Building Resilience to Climate Change: Water Stewardship in Rainfed Agrarian Villages in Maharashtra, India

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Contents

Introduction 2
Key Challenges for the Water Sector and Rainfed Agriculture 2
Groundwater: The Backbone of Arid and Semiarid Regions 3
Impacts of Climate Change on Groundwater Resources 3
The Theoretical Framework Adopted in the Water Stewardship Initiative 4
Existing Frameworks and Models of Explaining Human Behavior 4
Overview of the Water Stewardship Initiative 7
Water Governance: The Concept and Experiences 8
Rationale and the Objectives of the Water Stewardship Initiative 9
The Water Stewardship Approach 10
Specific Objectives of the WSI 11
Key Components and Processes Adopted in the WSI 12
Institutional Development and Capacity Building 12
Preparation and Implementation of Water Budgets 14
Piloting Key Principles of the Maharashtra Groundwater (Development and Management) Act 2009 17
Results and Outcome of the WSI 19
Recommendations 21
Conclusion 22
References 23

Abstract

In rain-dependent drylands of India, unseasonal rainfall and decrease in precipitation cause losses in agriculture-related livelihoods and water scarcity for humans and livestock. Traditional knowledge and local water governance practices of rural communities are unable to cope with these newer risks and losses. Hence, it is necessary to equip people with knowledge and tools to take informed decisions at

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the farm, enterprise, and community levels that enhance resilience and adaptive capacities. This chapter is based on lessons learnt and observations from implementing a Water Stewardship Initiative (WSI) that seeks to facilitate a cognitive and organizational shift by bringing science, policy, and governance together at the level of practice and community action. This initiative was launched by the Watershed Organisation Trust, a not-for-profit organization, in 100 villages in Maharashtra State, India. In the WSI, the approach adopted is of "co-production of knowledge for behavioral and institutional change" toward building the communities' knowledge and capacity to effectively face varying weather conditions. This chapter presents the approach, key concepts, and a process applied in the WSI and highlights its potential to be taken forward in other similar regions. It has the potential to influence state policies in the water sector.

Keywords
Behavioral change · Equity · Drought · Governance · Resilience · Sustainability · Water budget · Water security · Water stewardship

Introduction

In the rain-dependent drylands of India, increasing droughts and climate variability are observed to cause a drastic fall in agricultural production and acute water scarcity for domestic use. Models indicate that by 2025, in the absence of appropriate action to save water, the combination of population growth, economic growth, and climate change will create scarcity far and wide (Roger 2008). As a result of the rapid reduction in India's groundwater, the per capita freshwater availability is lowered to 1545 cubic meters per year, as against the 5000 cubic meters per capita per year when India become independent in 1947 (Singh and Rahal 2013). This is far lower than the 1700 cubic meters that is the threshold for water stress (Khurana and Sen 2012; Prakash et al. 2013). Hence it is necessary to equip communities with the knowledge and tools to take informed decisions at farm, enterprise, and community levels that build adaptive capacities and enhance their resilience.

Key Challenges for the Water Sector and Rainfed Agriculture

Maharashtra, the third largest state in India, has a total geographical area of 30.76 million hectares (mha) of which 52% is prone to drought (GSDA 2014). In groundwater-dependent arid and semiarid regions, water resources required to meet the multiple demands, such as livelihoods, food, and domestic use for an increasing population, are at risk due to the increasing area under agriculture and irrigation (dependent on groundwater extraction) and changes in the rainfall regime. Users are barely literate about water and its judicious use; they consider groundwater

a private good. The lack of appropriate and effective governance mechanisms for water resources has established the rule of capture resulting in anarchy in groundwater management (Shah 2009).

The general understanding in India is that water beneath the land belongs to the owners of land (Ballabh 2008), which is well described by Ramaswamy Iyer (2003), "water is attached like a chattel, to the land property." This has led to mismanagement of groundwater resources particularly by the better-off in rural areas, putting responsibility on the state to provide water for all, while it negates the responsibility of communities to manage their locale specific resource. Market price fluctuation for farm produce and a shift to high external input commercial crops worsens the groundwater crisis and farmers' woes. It is not just the economic and productive uses of water, i.e., livelihoods that are under threat, but water for domestic and sanitation needs and particularly the work load of women.

Groundwater: The Backbone of Arid and Semiarid Regions

In the 1950s and 1960s, the share of surface water to groundwater in irrigation was around 60% and 30%, respectively (Shankar et al. 2011). By the end of the last decade, groundwater replaced surface water irrigation as the main source (ibid.). A report of the "Expert Group on Groundwater Management and Ownership" of the Planning Commission in 2007 states that in 2004, 28% of India's blocks showed alarmingly high levels of groundwater extraction (Planning Commission 2011) due to its use in irrigation. Today, irrigation in India is highly dependent on groundwater sources with nearly 90% of the rural water needs met by groundwater sources (Prakash et al. 2013), making it the backbone of India's agriculture and drinking water security (Shah 2013).

A recent report of the Groundwater Surveys and Development Agency (GSDA), a leading state agency in Maharashtra, indicates that since the past 5 years in many regions of the state, the water level by the month of October is drastically reduced. The report points out that of the 353 blocks, in 230 blocks (10,167 villages), the water level has dropped by over 1 m; in 2587 of the 10,167 villages, the groundwater level has decreased by over 3 m. The report also warns that 7139 villages in 132 blocks may face water scarcity for drinking water during 2018 (GSDA 2017). The CGWB report (2017) states that in the last 10 years, groundwater levels have fallen in around 50% area of Maharashtra (TOI 2018).

Impacts of Climate Change on Groundwater Resources

In water resources management today, climate change and global warming are of growing concern as India is one of the largest and most important regions of high overall human vulnerability (Thow and Blois 2008). The climate change phenomenon is directly related to patterns of the monsoon behavior and change in temperature, as global warming is likely to intensify, accelerate, or enhance the

global hydrological cycle (IPCC 2008). Data shows that the hydrological cycle is already being impacted (Dragoni and Sukhija 2008). Precipitation forecasts for India suggest higher but more variable rainfall, except in the drier parts, where rainfall could decrease. While the intensity of rainfall may increase, the actual number of rainy days may decrease. The changing patterns of rainfall and runoff are expected to significantly impact groundwater recharge and availability (Zbigniew et al. 2009), thus in water-scarce years, farmers and other users will mostly depend on groundwater options to compensate for inadequate rainfall and surface water supplies. The scenarios also indicate that after good rainfall years, the dry period of low or no rainfall which is currently of 2–3 years may increase to 4–5 years, and with the average global temperature rising, the rate of evaporation of surface water will also increase.

Therefore, in the rain-dependent drylands of India within which much of Maharashtra falls, erratic rainfall and drought will result in a drastic drop in agricultural production and acute water scarcity for drinking and livelihood needs. Hence it is necessary to prepare and equip rural communities and farmers with knowledge, skills, and the means to address these challenges. This chapter is based on experiences in 100 villages where the Water Stewardship Initiative (WSI) is implemented by the Watershed Organisation Trust (WOTR) with an aim to facilitate a cognitive and organizational shift by bringing science, governance, and policy together at the level of practice and community action. The approach adopted in WSI is of "co-production of knowledge and learning for behavioral and institutional change" toward building community knowledge and enhancing their capacities to effectively deal with varying weather conditions.

