CHAPTER 15

Understanding the Mental Models that Promote Water Sharing for Agriculture Through Group Micro-Irrigation Models in Maharashtra, India

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15.1 Introduction

Water security is considered as a tolerable level of water-related risk to society (Grey et al., 2012). David Grey and Claudia W. Sadoff (2007) defined water security as 'the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production (agriculture, industry, energy and transport), coupled with an acceptable level of water-related risks to people, environments and economies'. The concept of tolerable and acceptable levels refer to the threshold (Falkenmark et al., 1989; Alcamo et al., 2000; Sullivan, 2002; Young et al., 2019) below which the water security elements of availability, accessibility, safety and affordability (Agarwal et al., 2000; Young et al., 2021) are compromised leading to crisis in the domains of health, livelihood, ecosystems and production. Several factors affect water security such as an increasing population, urbanization, economic development, lifestyle changes, water pollution, etc. (Falconer & Norton, 2012), however in the domain of agricultural production, that our study focuses on, the most important factors affecting water security are climate change and excessive abstraction of freshwater (surface and groundwater). Climate change further aggravates the excessive abstraction of surface and groundwater.

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The Intergovernmental Panel on Climate Change (IPCC) report (Bates et al., 2008; Field et al., 2012) pointed out that climate change would have a greater impact on the freshwater resources resulting from higher climatic and hydrological variability with consequences reaching out to the society and water security (Habiba et al., 2014). In the Indian context, studies have found that the average temperature has increased by about 0.7 °C during the period 1901–2018. It has mainly been caused by anthropogenic aerosols and changes in land use land change. Rainfall data trends comparison between 1951–1980 and 1981–2011 shows a shift towards more frequent dry spells (27% higher). During the last 6 to 7 decades, the frequency of drought conditions has significantly been increasing. The data climatology and weather data for 1951–2016 showed at least 2 droughts per decade occurred in the regions of the southwest coast, southern peninsula, central India, and north-eastern India. Climate model projections indicate an increased frequency (>2 drought in each decade) in the coming future caused by increased monsoon variability and a warmer atmosphere (Krishnan et al., 2020; Maharana et al., 2021). This reducing trend of the only source, i.e.; rainwater, to support most of the surface and groundwater affect the recharge rate of groundwater in India (Bhanja et al., 2019; Kumar et al., 2021). Simultaneously, the dependence of humans on freshwater for domestic, irrigation and industrial use is increasing exponentially. The increasing demand and the low recharge rate of freshwater put pressure on this natural resource. It severely affects groundwater quantity and quality (Kulkarni & Shankar, 2014; Dangar et al., 2021; Chindarkar & Grafton, 2018). The 2011 Ministry of Water Resources report of the Government of India says, freshwater reserves have reduced from 5177 m^3 in 1951 to 1820 m^3 in 2001, reducing to more than half i.e. 1545 m^3 in 2011 (Kumar et al., 2021). Groundwater supplies for 85% of rural domestic needs and 62% of the agricultural production needs. In 2013, where 70% of irrigation was dependent on groundwater, it drastically increased to 90% in 2018 (Saha et al., 2018; Joshi et al., 2021).

Agricultural production and farmers livelihood are sensitive to climate variability. The temporal and spatial variability of climate change holds the potential to impede food production and supply (Tirkey et al., 2018; Bewketa & Conwayb, 2006). Crop development has a systematic regime, compatible with a certain type of climate, adequate water supply and inputs, to follow (Challinor & Wheeler, 2008). Even the slightest variation in these elements creates a yield gap, causing reduction in production output and its quality (Agarwal, 2007; Rötter & Geijn, 1999; Mora et al., 2015). The quantity and quality of crop yields have a bearing on the market compensation farmer receive as an income (Kawasaki & Uchida, 2006). Since climate change cannot be regulated at the local level, the natural response of farmers to sustain production, to maintain if not increase the level of income they have been receiving, is to over-indulge in the extraction of groundwater. The extraction of groundwater is happening at a much faster rate than it can naturally replenish, majorly from monsoon rainfall (Famiglietti, 2014). As groundwater levels drop, wells are dug to deeper levels which have implications on the wealth of the farming community. This over-indulgent behaviour has far-reaching consequences at the farmer's level and the environmental and ecosystem levels. At the farmers' level, subsidies for and accessibility of technology and electricity have led to an explosion in groundwater extraction (Srinivasana & Kulkarni, 2014; Janakarajan & Moench, 2006). These benefits are reaped by wealthy farmers, however, farmers living on subsistence face the problem of inequity of access to the distribution of water, which widens the economic and social divide (Cuadrado-Quesada & Joy, 2021; Vaidyanathan, 1996). According to the 2015–2016 Agricultural Census of the Government of India, about 86.08% of the farmers are small and marginal farmers operating an area of 46.94% and 13.35% are medium farmers operating an area of 43.99% (GoI, 2019), of these, many are economically weaker and are unable to make huge individual investment. As a result, these are the farmers subject to problems of inequity and are compelled to take up agricultural practices that are unsustainable in nature. At the environmental and ecosystem level, mismanagement in groundwater extraction causing soil subsidence, reduction in vegetation area, disturbing the biota essential for crop development, etc. (Carrillo-Rivera et al., 2008; Danielopol et al., 2003) are constraining agricultural out-turn. These issues have been prevailing for long and are seen to be widening with time as farmers behaviour becomes more aggressive towards resources.

Irrigation as a concerted effort was adopted as an adaptation strategy to address water security. Various irrigation-related schemes, technology, practices and management approaches and adaptation strategies have been implemented to manage water use, besides watershed development that improves water security. For instance, In India, the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) project by the Department of Agriculture and Farmers Welfare, Govt. of India, promotes end-to-end solutions in irrigation supply, micro-irrigation technologies such as drips and sprinklers, etc. Precision irrigation management systems, a sustainable water security adaptation strategy, ensure precise supply of water to crops at precise locations at precise time however uniformly distributed across the irrigated area (Smith & Baillie, 2009; Zhang et al., 2021). However, in the backdrop of the magnitude of farmers with economic and resource constraints, the uptake of these technology and management practices individually and for a sustained period becomes difficult. To support such farmers, the Watershed Organisation Trust, an NGO based in Pune, India, established an irrigation management system to be implemented through a group, called the Group Micro-irrigation Model (GMI). This system entails sharing water as a common pool resource along with the application of climate-resilient agricultural practices. Our study focuses on the behavioural aspects related to the adoption of the system, sharing of water resources and cooperative management by the group. Through the mental model method, we draw a mental structure of the group of farmers who use this approach. It covers the interaction between the external resources and their perspectives, beliefs and attitudes to understand their point of view for adopting a sustainable practice of sharing water, from their experiences of joining and operating in the group. This study aims to highlight the importance of considering the drivers of people's behaviour as an independent component, which has been given limited attention in the Indian context, and in framing sustainability and adaptation frameworks and studies. Besides, it also has relevance for the practitioners and policymakers, as factoring these aspects will enhance their ability to formulate effective water-sharing policies, and/or other sustainable and adaptation interventions.

