Collective action against water insecurity in peri-urban areas: learnings from the global south

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Abstract

Growing urban population have increased the pressure on ecosystems specifically water resources. While the urban demographics is changing, climate change is affecting the hydrological cycle affecting the precarious balance between availability and demand. Agenda 2030, calls for inclusive and participatory approach to reduce poverty and achieve the set goals. The paper delineates how a participatory and inclusive approach can lead to reducing water insecurities in the global south. It explains the use of fuzzy cognitive maps to capture stakeholder knowledge to help bridge the gap between scientific research and policy making through stakeholder participation.

Keywords: Participatory water management, Climate Change, Peri-urban areas

1. Introduction

India's carbon contribution is lower than many other developed/developing countries of the world. But this is set to change dramatically in the coming decade due to increasing urban population. As urban population grows, pressure on ecosystems increases, large quantities of food, fuel and water need to be moved into urban areas and huge amounts of garbage and sewage have to be moved out (Base.d-p-h.info, 2010). Ecosystems such as Aquifers and wetlands, farmlands and forests are essential for survival of urban areas as much as transport networks. Water resource, one of the most vital and the most abused resource, is the best example of the precarious relationship between urban areas and natural systems. The city of Aurangabad, Maharashtra gets its water from 118 km, a journey that involves enormous expenditures (Janaagraha.org, 2015)

Over the past decade, a new amalgamated space that straddles the boundaries of urban areas has been drawing the attention of scholars. Known as the 'Peri-Urban Interface' (PUI), this area is defined as 'zone of (dynamic) transition or interaction between urban and rural areas; usually used in the context of rapidly urbanizing poor countries' (Simon, 2008). These dynamic zones are the main sources of supply of resources such as water to meet the needs of urban areas and act as recipients of waste generated within the surrounding urban areas. Hence, we can ascertain that there is a bi-directional flow between urban and peri-urban areas resulting in a flux or a dynamic state which is in transition.

While urban demographic transformation is unfolding, the changing climate is expected to affect the hydrological cycle. This change is likely to affect precipitation patterns, with some areas becoming wetter and other becoming drier. In this regard, the trends in climate and demographics will pose a fundamental challenge, how will water be provided to urban areas in a sustainable manner (McDonald et al. 2011). To evaluate how climate change will affect the precarious balance between water availability and demand, it is crucial to assess the entire array of social costs or benefits of any change in water availability and use. Institutions that govern water resources, play an important role in determining the overall water security in view of the impacts [*social*], as well as sectoral gains and losses (Ipcc.ch, 2007).

United Nations, define water security as ‘ the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality of water for sustaining livelihoods, human well-being, and socio-economic development to ensure protection against water-borne pollution and water related disasters, and to preserve ecosystems in a climate of peace and political stability’ (Unwater.org, 2013). Access to potable water and sanitation is considered a basic human right and yet billions do not have easy access to these services. It is estimated that approximately 1.8 billion people use a water source that has faecal contamination and approximately 40% of the world’s population suffers from water scarcity (United Nations, 2016).

The UN’s Sustainable Development Goal 6 and Goal 11 address this shortcoming by aiming to provide clean water and sanitation to all by 2030, through an inclusive and participatory process. While water crisis is a common phenomenon across developing countries, India has the largest population of 76 million people who do not have access to clean water. A much larger proportion of the country’s population is faced with water scarcity and is forced to make do with irregular access to water (WaterAid America, 2016). Residents in peri-urban areas largely fall into this second category and have to negotiate with water insecurity that is driven by several factors unique to the peri-urban space.

This paper looks at how collective action can lead to an improved management and governance of water resources. The paper uses cognitive mapping approaches to capture knowledge among various stakeholders and develops a scenario for identifying policy options to improve water security in peri-urban regions.

1.1 Study Area

The area located in the periphery of Bangalore city, known as the silicon valley of India was chosen for the study. Eight villages located 60kms from the city falling under the jurisdiction of Manchanayakanahalli gram panchayat were chosen. The region though, under the jurisprudence of the gram panchayat [rural] has nearly 96% of the working population are classified as main workers and are shown to be engaged in activities other than agriculture (Census of India, 2011), which can be described an urban characteristic[1].

