh and a group of colleagues in 1985. Young Rajendra freshly graduated from Ayurveda studies at the time travelled to Gopal Pura to establish as a physician. After noticing the needs in terms of water resources in the village he sets himself on a personal endeavor to repair the rundown traditional water structures that used to recharge the local groundwater and provide for rainwater harvesting. After an initial success he got a very fast renown and the involvement extrapolated from single village to several and later to watershed level and today his consultancy is wanted at Indian National level as well in other countries. Many international and local institutions honored TBS and Rajendra specifically with several prizes the most prestigious of which was the Stockholm Water Prize which Rajendra received last year. The man remains very close to the people at community level. His main pride

draws from the achievements he has done for “his community” as he calls it. He stands ferociously against privatization of water resources and all private sector industries that interfere with the water cycle. Rajendra believes that his works rejuvenated the area from a geoengineering perspective by countering the damage that had been done during the intense deforestation phase. He calls for people to give “the love and affection” to nature and from there on to draw all their decision. He also considers that the lore of a village elder back the days educated him the equivalent of doctoral studies in three days of listening.

With Rajendra away for works at national level while keeping a constant eye on the works in Rajasthan, Maulik Sisodia is the main figure in the organization. Being the son Rajendra, Maulik is De-Facto person expected to inherit of the organization. After his business administration studies and working in profit making sectors for a while, he joined TBS to take care of all the administrative aspects required. Amongst other things he takes care of development of awareness programs, project reporting, educational workshops, funds procurement, advertising and applying for prizes. His wife even fills the role of personal assistant to Rajendra. Maulik dislikes the fact that the population they work with out-migrates but think that it falls under a Maslow’s pyramid of needs hierarchy. He considers that after receiving their basic needs the local population now wants to elevate itself into higher levels of needs that can only be provided for in the cities. He tries to promote the idea that the rural rich become the urban poor. Would tend to want an urban infrastructure for his community but believes that development brings along destruction also. He would not want the agricultural sector to get affected by other developmental needs because of a basic principle that India cannot afford to import its food at no point. From another perspective Maulik fears a time were aid is not provided anymore and believes that soon providers will want to ask for results and aid might turn into loans. This is the reason why at TBS they do not accept to do any project on complete aid basis but always require a capable population to take part in it. For a more involved community his works mainly focus on dissemination of information and also on sowing the seeds in the youth for better thinking in the future.

Another important aspect of TBS identity is its personnel on the ground. The type of works TBS is involved in did not only handle construction of edifice but also largely handled community empowerment and enabling strategies. With their interpersonal skills and relationship closeness to all individuals in the community they have doors opened to them wherever they go. The people feel that they are at one with the organization and this is mainly due to the fact that people from TBS sit down with them for talks and interaction on a daily basis. Because of this they listen to what TBS has to say and know that anything done by TBS personnel will be in their favor. Partners of the organization are many and TBS does not accept any aid originating from organizations that have deterring activities on water resources. Aiding organizations are mainly interested in efficient use of their provided aid the reason why they find TBS interesting from both a renown as well as results points of view.

Gram Vikas Mandal Naryuwak Laporja

The youth club of Laporja as its name translates into started in the same way that TBS started. Also freshly graduated Laxman Singh came back to his village and started his work back in 1977. Surrounded by vibrant

young individuals from Laporiya and other nearby villages who were eager to help improve community conditions, he started teaching them and organizing them into groups. After working this way for around 10 years, this youth campaign was registered under GVNML. For a period of time Laxman has also worked at TBS and still is partner in the organization. He also today is a man who built a famous organization that has been repetitively acclaimed and honored by important prizes. The set principles where his ideas emanated from are protection of nature in all forms. A very big emphasis was given in his work on forbidding the cutting of trees and the killing of animals. While he is perceived as a leader in his community he mainly considers himself to be a guardian instead. Coming from an enabling perspective and refusing to directly provide he required the community to take part in the projects performed and refused to execute any project where they did not. A major difference between GVNML and TBS is that Laxman is more open to collaboration with the private sector. He would want to see his care for the nature in all communities and is saddened by trends in today's life that are separating the people from nature. This comes from the thought that our interaction with nature is vital to life which is pretty much in line with socio-ecological interactions.

Another prominent individual in GVNML is Jagveer Singh the brother of Laxman. While still completing his studies, Jagveer contributed to a large extent in the development of the Chauka system. Later on he joined the Catholic Relief Organization where he worked in collaboration with TBS on many projects based on community development. After a while Jagveer joined GVNML on a full time basis and takes care of all the administrative aspects of the organization as well as project management. His latest work was the evaluation performed on a group of villages to identify the needs of the "poorest of the poor" to which he give the biggest importance in development. Preserving tradition and structured relationships between the different types of individuals in society is an important thing from his perspective. He finds a large problem of water resources management as well as Land management originates in free-riding and prioritization of self-interests. In terms of rights on water Jagveer second the idea that one should naturally have the right on water that precipitates within one's own land. He sees a big future for rainwater harvesting especially roof rainwater harvesting and find it a necessity to implement given trends in water demand.

Concerning interaction at community level, the role GVNML plays slightly differs from the one TBS plays. TBS has approached community management from the active listener perspective solely taking their ideas from the people themselves. GVNML plays more of a direct stirring role administering expert prescriptions of their own design. The IOCL CSR development project decided on a five years period and directly contracted by GNMLV covers implementations of water collection tanks and distribution, water filtering and cooling systems, sanitary infrastructure, school development as well as community awareness programs in seven villages. The investigation prior to this project that led to the formulation of a report with recommendations for areas to develop was conducted by community consultants. With the work is still conducted in a participatory approach with community involvement. It is however not the product of the community itself as in the case of decision making settings for projects done by TBS.

Experts Knowledge

After the investigation in Rajasthan the third part of the study was spent in Patna with several individuals at the Department of Environment and Water Management. Knowledge acquired there is split into two sections. First of all the Bihar state was home to a largely widespread traditional water harvesting and irrigation system called the Ahar and Pine which downfall pin points important aspects to be maintained for our SES. Second and after conducting a presentation of the approach to the study and findings in Rajasthan a group of scientist and researchers at the department weighed the development items from their perspective.

The Downfall of Ahar and Pine

This system has in the last century almost disappeared with many associated impacts on water resources availability in the state although water in Bihar is relatively abundant. Experts about this system who have been following out on its downfall gave a comparative base for understanding the events that have happened on our SES scale concerning management of traditional water harvesting techniques. According to Renji Joseph who also heads an NGO that works on community level but in Bihar the problems that lead to the downfall of the Ahar and Pine are of two types.

The first problem is related to land tenure right after the land redistribution. The Ahar and Pine which used to be owned by one ruler who held all the agricultural lands was a single unit with personal management interests. The ruler that used to organize the yearly desilting campaigns for rehabilitation of the Pine channel was basically doing something for his own interests. With the fragmentation of the land ownership amongst the agrarian population came a loss of interest from the owners situated on the section of the channel that did not heavily silt up. The effort required at lower sections was bigger than the capabilities of the single plot owners to deal with. Even more in 2002 people were shot dead when trying to rejuvenate a Pine by landowners on the Pine pathway because of loss of land related issues.

In addition to the Land Tenure problem came fragmentation of responsibilities with the different governance institutions of the democratic bureaucracy that was established with the federation. Management of a structure such as the Ahar & Pine that use to be the responsibility of the local ruler to maintain is now under the jurisdiction of: The Revenue Department, The Agriculture Department, The Minor Irrigation Department, as well as the Public Health Engineering Department. This fragmentation of responsibilities led to a complete lack of accountability and an absence of culpability in the governance structure.

Some structures did however survive. Large campaigns led by civil society and farmers associations to maintain the pine were formed. This came after consciousness arose in areas where Ahar & Pine was the only source of water that agriculture cannot do without it and it is in the interest of everybody to maintain them. A governmental support scheme was used for financing the maintenance efforts in the 80s. The “Rajib Ghandi Drinking Water Mission” scheme does not exist anymore nowadays but people still gather on a yearly basis to desilt the Pine.

Development Items Weighs

The audience that participated in the weighing was composed of university teachers, researchers, doctoral students, master students and independent research institutions representatives. All working and

Table 13: Results from experts weighing of development items impacts (Red: Lowest weighed; Yellow: Highest weighed)

Seq	Criteria	Weigh	Vs Water	Vs Gender	Vs Job Security	Vs Sanitation	Vs Education	Vs Agriculture	Vs Cooperation
1	Fighting Poverty	8.19	-9.66%	20.18%	16.96%	11.02%	-10.88%	-7.75%	9.17%
2	Gender Equity	6.81	-24.83%	0.00%	-2.68%	-7.63%	-25.85%	-23.24%	-9.17%
3	Industry & Technology	7.06	-22.07%	3.67%	0.89%	-4.24%	-23.13%	-20.42%	-5.83%
4	Food Security	7.94	-12.41%	16.51%	13.39%	7.63%	-13.61%	-10.56%	5.83%
5	Sanitation	7.38	-18.62%	8.26%	5.36%	0.00%	-19.73%	-16.90%	-1.67%
6	Agriculture Support	8.88	-2.07%	30.28%	26.79%	20.34%	-3.40%	0.00%	18.33%
7	Job Security	7.00	-22.76%	2.75%	0.00%	-5.08%	-23.81%	-21.13%	-6.67%
8	Water Security	9.06	0.00%	33.03%	29.46%	22.88%	-1.36%	2.11%	20.83%
9	Cooperation	7.50	-17.24%	10.09%	7.14%	1.69%	-18.37%	-15.49%	0.00%
10	Environment Protection	8.69	-4.14%	27.52%	24.11%	17.80%	-5.44%	-2.11%	15.83%
11	Strong Governance	7.31	-19.31%	7.34%	4.46%	-0.85%	-20.41%	-17.61%	-2.50%
12	Health & Medication	7.94	-12.41%	16.51%	13.39%	7.63%	-13.61%	-10.56%	5.83%
13	Education	9.19	1.38%	34.86%	31.25%	24.58%	0.00%	3.52%	22.50%

studying in fields related to water resources. In total 18 provided their weighs for each item in the list. These were added up and averaged to get a final weigh for every item (Table 13). Since the purpose was to compare the level of importance associated to each a comparison was set to quantify the relative importance of each item with respect to every other another. The weighs assigned on a scale of 0 to 10 with increments of 1 had a highest averaged value at 9.19 for Education and lowest averaged value at 6.81 for Gender Equity. The Average weigh was at 7.92 and the standard deviation was 0.82.

