MULTIPLE-USE WATER SERVICES TO REDUCE POVERTY AND VULNERABILITY TO CLIMATE VARIABILITY AND CHANGE

A Collaborative Action Research Project in Maharashtra, India

Final Report

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Multiple Use Water Systems to Reduce Poverty, and Vulnerability to Climate Variability and Change

Executive Summary

Rural water supply schemes in India are generally designed for single use, i.e., domestic use. The multiple water use priorities of poor rural households in order to reduce their hardship, and enhance food production, health and income means that in water-scarce areas, the domestic water use can run into conflict with productive water use. The failure of water supply agencies to design the water supply system for multiple uses results in the communities not being able to realize the full potential of water as a social good. This is because they end up spending long hours trying to fetch water for productive needs, or reallocating the available supplies for productive needs.

Another likely outcome is that the water supply scheme ends up being used for productive as well as domestic needs. While some uses might get absorbed by the system, some uses can damage the very system. This is compounded by the often irregular and unreliable nature of water supplies. Water supply systems, which do not take into account the needs of rural communities for sustainable livelihoods, fail to occupy an important place in their day to day life. As they do not perform economic activities out of the water supplied, communities show low level of willingness to pay for the services. This affects the sustainability of the systems as official agencies are not able to recover the costs of their operation and maintenance.

Today, there is growing appreciation of the fact that a marginal improvement in drinking water supply infrastructure and the volume of water supplied could enhance the value of water supplied remarkably in social as well as economic terms. But, planning of water supply systems for multiple uses is hindered by lack of comprehensive data on the incremental costs and returns. Over and above, water supply planners often believe that additional water resources to meet multiple needs would be difficult to find in a local area. Hence, there is a need to explore such a system to assess their real costs, to ascertain the sustainability of water supplies, to gain insights into institutional development for its management, and outcomes and impacts.

This report covered the findings of a pilot project undertaken on developing and implementing a multiple use water systems in villages, one each from three regions of Maharashtra, which represent three different agro-ecological and socio-economic settings. The goal of this project was to develop replicable models of Multiple Use Systems (MUS), which can provide year-round access to water for domestic and productive uses under varying climates for vulnerable households in three *Gram Panchayats* of rural Maharashtra. The project consisted of a research phase, an implementation phase and a post implementation impact assessment phase

The report identifies various household water requirements for domestic and productive uses; study the feasibility of retrofitting the existing village water supply schemes in these villages, including the specific technical interventions finally chosen for each pilot village, which in turn helps to extend their services beyond domestic water supply to provide water for needs like livestock drinking, kitchen gardens and homesteads; suggests institutional arrangements for the management

of multiple use services, which integrates the existing institutions at various levels from village, to the taluka, district and to the state and their interactions; and assesses the impact of the interventions on the vulnerability of the sample households.

The research started with the following: identification of various domestic and productive water needs of the village households; development of a composite index, which captures the vulnerability of rural households to problems associated with lack of water for multiple needs; assessment of multiple use vulnerability of sample rural households in the three villages of Maharashtra; the analysis of socio-economic and livelihood dynamic of the sample households, with particular reference to the impact of climate variability on the HH is undertaken. Documentation of the key steps followed for designing of MUWS models that are suited to the three different settings, and the description of the final outcomes; and, documentation of the key steps involved in working out the institutional arrangements for implementing these MUWS systems and the final outcome.

This was followed by an implementation phase in which the interventions chosen for piloting, backed by DPRs, were executed in the villages. However, the models chosen through research could not be taken up for implementation due to financial constraints faced by GSDA, the implementing agency. Alternative interventions, which, though theoretically less effective than the model MUWS interventions, were developed for each village. The selection of these interventions involved necessary geophysical investigation in the village for their technical efficacy, and rigorous community consultations for their utility and appropriateness. The specific components of the DPRs were implemented before the onset of the monsoon season of 2012. Subsequently, the impact of the interventions on the vulnerability of sample households was assessed using a household survey. Computation of the vulnerability index and its comparison with the values computed prior to the interventions was done subsequently.

The assessment of household vulnerability index after implementation showed some extent of reduction in the vulnerability of some of the sample households to problems associated with lack of water for multiple needs. The highest vulnerability reduction was found in the case of Kerkatta village, which had the highest number of vulnerable households before the intervention. However, to what extent these interventions are really useful in improving the household supply situation in the villages and thereby reducing the HH vulnerability would be known only during summer when the water sources, which are now augmented through the technical interventions, get dried.

The report is organized into 10 sections. The first section deals with the rationale for designing and piloting MUWS. This is accompanied by a brief introduction on the challenges inherent in converting an existing water supply system, presented in Section 2. In the third section, the research objectives and methodology are discussed. Section 4 deals with the process of selection of pilot villages for the action research. Section 5 deals with the development of the vulnerability index. Section 6 presents the results of primary survey with regard to sources of water for different domestic and productive water needs, the access and use of water, and the multiple use vulnerability assessment of the sample households. This is followed by an analysis of socio-economic dynamic of the sample households, with particular reference to the impact of climate variability on the socio-economic production functions in section 7.

In section 8, the synthesis of a review of the MUWSs from around the world is presented, followed by the description of the ideal MUWS model designed for each of the three locations, and the alternatives chosen for final implementation. In Section 9, the synthesis of a review undertaken of several micro level institutions engaged in local water management activities in different parts of India is presented. Subsequently, the institutional arrangement worked out for managing MUWS in the pilot village contexts is presented. Section 9 discusses the progress in implementation of the alternative interventions in the pilot villages and the impact of the interventions on the household vulnerability index of the sample households. Section 10 covers the conclusions.

1. Rationale for Piloting Multiple Use Water Systems

The rural water supply schemes in Maharashtra are generally planned for meeting the domestic water supply needs of the population. But, rural populations have many productive water needs. Households need water for meeting livestock needs, particularly livestock drinking[1]. Rural households, which do not have their own farm land and irrigation sources, prefer water for growing vegetables to meet their domestic needs as it is important for the nutritional security of the families. Households, which are not dependent on agriculture and allied activities for their livelihood, may need water for meeting one or more of the productive water needs such as pottery, fishery, pickle-making and duck-keeping. This will be important for households that are economically poor.

The type of productive water need of a household would depend on the cultural background, the agro-climatic setting and occupational profile of the household. As regards the influence of culture, tribal communities in India generally keep small ruminants such as goat; they also raise chicken; undertake backyard cultivation of vegetables; the tribal communities in north-eastern region rear pigs in their homestead. The influence of agro climate, in high rainfall, sub-humid regions of India, especially in the western Ghat region prompt farmers to raise fruit trees, especially mangoes and guava, as these trees can grow without irrigation. Livestock keeping is emerging as a major source of livelihood even in many low and medium rainfall, arid and semi arid regions of India, especially in areas where cereal crops are intensively cultivated, which makes the availability of dry and green fodder (Kumar, 2007; Singh, 2004). Farmer-households, which own land with irrigation sources, generally grow vegetables in their fields, and therefore would not need water for productive needs in their dwelling premises. Cattle rearers would need water for livestock drinking, unless they have irrigation sources. Families which have regular sources of income from employment would be able to manage without water for productive needs, as their economic conditions would allow them to buy vegetables and milk from the market.

In rural areas, conflicts occur between using water for meeting economic goals and meeting social goals. When water becomes scarce, the poor communities often compromise on their personal hygiene requirements in an effort to meet water requirements for productive needs. Failure on the part of the water supply agencies to maintain supply levels that cover productive as well as domestic needs would result in the households not being able to realize the full potential of water as a social good. This can happen because of two reasons: 1] available water gets reallocated (van Koppen et al., 2009)[2]; and 2] they end up spending substantial amount of time and effort to find water sources to meet the productive needs, which would reduce their ability to fetch water from public systems and use for personal hygiene such as washing, bathing and sanitation. This generally impacts on their productivity in the long run as the communities would become susceptible to water related diseases.

Another possible outcome is that the agency has not designed the infrastructure for multiple uses (like cattle drinking, homestead irrigation), but the system by default becomes a multiple use system. While some of the unplanned uses may get absorbed by the system, other uses can damage it (van Koppen *et al*., 2009). This is compounded by the often intermittent and unreliable nature of water supplies. Water supply systems that do not consider the needs of rural communities for sustainable livelihoods, fail to play an important role in their day to day life. As they

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[1] But, this is applicable to agricultural families which have no source of irrigation. Families which have sources of irrigation would be able to shift their families and cattle to the farms.

[2] Systems planned for drinking water and other domestic uses are used for cattle watering, irrigation and a range of other small-scale productive uses (Lovell, 2000; Moriarty *et al*., 2004).

are not able to perform economic activities out of the water supplied through public systems, communities show low level of willingness to pay for the water supply services. This affects the sustainability of the systems as official agencies are not able to recover the costs of their operation and maintenance. Thus a vicious circle is perpetuated.

But, there is growing appreciation of the fact that whenever such unplanned uses take place from “single use systems” without causing much damage to the physical infrastructure, it brings about improvements in all four dimensions of livelihood related to water. These dimensions are: freedom from drudgery; health; food production; and, income (van Koppen *et al*., 2009). This leads us to the point that a marginal improvement in drinking water supply infrastructure and a marginal increase in the volume of water supplied could enhance the value of water supplied remarkably in social as well as economic terms. But, as many scholars note, planning of water supply systems for multiple uses is restricted by lack of comprehensive data on the incremental costs and returns (Meinzen-Dick, 1997; van Koppen *et al*., 2006; van Koppen *et al*. 2009)[3].

Often it is believed that additional water resources to meet multiple needs would be difficult to find in a water supply scheme. Contrary to this, in most instances, ensuring sustainable allocation of water for the household needs from the available resources, rather than overall availability of water in a locality is a real issue. This is evident from the fact that at the regional level, water requirement for household needs would be a small fraction of the total water required, and even in the most water-scarce region, huge amount of water is consumed in irrigated production of crops. Hence, there is a need to pilot such a system in different agro climatic and socio-economic setting to assess their real costs, to ascertain the sustainability of water supplies, to gain insights into institutional development for its management, and their outcomes and impacts.

The piloting was done in three locations, each one representing a unique agro-climatic and socio-economic setting. It starts with designing systems that can supply water for multiple needs in the village on a sustainable basis throughout the year, and working out institutional arrangements for their implementation. Subsequently, a full-fledged social cost-benefit analysis of the project will be carried out to on the basis of the direct costs incurred for the project, direct benefits accrued from it, and the positive and negative externalities it induces on the society, using primary data collected from the households on various attributes.

2. Introduction to the Project

Many water systems, which are planned as single use systems by default function as multiple use systems. This is applicable drinking water supply schemes as well as irrigation systems (Meinzen-Dick, 1997; Moriarty *et al*., 2004; van Koppen *et al*., 2006; van Koppen *et al*., 2009). Often, these unplanned uses result in major improvements in all dimensions of water-related livelihoods (van Koppen *et al*., 2009). But, in order for communities to realize the full social and economic value of the assets, good and services provided by such systems, it is necessary to design them for multiple goods and services.

The design of a multiple use system would require: identification of different water needs; and assessment of the demand in terms of quantity, quality and reliability of water required, and physical access (distance) to the source and frequency of supply, as all these factors would determine the health and livelihood outcomes of water supply (Nicole, 2000). It also requires finding

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[3] Renwick et al. (2007) had carried out a broad analysis of the incremental costs and benefits from various levels of MUS, i.e., basic MUS; intermediate level MUS; and high level MUS, covering both new systems and up-gradating of existing systems.

a source which together can supply sufficient water to meet these needs. But, types of household water needs are not same across communities. They can change according to the cultural setting; the occupational profile of the households, and the agro climate in which the communities live. Further, the health and livelihood benefits of a water system can be maximized if they are targeted at the most vulnerable households (Howard, 2005; Nicole, 2000).

Hence the challenges of designing multiple use systems for a village or a community are many. It starts from identification of various water needs that, if fulfilled, can generate the maximum health and livelihood benefits for the community to identifying the sources of water, which can meet the new demands in terms of quantity, quality, and reliability to fixing the levels of multiple use service (including the improvements in the physical infrastructure to raise the rate of supply or to improve the access) in a way that the incremental costs do not exceed the incremental benefits. Obviously, improving the service beyond a certain level could result in significant cost escalations, both the resource cost and cost of water supply infrastructure. Therefore, designing a multiple use system will be a compromise between the communities' priorities and what is economically viable. Finally, in order to maximize the health and livelihood benefits, it is important that the MUS interventions target the most vulnerable populations in the village.

Under the ongoing project, we have explored the possibility of retrofitting the existing single use water supply systems in three locations of Maharashtra, rather than designing new MUS systems. The existing water supply schemes considered here are the individual village-level rural water supply schemes, built by the Groundwater Survey and Development Agency of Maharashtra. For this, we have identified the different water needs of sample households in all the villages, including those which are domestic and those which are productive, based on an intensive primary survey of sample households covering nearly 50% of the total population. We have also assessed the vulnerability of these sample households to problems associated with lack of water for these needs to identify the most vulnerable households, which need to be provided with MUS services. For this, we have used a MUS vulnerability index, developed by the project team.

Based on a review of multiple use systems from many countries around the world, we have designed three MUS models, one for each location that fits into its unique physical and socio-economic settings. The model design involved understanding the key (social and technical) feature of various MUSs encountered in the review and which make them function effectively, and short-listing those which are in physical settings that most closely resemble our project locations and which have survived; and implanting the features of these MUS on the water supply systems existing in the three localities. The institutional arrangement for management of these MUS were worked out by undertaking detailed study of the institutional arrangements in selected micro level water institutions, identifying the institutional characteristics that contribute to success of the institutions; determining the institutional arrangement that is most relevant for the multiple water use services that the local MUS has to perform; and, implanting these institutional characteristics into the institutional arrangement proposed for the MUS.

This report also includes outputs of analysis of primary data collected from the sample households on their socio-economic and livelihood dynamic. The changes in outputs from the socio-economic production functions that are directly or indirectly dependent on water such as crop production, livestock and dairy production, outputs from kitchen garden, income from farm labour etc., between normal and drought years were used to assess the impact of climate variability on socio-economic and livelihood dynamics of the rural households.

3. Goal, Objectives and the Methodology

3.1 Goals and Objectives

The goal of this project is to develop replicable models of Multiple Use Water Systems (MUWS), which will provide year-round access to water for domestic and productive uses under varying climates for vulnerable households in three *Gram Panchayats* of rural Maharashtra. The project has the following objectives:

1. To identify and assess the key domestic and productive water needs of poor rural households and the different physical and socio-economic factors that lead to improved access to and safe use of water by them which can produce positive developmental outcomes.

2. To develop an index reflecting the vulnerability of poor rural households to negative consequences of inadequate and unreliable access to water for their multiple needs in the context of climatic variability and livelihood security of these households.

3. To design sustainable Multiple Use Water Systems for the most vulnerable households in at least three programme locations (DPR) and institutional arrangements for their implementation based on background research.

4. To pilot the model of MUSs based on DPR in three project locations in Maharashtra.

5. To influence the relevant water sector departments in Maharashtra to adopt an MUS approach in the design and implementation of new schemes or in the rehabilitation of existing ones.

3.2 Methodology

The methodology employed for achieving various objectives are described as follows:

Objective 1: In order to identify and assess the different water needs of the poor rural households, a survey was undertaken covering these households using the tool already designed and developed. The focus was on the quantity and quality of water required for various socio-economic reproduction functions. They included water for drinking & cooking; water for domestic uses such as washing, bathing and toilet use; water for livestock drinking; and water for kitchen gardens.

Participatory research methods was employed to identify the range of physical and socio-economic factors that determine the vulnerability of poor rural households to negative consequences of reduced access to adequate and reliable water supplies for these needs; and the order of ranking. Some of the factors are: number of water supply sources; reliability of water from the source; distance of the household to the source; the time required in fetching water; the quantum of water obtained; the storage facilities available for storing water; the demand for water for meeting various needs in terms of quality and quantity.

Objective 2: Developing a Water Supply Vulnerability Index: The above factors were used to derive a water supply vulnerability index for poor rural households that truly reflect the negative consequences associated with inadequate and unreliable access to water supply for multiple needs. This will be a composite index with several sub-indices.

Some of the most widely known indices related to water such as the Water Poverty Index developed by Kellee Institute (Sullivan, 2002), the physical water scarcity index developed by M. Falkenmark, and the more recent ones, including the sustainable water use index developed by Kumar and others (Kumar *et al.*, 2008) in IWMI and the WATSAN vulnerability index developed by Arghyam/IRAP (2010) were studied for the purpose.

Objective 3: Data pertaining to factors determining the vulnerability of the poor households to the negative consequences of inadequate water supply for multiple needs from the existing water supply systems will be collected through the primary survey in the three villages using the research tool already developed. These data, which form the benchmark for assessing the performance of the interventions, will be used to compute the water supply vulnerability index during pre MUS interventions.

Socio-economic & Livelihood Impacts of Climate Variability: The impact of climate change and variability on the water-based livelihoods was worked out by analyzing the changes in outputs from the socio-economic activities of these poor rural households that are dependent on water availability directly or indirectly. DFID's livelihood framework will be used for this analysis (Diagram 1).

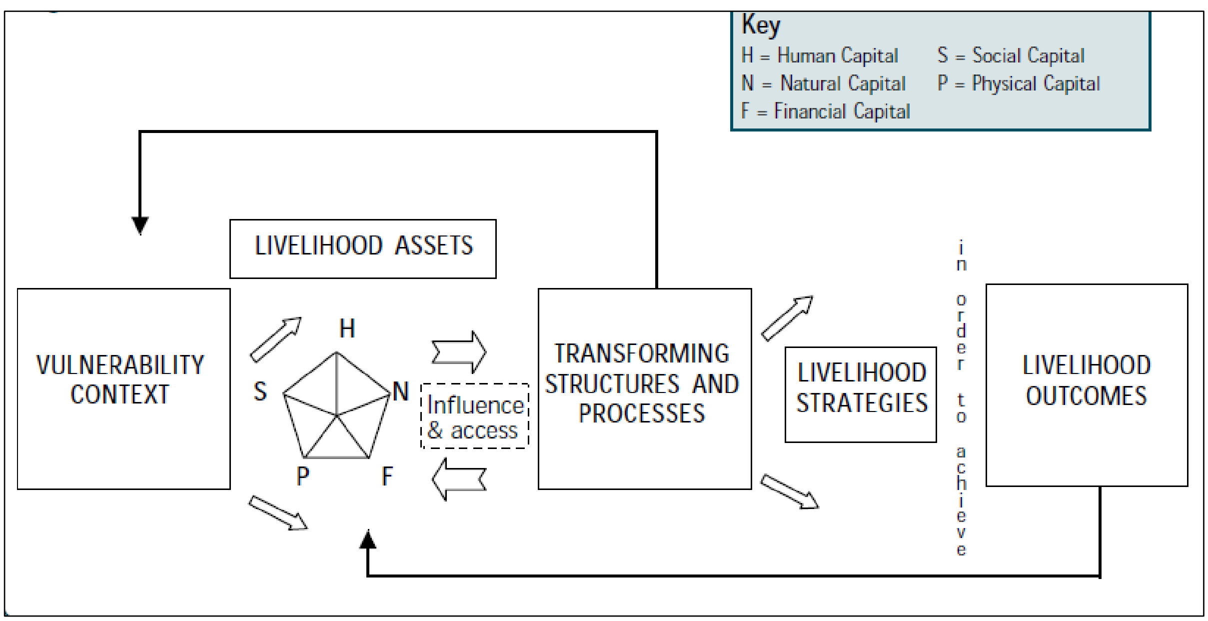


Diagram 1: DFID Sustainable Livelihood Framework
Source: Carney, 1998

Objective 4: The design of Multiple Use System was evolved on the basis of: 1] review of successful models of MUS in different parts of the world, with special reference to the hydrological regime, socio-economic conditions, and climate in which they are embedded; 2] understanding the technical features of the models that contribute to their good performance; 3] mapping the hydrological, geo-hydrological, socio-economic, cultural and climatic conditions of the locality, and selecting successful models from regions which closely resemble the locality; 4] study of existing water supply system of the locality which have the potential to meet multiple use water services; and, 5] introducing these technical features of the selected MUS into the local system.

<u>Review of MUS Models</u>: published and grey literature on the features and functioning of successful MUS models around the world, particularly those used by the poorest communities in countries such as Sri Lanka, Mexico, Ethiopia, Thailand, South Africa, Nepal, Bangladesh and India were studied. The study would cover listing of physical (hydrological and climatic), socio-economic and cultural setting in which these systems are embedded. The focus of the study was their technical features that contribute to good system performance. The technical features included the infrastructure design features, water use system (farming system etc.).

<u>Resource mapping</u>: a detailed analysis of hydrology, geo-hydrology, soils, evaporation and potential evapo-transpiration in the region and the villages under study was carried out. The hydrological analysis comprised of studying rainfall characteristics such as rainfall pattern and inter-annual variability in quantum and number of rainy days, aquifer characteristics and water level fluctuations across seasons and over the years, and the frequency of occurrence of meteorological droughts..

<u>Socio-economic mapping</u>: to include socio-economic and cultural profile of the region and the villages under study. This included landholdings and livestock holding of the poor rural households, other occupations of these households that are not land based, ownership of irrigation facilities and use of irrigation water by these households, their educational status, and cultural practices, which have implications for water collection and use.

<u>Study of water supply systems in the locality</u>: drip kits for vegetable production; common property ponds and tanks, which meet multiple water needs of poor rural households; private hand pumps, water from which is used for meeting various household needs, including kitchen gardens, backyard horticulture etc. The focus was on identifying systems which have the potential to be converted to full-fledged MUS.

The technically feasible MUS models once chosen on the basis of the above steps was shared with the members of the community to identify the one which is socially most acceptable.

Objective 5: The institutional arrangement (organizational structures; rules and regulations; and finance) for management of MUS would be worked out by: 1] undertaking a detailed study of institutional arrangements in selected water institutions in India, with special reference to the types of services they provide; 2] identifying the institutional characteristics (design features, operating principles, administrative structures, and rules and regulations) that contribute to the effectiveness of these institutions; 3] determining the institutional arrangement that is most relevant for the kind of services that the local MUS has to perform; and, 4] introducing these “ideal institutional characteristics” into the institutional arrangement proposed.

The pilot interventions of MUS were made by GSDA with the involvement of the members of the community who are identified as the most vulnerable in the village. This selection was done on the basis of the household level vulnerability index. Detailed project report was prepared for the MUS design evolved, with cost estimates. An appropriate institutional arrangement will be determined on the basis of that found to be most relevant from the case studies; and with the built in "institutional characteristics".

In order to analyze the impact of MUS interventions on poor households' vulnerability, the water supply vulnerability index would be assessed for the households using data obtained from repeated survey. This will be compared against the values assessed during the benchmark survey carried out initially.