15.2 Study Area

The state of Maharashtra, characterized by varied geography, topography and climatic conditions has led to regional differences in environmental conditions, thus allowing to group into different agro-climatic zones (FAO, 1996; Gajbhiye & Mandal, 2000). This diversity in the environmental conditions has divided the state into 4 meteorological regions and 9 agro-climatic zones. They can be differentiated based on soil conditions, precipitation, weather, and physiography and crop suitability. The Very High Rainfall with Lateritic Soils, Very High Rainfall with Non-Lateritic Soils and the Ghat agro-climatic zone forms the Konkan meteorological region; the Transition Zone I, Transition Zone II and part of the Scarcity Zone form the Madhya Maharashtra region; the rest of the Scarcity Zone and the Assured Rainfall Zone form the Marathwada region and the Moderate Rainfall Zone and High Rainfall Zone with Soils from Mixed Parent Material form the Vidharbha region. The Madhya Maharashtra and the Marathwada region being located in the interior of the state and with the Western Ghat range of the elevation of about 1200 m above mean sea level obstructing monsoon flow, has rendered the regions to be semi-arid (Ratna, 2012; Kelkar et al., 2020).

The Group Micro-Irrigation models were chosen to be established in the semi-arid region of Marathwada and Madhya Maharashtra which needs water-related adaptation strategies the most as compared to other regions. In the Marathwada region, the GMI model was installed in the village of Tigalkheda in the Bhokardhan block of Jalna district. And in Madhya Maharashtra, two models were installed in the villages of Bhangadewadi and Ranmala hamlet belonging to the Dhawalpuri Panchayat in the Parner block of Ahmednagar district. These two villages are to a distance of approximately 5 km from each other. Figure 15.1 illustrate the location of these three models:

Jalna: GMI Group I—Tigalkheda

The district of Jalna is located in the central part of Maharashtra state and is a part of the scarcity zone in the Madhya Maharashtra region (Ratna, 2012; Kelkar et al., 2020). Its district boundaries stretch for about 7687.39 sq.km.

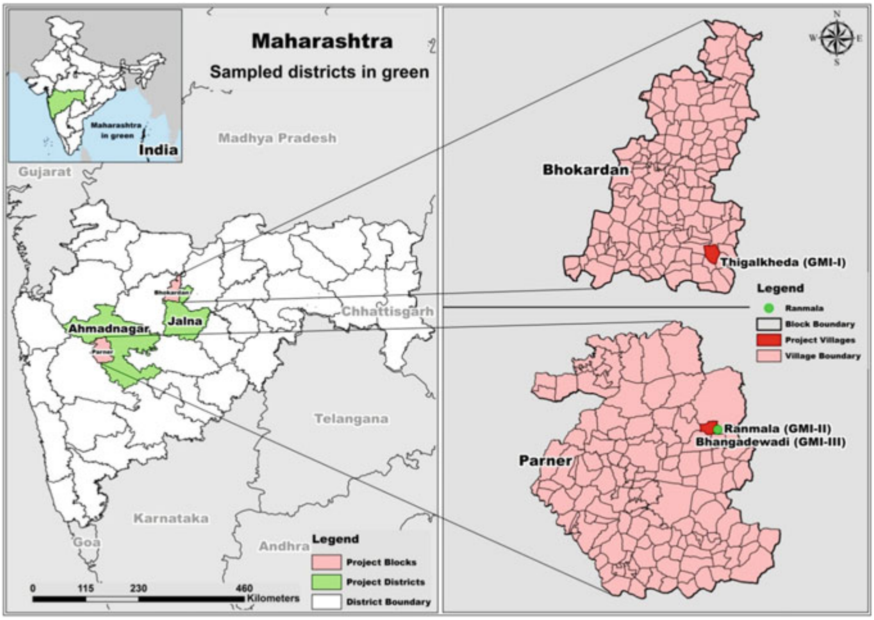

Fig. 15.1 Location map of the study area

Jalna district is 400–500 km away from the coastline of the state towards the east and about 160–170 km east of the Ahmednagar district where our other two GMI group models are installed. It belongs to the Marathwada region. The physiography of the region are of 04 types: Ajantha and Satmala hills (part of the Western Ghats), undulating (wave-like structure) plateau, denudation (reduction in elevation caused by either weathering, erosion, deposition or transportation) slope and older flood plain. Most of the central and southern part of the district comprise of undulating and denudation slopes. Jalna is divided into 4 revenue sub-divisions, of which Bhokardhan block is one. The GMI group I established falls in the Bhokardhan sub-division. Bhokardhan lies on the northernmost side of the Jalna district. The block is mostly of denudation and older floodplain physiography. The normal annual rainfall in this region varies between 400 and 600 mm on average with, sometimes, even less than 37 rainfall days as compared to the overall 122 rainfall days of monsoons of the state. The unconfined aquifer, that is the primary level of groundwater, is of weathered/fractured basalt form at a depth of 5 m to 30 m, while the second aquifer of jointed/fractured basalt form goes 35 m to 145 m deep (CGWB, 2016).

GMI Group I—Tigalkheda Model Details

Tigalkheda village lies on the southeastern side of the Bhokardhan block. The distance of the village between the Jalna district headquarters located in the Jalna main town is approx. 34 km and located to its north and approx. 29 km between Bhokardhan town located to south-east. The nearest water body to the village is the Khadakpurna dam which is approx. 40 km to its east. It has no evidence of groundwater influence on the village. The model in the village area is located at 20.118005 latitudes and 75.866839 longitude. It was establishment commenced in the year 2017 between April and May. After an aquifer delineation was conducted an area of 32.45 acres of area was selected. This area had 03 wells tapping the same aquifer. The model restricts the extraction of water from multiple resources (dug-wells) for agricultural use and facilitates sharing water from one well only. An automation and fertigation system of water distribution was installed next to one of these dug-wells with drips attached to it and spread across the 32.45 acres of adjacent farmlands. Before the installation, the selected dug-well was de-silted to increase the depth by 35.38 ft. in order to increase the storage capacity to 50 ft. The 32.34 acres of the area belong to 14 farmers who belong to the same familial lineage. Of these, 3 farmers belong to the small (2.6 to 5 acres landholding), 6 farmers to medium (5.1 to 10 acres landholding), 1 to marginal (>2.5 acres landholding) and 4 to large (<10 acres landholding) land class categories. The area allocated for the GMI model range between 0.45 to 5 acres. This group was engaged with rain-fed farming only.