The Theoretical Framework Adopted in the Water Stewardship Initiative

As discussed in the above section, at the center of this initiative is the motivation and mobilization of individuals and community for behavioral change around water-use practices. The initiative is designed to address the drivers of the individual's behavior and how these can be used to enable the primary actors to take appropriate measures for water use that is economically efficient, socially fair, and environmentally sustainable.

Existing Frameworks and Models of Explaining Human Behavior

In existing literature and analysis of behavioral change practices, the "Theory of Planned Behavior" proposed by Ajzen and Fishbein, the "Social Cognitive Theory" of Albert Bandura, "Institutional Analysis and Development Framework (IAD)" of Elinor Ostrom, and "Governance Dynamic Framework (GDF)" of Subodh Wagle are important and widely used frameworks that analyze the behavioral underpinnings of individuals and of the community as a whole.

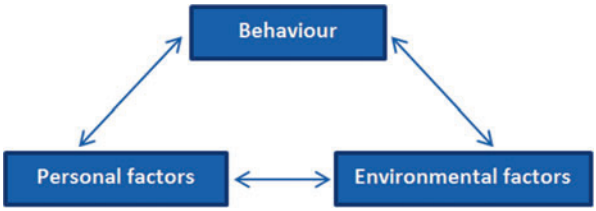

Fig. 1 The social cognitive theory model. (Adapted from Bandura 1986)

Theory of Planned Behavior (TPB)

The TPB proposes the "intention" of an individual, driven by beliefs and values of the outcome of the action, and also of opinions of society, i.e., general social pressure, that trigger one's (individual) behavior (Fishbein and Ajzen 1975). When seeking behavioral change, the intention, i.e., the personal gain, is seen as most important; hence it is necessary to present information to an individual such that it addresses both the outcome of the intention and the subjective norms that support the desired behavior (Sommer 2011). However, the individual must have the confidence of being able to achieve the desired behavior which is manifested by a perceived control over opportunities, resources, and skills needed for change. In short, the theory states that the attitude toward behavior, subjective norms, and perceived behavioral control together shape an individual's behavioral intentions and actions.

Social Cognitive Theory

The "social cognitive theory" proposes that external and environmental factors shape an individual's behavior rather than inner forces. As depicted in Fig. 1, the external situation in which an individual is located (environmental factor) drives a person's behavior, which is also influenced by individual traits and motivational forces (personal factors) (Bandura 1999).

To enhance levels of self-efficacy (personal factors), the individual's confidence needs to be boosted by provisioning of resources and support. However this theory proposes the need for incentives, rewards, and an encouraging environment for shaping good behavior.

Institutional Analysis and Development (IAD) Framework

The IAD framework developed by Elinor Ostrom (2011) helps to understand how actors/stakeholders behave in particular action situations and how the dynamics of their interactions and behavior are shaped by rules and norms in the given context. Applied and tested in a range of situations, it systematically analyzes how individuals behave in the structure of situations faced and determines how rules and attributes of the surrounding environment and local community affect these situations over time (Smajgl et al. 2009). While this theory acknowledges that in simple situations individuals may act rationally, it posits that in complex circumstances, individuals lack complete knowledge and means to act in a fully economically rational manner (Ostrom et al. 1992; Polski and Ostrom 1999).

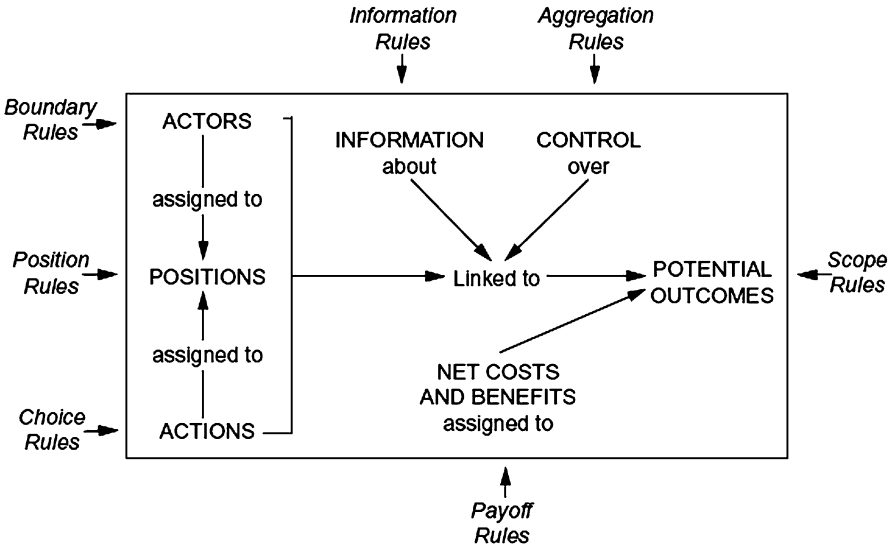

Fig. 2 Rules as exogenous variables directly affecting the elements of an action situation. (Adapted from Ostrom 2011)

Central to the IAD framework is the "action arena" characterized by the (a) physical and (b) social context and (c) institutional arrangements (Polski and Ostrom 1999). These three attributes contextualize the action arena where underlying factors affecting the action output are addressed. According to the IAD framework, as depicted in Fig. 2, all action situations include seven elements: (1) *participants* who have specific (2) *positions* that decide between various (3) *actions* based on (4) *information* they have about how the actions are (5) *linked* to possible (6) *outcomes* and the ensuring (7) *costs and benefits* (Ostrom 2011). These seven types of working rules can affect the structure of an action situation (actor's behavior). As illustrated in Fig. 2, the cumulative effects of these seven types of rules affect an action situation while the individual takes decisions and acts.

Governance Dynamic Framework (GDF)

GDF presents a schema of interactions between behaviors of actors involved and the relevant public policies and development interventions (Wagle 2011). The framework explains that the misalignment between the goals of policies or programs and actors' behaviors mainly occurs because actors are not fully prepared to take appropriate actions. Thus preparedness of the actor to adopt expected behavior/actions is at the center of GDF (Kale 2018). Preparedness of actors comprises of four preparedness elements (PEs), viz., (a) awareness, (b) vision, (c) willingness, and (d) abilities, which are influenced by innate factors related to the actors. These innate factors related to the actors that shape the preparedness elements are here referred to as preparedness determinants (or PDs) which include (i) internal norms (unwritten, informal rules), (ii) interests (tangible and intangible), (iii) information and

knowledge the actors have, (iv) formal rules of the governing agencies (where the actors function), (v) resources and capabilities of the actors, (vi) pressures and enticements from other actors, and (vii) environmental factors (that make the expected behavior more convenient). Thus, the GDF presents an extensive set of determinants which shape the individual's behavior and recommends that, while making any efforts toward changing the actor's behavior, the preparedness determinists have to be well addressed.