4.0 Selection of the Pilot Villages

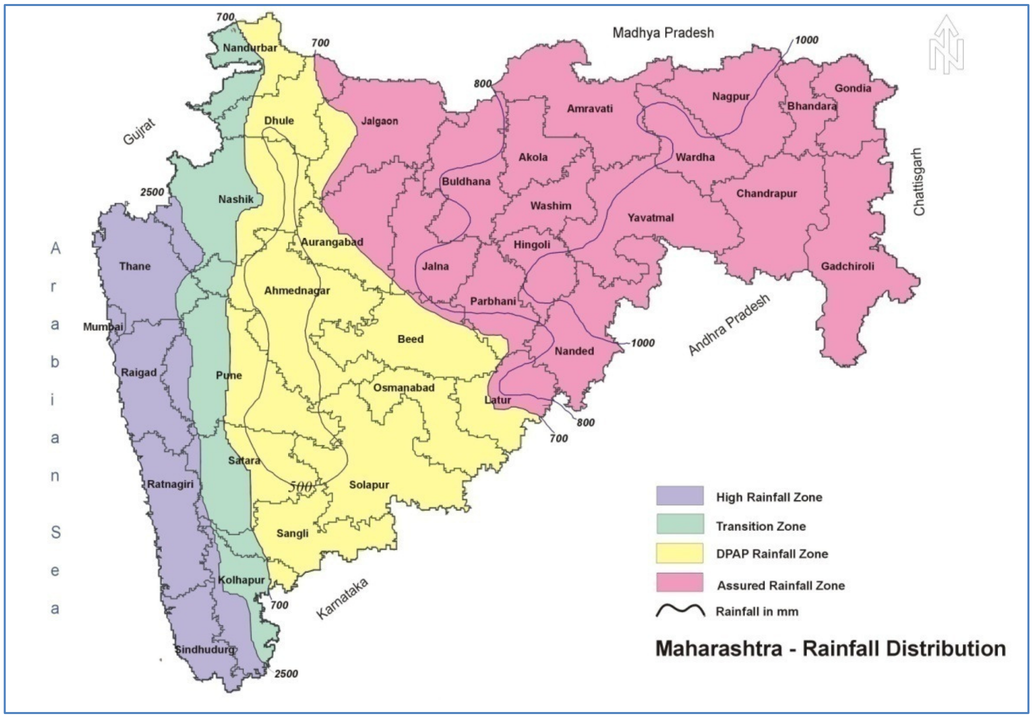
The three locations for project were selected in such a way that they represent three distinct typologies. The three possible typologies are as follows. 1) a village located at the foothill of the hilly region, characterized by high rainfall and plenty of local streams flowing down from high altitudes fed by base flows from hilly aquifers; 2) a village located in hard rock plateau areas with low to medium rainfall, with the rural water supplies heavily dependent on the limited groundwater resources in the Deccan trap formations; and, 3) a village located in the foot of hilly forested land with assured rainfall, with extremely limited groundwater, but endowed with local streams.

In order to identify the most appropriate locations for undertaking the action research, we have visited six villages from three districts of Maharashtra, which represented these three distinct typologies. The first district, Satara, in western Maharashtra, is part of the Western Ghats. The second district, i.e., Latur falls in the central plateau area. The third district, i.e., Chandrapur falls in the tribal area of Vidarbha, at low altitudes.

Satara

The district of Satara in western Maharashtra is in the transition region with respect to rainfall. The rainfall is highest in the western fringes exceeding 2500mm. Then it reduces abruptly to 700mm towards the central parts, and the rainfall is in the range of 700-500mm in the eastern half of the district. The region is at an altitude of 600-1200m above mean sea level. The eastern side is drought prone (Map 1, Source: Groundwater Survey and Development Agency, Pune, Maharashtra).

Map 1: Rainfall Isohyets of Maharashtra



The villages in the foothills (on the Western Ghats) are endowed with natural springs. These springs originate from the outflow of groundwater occurring in the rock formations overland, and are active for most part of the year. The area is drained by streams which flow in the south east direction, and join the tributary of Krishna River. The small stream form the source of water for domestic uses (like washing and bathing) and irrigation during the winter season. The area is underlain by basalt, which has very poor porosity and transmissivity (Figure 2, Source: Groundwater Survey and Development Agency).

The two villages selected for preliminary survey from Jawali taluka of Satara district, viz., Kedanbe and Varoshi fall on the western fringe of the district and therefore have high rainfall, close to 2,500mm, and are not affected by droughts. Plantations of mango, guava and bush fruits (like black berry) is quite common in the area. There are very few farm wells in the area and water remains in them only for a few months of monsoon due to excessive groundwater flow gradients. A few bore wells drilled deep to the fractured zone and which cater to the domestic water supply needs during summer season when the springs dry up. The crops grown are paddy (rain-fed) and wheat (winter) in Kedanbe; and rain-fed paddy and hybrid jowar in Varoshi. The general physical and socio-economic characteristics of the villages are furnished in Table 1. The water supply in both the villages is largely dependent on springs and the schemes are operated on gravity. Households access water from the public systems through common stand posts. The overall water supply situation is better in Varoshi as compared to Kedanbe, with greater coverage of households from the schemes.

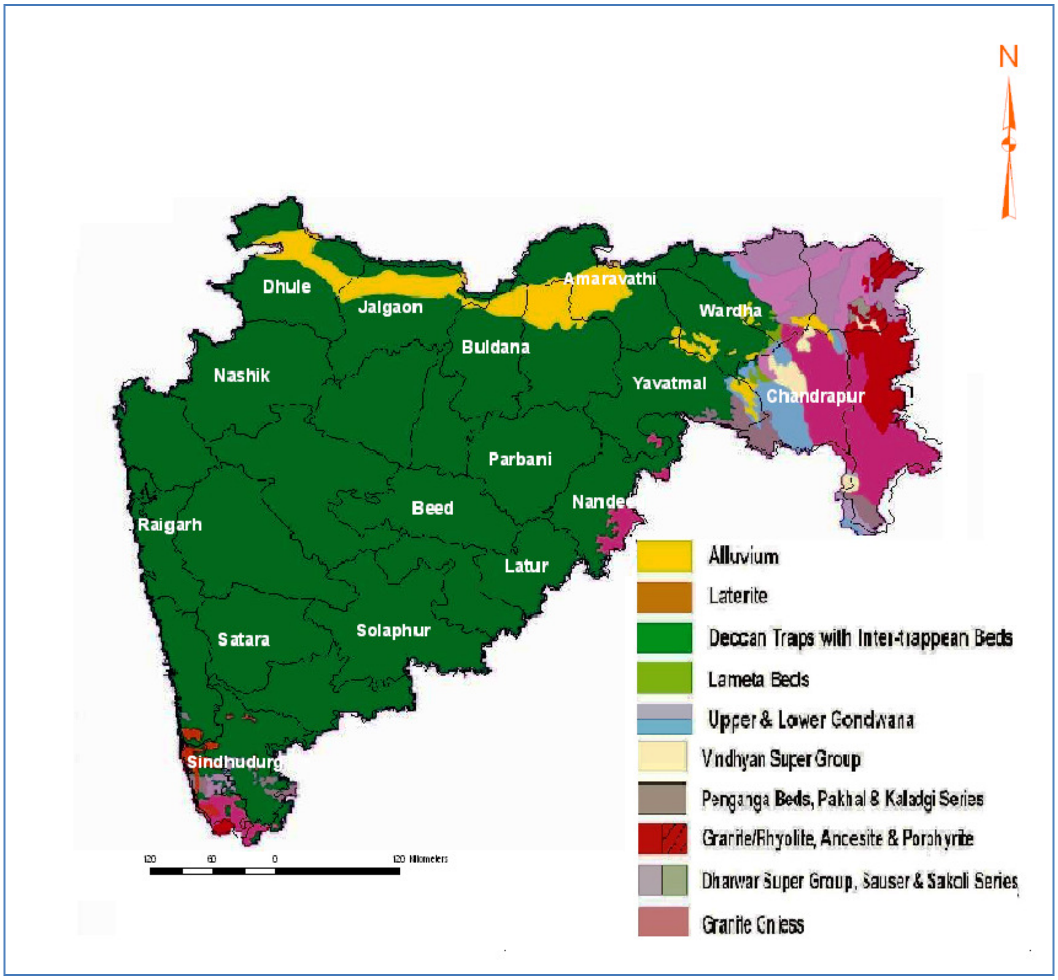
Latur

Latur district in Marathwada region is part of the central plateau. The region receives low to medium rainfall. The rainfall is around 700 mm in the south western parts, and increases to 800mm and above in the north eastern parts (Map 1). Half the district (in the south western parts) is drought prone. The area is well drained by a river, named Manjara, flowing in the south east direction dividing the district into two, and merging into Godavari river system. The surface water resources are limited. The region has few tanks and ponds. The groundwater occurs in the basalt formation of lava flows, and groundwater potential is very poor (Map 2). The open wells, which tap the weathered zones, get dried up quickly with the onset of winter and when people start pumping water for irrigation.

The two villages selected for preliminary survey, from the district are Makani (Nilanga taluka) and Kerkatta (Latur). Both the villages have public water supply schemes based on bore wells. There are a few public hand pumps also, which supplement domestic water supply. In Kerkatta, all households have individual water supply connections, whereas in Makani, only half of the households have individual connections. Livestock keeping is a major occupation in both the villages, while all households in Kerkatta have one or two dairy animals.

There are very few successful bore wells, which tap the deep fractured layer below the weathered zone. Agriculture is the major occupation in the area, and is mainly rain dependent (with *soya bean* as the main crop), with a very few wells actually running during winter months, and can be used for irrigating winter crops. The irrigated area (winter wheat) is very small, in comparison to the total cultivable area. The crops grown are: wheat, jowar and gram in Latur area; and soya bean, wheat, pigeon pea and gram in Nilanga area. Animal husbandry is the second largest occupation in the villages with cows and buffaloes. All the households in Kerkatta have 1-2 dairy animals.

Map 2: Geological Map of Maharashtra



Chandrapur

Chandrapur district in Vidarbha region falls in the medium to high rainfall region with a mean annual rainfall of 1430mm. As Map 1 indicates, this is an "assured" rainfall zone; and does not experience meteorological droughts. The number of rainy days in a year is in the range of 60-70. The region is at an altitude of 150-300m. The area is well drained by three tributaries of the Godavari river system. They are Wardha, Wainganga and Penganga. The district has significant hilly forested area, and there is significant tribal population. The underground formations in the region are characterized by wide heterogeneity with granite gneiss (on the eastern side), lower Gondwana formations, Penganga beds, Vindhyan super group and patches of alluvium (Figure 3). All the formations except alluvial patches have very poor groundwater potential. As a result, well failure rate is very high. The wells yield only for few months. Deep bore wells are used for drinking purpose.

The villages selected for the preliminary survey, viz., Chikhali and Asapur, are located at the foot of forested hills. The population in these villages is predominantly tribal. Both the villages have open wells, supplying water for domestic use. A few hand pumps supplement water supply from wells. All households in the villages get individual piped water supply. The second village experience severe water shortage during summer. During summer, the Panchayat supplies water through tankers. In the first village, i.e., Chikhali, agriculture is a major occupation. There are around 40 irrigation wells, but only five are functional. The crops grown are: cotton, pigeon pea and jowar. Animal husbandry is the second largest occupation in the first village, with large population of goat, next to cows and bullocks. In the second villages, 80% of the households are landless. They go to neighbouring villages to work in work in chilly farms to earn their livelihoods.

The following physical and socio-economic criteria were used to short-list three villages for the action research: 1] larger proportion of households in the village have good physical access to water for drinking and cooking and other household uses from public systems, either through individual tap connections or through nearby stand posts; 2] the villages are predominantly agrarian, but a significant section of the farm households are not able to meet their farming needs from the available water sources (ponds, tanks and wells), and therefore demand water for multiple purposes from the public systems, including water for livestock, water for kitchen garden to improve their livelihoods; and, 3] the current public water supplies across seasons are less than adequate to meet these needs largely due to competition from agriculture, but conditions are favourable for augmenting the available supplies and improving the physical access, through technological and institutional measures.

With these considerations, out of the six villages which were surveyed, Varoshi (Jawali taluka of Satara district) of Western Maharashtra; Kerkatta in Latur taluka of Latur district of Marathwada and Chikhali in Jivati taluka of Chandrapur district of Vidarbha region were selected for the action research. They represent three different agro-ecological zones in the state, one from the high rainfall zone of western Maharashtra located in the foothills of Western Ghats, with high humidity; another from the low to medium rainfall zone of central plateau, which is drought-prone and experiencing high degree of aridity; and the third one from the assured rainfall zone of Vidarbha, at the foot of hills, with rainfall exceeding 1400mm. All the villages face problems of inadequate availability of water for meeting multiple needs such as animal drinking, vegetable cultivation throughout the years and water for basic needs during summer months. Quality and reliability of water are not issues in any of the villages.

5.0 Development of MUS Vulnerability Index for Rural Households

5.1 <u>Water Supply Surveillance</u>

Water supply surveillance is defined as: 'the continuous and vigilant public health assessment and oversight of the safety and acceptability of water supplies' (WHO, 1976; 1993; 2004). Many millions of people, in particular throughout the developing world, use unreliable water supplies of poor quality, which are costly and are distant from their home (WHO and UNICEF, 2000). Over the years, there is growing realization that communities in the rural areas need water for productive as well as domestic uses, indicating the need for an increase in the quantity of the water supplied from public systems along with quality (Renwick, 2008; Nicole, 2000; van Koppen *et al*., 2006). This is important for meeting the millennium development goals (van Koppen *et al*., 2006).

Traditionally, water supply surveillance generates data on the safety and adequacy of drinking water supply in order to contribute to the protection of human health. Most current models of water supply surveillance come from developed countries and have significant shortcomings if directly applied in a developing country context. Not only the socio-economic conditions, but also the nature of water supply services is different. Water supply services in developing countries often comprise a complex mixture of formal and informal services for both the 'served' and 'un-served' (Howard, 2005).

Many millions of households in India do not have access to "tap" connections at home. Only 24.2 per cent of the rural population have access to tap connections (source: based on Census of India, 2001), and as a result a majority of the rural population depend extensively on private wells, hand pumps, bore wells and ponds and tanks, that provide untreated water, for domestic water supply (NSSO, 1999), a trend found in many other parts of the developing world (Gelinas *et al*., 1996; Rahman *et al*., 1997; Howard *et al*., 1999). Given the informal nature of the sources and 'services', the data on actual water use by the households by the communities are absent. The problem is compounded by the lack of clarity on the supply norms for fulfilling multiple water needs of rural population.

Nevertheless, the sources that are reliable and that can provide adequate quantity of water of sufficient quality to meet various productive and domestic needs seem to be far less than adequate. It is evident from the fact that the rural poor tend to compromise on their basic needs, with resultant undesirable outcomes on health and hygiene, and livelihoods of rural communities. Therefore, a well designed and implemented water supply surveillance in relation to domestic and productive needs of the community is important to provide input into water supply improvements. The key to designing such a programme is information about the adequacy of water supplies and the health and livelihood security risks faced by populations due to lack of it at national or sub-national levels. This will help identify areas that are vulnerable. But, as Nicole (2000) notes, there are a range of natural, physical, social, human, economic, financial, institutional factors influencing the vulnerability of the rural population to problems associated with inadequate supply of water for consumption and production needs. They are not captured in the traditional surveillance programmes.

5.2 Past Approaches to Water Supply Surveillance

The inextricable link between water security, health, livelihood and economic gains is quite well established (Botkosal, 2009; HDR, 2006; Nicole, 2000). Improving water security of the poor brings about significant health and poverty reduction benefits (DFID, 2001; HDR, 2006: 42; WHO, 2002). The economic losses due to deficit in water supply of sufficient quantity, quality and reliability are disproportionately higher for the poor communities. This is owing to greater risk of employment loss, health costs, loss of productive workforce and water-based livelihoods (HDR, 2006: 42).

As Nicole (2000) argues, a demand responsive approach to water supply requires that the livelihood needs of the community are also taken into account, rather than the supply requirements for human consumption and sanitation needs. Therefore, an assessment of water supply at the household level, based on the old norms worked out on the notion of water supplies that serve human health and hygiene needs would be grossly inappropriate. In India, the monitoring of rural water supply is based on simplistic considerations, involving data on number of households covered by different types of water supply systems; and the characteristics of the sources. The data gathered through such surveys are silent on the amount of water actually consumed by the population, and the quality and reliability of the supplied water, all of which determine the health and livelihood outcomes.

5.3 Why Vulnerability Index for MUWS?

The foregoing discussion suggests that comprehensive approaches to water supply surveillance were by and large lacking for quite some time. The approaches to water supply surveillance that allow targeting of surveillance activities on vulnerable groups were assessed by G. Howard using case studies from Peru and Uganda. The Peru case study attempted to incorporate some measures of vulnerability into the surveillance programme design through a process of "zoning" that was based on water service characteristics. Whereas the Uganda case study involved development of a semi-quantitative measure of community vulnerability to water-related diseases, to zone the urban areas and plan surveillance activities. The zoning used a categorization matrix, which was developed incorporating a quantitative measure of socioeconomic status (education, sources of livelihood, family size and type of housing), population density and a composite measure of water availability and use (Howard, 2005).

But, the main limitation of the approach is that they try to assess the vulnerability of the household against lack of water for human consumption and sanitation. They do not take into account the multiple water needs of the community, particularly the poor in rural areas. There are many factors such as the family occupations, social profile, financial stability which determines the household water needs for productive purposes.

Identifying the most vulnerable groups is not an easy task due to the complex interplay of a wide range of factors. Factors such as poor reliability (continuity of supply), costs (affordability) and distance between a water source and the home may all lead households to depend on less safe sources, to reduce the volume of water used for hygiene purposes and to reduce spending on other essential goods, such as food (Lloyd and Bartram, 1991; Cairncross and Kinnear, 1992; Howard, 2002). The evidence suggests that water interventions targeted at poor populations provide significant health benefits and contribute to poverty alleviation (DFID, 2001; HDR, 2006; WHO, 2002). Though it appears that poverty is a major factor deciding vulnerability, it is just one of the many complex factors which would eventually determine the outcomes of family's high vulnerability to lack of water for multiple uses.

The factors that can influence vulnerability of a household to problems associated with lack of water for multiple uses could be: 1] degree of access to water supplies for human consumption, personal hygiene and productive uses such as livestock consumption in terms of quantity and desired quality, and the level of use; 2] social profile and family occupations; 3] social institutions and ingenuity; 4] condition of water resources; 5] climatic factors; and, 6] financial condition (source: based on Lloyd and Bartram, 1991; Cairncross and Kinnear, 1992; DFID, 2001; Howard, 2002; Hunter, 2003; Nicole, 2000; Sullivan, 2002; WHO, 2002). The second and fifth factors influence the vulnerability by changing the household water demand. This may not be always in terms of the quantum of water, but in terms of the reliability of the supply. The third and fourth factors can change the external environment, which influences water supply. Here again, the degree of access depends on the presence/absence of social institutions and local custom and traditions, which are quite characteristic of poor and developing countries.

We would explain how climate influence household water demand. It has a major bearing on the adverse effect of lack of water for hygiene and environmental sanitation. In arid and semi arid climates, breeding of water-related insect vectors would be less during hot weather conditions. In flood prone areas and areas receiving high rainfall, the occurrence of water-based diseases are likely to be more, and therefore more caution needs to be exercised in the disposal of human and animal excreta (Hunter, 2003: 37). At the same time, the demand of water for meeting livestock needs, and irrigating fruit trees and kitchen garden etc., would increase with increase in aridity and temperature. So is the demand for water for washing and bathing. Arid areas are also drought-prone. Hence, there is a need to develop a composite index which takes into account these complex factors in assessing the vulnerability of rural households to inadequate supplies of water to meet multiple needs so as to make surveillance more targeted.

5.4 <u>Deriving a MUWS Vulnerability Index</u>

This study started with the premise built on the knowledge from extensive review of past research studies dealing with related topics that the vulnerability of a household to inadequate supply of water to meet drinking water, sanitation and livelihoods needs is determined by four broad parameters: 1] capital assets and good; 2] sequencing and time; 3] institutional linkage; 4] knowledge environment. The capital assets can be further divided into natural capital, social capital, physical capital, financial capital (Nicole, 2000). It is evident that while some of the capital asset (physical capital and human capital) related parameters would determine the access to water supply and its use, the natural capital related parameters, institutional linkage and knowledge environment would change the external environment which influence the supply and use for water. On the other hand, the capital assets such as natural capital, social capital and financial capital influence the demand for water.

All these parameters are factored in six broad sub-indices we have discussed previously. They are: 1] water supply and use; 2] family occupation and social profile; 3] presence of social institutions and ingenuity; 4] water resource endowment; 5] climate and drought proneness; and, 6] financial stability. Each one of these six broad factors constitutes one sub-index. The number of "minor" factors which together are considered to be influencing the measure of these sub-indices, the methods and procedure for their computation, and sources of data are explained in the table below.

The composite index of "MUWS vulnerability" will have a maximum value of 10.0, meaning zero vulnerability; lower values of the index meaning higher vulnerability. It is composed of six sub-indices (from A to F: Table), each one will have unequal weightage in deciding the value of the index. The maximum value of sub-index A will be 3.0; that of B, C and D will be 1.0; and that of E and F will be 2.0 each. The sub-sub index also will have equal weightage (measured on a scale of 0 to 1.0). The sum of the values of all sub-indices under sub-index A would be multiplied by 0.30 to obtain the value to be imputed into the mathematical formulation for estimating the composite index. The sum of the values of all sub-indices under sub-index "B" would be divided by three (3) and "D" would be divided by two (2) to obtain the value to be imputed into the mathematical formulation for estimating the composite index. The sum of sub-sub indices under sub-index "E" would be multiplied by 0.50. The value of the sub-index, "F" would be multiplied by 2.0.