Ahmednagar: GMI Group II—Ranmala and GMI Group III—Bhangadwewadi

The district of Ahmednagar is the largest by area coverage in Maharashtra state, covering 17,196 sq.km of the total state area of 307,713 sq. km. It lies about 200–250 km to the east of the western coastline of India, in the state. The district's physiography has four major landforms i.e.; Ghats and hills (7.6%), foothills (19.4% area), plateau (3.71% area) and plains (69.30% area). The Ghats and the majority of the hills fall on the western side of the district (part of the western mountain range [Western Ghats]), shifting the landform to foothills, plateau and plains towards the eastern side. Due to the orographic effect caused by the Western Ghats, the majority of the district area that fall on the leeward side/rain-shadow side, receives scant rainfall of about on an average of 574 mm annually spread over 47–59 rainfall days as compared to 3200 mm average rainfall in 95–110 days in its neighbouring district of Raigad that lies on the west coast and to the windward side of the Western Ghats. Ahmednagar district is one of the drought-prone districts in Madhya Maharashtra (Ratna, 2012; Kelkar et al., 2020). The district consists of 7 revenue divisions, with each division having 2 blocks under its administration. The two GMI models in Ahmednagar were established in the Parner block belonging to the Shrigonda revenue division. This block is located on the southwestern side of the district. It is part of the plateau region of the district, with hillocks at certain places. The unconfined aquifer, the primary source of groundwater replenished by rainfall water, in this region, is to a depth of 20–40 mbgl. Therefore, the scant rainfall conditions with a low groundwater holding capacity of the region compel farmers to carry out rainfed farming or sustain on irrigation.

GMI Group II: Ranmala Model Details

Ranmala village is located 28 km west of the Ahmednagar district headquarters. It lies on the plain region of the Parner block. The nearest water body from the village is the Bhalwani Lake to its east, with no evidence of groundwater influence in the model area. The Ranmala GMI model is located at 19.15054 latitude and 74.534989 longitudes. It was inaugurated in May 2020. This group consists of 06 farmers, of which 04 farmers belong to the medium land class category (5.1 to 10 acres landholding) and 02 farmers belong to the small land class category (2.6 to 5 acres landholding). In this group, only two farmers i.e.; 01 small and 01 medium farmer land class category, own a water resource. Each of the farmers allocated 1 acre each, adjacent to each other, i.e.; 6 acres total, for the model. Water for this model is distributed from one dug-well owned by one of the group farmers. The dug-well earlier which was in a dilapidated condition, was reconstructed. The automation and fertigation system of water distribution was connected after due approval was obtained from the well owner. Drips pipelines attached to the system then were distributed to each 1 acre of land of the model.

GMI Group III: Bhangadewadi Model Details

Bhangadewadi village is situated approximately 29 km to the northeast of Parner town and 30 km west of Ahmednagar district headquarters. The nearest water body from the village is the Kalu dam, Dhoki, to its west at about 9–10 km distance. Water to this GMI group farms is supplied from this dam. A check dam (weir) is constructed downstream of the Kalu dam for the purpose of obstructing excess water flow. This surface water is lifted through a pipeline and transferred for about 9 km to a farm pond situated midst the group farmland. An automation and fertigation system of water distribution is connected to this farm pond from which water is distributed to all farms. The Bhangadewadi GMI model is located at 19.150983 latitudes and 74.512865 longitudes. It started its operation from April–May 2020. There are a total of 47 farmers who have allocated 65.5 acres of their adjacent lands for the model. Of these 47 farmers, 19 are medium (5.1 to 10 acres landholding), 24 are small (2.6 to 5 acres landholding), 2 are marginal (>2.5 acres landholding) and 2 large (<10 acres landholding) land category farmers. They allocated land in the range of

Table 15.1 GMI Tigalkheda, Ranmala and Bhangadewadi group details

GMI model	*District*	*Location*	*Year of establishment*	*Type of farmers*	*No. of farmers*	*Total land owned (acres)*	*Area under GMI (Acre)*	*Water source*
GMI-I	Jalna	Tigalkheda, Bhokardan Block	April–May, 2017	Marginal (0.1–2.5 acres)	1	2	1.25	1 Shared Dug-well
				Small (2.6–5 acres)	3	12	3.7	
				Medium (5.1–10 acres)	6	49.5	17.25	
				Large (>10 acres)	4	52	10.25	
				Total	14	115.5	32.45	
GMI-II	Ahmednagar	Ranmala, Parner Block	May, 2020	Marginal (0.1–2.5 acres)	–	–	–	1 Shared Dug-well
				Small (2.6–5 acres)	2	9	2	
				Medium (5.1–10 acres)	4	36	4	
				Large (>10 acres)	–	–	–	
				Total	6	45	6	

GMI model	*District*	*Location*	*Year of establishment*	*Type of farmers*	*No. of farmers*	*Total land owned (acres)*	*Area under GMI (Acre)*	*Water source*
GMI-III		Bhangadewadi, Parner Block	April–May, 2020	Marginal (0.1–2.5 acres)	2	4	3	Surface water (lifted from Kalu dam excess water stored in check dam downstream) to Farm pond
				Small (2.6–5 acres)	24	91	27.5	
				Medium (5.1–10 acres)	19	152	31.5	
				Large (>10 acres)	2	28	3.5	
				Total	47	275	65.5	

3 to 0.5 acres for the model. In this group, 22 farmers have water resources while the rest have been doing rainfed farming (Table 15.1).

15.3 Group Micro-Irrigation Intervention

The initial stage of the group formation was about promoting the GMI concept among the farmers through group meetings. Key people of the villages were approached to discuss the potential of the model, who further disseminated the information to fellow farmers. After back-and-forth discussions, we finally arrived at the aforementioned groups to begin with the establishment of the models. Water sharing from common resources and application of the Climate Resilience Agriculture (CRA) practices were the crux of the model to which the group agreed to comply. The two approaches are explained below.

GMI Operations

The Group Micro-Irrigation (GMI) approach considers water as a common good rather than privately owned. This approach intends to promote managing scarce water resources in a judicious and equitable way. The GMI approach has four integral components: (1) Groundwater management by supporting both the supply and demand side needs, (2) Application of Climate-Resilient Agriculture (CRA) practices, and (3) Supporting farmer's market linkages, and (4) Providing tools and techniques to support agricultural operations through applied research.