Behavioral Change Approach Adopted in WSI

The understanding behind development of the WSI is that rural farming households in water scarce regions are driven by market pulls and the need for income from an increasingly uncertain agriculture. Access to water resources holds the key to success, particularly as low rainfall, delayed monsoons, prolonged dry spells during monsoons and droughts are on the increase. Water in rural areas is considered a private resource; those who can capture such a resource draw maximum benefits, an idea which unintentionally is supported by some government schemes. Excessive extraction of groundwater by a few causes inequity, yet people tolerate it considering this their "fate." In a nutshell, the different dimensions of groundwater and its availability (the invisible resource) are barely discussed at village level.

Hence to bring people together to manage water resources responsibly, it is necessary to demystify knowledge through providing scientific information in a manner that is understandable by the village community. Technical tools for preparing sound water budgets, bringing various village groups (based on land and water accessibility) to actively engage in a realistic understanding of their context and preparation of plans, are easily accepted by people. Besides capacity building and trainings, workshops and discussions around real-life situations in their villages get people actively engaged. But most of all, putting the village community at the center, not as recipients of generosity but as key players and "stewards" with responsibility and authority to develop and use their resources, is an important attitude required in the WSI.

Contribution of WSI to the SDGs and Policy Process

The WSI provides important contributions for achieving the Sustainable Development Goals – SDG 6, 12, 13, and 16 – and in the context of climate change where 1.5–2 °C temperature rise is expected by the end of the twenty-first century (IPCC 2014). The water budget process discussed here becomes useful to build the community's capabilities to adapt to adverse conditions and reduce threats while obtaining water for agriculture and drinking needs.

Overview of the Water Stewardship Initiative

This section provides an overview of experiences of local water governance in India and, in particular, the WSI that the Watershed Organisation Trust (WOTR) has implemented in 100 villages in Maharashtra.

Water Governance: The Concept and Experiences

The concept of people managing water resources is not new in India. Groundwater depletion and the consequent misery have triggered attempts to create a new social order of "community-based natural resource management" (CBNRM). The argument behind CBNRM is that there exists a certain kind of cooperation and community solidarity within village communities that sustains with endogenous or exogenous stimuli when the expected outcomes are for the benefit of the concerned group (Lopez-Gunn and Cortina 2006). These ideas are echoed in experiments by social entrepreneurs like Anna Hazare and Popat Rao Pawar, the best-known examples of community revival through participatory watershed and water resource management in Maharashtra (World Bank 2010). Besides these, there are numerous successful participatory watershed development projects where NGOs put community at center. The works of Hardevsingh Jadeja in Rajsamadhiala village near Rajkot; Swaminarayan Sampraday and Swadhyaya Pariwar in Saurashtra, Gujarat; Rajendra Singh of Tarun Bharat Sangh in Rajasthan; and the late Vilasrao Salunke's Gram Gaurav Pratishthan in Maharashtra are few pioneering voluntary, self-regulated community-based experiments toward sustainable use of groundwater (Shah 2009). These experiments went beyond just harvesting rainwater to invoking visions of its sustainable and judicious use. However, most of such successful initiatives are characterized by the presence of charismatic leadership and/or are location specific; therefore do not offer a process-based approach/model that can be upscaled. The Andhra Pradesh Farmer-Managed Groundwater Systems (APFAMGS) project stands apart. The APFAMGS experiment indicates that carefully designed community-based approaches hold significant promise for addressing groundwater use, especially in hard-rock aquifers (World Bank 2010). These successful initiatives, however, challenge the underlying assumptions in the discourse and practice of groundwater management in India that "legal and policy reform is a necessary first condition for attempting groundwater management in the country" (ibid.).

At the international level, Integrated Water Resource Management (IWRM) is promoted since the 1990s. For equitably maximizing economic and social welfare without compromising the sustainability of vital ecosystems, IWRM promotes a coordinated development and management of water, land, and related resources (UNEP-DHI 2009; Harsh 2012). In many developed countries, the IWRM framework is practiced by allocating water through regulation and incentive mechanisms such as water pricing (Shah and Prakash 2010) which increases the efficiency of water use and allows for better maintenance of the water-related infrastructure. However, in countries like India, the challenge in applying IWRM practices is mainly in formalizing the existing informal water economy (Shah and Koppen 2016) where the number of water users is large and water resource management is compartmentalized into surface and groundwater managed by departments and agencies. As the proportion of the population in India which does not have access to the most basic facilities of safe and adequate drinking water and sanitation is large, putting a price on water for these sections is not justifiable and possible (NWM 2010). For promoting IWRM practices, the financial, infrastructure, and human

capacities of countries to fulfill the responsibility of water governance matters a lot, which are, however, inadequate in India (Azhonia et al. 2017). Although in many countries the IWRM approach is not very successful (ADB 2007), it has provided an important framework for integrated water management and a tool for establishing multi-stakeholder dialogue.

At the global level, systematic large-scale experiences in community-based groundwater management come principally from Mexico and Spain, which have adopted community-based models as central in their official groundwater governance and management policy. In these countries, groundwater user associations or aquifer management councils are statutorily promoted as the institutions for collective and participatory self-governance of aquifers. While these community institutions have been successful in some aspects, they have not been able to achieve the basic objective of demand management to ensure sustainable use of groundwater resources (Shah 2009). The assessment of such experiences for possible application in India indicates that merely substituting the community by the state cannot work unless groundwater management interventions are structured to serve the basic interests of and management by the users while taking into account the socioeconomic realities of the ecosystem needs of each particular groundwater setting (Kale 2018). Therefore, while it is clear that the circumstances of groundwater use in most settings of India necessitate the adoption of community-based interventions, the growing and explosive demand on groundwater use is the cause of overexploitation of aquifers, and its management is a challenge for both people and the government.

Rationale and the Objectives of the Water Stewardship Initiative

Considering the above discussion, there is an urgent need to move beyond supply-side enhancement of participatory watershed development (WSD) toward the demand-side management and improvement in water governance at the local level. This is the underpinning of the Water Stewardship Initiative. In these 100 villages, soil and water conservation structures and/or WSD is ongoing or has been completed, and while water availability and agriculture productivity show a marked increase (Vani et al. 2007), these villages also experience water shortage for irrigation and domestic use in summer. It's because of the absence of effective regulations on water use, the shift to cash crops, and increased lifting of groundwater for agriculture particularly by the better endowed farmers. Watershed Committees have not been proactive and are not confident enough to set up water-use norms and practices. Unequal water access in villages has reached to an extent where better-off farmers have water available in their farm ponds promoted through government schemes, even in the dry season and drought periods, while in the same period, the lesser endowed farmers and women struggle to fetch water for their basic needs from public tankers (Kale 2017). It is assumed that the state is responsible for meeting the various water needs of the people, while individuals and communities do not have any responsibility which reinforces a dependency syndrome. Community action which is the key to village development and progress is lacking in most villages.

At another level, healthy dialogue and cooperation between government officials and village communities does not occur besides the implementation of government schemes, e.g., in the water context, those who have water resources and can construct farm ponds and apply for micro-irrigation, both of which are beneficial to the resource rich. Moreover, water extraction for agriculture generally lacks relevant scientific information and knowledge of the agroclimatic and hydrogeological conditions that are essential for planning appropriate water use.