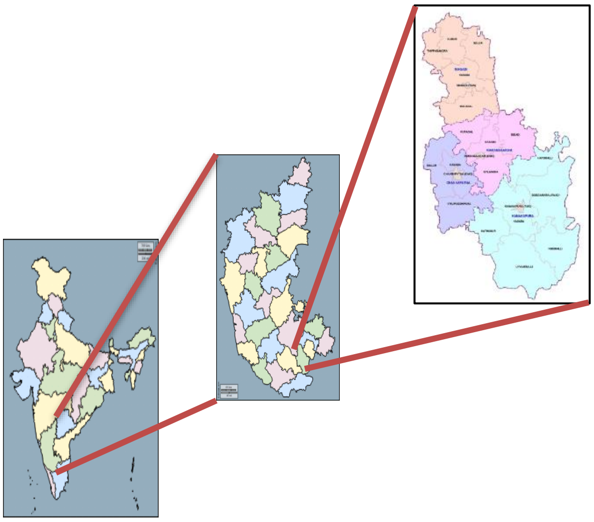

Figure 1: Study Area Representation

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[1] The Indian census defines urban areas as any area with more than 70% of the population engaged in non-agricultural activities.

2. Methodology

The study approach is based on the principles of constructive engagement and emphasises the need to move research away from top-down, extractive information gathering to participatory, bottom-up and inclusive knowledge generation. Hence, Climate Change Score Cards (CCSC), developed by PAC was used to develop community centred scenarios based on stakeholder inputs in this study. This study focuses on citizen-centred scenario planning as a practical and potentially powerful tool for local-scale vulnerability analysis and adaptation planning in social–ecological systems within the context of multiple interactions and stressors. As mentioned by Bennett et al., (2016) Community-based scenario water resource planning is proved to have significant potential as an anticipatory action research process for incorporating multiple stressors into vulnerability analysis and adaptation planning.

2.1 Climate Change Scorecard

Climate change scorecard (CCSC) is an adaptation of the community score card (CSC), a well-known social accountability tool. CSC consolidates peoples' opinion and facilitates an informed dialogue between communities and the local governance structures. Conventionally, a CSC aims to bridge the dialogue between two main actors: the people and the state. In the case of climate change there are not two, but three important dimensions: the people, the state and the environment. To account for this, systematic integration of information on local governance, local climate and livelihoods was established using CCSC. The tool supports communities to prioritize issues and provides a platform for dialogue with relevant decision makers. Climate change scorecard is undertaken in four distinct phases:

2.1.1Exploratory Phase

This is the initial phase where primary visioning exercises were undertaken through scoping visits and field visits to understand the on-ground conditions. This stage also included primary visioning exercises, including a household questionnaire survey. The survey was conducted to assess drinking water security in the study area. The survey covered 475 households in eight villages in the Taluk. This phase also included an analysis of various plans and other policies that have a say in the management of water resources in the area.

2.2.2 Analytical Phase

The second phase of the study which involved assessing the vulnerability of the local communities based on the data collected in the exploratory phase. Fuzzy cognitive maps were drawn to capture the vulnerability of communities to climate change and urbanisation and were used to simulate different policy options through neural network computations.

The phase included analysis of climate data (rainfall, average temperature, cloud cover, potential evapotranspiration, and reference crop evapotranspiration and vapour pressure) available from secondary sources apart from gathering data using fuzzy cognitive maps.

Interviews and Drawing Fuzzy Cognitive Maps

In this research 30 interviews were conducted with stakeholders belonging to four different stakeholder groups (Figure 2). In total 221 people (86 men and 135 women) participated in the drawing of 240 maps. Before drawing cognitive maps, the field staff drew their own maps to understand the local ecosystem. Thus, the interviewers were aware of their map and realised their biases while drawing maps with the stakeholders (Ozesmi and Ozesmi, 2003; Ozesmi 1999).