Gender Equity oddly ranked lowest in weighs although more than half of the audience was women. It was weighed 35% of less importance than Education which got the highest weigh. Water Security which had come first in the population surveys was in second importance ranking in the opinion of the experts who ranked it 23% more important than Job Security, 22% more importance than industry and technology and 19% more important than Strong Governance. Agriculture Support which had gathered absolutely no vote amongst the population was judged 11% more important than both Food Security and Health and Medication. Cooperation was judged 9% more important than Fighting Poverty and 7% more important than Job Security.

Other Stakeholders

CSR obligations force companies to spend 2.5% of their annual profits on community development projects in the geographical where they perform their works. A big portion of this money goes into Water Resources, Agriculture Support and Community Awareness. Two cases of major relevance are talked about here. One is the case of IOCL embarked on a 5 years plan to implement developments in choice villages in areas where their North Indian pipeline is crossing. Another case is the water treatment plant implemented by the RSMM where they filter their mine effluent thru reverse osmosis as part of their CSR.

The pipeline division of IOCL has adopted a well-defined policy for its CSR initiative, under this they are implementing various developmental activities in the villages falling under what they call their pipeline priority area. The company had identified 19 villages of interest for CSR

initiative. In order to implement adequate needed developments a baseline study of these villages and the population conditions was performed. The main purpose of this study was to understand the actual field conditions in terms of village infrastructure, availability of natural resources and access to the fundamental services. A major focus was also on recording the views of the community members about the challenges they are facing and possible solutions. GVNML has conducted the study accordingly and results with recommendations were reported back to IOCL. A decision was adopted to implement some of the recommendations in the study. These covered construction of Water Tanks and neighborhood distribution networks, installation of filters and water coolers, community awareness campaign on the adequate use of water and on sanitation. When asked if IOCL is cooperating with other stakeholders and governance organizations in the places they are developing at least in order not to repeat jobs done by others he said no. There is in fact in one of the village schools that will be refurbished as part of the plan an installed water filter which was financed by the Ministry of Education but was never used. IOCL plans to install another filter due to the fact that one cannot disrupt government property and they hence cannot do anything about the one already installed.

The RSMM on their part have a Lignite mine in the district of Nagaur with a very special condition concerning water. The mining activities cover an area of 10.63 Km² and are divided into six mining areas with around 6,000,000 m³ extraction capacity. Due to the size of the mine it needed central government committee clearance and accordingly needed associated social and environmental impact assessment reports. In 2003 the mined was cleared for extraction and mining started. Although the EIA was conducted misestimates about the groundwater aquifer were tremendous. This resulted in an unexpectedly huge amount of saline water pumping needed and associated contamination of surface water. A new hydrological report was issued and based on that the mine was forced to treat 20 Million Liters of saline water per day out of the 65 Million Liters pumped. Treatment plants were constructed on size where the 20 Million Liters Daily required is filtered. Total dissolved solids concentration is reduced from 12000 TDS to around 1000 TDS. The effluent water on a daily basis reaches 13 Million Liter which is discharged to percolate back into the aquifer. The remaining 7 Million Liter Brine is left to evaporate in PVC impermeable shallow ponds in the mining site premises.

Finalized Resilience Assessment

The SES defined and analyzed in the baseline assessment rectified according to all the findings from the field investigation forms the base for the final steps of the assessment. The modifications to the baseline defined system after the findings on the ground were minor. System temporal boundaries are now set to a ten year projection in the future to account for possible phase change into the collapse omega phase. The issues of concern to the SES as well as its valued components remain as defined in the baseline. Absence or weakness in community leadership has been identified as a collapse leading disturbance in several cases when it comes to management of locally implemented structures. The factor changes in community leadership also have a cascading impact creating other stresses. Pathways of cross-scale interactions are also directly triggered by changes in community leadership factors giving it extrapolated effects on the multi-scale systems level. Results from the evaluation of important development areas fit the baseline observations.

Table 14: SES formal governance institutions and role regarding issues of concern

	Main Issue	Issue 1			Issue 2		Issue 3	Overarching		
Concerned Institutions	N/A	Panchayat	PHED	GWD	Gram Sabha	Agriculture Ministry	PHED	NGOs	Family Unit	State Gov.
Enhance Flexibility	N/A	Yes	No	No	Yes	No	No	Yes	No	Yes
Restrain Flexibility	N/A	No	No	No	Yes	Yes	No	No	No	No
Decision making level	N/A	Community	District	Tehsil	Community	State	State Level	Community	Household	State
Appropriate	N/A	Yes	No	No	Yes	No	No	No	Yes	Yes
Rule Enforcement	N/A	Yes	No	No	Yes	No	No	Yes	Yes	Yes

The de-prioritization of Job Security and Gender Equity are noticeable. Technological capabilities and Agriculture Support were also judged by the local population as having less importance than previously perceived even having a negative impact on the long run. Expert insight nonetheless gives them a high consideration.

SES Governance System

The formal governance system responsible of managing the issues of concern in our SES can now be defined (Table 14). This network of institutions includes the state ministry, the Panchayat body, the Public Health Engineering Department (PHED), the Ground Water Department, the Ministry of Agriculture, the local NGOs, as well as the community level Gram Sabha and the unofficial internal family management structure.

The PHED body does not directly intervene at community level. Its responsibilities cover both water resources management as well as WASH related issues. It is necessary for this department to span down their involvement from state and district level to cover community level. To improve their role it could be necessary to introduce community awareness programs in education. It is also necessary to push forward regulations concerning use of resources and adequate disposal after usage as well as to create a sanctioning mechanism for conformity. The Groundwater department needs to take interest in activities at community level also. The groundwater extraction needs to be monitored and the available water evenly split amongst all communities in the catchment. New regulations and laws need to be established to monitor the groundwater extraction with possible metering needs. The agriculture ministry needs to develop a mechanism to communicate strategical changes in agricultural planning at community level. This is performed thru auxiliary institutions at the moment such as the Panchayat and the Agricultural Banks. However this needs to be performed by a separate institution to avoid conflicts of interest and reach a transparent communication of information to all farmers. Finally the NGOs which have been playing a respectable role at community level need to reach out to the other institutions in the network and coordinate interactions across the scales. They are the most fit to do it as well as the most trusted by the local communities.

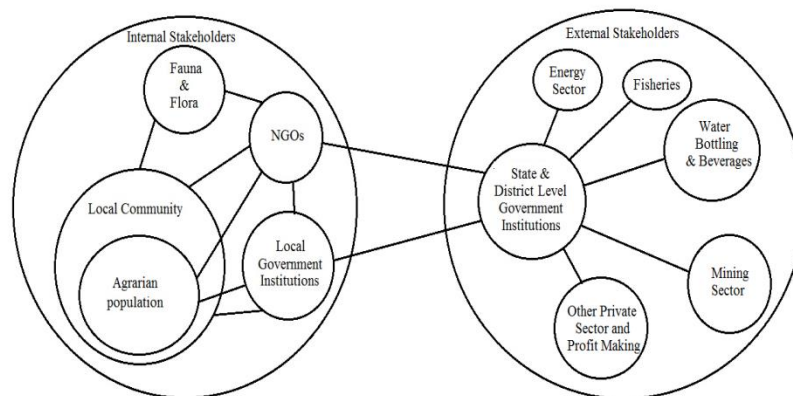


Figure 25. SES Stakeholders Communication Networks

SES Stakeholders

The stakeholders in the SES can be considered split into two separate groups (Fig. 21). On one hand actors at community level and smaller focal scales have a strong correlation between each other. The agrarian production sector is completely made up of local community members. These are in relative agreement with other stakeholders besides when it comes to external resources users such as fisheries or mining sectors. However when these latter are a community scale institutions they also are made up of local community residents. The local Fauna and Flora is rather protected by the local communities which have learned to live in harmony with the ecosystem thru the years and understand its requirements.

Table 15: SES Stakeholders influence power and conflict mapping

List of Stakeholders	Formal Power	Informal Power	Conflict With Others	Conflict Resolution in Place?
Internal Community Level Stakeholder				
Agrarian Population	Weak	Weak	No	-
Local Residents	Weak	Intermediate	Fisheries	Closing Fisheries
Government Institutions (Local)	Strong	Intermediate	No	-
Local Fauna	Weak	Weak	Mining Sector, Fisheries	No
Local Flora	Weak	Weak	Mining Sector, Fisheries, Agrarian Population	No
NGOs	Weak	Strong	Mining Sector, Fisheries, Bottling and Beverages	Only recently after surviving fights
External and Larger Focus Scale Stakeholders				
Government Institutions (External)	Strong	Strong	No	-
Mining Sector	Intermediate	Strong	NGOs	Restricted Extraction of Resources
Energy Sector	Intermediate	Intermediate	No	-
Fisheries	Weak	Weak	Local Resident, NGOs	Fisheries Closed
Bottling and Beverages	Intermediate	Strong	NGOs	No
Other Profit Making	Intermediate	Intermediate	No	-

On the other hand external stakeholders form a group of their own due to the fact that their interests are usually in concordance with each other. Their communication pathways are not interconnected but rather centralized on government institution. Profit maximizing use of resources united these stakeholders in terms of interest. The mining, fisheries, water bottling, energy and other sectors all make part of that group. Their cooperation with the local communities is rather restrained and only happens when conflicts emerge. Their formally declared power level is rather low but their influence and vested power is very strong mainly due to financial capabilities and promises.