The Water Stewardship Approach

To address the challenges discussed above, WOTR designed an approach to "Water Stewardship" that brings key actors into a dialogue to achieve mutual cooperation, to develop a plan of action and implement the same. The "Water Stewardship" approach treats all water users as important stakeholders – "water stewards" – with the potential to be "good water managers" who also protect the resource base and ensure its sustainable, judicious, and efficient use (AWS 2014). This concept considers the needs of every individual, their livelihoods and livestock, along with the ecosystem. The use comes with a responsibility and accountability to oneself and the community for its proper management. The different water users are not passive beneficiaries who may exploit the resource, but custodians who also have the responsibility to protect and manage it for the generations to come.

In WSI, the water resource is seen as public trust rather than private entity. Hence this approach sees the necessity to bring the different users/stakeholders together on one platform to discuss, dialogue, be informed, and come to a consensus in preparing a plan and executing the same. The water stewardship approach has three levels of important actors: (1) the primary stakeholders, i.e., all households within a given geography of a village who are the water users for different purposes; (2) the secondary stakeholders are the neighboring villages that affect or are affected by the water availability of a particular village, e.g., the downstream and upstream villagers; and (3) the tertiary stakeholders are decision-makers, administrators (government officials), water experts, donor agencies, and civil society agencies, who influence the water-related activities at the village level. These diverse stakeholders need to come on one platform for a common understanding and collective planning for the sustainable management of this precious resource. Hence, the WSI requires not just a set of actions to be carried out by the primary and secondary stakeholders but also needs to be informed by sound scientific knowledge so as to make informed decisions. Consensus building through dialogue and workshops (stakeholder engagements) is important where perspectives, aspirations, and conflicts between the different groups are encouraged to surface and sustainable solutions are sought.

This chapter presents the experience of WSI implemented in 100 villages in Maharashtra, India. To find pathways to address the critical balance between supply and demand-side management and achieve water security in varying weather situations, a scalable WSI model is implemented in a semiarid region, regularly affected by drought and heavily dependent on groundwater for agriculture and

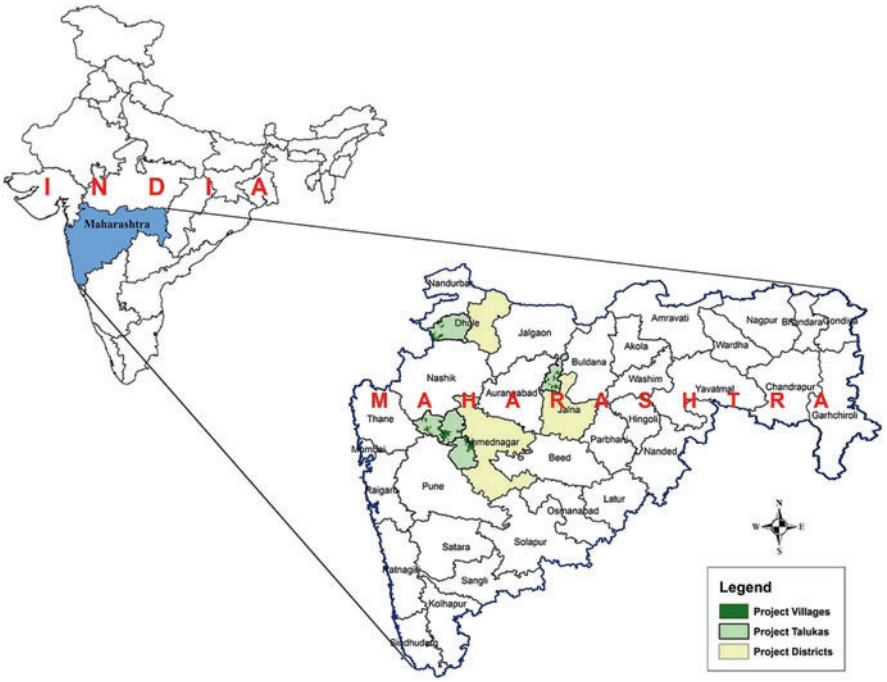

Fig. 3 Locations map of the project villages of WSI

domestic use. These villages are spread over five blocks in three districts (refer to Fig. 3). In this region, both extreme weather events and slow-onset disasters (low rainfall, droughts, and drought-like conditions) and increase in annual and summer temperature affect income from agriculture and increase pressure on water requirement for living, livelihoods (agriculture and livestock), and nature.

The goal of the WSI is to ensure that water at the local level is managed in a responsible manner and is socially equitable, environmentally sustainable, and economically efficient in climate-varying conditions.

Specific Objectives of the WSI

In line with the goal, the five specific objectives set for the WSI are:

1. Building skills and capacities of villagers to prepare the Village Annual Water Budget that ensures water availability for domestic use and that minimizes crop losses.
2. All households of the village are motivated and facilitated to prepare plans for harvesting rainwater (in the initial years) and for increasing water productivity

("more crop per drop") through the adoption of water-efficient technologies and practices.
3. The village – either the Grampanchayat or its subcommittee – is motivated, organized, and guided to formulate norms for water management and to implement effective water governance arrangements such that it ensures equitable access to and availability of water for domestic use for all local inhabitants throughout the year.
4. To promote a common understanding and trust between different stakeholders of the water sector, i.e., the primary, secondary, and tertiary stakeholders.
5. Develop workable operational guidelines to upscale the initiative in similar conditions (arid and semiarid regions) with appropriate contextual modifications.

Key Components and Processes Adopted in the WSI

This section provides the details of different components, activities, and processes adopted and executed in the WSI that are essential for achieving the desired outcomes. While implementing these components, conscious effort was made to achieve quantifiable targets as well as qualitative richness to ensure the motivation as well as skills and capacity enhancement of the primary stakeholders.

Institutional Development and Capacity Building

As institutions are the "pillars of governance," in the WSI, the Village Water Management Team (VWMT) is responsible for water stewardship. *Jal Sevaks* support and guide the VWMT toward meeting the goal of sustainable water management.

Jal Sevaks

Jal Sevaks (water volunteers) are crucial to this initiative. They play the important role of organizer, facilitator, and motivator to VWMTs for the preparation and implementation of water stewardship plans. *Jal Sevaks* are committed and motivated rural youth having a passion for the progress of their villages and are capacitated to handle various challenges in the water sector at the level of village and cluster of villages. They organize villagers of all land and water ownership categories to (1) form Village Water Management Team (VWMT), (2) conduct a baseline inventory of the existing soil and water harvesting structures with detailed measurements, (3) facilitate and guide the VWMT to prepare water stewardship plans, and (4) motivate villagers to implement the same. The *Jal Sevaks* promote water literacy and its management.

However for effectiveness (achieving good impacts and outcomes) and for addressing conflicts and challenges, the *Jal Sevaks* require continuous skill enhancement (Kale et al. 2018) and handholding through interactions and on-field experience, particularly to engage with their own community. As water management is

Photo 1 Exposure visit of *Jal Sevaks* to learn water budget preparation. (Photo Credit: Mohan Dhuldhar, WOTR)

based on water available in the year, i.e., related to climate variability, bimonthly training workshops equip the *Jal Sevaks* to prepare weather-varying water budgets. As they have an intense time-consuming role extending to a number of villages, financial incentives motivate the *Jal Sevaks* to give dedicated time and effort toward the WSI (Photo 1).