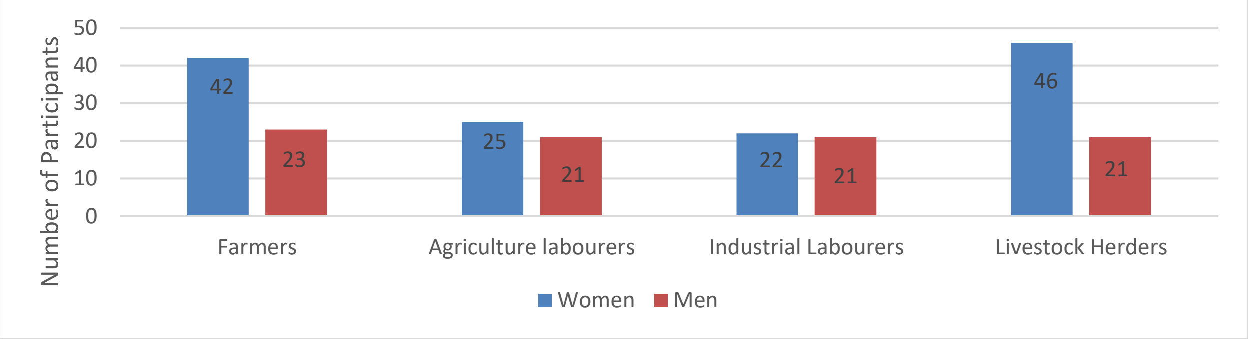


Figure 2: Composition of the Stakeholders in the study villages

Cognitive maps were drawn as prescribes by Ozesmi (1999) and Carley and Palmquist (1992). The interviewer listed the names, occupation and gender of the correspondents on the chart paper. The stakeholders were explained the reasons behind the research before the start of the interview. Once the correspondents understood this, they were asked: 'If I mention variation in Rainfall and water security, what are the factors, things, variables that come to your mind?' Similarly, questions were asked for increase in temperature and urbanisation.

The interviewees were then asked to list the factors on the paper. Once listed the respondents were asked to explain the relationships between the variables and draw lines between them to represent their relationships. Respondents are then asked to mark these lines with arrows to indicate their directions, and give signs of positive or negative and strengths: high (1), moderate (0.5) and low (0). If the interviewees seemed confused, or not focussed on the mapping, they were asked non-directional questions. The process continued till the interviewees felt they had nothing more to add, thus completing the map.

After the completion of the maps, they were transformed into adjacency matrix according to principles of graph theory. The variable V_i were listed on vertical axis and V_j on the horizontal axis thus, forming a square matrix.

Condensed Cognitive maps and calculating the indices

The square matrix developed by individual stakeholders was combined into village wise cognitive maps by adding the augmented matrices as developed by Kosko (1988). Each of the stakeholder maps were given equal weightages before being condensed. Condensation is undertaken to reduce the complexities associated with fuzzy cognitive maps, due to numerous variables and connections between them. As FCMs are quiet complex, graph theory indices provide as simplified way to analyse their structure (Ozesmi and Ozesmi, 2003).

The first step is to identify the number of variables (N) and the number of connections (C) in the condensed map. The density of the cognitive map (D) is an index of connectivity: D = C/(N(N-1)) or D = C/N^2 if the map has self-loops i.e., if a variable can have a causal effect on itself (Hage and Harary, 1983; Ozesmi and Ozesmi, 2003). Ozesmi and Ozesmi (2003) provide details on how to calculate the other indexes upon counting the number of different types of variables. The variables are defined as outdegree [od (V_i)], row of sum of absolute values of a variable in the adjacency matrix and shows the cumulative strength of connections (a_{ij}) exiting the variable

$$od\ (Vi) = \sum_{k-1}^{N} aik$$

The indegree [id(V_i)], is the column sum of absolute values of the variables and shows the cumulative strength of connection (a_{ij}) entering the variable

$$id\ (Vi) = \sum_{k-1}^{N} aki$$

This calculation is used to identify the transmitter variables [indicating forcing functions] which, have a positive outdegree and a zero indegree. The receiver variables [indicating utility functions] have a zero outdegree and a positive indegree. Ordinary variables have positive outdegree and indegree (Bougon et al., 1977; Eden et al., 1992; Harary et al., 1965). Furthermore, the centrality of a variable is assessed to calculate the contribution of a variable in a cognitive map, which is the summation of the indegree and outdegree (Harary et al., 1965). The centrality of the variable is calculated by

$$Ci = td(Vi) = od(Vi) + id(Vi)$$

The next step is to calculate the complexity index of the map, which is the ratio of receiver to transmitter variables (R/T). Maps with large number of receiver variables are seen to be complex because they reflect many outcomes and implications that are a result of the system (Eden et al., 1992; Ozesmi and Ozesmi, 2003).