Deriving a Household Level MUWS Vulnerability Index

Sr. No	Parameters	Quantitative criterion for measurement	Method of data collection
A	**Water Supply and Use**		
1	Access to water supply source (primary)	Vulnerability decreases with improved access. Access is an inverse function of the distance. The index is a function of the distance to the source from '0" within the dwelling to a maximum of 1km and above in	Primary survey

		gradations of 0.20[1]	
2	Frequency of water supplies	Vulnerability increases with decrease in frequency of water delivery[2].	Do
3	Ownership of alternative water sources	Ownership of an alternative water source would increase the overall access and reduce the vulnerability[3]	Do
4	Distance to the alternative source "owned"	Distance to the alternative source, would increase the vulnerability. Often, the alternative sources are farm wells, which are located outside the village[4].	Do
5	Access to other alternative sources	Vulnerability decreases with no. of alternative sources[5].	Do
6	Capacity of domestic storage systems	Vulnerability to lack of regular water supplies decreases with increase in volume of storage systems in place[6]	Do
7	Quantity of water used	The vulnerability increases with decrease in quantum of water used against the requirement. The vulnerability can be treated as zero when all the requirements in the household are fully met[7].	Do
8	Quality (chemical, physical and bacteriological) of domestic water supplies	Poor quality of drinking water increases vulnerability; Bacteriologically, physically & chemically pure is the best water[8]	Lab test results/ perceptions
9	Total monthly water bill as a percentage of monthly income	Vulnerability increases with increasing % of total family income spent on water. An expenditure level of 10% of monthly income is treated as highest and most vulnerable[9]	Primary survey
B	**Family Occupation and Social Profile**		
1	Family Occupation	Vulnerability will be low for families having regular source of livelihood that are not dependent on water. Those who are dependent on irrigated crop production are considered to be not vulnerable. But, those who are dependent on dairying will be vulnerable. The vulnerability will reduce if they depend on wage labour and other sources of livelihood that do not require water[10]	Do
2	Social Profile	Vulnerability is also a function of the social profile. The families having school going children are more	Do

		vulnerable to inadequate quantity, quality and reliability of water supplies. So, is the case with families having office-going adult. But, The vulnerability would reduce with the presence of surplus labour availability[11].	
3	Health expenditure	Vulnerability is also a function of family's health expenditure. Those which incur large expenditure for water-related diseases are likely to be more vulnerable. However, this is also dependent on what percentage of the family income it constitutes[12].	Do
C	**Social Institutions and Ingenuity**	Community's vulnerability to the problems associated with lack of water increases in the absence of social/community institutions; social ingenuity[13]	Primary survey (but qualitative to be obtained from discussions)
D	**Climate and Drought Proneness**		
1	Climate (whether semi arid/arid/hyper-arid or sub-humid/humid	The vulnerability to lack of water for environmental sanitation is a function of climate. It increases from hot & arid to hot & semi-arid to hot & sub-humid to hot & humid to cold & humid[14].	Secondary data on climate
2	Aridity and drought proneness	The vulnerability due to lack of water for domestic uses, livestock increases with increase in aridity as it would increase the demand for water for washing, bathing, livestock drinking and irrigation of vegetables and fruit trees. Aridity areas are also drought prone[15].	Do
E	**Condition of Water Resources**[16]		Do
1	Surface and groundwater availability in the area	A renewable water availability of 1700 m^3 per capita per annum is considered adequate for a region or town, estimated at the level of river basin in which it is falling[16].	Secondary data
2	Variability in resource condition	Higher the variability, greater will be vulnerability[17].	Do
3	Seasonal variation	Regions which experience high seasonal variation in water availability are highly vulnerable[18]	Do

4	Vulnerability of the resource to pollution or contamination	Surface water is more vulnerable to pollution than groundwater. Shallow aquifer is more vulnerable than deep confined aquifer[19].	Do
F	**Financial Stability**	Overall financial stability of the family would influence the vulnerability. This is different from the earnings from current occupations. The savings in banks/post office; ownership of productive land, which is not mortgaged[20].	Primary survey

Notes about computation of the index

1. Within the dwelling is "1.0"; within the premise is ".80"; within 0.2 km distance is ".60"; between 0.2 and 0.5 km is "0.4"; 0.5 and 1.0 is "0.2" and more than 1.0 km is "0".

2. Frequency can be indexed as total hours of water supply in a week as a fraction of no. of hours.

3. It is assumed that the ability to manage water would be highest in the case of a functional open well, followed by bore well, hand pump and farm pond in the decreasing order. The value of the sub-index would be 1 in the case of ownership of a functional open well, followed by 0.70 for a bore well; 0.50 for ownership of a hand pump; and 0.30 for ownership of a farm pond.

4. Within the premise is "1.0"; within 0.2 km distance is ".80"; between 0.2 and 0.5 km is "0.6"; 0.5 and 1.0 is "0.4" and more than 1.0 km is "0.20".

5. The value of sub-index for this attribute would be "1.0" if there are four alternate sources & above, and the value would decrease proportionately with decrease in number of alternative sources.

6. It would decrease with increase in the ratio of the actual storage capacity available" to the "storage capacity required"; and the value of the index would be higher. The storage capacity required would be an inverse function of the frequency of water supply. If supply comes once daily but during odd hours, then it can be assumed that the volume of water for the entire day's use would be required to be stored. So, the storage capacity would be "n*f". If it comes during day time for less than an hour, then half the daily water use would be the storage requirement. For more than one hour, the storage requirement would be minimal (around 20 litre per capita). With alternate day water supply, it could be the 2*n*f. For once in three days, it would be 3*n*x f and likewise. For round the clock water supply, the storage requirement would be zero, and here the ratio can be assumed as 1.

7. This sub index is computed by taking the volume of water used (x) as a fraction of the minimum required (n), i.e., $\frac{x}{n}$ where n water requirement as per norms. The value of n

should be estimated by considering the human requirement of 50 lpcd (basic survival need as suggested by Glieck, 1997); the animal requirements decided by the types of livestock and the size; and the requirement for kitchen garden. Going by literature, an amount of 75litre per day per day is sufficient for kitchen gardens (van Koppen *et al*., 2009).

8. The value of the sub-index "m" would be 0.33 if the water is pure either bacteriologically or physically or chemically. The value would be 1.0 if pure on all counts.

9. The value of the sub-index would be "0" if the family spends 10% or more of its monthly income on obtaining domestic water supplies, and would keep on increasing with reducing amount of money spent in water bill. The mathematical formulation for computing the index therefore is $[1-W_C/MI]$; where W_C is the monthly expenditure on securing water supplies, and MI is the monthly family income.

10. The vulnerability induced by family occupation is considered to be zero, if the adults in the family are engaged in livelihoods that are not dependent on water in the village. The vulnerability is also considered to be zero for families having crop production with own irrigation facilities. The families purely dependent on dairy farming would be assumed to have highest vulnerability (sub-index value=0.0), as the water for cattle drinking will have to be managed.

11. For families having school going children and office going adults, the situation could be treated as most unfavourable. Here, the sub-index could be assumed as 0.0 (lowest), meaning highest vulnerability. The families having either of these, the value could be assumed as 0.33. For families having neither of these, the value would be treated as 0.67. For families, having surplus labour in the HH for fetching water from distance, the sub-index could be assumed as 1.0.

12. The value can range from 1.0 for no expenditure on water related health to "0.0" for the health expenditure equal to 10% or more of the annual income from all sources. It can be computed as: $1-10*X/AI$; where AI is the total average annual income from all sources, and x is the health expenditure.

13. The value can range from "0" for the absence of social institutions or ingenuity to 0.50 for presence of either of these to 1.0 for the presence of both. Social institutions would include: WATSAN committees (Y=0.50; No=0). Social ingenuity would include: existence of water sharing traditions between households during crisis (Y=0.25; No =0.0) and practice of re-using water in households--using bathing/washing water for toilet flushing, use of sand & ash for cleaning utensils etc. (Y=0.25; No-0.0).

14. The value ranges from "0.0" for cold & humid to "1.0" for hot & arid with increment of "0.20"

15. The value ranges from "1.0" for cold & humid to "0.0" for hot & arid with reduction of "0.20".

16. A renewable water availability of 1700 m^3 per capita per annum is considered adequate for a region or town, estimated at the level of river basin in which it is falling. The value of the index is computed by taking the amount of renewable water as a fraction of the desirable level of 1,700m^3

17. The index is computed an inverse function of the coefficient of variation in the rainfall variability in that basin/sub-basin (1-x/100); where x is the coefficient of variation in rainfall.

18. For alluvial areas, the value of this index is considered as 1. For hard rocks, the value is considered as 0.3. For sedimentary and alluvial deposits, the value is considered as 0.65.

19. Shallow groundwater areas; river/stream/reservoirs in the vicinity of industries are highly vulnerable with a value of the sub-index equal to 0.0; distant reservoir in the remote virgin catchments and groundwater from deep confined aquifers has a pollution vulnerability index of 1.0; shall groundwater in rural areas to have medium vulnerability with a value of 0.50.

20. The family having 1.0 ha of productive land member in a semi arid, water-scarce region, or 0.5 ha of productive land per member in a water-rich area are considered to be financial stable, with zero vulnerability, and the vulnerability is assumed to increase gradually with reducing size of land owned, with highest vulnerability for landless. Again, the lack of ownership of land can be compensated by income savings, with a total saving of Rs. 20,000 equivalent to 0.5 ha in water-rich area and 1.0 ha in a water-scarce area. This index could be computed as "x/0.5" and "x/1.0" for land holdings in water-rich and water-scarce areas (where x is the land holding size in ha), respectively.

6.0 Household Water Needs and MUS Vulnerability of the Households

Before we discuss the issue related to vulnerability of the HHs, we would present the results of household survey with regard to access to and use of water for various domestic and productive needs. The results are discussed in the following order: 1] the average family size of the HHs; 2] the educational status of the family across different segments; 3] the occupational profile of family members across different classes; 4] the sources of water supply, for meeting different water needs (such as drinking & cooking, washing, bathing, sanitation use, watering kitchen gardens, drinking water for livestock) across seasons; 5] accessibility of different sources of water in terms of the distance to the source and the extent of use of that for a given purpose; 6] average distance travelled and the time spent for water collection by caste groups and income segments; 7] average size of water storage facilities available at the household level; 8] the average per capita water use for different purposes in different seasons and the number of months for which it is available in each season in a typical normal rainfall year and a drought year. It is important to remember that the occupational profile, the characteristics of water supply sources, the distance to the sources, the types of storage available for water etc. would in a great way influence the types of water use and the amount of water used in volumetric terms.

6.1 <u>Varoshi, Jawali taluka, Satara District, Western Maharashtra</u>

6.1.1 Characteristics of the Village Water Supply Scheme

The village water supply schemes in the three villages show distinct features. The water supply scheme in Varoshi is based on natural springs. Water from the springs is collected in intermediate surface storage systems (GSR, i.e., ground surface reservoirs) through long-distance steel pipes, and then distributed to various smaller tanks located at different locations in different hamlets of the village. There are two GSRs of 7,000 litre capacity and 5 GSRs of 3,000 litre capacity. The small surface storage tanks are provided with taps. Water is also supplied through public stand-posts in the streets. The households collect water from these taps. No pressurizing devise is used for supplying water to the storage tanks as water is available at a good hydrostatic head by virtue of the height from which the spring originates. In addition to spring, the village also has two bore wells, connected with pumps, which become the main source of water during the months of summer. There is also one functional public hand pump in the village.

6.1.2 Average Family Size

The average family size with respect to the social group in the case of Varoshi village is presented in Table 1. The average family size is 6.6, 5.2 and 6.1 for Schedule Caste, Other Backward Class and General group, respectively. An average scheduled cast family appears to be larger in size, as compared to OBC and general casts. Also, the number of adult population in an average scheduled cast family (2.5) is higher than that of the OBC (1.7) and general category (2.16).

Table 1: Average Family Size

Name of Social Group	Family Size	Number	Per cent
Schedule Cast (SC)	Average family size	6.64	100.00
	1. Adult Male	2.50	37.63
	2. Adult Female	2.07	31.18
	3. Children male	1.29	19.35
	4. Children female	0.79	11.83
Other Backward Class (OBC)	Average family size	5.22	100.00
	1. Adult Male	1.70	32.50
	2. Adult Female	1.87	35.83
	3. Children male	0.70	13.33
	4. Children female	0.96	18.33
General	Average family size	6.09	100.00
	1. Adult Male	2.16	35.60
	2. Adult Female	2.02	33.25
	3. Children male	1.10	18.06
	4. Children female	0.79	13.09

Source: Authors' own analysis using primary data

6.1.3 Educational Status

The educational status details of BPL and Non-BPL families in Varoshi village are presented in Table 2. About 40.74% of males belonging to BPL category have attended the primary school, while as 47.17% of females from the same category have attended primary school. Nearly 46.30%

of males (BPL) and 18.87% (BPL) have attended secondary school. The male and female illiterates (BPL) are 9.26% and 33.96% respectively.

Against this, 41.6% of males under non-BPL category have attended the primary school, where as 42.99% of females (Non-BPL) have attended primary school. Nearly 45.34% of males (BPL) and 28.50% (Non-BPL) have attended secondary school. The male and female illiterates (Non-BPL) are 9.75% and 27.57% respectively. What emerges from these results is that generally the percentage of people who are literate is higher in non-BPL families, and the difference is remarkable when they are looked at from a gender perspective.

Table 2: Educational Status (Varoshi)

Particulars	Male/ Female	Primary	Secondary	Graduation	Post Graduate	Illiterate
	BPL Category					
Average number	Male	1.51	1.72	0.14	-	0.34
Per cent		40.74	46.30	3.70	-	9.26
Average number	Female	1.22	0.49	-	-	0.88
Per cent		47.17	18.87	-	-	33.96
	Non-BPL Category					
Average number	Male	1.38	1.51	0.06	0.06	0.32
Per cent		41.53	45.34	1.69	1.69	9.75
Average number	Female	1.25	0.83	0.03	-	0.80
Per cent		42.99	28.50	0.93	-	27.57

Source: Authors' own analysis using primary data

6.1.4 Occupational Profile

The occupation profile details are given in Table 3. About 20.75% of males (BPL) and 44.44% females (BPL) are engaged in agriculture as their main occupation. Very few, i.e., 5.7% of males (BPL) are in regular employment (service. About 35% of males (Non-BPL) and 57.8% females (Non-BPL) are in engaged in agriculture. Thus, the proportion of persons engaged in agriculture is higher for non-BPL families. As regards labour (farm & non-farm labour), a significantly large percentage (32 per cent) of the BPL families earn their income from it, whereas only 8.5 per cent of the non-BPL families are dependent on wage labour (farm & non-farm). Hence, the proportion of people engaged in wage labour is less for non-BPL families.

Table 3: Occupational Profile

Particulars	Male/ Female	Agriculture	Dairying	Service	Farm/non-farm labour	Petty Trade	Studying	Others
	BPL Category							
Average number	Male	0.76	0.07	0.21	0.76	-	0.34	0.28
Per cent		20.75	1.89	5.66	20.75	-	9.43	3.70
Average number	Female	1.40	0.07	-	0.35	0.14	0.49	0.14

Per cent		44.44	2.22	-	11.11	4.44	15.56	4.44
	Non-BPL Category							
Average number	Male	1.16	0.07	0.60	0.16	0.04	0.97	0.31
Per cent		34.96	2.21	18.14	4.87	1.33	29.20	9.29
Average number	Female	1.62	0.11	0.05	0.11	0.02	0.90	0.11
Per cent		55.76	3.64	1.82	3.64	0.61	30.91	3.64

Source: Authors' own analysis using primary data

6.1.5 Sources of Water Supply

The various sources of water supply for different uses during different seasons across the Varoshi village are presented in Table 4. The most striking fact is that number of the households depending on public bore wells is much larger than that depending on common stand post. This is in spite of the fact that the average distance to common stand post is larger than that to the public tube well, across the economic segments (Table 5), across seasons. Another interesting phenomenon us that a large number of households depend on farm wells (of others) during summer months to meet their drinking & cooking needs, other domestic needs, and livestock drinking and homestead gardens. As a matter of fact, it can be seen that many households have to depend on multiple sources of water during these months. This is a clear indication of the scarcity of water from the public sources (viz., common stand post and public bore well), as the distance to these public sources located within the village is much smaller than the private wells located in the agricultural area of the village.

Table 4: Sources of Water Supply (Season-wise)

Sources of water supply	Number of Families depending on various sources														
	Drinking & Cooking			Other domestic uses including washing, bathing & sanitation			Homestead gardens			Livestock			Small scale enterprise		
	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S
1. Common stand post	29	7	31	29	30	26	6.0	7	5	12	15	13	1	1	1
2. Owned open well	1	1	1	1	-	1	-	-	-	-	-	-	-	-	-
3. Owned bore well	7	7	10	7	1	7	3	3	4	5	5	5	-	-	-
4. Shared open well	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
5. Shared bore well	2	2	2	2	-	2	-	-	-	2	2	2	-	-	-
6. Public open well	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Public bore well	64	63	63	65	4	65	6	7	7	27	28	30	-	-	-
8. Own farm well	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9. Farm well: neighbours/ other	-	-	85	-	-	85	-	-	10	-	-	39	-	-	1
10. Any other	-	-	1	-	-	1	10	10	10	-	-	1	-	-	-
M= Monsoon, W= Winter and S=Summer															

Source: Primary survey of sample households

6.1.6 Accessibility of the Sources

The various sources of water, number of users and distances of these sources are presented in Table 5. The values are given in table separately for both BPL (below poverty line) and Non-BPL (All families other than BPL) families. What is striking is that the distinct difference between BPL families and non-BPL families when it comes to tapping difference source of water for meeting domestic and productive needs. In the case of non-BPL families, there are seven different sources of water, whereas in the case of BPL families, there are three sources of water, i.e., the common stand posts, public bore well and farm wells owned by others. The proportion of families which have access to more than once source is also higher for non-BPL households.

Table 5: Accessibility of Sources

	Accessibility And Characteristics of Different Sources of Water For Domestic And Productive Uses																											
	BPL														NON – BPL													
Source of Water	Piped Water Supply	Hand Pump	Common Stand Post	Owned Open Well	Owned Bore Well	Shared Open Well	Shared Bore Well	Public Open Well	Public Bore Well	Own Farm Well	Farm Well of Neighbours / Others	Irrigation Tank / Pond	Spring	Tanker Water Supply	Piped Water Supply	Hand Pump	Common Stand Post	Owned Open Well	Owned Bore Well	Shared Open Well	Shared Bore Well	Public Open Well	Public Bore Well	Own Farm Well	Farm Well of Neighbours / Others	Irrigation Tank / Pond	Spring	Tanker Water Supply
Number of Users			6						17		22						24	1	9		2		47	1	61			
Distance (m)			18.90						46.06		118.30						23.60	200	40		10		39.15	30	253.15			

Source: Authors' own analysis using primary data

6.1.7 Distance Travelled and Time Spent in Water Collection

The average distances travelled and time spent in water collection are given in Table 6. The average distances travelled by the BPL families to collect water during rainy season, winter season and summer season are 254.4, 254.4 and 566.4 meters respectively. Similarly the average distances travelled by the Non-BPL families to collect water during rainy season, winter season and summer season are 271.6, 271.6 and 1194.1 meters, respectively. What emerges from this analysis is the fact that the non-BPL families often traverse large distances to fetch water, and this distance can increase. This does not mean that they have greater hardship, but only shows that they have alternative sources of water to bank on, when there is acute shortage of water during summer months. These sources include own bore wells in the farm, and bore wells of neighbours.

Table 6: Distance travelled and Time Spent in Water Collection

Particulars	Rainy	Winter	Summer
Distance Travelled			
BPL Category			
1. Average distance (m)	254.45	254.45	566.36
2. Minimum distance	18	18	60
3. Maximum distance	1000	1000	1600
Non-BPL Category			
1. Average distance (m)	271.58	271.58	1194.06
2. Minimum distance	0	0	0
3. Maximum distance	3200	3200	8000
Time Taken			
BPL Category			
1. Average time (Hrs.)	0.29	0.29	0.86
2. Minimum time (Hrs.)	0.075	0.075	0.27
3. Maximum time (Hrs.)	0.66	0.66	1.66
Non-BPL Category			
1. Average time (Hrs.)	0.32	0.32	1.12
2. Minimum time (Hrs.)	0.054	0.054	0.1
3. Maximum time (Hrs.)	2.00	2.00	4.33

Source: Authors' own analysis using primary data

The average time spent (in hours) by the BPL families to collect water during rainy season, winter season and summer season are 0.29, 0.29 and 0.86, respectively. Whereas, the average time spent in hours by the Non-BPL families for the same is 0.32, 0.32 and 1.1, respectively. Hence, there is a marginal difference in the time spent on fetching water, with more time in the case of non-BPL families. This runs against the conventional wisdom that the poor spent more time collecting water. What is important to note is that the poor do not have alternative sources to bank on when the public water supply system fails whereas the rich have alternative sources of water. Hence, merely looking at the time spent in water collection is not an indicator of the hardship. One also has to look at the average amount of water consumed by the different economic segments like BPL and non-BPL families. It is important to remember that the size of livestock holding and the maintenance of kitchen garden etc. could increase the water requirement significantly.

6.1.8 Average Size of Storage Facilities Available at the Household Level for Water

The storage facilities available at the household level for water are presented in Table 7. The average storage capacities for water for BPL families for drinking and cooking are 12.3 and 14.1 litres respectively. Similarly the average storage capacities for BPL families for bathroom, toilet use and livestock use are 153.4, 144.6 and 130.0 litres, respectively.

Table 7: Average Size of Storage Facilities Available at the Household Level for Water

Water use for	Average Capacity (Litre)	Minimum Capacity (Litre)	Maximum Capacity (Litre)
BPL Category			
1. Drinking	12.3	10	20
2. Cooking	14.1	10	50
3. Bathroom use including hand wash	153.4	10	500
4. Toilet Use	144.6	15	500
5. Livestock Use	130.0	15	300
Non-BPL Category			
1. Drinking	19.1	5	80
2. Cooking	19.1	5	80
3. Bathroom use including hand wash	256.4	10	3000
4. Toilet Use	248.0	10	3000
5. Livestock Use	324.9	15	3000

Source: Authors' own analysis using primary data

The average storage capacities for water for non-BPL families for drinking and cooking are 19.10 litres each. Similarly the average storage capacities for Non-BPL families for bathroom, toilet use and livestock use are 256.4, 248.0 and 324.9 litres, respectively. Therefore, the average figures are much higher. Hence, the non-BPL families have better storage facilities for water, which would help them tide over the crisis emerging out of interruptions in water supply.

6.1.9 Average per Capita Water Use for Different Purposes of the Households

The average per capita daily water use for different purposes of the households, for both normal year and drought year are given in Table 8a. What appears is that there isn't much difference in the volumetric use of water between normal year and drought year, contrary to what one would normally presume. The reason might be that these are basic survival needs which one would not like to compromise, and would find many ways to manage the water to attain the same. But, from the point of view of vulnerability, what is striking is the wide variation in water use across families both not only for other domestic such as washing, bathing and sanitation, but also for some of the very basic survival needs such as drinking and cooking. This can be attributed to the difference in physical access to the water sources, and the source characteristics.

Table 8a: Average per Capita Daily Water Use for Different Purposes of the Households

Average Water Requirement/ availability during		Drinking and Cooking			Other domestic uses including washing, bathing & sanitation use		
		Monsoon	Winter	Summer	Monsoon	Winter	summer
Requirement	Quantity (Lt)	6.19	6.19	6.60	23.60	23.60	24.19
	Range	1.67-13.33	1.67-13.33	1.67-15.00	3.75-85.71	3.75-85.71	3.75-85.71

	Months	4.0	4.0	4.0	4.0	4.0	2-4
Normal Rainfall Year	Quantity (Lt)	6.13	6.19	6.61	23.60	23.60	24.04
	Range	0.6-13.33	1.67-13.33	0.5-20.00	3.75-85.71	3.75-85.71	3.75-85.71
	Months	4.0	4.0	4.0	4.0	4.0	4.0
Drought year	Quantity (Lt)	6.18	6.11	6.35	23.65	23.33	23.61
	Range	1.67-13.33	1.67-13.33	1.67-13.33	3.75-85.71	3.75-85.71	3.75-85.71
	Months	2-4	4.0	4.0	4.0	4.0	4.0

Source: Authors' own analysis using primary data

The average daily household level water use for livestock drinking, homestead garden and small enterprises, against the requirements are given in Table 8b. The estimates consider only those households which have the particular enterprise, be it raising kitchen garden or livestock production or small enterprise. The figures show marginal difference in household level water use between normal year and drought year for kitchen garden and livestock drinking and there are no general trends emerging with regard to water use for any of these sub-sectors of household water use.