Thus, by engaging rural youth (*Jal Sevaks*) and building their capabilities, WSI has resulted in developing a cadre of motivated and skilled water stewards who can take forward water management practices in villages.

The Village Water Management Team (VWMT)

As discussed earlier, the water stewardship approach goes beyond treating water users as passive "beneficiaries" or "target" groups and looks on them as "water managers." Provided with adequate information and knowledge of the different aspects of water as a "good" essential for life, as a "resource" meant for all living creatures and for the ecosystem, and as a resource that needs to be used and protected, the VWMT is motivated to understand their responsibility of governing the water resource effectively. All users are considered stewards of their respective water resource; therefore they necessarily need to adopt good water management practices. To sensitize this diverse set of village-level stakeholders, representatives of different categories of households within a village, e.g., landownership groups, landless, women, and other water-dependent livelihood groups, are selected to form the

VWMT. This team is responsible for the preparation and execution of village water stewardship plans that engage all villagers.

VWMTs are appropriately capacitated to lead and be responsible for water governance in the village. Their roles and responsibilities include to create a positive environment for adoption of water management, ensure that the Gramsabha (village general body meeting) takes the appropriate and timely resolutions required to meet good water management practices, monitor the local rainfall and collect groundwater data, and implement the water stewardship plan in the village, which includes (1) half yearly water budgets, (2) water-saving/conservation plan, (3) water-use efficiency plan, (4) setting the necessary rules/norms to implement these plans, and (5) approach different government departments, NGOs, and corporates to obtain the necessary support for convergence to realize the water stewardship plans.

Bringing Diverse Stakeholders Together Through an Engagement Process

For good water management, the diverse stakeholders who have a shared problem and use the same resources at various levels (within a village, clusters of villages, and aquifer) need to be engaged in focused dialogue. During such events, sharing of scientific information of the cluster of villages or even of the block is useful to develop a common understanding of the landscape, the water resources, and the climate variability – all of which affect the livelihood of the particular group of villages. In such a forum, the stakeholders understand the link of one village to another and how together they can take decisions to improve crop production while using the available water sustainably. Stakeholders need to meet at least every half year to plan and act accordingly, based on water availability. Bringing the respective government officials, experts, and facilitating agencies (tertiary stakeholders) to these engagements further strengthens the WSI. Stakeholder engagement workshops foster free and healthy discussions and interaction between participants and help uncover the various aspects and surface queries particularly the sticky problems. Relevant scientific information presented during such discussions provides a good basis for understanding the problematic aspects of water management.

Preparation and Implementation of Water Budgets

Once the VWMT is motivated to take concrete action for improving their village water health status and address related problems, they are guided to prepare the village water budget. Most of the existing water accounting and budgeting tools are either at river basin or at a macro-watershed level where its application faces many difficulties (Kale and Sathe 2017). This water-budgeting tool presents a practical and sound method at village and micro-watershed level for approximately 1000–2000 ha. The tool and methodology is described in detail in the Manual for Water Stewardship (Kale et al. 2018) based on WOTR's experience in water budgeting of over 10 years. The tool is designed for agrarian villages to facilitate and mobilize them to prepare appropriate crop plans based on the available water

including rainfall decrease and also ensure water for domestic use and livestock for all households throughout the year. The water budget preparation process follows three steps: (1) calculation of the total water availability, (2) calculation of the water requirement for different uses, and (3) planning the use of the balance water for different crops.

Preparation of the Village Water Budget

The exercise of water budget preparation is done twice during the agriculture year: around the month of March, the first water budget is prepared which calculates the annual requirement, i.e., for domestic use and livestock and water use for agriculture in the monsoon, winter, and summer seasons. This helps to assess the amount of water that can be harvested within the village from structures earlier constructed and to identify those that require maintenance. The second water budget is prepared in the first week of October (post-monsoon), to precisely calculate the available water at the end of the monsoon and to plan its use for all needs particularly for agriculture in the winter and summer seasons. Currently water for ecosystem services is not factored in the water budget tool applied in the WSI, as estimates of water requirements for ecosystem services in the Indian context is not yet available.

Based on the water available for agriculture including perennial horticulture, villagers discuss and decide the types of crops to be sown and the area (number of hectares) that can be cultivated. Often, a water budget results in deficit water because people cultivate a greater area than planned; besides they may also cultivate water guzzling crops. An understanding of the water available provides them the opportunity to revise their crop plans so as to minimize the deficit and thus crop loss.

The water-budgeting exercise may result in either surplus water in the village, after meeting all water requirements, or a deficit in meeting these requirements. The results of the exercise highlights to the VWMT and villagers the overall picture of the water-use plans for agriculture. It gives them the opportunity to understand their water resources and the potential and different water needs of the members of all categories of households of their village. Through this exercise in most villages, people become aware that the area of agriculture planned is greater than the water available – which would otherwise lead to crop and investment loss. They are also aware that they often compromise the water needs for domestic use and for livestock. The exercise is thus an eye opener. As a first reaction, the VWMT and villages make efforts to revise the total water required for crops by reducing the area under cultivation; however, even after this revision, the deficit remains. To address the deficit, the water stewardship tool provides three sub-plans which focus on supply- and demand-side measures, as well as governance mechanisms: (1) additional water-harvesting plan, (2) water-saving plan, and (3) preparation of social governance rules to ensure the efficient water use.

The Water-Harvesting Plan

To address water deficit in the budget, a water-harvesting plan gives an opportunity to inhabitants to increase the water-harvesting potential within the village either by

repairing defunct water-harvesting structures or, where appropriate, undertaking new soil and water conservation measures.

Water-Saving Plan

Besides addressing the supply side, it is important that water-saving measures are adopted through water-use efficiency practices in irrigation along with soil quality-enhancing practices. Water-saving plans enable villagers to assess the existing water-use practices and determine the initiatives that can increase water saving. Water-saving plans include the use of micro-irrigation (drip, sprinklers), mulching that reduces evaporation, and organic and vermicompost that increases the biomass content of soil. The VWMT motivates its farmers to adopt these practices and assists in linking them with the different government schemes.

Water Governance (Social) Rules

For implementation of crop plans based on the water-budgeting exercise and the sustainable, equitable, and efficient regulation of water use, it helps when villagers themselves formulate the rules to control their own behavior and practices. Initiated by the VWMT, the rules are decided upon at the Grampanchayat level and ratified at the Gramsabha, so that it becomes obligatory to all in the village. Here are some examples of rules prepared: (1) no direct lifting/pumping of water from surface water bodies such as check dams and percolation tanks, (2) government norms for the depth (not more than 200 ft) for borewells to be complied with, and (3) ban or limit on the area under water guzzling crops. Thus, the water stewardship plan is a comprehensive tool that motivates villagers for water governance as well as helps them to implement and monitor their actions.

Execution of the Water Stewardship Plans

The effectiveness of the processes and transparency in its execution determines the level of success of the WSI. These are essential to achieve the expected impacts.