2.2.3 Synthesis Phase

Six policy simulations were undertaken to identify points of action. The simulations were based on graph theory formulae and neural network computations. The models were initially run to reach a steady state and develop a business as usual scenario. Model assumptions were then postulated to develop scenarios with the intention of improving water security in the study area. The model assumptions were made based on the findings from the analysis conducted in previous two phases. Once the models were run, the outcomes were discussed with expert groups and local communities. Sharing of the outcomes helped to identify any missing connections and develop an action plan for improving the status of water resources in the area thus creating a water secure ecosystem.

2.2.4 Policy Discourse and Dialogue Platform

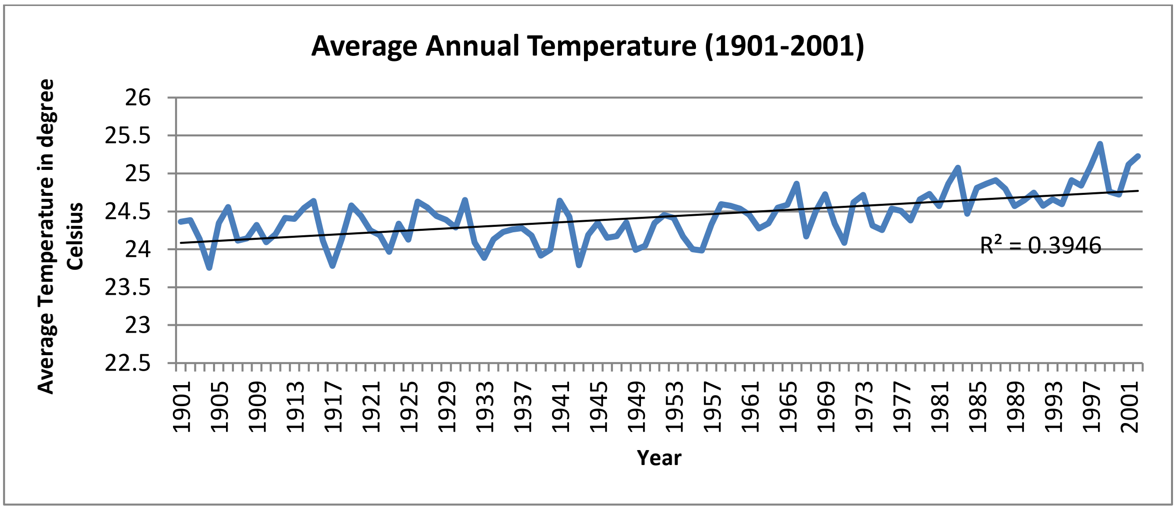
This stage of the study builds upon one of the targets of SDG 6 to support and strengthen participation of local communities in improving water management. A dialogue platform was developed within the study area comprising of community representative, experts, and local government and industry representatives. The study findings were presented at the platform for discussion and identify options that can be undertaken by all the stakeholders to improve water security in the region.

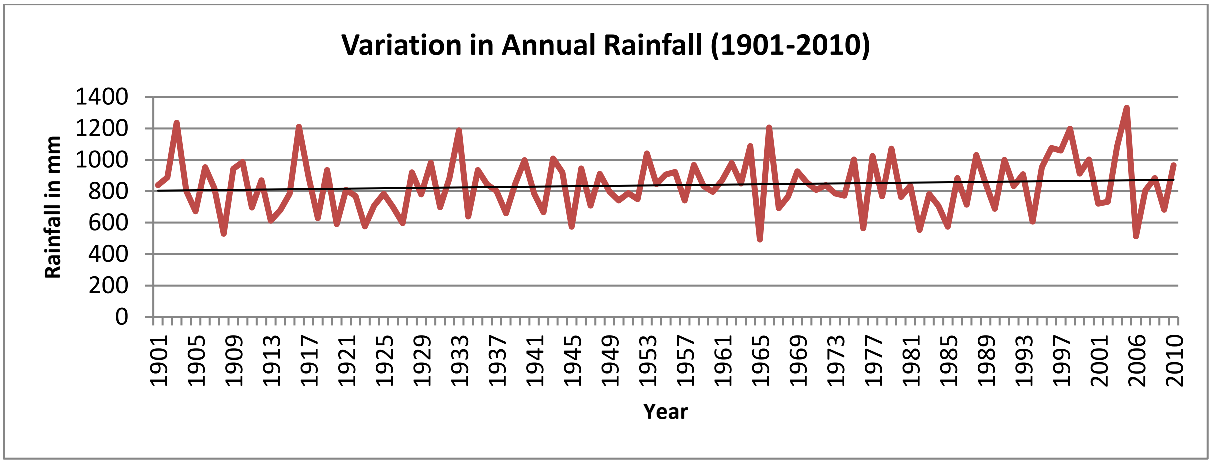
3. Results

The results of the analysis of the information gathered and generated in the four phases of the study reveals that water insecurity in these areas is more likely to be a function of high demand and poor management; rather than absolute scarcity of water. This section details the results from the climate data analysis, interviews and questionnaire surveys conducted and the capture of stakeholder [*local*] knowledge to prioritise options to reduce water insecurities.