Table 8b: Average Daily Household Level Water Use for Productive Needs in Different Seasons

Average Water Requirement/ Use (Litre)	Homestead Garden			Livestock			Small Scale Enterprise		
	Monsoon	winter	Summer	monsoon	Winter	summer	monsoon	winter	summer
Requirement	33.3	36.7	38.6	52.16	55.2	57.50	3000.0	4000.0	4000.0
Normal Rainfall Year	33.3	39.6	37.6	54.56	55.2	57.10	3000.0	4000.0	4000.0
Drought Year	32.0	35.7	37.6	59.0	53.3	57.45	3000.0	4000.0	4000.0

Source: Authors' own analysis using primary data

The estimates of daily household level water use for different domestic and productive needs are summarized in Table 8c.

Table 8c: Average Household Water Use in Various Sectors in Different Economic Segments

BPL Category			
	Average per Family	**Range**	**Number of Months of Availability**
1. Drinking & Cooking	28.86	5-50	4.0
2. Other domestic uses including washing, bathing & sanitation use	112.73	30-200	4.0
3. Homestead gardens	-	-	-
4. Livestock	43.00	20-80	4.0
5. Small scale enterprise	-	-	-
Non-BPL Category			
1. Drinking & Cooking	36.09	10-80	4.0
2. Other domestic uses including washing, bathing & sanitation use	140.13	30-600	4.0
3. Homestead gardens	33.33	10-80	4.0
4. Livestock	53.30	10-150	4.0

5. Small scale enterprise	3000.00	3000-3000	4.0

Source: Authors' own analysis using primary data

Table 8c shows that there is significant difference in average household water use between the non-BPL and BPL families, with non-BPL families showing higher water use in all sub-sectors of household water use such as drinking & cooking, other domestic uses, livestock use, kitchen garden and small scale enterprises. In the case of livestock drinking, the difference could be because of the larger size of the animal holding of the family or family owning live stock types which consume more water (such as buffalo). This difference in water perhaps explains the larger amount of time spent and distance covered by the non-BPL households in water collection (see Section Distance Travelled and Time Spent in Water Collection), and the larger storage facilities available for water at the household level. Also, more importantly, while the non-BPL families use water for homestead gardens, the BPL families do not have them.

6.2 Village Kerkatta

6.2.1 Characteristics of the Village Water Supply Source

In the case of Kerkatta, the only water supply source is groundwater. Wells are constructed by the Panchayat to supply water to the households. The water from the wells is pumped into overhead tanks using motors. Water from the overhead tanks is supplied through pipelines to the individual tap connections provided. All households have private tap connections. There are two public wells, one for drinking purpose and the other for domestic purpose.

6.2.2 Average Family Size

The average family size with respect to the social group in the case of Kerkatta village is presented in Table 9. The average family size is highest for general caste, followed by OBC community and lowest for scheduled caste families. Again, there is some difference in the composition of families across castes, with general castes showing highest percentage of male adults (49.8). The percentage of adult females is in the range of 20.8 to 24.2, with lowest in the case of general caste.

Table 9: Average size of family member according to Economic Status

Name of Social Group	Family Size	Number	Per cent
Schedule Cast (SC)	Average family size	7.11	100.00
	1. Adult Male	3.11	43.74
	2. Adult Female	1.72	24.19
	3. Children male	1.24	17.44
	4. Children female	1.04	14.63
Other Backward Class (OBC)	Average family size	7.73	100.00
	1. Adult Male	3.32	42.95
	2. Adult Female	1.73	22.38
	3. Children male	1.36	17.59
	4. Children female	1.32	17.08
General	Average family size	9.04	100.00

	1. Adult Male	4.50	49.78
	2. Adult Female	1.88	20.80
	3. Children male	1.66	18.36
	4. Children female	1.00	11.06

Source: Authors' own analysis using primary data

6.2.3 Educational Profile of the Households

The educational status details of BPL and Non-BPL families in Kerkatta village are presented in Table 10. About 25% of males belonging to BPL category have attended the primary school, while about 30% of females from the same category have attended primary school. Nearly 46.30% of males and 30% females (from BPL families) have attended secondary school. Further, nearly 13% of the males and 7 per cent of the females in the sample households are graduates. The male and female illiterates (BPL) are about 16% and 34%, respectively.

Against this, 15% of males under non-BPL category have attended only primary school, whereas 17% of their female counterparts have attended primary school. Nearly 45% of males (BPL) and 36% females (Non-BPL) have attended secondary school. Also, 23% of the males and a greater percentage (28%) of the females are graduates. Interestingly, 11% of the males in the sample households have post graduate degree. The male and female illiterates (Non-BPL) are 9.75% and 27.57% respectively. What emerges from these results is that while generally the literacy rate is high, percentage of people who are literate and who have higher qualifications is much higher in non-BPL families. Also, the situation with regard to literacy is much better in Kerkatta when compared to Varoshi.

Table 10: Educational Qualification of Sample Respondents under Different Economic Segments

Particulars	Male/ Female	Primary	Secondary	Graduation	Post Graduate	Illiterate
	BPL Category					
Average number	Male	0.87	1.61	0.45	0.00	0.55
Per cent		25.00	46.30	12.96	0.00	15.74
Average number	Female	0.87	0.87	0.19	0.00	1.00
Per cent		29.67	29.67	6.59	0.00	34.07
	Non-BPL Category					
Average number	Male	0.80	2.40	1.23	0.58	0.31
Per cent		15.03	45.09	23.12	10.98	5.78
Average number	Female	0.68	1.41	1.11	0.06	0.68
Per cent		17.19	35.94	28.13	1.56	17.19

Source: Authors' own analysis using primary data

6.2.4 Occupational Profile of the Households

The occupation profile details are given in Table 11. About 14% of males (BPL) and 3% females (BPL) are engaged in agriculture as their main occupation. Very few, i.e., 2.5% of males (BPL) and 3.6% of the females in the sample households are engaged in dairying. Nearly 4% of the male from BPL households are in regular employment. Much larger percentage of the people from BPL families are engaged in farm & non-farm labour, with their percentage being 20 and 21 for males and females, respectively.

About 19% of males (Non-BPL) and 11% females (Non-BPL) are in engaged in agriculture. Therefore their proportion of persons engaged in agriculture is much higher for non-BPL families. As regards dairying, around 10.3% of the males and 8% of the females belong to non-BPL category are engaged in this. As regards labour (farm & non-farm labour), lesser percentage (10%) of the non-BPL families are dependent on it as a source of income. Hence, the proportion of people engaged in wage labour is less for non-BPL families.

Table 11: Occupation-wise distribution of average size of family members

Particulars	Male/ Female	Agriculture	Dairying	Service	Farm/non-farm labour	Petty Trade	Studying	Others
	BPL Category							
Average number	Male	0.91	0.15	0.23	1.25	0.61	0.53	0.08
Per cent		14.20	2.4	3.6	19.5	9.5	8.3	1.2
Average number	Female	0.19	0.23	0.00	1.37	0.53	0.30	0.04
Per cent		3.0	3.6	0.00	21.3	8.3	4.73	0.6
	Non-BPL Category							
Average number	Male	1.72	0.95	0.11	0.95	0.3	0.8	0.8
Per cent		18.6	10.3	1.2	10.3	3.4	8.3	8.6
Average number	Female	1.01	0.87	0.03	0.45	0.27	0.6	0.42
Per cent		10.9	9.5	0.30	4.9	2.9	6.3	4.6

Source: Authors' own analysis using primary data

6.2.5 Sources of Water Supply

The various sources of water supply for meeting different requirements of the households during different seasons across Kerkatta village are presented in Table 12. The most striking feature is that largest number of households depends on individual tap connections (58-36) for drinking water supply and other domestic needs, followed by hand pumps (19-25). Fewer households depend on common stand posts. An interesting phenomenon is that the number households depending on private tap connections and stand posts decline significantly during summer months, as the supply dwindle and many more families start depending on farm wells (55), and hand pumps.

For meeting livestock drinking and homestead gardens requirements, a larger percentage of the households (which undertake these activities depend on private tap connections. Here again, their number decline as summer advances, and larger number of families depend on farm wells and hand pumps. This is a clear indication of the scarcity of water from public sources.

Table 12: Sources of Water Supply (Season-wise)

Sources of water supply	Number of Families depending on various sources				
	Drinking & Cooking	Other domestic uses including	Homestead gardens	Livestock	Small scale enterprise

				washing, bathing & sanitation											
	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S
1. Individual tap	58	58	36	60	59	37	11	12	5	20	21	20	1	1	0
2. Hand pump	19	19	25	17	17	23	0	0	0	5	5	7	0	0	0
3. Common stand post	13	13	7	14	15	8	2	2	2	3	3	2	0	0	0
4. Pawned open well	2	2	5	2	2	5	0	0	0	2	3	6	0	0	1
5. Owned bore well	1	1	3	1	1	3	0	0	0	0	0	3	0	0	0
6. Shared open well	1	1	1	0	0	0	0	0	1	1	1	1	0	0	0
7. Shared bore well	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Public open well	2	2	5	4	4	7	1	1	2	0	0	2	0	0	0
9. Public bore well	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. Own farm well	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11. Farm well neighbours/ other	12	12	55	10	10	51	0	0	9	2	1	23	0	0	0
12. Irrigation tank/ pond	0	0	0	0	0	0	0	1	0	16	18	6	1	0	0
13. Spring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14. Tanker water supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15. RWHS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16. Any other	0	0	1	1	2	3	6	5	5	0	0	0	0	0	0
M= Monsoon, W= Winter and S=Summer															

Source: Primary survey of sample households

6.2.6 Accessibility of Sources

The various sources of water, number of users and distances of these sources are presented in Table 13. It can be seen that when it comes to tapping difference source of water for meeting domestic and productive needs, the BPL families appear to have better access to water sources (six of them) in terms of number of households which have access to more than one source and the physical distance to the sources, though the non-BPL families depend on larger number of sources (eight of them).

Table 13: Accessibility of Sources

	Accessibility And Characteristics of Different Sources of Water For Domestic And Productive Uses																											
	BPL														NON – BPL													
Source of Water	Piped Water Supply	Hand Pump	Common Stand Post	Owned Open Well	Owned Bore Well	Shared Open Well	Shared Bore Well	Public Open Well	Public Bore Well	Own Farm Well	Farm Well of Neighbours / Others	Irrigation Tank / Pond	Spring	Tanker Water Supply	Piped Water Supply	Hand Pump	Common Stand Post	Owned Open Well	Owned Bore Well	Shared Open Well	Shared Bore Well	Public Open Well	Public Bore Well	Own Farm Well	Farm Well of Neighbours / Others	Irrigation Tank / Pond	Spring	Tanker Water Supply
Number of Users	24	16	12							2	30	1			2	14	3	6	4	1					24	2		
Distance (m)	2.01	53.13	39.20							150	388.00	1000.00			3.64	52.70	50.0	335.3	400.5	5.0					732.3	1000.0		

Source: Authors' own analysis using primary data

6.2.7 Distance to the Water Sources and Time Spent in Water Collection

Table 14 provides the average distance covered by households belonging to BPL and non-BPL households for collecting water for household needs, and the time spent in water collection, in different seasons. What emerges from the results is that the non-BPL households travel more distance and spend more time fetching water for their household needs. This is the result of the fact that their water sources are located farther than those of the BPL households (see Table 13).

Another interesting phenomenon is that both in the case of BPL families and non-BPL families, the average distance travelled for fetching water and the time spent for the same increase remarkably during summer, while decreases during winter months.

Table 14: Distance to Water Sources and Time Spent in Water Collection

Particulars	Rainy	Winter	Summer
BPL Category			
1. Average distance (m)	**344.92**	**344.92**	**1584.00**
2. Minimum distance	6.00	6.00	16.00
3. Maximum distance	3400.00	3400.00	9600.00
Non-BPL Category			
1. Average distance (m)	433.25	433.25	2096.90
2. Minimum distance	10.00	10.00	10.00
3. Maximum distance	4800.00	4800.00	12000.00
BPL Category			
1. Average time (Hrs.)	0.76	0.56	1.21
2. Minimum time (Hrs.)	0.15	0.15	0.25
3. Maximum time (Hrs.)	3.00	3.00	4.00
Non-BPL Category			
1. Average time (Hrs.)	0.88	0.66	1.07
2. Minimum time (Hrs.)	0.25	0.25	0.25
3. Maximum time (Hrs.)	4.50	4.50	5.00

Source: Authors’ own analysis using primary data

6.2.8 Storage Facilities Available at the Household Level for Water

The storage facilities available at the household level for water are presented in Table 15. The average storage capacities for water for BPL families for drinking and cooking are 17.1 and 14.5 litre, respectively. Similarly the average storage capacities for BPL families for bathroom, toilet use and livestock use are 84.2, 58.6 and 39.2litre, respectively. The corresponding average figures for their counterparts under non-BPL category are much higher. Hence, the non-BPL families have better storage facilities for water, which would help them tide over the crisis emerging out of interruptions in water supply.

Table 15: Capacity of the Storage Facilities

Water use for	Average Capacity (Lt)	Minimum Capacity (Lt)	Maximum Capacity (Lt)
BPL Category			
1. Drinking	17.1	10.00	60.00
2. Cooking	14.5	10.00	60.00

3. Bathroom use including hand wash	84.2	15.00	200.00
4. Toilet Use	58.6	10.00	200.00
5. Livestock Use	39.2	5.00	200.00
Non-BPL Category			
1. Drinking	25.6	10.00	50.00
2. Cooking	16.2	1.00	50.00
3. Bathroom use including hand wash	167.8	20.00	500.00
4. Toilet Use	101.00	10.00	500.00
5. Livestock Use	122.5	2.00	2000.00

Source: Authors' own analysis using primary data

6.2.9 Average per Capita Water Use for Different Purposes of the Households

The average per capita daily water use for different domestic purposes, for both normal year and drought year are given in Table 16a. As the table indicates, there is slight difference in the volumetric use of water between normal year and drought year in water use for drinking & cooking. The difference becomes slightly wider when it comes to other domestic uses such as washing, bathing and toilet use. But, from the point of view of vulnerability, what is striking is the wide variation in water use across families both not only for other domestic such as washing, bathing and sanitation, but also for some of the very basic survival needs such as drinking and cooking. This can be attributed to the difference in degree of access to water sources, and the source characteristics. As we have seen in the earlier sections, some families have access to multiple sources.

Table 16a: Average per Capita Daily Water Use for Different Purposes of the Households

Average Water Requirement/ Use During		Drinking and Cooking			Other domestic uses including washing, bathing & sanitation use		
		monsoon	Winter	Summer	Monsoon	Winter	summer
Requirement	Quantity (Lt)	4.70	4.70	5.61	16.74	17.19	17.63
	Range	0.67-10.0	0.67-10.0	1.03-15	1.03-42.86	1.03-50	1.03-50
	Months	4.0	4.0	4.0	4.0	4.0	4.0
Normal Rainfall Year	Quantity (Lt)	5.15	4.71	5.56	17.19	17.24	17.73
	Range	0.67-50.0	0.67-10.0	1.03-15	1.03-50.0	1.03-50.0	1.03-50.0
	Months	4.0	4.0	4.0	4.0	4.0	4.0
Drought year	Quantity (Lt)	4.53	4.53	5.31	15.07	15.51	16.13
	Range	0.67-10	0.67-10	1.03-10	1.03-37.50	1.03-41.67	1.03-41.67
	Months	4.0	4.0	4.0	4.0	4.0	4.0

Source: Authors' own analysis using primary data

The average daily household level water use for livestock drinking, homestead garden and small enterprises, against the requirements are given in Table 16b. The estimates consider only those households which have the particular enterprise, be it raising kitchen garden or livestock production or small enterprise. The figures show marginal difference in household level water use between normal year and drought year for kitchen garden and livestock drinking. Also, difference in volumetric water use exists across seasons, with larger quantities used in summer months for livestock drinking and watering kitchen gardens.

Table 16b: Average Daily Household Level Water Use for Productive Needs in Different Seasons

Average Water		Homestead Garden	Livestock	Small Scale Enterprise

Requirement/ availability during		M	W	S	M	W	S	M	W	S
Requirement	Quantity (Lt)	41.3	41.3	44.7	62.6	65.3	71.5	60.0	60.0	60.0
	Range	10-225	10-225	10-225	4-540	10-540	10-540	60-60	60-60	60-60
	Month	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Normal Rainfall Year	Quantity (Lt)	41.3	39.5	44.7	66.5	67.4	71.7	32.0	60.0	60.0
	Range	10-225	4-225	10-225	10-540	10-540	10-540	4-60	60-60	60-60
	Month	4.00	4.0	4.0	4.00	4.0	4.0	4.00	4.0	4.0
Drought year	Quantity (Lt)	43.2	42.2	44.6	66.4	66.3	70.8	60.00	60.00	60.00
	Range	10-225	10-225	4-225	10-540	10-540	4-540	60-60	60-60	60-60
	Month	4.00	4.0	4.0	4.00	4.0	3.96	4.00	4.0	4.0
M= Monsoon, W= Winter and S=Summer										

Source: Authors' own analysis using primary data

The estimates of daily household level water use for different domestic and productive needs are summarized in Table 16c. It shows clearly that the daily water use is higher for non-BPL families for drinking & cooking as well as other domestic uses. This is in spite of the better access the BPL families have to water sources in the village. But, it is to be kept in mind that the average family size is much higher for non-BPL families (9.25) when compared to their BPL counterparts (6.4). Nevertheless, the incremental water use found in the case of non-BPL families for washing, bathing and toilet use (146.3litre/day against 88.3litre/day) does offset the larger family size, while it does not offset in the case of water use for drinking & cooking.

Table 16c: Average Household Water Use in Various Sectors in Different Economic Segments (litre/day)

BPL Category		
	Average per Family	**Range**
1. Drinking & Cooking	29.7	10-90
2. Other domestic uses including washing, bathing & sanitation use	88.3	20-300
3. Homestead gardens	21.5	10-40
4. Livestock	36.4	10-100
5. Small scale enterprise		
Non-BPL Category		
1. Drinking & Cooking	35.3	10-120
2. Other domestic uses including washing, bathing & sanitation use	146.3	12-500
3. Homestead gardens	77.4	30-225
4. Livestock	81.4	20-540
5. Small scale enterprise	60.00	60.00

Source: Authors' own analysis using primary data

6.3 <u>Chandrapur</u>

6.3.1 Characteristics of the Village Water Supply Source

In Chikhali, like in the case of Kerkatta, groundwater is the source of water supply. An open dug in the crystalline hard rock formations is the main water supply source. Water from the open well is pumped into overhead tanks. From these tanks, water is supplied to individual household tap connections through pipelines. There are 170 individual tap connections in the village. In addition to the open well, there are three functional hand pumps in the village.

6.3.2 Average Family Size

The average family size with respect to the social group in the case of Chikhali village is presented in Table 17. The average family size is 4.0, 7.08, 5.28, 4.5 and 1 for Schedule Caste, Schedule Tribe, Nomadic Tribe, Other Backward Class and General group, respectively. An average scheduled tribe family appears to be larger in size, as compared to SC, NT, OBC and general casts. Whereas, the number of adult male population in an average scheduled cast family (2) is higher than that of the ST (1.72), NT (1.83), OBC (1.3) and general category (1).

Table 17: Average Family Size

Name of Social Group	Family Size	Number	Per cent
Schedule Cast (SC)	Average family size	4.00	100.00
	1. Adult Male	2.00	50.00
	2. Adult Female	1.00	25.00
	3. Children male	1.00	25.00
	4. Children female	-	-
Schedule Tribe (ST)	Average family size	7.08	100.00
	1. Adult Male	1.72	24.29
	2. Adult Female	1.65	23.31
	3. Children male	1.92	27.12
	4. Children female	1.79	25.28
NT	Average family size	5.28	100.00
	1. Adult Male	1.83	34.66
	2. Adult Female	1.52	28.79
	3. Children male	0.86	16.29
	4. Children female	1.07	20.27
Other Backward Class (OBC)	Average family size	4.5	100.00
	1. Adult Male	1.3	28.89
	2. Adult Female	1.3	28.89
	3. Children male	1.4	31.11
	4. Children female	0.5	11.11
General	Average family size	1.00	100.00
	1. Adult Male	1.00	100.00
	2. Adult Female	-	-
	3. Children male	-	-
	4. Children female	-	-

Source: Authors' own analysis using primary data

6.3.3 Educational Status

The educational status details of BPL and Non-BPL families in Chikhali village are presented in Table 18. About 19.11% of males belonging to BPL category have attended the primary school, while as 16% of females from the same category have attended primary school. Nearly 19.11% of males (BPL) and 7.11% (BPL) have attended secondary school. The male and female illiterates (BPL) are 15.56% and 21.33% respectively.

Against this, 24.86% of males under non-BPL category have attended the primary school, where as 24.22% of females (Non-BPL) have attended primary school. Nearly 36.42% of males (BPL) and 32.03% (Non-BPL) have attended secondary school. The male and female illiterates (Non-BPL) are 13.87% and 35.16% respectively. What emerges from these results is that generally the percentage of people who are literate is higher in non-BPL families, and the difference is remarkable when they are looked at from a gender perspective.

Table 18: Educational Status

Particulars	Male/ Female	Primary	Secondary	Graduation	Post Graduate	Illiterate
	BPL Category					
Average number	Male	0.97	0.97	0.02	0.05	0.79
Per cent		19.11	19.11	0.44	0.89	15.56
Average number	Female	0.81	0.36	0.02	-	1.08
Per cent		16.00	7.11	0.44	-	21.33
	Non-BPL Category					
Average number	Male	1.36	2.00	0.13	-	0.76
Per cent		24.86	36.42	2.31	-	13.87
Average number	Female	0.98	1.30	-	-	1.43
Per cent		24.22	32.03	-	-	35.16

Source: Authors' own analysis using primary data

6.3.4 Occupational Profile

The occupation profile details are given in Table 19. About 18.63% of males (BPL) and 18.63% females (BPL) are engaged in agriculture as their main occupation. About 25.68% of males (Non-BPL) and 24.9% females (Non-BPL) are in engaged in agriculture. Thus, the proportion of persons engaged in agriculture is higher for non-BPL families. As regards to labour (farm & non-farm labour), a significantly large percentage of males (15.69%) and females (13.73%) of the BPL families earn their income from it, whereas only 8.17% of males and 8.56% of females of the non-BPL families are dependent on wage labour (farm & non-farm). Hence, the proportion of people engaged in wage labour is less for non-BPL families.