The primary component comprises taking water-related measures such as harvesting rainwater and construction of soil and water conservation structures to recharge groundwater. These measures support the supply-side needs. While, collectivization of private groundwater resources, sharing water from the same aquifer and equitably distributing of water through a common micro-irrigation system to the farm area of the group, supports the demand side needs. This entails the development and maintenance of the collectivized common groundwater resources, pumping house and water distribution pipe network that is spread across the field of the farmers who are part of the group. An automation system is installed to eliminate the manual work of supply water and send precisely equitable distribution of water to each farm. Groundwater collectivization is a sustainable water security solution for the conservation, efficient use and equitable distribution of groundwater by considering the resource as a common resource. Key principles of this component are common sharing, social regulations, technical support and gaining a scientific understanding of the operations. The second component suggests adopting CRA practices to boost soil health and plant resilience to ensure a good harvest in the face of weather and environmental challenges. The third component involves market linkages support for better market prices by forming new and engaging with existing FPOs. And the last component comprises integrating applied research to generate tools and techniques to support farmers in evaluating their agricultural performance. This will help them make informed agricultural decisions for next seasons. Assessments are also conducted to provide research-based evidence on the impact of various measures undertaken. This method considers creating simple tools and methods like maintaining field books by farmers, crop water budgeting and planning and assessing groundwater availability by testing well water depth and pump discharge.

GMI approach provides a robust solution with the adoption of both micro-irrigation and climate-resilient farming practices, which are otherwise stymied due to financial and institutional constraints. Besides, it also has social benefits as it creates an attitude of cooperation rather than competition and strengthens interpersonal relationships through constant and effective coordination.

Climate-Resilient Agriculture Practices

Climate change and variabilities like erratic rainfall, frequent interchanging dry–wet spells, intensive short-duration rainfall, and other extreme weather events affect agricultural production negatively at the local and global levels. Additionally, the excess and injudicious use of chemical inputs, excessive water application, and faulty agricultural practices, as an outcome of these externalities, have triggered the severe loss of soil health. These multidimensional impacts of climate change have made farmers realize the importance of following sustainable ways to build resilience to manage agriculture (Chaubey et al., 2018; Patra et al., 2016; Nayak & Solanki, 2021). In this regard, to combat the situation Climate-Resilient Agriculture practices were devised to sustainably improve agricultural production. CRA is an approach that uses natural resources existing in the surrounding, rather than synthesized, to achieve continuing higher productivity in the context of climate variability (Lorenz & Lal, 2018).

The Watershed Organisation Trust (WOTR) consults a package of CRA practices for a variety of crops including indigenous and climate stress-tolerant crop varieties. The package of practices involves applying techniques of water conservation like in-situ moisture conservation, use of micro-irrigation, mulching, and water harvesting structures for protective irrigation. Apart from water application, this package also suggests methods of conservation agriculture like minimum tillage, contour cropping, intercropping, mixed cropping, and crop rotation. To manage the sudden climate changes information use of weather-based location and crop-specific advisories are provided. WOTR has developed an android mobile software to disseminate this information.

CRA also provides Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) solutions. Integrated Nutrient Management (INM) helps to efficiently and in a balanced way, use organic and synthetic fertilizers based on the existing soil health status. This deals with the application of organic and inorganic fertilizers, in addition to farmyard manure, vermin compost, legumes in rotation and crop residue for sustaining soil health for the long term. And, Integrated Pest Management (IPM) is an approach for pest and disease management that includes bio-pest management practices such as the use of insect traps, trap crops and bio-pesticides. The application of these approaches is flexible and applied as per the needs of the agricultural conditions. The IPM approach use a wide range of information related to the life cycles of pests and how they interact with the environment. This information, combined with the pest control methods, is applied by the best economical means to manage pest damage. It is ensured there is low damage to people, property and the environment.

15.4 Research Approach and Methodology

Mental Model Approach

Mental Models can be defined as a cognitive representation of the real world system. The real world system image in the mind is drawn from the individual's selected concepts and relationships which are the basis for the formation of perceptions and experiences that he or she further uses to make decisions (Doyle & Ford, 1998; Johnson-Laird, 1983). This approach is useful in a qualitative study (Desthieux et al., 2010) enquiring the cognitive representation of the environmental system of a person. It gives us an understanding of how an individual structure the environmental issues in his/her mind, how it changes over time and how these changes might influence the behaviour and actions in the future (Lynam & Brown, 2012). Mental models are also one of the important tools useful in exploring the different understanding of concepts one holds about a particular issue, integrating perspectives from various stakeholders and assisting in the decision-making processes of resources related to complex systems, while also learning about the social system (Pahl-Wostl & Hare, 2004). In the context of water resource management, this has been used to understand the perceptions and dynamics of water-related issues and the impact of climate change on it (Kolkman et al., 2007; Levy et al., 2018). M. J. Kolkman's frames and mental model's framework is mentioned below to demonstrate how a mental model is structured. The mental process entails uncovering and segregating systematically hidden information and identifying feedback and delay that enable or inhibit the sustainable function of natural resources (Jones et al., 2011). It basically helps in understanding the cause and effects as an interaction between the individual's mind and the external world (Doyle & Ford, 1998). The process of representing this information in a mental model further involves converting the data into a visual representation in the form of diagrams or models. The concepts and relations are connected and highlighted to show the flow of perceptions of the individual or the group. In our study, we have used the indirect elicitation technique of constructing mental models, that is to draw a conceptual and relational model extracted from interviews or verbal texts (Jones et al., 2011; Wood et al., 2012). In this, we have created models that represent the group's experience, beliefs, values

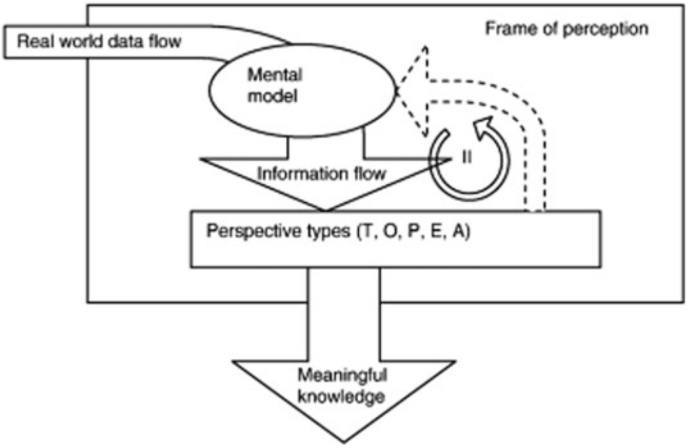

Fig. 15.2 Theoretical framework by Kolkman et al. (2007)

and understanding of sustainable groundwater resources from the information obtained through interviews received in a narrative form (Fig. 15.2).