The connection and communication between these two groups is mainly guaranteed by government institutions responsible of governance as well as those having a stake in the resources. These are split amongst the two types (Table 15). Local leadership and honor derived from being influential individuals in the community puts the Gram Sabha and Panchayat bodies amongst the internal stakeholders group. Other institutions such as the larger-scale institutions and governmental departments have more interaction with external stakeholders than local ones. NGOs are mainly part of the local stakeholders and closely interact at community level. Their span of connections reaches outside the community and their can influence external stakeholder thru different means and shared interests.

DISCUSSION

The resilient SES identified and dissected in the assessment can be summarized into a conceptual model for use in planning. The model used in the Resilience Assessment Workbook for Practitioners (Fig. 22) was specifically developed for this purpose. Applying the findings synthesized in the performed identification of the resilient SES to other communities within Rajasthan. Missing components and interaction pathways can accordingly be provided for and activated to play their role in building the resilience of these other systems.

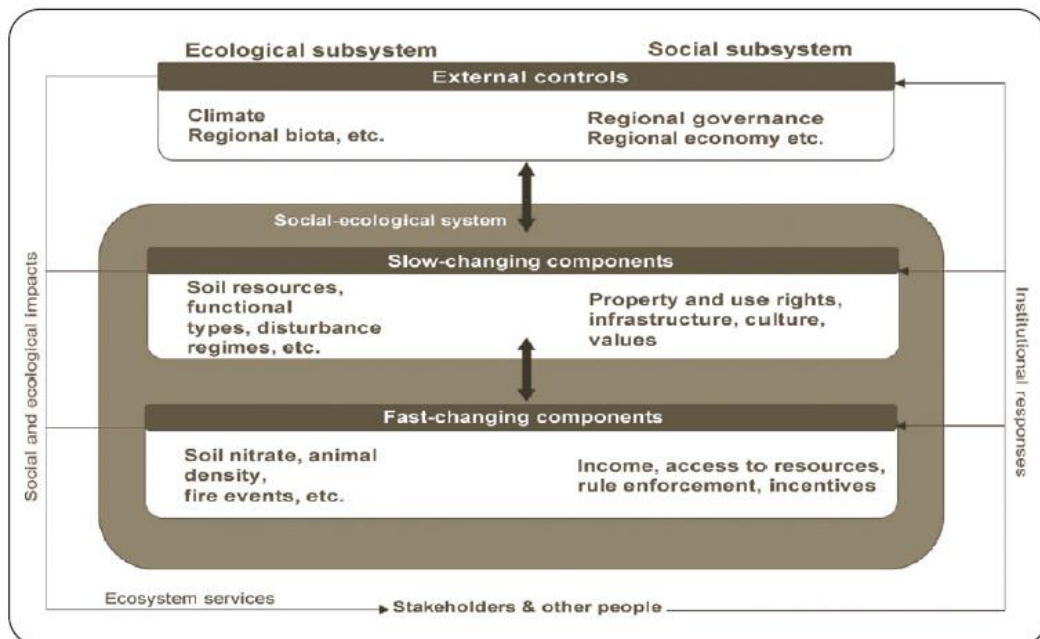


Figure 26. Conceptual Integrated SES Model (Resilience Alliance, 2010)©

Implementing the SES Model for the Karoli District

As discussed the district of Karoli is rather similar in ecological conditions, natural resources and social composition to most other northeastern parts of the Rajasthan state. TBS have been recently increasing their works in Karoli. Structuring these works in a way that ensures resilience can help channeling implementations in a way that guarantees long term sustainability. For this a comparative between the current SES at community level in Karoli and the synthesized resilient system needs to be drawn. This directly highlights contextual modifications that need to be made to reach resilience based stewardship.

The framework and scale of the SESs in Karoli as well as the main issues of concern and disturbance sources are the same as the ones for the defined resilient SES. Major differences between the two SES remain in the valued components of the systems. Communities in Karoli highly rely of mining activities, salt extraction, as well as brick making for their livelihoods. These activities have a high impact on the integrated land and water resources usage and need to be provided for. The stakeholders from these activities hence move from being external SES stakeholders to internal ones with direct interests in governance of resources. While they themselves perform a stress in terms of drought inducing factors they play a large role in countering outmigration.

Local community governance institutions need to coordinate the interaction between these new stakeholders. In other terms the NGOs working on Karoli SES now need to provide for both the need of the agrarian population as well as the miners population. Local governmental institutions also need to be provided with the means to satisfy the needs of both parties. The miners population on the other hand needs to be aware of the other community needs in terms of IWRM and perform their activities in a way that does not disturb that. This probably necessitates larger scale prescriptive governance where the mining ministry collaborates with PHED at district scale to set regulations that ensure IWRM.

Topographic differences also need to be taken into consideration. Structures that were adequate for integrated rainwater harvesting in Alwar might not give the same results in Karoli. The NGOs helping the local community implement rainwater harvesting structures have a role to play in stirring the choices in the direction needed. They need to be careful not to fall into the blinding traps of a previous success. In other terms instead of conducting educational workshops to teach how they have been doing things successfully these workshops need to be addressing how things have been and can be done in general. Collaboration between different NGOs working on different SES contexts is highly encouraged for knowledge dissemination. Local community leadership plays an essential role as proved previously. The Karoli communities need to foster their own internal leaders. These need to be identified amongst the population and given incentives to stand up and be role models for the others. Externally assigned leadership does not play this role and does not ensure continuity on the long run.

Top-down v/s Bottom-up Dichotomy

The main point behind adaptive governance is to the ability to learn through the process and implement changes accordingly. What is most valuable in this context is hence the ability to take in valuable inputs and

use them disregarding their source and the agent that is performing the implementation. Due to the nested Panarchy interaction pathways of SESs it is absurd to say that any solely Top-down or other solely Bottom-up implementations can function on the long run. Institutions have to be aware of this fact and develop communication networks between the Grass-Root level and the State- and Market-levels. What is found to be successful using a Bottom-up approach needs to be acknowledged and integrated from a holistic Top-down perspective. Similarly what has been successful from a Top-down perspective needs to be accepted and implemented at community scale. A repetitive fine-tuning process and reduced resistance to change need to be allowed to happen.

The community hence needs to feel at one in the bigger system it makes part of. Sharing resources available under the geographical extent of one community to satisfy larger scale needs is mandatory. The community scale governance has to understand these needs and allow sharing. On the other hand the larger scale Top-down implementations targeted at sharing these resources need to be performing an equitable repartition. Transparency and absence of corruption are necessary to come across feelings of frustration and deprivation. Inclusion of the grass-root level opinion concerning the larger-scale usage of resources needs to be provided for in some form. To the most feasible democratic way of doing it is thru participatory planning where prioritized topics are highlighted by the grass-root stakeholders themselves.

Strategies and Barriers for Implementing Adaptive Change

The ability to implement organizational change is a necessity to reach adaptive governance. This is usually constrained by the absence of financial resources to allow for it. It is necessary to allocate the adequate personnel to perform the needed management, innovate, cooperate and communicate what they learn. Without these interactions adaptive governance cannot exist. The SES has to be functioning in a way that provides the adequate resources to sustain these actors. Incentives do not have to be categorically financial but can be of different intrinsic values such as prizes distribution or other honoring arrangements like the ones performed by GVNML.

Changing the public perception when it comes to issues relating to governance is also primordial to evade scenarios like the Tragedy of the Commons or other Free Rider forms. People at individual level need to be aware of the stakes pertaining to all the other stakeholders in the SES and the impact of their actions on these. Awareness since early childhood is needed to build-up understanding of the problems related to things like refusing to share their portion of land for the grater profit of the community. The different interests amongst the stakeholder groups need to be understood and known to all. The fact that only through thinking of the holistic benefit of all leads to a sustainable development for the future needs to govern the decisions taken by every different component of the community. This can be explained thru repetitive awareness and education drawing from live examples where different scenarios led to failure.

To implement change at community level it is mandatory to have the green light from the larger-scale political context the community is part of. Changes in this regards also disrupt the process of implementing adaptive change. With changes at political level come changes in power interests. This can lead to lack of support required from the larger scale systems and even possible implementation of opposing policies. This

can be countered by lobbying for drawing governance directly from public polls and requiring public support to implement policy changes. It can also be countered by influencing key people at decision making level by disseminating knowledge and insight on possible downturns of restrictive acts.

Study Limitations

Due to the large emphasis on creating a model to be implemented on other communities qualitative aspects of the SES components and services were the most prevalent during this study. The exact quantification of factor change parameters as well as threshold triggering stress volumes were not defined in this process. When implementing the defined resilient model on one specific SES it could be necessary to define exact values to these parameters.

Availability of usable and transparent data is mandatory. The data available is more general than community SES scale specific. More emphasis needs to be given to community scale data acquisition and communication. Moreover aggregated data needs to be clear of conflicts of interests. It is highly probable that figures available draw from specific interest to be displayed as they are. Third party and non-stake holding external entities need to be the most used source of data that such studies are performed with.

Future Research Prospects

The findings in this study highly encourage developing a quantified model that integrates all of the parameters assessed during this resilient SES definition. When such a model is at hand identifying further SESs that can more or less easily build the resilience found in our system can even be charted on a map. For this to be performed a longer timeframe to perform the study is mandatory. Moreover the mobilization of a team of individuals with several fields of specialization within the topics covered also helps. Multi field study and research groups can provide in-depth inputs to aspects which would otherwise be shallowly covered by one individual. The model generated can then be applied for any other place in the world that has similar conditions to the ones in the Rajasthan communities.

CONCLUSION

Resilience thinking applied to strategic planning can help preserve the valued components that SESs in Rajasthan have developed across the ages. If these components are reinforced and their resilience fostered they can help in avoiding population outmigration originating from drought stresses. The SESs of Rajasthan which have been helped to develop community participation for rejuvenation of traditional systems for local water resources management have proved to be the most resilient against water stresses. These implementations nurtured by grass-root organizations have extrapolated from simple water harvesting to a holistic setting that includes encouraging community leadership, awareness and education, gender equity, sanitation and health and other areas of interest for sustainable development. All of this has led to better living conditions in these communities which directly reduced the tendencies for outmigration. Several other communities in Rajasthan need similar implementations especially those which are at point of their adaptive cycle where they are getting out of the exploitation phase and need reinforced component to help them remain in the conservation phase. The Karoli district is a major example of this scenario. Using

resilience thinking to create in Karoli a resilient SES according to the model synthesized in this study helps channeling implementations into building up resilience. The planning strategy also has to take into consideration all the barriers to adaptive governance discussed in order to achieve the required results. Further research and development of this synthesized model with quantification of relevant factors can also be used on a global scale where resource conditions are similar to the ones in Rajasthan.