Table 19: Occupational Profile

Particulars	Male/ Female	Agriculture	Dairying	Service	Farm/non-farm labour	Petty Trade	Studying	Others

	BPL Category							
Average number	Male	0.95	-	-	0.80	0.05	0.85	0.07
Per cent		18.63	-	-	15.69	0.98	16.67	1.47
Average number	Female	0.95	0.02	0.02	0.70	-	0.67	-
Per cent		18.63	0.49	0.49	13.73	-	13.24	-
	Non-BPL Category							
Average number	Male	1.41	-	0.28	0.45	0.11	0.79	0.09
Per cent		25.68	-	5.06	8.17	1.95	14.40	1.56
Average number	Female	1.37	-	0.09	0.47	0.02	0.43	-
Per cent		24.90	-	1.56	8.56	0.39	7.78	-

Source: Authors' own analysis using primary data

6.3.5 Sources of Water Supply

The various sources of water supply for different uses during different seasons across the Chikhali village are presented in Table 20. The most noticeable fact is that the number of households depending on individual tap connections is much larger than those dependent on any other available water source. Another interesting phenomenon is that a large number of households depend on public open wells to meet their drinking & cooking needs, other domestic needs, and livestock drinking requirements. As a matter of fact, it can be seen that many households have to depend on multiple sources of water during different seasons. This is a clear indication of the scarcity of water from different sources.

Table 20: Sources of Water Supply (Season-wise)

Sources of water supply	Number of Families depending on various sources														
	Drinking & Cooking			Other domestic uses including washing, bathing & sanitation			Homestead gardens			Livestock			Small scale enterprise		
	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S
1. Individual tap	63	63	63	68	68	68	6	5	6	19	19	44	-	-	-
2. Hand pump	4	4	4	3	3	3	1	1	1	2	2	2	-	-	-
3. Common stand post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Pawned open well	-	-	-	1	1	1	-	-	-	-	-	2	-	-	-
5. Owned bore well	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Shared open well	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
7. Shared bore well	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Public open well	27	27	30	23	22	26	-	-	-	6	6	13	-	-	-
9. Public bore well	4	4	4	2	2	3	-	-	-	-	-	1	-	-	-
10. Own farm well	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

11. Farm well: neighbours/ other	3	3	3	3	3	2	1	1	1	1	1	1	-	-	-
12. Irrigation tank/ pond	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13. Spring	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14. Tanker water supply	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15. RWHS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16. Any other	1	1	1	2	2	1	7	12	11	34	33	4	-	-	-
M= Monsoon, W= Winter and S=Summer															

Source: Primary survey of sample households

6.3.6 Accessibility of the Sources

The various sources of water, number of users and distances of these sources are presented in Table 21. The values are given separately for both BPL (below poverty line) and Non-BPL (All families other than BPL) families. What is striking is that the distinct difference between BPL families and non-BPL families when it comes to tapping difference source of water for meeting domestic and productive needs. In the case of non-BPL families, there are six different sources of water, whereas in the case of BPL families, there are only four sources of water. The proportion of families which have access to more than one source is also higher for non-BPL households.

Table 21: Accessibility of Sources

	Accessibility And Characteristics of Different Sources of Water For Domestic And Productive Uses													
	BPL													
Source of Water	Piped Water Supply	Hand Pump	Common Stand Post	Owned Open Well	Owned Bore Well	Shared Open Well	Shared Bore Well	Public Open Well	Public Bore Well	Own Farm Well	Farm Well of Neighbours / Others	Irrigation Tank / Pond	Spring	Tanker Water Supply
Number of Users	29	3						19	2					
Distance (m)	3.41	38.33						448.95	50.0					

	Accessibility And Characteristics of Different Sources of Water For Domestic And Productive Uses													
	NON – BPL													
Source of Water	Piped Water Supply	Hand Pump	Common Stand Post	Owned Open Well	Owned Bore Well	Shared Open Well	Shared Bore Well	Public Open Well	Public Bore Well	Own Farm Well	Farm Well of Neighbours / Others	Irrigation Tank / Pond	Spring	Tanker Water Supply
Number of Users	42	1		2				11	2		2			
Distance (m)	2.38	250.0		100.00				335.45	100.00		65.00			

Source: Authors’ own analysis using primary data

6.3.7 Distance Travelled and Time Spent in Water Collection

The average distances travelled and time spent in water collection are given in Table 22. The average distances travelled by the BPL families to collect water during rainy season, winter season and summer season are 1356.16, 1356.16 and 1383.0 meters respectively. Similarly the average distances travelled by the Non-BPL families to collect water during rainy season, winter season and summer season are 234.88, 234.88 and 340.44 meters, respectively. What emerges from this analysis is the fact that the BPL families often traverse large distances to fetch water, and this distance can increase.

Table 22: Distance travelled and Time Spent in Water Collection

Particulars	Rainy	Winter	Summer
Distance Travelled			
BPL Category			
1. Average distance (m)	1356.16	1356.16	1383.00
2. Minimum distance	10.00	10.00	10.00
3. Maximum distance	16000.00	16000.00	16000.00
Non-BPL Category			
1. Average distance (m)	234.88	234.88	340.44
2. Minimum distance	8.00	8.00	8.00
3. Maximum distance	4000.00	4000.00	4000.00
Time Taken			
BPL Category			
1. Average time (Hrs.)	1.13	1.13	1.21
2. Minimum time (Hrs.)	0.16	0.16	0.16
3. Maximum time (Hrs.)	10.50	10.50	10.83
Non-BPL Category			
1. Average time (Hrs.)	0.52	0.39	0.57
2. Minimum time (Hrs.)	0.16	0.16	0.16
3. Maximum time (Hrs.)	1.50	1.50	3.00

Source: Authors’ own analysis using primary data

The average time spent (in hours) by the BPL families to collect water during rainy season, winter season and summer season are 1.13, 1.13 and 1.21, respectively. Whereas, the average time spent in hours by the Non-BPL families for the same is 0.52, 0.39 and 0.57, respectively. Hence, there is a significant difference in the time spent on fetching water, with more time in the case of BPL families. This clearly indicates that the poor spent more time collecting water. What is important to note is that the poor do not have alternative sources to bank on when the public water supply system fails whereas the rich have alternative sources of water. Hence, merely looking at the time spent in water collection is not an indicator of the hardship. One also has to look at the average amount of water consumed by the different economic segments like BPL and non-BPL families.

6.3.8 Average Size of Storage Facilities Available at the Household Level for Water

The storage facilities available at the household level for water are presented in Table 23. The average storage capacities for water for BPL families for drinking and cooking are 12.10 and 13.7 litres respectively. Similarly the average storage capacities for BPL families for bathroom, toilet use and livestock use are 127.50, 125.0 and 126.30 litres, respectively.

Table 23: Average Size of Storage Facilities Available at the Household Level for Water

Water use for	Average Capacity (Litre)	Minimum Capacity (Litre)	Maximum Capacity (Litre)
BPL Category			
1. Drinking	12.10	10	20
2. Cooking	13.70	10	100
3. Bathroom use including hand wash	127.50	10	500
4. Toilet Use	125.00	15	500
5. Livestock Use	126.30	10	500
Non-BPL Category			
1. Drinking	14.10	10	50
2. Cooking	13.92	10	50
3. Bathroom use including hand wash	172.30	15	500
4. Toilet Use	172.30	15	500
5. Livestock Use	141.41	10	400

Source: Authors' own analysis using primary data

The average storage capacities for water for non-BPL families for drinking and cooking are 14.10 and 13.92 litres respectively. Similarly the average storage capacities for Non-BPL families for bathroom, toilet use and livestock use are 172.30, 172.30 and 141.41 litres, respectively. Therefore, the average figures are much higher. Hence, the non-BPL families have better storage facilities for water, which would help them tide over the crisis emerging out of interruptions in water supply.

6.3.9 Average per Capita Water Use for Different Purposes of the Households

The average per capita daily water use for different purposes of the households, for both normal year and drought year are given in Table 24 a. Data indicate that there is a significant difference in the volumetric use of water between normal year and drought year for drinking & cooking purpose and other domestic uses. From the point of view of vulnerability, what is striking is the wide variation in water use across families both not only for other domestic such as washing, bathing and sanitation, but also for some of the very basic survival needs such as drinking and cooking. This can be attributed to the difference in physical access to the water sources, and the source characteristics.

Table 24 a: Average per Capita Daily Water Use for Different Purposes of the Households

Average Water Requirement/ availability during		Drinking and Cooking			Other domestic uses including washing, bathing & sanitation use		
		Monsoon	Winter	Summer	Monsoon	Winter	summer
Requirement	Quantity (Lt)	6.32	6.43	8.37	20.19	20.30	20.89
	Range	1.67-20	1.67-20	3.33-20	7.50-60	7.50-60	2-60
	Months	4.0	4.0	4.0	4.0	4.0	2-4
Normal Rainfall	Quantity (Lt)	6.31	6.33	8.44	19.83	20.19	20.65

Year	Range	1.67-20	1.67-20	3.33-20	1.33-60	7.50-60	6.67-60
	Months	4.0	4.0	4.0	4.0	4.0	4.0
Drought year	Quantity (Lt)	7.39	7.23	11.22	14.76	12.54	15.38
	Range	6.25-10	5.56-10	8.57-20	10-33.33	10-20	11.43-30
	Months	4.0	4.0	4.0	4.0	4.0	4.0

Source: Authors' own analysis using primary data

The average daily household level water use for livestock drinking and homestead garden, against the requirements are given in Table 24 b. The estimates consider only those households which have the particular enterprise, be it raising kitchen garden or livestock production. The figures show significant difference in household level water use between normal year and drought year for kitchen garden and livestock drinking. This clearly indicates the water scarcity felt by households during the drought years.

Table 24 b: Average Daily Household Level Water Use for Productive Needs in Different Seasons

Average Water Requirement / Use (Litre)	Homestead Garden			Livestock			Small Scale Enterprise		
	monsoon	winter	Summer	monsoon	Winter	summer	monsoon	winter	summer
Requirement	66.11	65.26	69.47	59.34	58.85	76.32	-	-	-
Normal Rainfall Year	61.90	64.90	30.00	60.14	59.52	71.05	-	-	-
Drought Year	20.00	20.00	20.00	35.00	50.00	60.00	-	-	-

Source: Authors' own analysis using primary data

The estimates of daily household level water use for different domestic and productive needs are summarized in Table 24 c.

Table 24 c: Average Household Water Use in Various Sectors in Different Economic Segments

BPL Category			
	Average per Family	**Range**	**Number of Months of Availability**
1. Drinking & Cooking	6.66	1.67-20	4.0
2. Other domestic uses including washing, bathing & sanitation use	17.86	1.33-60	4.0
3. Homestead gardens	52.50	40-180	-
4. Livestock	51.55	10-240	4.0
5. Small scale enterprise	-	-	-
Non-BPL Category			
1. Drinking & Cooking	5.97	3.33-10	4.0
2. Other domestic uses including washing, bathing & sanitation use	21.80	3-40	4.0
3. Homestead gardens	74.44	20-200	4.0
4. Livestock	64.76	5-300	4.0
5. Small scale enterprise	-	-	-

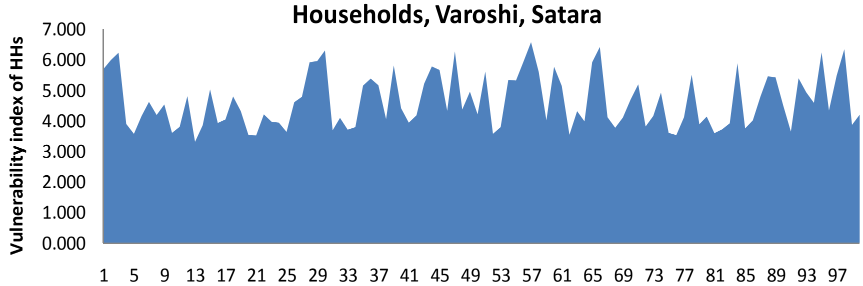
Source: Authors' own analysis using primary data

Table 24 c shows that there is significant difference in average household water use between the non-BPL and BPL families, with non-BPL families showing higher water use in most of the sub-sectors of household water use such as , other domestic uses, livestock use, and kitchen garden. In the case of livestock drinking, the difference could be because of the larger size of the animal holding of the family or family owning live stock types which consume more water (such as buffalo). This difference in water perhaps explains the larger storage facilities available for water at the household level. Also, more importantly, the non-BPL families use much more water for homestead gardens than the BPL families.

6.4 Multiple Use Vulnerability of the Sample Households

The vulnerability index was computed for all the sample households of the three pilot villages. For computation, several of the natural, physical, social and socio-economic and financial variables, influencing the vulnerability are considered, with the values of the respective variables being obtained from primary household survey, analysis of primary data and in a few cases the secondary data. In the case of Varoshi, the value of the index was found to be varying from 3.31to 6.58. Figure 1 shows the values for all the sample households. Out of the 100 households surveyed, 67 households have vulnerability index values lower than 5.

Figure 1: Multiple Use Vulnerability Index for Sample Households, Varoshi, Satara



The computed values of multiple use vulnerability index at the household level for the sample households in Kerkatta village of Latur are provided in Figure 2. The values range from a lowest of 2.21 to a highest of 6.32. Out of the 100 households, 81 are having values lower than 5.0, and therefore are considered vulnerable from multiple water use point of view.

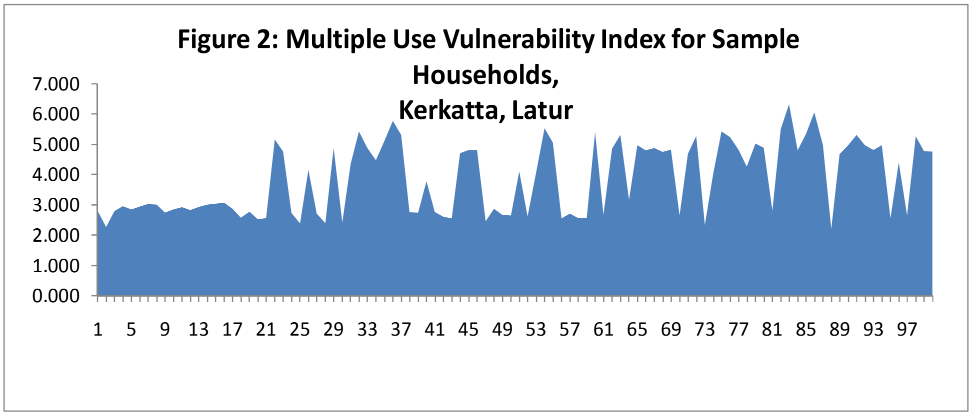


Figure 2: Multiple Use Vulnerability Index for Sample Households, Kerkatta, Latur

The computed values of multiple use vulnerability index at the household level for the sample households in Chikhali village of Chandrapur district are provided in Figure 3. The values range from a lowest of 3.15 to the highest of 6.37. Out of the 100 households, 30 have vulnerability index lower than 5.0, and hence are treated as highly vulnerable.

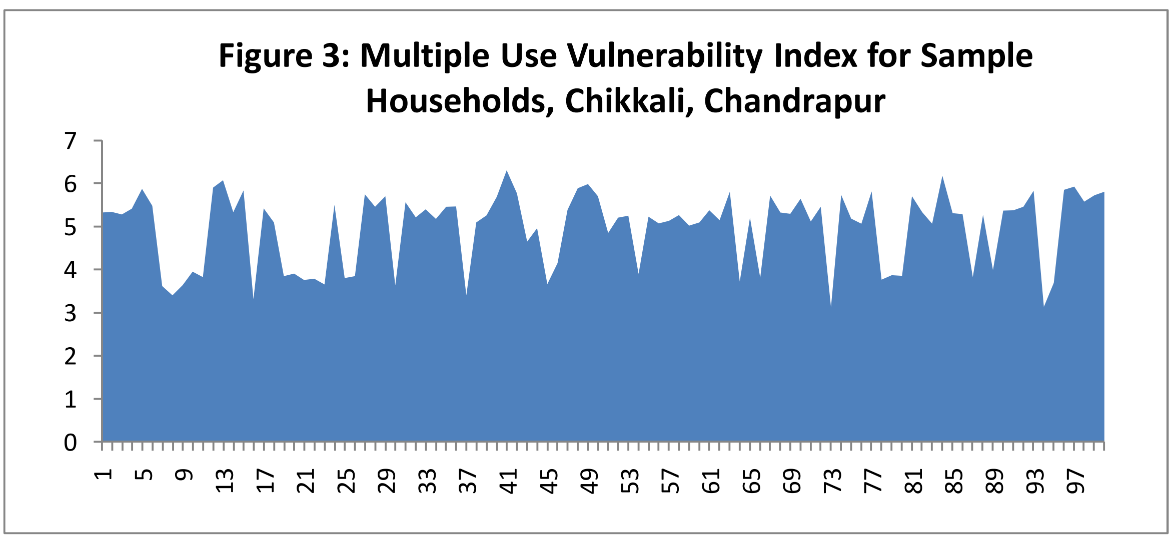


Figure 3: Multiple Use Vulnerability Index for Sample Households, Chikkali, Chandrapur

7.0 Socio-economic and Livelihood Dynamics of the HHs and Impacts of Climate Variability

The socio-economic and livelihood analysis included the following: 1] the average landholding of different class segments; 2] the average (gross and net) income from rain-fed and irrigated crops in normal and drought year; 3] the average holding of different categories of livestock under different segments; 4] the average feed and fodder inputs for different types of livestock; 5] income from dairy farming in different seasons for different types of livestock; 6] the various crops raised in kitchen gardens, and the amount of vegetables and fruits produced from them; 7] total annual income of the households from various occupations ; 8] wage employment earned by different economic segments in the farm and non-farm sector during different seasons and the rates; 9] the impact of drought on wage labour in farming; and, 10] efforts made by communities during drought years to reduce water demand for households needs. They are discussed in the same sequence in the sub-sections from 6.1 to 6.10.

7.1 Varoshi Village, Jawali, Satara

7.1.1 Average Land Holding Size of Different Classes

The average land holding sizes of different classes are presented in Table 25. For BPL families, the average own land holding size comes to around 0.46 acres. Similarly, for Non-BPL families, the average own land holding size is around 2.21 acres. It is clear from the table that the non-BPL families are distinguished by greater amount land owned, cultivated and irrigated. In the case BPL households, there is no irrigation. Further, the non-BPL families are engaged in land leasing in a big way with an average leased out land of 2.00, and this seems to be happening within the category as the average amount of land leased in by BPL families appear to be quite low (0.20 ha).

Table 25: Average Land Holding Size of Different Classes

Land size (Acre)	Own Holding	Cultivated land	Irrigated land	Land leased out	Land leased in	Land left fallow
BPL Category						
Average	0.46	0.41	-	0.20	-	0.50
Minimum	0.05	0.05	-	0.2	-	0.5
Maximum	2	2	-	0.2	-	0.5
Non-BPL Category						
Average	2.21	1.11	1.27	2.00	0.59	
Minimum	0.0125	0.0125	0.0125	0	0.125	0.05
Maximum	25	11	6	4	1.5	15

Source: Authors' own analysis using primary data

7.1.2 Average Yield, Gross and Net income from Irrigated and Rain-fed Crops under Normal and Drought Conditions

The average yield, Gross and net income from irrigated and rain-fed crops are given in Table 26a and Table 26b, respectively. The major difference between irrigated production and rain-fed production is in the crops chosen in different seasons. Several crops such as vegetables and fruits are grown under irrigated condition only. Some crops are grown in summer also under irrigated conditions. Though generally, the yield under irrigated condition was higher than in rain-fed conditions (groundnut, potato) in a normal rainfall year, in the case of paddy, the yield under rain-fed conditions was higher. This could be because of the fact that the crops, which are generally grown in rain-fed conditions, had to be irrigated because of delayed rains. Another important observation is that during drought years, many of the crops, which grown during normal rainfall years, are not taken up by the farmers, including those who are having irrigation sources. Here again, the yield during drought years was found to be lower than that under normal rainfall conditions except for wheat. What is important to note is that in the case of crops under rain-fed conditions, the impact of drought is much more pronounced, in terms of yield reduction.

Table 26 a: Average Yield, Gross and Net Income from Irrigated Crops under Normal and Drought Conditions

Name of season	Name of the crops	Total cost of input	Crop yield (Kg)		Gross income (Rs)		Net income (Rs)	
			Normal year	Drought year	Normal year	Drought year	Normal year	Drought year
Monsoon	Rice	8620.7	962.6	916.4	15852.5	15287.36	7231.8	6666.7
	Groundnut	29000.0	3500.0	2500.0	42000.0	30000.00	13000.0	1000
	Potato	45000.0	6000.0		60000.0		15000.0	
	Straw berry	519230.8	23076.9		1141025.6		621794.9	
Winter	Wheat	6670.1	1532.1	1626.0	21693.9	23023.45	15023.8	16353.4
	Vegetable	13828.5	2415.5		38768.1		24939.6	
	Chick pea	13104.8	2419.4	1612.9	32661.3	21774.15	19556.5	8669.3
	Pea	7500.0	750.0		15000.0		7500.0	
Summer	Vegetable	30000.0	3333.3		50000.0		20000.0	

(Source: Authors' own analysis using primary data)

Table 26 b: Average Yield, Gross and Net Income from Rain-fed Crops under Normal and Drought Conditions (Rs/Ha)

Name of season	Name of the crops	Total cost of input	Crop yield (Kg)		Gross income (Rs)		Net income (Rs)	
			Normal year	Drought year	Normal year	Drought year	Normal year	Drought year
Monsoon	Rice	11900.9	1411.7	1022.5	22459.5	17203.0	10558.5	4366.2
	Hybrid Jowar	12760.9	2803.6	1612.9	32585.39	18741.9	19824.5	5981.0
	Finger Millet	11842.1	2105.3	1973.7	24342.11	19736.8	12500.0	7894.7
	Groundnut	8404.8	2083.3	1785.7	24999.90	21428.6	16595.2	13023.8
	Potato	28431.4	5294.1	3137.3	54901.96	21960.8	26470.6	4101.9
Winter	Wheat	18255.1	3010.2	1428.6	44285.71	21014.2	26030.6	2759.2
	Jowar	5263.2	1315.8	-	13157.89		7894.7	
	Chilli	9250.0	2000.0	-	40000.00	-	30750.00	-

(Source: Authors' own analysis using primary data)

As regards the net income, there is huge variation in income for the same crop under irrigated and rain-fed conditions. While one normally presumes that the crop would give higher returns under irrigated conditions, this does not appear to be true in the case of our study village. For many crops, the returns under rain-fed condition are higher (paddy, wheat, potato and groundnut) than that under irrigated condition in normal rainfall years. But, the impact of drought on net return was also found to be much higher for crops under rain-fed plots. For instance, in the case of rain-fed rice, the net return came down from Rs. 10,558 to Rs. 4,366 per ha, whereas in the case of irrigated rice, the drop was from Rs. 7,231.8 to Rs. 6,666.7 per ha. In the case of rain-fed wheat, the drop was from Rs.26, 023 to Rs. 2,759 per ha, whereas in the case of irrigated wheat, there was a marginal increase in net return from Rs. 15023 to Rs.16353 per ha. The same trend was found in the case of potato also. The only exception was groundnut, in which case, the decline was very sharp for irrigated plots.

7.1.3 Livestock Holding Types and Size of Different Class Segments

Details of livestock holding types and size of different caste segments are given in Table 27.