The agriculture system is a composite of environmental resources that are managed by humans to produce food and food-related resources. The action an individual takes is the outcome or the behaviour one arrives at based on the quantum of resources one has, the influence of the external factors on these resources and the psychological attitude one possesses that is shaped by their experiences and perceptions about the system. Here, we have classified the behaviour influencing factors into three groups and drawn a mental model elaborating on the consequences of these factors:

1. **Behavioural aspects**—Behavioural aspects in a human are responsible for one's behaviour after considering the endogenous (socio-economics) and exogenous (outside forces) factors. These aspects are perceptions, beliefs, moral norms, habits, attitudes, feelings & emotions, thoughts, knowledge, etc. based on the cognition of a being, from the senses and thought processes one develops from external experiences.
2. **Endogenous** (Socio-economics/Dependent variables)—The factors are the tangible resources farmers physically deal with while having them in their possession. Farm characteristics such as farm size, soil quality, mechanization, number of plots, labour, distance between market and farm, membership with the institutions, etc. The factors are receptors of the individuals' behaviour from the decisions made.
3. **Exogenous** (outside forces/independent variables)—These factors are those that are not in the farmer's control. These are outside forces that have an effect, in the form of support or pressure on the resources the farmers deal with. The factors involve market functioning (price), climatic

factors, market, institutional support and assistance, national and local policy and planning, accessibility of information and inputs, etc. These have a direct or indirect impact on the socio-economic factors. The intensity of these factors on the dependent variables has a bearing on the decision-making process of an individual.

Behaviour is an outcome of the psychological processes of perception, attention, memory, language, motivation, emotions, etc. when encountered with external events which require a response and reaction to (Heidbreder, 1945; Resick et al., 2010). In the water management context, understanding the psychological functioning is imperative as it determines the coping, adaptive and/or sustainable behavior of an individual towards surface and groundwater resources (Blackstock et al., 2010; Waldman et al., 2020).

Data Collection

For the study, a stratified sampling technique was applied to select members from the 03 GMI group for the interviews. Since each group is a composition of farmers belonging to different class categories, namely; marginal, small, medium, and large land owing class categories, the list was bifurcated accordingly and selections were made proportional to the composition in each category. The purpose to follow this technique was to cover the perspectives of farmers coming from different land class backgrounds. There were about 26 respondents selected for the interviews. Table 15.2 shows the details of this bifurcation. They were approached to with the help of WOTR's local staff or Jal Shevak/Wasundhara Sevak.

A semi-structured open-ended questionnaire was prepared pertaining to questions related to water, agriculture, climate, market, GMI group formation and functioning, relation with group members and related points, etc. The questions were framed in a way to capture the extensive narrative each member had about the aforementioned topics. The duration of interviews ranged between 30 minutes to 1 hr 15 minutes. The interviews were conducted in Marathi, the local language of the model villages. They were recorded in an audio recorder. The member were asked open-ended questions including, but not limited to, the following questions:

1. What was the agricultural, water, and market sales condition before joining the GMI group? What challenges did you face then?
2. What were the encouraging/supporting factors that led you to join the GMI group?
3. What changes do you see in the agricultural, water, and market sales condition after joining the group?
4. How has your relationship been with the group members before and after joining the group?

5. Are there any suggestions you would like to give for better functioning of the model and group?

Data Analysis

Interview Translation
As mentioned above, the 26 interviews were recorded in Marathi language. They were translated and transcribed in English for the purpose of initiating the analysis. It is pertinent to be familiar with the local context, intonnation and terminology to capture the essence of the interviews and translate the same in English. Hence, the audio was divided between two researchers who were familiar with all these aspects. Once the interviews were translated, there was one round of data scrutiny done by the other two researchers who conducted the interviews. The scrutiny involved listening to the audio interviews and reviewing the translation. It was done to ensure data accuracy and capture those that were missing. After this process, the translated files were assembled to proceed with the next step of coding the interviews.

Interview Coding
The output of the translated interviews was in a narrative form transcribed on word files. The next step required separating the narrative into its respective themes. Themes are narratives having a common reference point and different ideas around it have an association to (Vaismoradi et al., 2016; Graneheim & Lundman, 2004). The Dedoose qualitative analysis software was used for this process of separating and recording the themes. All 26 interviews word

Table 15.2 Interviewed group details

Group micro-irrigation group details		*Jalna*	*Ahmednagar*	
		bhokardhan block	*Parner block*	
		Tigalkheda—GMI group I	*Ranmala—GMI group II*	*Bhagadewadi–GMI group III*
GMI Area (acre)		32	6	65
Total. No. of Farmers		14	6	47
Farmers Composition	Marginal	1	–	2
	Small	3	2	24
	Medium	6	4	19
	Large	4	–	2
Interviews conducted	Marginal	1	–	1
	Small	2	2	6
	Medium	2	2	7
	Large	3	–	1

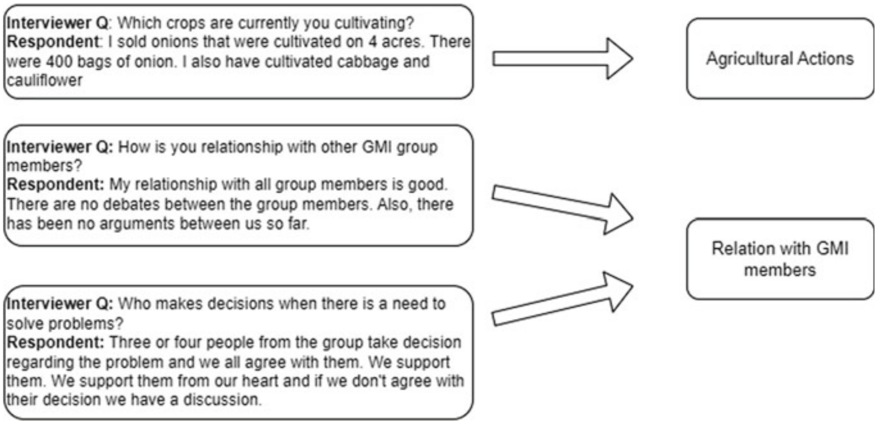

Fig. 15.3 Thematic segregation of narrative data

files were uploaded on the software. After this, there were codes created for each theme (thematic code) such as water actions, water challenges, climatic conditions, reasons for joining the GMI group, etc. The codes were created considering the objective of the analysis i.e.; to identify the factors responsible for the farmers' behaviour (output as an outcome of inputs (factors)) for adopting sustainable agricultural practices or technology to adapting from climate-related challenges and vice-versa. Each word file was scanned, narratives were highlighted and added to their respective thematic code (Fig. 15.3). These steps are illustrated below:

Analysis

Once the narratives were added to their respective thematic codes, the next step was to start with the analysis of the segregated data. The data was downloaded in the form of an Excel sheet. The codes were clustered and added under the psychological, endogenous, and exogenous categories as where they belonged to. Within each category, the codes were added under the titles 'enablers' and 'disablers'. Enabler in the psychological aspects means positive perception, in the endogenous aspects means positive behavioural outcomes and in the exogenous aspects means external factors supporting the endogenous aspects. And, the disablers are the existing challenges highlighted in the perceptions, endogenous and exogenous aspects that are dissuading factors to GMI adoption. These are the factors, according to the farmers, that suppress the optimal capability of the GMI model of water sharing. Following this step of separation, the mental models for each GMI models were created. The positive variables are coded in *black* and the disablers are highlighted in *red*. The results of these models are elaborated below.