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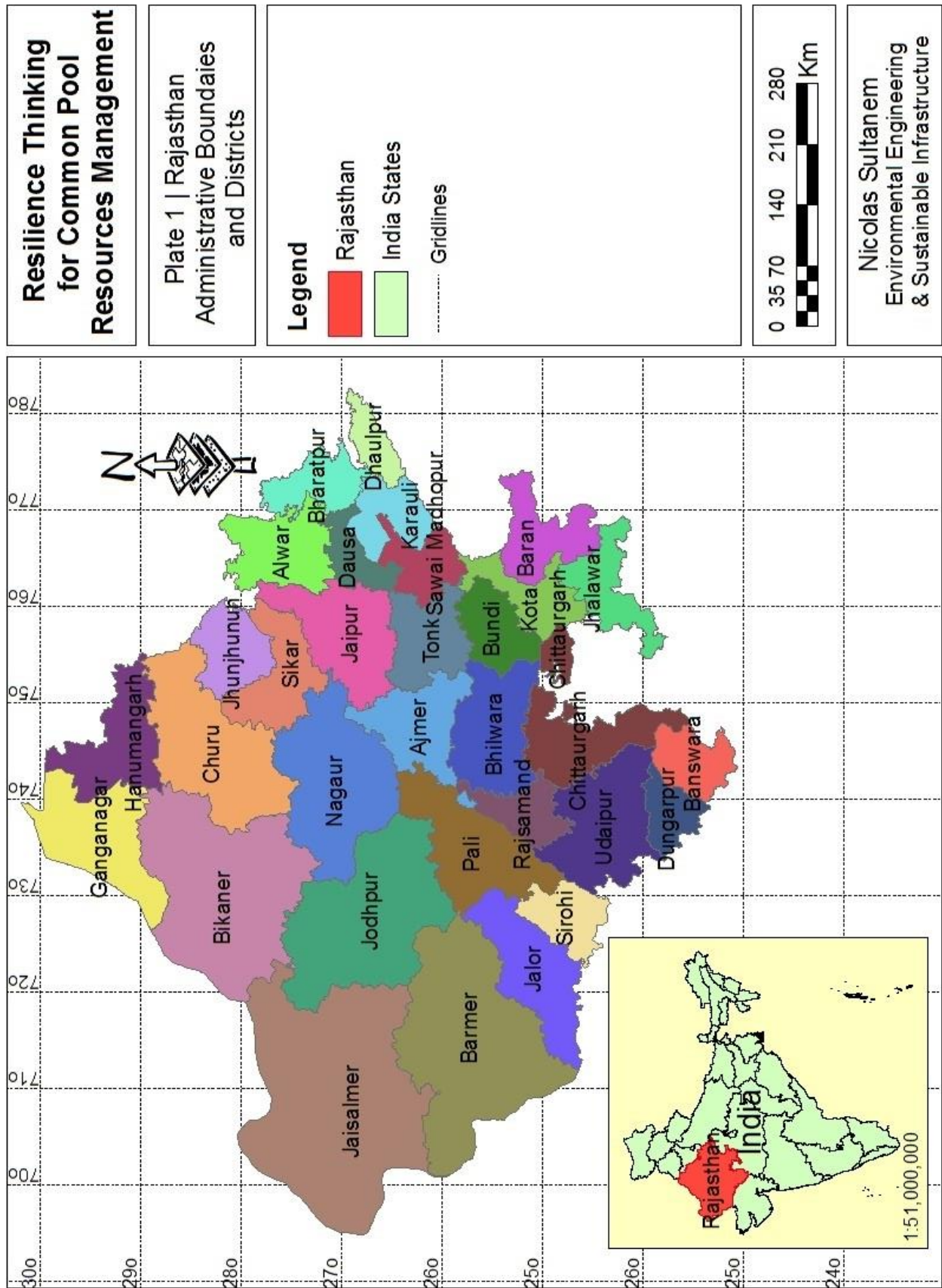
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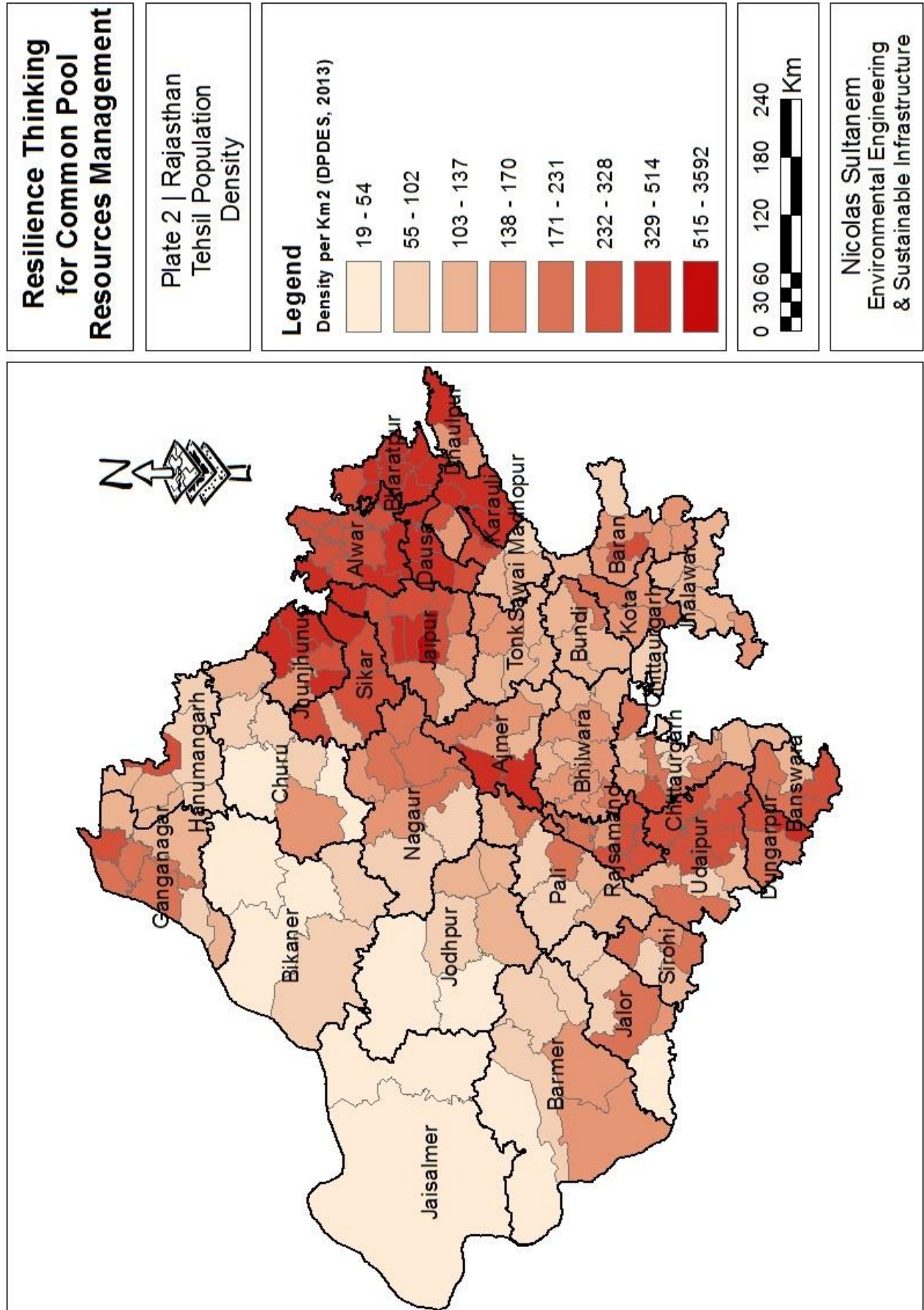
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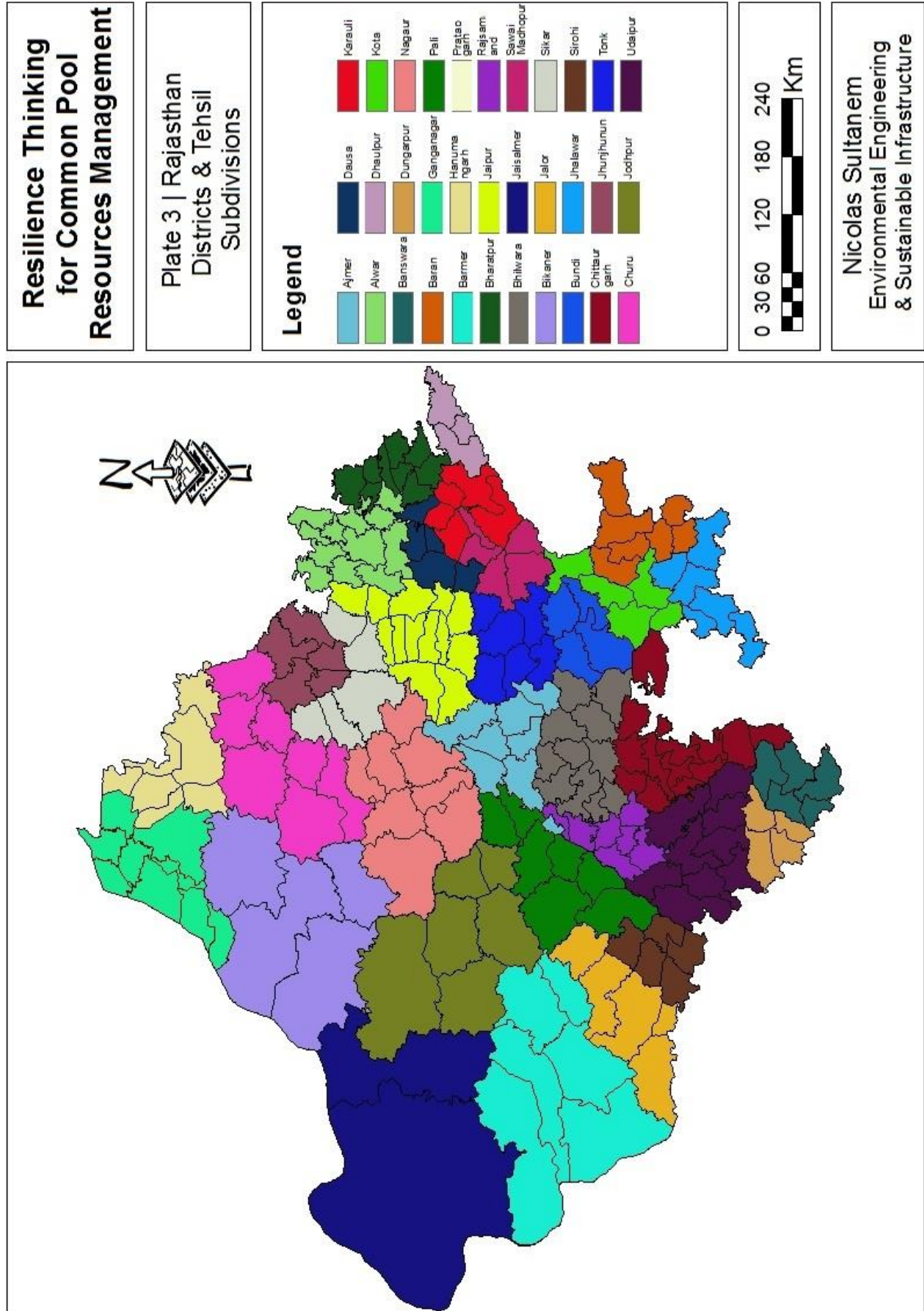