Clarity on the water stewardship plans and water-budgeting processes are shared in the Gramsabha by the VWMT, and only after open discussions, it is ratified by the Gramsabha. All the necessary social norms required for ensuring sustainable and judicious water use in the village and execution of the water budget plan are discussed and finalized by the Gramsabha. The final water budget details are displayed on a notice board located at a public place within the village.

In our experience of its implementation, during the pre-monsoon period (March to May 2016–2017 and 2017–2018), the VWMT and *Jal Sevaks* sensitized and mobilized villagers for contributing *shramdaan* (sweat equity) to repair the soil and water conservation structures. In few villages people constructed new stone bunds, continuous contour trenches (CCT), and water absorption trenches (WAT). In other villages, besides *shramdaan*, villages were able to access government schemes. After preparing the water conservation plans, the VWMT presented the same to the concerned district government officials, which initiated a dialogue between the government authorities and the proactive local community. Thus, preparing and executing water stewardship plans create a space for people to work

together for water management in a way that generates a positive relationship with the respective government departments and both contribute to responsible water management.

Piloting Key Principles of the Maharashtra Groundwater (Development and Management) Act 2009

The Maharashtra Groundwater (Development and Management) Act 2009 (henceforth referred to as the 2009 Act) (GoM 2013) came into force in the State in December 2013. The broad objective of the 2009 Act is to strike a balance between protecting drinking water sources and promoting the optimum utilization of groundwater for irrigation. For ensuring the supply of adequate drinking water and sustainable groundwater use, the main approach set in the law is to create an institutional structure for community participation, which was absent in the provisions of the earlier 1993 Groundwater Act of the state (Phansalkar and Kher 2006). To achieve the abovementioned broad objective of the 2009 Act, two new governing agencies, i.e., the State Groundwater Authority and the Watershed Water Resource Committee (WWRC), are proposed. Limiting the depth of wells, securing drinking water availability throughout the year, aquifer-based groundwater use plans, and prospective crop plans based on groundwater budgets are few important measures proposed in the State's 2009 Groundwater Act (Kale 2018). These broad strategies are further articulated for three types of areas based on water stress: (i) notified area, (ii) scarcity area – within the notified area, and (iii) non-notified area (GoM 2013).

The 2009 Act is well intended and focuses on institutional building with remedial measures; however it is somewhat vague on provisions regarding allocation of necessary resources and the capabilities required to effectively carry out functions. The WWRC is considered an important governing agency at the local level, and has been given major functions and authority such as granting permission for sinking wells, implementing prospective crop plans; yet, the proper process and system for establishing transparency and accountability in its functioning is not elaborated in the 2009 Act. However, the effective implementation of provisions proposed in the Act regarding preparation and implementation of prospective crop plans, limiting the depth of wells and mandatory permissions for new wells, has potential to change the status quo in the area of groundwater overexploitation in the state.

In the WSI, key principles of the 2009 Act are tested on a pilot basis with the intent to operationalize the Act.

Prospective Crops Plans

The Act mandates preparation and implementation of prospective crop plans based on the available water stock. In the WSI, in all project villages, capacities and skills of the VWMT and villagers have been developed to prepare and execute water-budgeting plans, which include both supply- and demand-side measures and ensure drinking water availability. These plans are prepared and executed by the VWMTs.

Photo 2 Aquifer management workshop at Bhokardan block with 3D maps (CDVI). (Photo Credit: Eshwer Kale, WOTR)

Institutional Governance at Aquifer Level

The Act proposes formation of the WWRC comprising of 11 villages or more. This scale is proposed considering an aquifer boundary where villages share the common aquifer. They come together to benefit from the aquifer by managing it in a sustainable manner. To explore the practical possibilities, aquifer-based management is piloted in the Bhokardan block of Jalna district, where representatives from 14 villages share a common aquifer work together. Water resource literacy was initiated by applying the tool called CoDriVE-Visual Integrator (CDVI) which resulted in a three-dimensional model of the landscape above and the shallow aquifer characteristics below surface level. A group comprising of key persons from these 14 villages formed the aquifer-based committee. They were capacitated with motivational exercises and activities to plan water use at the aquifer level (Photo 2).

Rules for Water Use

The Act bans sinking deep well (below 60 m) in notified areas and has a provision to levy a cess on extracting groundwater below 60 m in non-notified areas. Currently in the WSI, communities formulate their own rules rather than have these externally enforced. However, it is acknowledged that strict policy rules at the state level create a supportive policy environment for motivating villagers to frame Grampanchayat and aquifer-level rules. In the project, through the intensive stakeholder engagement process at the cluster of villages' level, and by informing villagers of the key provisions of the 2009 Act, the VWMTs were motivated to frame rules considering their local context. In more than 80 villages, the VWMTs have framed such rules that have been ratified by the Grampanchayat. The rules framed are mainly regarding the

ban on directly lifting of water from water-harvesting structures, putting a ceiling on the depth of borewells, and/or the ban on borewell drilling in the village and a ban on growing water-intensive crops.

Registration of Groundwater Abstraction Structures

Registration of all wells is a precondition for applying the regulations. In the WSI, in sample villages the process of recording the details of all water-harvesting structures and wells, including detailed well inventory, has been completed.

Results and Outcome of the WSI

In project villages, the execution of different components of WSI resulted in improving the overall level of water management, specifically in terms of supply- and demand-side water management and better institutional environment to govern it. These impacts are observed as changes in the behavior of people (water stewards) regarding water-use practices, access, and crop management.

Changes in Behavior of the Water Stewards

Feedback from the primary stakeholders of different regions shows that discussions and information received during the stakeholder engagement workshops have changed the perspective of many villagers; they have come to understand new aspects they were not aware of. As shared by some participants, the stakeholder engagement workshops provided them an opportunity to deliberate and discuss on water issues as a "shared problem," leaving aside all other differences and dynamics of the village. They learnt how to calculate the water budget and to use water efficiently. Many shared that they now understand water as a common property and that everyone has a right to it; therefore water should be used judiciously. Mrs. Meera Ramesh Shinde, a VWMT member from Lingewadi village, Jalna, describes how the situation has changed in her village.

Mrs. Meera Ramesh Shinde (Lingewadi, Jalna)

"Earlier, for fetching drinking water, no private well owners allowed others to draw water from their wells. After exposure and learning about this in stakeholder engagement workshops and discussions of the same within the village, some well owners now switch on their private pumps to allow others to take water for home use. As water is needed for all, even for the animals and birds, we have made special water-troughs for the animals in the remote hilly area where monkeys, wild boar, and deer face difficulties in finding water in summer. They now frequently come and drink water from these troughs."

Although formulation and enforcement of rules regarding water use at village level is challenging, in some villages, the inhabitants have taken the initiative. Mr. Kisan Sakharam Icche, VWMT members from Kotha Jahangir who is also the village Sarpanch, explains how the stakeholder engagement workshops motivated their VWMT for setting village-level rules.