15.5 Results

This results section explains the mental models of the farmers of the three diverse features in terms of GMI model structure and locations they belong to.

Mental Model Flow of GMI Group Farmers in Tigalkheda

In the Tigalkheda GMI model, the farmers mentioned that the perception of better, clear and timely, guaranteed and systematic agricultural, water supply and transportation operations were the encouraging factors to join the GMI group. They believe group unity formed from their father's and grandfather's times and faith in a key person have made it easier, mentally, to join the group. They have been witnessing faster growth in agriculture, an increase in knowledge due to the operation as a group. Earlier, they were pessimistic about the success of the model, however, discussions, enquiries and clarification, and support from family members changed their view about the model. The resultant (actions/behaviour) of these positive aspects was adopting the micro-irrigation model. They talked about cultivating food and vegetable crops for commercial sales. They started using upgraded technology and transitioning gradually from complete chemical to organic fertilizers. They shared about the use of water from their ancestral well, refurbished for the model, working efficiently through drip irrigation. The systematic functioning of the GMI has contributed to an increase in income. From the external sources they received assistance and guidance from key village persons, WOTR and the Agricultural departments' officers for water efficient use and agriculture. Due to better quality of farm produce they received good market rates. Merchants have started visiting their farms to make purchases of production, and they also sell the produce to NAFED-FPO who give them better prices. Since merchants have been purchasing directly from their farms, they have been saving most of their transportation costs. There are some who continue transporting production for sales individually or in small groups.

Besides these positive aspects, they reported negative perceptions and challenges they are currently facing. They reported that during the formation of the group some farmers were discouraged by other farmers to join. Moreover, as people have different perspectives and goals, it takes time to unite the farmers for participating in the intervention. They mentioned climate change including increasing instances of dust storms, erratic and irregular rainfall and fog occurrences to be the major deterrent factor for the challenges they face in agriculture. They face crop damage due to erratic and irregular rainfall, therefore low production. Water in the GMI well is available only till February or March, therefore cultivation is restricted to these months and hence they are unable to reach the optimal functioning of the GMI. As water availability is still a concern, they cannot take high-yielding crops. The cost of cultivation and transportation has increased due to climate change. Inconsistent market rates are the cause they think doing single-farming or taking different crops is more beneficial. And continuous electricity supply is an issue also contributing to low production (Fig. 15.4).

Mental Model Flow of GMI Group Farmers in Ranmala

In the Ranmala GMI group, their primary motive to opt for the GMI model was to make water available and have technology for efficient use of water. The participating farmers intended to receive guaranteed, systematic, organized planning and distribution of water supply, production and transportation of sale. They believed group farming would reduce transportation costs that they pay individually. They believed these aspects for them was believed to bring prosperity to farming in the future. These farmers too were pessimistic about the success of the model, however with being battered by the water crisis, after discussions they accepted the idea of forming a group. Sustained belief in key persons who help operate the group also has helped them maintain the change in their perspective. Talking about the inter-relational aspect, they mentioned that as members belong to the same village or relatives, therefore there is better coordination and no conflicts. They think that increasing memberships in the existing group or forming a new group require farmers to have a good level of compatibility with other member farmers, like-mindedness and trust in each other for handling water distribution. This positive change in perception and uptake of the model has encouraged them to cultivate commercial crops such as food and vegetable crops (cereals, cauliflower, cabbage, etc.). Earlier, the land was uneven, but later land leveling was done to start the cultivation. Land levelling work was a part of the GMI model essentials. They mentioned about improvement in crop production after upgrading to new technology, transitioning to organic fertilizers and efficient use of water. Better quality crop production has given them better market rates. Also, they started selling the farm produce in groups which have reduced their transport costs.

On the other side, they shared disappointment about the GMI operations which led one member to withdraw from the model. Here too, changing weather conditions is a major factor in the disturbance of the agricultural operations in this group. Water through GMI is available till February or March. Weather-varying conditions are causing low productivity, increasing instances of pests and insect attack, and crop damage due to low water supply, therefore causing an increase in chemical fertilizer usage. As their financial status is comparatively lower, they are unable to make capital investments. And even if they wish to make investments, low rainfall and groundwater availability dissuade them. Shortage of labour during the harvest season is another reason for the low production. They have issues with bulk production as they receive insufficient market rates when the supply is more and demand is less (Fig. 15.5).