Table 27: Livestock Holding Types and Size of Different Caste Groups

Breed	All social group	Schedule Caste	Other backward Class	General Category
Indigenous cow				
Milch	1.14	-	-	1.14
Dry	1.14	-	1.0	1.17
Calf	1.25	-	1.0	1.33
Crossbred cow				
Milch	1.00	-	-	1.00
Dry	0.00	-	-	0.00
Calf	1.00	-	-	1.00
Buffalo				
Milch	1.11	1.00	3.00	1.00
Dry	1.33	1.00	1.00	1.56
Calf	1.42	0.00	1.50	1.40

(Source: Primary survey of sample households)

Table 27 shows that the families belonging to general category keep different types of livestock, such as cows (both indigenous and cross bred) and buffaloes. Whereas, the families belonging to scheduled caste own only buffaloes and OBCs own buffaloes and indigenous cows. Nevertheless, on an average, the OBC families appear to own larger number of buffaloes as compared to general castes and SCs.

7.1.4 Average Feed and Fodder Inputs for Different Types of Livestock

The details of average fee and fodder inputs for different types of livestock during different seasons and their prices are provided in Table 28. It is quite clear from the table that the quantum of green fodder fed to dairy animals (cows, buffaloes and goat) and draught animals is highest during monsoon, where plenty of natural grass is available in the area owing to humid climate, high rainfall and presence of common land. The quantum of dry fodder during the season is nil for cows (both cross bred and indigenous), whereas buffaloes are fed with dry fodder during monsoon also, though the quantum is lowest as compared to other seasons. The quantum of dry fodder fed to animals is highest during summer months. In the case of bullocks, dry fodder is fed during monsoon also. Among all the dairy animals, buffaloes consume maximum amount of dry and green fodder.

Table 28: Average Feed and Fodder Inputs for Different Types of Livestock

Name of feed & fodder	Monsoon		Winter		Summer	
	Quantity	Price	Quantity	Price	Quantity	Price

	(kg)	(Rs/kg)	(kg)	(Rs/kg)	(kg)	(Rs/kg)
Indigenous Cow						
Dry Fodder						
1. Paddy straw & dry grass	0.00	0.00	15.27	0.13	14.77	0.13
Green Fodder						
1. Rice and Green grass	19.77	0.12	10.00	0.11	0.00	0.00
Concentrate						
1. Cattle feed	0.95	10.50	0.95	10.50	0.95	10.50
Crossbreed Cow						
Dry Fodder						
1. Paddy straw, Maize & dry grass	0.00	0.00	16.00	0.10	16.00	0.10
Green Fodder						
1. Maize and Green grass	20.00	0.10	10.00	0.10	0.00	0.00
Concentrate						
1. Cattle feed	1.00	10.00	1.00	10.00	1.00	10.00
Buffalo						
Dry Fodder						
1. Paddy straw & dry grass	13.17	0.10	19.30	0.10	20.97	0.10
Green Fodder						
1. Paddy and Green grass	25.80	0.10	13.32	0.10	40.00	0.10
Concentrate						
1. Cattle feed	1.36	10.95	1.30	10.45	1.38	10.60
Goat						
Dry Fodder						
1. Dry grass	1.00	0.10	4.50	0.10	4.50	0.10
Green Fodder						
1. Green grass	6.43	0.10	3.60	0.10	0.00	0.00
Concentrate						
1. Cattle feed	0.00	0.00	0.00	0.00	0.00	0.00
Bullock						
Dry Fodder						
1. Paddy straw & dry grass	40.00	0.10	21.18	0.10	22.94	0.10
Green Fodder						
1. Paddy and Green grass	28.65	0.10	17.15	0.10	20.00	0.10
Concentrate						
1. Cattle feed	1.79	13.21	1.67	13.33	1.69	13.13

Source: Authors' own analysis using primary data

7.1.5 Income from Dairy Farming in Different Seasons for Different Livestock Types

The details regarding income from dairy farming in different seasons for different livestock types are given in Table 29. The average milk yield is highest for buffaloes, followed by cross bred cows. But, significant variation in yield is found across seasons. In the case of buffaloes and indigenous cows, the milk yield goes up during monsoon season when the region experiences very cold climate. In the case of cross bred cows, the highest yield appears to be during winter season. However, in all the cases, the lowest milk yield was found during summer months.

Table 29: Income from Dairy Farming in Different seasons for Different Types of Livestock

Dairy animal	Average milk production (Lt/day/animal)			Average milking days			Milk Price (Rs/litre)
	Monsoon	Winter	Summer	Monsoon	Winter	Summer	
Indigenous cow	2.68	2.39	1.89	106.00	95.00	67.00	9.79
Crossbred cow	2.33	2.50	2.17	120.00	100.00	60.00	10.67
Buffalo	4.19	4.03	2.95	119.03	104.52	60.32	11.03
Goat	0.63	0.50	0.38	87.50	73.33	10.00	-

(Source: Authors' own analysis using primary data)

On an average, a 20% drop in milk production was reported by the sample households for the drought year. The minimum and maximum reduction in milk production reported were 10% and 30%, respectively.

7.1.6 Different Crops Raised in Kitchen Gardens and the Quantities

The mean size of the kitchen garden was estimated to be 107 sq. feet. The details of various fruit and vegetable crops which the families raise in their kitchen gardens and in the backyard of their houses and the average amount of produce are given in Table 30. It can be seen that the families raise a wide variety of fruits and vegetables in the area. The cold and humid climate of the region is quite favourable for crops such as mango, jack fruit, papaya, banana, lemon, coconut, arac nut, Sapota, and teak. The climate is also quite favourable for growing several of the vegetables such as French bean, brinjal, chilly, pumpkin and cucumber. Every family has at least 2-3 fruit trees in its backyard.

Table 30: Various Crops Raised in Kitchen Gardens and the Amount of Produce

Name of Fruits/ vegetable grown	Total number of such		Sapling & Planting cost (Rs)	Fertilizer/ Pesticide Cost (Rs)	Yield (Kg)
	Fruits	Vegetable			
Coconut	1	-	200.00	-	No yield
Banana	8.1	-	100.00	-	43.33
Papaya	1.33	-	15.00	-	30.00
French Bean	-	2.25	13.33	175.0	22.50
Brinjal	-	3.80	35.00	-	2.50
Rose	5	-	-	-	3.00
Mango	3.88	-	143.33	-	41.33
Pumpkin	-	1.5	-	-	7.50
Lemon	1.25	-	-	10.00	-
Guava	1.50	-	50.00	-	11.50
Cane (Bamboo)	65.0	-	-	-	-
Custard apple	1.0	-	-	10.0	5.0
Chilli	-	6.0	10.0		2.10
Cucumber	-	2.0	-	-	-
Bullock heart	1.0	-	-	-	-

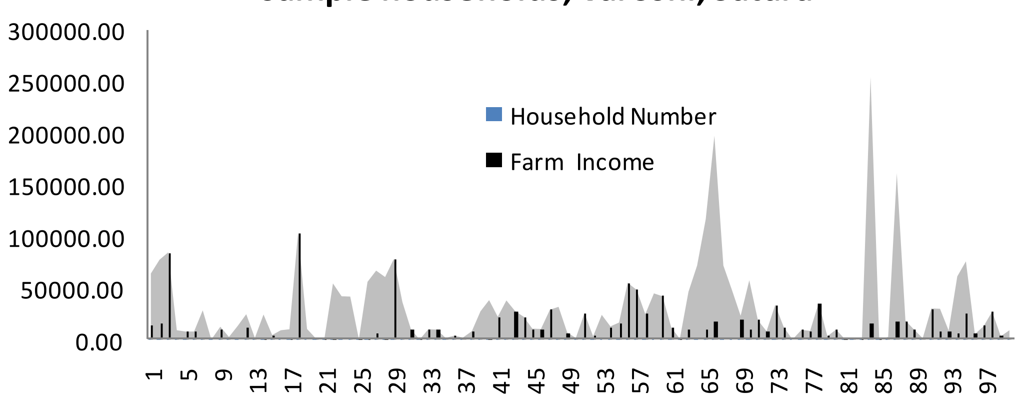
Periwinkle	1.0	-	-	-	1.0
Bitter Guard	-	1	5.00	-	1.0
Potato	-	25.0	50.0	200.0	20.50
Areca nut	1	-	-	-	-
Mango	1.50	-	-	-	1
Jack fruit	3.67	-	-	-	
Jambu Plum	1.0	-	-	-	-
Sapota	1.0	-	100.0	-	2.0
Tea	25	-	10	20.0	20.0
Siket dolichos	5.0	-	-	-	5.0
Teak wood	1.0	-	-	-	-
Shoe flower	2.0	-	-	-	2.0
Jasmine	2.5	-	-	-	5.5
Pomegranate	1.0	-	-	-	25.00

Source: Primary survey of sample households

7.1.7 Total Annual Income of the Households from Various Occupations

Figure 4 shows the graphical representation of the total annual income from various occupations and income from farming, which includes dairying. The total annual income of the surveyed families was estimated to be ranging from just Rs. 100 for a family which does not have any source of income to Rs.2,54,900 for another family which has major share of its income (94 per cent) coming from non-farm sources. The agricultural income was found to be nil for 11 families, and for the rest it was estimated to be varying from Rs. 100 to Rs. 103790. The non-farm income was found to exist for nearly 38 families, ranging from a minimum of Rs. 3000 per annum to a maximum of Rs. 240000. For nine families, the income was less than Rs. 1000 per annum.

Figure 4: Total annual income and income from farming for sample households, Varoshi, Satara



7.1.8 Wage Employment Earned by Different Segments in the Farm and Non-Farm Sector during Different Seasons and Rates

The details of the wage employment earned by different segments in the Farm and Non-Farm sector during seasons and rates are given in Table 15. It shows that the number of days for which an average BPL family is engaged in wage labour is much higher than that of non-BPL families. The difference becomes more significant during summer months, when four members of an average BPL family are engaged in wage labour for an average of 35 days during the season. But, wage labour absorption in terms of number of days of employment is greater from non-farm sector.

Another interesting finding from the analysis is that the wage rates earned by women are much less as compared to their male counterparts. Differences are also found in wage rates across economic segments. Interestingly, the female labourers from non-BPL families earn much less in farming sector as compared to their counterparts in the BPL category. In contrast to this, the female labourers from non-BPL families engaged in non-farm sectors earn much more as compared to their counterparts in BPL category. This could be because of the difference in nature of wage labour they are engaged in.

Table 31: Wage Employment Earned and Wage Rates

Social group	No. of family member engaged		No. of days employed during season		Wage Rate (Rs/day)			
	Farm	Non-farm	Farm	Non-farm	Farm (male)	Farm (Female)	Non-farm (male)	Non-farm (Female)
Monsoon								
BPL Category	1.67	1.40	57.78	82.22	82.86	91.67	110.00	53.33
Non-BPL Category	1.42	1.52	54.17	75.45	91.82	65.00	181.67	134.17
Winter								
BPL Category	1.67	1.44	60.00	80.00	82.86	100.00	95.56	53.33
Non-BPL Category	1.42	1.52	48.33	80.87	91.82	65.00	180.00	134.17
Summer								
BPL Category	1.50	4.09	35.00	91.00	86.00	120.00	107.50	53.33
Non-BPL Category	1.25	1.54	35.00	87.08	90.00	67.50	182.63	134.17

Source: Authors' own analysis using primary data

7.1.9 Impact of Drought on Wage Earning from Farm and Non-Farm Sector

The details of the impact of drought on wage earning from farm sector are given in Table 32. As per the table, some families in the non-BPL category reported increase in farm labour to the tune of 60 per cent, the average increase reported by some of their BPL counterparts was 10%. While a reduction in farm labour to the tune of 10 per cent was reported by non-BPL families, BPL families reported an average reduction of 20%. Such a trend comes perhaps because of the fact that during droughts the non-BPL families are not able to cultivate during winter months in their own farms, due to which they are able to use the surplus family labour to work in others' farms.

As regards non-farm labour, no major trend seems to be emerging with regard to impact of drought. Same is the case with wage rates. While some in the BPL families reported increase in wage labour to the tune of 20 per cent, no one from non-BPL category reported increase in wage labour. Whereas an average reduction in wage labour to the tune of 30 per cent was recorded by some BPL families, an average 18 per cent reduction was reported by some non-BPL families.

Table 32: Impact of Drought on Wage Earning from Farm and Non- Farm Sector

Social group	Increase or decrease in farm wage labour			Increase or decrease in non-farm wage labour			Increase or decrease in wage rate		
	Increase	Decrease	No Change	Increase	Decrease	No Change	Increase	Decrease	No Change
BPL Category	10.00	20.00	1.00	20.00	30.00	1.00	10.00	10.00	1.00
Non-BPL Category	60.00	10.00	1.00		18.00	1.00	20.00	10.00	1.00

Source: Authors' own analysis using primary data

7.1.10 Efforts to Reduce Household Water Demands during Drought Years

The details regarding efforts to reduce the water demands during drought years are presented in Table 33. Out of 100 families surveyed, 49 families had an opinion that they reducing the household water demand by reducing the frequency of bathing and washing. Very few families reported reducing the number of animal holdings.

Table 33: Efforts to Reduce Household Water Demands during Drought Years (Varoshi)

Activities for reducing water demand	**Number of Families**
Reducing the frequency of bathing & washing	49
Reducing the no. of animal holdings	3
Reducing area under irrigation	1
Reducing area under crop which take more water & increasing area under low water consuming ones	1
Reducing area under green fodder & buying dry fodder	1

Source: Primary survey of sample households

7.2. Kerkatta, Latur

7.2.1 Landholding

The average land holding sizes of different classes are presented in Table 34. For BPL families, the average own land holding size comes to around 3.25 acres. But, for Non-BPL families, the average own land holding size is nearly two times higher (9.14 acres). Also, both cultivated and irrigated lands are higher for non-BPL families. But, average irrigated area is only around 2/3rd of the cultivated area. Another important observation is with regard to the amount of land left fallow. On an average, nearly half the land is left fallow in the case of BPL families, while around 42% of the land is left fallow in the case of non-BPL families. The poor quality of land and the lack of irrigation facilities are the major reasons for this. It is clear from the table that the non-BPL families are endowed with greater amount land, cultivated and irrigated. Unlike what was found in the case of Varoshi in western Maharashtra, land leasing is not practised in this village.

Table 34: Average size of land holding (Acres)

Land size (Acre)	Own Holding	Cultivated land	Irrigated land	Land leased out	Land leased in	Land left fallow
BPL Category						
Average	3.25	2.73	1.83	-	-	1.55
Minimum	0.05	0.05	0.50	-	-	0.50
Maximum	10.00	5.00	4.00	-	-	5.00
Non-BPL Category						
Average	9.14	7.97	4.83	-	-	3.35
Minimum	1.50	1.00	0.50	-	-	0.50
Maximum	50.00	50.00	18.50	-	-	15.00

Source: Authors' own analysis using primary data

7.2.2 Average Yield, Gross and Net income from Irrigated and Rain-fed Crops under Normal and Drought Conditions

The estimates of inputs costs for crop production, and yield, gross return and net return from crops are given for irrigated crops and rain-fed crops in Table 35 a and Table 35 b, respectively. The farmers, who have irrigation facilities, take up several crops such as wheat, chick pea, barley, pea, lentil and sugarcane. Here, sugarcane is an annual crop, and others are winter crops. Unlike in the case of western Maharashtra, farmers are not able to produce any crops during drought years due to severe groundwater shortage. The table shows that lentil gives highest net return per ha. This is owing to the recent astronomical increase in price of lentil in Indian market, owing to acute shortage of this produce. Wheat gives the lowest return per ha of Rs. 12, 919.

Table 35 a: Average Yield, Gross and Net Income from Irrigated Crops under Normal and Drought Conditions

Name of season	Name of the crops	Total cost of input	Crop yield (Kg)		Gross income (Rs)		Net income (Rs)	
			Normal year	Drought year	Normal year	Drought year	Normal year	Drought year
Winter	Wheat	5063.59	1386.96	-	17982.61	-	12919.02	-
	Chick pea	4378.11	994.20	-	22218.91	-	17840.80	-
	Barley	2936.51	634.92	-	19047.62	-	16111.11	-
	Pea	14000.00	2000.00	-	40000.00	-	26000.00	-
	Lentil	23000.00	10000.00	-	400000.00	-	377000.00	-
	Sugarcane	68778.95	110526.32	-	238421.05	-	169642.11	-

Source: Authors' own analysis using primary data

The rain-fed crops grown by the farmers soya bean, maize, paddy, hybrid jowar, green gram, millet, sunflower, black gram, groundnut and jowar, chamomile and roses. The net return is highest for roses, and second highest for chamomile. None of the crops are grown in drought years due to water scarcity.

Table 35 b: Average Yield, Gross and Net Income from Rain-fed Crops under Normal and Drought Conditions (Rs/Ha)

Name of season	Name of the crops	Total cost of input	Crop yield (Kg)		Gross income (Rs)		Net income (Rs)	
			Normal year	Drought year	Normal year	Drought year	Normal year	Drought year
Monsoon	Rose	90000.00	1818.18	-	545454.55	-	455454.55	-
	Chamomile	295000.00	20000.00	-	600000.00	-	305000.00	-
	Soya bean	6469.73	2338.57	-	48542.60	-	42072.87	-
	Maize	3600.00	2030.77	-	17400.00	-	13800.00	-
	Paddy	2821.28	989.36	-	9106.38	-	6285.11	-
	H. Jowar	3320.07	1401.32	-	11730.26	-	8410.20	-
	Pigeon pea	4286.18	1174.93	-	47371.47	-	43085.29	-
	Green gram	2713.51	283.78	-	9594.59	-	6881.08	-
	Sunflower	4733.02	827.91	-	15860.47	-	11127.44	-
	Millet	6466.67	1555.56	-	12888.89	-	6422.22	-
	Black gram	4177.78	1000.00	-	32777.78	-	28600.00	-
	Sesame	3616.67	366.67	-	12600.00	-	8983.33	-
	Groundnut	6843.75	1302.08	-	24635.42	-	17791.67	-
	Jowar	5068.55	1161.29	-	11854.84	-	6786.29	-

Source: Authors' own analysis using primary data

7.2.3 Livestock Holding

Table 36 provides data on livestock holding of the sample households. The families keep buffaloes, local species of cows, cross bred cows, sheep, goat and bullock.

Table 36: Average Size of Livestock Holding

	Indigenous cow	Crossbred cow	Buffalo	Sheep	Goat	Bullock
Milch	1.00	2.00	1.33	1.00	1.00	-
Dry	1.30	1.00	1.73	1.00	1.00	-
Calf	1.22	2.00	1.60	-	-	-
Total Animal						2.14

Source: Authors' own analysis using primary data

7.2.4 Average Quantity of Feed and Fodder for Different Types of Livestock in Different Seasons

The details of average fee and fodder inputs for different types of livestock during different seasons and their prices are provided in Table 37. It is quite clear from the table that the quantum of green fodder fed to dairy animals (cows, buffaloes and goat) and draught animals is highest during monsoon, where plenty of natural grass is available in the area owing to humid climate, high rainfall and presence of common land. Also, it is highest among all fodder inputs provided to animal during that season. The quantum of dry fodder provided to animals during the rainy season is lowest among all seasons for all animals, except for sheep. The quantum of dry fodder inputs to animals is highest during summer months. In the case of bullocks, dry fodder is fed during monsoon also. Among all the dairy animals, bullocks consume maximum amount of dry and green fodder.

Table 37: Average Feed and Fodder Inputs for Different Types of Livestock

Name of feed & fodder	Monsoon		Winter		Summer	
	Quantity (kg)	Price (Rs/kg)	Quantity (kg)	Price (Rs/kg)	Quantity (kg)	Price (Rs/kg)
Indigenous Cows						
Dry Fodder						
1. Paddy straw, maize straw & dry grass	7.00	0.18	17.69	0.30	17.97	0.30
Green Fodder						
1. Rice, Jowar, Maize and Green grass	21.29	0.11	8.85	0.12	8.75	0.20
Concentrate						
1. Cattle feed	0.93	10.33	0.98	10.00	0.98	10.41
Cross Bred Cows						
Dry Fodder						
1. Paddy straw and Maize	10.00	0.30	18.33	0.27	18.33	0.27
Green Fodder						
1. Green grass	18.33	0.10	20.00	0.10	-	-
Concentrate						
1. Cattle feed	1.33	10.67	1.33	10.67	1.33	10.67
Buffalo						
Dry Fodder						
1. Paddy straw & dry grass	10.00	0.67	19.82	0.23	20.05	0.23
Green Fodder						
1. Maize and Green grass	20.38	0.11	13.43	0.12	12.67	0.85
Concentrate						
1. Cattle feed	1.22	10.97	1.24	10.94	1.22	10.89
Sheep						
Dry Fodder						
1. Dry grass	4.00	0.10	3.00	0.10	3.00	0.10
Green Fodder						
1. Green grass	4.00	0.10	4.00	0.10	-	-
Concentrate						
1. Cattle feed	-	-	-	-	-	-
Goat						
Dry Fodder						
1. Dry grass	-	-	3.50	0.10	3.50	0.10
Green Fodder						
1. Green grass	6.00	0.10	3.00	0.10	-	-
Concentrate						
1. Cattle feed	-	-	-	-	-	-
Bullock						
Dry Fodder						

1. Dry grass and paddy straw	9.00	0.10	28.95	0.17	29.19	0.17
Green Fodder						
1. Paddy and Green grass	31.90	0.10	14.38	0.10	12.50	0.10
Concentrate						
1. Cattle feed	1.59	10.00	1.59	10.00	1.59	10.00

Source: Authors' own analysis using primary data

7.2.5 Income from Dairy Farming in Different Seasons for Different Livestock Types

The details regarding yield and income from dairy farming in different seasons for different livestock types are given in Table 38. The average milk yield is highest for cross bred cows, and is 4-5 times higher than that of buffaloes and indigenous cows. But, significant variation in yield is found across seasons. For all animals, the yield is highest during monsoon, followed by winter and lowest for summer.

Table 38: Average milk production (Lt/day/animal), average milking days and average milk price (Rs/litre)

Dairy animal	Average milk production (Lt/day/animal)			Average milking days			Milk Price (Rs/Lt)
	Monsoon	Winter	Summer	Monsoon	Winter	Summer	
Indigenous cow	4.48	4.27	3.29	120.00	113.33	62.38	15.08
Crossbred cow	25.00	25.00	20.00	120.00	120.00	60.00	12.00
Buffalo	5.27	5.27	3.45	120.00	116.36	72.00	20.09

Source: Authors' own analysis using primary data

The average reduction in milk production during the drought year was estimated to be around 36.5%. While the minimum reduction reported during the drought year was 20%, the maximum reduction was 50%. These figures are much higher than what was found in the case of Varoshi in western Maharashtra. Such high reduction is essentially because of the severe drought experienced in Latur region.