Kisan Icche (Sarpanch, Kotha Jahangir, Jalna)

"Getting motivated through Stakeholder Engagement workshops, we passed a resolution in the Gramsabha on the ban on drilling new borewells and changing crops in the rabi (winter) season in the village. We tried to convince every irrigated farmer to use sprinkler and drip instead of flood irrigation and this year (2017-18), almost 60 to 70% farmers installed drips and sprinklers. Because of the rule, not a single bore well was drilled during this year in the village."

In Kotha Jahangir, the Gramsabha passed a resolution to ban the drilling of borewells deeper than 150 ft, and farmers have to take permission from the Grampanchayat before drilling a borewell. They have also passed a resolution in the Grampanchayat to ban sand extraction from the river bed. Such locally appropriate rules are made in more than 80 villages. The stakeholder engagement workshops have succeeded to some extent in building a common understanding and consensus, changing perspectives and motivating villagers to work together toward the efficient and judicious use of water.

Changes in Local Water Governance

In all 100 villages, VWMTs are formed and members are ratified by the Grampanchayat. Most of the VWMT members have participated in different stakeholder engagement workshops, where they have prepared water stewardship plans comprising of *Jal-Arogya takta* (water health chart), water budget, water-harvesting, and water-saving plans. In many villages, the VWMT succeeded in mobilizing their people for *shramdaan* to repair water-harvesting structures. The exercise of preparing governance rules at the village level is an important contribution of the WSI, particularly as state agencies are still struggling to enforce external regulations on villages for water management. The VWMTs in most of villages have compiled with their water stewardship plans and have submitted the same to district authorities. This is an important exercise where government authorities also experience an encouraging atmosphere at village level to implement their schemes. Villagers too have found a space to interact and dialogue with government authorities.

24 *Jal Sevaks* facilitated and motivated the VWMTs in these 100 villages. They have collected timely and relevant data regarding soil and water-harvesting structures and other socioeconomic details of the villages. In all these villages, water budgets are displayed on boards in prominent locations where the VWMTs regularly update the water budget for the current season. In all the villages, two manually operated rain gauge units are installed, where the VWMT members monitor the local rainfall. These activities have resulted in creating important spaces for villagers to discuss and share their interest and concern regarding water management practices.

Benefits of Increase in Water Availability and Governance

Between the 100 villages, they annually harvested a total of approximately 38 billion liters of water stored in different water-harvesting structures and brought this under governance through water budgets and local rules. In more than 60 villages, people provided *shramdaan* to repair water-harvesting structures or construct new ones (61 sand-bag dams across streams) and implemented the soil- and water-harvesting project of the government or other funding sources – a convergence initiative. Through these efforts, 8.95 billion liters of additional water-harvesting potential has been created. More than 2000 farmers have adopted practices of micro-irrigation (drips, sprinklers, and mulching) and, through this, saved 3.24 billion liters of water.

The WSI has promoted a community-embedded scientific method of water budgeting at the village level with appropriate governance practices, which enables villagers to effectively handle water stress especially in times of low rainfall. The latter is increasingly becoming a norm (however, if the climate event is very severe, external assistance is required). Ultimately, water security achieved by this exercise leads to an increased and sustained production of crops and livestock as well as water for households and livelihoods.

Stakeholder engagement workshops brought together the hundreds of "Water Stewards," researchers, scientists, and administrators and resulted in an important forum where different aspects of water scarcity and climate change, impacts on livelihoods, and ways to adapt and address these crises were discussed. This helped villagers to understand how climate change impacts them and helped prepare them to better adapt to climate variability. These various actions and interventions work toward building resilience of villagers and the farming community to adapt to climate variability and build their resilience.

Recommendations

Lessons learnt from the experience of the Water Stewardship Initiative can contribute singularly to the sensitive but crucial issue of groundwater use and governance:

1. State governments, donors, NGOs, and even villagers almost exclusively consider addressing drought through supply-side enhancement, e.g., watershed development and soil and water conservation. While this is important, it is the demand-side management and water-use efficiency that are more important, essential, sensitive, and challenging.
2. Villages cannot work in isolation along administrative boundaries to manage their water resources, especially groundwater. The shared aquifer resource lends itself to bringing the related villages together, to work not just on water management but also crop planning and management, which can be further incentivized by promoting market linkages.
3. Promoting water stewardship and building the capacities of communities for water budgeting and effective governance is a medium term (5–8 years) process. In a project mode of generally 2–3 years, sustainability of the efforts put in is

threatened. Given the fact that villages face constant change from exogenous factors, a medium-term commitment with progressively tapering external inputs and involvement is necessary to achieve a sustainable breakthrough.

4. As water for agriculture is the predominant use, women are generally left out. However, women in rural areas are also farmers, and water budgeting also includes water for domestic use; hence it is necessary that women are adequately represented in the VWMT and in all its activities. Including them in the various components of the WSI will bring in a rich diversity of perspectives for managing water, besides addressing gender concerns.
5. Building the skills of local educated youth in conducting water literacy, water budgeting and crop planning is the real need of hour. It motivates youth to be actively engaged in productive and managerial roles and can become a source of income. The *Jal Sevaks* are very useful for this purpose and can contribute meaningfully to the progress and development of their villages.

Conclusion

The phenomenon of climate change being little understood by rural communities, the hydrogeological frame within which each aquifer is set and the unknown quantity of water in the aquifers provide an occasion, reason, and platform that can bring people within a village and aquifer to work together. Empowering communities with scientific knowledge and information and treating them as "stewards" rather than as "beneficiaries/target population and opportunists" place responsibility on them which, when given proper guidance and skill enhancement, they are willing to assume, as demonstrated. They are open to facts and learning new ideas together, discuss their concerns and aspirations openly, dialogue and address conflicts, and work together to find solutions to manage groundwater more effectively and fairly.

Enhancing the skills of the local people, particularly the youth to manage their water resources scientifically while also improving agriculture productivity (through crop-water management) and income through better market access will further incentivize people for sustainable and equitable groundwater management. However, when this is backed by policy and law (e.g., the 2009 Act), there are greater chances of continuity of effective water management practices on the ground. Moreover, as clusters of villages work together, space is created for dissemination of good management practices to neighboring villages and beyond.

The Water Stewardship Initiative responds to a growing social, economic, and ecological demand. It outlines a pathway to ensuring more equitable, efficient, and sustainable use of water for life, livelihoods, and nature in a changing climate that tends toward increasing water stress and scarcity. The WSI has relevance to and offers important lessons to shape the existing legislative framework that seeks to regulate water use. There is, therefore, an urgent need to widely promote the Water Stewardship Initiative in water-stressed, arid, and semiarid regions.