3.1 Climate Data Analysis

Climate data for the district was analysed based on the data provided by the Indian Meteorological Organisation. There is no local [village] level data available for the time period (1901-2000) and hence, the paper had to make do with the district level data. The time series analysis, of the average temperature of the region for the years 1901-2001 indicates that there is an increase in temperature of nearly 0.5^{O} centigrade in the last century. An analysis of the annual rainfall between the years 1901-2010 indicates a large variation in the region and is can be seen that has been erratic with increase in the intensity of rainfall but decrease in the number of rainy days.





3.2 Stakeholder perception on water security

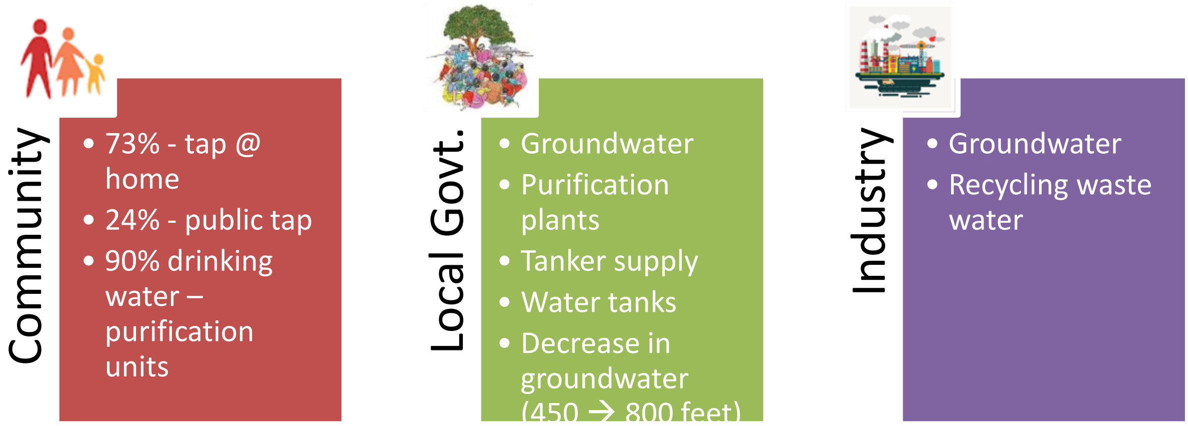
The findings of the survey are classified through the lens of accessibility, quantity and quality of water and are detailed below.

3.2.1 Water Accessibility and Quantity

The study findings indicate that the region is home to numerous water bodies which are either encroached upon and/or polluted and cannot be used for consumption. The Arkavathy River flows through the study area, but is highly contaminated as it is the main channel for flow of sewage from the city of Bangalore and also the industrial estates located upstream. When it comes to household water, it is supplied by the local government through various schemes and programs. Majority of the households in the region possess an easy access to water either in the form of tap at home or public taps located within 500 meters. In regard, to drinking water 90% of the households purchase water from the purification (Reverse Osmosis) plants set-up by the local governments in collaboration with industries located in the region under their CSR activities.

The local government which is responsible for supply of water to the households indicate that they are able to meet only 80% of the demand. The remaining 20% is usually through private tube wells and the purification plants set-up in conjunction with the industries. The local government representatives highlight that there has been a drastic decrease in the levels of groundwater in the past decade from 400 to nearly 850 feet. Considering that all stakeholders in the area draw water from a common aquifer, the decisions of individual stakeholders impact the entire community in the area. Given the current lack of formal regulations against excessive water extraction, policy intervention may be necessary to ensure sustainable water management.