7.2.6 Different Crops Raised in Kitchen Gardens and the Quantities

The details of various crops raised by sample households in Kerkatta are provided in Table 39. What is important is that very few household maintain kitchen gardens. Even among them, they take it up in very small areas, with a few plants and trees. Unlike what was found in the case of Varoshi, in Kerkatta, lesser number of varieties of fruits and vegetables are found to be raised (15 against 19 in Varoshi). The plants are also lesser in number.

Table 39: Various Crops Raised in Kitchen Gardens and the Amount of Produce

Name of Fruits/ vegetable grown	Total number of such		Sapling & Planting cost (Rs)	Yield (Kg)
	Fruits	Vegetable		
Coconut	1	-	100.00	No yield

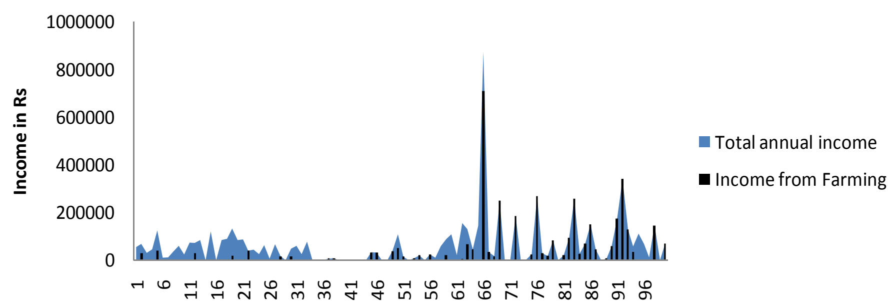
Papaya	4	-	-	-
Brinjal	-	21		20
Rose	2			1.5
Mango	1.3			50.0
Guava	10		100.00	4.0
Custard apple	4			75.0
Chilli	25			20.0
Bitter Guard	4			7.0
Mogra	1			1.0
Pomegranate	1		25	7.5
Tamarind	7			300.0
Bell	1			2.0
Almond	8.7			110.9
Drumstick	88.4			68.3

Source: Primary survey of sample households

7.2.7 Total Annual Income of the Households from Various Occupations

The total annual income from various occupations of the sample households are graphically represented in Figure 5. The estimated annual income from various sources and the total income from farming alone for the sample households are provided in Figure 5. Twenty two out of the 100 families did not report any income. For the rest of the households, the income varied from a lowest of Rs. 1080 to Rs.874300 per annum. Out of 100, 49 families are found to have income from farming (including dairying), and was estimated to be varying from a lowest of Rs. 2000 per annum to the highest of Rs. 706300 per annum.

Figure 5: Total annual family income and income from farming of sample households, Kerkatta, Latur



Source: Based on authors' own analysis using primary data

7.2.8 Wage Labour Earned by Households during Different Seasons

The details of the wage employment earned by different segments in the Farm and Non-Farm sector during seasons and rates are given in Table 40. It shows that the number of days for which an average non-BPL family is employed as wage laborer is much larger than that of BPL families. This is contrary to the population notion that families having large holdings would generally prefer to work in their own farms, than working as wage labourers. Perhaps such a phenomenon is happing because of acute shortage of water due to which the families are not able to cultivate in their land, particularly in summer.

The difference in wage labour earned becomes more significant during summer months, when 5.6 members of an average non-BPL family are engaged in wage labour for a total of 164 days during the season. The wage employment is greater from non-farm sector in all the three seasons. This could be because of the proximity to big towns such as Latur, which attract skilled and unskilled labourers for non-farm sector. Another interesting observation is that the wage rates for women are much less as compared to male labourers in non-farm sector as well as farming sector.

Table 40: Wage Employment and Wage Rates in Different Seasons

Social group	No. of family member engaged		No. of days employed during season		Wage Rate (Rs/day)			
	Farm	Non-farm	Farm	Non-farm	Farm (male)	Farm (Female)	Non-farm (male)	Non-farm (Female)
Monsoon								
BPL Category	2.15	1.88	70.37	85.00	92.92	49.77	121.88	58.57
Non-BPL Category	2.83	1.00	93.85	120.00	103.08	50.38	-	-
Winter								
BPL Category	2.16	1.90	62.40	86.00	92.27	48.96	125.00	61.11
Non-BPL Category	3.25	3.00	74.29	106.67	107.50	48.22	109.00	46.80
Summer								
BPL Category	2.27	1.90	42.67	88.00	96.92	52.00	117.11	59.47
Non-BPL Category	5.67	2.44	62.50	101.88	100.00	63.33	107.78	53.33

Source: Authors' own analysis using primary data

7.2.9 Impact of Droughts on Wage Employment

The details of the impact of drought on wage earning from farm sector are given in Table 41. As per the table, a reduction in farm labour to the tune of 30 per cent was reported by BPL families, non-BPL families reported an average reduction of 24% in wage labour. These trends are generally in conformation with what one would generally presume. Ideally, during droughts, the employment opportunities in farming would reduce because of reduced crop cultivation. As regards non-farm labour, an increase in wage employment to the extent of 35% was reported by BPL families, whereas the average figure reported by non-BPL families was 22 per cent. Also, a 10% reduction in non-farm employment was reported by some BPL families. The increase in non-farm wage employment during drought years could also be attributed to the reduced employment opportunities in the farm sector.

Table 41: How does the farm and non-farm employment change during drought years (%)

Social group		Increase or decrease in farm wage labour			Increase or decrease in non-farm wage labour			Increase or decrea	
		Increase	Decrease	No Change	Increase	Decrease	No Change	Increase	Decreas
BPL Category	Average	-	30		35.00	10.00	-	10.00	10
Non-BPL Category	Average	-	24	5	22.0	-	-	-	

Source: Authors' own analysis using primary data

7.2.10 Efforts to Reduce Household Water Demands during Drought Years

The details regarding efforts to reduce the water demands during drought years are presented in Table 42. Out of 100 families surveyed, 50 families had an opinion that they reducing the household water demand by reducing the frequency of bathing and washing. Only two families reported reducing the number of animal holdings as an option to reduce water demand. This also shows that families having livestock would be more vulnerable to the negative consequences of droughts such as reduced water availability.

Table 42: Special Efforts Made by Households during Droughts to Reduce the Water Demand

Activities for reducing water demand	**Number of Families**
BPL Category	
Reducing the frequency of bathing and washing	24
Reducing animal holding	1
Non-BPL Category	
Reducing the frequency of bathing and washing	26
Reducing animal holding	1

Source: Primary survey of sample households

7.3 Chikhali, Chandrapur

7.3.1 Average Land Holding Size of Different Classes

The average land holding sizes of different classes are presented in Table 43. For BPL families, the average own land holding size comes to around 5.30 acres. Similarly, for Non-BPL families, the average own land holding size is around 8.83 acres. It is clear from the table that the non-BPL families are distinguished by greater amount land owned, cultivated and irrigated. In the case BPL households, there is no irrigation. Further, the non-BPL families are engaged in land leasing in a big way with an average leased out land of 0.55 acres, and this seems to be happening within & across the category as the average amount of land leased in by BPL families appear to be quite high (0.66 ha).

Table 43: Average Land Holding Size of Different Classes

Land size (Acre)	Own	Cultivated	Irrigated	Land	Land	Land left

	Holding	land	land	leased out	leased in	fallow
BPL Category						
Average	5.30	5.04	0.00	0.31	0.66	0.40
Minimum	2.00	0.00	0.00	0.00	0.00	0.00
Maximum	13.00	13.00	0.00	5.00	13.00	5.00
Non-BPL Category						
Average	8.83	8.85	0.49	0.55	1.13	0.38
Minimum	1.00	0.00	0.00	0.00	0.00	0.00
Maximum	28.00	31.00	10.00	13.00	10.00	10.00

Source: Authors' own analysis using primary data

7.3.2 Average Yield, Gross and Net income from Irrigated and Rain-fed Crops under Normal and Drought Conditions

The estimates of average yield and gross and net income from irrigated and rain-fed crops are given in Table 44a and Table 4 b, respectively. Wheat and chilly are grown with irrigation whereas pulses, soya bean and cotton are grown under rain-fed condition. Another important observation is that during drought years, farmers do not grow any crops.

Table 44 a: Average Yield, Gross and Net Income from Irrigated Crops under Normal and Drought Conditions

Name of season	Name of the crops	Total cost of input	Crop yield (Kg)		Gross income (Rs)		Net income (Rs)	
			Normal year	Drought year	Normal year	Drought year	Normal year	Drought year
Winter	Wheat	11010.42	1203.13	-	15437.50		4427.08	-
	Chilli	6625.00	875.00	-	35000.00		28375.00	-

Source: Authors' own analysis using primary data

Table 44 b: Average Yield, Gross and Net Income from Rain-fed Crops under Normal and Drought Conditions (Rs/Ha)

Name of season	Name of the crops	Total cost of input	Crop yield (Kg)		Gross income (Rs)		Net income (Rs)	
			Normal year	Drought year	Normal year	Drought year	Normal year	Drought year
Monsoon	Cotton	16589.00	1361.45	-	40074.30		23485.30	-
	Soya bean	11685.52	1099.13	-	20512.50		8826.98	-
	Pigeon Pea	6444.88	542.26	-	17352.38		10907.50	-
	Rice	2975.00	1150.00	-	9200.00		6225.00	-
	Green gram	6326.88	354.69	-	11753.91		5427.03	-
	Jowar	5612.13	1169.06	-	9307.09		3694.96	-
	Black gram	5887.50	497.50	-	15025.00		9137.50	-
	Chick pea	9791.67	843.75	-	28666.67		18875.00	-
	Tur	5125.00	312.50	-	10000.00		4875.00	-

Source: Authors' own analysis using primary data

As regards the net income, there is huge variation in income within and across the crops, which are irrigated and which are rain-fed. Wheat and chilly, which are irrigated, produces a net income of Rs. 4,427.08 and Rs. 28,375.00 per hectare respectively. Within the rain-fed crops, cotton produces highest net return (Rs. 23,485.30/ha.) followed by chickpea (Rs. 18,875/ha.), pigeon pea (Rs. 10,907.50/ha.), black gram (Rs. 9,137.50/ha.), soya bean (Rs. 8,826.98/ha.), rice (Rs. 6,225/ha.), green gram (Rs. 5,427.03/ha.), tur (Rs. 4,875/ha.) and jowar (Rs. 3,694.96/ha.).

7.3.3 Livestock Holding Types and Size of Households

Details of livestock holding types and size of households are given in Table 45.

Table 45: Livestock Holding Types and Size

Type of Livestock	Milch	Dry	Calf	Total
Indigenous cow	3.50	1.89	2.50	
Crossbred cow	0.00	0.00	0.00	
Buffalo	0.00	0.00	0.00	
Sheep	1.00	0.00	0.00	
Goat	2.50	2.14	3.00	
Bullock	-	-	-	2.15

Source: Primary survey of sample households

Table 45 shows that the households own significantly higher number of indigenous cows (milch) in comparison to that of sheep and goat.

7.3.4 Average Feed and Fodder Inputs for Different Types of Livestock

The details of average fee and fodder inputs for different types of livestock during different seasons and their prices are provided in Table 46. It is quite clear from the table that the quantum of green fodder fed to dairy animals (cows and goat) and draught animals is higher during monsoon and summer. The quantum of dry fodder fed to goats is highest during summer months whereas for cows and bullocks it is more during monsoon. Among all the dairy animals, cows consume maximum amount of dry and green fodder.

Table 46: Average Feed and Fodder Inputs for Different Types of Livestock

Name of feed & fodder	Monsoon		Winter		Summer	
	Quantity (kg)	Price (Rs/kg)	Quantity (kg)	Price (Rs/kg)	Quantity (kg)	Price (Rs/kg)
Indigenous Cow						
Dry Fodder						
1. Paddy straw & dry grass	25.63	0.33	20.33	0.28	19.92	0.26
Green Fodder						
1. Green grass	23.95	0.10	17.22	0.10	24.00	0.10
Concentrate						
1. Cattle feed	1.25	10.00	1.50	10.67	1.25	11.00
Goat						
Dry Fodder						
1. Dry grass	4.67	0.10	5.33	0.10	7.44	0.10

Green Fodder						
1. Green grass	5.07	0.10	3.00	0.25	4.00	0.10
Concentrate						
1. Cattle feed	1.00	7.00	1.00	7.00	1.00	7.00
Bullock						
Dry Fodder						
1. Paddy straw & dry grass	36.36	3.40	33.41	0.24	33.62	0.22
Green Fodder						
1. Paddy and Green grass	36.91	0.10	21.33	0.10	37.57	0.10
Concentrate						
1. Cattle feed	1.85	9.50	1.68	9.73	1.58	10.00

Source: Authors' own analysis using primary data

7.3.5 Income from Dairy Farming in Different Seasons for Different Livestock Types

The details regarding income from dairy farming in different seasons for different livestock types are given in Table 47. The average milk yield is highest for indigenous cows, followed by goats. But, significant variation in yield is found across seasons. In the case of indigenous cows, the milk yield goes up during monsoon season. In all the cases, the lowest milk yield was found during summer months.

Table 47: Income from Dairy Farming in Different seasons for Different Types of Livestock

Dairy animal	Average milk production (Lt/day/animal)			Average milking days			Milk Price (Rs/litre)
	Monsoon	Winter	Summer	Monsoon	Winter	Summer	
Indigenous cow	1.13	1.06	0.94	120.00	120.00	70.00	14.00
Goat	0.50	0.50	-	90.00	90.00	-	-

Source: Authors' own analysis using primary data

7.3.6 Different Crops Raised in Kitchen Gardens and the Quantities

The details of various fruit and vegetable crops raised by sample households in their homestead are given in Table 48. The details of various fruit and vegetable crops which the families raise in their kitchen gardens and in the backyard of their houses and the average amount of produce are given in Table XIV. It can be seen that the families raise a wide variety of fruits and vegetables in the area. The climate of the region is quite favourable for crops such as mango, papaya, banana, lemon, guava, custard apple, pomegranate and almond. The climate is also quite favourable for growing several of the vegetables such as bitter gourd, brinjal, chilly, pumpkin, lady finger and cucumber.

Table 48: Various Crops Raised in Kitchen Gardens and the Amount of Produce

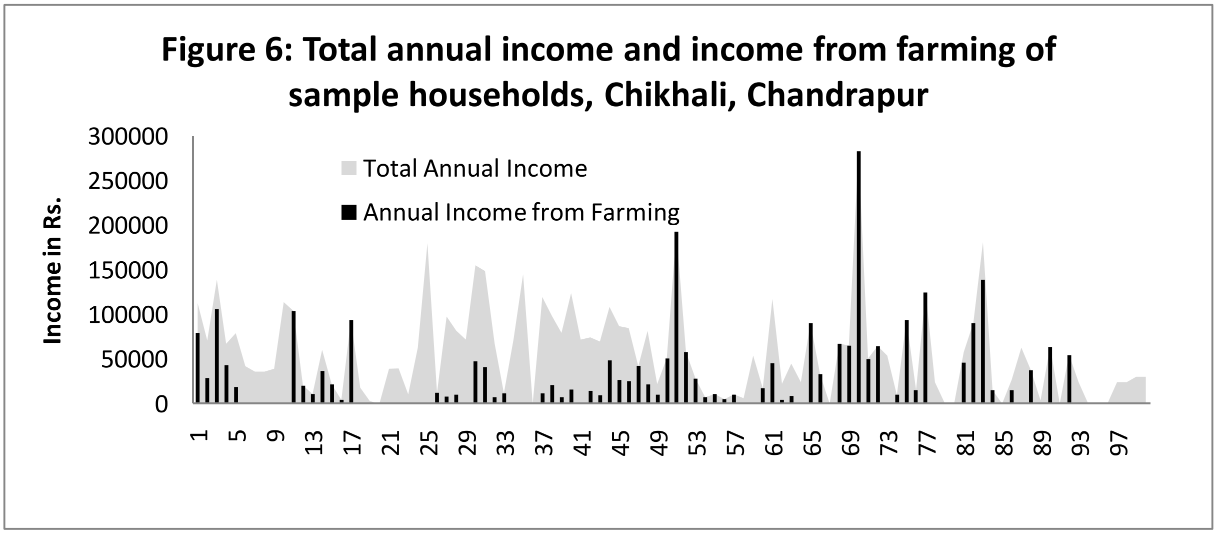
Name of Fruits/ vegetable grown	Total number of such		Sapling & Planting cost (Rs)	Fertilizer/ Pesticide Cost (Rs)	Yield (Kg)
	Fruits	Vegetable			
Maize	32.50	-	-	-	12.50

Banana	3.00				30.00
Papaya	1.00				110.00
Brinjal		9.56			17.14
Rose	4.00				-
Mango	1.50				15.00
Pumpkin	3.00			100.00	33.33
Lemon	1.00				20.00
Guava	1.00				20.00
Custard apple	1.50				41.67
Chilli		5.50			8.50
Cucumber		2.33			10.00
Bitter Gourd		1.5			12.33
Jambu Plum	1.00				15.00
Pomegranate	1.33				20.00
Marigold	15.22				10.13
Ridge guard		2.00			6.25
Lady’s finger		10.00			20.00
Almond	1.00				10.00
Tomato		6.50	10.00		30.00
Flower	7.70				11.67
Neem	1.00				5.00
Beans		12.00			-
Green vegetables		5.50			30.00
Mogra	4.00				1.00
Jaswand	3.00				1.00
Shoe flower	2.00				5.50
Black berry	1.00				10.00

Source: Primary survey of sample households

7.3.7 Total Annual Income of the Households from Various Occupations

The total annual income from various occupations of the sample households are graphically represented in Figure 6. The estimated annual income from various sources and the total income from farming alone for the sample households are provided in Figure 5. Nine out of the 100 families did not report any income. For the rest of the households, the income varied from a lowest of Rs. 1080 to Rs. 283306 per annum. A total of 64 families are found to have income from farming (including dairying), and was estimated to be varying from a lowest of Rs. 1080 per annum to a highest of Rs. 283306 per annum.



Source: Based on authors' own analysis using primary data

7.3.8 Wage Employment Earned by Different Segments in the Farm and Non-Farm Sector during Different Seasons and Rates

The details of the wage employment earned by different segments in the Farm and Non-Farm sector during seasons and rates are given in Table 49. It shows that the number of days for which an average BPL family is engaged in wage labour (Farm) is much higher than that of non-BPL families. However, on an average more number of members from non-BPL families are engaged in wage labour during winter (2.67) and summer (2.50) months than the BPL families. This can be explained by their involvement in non-farm sector of the rural economy.

Another interesting finding from the analysis is that the wage rates earned by women are much less as compared to their male counterparts. Differences are also found in wage rates across economic segments. Interestingly, the female labourers from non-BPL families earn less in farming sector as compared to their counterparts in the BPL category. In contrast to this, the female labourers from non-BPL families engaged in non-farm sectors earn much more as compared to their counterparts in BPL category. This could be because of the difference in nature of wage labour they are engaged in.

Table 49: Wage Employment Earned and Wage Rates

Social group	No. of family member engaged		No. of days employed during season		Wage Rate (Rs/day)			
	Farm	Non-farm	Farm	Non-farm	Farm (male)	Farm (Female)	Non-farm (male)	Non-farm (Female)
Monsoon								
BPL Category	2.27	1.56	96.32	67.50	100.53	57.57	105.56	60.00
Non-BPL Category	1.92	1.00	48.64	110.00	96.67	53.00	150.00	70.00
Winter								
BPL Category	2.33	1.50	101.43	99.00	100.00	57.50	107.00	61.11

Non-BPL Category	2.67	1.00	92.22	120.00	100.00	54.29	150.00	70.00
Summer								
BPL Category	2.33	1.58	91.96	102.50	83.75	48.26	101.54	59.17
Non-BPL Category	2.50	1.00	56.67	120.00	100.00	53.33	150.00	70.00

Source: Authors' own analysis using primary data

7.3.9 Impact of Drought on Wage Earning in Farm and Non-Farm Sectors

The details of the impact of drought on wage earning from farm sector are given in Table 50. No major trend seems to be emerging with regard to impact of drought. Same is the case with wage rates. However, some in the BPL families reported no change in wage labour or wage rates during drought year.

Table 50: Impact of Drought on Wage Earning from Farm and Non- Farm Sector

Social group	Increase or decrease in farm wage labour			Increase or decrease in non-farm wage labour			Increase or decrease in wage rate		
	Increase	Decrease	No Change	Increase	Decrease	No Change	Increase	Decrease	No Change
BPL Category	-	-	5	-	-	5	-	-	5
Non-BPL Category	-	-	-	-	-	-	-	-	-

Source: Authors' own analysis using primary data

7.1.10 Efforts to Reduce Household Water Demands during Drought Years

The details regarding efforts to reduce the water demands during drought years are presented in Table 51. Out of the 100 families surveyed, 18 families had an opinion that they reduce the household water demand by reducing the frequency of bathing and washing. 14 and 10 families also reported reducing the number of animal holdings and area under green fodder respectively.

Table 51: Efforts to Reduce Household Water Demands during Drought Years

Activities for reducing water demand	**Number of Families**
Reducing the frequency of bathing & washing	18
Reducing the no. of animal holdings	14
Reducing area under irrigation	0
Reducing area under crop which take more water & increasing area under low water consuming ones	0
Reducing area under green fodder & buying dry fodder	10

Source: Primary survey of sample households

8.0 Design of MUW System for three Locations in Maharashtra

Here, we would describe the Multiple Use Water System (MUWS) models that are identified as technically feasible for three different regions of Maharashtra. The model design involved a five step process as follows: a] an extensive review of MUWS models from around the world, with particular reference to the physical settings under which they work, and the key design features that result in their good performance; b] study of the physical (hydrology, geology, geo-hydrology and climate and topography) features of the locations selected for piloting; c] selection of MUWS models from regions that closely resemble the pilot locations vis-à-vis the physical settings; d] identification of multiple water needs of the pilot villages based on primary survey; e] study of the water supply systems available in the pilot locations, which have the potential to become MUWS; and, f] implanting the special features of MUWS into the existing systems so as to improve their performance in terms of their ability to meet multiple water needs.

8.1 Review of MUWS from Around the World

In this section, we have summarized the results of an extensive review undertaken on multiple use water systems around the world. The results are presented with regard to the physical settings in which the systems work in terms of hydrology, geology and topography; the description of the MUWS, covering the physical and socio-economic aspects of water supply and use; and the key features of the MUWS which result in their good performance. A total of 17 different types of MUW systems, from countries as far and wide as India, Brazil, Colombia, Ethiopia, north eastern Morocco, rural and urban Zimbabwe, Bolivia, China, hills of Nepal, Northeastern Thailand, South Africa, Sri Lanka, Vietnam and flood plains of Bangladesh were covered in the review. From within India itself, systems from Karnataka, Maharashtra and Indo Gangetic plains were covered.