References

ADB (2007) Institutional options for improving water management in India: the potential role of river basin organization. Publications stock No. 110507. Asian Development Bank, New Delhi

AWS (2014) The AWS International Water Stewardship Standard. Alliance for Water Stewardship. Available at http://a4ws.org/wp-content/uploads/2017/04/AWS-Standard-Full-v-1.0-English.pdf

Azhonia A et al (2017) Adapting water management to climate change: institutional involvement, inter-institutional networks and barriers in India. Glob Environ Chang 44(2017):144–157. Elsevier

Ballabh V (2008) Governance of water: institutional alternatives and political economy. Sage, New Delhi

Bandura A (1986) Social foundations of thought & action: a social cognitive theory, 1st edn. Prentice-Hall, Englewood Cliffs

Bandura A (1999) Social cognitive theory: an argentic perspective. Asian J Soc Psychol 2:21–24. Available https://www.uky.edu/~eushe2/Bandura/Bandura1999AJSP.pdf

Dragoni W, Sukhija B (2008) Climate change and groundwater. Geological Society, London

Fishbein M, Ajzen I (1975) Belief, attitude, intention and behavior: an introduction to theory and research. Addison-Wesley Publication Company, Philippines. Available at http://people.umass.edu/aizen/f%26a1975.html

GoM (2013) Maharashtra Groundwater (Development and Management) Act, 2009. Government of Maharashtra. Available at http://bombayhighcourt.nic.in/libweb/acts/Stateact/2013acts/2013.26.PDF

GSDA (2014) Report on the dynamic groundwater resources of Maharashtra (2011–2012). Groundwater Surveys and Development Agency, GoM and Central Ground Water Board, Central Region, Government of India, Nagpur. Available at https://gsda.maharashtra.gov.in/GWSpdf/Talukawise_GWA2011-12.pdf

GSDA (2017) Comparative study of water levels in Oct 2017. Report submitted by Groundwater Survey and Development Agency to Government of Maharashtra, Water and Sanitation Department

Harsh J (2012) IWRM and IRBM concepts envisioned in Indian water policies. Curr Sci 102(7):986–990

IPCC (2008) Climate change and water, IPCC technical paper VI. Available at https://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf

IPCC (2014) Climate change 2013: the physical science basis (eds: Stocker TF et al). Cambridge University Press, Cambridge, UK

Iyer R (2003) Water: perspectives, issues and concerns. Sage, New Delhi

Kale E (2017) Problematic uses and practices of farm ponds in Maharashtra. Econ Polit Wkly LII(3):20

Kale E (2018) Governing the misgoverned. PhD thesis, Tata Institute of Social Sciences, Mumbai

Kale E, Sathe M (2017) Groundwater budgeting. Econ Polit Wkly 52(42–43):4

Kale E et al (2018) Promoting efficient, judicious and sustainable water use: manual on developing water stewardship. Manual under publication, W-CReS, Watershed Organisation Trust

Khurana I, Sen R (2012) Drinking water quality in rural India: issues and approaches. WaterAid. Available at http://www.wateraid.org/documents/plugin_documents/drinking_water.pdf

Lopez-Gunn E, Cortina L (2006) Is self-regulation a myth? Case study on Spanish groundwater user associations and the role of higher-level authorities. Hydrogeol J 14:361–379. https://doi.org/10.1007/s10040-005-0014-z

NWM (2010) Draft guidelines for integrated water resources development and management. National Water Mission, Government of India, Central Water Commission, Basic Planning and Management Organization, New Delhi

Ostrom E (2011) Background on the institutional analysis and development frameworks. Policy Stud J 39(1):7

Ostrom E et al (1992) Covenants with and without a sword – self-governance is possible. Am Polit Sci Rev 86(2):404–417

Planning Commission (2011) Twelfth five year plan (2012–2017): Faster, more inclusive and sustainable growth, sage publication, India. Available at http://planningcommission.gov.in/plans/planrel/fiveyr/12th/pdf/12fyp_vol1.pdf

Phansalkar S, Kher V (2006) A decade of the Maharashtra groundwater legislation: analysis of the implementation process. Law Environ Dev J 2(1):67. Available at http://www.lead-journal.org/content/06067.pdf

Polski M, Ostrom E (1999) An institutional framework for policy analysis and design. Working paper No.W98–27, The Vincent and Elinor Ostrom workshop in political theory and policy analysis. Indiana University, Bloomington. Available at https://mason.gmu.edu/~mpolski/documents/PolskiOstromIAD.pdf

Prakash A et al (2013) Water in India: situation and prospects. UNICEF, FAO, SaciWATERs

Roger P (2008) Facing freshwater crises. Sci Am. Available at http://ohm.ecce.admu.edu.ph/wiki/pub/Main/ResearchProjects/Facing_the_Freshwater_Crisis_Scientific_American.pdf

Shah T (2009) Taming the anarchy: groundwater governance in South Asia. International Water Management Institute (IWMI), Colombo

Shah (2013) Water: Towards a paradigm shift in the twelfth plan, economic and political weekly, January 19, 2013 XLVIIII No 3

Shah T, Koppen B (2016) The precept and practice of integrated water resources management (IWRM) in India. In: Narain V, Narayanamoorthy A (eds) Indian water policy at the crossroads: resources, technology and reforms. Global issues in water policy, vol 16. Springer, Cham

Shah A, Prakash A (2010) Integrated water resource management in India: from critique to constructive engagement. Central Research Institute for Dryland Agriculture, Hyderabad, pp 333–346

Shankar V et al (2011) India's groundwater challenge and the way forward. Econ Polit Wkly XLVI(2):37

Singh Y, Rahal A (2013) Climate change-impact on agriculture and adaptive and mitigative measures. Kurukshetra, Ministry of Rural Development, Government of India, p 39

Smajgl A et al (2009) Outback institutions: an application of the Institutional Analysis and Development (IAD) framework to four case studies in Australia's outback. DKCRC report 31. Desert Knowledge Cooperative Research Centre, Alice Springs

Sommer L (2011) The theory of planned behaviour and the impact of past behaviour. Int Bus Econ Res J 10(1):91. Available at https://clutejournals.com/index.php/IBER/article/download/930/914

Thow A, Blois M (2008) Climate change and human vulnerability: mapping emerging trends and risk hotspots for humanitarian actors. Discussion paper, Maplecro. Available at https://reliefweb.int/sites/reliefweb.int/files/resources/E5549F80673D1E38C12574B0004B698F-care_mar2008.pdf. Accessed on 12 Apr 2018

TOI (2018) Times of India. Dated 22 March 2018. News available at https://timesofindia.indiatimes.com/city/nagpur/groundwater-level-falling-in-almost-50-area-ofmaharashtra/articleshow/63404707.cms. Accessed on 15 May 2018

UNEP-DHI (2009) Integrated water resources management in action. World Water Assessment Programme, DHI Water Policy, UNEP-DHI Centre for Water and Environment

Vani S et al (2007) Best-bet options for integrated watershed management. In: Proceedings of the comprehensive assessment of watershed programs in India. ICRISAT, Hyderabad

Wagle S (2011) Policy and governance: perspective and analytical framework for management of urban sewage. Available at http://gangapedia.iitk.ac.in/sites/default/files/Second%20Set%20of%20Report/009_PLG_Poiic%20and_Governance_Perspective.pdf

World Bank (2010) Deep wells and prudence: towards pragmatic action for addressing groundwater overexploitation in India. The International Bank for Reconstruction and Development/The World Bank, Washington, DC

Zbigniew W et al (2009) Will groundwater ease freshwater stress under climate change? Hydrol Sci J 54(4):665. https://doi.org/10.1623/hysj.54.4.665. Special issue: Groundwater and Climate in Africa