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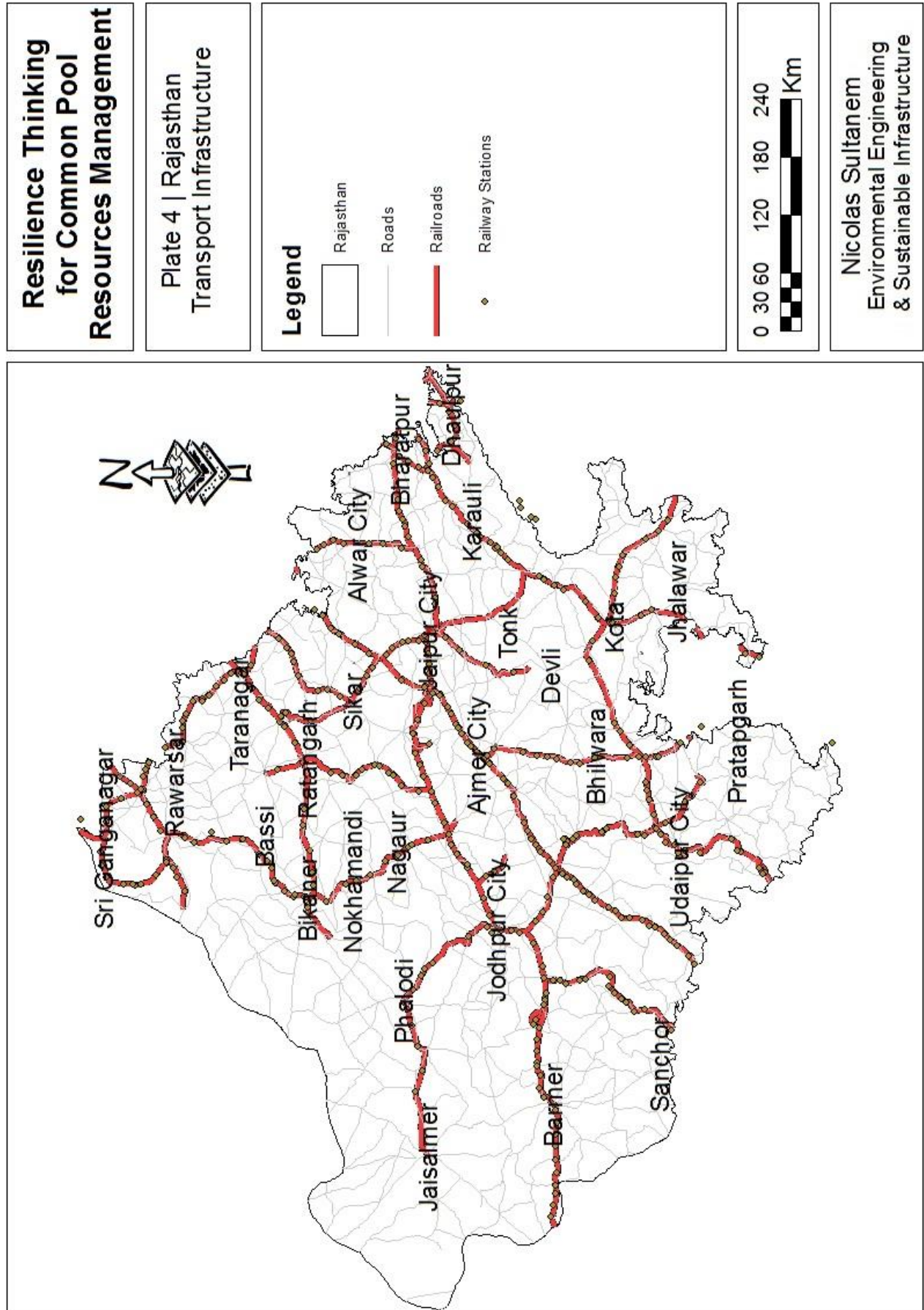
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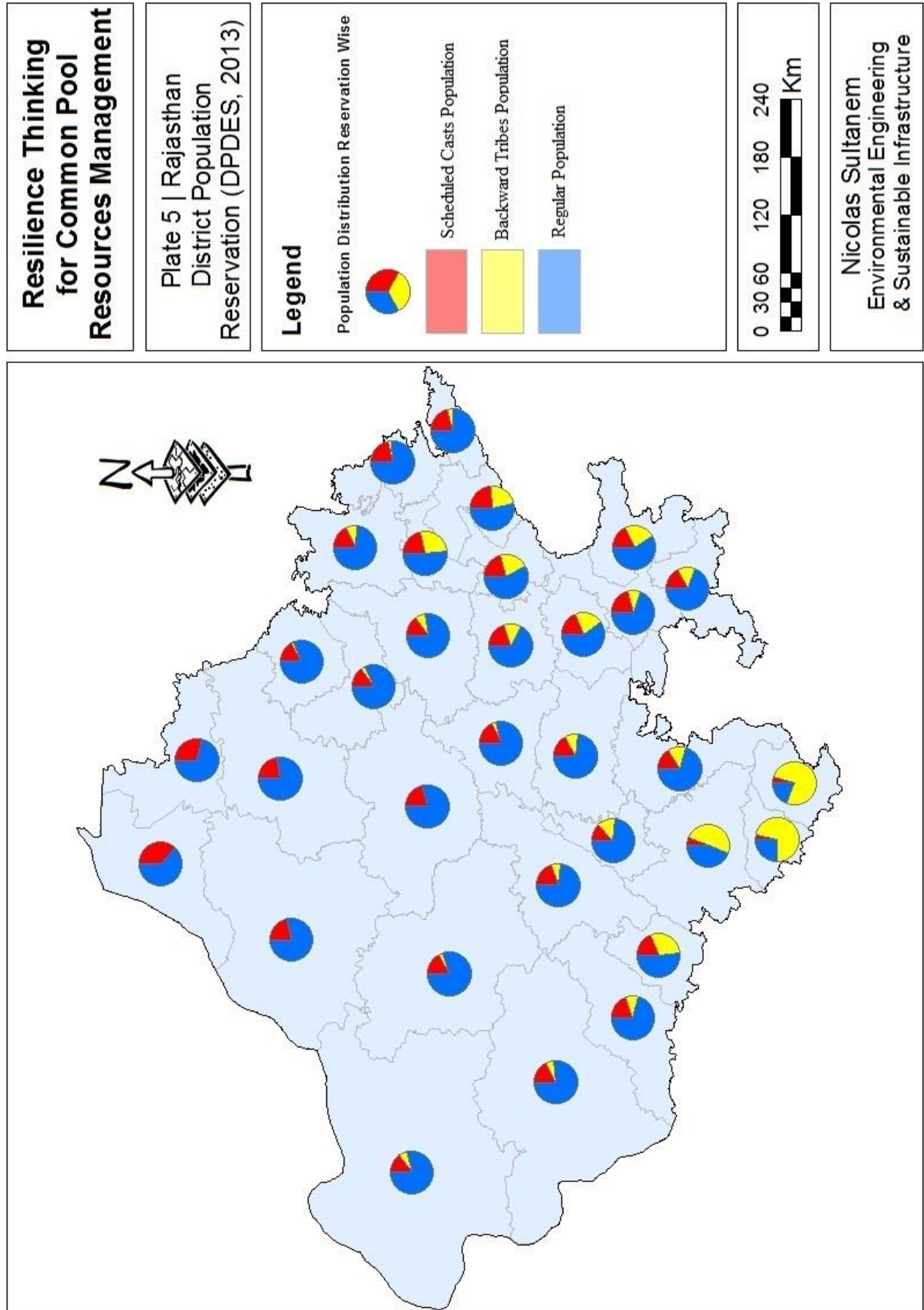
CARTOGRAPHIC PLATES