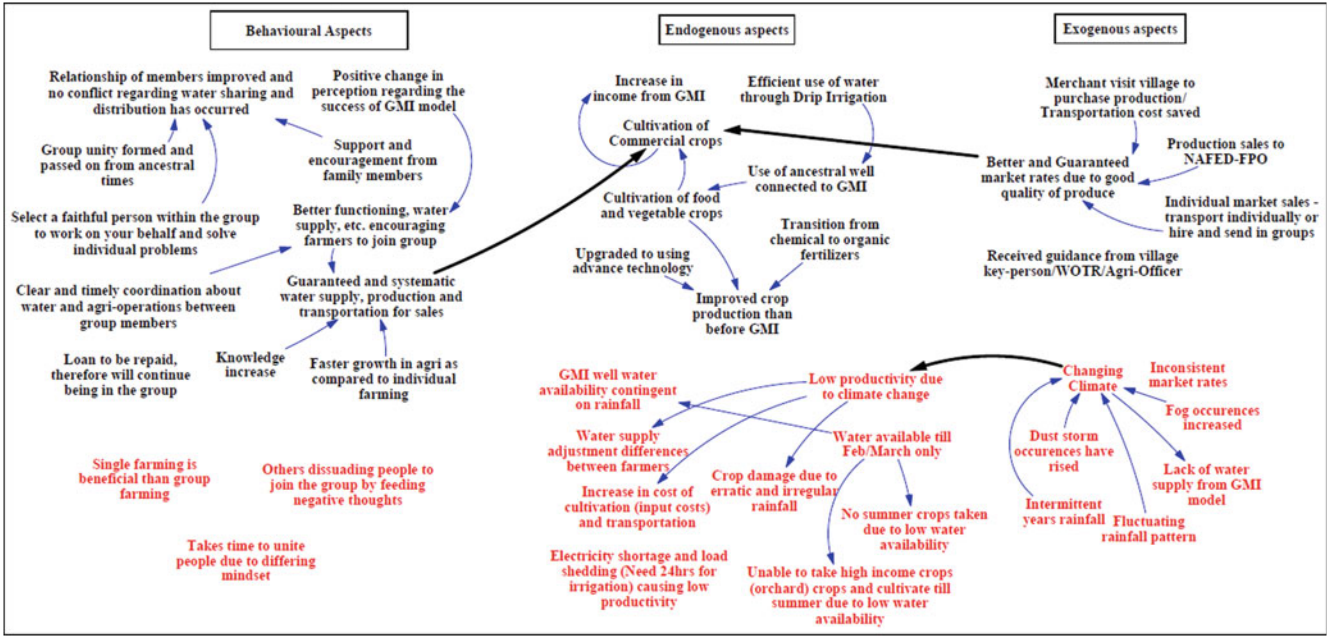

Fig. 15.4 Tigalkheda GMI group mental model

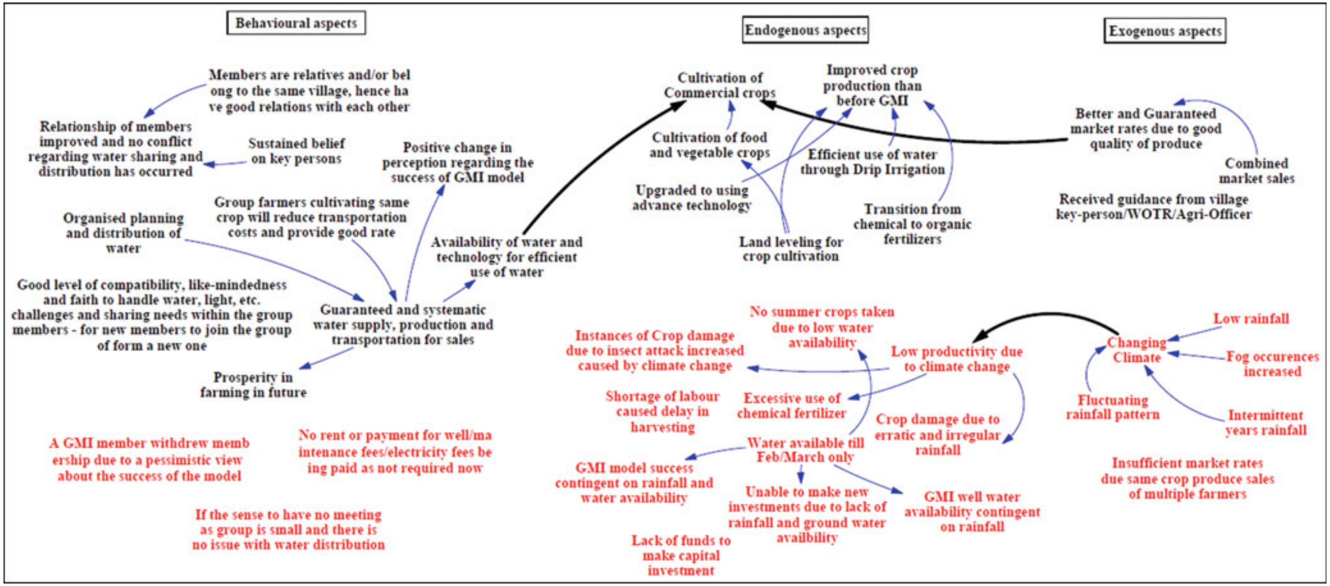

Fig. 15.5 Ranmala GMI group mental model

Mental Model Flow of GMI Group Farmers in Bhangadewadi

In the Bhangadewadi group, members mentioned the perception of guaranteed, systematic, clear and timely coordinated water supply, production and transport led them to join the group. The other factors that encouraged group decision-making was engaging in joint farming, easy access to schemes and grants. The absence of water resources led them to change their pessimistic view of the model and joined the GMI group. Exposure visits to the model village of Tigalkheda, Jalna, helped increase their knowledge about the model and also helped realize the importance of micro-irrigation over flood irrigation. They believe they are receiving water as per their requirement and would feel the shock of water scarcity only in famine situations. They have good relations with the group members because they belong to the same village or are relatives. According to them, good management of water within the GMI group would attract new memberships. These positive feedbacks from their perceptions have led them to join the group and start cultivating commercial crops such as food, vegetables and horticulture crops. There were land levelling work done, the farmers transitioned to using organic fertilizers, upgraded to using advanced technology. They have been applying fertilizers through a drips system. They did not have to wait for the entire duration of irrigation as before as it is automated. There is efficient use of water being done through drip irrigation, their land fertility has improved and have water until summer at times. There are smaller groups formed within the group taking up same crops to manage for good market rates. And their productions has increased they reported that they have been receiving a good return on their production that has increased their income and further reduced their debts. Merchants have been visiting villages and as the sale is done as a group their cost of transportation has been reduced.

Climate change has been a major factor causing low production. Apart from these, they mentioned inconsistent and insufficient market rates as problems. They also consider bulk production reducing the chances of getting a better price. Some have mentioned government officers and their schemes and support do not reach general farmers. Climate change has caused an increase in borrowed funds to agricultural operations as cost of inputs has increased, and excessive chemical fertilizer application. They mentioned most of the market fertilizers they receive are adulterated. Shortage of labour causes delays in harvesting and cultivating unsustainable crops. They were unable to automatize the system further due to a lack of funds. Some are dissuaded from taking up organic crops as they have to delay results with regard to an increase in productivity and therefore income. Regarding the perceptions, they believe a smaller group size with a comparatively lesser land area would have been better for better management, adequate supply of water and get the good market price. Electricity problems, according to them, dissuade new membership as water-related issues may arise later. Uniting people for the formation of groups is tedious (Fig. 15.6).