There is also a mention of the increase in the number of private tube wells (individual and collective) which is used by the households to meet their needs. These private tube wells have also given rise to an informal business of water supply through tankers within the area to supply water to water starved Bangalore city. The industry representatives mentioned that they are mostly dependent on groundwater to meet their demands. Large industries located in the area also identified themselves to be recycling water and are working hard to create water positive or water neutral footprints.



Community

- 73% - tap @ home
- 24% - public tap
- 90% drinking water – purification units

Local Govt.

- Groundwater
- Purification plants
- Tanker supply
- Water tanks
- Decrease in groundwater (450 → 800 feet)

Industry

- Groundwater
- Recycling waste water

3.2.2 Water Quality

With regard to water quality all the stakeholders are aware that water resources in the region are highly contaminated and are not suited for consumption. The state government has declared groundwater in the region to be fluoride contaminated and has declared the groundwater to be unsafe for drinking. The local government and the communities aware of this are still highly dependent on groundwater to meet all their requirements. Though purification plants are set-up and being used, an analysis of the water sample conducted by the study team indicated low P^H content with metal corrode in some of the collected samples.

Community

- Contaminated
- High salt content

Local Govt.

- Fluoride contamination
- Groundwater unsafe for drinking

Apart from the above findings, it was also revealed that there is a lack of awareness among the households regarding measures that can be adopted by households to improve both surface and groundwater sources. Only 44 per cent of the households mentioned to have gathered some information about rainwater harvesting from television and other sources of media. Improving, water sources through modern techniques and rejuvenation of water bodies may have a considerable impact on overall water and livelihood security.

3.2.3 Modelling Policy options using Cognitive Maps

The 160 fuzzy cognitive maps drawn were condensed into a single condensed map, it is evident from Figure 4 that the strongest connections are between variations in rainfall and affecting agriculture practices, availability of drinking water, quantity of drinking water including surface and groundwater available. In the Figure 3, the size of the block indicates the influence the variable has on other variables; the black lines indicate a positive impact and the red lines depict a negative impact of one variable on the other. Rainfall, temperature and urbanisation including agriculture and financial conditions seem to be the most influential variables in all the maps drawn. It can be seen that the variables of Agriculture, Groundwater, surface water and drinking water are highly negatively impacted as there are a high number of red links directed towards them.

Variation in rainfall is also said to reduce the food security of the communities; Increase in Temperature is seen to affect agricultural practices, reduce health of the communities, availability of fodder and hence cattle in the region and financial conditions in addition to water sources (ground and surface) and drinking water. Temperature is also seen to affect forests in a negative way. Whereas Industries are seen to have the highest impact on financial conditions of the local communities, this increase in financial conditions are seen to be offset by spending on health related issues caused due to changing climate and increasing urbanisation; Urbanisation is said to increase the sale of agricultural land, leading to increase in the number of industries and the level of pollution due to improper waste management systems. The maps also suggest that there has been an increase in the modern infrastructure facilities in the study area as a result of urbanisation (Figure 4).

Therefore from the map we can say that, if we are to improve the water security in the area which is negatively impacted by climate change and aggravated by urbanisation, there is a need to reduce pollution and reduce the conversion and sale of agriculture land. The map also indicates a positive relation between surface water bodies and groundwater; hence there is a need to improve surface water bodies such as lakes and tanks, present in large numbers in the region to improve groundwater, thus reducing the level of contamination and providing quality drinking water. This improvement in water sources will result in improved agriculture practices, as the current practice uses contaminated effluent water to cultivate crops which in turn harm the health conditions. Thus, improving water security will also lead to alternative benefits such as improving the health conditions of the communities, through improved food security.

Modelling different policy options in a fuzzy cognitive map helps identify and selecting the alternatives to achieve the goal of improving water security in the region. This paper presents just one example out of the six policy models simulated for the study. The policy simulations were performed done on the condensed cognitive map that includes an aggregation of individual maps drawn by all stakeholders with equal weightages. Steady-state conditions were first determined and all the variables were set to the value of 1. Various policy options were run on the models, a variable was fixed at 1 if a variable was to be kept high or fixed at 0 if it was to be eliminated. In this paper we highlight one of the six cases of policy options that were run. The case run included various ways to increase water availability. The proposed changes included reduction of pollution and sewage water (fixed at 0) and improving agriculture practices as shown in Figure 3. Modelling these assumptions we can see that, there is a positive change in the health, and drinking water availability in the region. Whereas, a moderate positive change can be seen in water (surface and ground) sources, in addition to forests and thus, fodder available resulting in a surge in the cattle population and thus improvements in the dairy sector. These outcomes also result in a strong positive increase in the financial conditions of the community. Thus, improving agriculture practices and reducing the current levels of pollution through effective enforcement of current policies is found to improve water security in the region. This improvement in the water sector will have positive repercussions on the health and financial conditions thus reducing local vulnerability to the impacts of climate change.