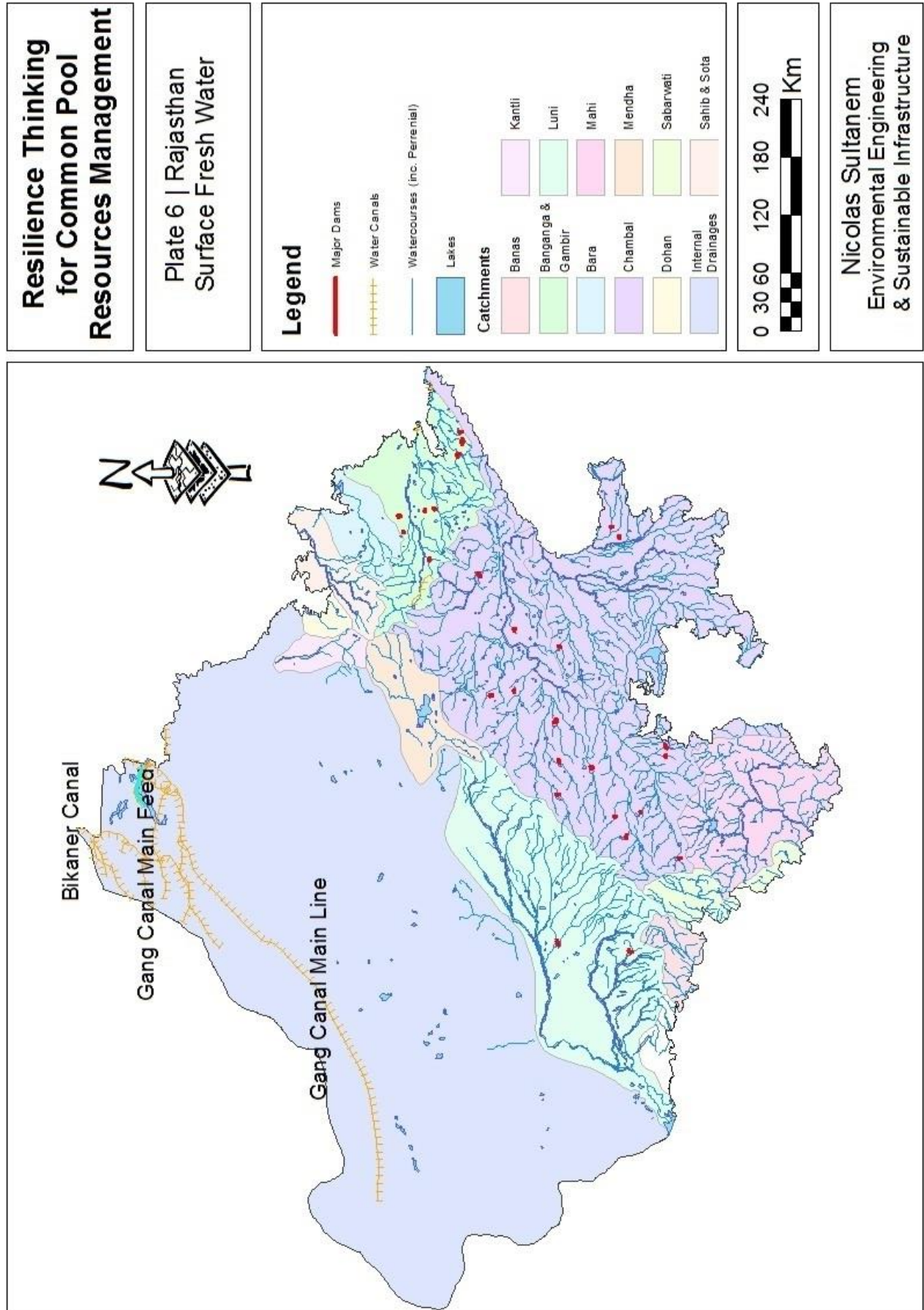


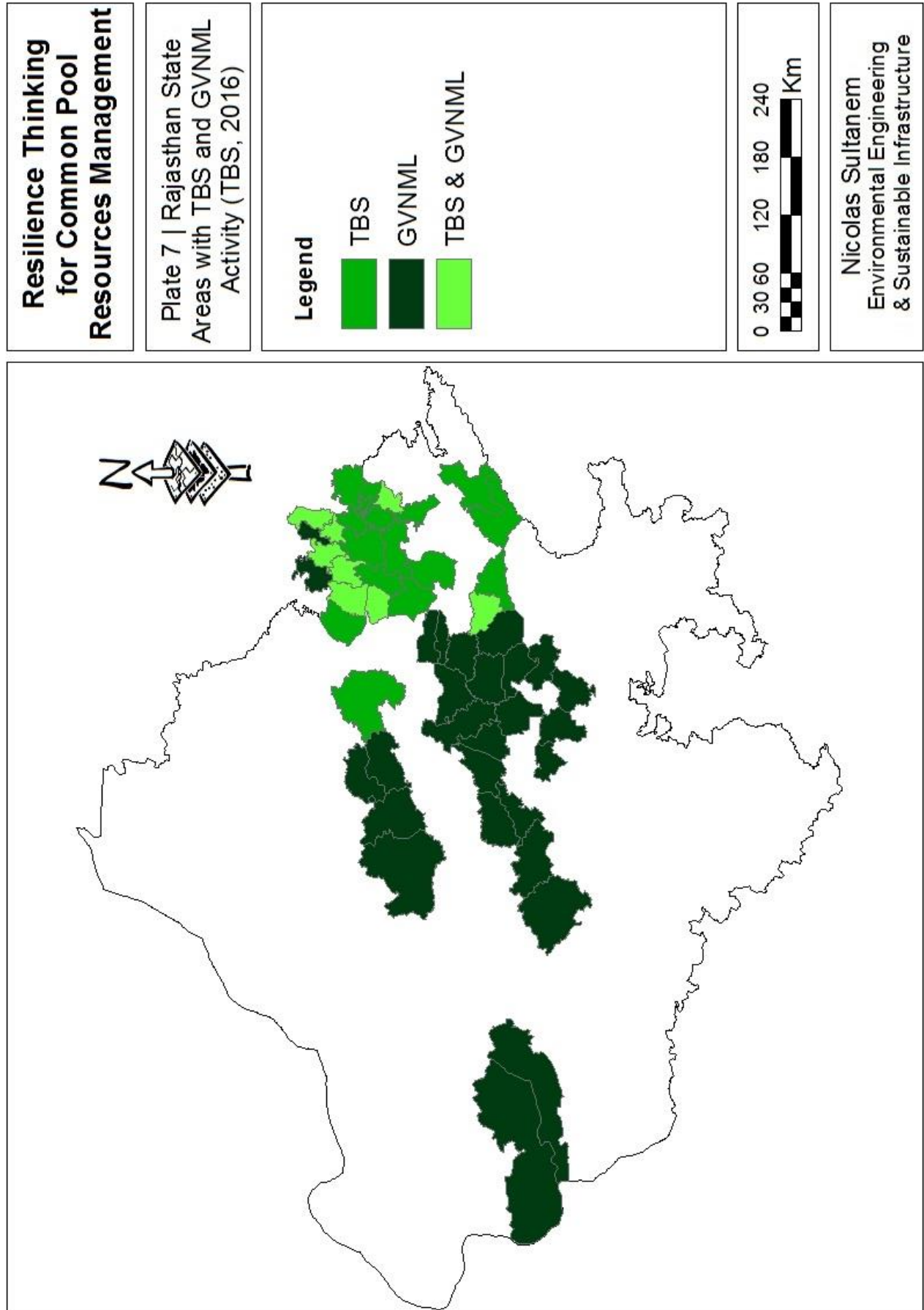


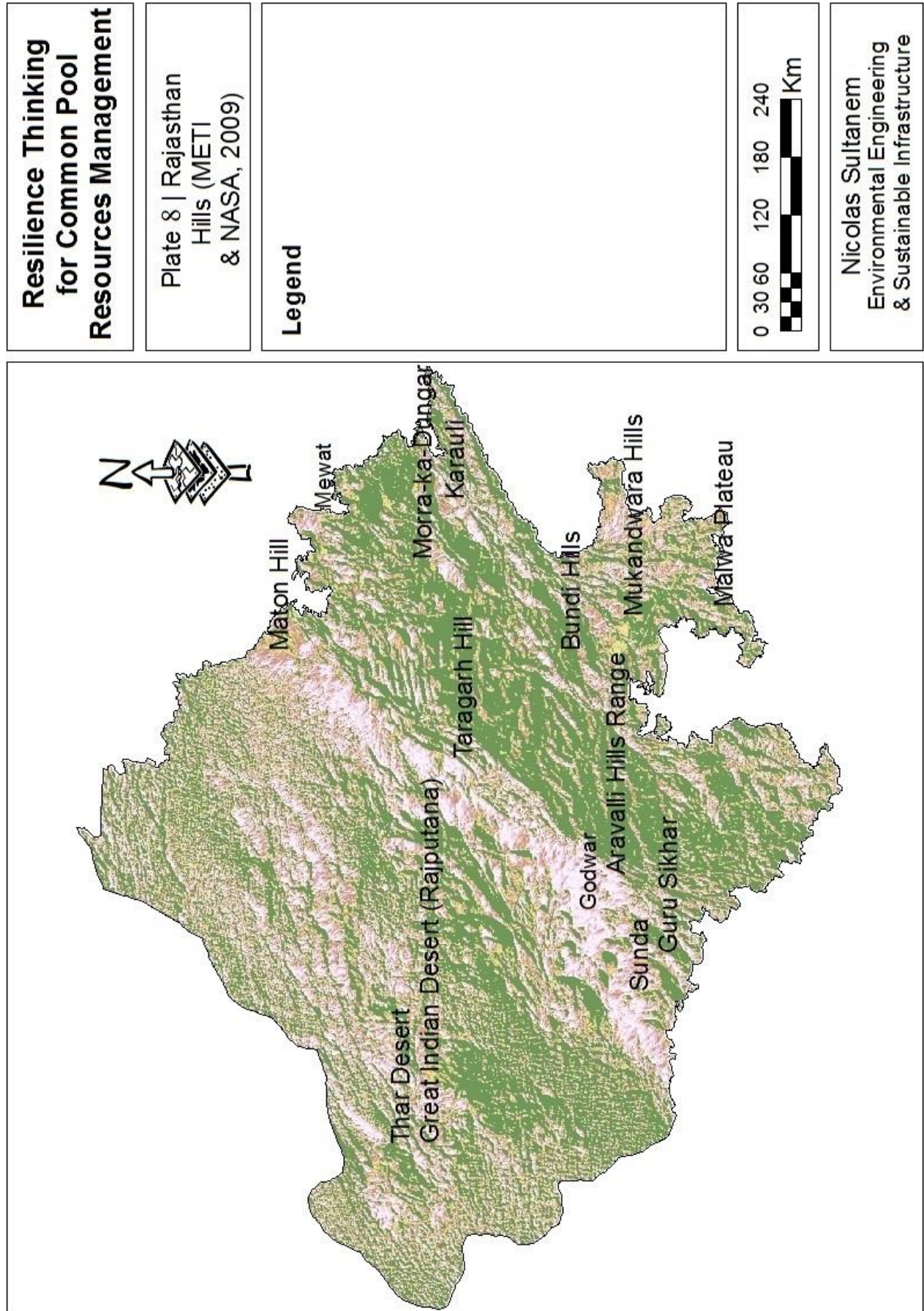