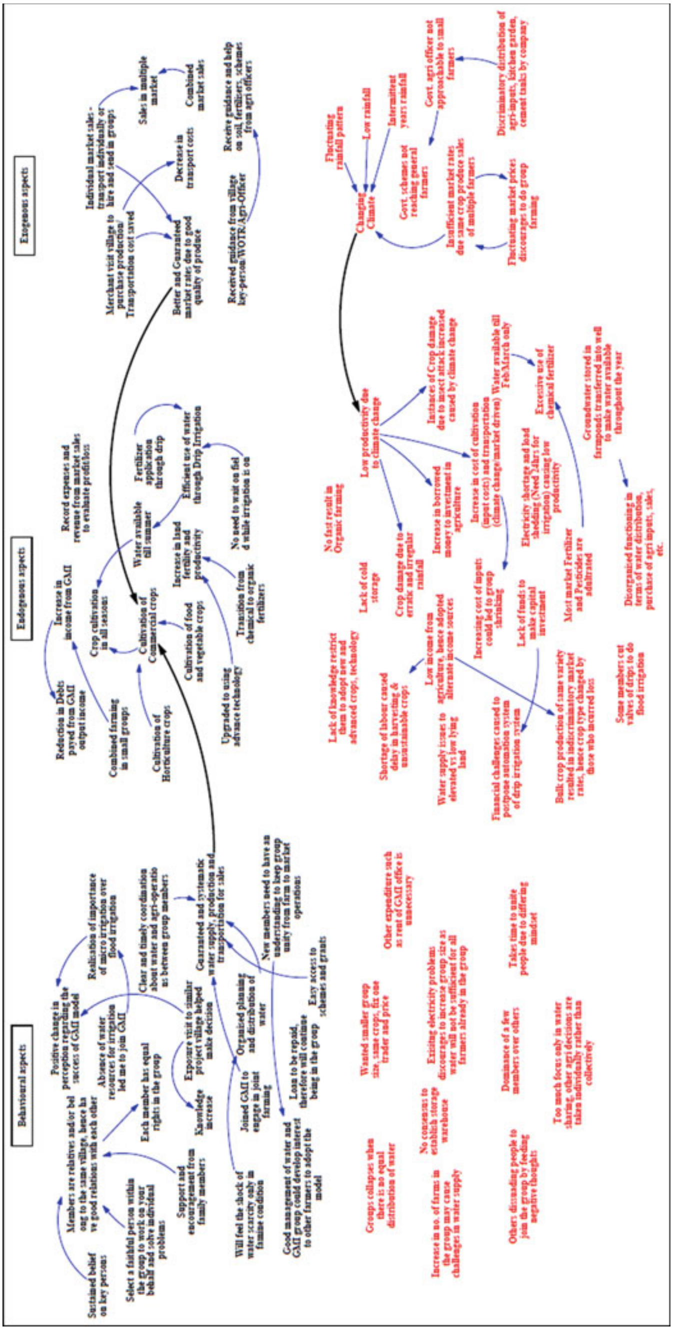

Fig. 15.6 Bhangadewadi GMI group mental model

15.6 Discussion and Conclusion

Groundwater is considered a reliable source of water; acting as a key parameter for the sustenance of economic activities. Any decrease in this, increases the level of vulnerability of the users against external forces such as climate change (Burke et al., 1999). P. M. Kelly and W. N. Adger defined vulnerability with the support of an analogy of a 'wounded soldier', with the perspective of drawing attention to the constraints a soldier possesses that limit his capacity to respond to stress i.e.; cope, recover or adapt to, effectively (Kelly & Adger, 2000). An individual or a social group's adaptive capacity is not only determined by the socio-environmental-economic factors such as five capitals (natural, physical, financial, social and human), access to knowledge, institutions, etc. in their surrounding but also the socio-cognitive factors perceptions, cognitive biases, etc. Studies conducted on the socio-cognitive factors for adaptation have found that adaptation are contingent on social values, perceptions and intentions of individuals and social groups, and that it is a more effective measure to assess adaptive capacity than the traditional socio-economic factors which are substitutes for measuring adaptation (Grothmann & Patt, 2005; Truelove et al., 2014; Mortreux & Barnett, 2017).

The socio-cognitive-behavioural aspect can be assessed from different dimensions of cognition that when combined becomes bases for a behavioural response. For instance, the risk-taking perspective and willingness play an important role in determining the level of involvement with adaptation and reduction in disaster risk. The absence of hope in oneself caused by the lack of the five capitals, to tackle water or climate setbacks, can be a barrier to one's adaptation capacity (Grothmann & Patt, 2005). An individual dependent on the psychological aspect of cognitive biases could be highly low in adaptation capacity and display unsustainable behaviour. Cognitive biases can be explained as a process of thinking deviating from rationality or creating a subjective reality based on decision heuristics, or cognitive shortcuts (attributes that comes easily to mind), social or cultural pressure or emotions (Waldman et al., 2019). Building adaptation capacity needs a well thought plan that should have far-reaching effects in the future. Motivation for adoption has majority of the time been a catalyst for an individual to overcome or safeguard from current and future stress. Practitioners and policymakers play an eminent role in stimulating this part of the cognition process. Such as in our study areas, farmers were motivated to adopt the GMI approach by providing the idea of having water available for multiple seasons by starting with sharing water through micro irrigation. Also, they were provided with financial assistance to begin with.

These factors as discussed are only a few of the long list of cognitive-behavioural aspects that need traction to study the adaptation process. In the Indian context, it is more of an urgency than just an exploratory phenomenon, considering the level of vulnerability to hazards emanating from climate change. India is a country of diverse beliefs, social practices, customs and knowledge, besides having diversity in climatic, topographical and ecological aspects. A thorough assessment is needed to understand the diverse perceptions, beliefs and conceptual understanding of the environmental factors that affect people and in particular farmers in India. There should be a gradual shift from a mere descriptive approach to a predictive approach to inform policy. Conducting such studies have the potential to generate salient approaches that when integrated will benefit policy and practices, raising it from sub-optimal levels to more impactful ones. To begin with adopting the already existing approaches such as the Theory of Planned Behaviour (TPB), the Value-Belief-Norm (VBN), Trans-theoretical Model (TTM), and other such approaches that explain or predict behavioural actions from different mitigation related dimensions, talk about motivating pro-environmental behaviour (Whitmarsh et al., 2021). In our context of water sharing, these approaches would be valuable in finding ways to accept the idea of common pool resources and encourage the adoption of group micro-irrigation with healthy agriculture practices as a community.

Limitation: Climate change and water stress produce dynamic effects. Therefore, the feedback process to the mental model will be fluctuating as some may come early and some may delay. In this uncertainty and complexity, the mental model captured for one particular time may or may not be replicable or scalable for some other place and time. Hence, multiple ways of addressing the problem are to be applied to cover a major extent of the issue. The mental model should be revisited to adjust the dynamic feedback. Not doing so will result in misinterpreting the reality and incorrectly informing policy recommendations or interventions that may lead to adverse effects. Therefore, caution needs to be exercised in capturing information and be more elaborate as possible.

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