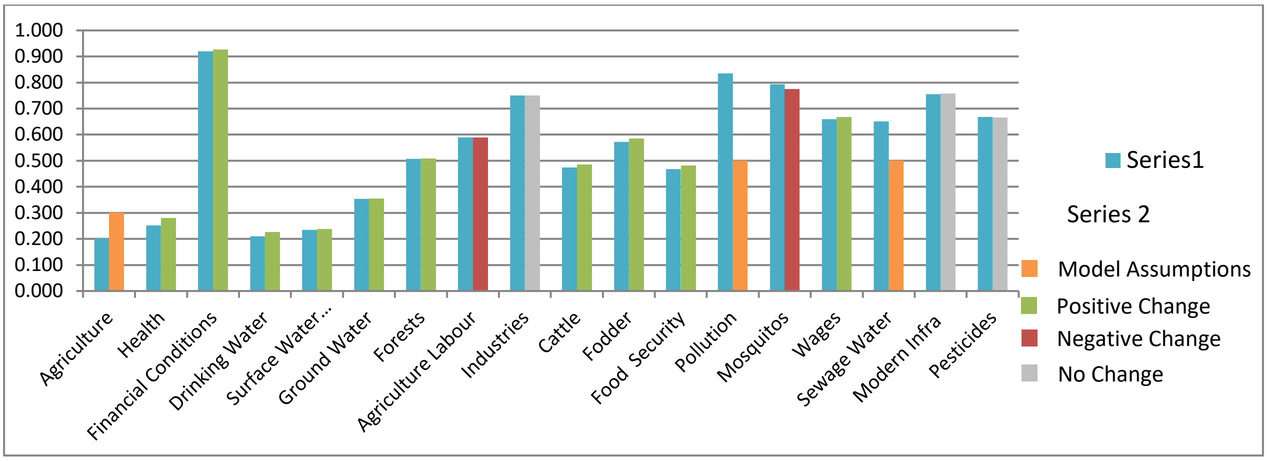


Figure 3: Policy Simulation for improving water security

3.2.4 Policy Discourse and Dialogue Platform

In line with the principles of constructive engagement, the findings from the study were shared with all the stakeholders at a dialogue platform. The platform was a culmination of community members, local government representatives, experts, bureaucrats, and industry representatives. The study findings were shared and policy options were simulated with inputs from the stakeholders present. The highlights of the dialogue platform are as below:

- The community members and industrial representatives called for the establishment of a common effluent treatment plant in the region to help recycle industrial effluents
- There was a call for decentralised sewage treatment plants and for up-gradation of the current plant from a secondary trickling mechanism to a tertiary treatment plant
- The local government invited industry representatives for an increased and improved communication/interactions
- The local government in conjunction with industry representatives decided to undertake awareness programs on building capacity of the community on water conservation measures
- The industry representatives have called to work together with local government to establish rainwater harvest structures to help improve the quality and quantity of groundwater
- The senior bureaucrat from the depart of ecology, forests and environment, Government of Karnataka directed the rural department to undertake rejuvenation of surface water bodies under the famed National Rural Employment Guarantee Scheme