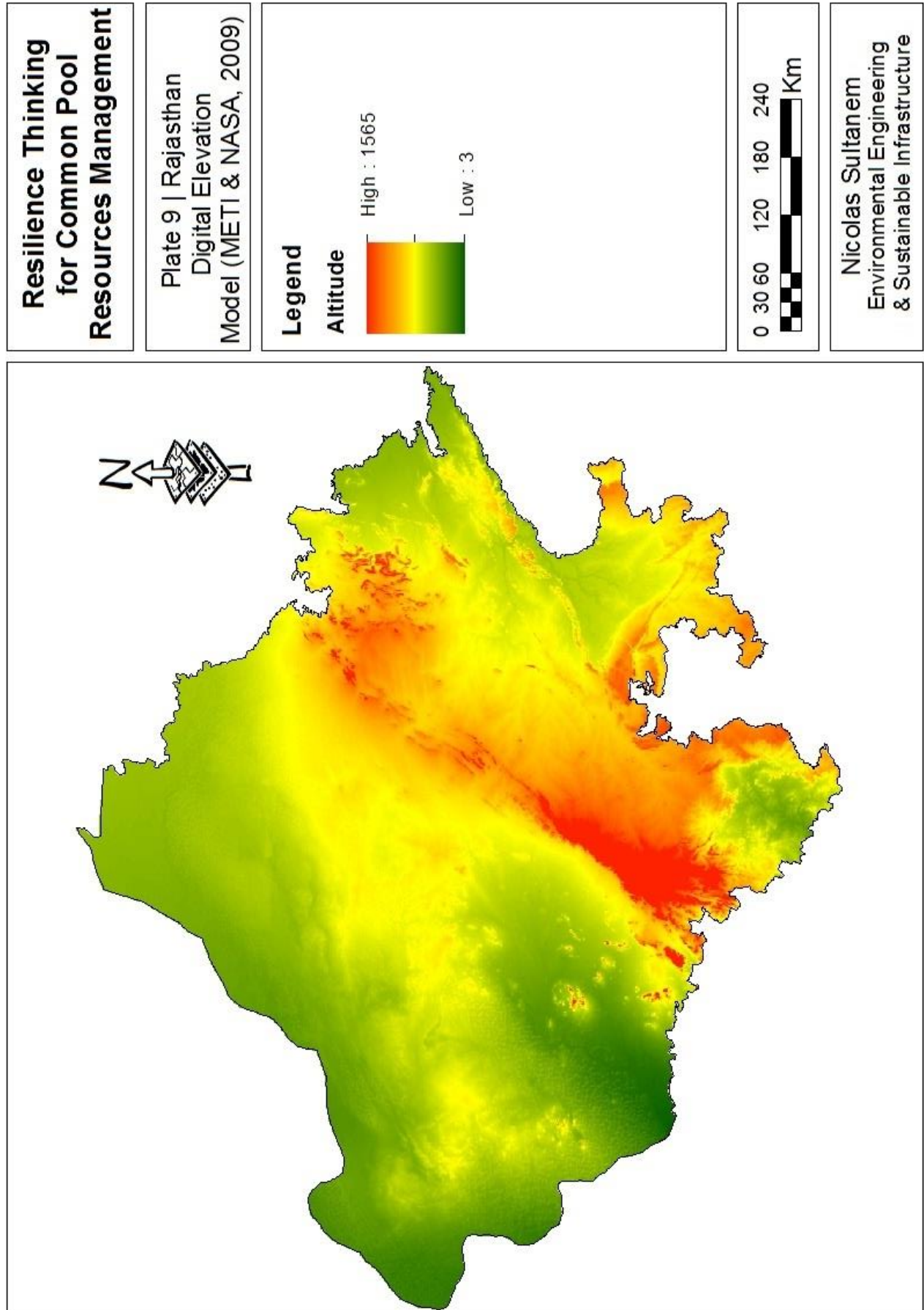


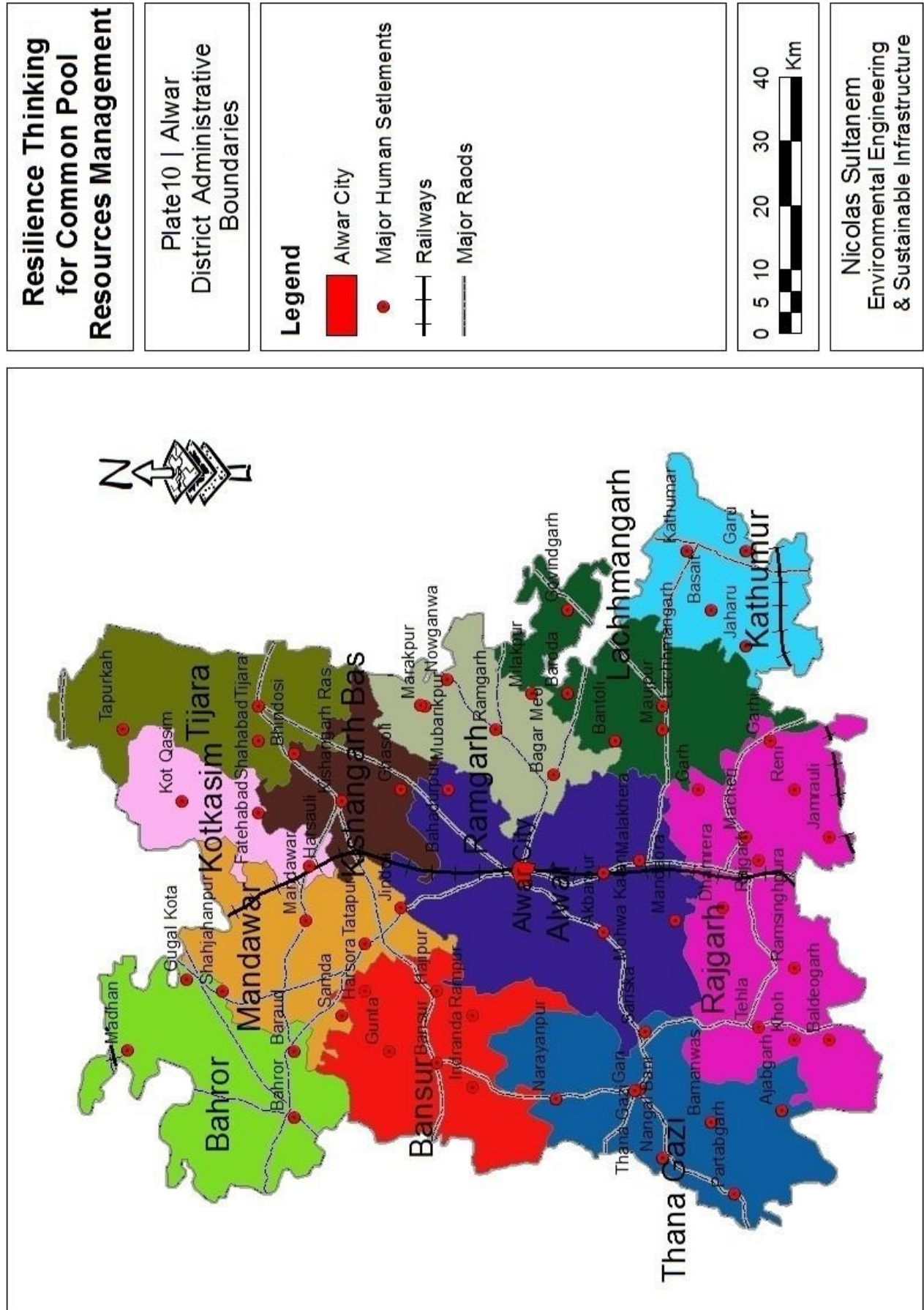


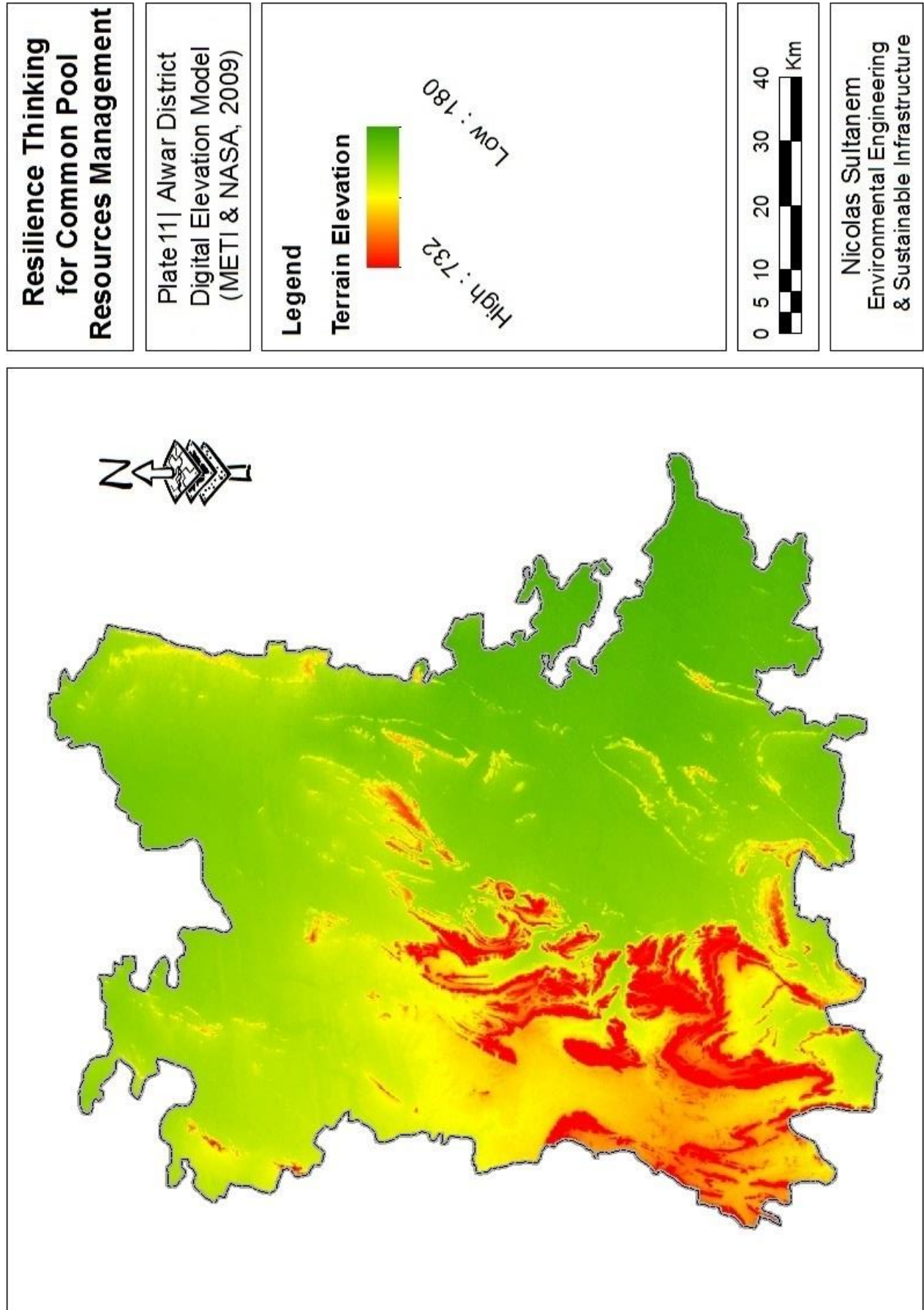