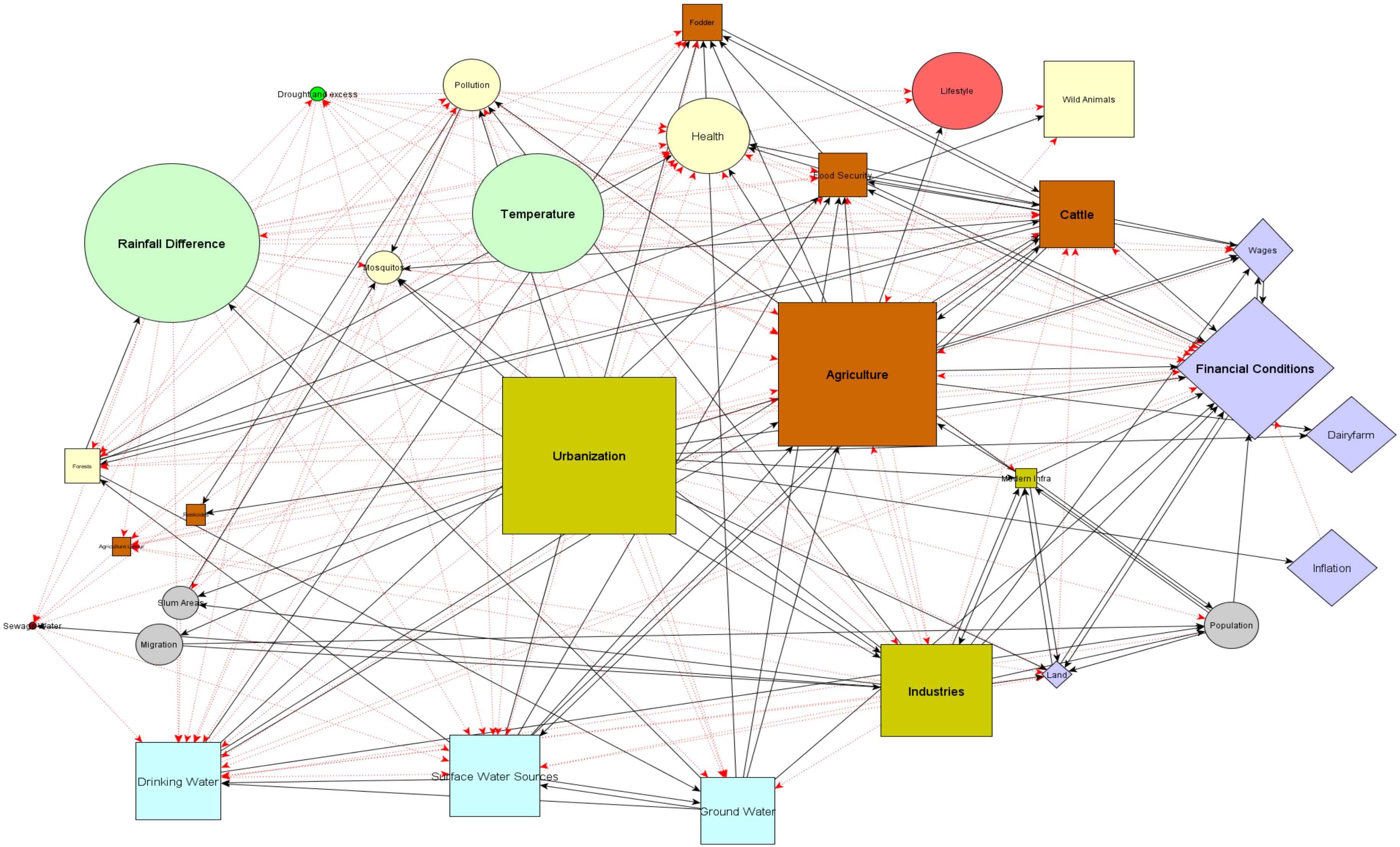


Figure 4: Condensed Cognitive Map Highlighting the Relationship between Climate Parameters and other variables

4. Conclusion

Agenda 2030 focuses on robust implementation to enhance inclusively and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management (SDG 11). The unplanned nature of development has resulted in indirect consequences in peri-urban areas which has wider implications on water security of the area. This paper assessed the double injustice brought upon due to unchecked resource extraction and_changing the climate on peri-urban communities. Simultaneously, a framework has been delineated for the need of inclusive and participatory planning to achieve the SDGs, specifically the goal 11. The framework highlights how citizen-centered scenario planning is a practical and potentially powerful tool that can be used as an anticipatory action research process.

Involvement of all stakeholders in the planning process is called for in most of the targets under SDGs. A stakeholder-centric design to identify issues based on perspectives of the local communities will help in incorporating multiple stressors into planning. This paper captures local knowledge of the communities and highlights how urbanization has changed the lifestyle of this agrarian Gram Panchayat which is further aggravated due to changes in climate. The issues identified acts as the foundation upon which solutions can be devised. The approach of this paper depicts how social concerns of citizens and communities can be mobilized to forge a collective will. Thus, the paper concludes that *“If we need a sustainable world for 2030 and beyond, we need to ensure responsive, inclusive, participatory and representative decision-making at all levels (SDG 16)”.*

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