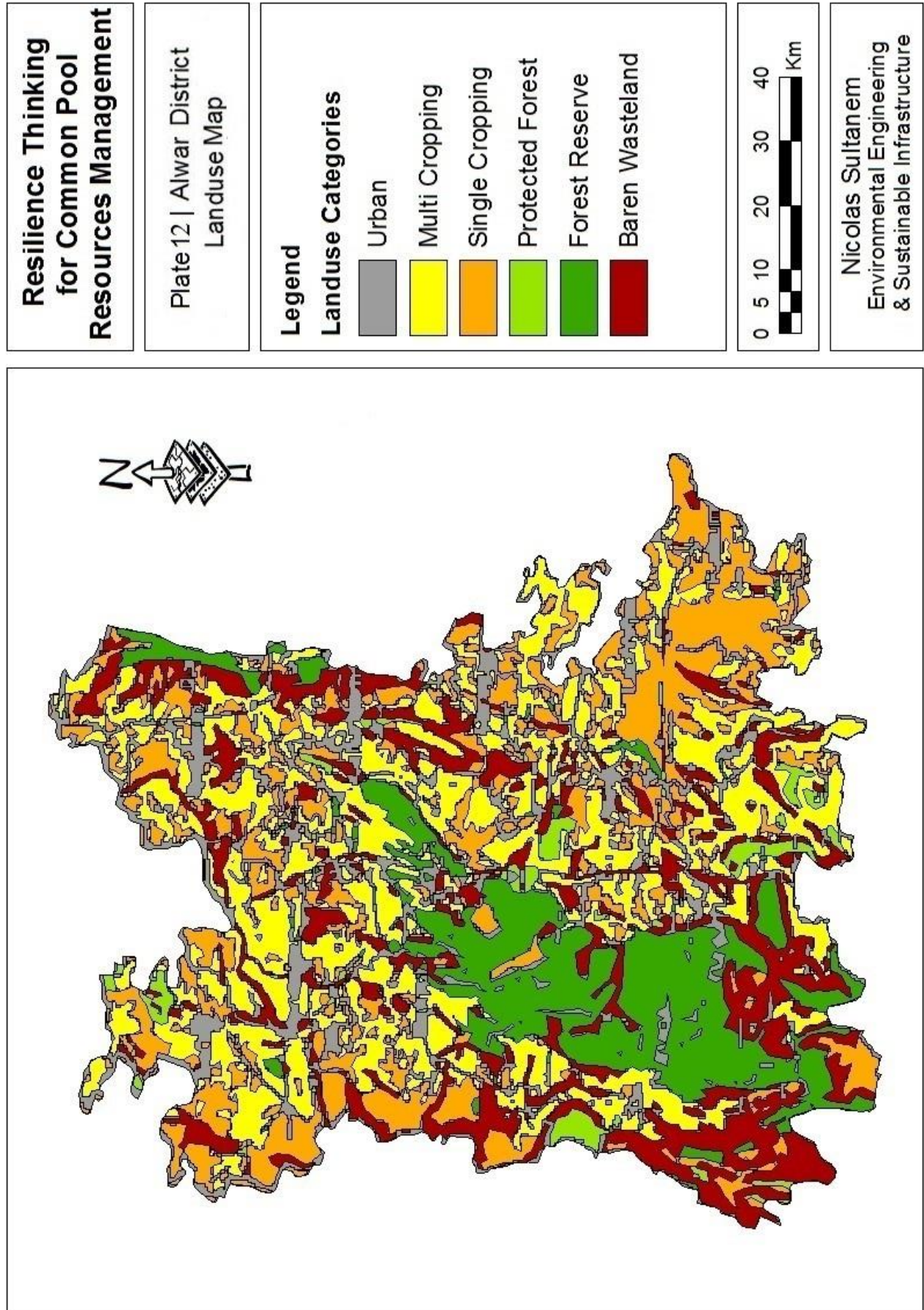


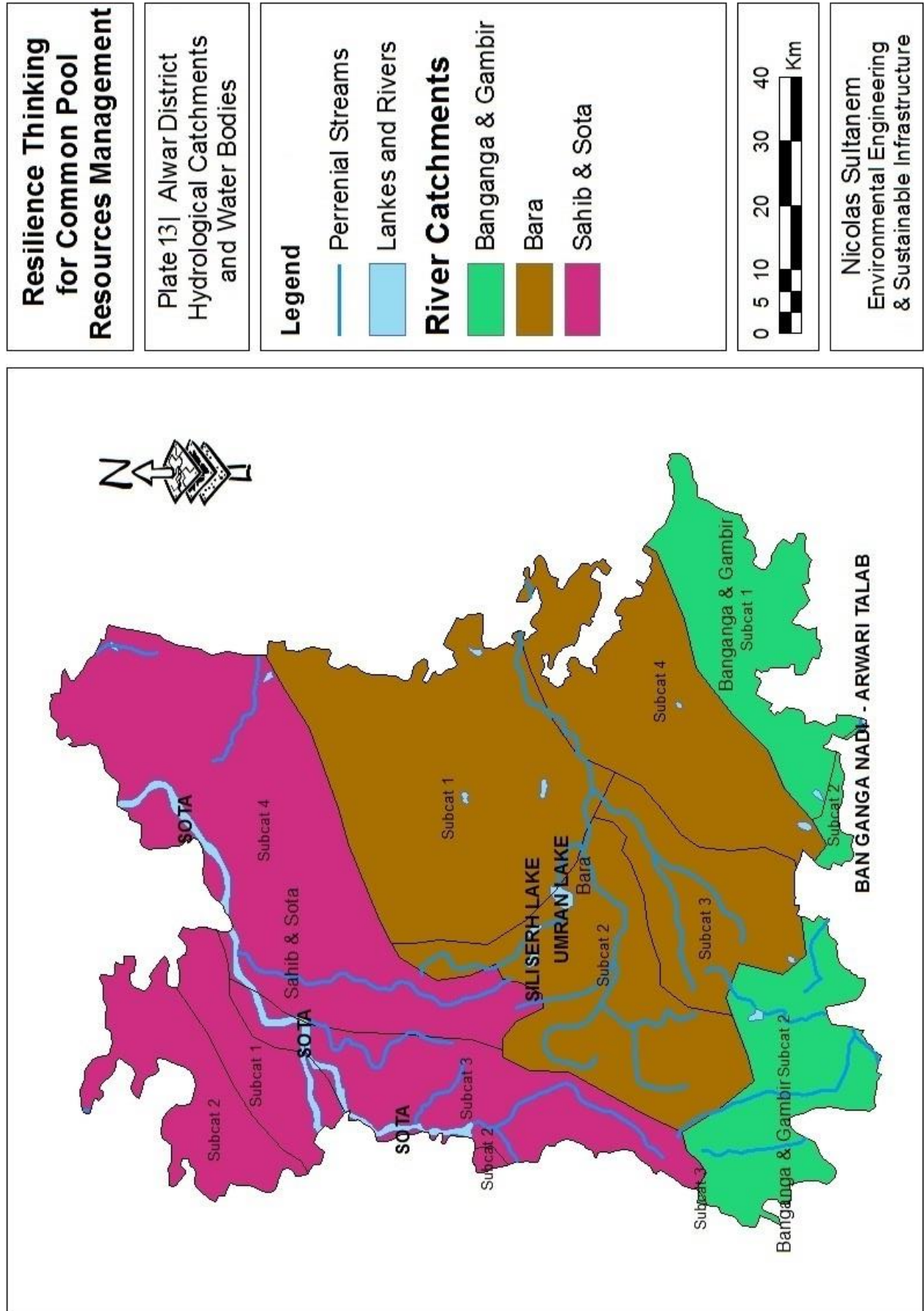












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