The results of the review are summarized in Table below. It shows that the MUSs display wide heterogeneity in size, the basic physical features and the services they provide. The source of water for MUS varies from springs (Nepal hills) to roof rainwater catchment system, deep bore wells, ponds and tanks (Northeastern Thailand) to a combination of RWHS in medium uplands and secondary reservoirs fed by canal seepage (IGP) to large artificial reservoirs initially built for hydropower (Brazil), off takes from rivers, and primary, secondary and tertiary canals of large schemes primarily built for irrigation, drainage and flood control (Hac Hung Hai, Vietnam and Shahapur canal in Karnataka), reservoirs of small communal dams (Zimbabwe) and flood plains (Bangladesh). The size varies from as small as small dams to large reservoirs and canal systems. The broad range of services provided by the systems are irrigation, power generation, flood protection, drainage, fisheries, homestead gardens, cattle drinking, domestic water supply, drinking water, brick making, recreation, environmental flows, cultural uses, industrial and municipal water supply.

While some of them are designed by the agency as multiple use systems, some of them have multiple use systems by default. In the process, the technical features of some of the systems have undergone changes. In Nepal hills, water from springs is collected in over-head tanks, and is distributed through two parallel distribution pipes, one for domestic water supply and the other for kitchen gardens. Where single distribution pipe is provided, two taps are provided to the stand post for avoiding conflicts over collection of water. Hence, different water use priorities of the communities are incorporated in the design itself. In the case of the canal systems in the IGP, fish trenches and raised beds were constructed for integrated agriculture and fishery using seepage from canals. Fishes are raised in the ponds, while horticultural crops, vegetables and pulses are grown on 3-m wide raised bunds. Additional runoff water harvested is used for providing supplementary irrigation to paddy. The seasonally waterlogged area is used for raising paddy and fish using nylon net. Rainwater harvesting systems in the plateau region of uplands irrigate the horticultural crops in their commands.

Sl. No	Location	Hydrology/Geology/Topography	MUS System	Key Features	Remarks
1	Nepal Hills	<u>Hydrology</u>: The average annual rainfall is 1800 -2200 mm/year <u>Geology:</u> Alternative strata of shale, schist, quartzite and phyllite, together with beds of limestone, and other rocks of granite and gneiss. <u>Topography:</u> The mid-hills include deep river valleys well below 1000m, while the nearby ridge tops may rise to more than 3000m.	• Springs are the sources of water in the hills of Nepal • Single tank storage with single line distribution system • Double Tank storage with two line distribution system. • Controlled Water supply for Domestic and Productive Use	• Separate Pipeline distribution system for Domestic purpose and productive use. • The design specification for domestic supply of 45l/capita/day (about 270 l/day for family) was used to calculate the domestic demand • The maximum productive use supply is generally 600-800 l/day/household • Micro Irrigation (Drip and sprinkler) at the hills of Nepal.	Double tank storage with two-line-distribution have successfully avoided conflict in dividing and delivering water for multiple uses
2	Northeast Thailand	<u>Hydrology:</u> The average annual rainfall is 1100 mm/year. <u>Geology:</u> Massive sandstone with slate and silt. A few characteristic basalt hills are also found. <u>Topography:</u> The general topography is rolling uplands	About 10 different sources of water: • Rainwater harvested from the roofs and stored in large jars. • Expensive bottle water from shops • Commercial tap (piped) water from outside the farm • Traditional source of water, shallow well • Deep bore wells • Ponds • Tanks • Nearby streams and canals • Run-on water from nearby fields	• Drinking water sourced from the rooftop rainwater stored in huge jars • Integrated use of resources • The productive uses of water include: watering vegetables, spices; watering livestock, (cows, poultry); keeping the fish tank adequately filled; irrigation of fruit trees and rice crop; raising of ducks and frogs	Model for farm development at local, regional and national level

		with the elevation of 100-300 meters above sea level.	• Rain Integrated Farming Farm ponds		
3	Indo-Gangetic-Basin	Hydrology: The average annual rainfall is 1200 mm/year. Geology: The Indo-Gangetic belt is the world's most extensive expanse of uninterrupted alluvium formed by the deposition of silt by the numerous rivers. Topography: The plains are flat and mostly treeless, making it conducive for irrigation through canals.	• Secondary Reservoir fed by canal seepage for integrated agriculture and fishery • Fish trenches-cum-raised bed • Rice-fish culture using nylon net under seasonally waterlogged lands • Rainwater harvesting reservoir in medium uplands in plateau regions (the command area of the pond consists of 100x70 m (0.7ha) area, in which litchi based multitier horticulture system has been adopted. • Fish production in the pond, vegetable /fruits/pulse production on the bunds measuring 3.0 m width around the ponds, supplementary irrigation to cereal production on a limited area of 50 x 25 m (0.125 ha) with surplus runoff storage during monsoon season, and irrigation through gravity fed drip irrigation to multitier horticulture are the uses of the harvested rainwater in the system. • Makhana based farming (makhana-cum-fish farming) in the littoral parts of the flood plain wetlands of North Bihar.	• Enhancement in overall productivity of water resources • It provides variety of food materials, e.g. fish, fruits, vegetables, eggs, etc. apart from cereals and other crops • Additional income was generated	Intensification of multiple use of water in the catchment may affect the downstream users

4	Colombia	<u>Hydrology:</u> The average annual rainfall is 1100 – 1200 mm/year. <u>Geology:</u> Sedimentary elements, pelagic sediments with Precambrian and Paleozoic metamorphic rocks bases, granite, volcanic rocks <u>Topography:</u> Altitudes reach more than 18,700 ft (5,700 m), and mountain peaks are permanently covered with snow.	• The micro-catchment is an area of in-migration and colonization from other parts of the country and as a weekend retreat for rich people from Cali. • These migration patterns have resulted in fractured and individualistic communities with little social cohesion, made possible by the easy availability of water. • Different Types of Water Supplies in Colombia: Public reticulation system (75.1%), Community reticulation system (9.9%), Wells (5.2%), Rainwater Harvesting (0.5%), Water vendors (0.6%), Direct abstraction from streams (7.4%), other (1.3%). • For Drinking Water Supply: Infrastructure such as Intakes and pipelines are provided in this System. • In a relatively small area, there are seven large water supply systems serving five communities • Productive and Recreational Use of Water: No separate or adapted infrastructure exists for these uses. Use is made of the drinking water supply infrastructure	• The net per capita for domestic purposes (drinking, washing, cooking, cleaning and sanitation) is about 150 lpcd (~600litrs/household/day). • Irrigation is practiced in 25% of the households. Most of this is vegetable gardening on small plots (on average 386 m2, with more than half of them less than 75 m2). In a few cases, people irrigate larger terrains, (about 0.6 ha) with crops such as beans; all other major crops (coffee, plantain and cassava) are rain fed. • On the basis of cropping pattern, water consumption for irrigation was estimated at 471 litre/ household/ day in the dry period. • Water consumption in households with animals averages 77litre/household/day. • For Recreational Use (Swimming pools), the daily consumption of 137 litre for a swimming pool of 50m3 (assuming that they change the water entirely once per year).	The WTP (Willingness to pay) survey showed that 80% of the current users are willing to an extra amount over and above the current tariff for water supply in order to maintain their access to productive uses.

5	Brazil	<u>Hydrology:</u> The average annual rainfall is 1000 – 1500 mm/year <u>Geology:</u> Metamorphic rocks of amphibolite to granulite facies and granitoids of Archean age, associated with the Proterozoic units that are represented usually by folded strips of green schist facies and sedimentary and volcanic coverings, (seldom metamorphosed) and several granitoids. <u>Topography:</u> Much of the terrain lies between 200 metres (660 ft) and 800 metres (2,600 ft) in elevation.	• All the major hydro-graphic basins of South America have been impounded by the construction of large reservoirs. • Initially built up with objective of providing hydropower for energy supply. • These artificial ecosystems were subjected in course of time to multiple uses. • Many Reservoirs are used for recreation, tourism, and fisheries as well as for water supply	The following are the reservoir functions: • Flood Control • Hydropower • Navigation, • Water Supply • Irrigation • Recreation • Tourism • Agriculture	The management of natural or artificial ecosystems is now in a transition stage from reactive, local and sectoral to predictive, at watershed level and integrated approach. The watershed as a unit for planning, management and development of negotiations is now internationally recognized as a useful and well designed approach
6.	Mzingwane catchment, Limpopo Basin, Zimbabwe	<u>Hydrology</u>: The annual average rainfall is 600 – 1000 mm/year. <u>Geology</u>: The craton is principally composed of granitoids, schist and gneisses and greenstone belts. <u>Topography</u>: Much of the country is high plateau with higher central plateau forming a	*Small Communal Dams* Catchment Size (km^2) • Dewa Dam: 4.0 • Denje Dam: 9.5 • Avoca Dam: 4.0 • Makoshe Dam: Na Mean Annual Runoff (m^3) • Dewa Dam: 152,000 • Denje Dam: 332,500 • Avoca Dam: 152,000 • Makoshe Dam: Na Capacity ($x10^3$ m^3) • Dewa Dam: 60 • Denje Dam: Na • Avoca Dam: 60	The water from these dams are mainly used for the following: • Livestock • Irrigation • Domestic (the average daily household daily consumption was obtained from household members, cross-checked with general per capita consumption and multiplied by the number of households) • Brick Making • Fishing • Recreation	Small dams are multipurpose structures whose uses have varying water consumption, water productivity and economic values.

		watershed between the Zambezi and Limpopo river systems.	• Makoshe Dam: 9.26 Type of Dam: • Dewa Dam: Earth • Denje Dam: Earth • Avoca Dam: Earth • Makoshe Dam: Earth Year Built • Dewa Dam: 1954 • Denje Dam: 1955 • Avoca Dam:1947 • Makoshe Dam: 1998 Households served • Dewa Dam: 150 • Denje Dam: 250 • Avoca Dam: 200 • Makoshe Dam: 150		
7.	Rural Zimbabwe		Elephant Pump	The Key features of the Elephant Pump are: • The water from the elephant pumps is used for domestic purpose and also for irrigation purpose • Fully protected water source, providing clean drinking water (Elephant Pump is the water source) • Rate of extraction of approximately 1 litre per second at 20m head • Low cost of construction (about one tenth inc cost for Afridev) • Ease and extremely low cost of maintenance • Ease of operation for children and the elderly • Suitable for extraction from depths of up to 30 metres.	The Elephant Pump can be used in conjunction with buffer tanks and hoses or drip-feed systems for irrigation. These increase the area which owners are able to irrigate and provide a valuable and reliable means for extracting water during the dry season. Bringing a water source closer to people, means that they can divert time previously spent

					collecting water to other useful tasks such as marketing their produce. Children in schools can now spend more time in class rather than collecting water.
8.	Fenhe Irrigation District, Shanxi Province China	<u>Hydrology</u>: The average annual rainfall is 700 mm/year <u>Geology:</u> The Paleozoic formations of China, excepting only the upper part of the Carboniferous system, are marine, while the Mesozoic and Groups of volcanic cones occur in the Great Plain of north China. In the Liaodong and Shandong Peninsulas, there are basaltic plateaus. <u>Topography</u>: The topography varies greatly in China, a vast land of lofty plateau, large plains, rolling land and big and small basins surrounded by lofty mountains.	FID Irrigation Scheme was originally built for two key services • Irrigation Water Supply • Flood Control	*Provisioning Services:* • Irrigation: Farmers have installed wells, which are sometimes shared by a cooperative, to pump water from a shallow aquifer. • Industry (Steel Manufacturing, Coal Power Generation, Coal Production): Industrial water is guaranteed to 95% and therefore takes higher priority over water irrigation. During times if shortage conflict can occur. Extraction points are on the main and secondary canals and separate deliveries are made for this purpose. • Hydropower: Two hydropower plants totally 22.6 mega watt capacity has been installed on the upstream reservoirs to take advantage of the energy producing potential of irrigation releases to the River. • Tree Plantations: *Regulating Services*: • Flood Protection • Drainage *Supporting Services:* • Groundwater Recharge	For domestic purpose, Taiyuan city utilizes a water reservoir from outside the FID area and local villages use deep aquifer wells (200m) that are not connected to the shallow aquifers used for Irrigation. Therefore, FID does not contribute to any domestic water supply.

				• Support to natural ecosystems *Cultural Services*: • Recreation and Tourism	
9.	Kirindi Oya River Sri Lanka	Hydrology: The average annual rainfall is 1200 -1800 mm/year. Geology: According to the geological history, 90 % of Sri Lanka consists of Precambrian metamorphic rocks. Topography: Most of the island's surface consists of plains between 30 and 200 meters above sea level.	KOISP was completed in 1986 and is located in the dry zone of Sri Lanka. A new reservoir Lunugamwehera is the main part of the KOISP and is meant to: • Secure Supply to the Old Ellegala Irrigation System (EIS) of approximately 4200 ha • Develop new areas in the left and right banks of the Kirindi Oya Basin	*Provisioning Services*: • Irrigation • Domestic water • Water for cattle • Fishery • Homestead garden (Water is used from the irrigated paddy fields) • Industry and Business *Regulating Services*: • Flood Protection • Environmental Flows *Supporting Services*: • Habitat Improvements (raw materials for construction, shade, cooling effect, material for flood protection) *Cultural Services:* • The social role of canal is important (people gather along the canal by evening)	KOISP is clearly a diversified MUS system, where irrigation water to crop and values generated by crops is not reaching 50 %. Animal production (cattle, poultry or aquaculture) is important in KOISP. It seems a common feature in rural areas
10.	Shahapur Branch Canal in the State of Karnataka India	Hydrology: The average rainfall id 750mm /year. Geology: Sandstone, limestone and shale Topography: The average elevation of Shahapur is 428m.	Branch Canal: The SCB irrigation scheme was originally built for: Irrigation water supply Flood control Power generation	*Provisioning Services*: • Irrigation • Domestic Water Supply • Water for cattle • Industry and Business • Hydropower • *Regulating Services*: • Environmental Flows (drainage support to natural eco systems) • Flood protection	Shahapur Branch Canal System is a MUS system with about 75 % of the benefit generated by irrigation, Fields (Crops + fallow): 69%, Domestic Water: 6%, Animals: 23%, Power Plants: 1%, Perennial Natural Vegetation: 1%). Cattle in the area are of great importance for farmers and

					people. The total volume consumed is 1.4895 million m^3 which is sourced from the irrigation system. In terms of estimated benefits the other uses seem to be low.
11	Bac Hung Hai Irrigation and Drainage Scheme Vietnam	<u>Hydrology</u>: The average annual rainfall is 1500 – 2000 mm/year. <u>Geology</u>: Early Paleozoic to the Quaternary, Paleozoic folded systems filled with thick (>12000 m), Paleozoic formations, Precambrian strata, Archean rocks, Cenozoic formations. <u>Topography</u>: Vietnam is mainly hills and densely forested mountains.	The water supply network consists of: • Intake that diverts from river using pumping and lifting stations. • Primary Canals • Secondary Canals • Tertiary Canals Bac Hung Hai irrigation scheme was originally built for 3 services: • Irrigation water supply • Drainage • Flood control	*Provisioning Services*: • Domestic Water • Irrigation • Water For Cattle • Fishery • Homestead garden • Industry and Business *Regulating Services:* • Environmental flows (including groundwater recharge) • Flood Protection • Sewage/drainage water *<u>Supporting Services:</u>* • Transportation • Habitat improvements (raw materials for construction, shade, cooling effect, material for flood protection) • Captured Fisheries *Cultural Services:* • Social Functions Linked to the infrastructure and management	
12	Flood plains of Bangladesh	<u>Hydrology</u>: The annual rainfall is 2300 mm. <u>Geology</u>: Alluvial soil deposits	Rice/fish production system in the flood plains	• Floodplains provide a wide range of eco system services, and provisioning services in particular which are subject to competing claims for rice/fish production. • Enhancing the productivity of aquatic floodplains in a sustainable and resilient manner calls for the diversification of	The value of multiple resource use approaches to enhance the productivity of floodplain wetlands in a suitable and

		<u>Topography</u>: Most parts of Bangladesh are less than 12 m (39.4 ft) above the sea level, and it is believed that about 50% of the land would be flooded if the sea level were to rise by 1 m (3.28 ft).		agriculture and fisheries production systems, the multiple use of seasonal surface water, as well as the conjunctive use and management of surface and groundwater in the case of Bangladesh floodplains. *Ecosystem benefits*: • Cropland • Fish culture/capture fisheries • Vegetables • Irrigation Channels	resilient manner is highlighted. In the Bangladesh floodplain this implies a major re-consideration of agriculture water management options to include other sources of food such as fish produced by capture fisheries and aquaculture
13	Northeastern Morocco	<u>Hydrology</u>: The average rainfall is 850 – 1600 mm/year <u>Geology</u>: Sedimentary rocks, Palaeozoic and Pre-Cambrian rocks, granitic and metamorphic base. <u>Topography</u>: Most of the country is above 500m contour and few lowlands, below 100m contour are located along the coast.	Irrigation canals are the main sources of water The water from irrigation canal is diverted and stored in storage tanks called Jboub	A full tanks could provide a household with water for periods ranging from one week to more than two months Apart from agriculture water was used for different purposes including the following: • Drinking • Watering livestock • Small scale brick marketing • Tree nurseries	• Farmers have been able to keep more livestock or poultry and develop other productive water-consuming activities, in the rain-fed Hassi Berkane area as well as in the Zebra irrigation system. • The situation in Zaio is comparable to the one in the Haouz plain in Central Morocco, where water storage tanks are filled with irrigation water and used for domestic

					purposes as well • Increased water allocations from the irrigation canal system for the Jboub, especially outside the main irrigation season, would make more water available for domestic and productive purposes. Higher water availability for domestic purposes, especially hygiene, is very important in the reduction of diarrheal diseases
14	Ethiopia	Hydrology: The annual average precipitation ranges from 420 – 1680 mm/year. Geology: • Precambrian (sedimentary, volcanic and intrusive rock units) • Late Paleozoic – Mesozoic (sandstone, limestone, shales, marl, dolomite and gypsum)	Communal piped systems with very scattered Standpipes	Average daily water use is about 8 to 17 lpcd	It is a basic domestic level of MUS

		• Cenozoic rock units (basalt, trachytes and associated dyke swarms, andesites, rhyolites, ignimbrites and pumice as ash. Sediments of Tertiary age, which are represented by sandstones, limestone, gypsum, anhydrites Topography: Elevation range: 1500 – 2400m.			
15	South Africa	Hydrology: The average rainfall is 500 mm. Geology: Gneiss, granite, kimberlite, trap basalt etc Topography: The elevation is 1000 – 4000 m	Communal piped systems with scattered standpipes	Average daily water use is 30 lpcd	Basic MUS
16	India (Nasik, Aurangabad and Ahmednagar)	Hydrology: The average annual rainfall is 300-500 mm/year. Geology: Deccan trap Topography: Maharashtra has three types of terrains namely Konkan coastline, Sahyadri mountain range or the Western *Ghats* and hilly region and the Deccan plateau.	Double tank Storage with two line piped distribution system with household connections	Average daily water use is 40 lpcd	Basic MUS

17	Bolivia	Hydrology: The average annual rainfall is 400 – 700 mm / year Geology: Tectonic and sedimentary environment. Topography: Elevation extremes 90 m to 6,542 m	a. Tankers b. Piped distribution systems with household connections	Average daily water use is a. 30 – 40 lpcd b. 60 – 80, with exceptions up to 140 lpcd	a. Basic MUS b. Intermediate MUS

8.2 MUWS Models for three Different Regions of Maharashtra

The three regions represent three unique physical settings in terms of topography, agro climates, geology and geo-hydrology. The salient features of the MUWS systems being discussed here are such that with those features, the existing drinking water supply systems would be capable of augmenting the existing water supply in the villages that are based on the local water sources of the area under consideration either by serving as a new source. The basic principle in the design of the MUWS model is that it increases the effective availability of water for household water supply, in order that the water supply system which is being retrofitted is able to meet various domestic and productive needs of the localities in question round the year. While the building of an MUWS system can be to raise the performance of an existing water supply system in terms of quality, quantity and reliability (Renwick, 2008), here the attempt is made to improve the quantity of water supply. In the subsequent section, we would discuss the key physical features of the three regions.

8.2.1 Design Considerations for MUWS Systems

1. While determining the additional water supply requirement for meeting multiple water needs of the HHs, an **increase in per capita water supply requirement** would be considered for only those households which have high vulnerability as per the MUS vulnerability estimates, and accordingly the aggregate demand for the village would be estimated by factoring in this as a percentage of the total sample size into the total population. Here, we treat all households having vulnerability index below 0.50 to be highly vulnerable. Higher the value of MUS vulnerability index, lower would be the vulnerability of the HH.

2. A multiple use system can provide varying levels of services—from basis MUS to an intermediate level MUS to a high-level MUS (van Koppen et al., 2009). The per capita water requirement for meeting multiple needs would be estimated based on broader consideration of domestic and productive water needs for majority of the poor village households rather than the specific needs of individual households. Obviously, this would be a function of the agro climate, local culture, and the traditional occupations of the village households. The agro climate would not only decide the type of water needs, but also determine the demand rates. Traditional vegetable growers, belonging to *Mali* community would like to have water for kitchen garden, whereas traditional cattle rearing communities would like to have water provisions for cattle.

3. Storage augmentation will be only for increasing the water supply potential of the system during the lean season. The lean season being referred to here is the season during which the water supply sources (such as rivers, streams, springs and aquifers) dry up or stat showing low yields. The duration of the lean season will have to be determined on the basis of data from the primary survey of sample households. It is assumed that in the remaining months, only change in operating rules of the water supply system would be able to meet the multiple water needs. This is based on the premise that the domestic and productive water requirement of the HHs will still be a small fraction of the total water demand (including that in conventional irrigated farming) in any village in India.

4. Improved access to water supply sources is important for the vulnerable households to improve the quantity and reliability of water supplies without much effort. For this, the physical distance of the poor households to water supply points (taps, stand-posts) should be minimized. The most ideal is the household connections.

5. The water requirement for kitchen garden is assumed to be 75 litres per family per day (source: van Koppen *et al*., 2009). Water requirement for livestock is taken from Singh (2004). Minor corrections for climate can be introduced in this, providing lower values for cold and humid climates.

8.2.2 MUWS Model for Different Locations

Western Maharashtra

The MUWS system being proposed for the first region (western Maharashtra) is one which harness the natural springs in the area. The discharge of the springs in the area is highly variable, with maximum discharge during the monsoon season, which slowly reduces towards the winter and summer and eventually drying up towards the month of April. The water needs during summer months are being met from bore wells of the area, and scarcity is felt. An underground reservoir is proposed to be built in the village, which is capable of diverting and storing water from the "flowing spring" during monsoon months. This should completely prevent evaporation, which would be high during summer months.

The volumetric storage capacity of this reservoir shall be fixed in a such a way that the stored water and the water pumped from the bore wells during the two summer months is sufficient to meet the domestic and productive water needs of the entire population during the two months of summer. As the spring discharge is very high and the domestic demands are relatively low during the rainy season, the diversion of water from the spring into an additional reservoir (other than the intermediate storage systems in the village built for water supply) does not adversely affect the water supply performance during the months of monsoon.

The reservoir and the bore wells can directly feed water into the intermediate storage tanks existing in the village for distribution among the clusters, and individual tap connections of the HHs. Here in this case, the productive water needs would include water for livestock drinking, water for irrigating the fruit trees, and water for kitchen gardens. This is based on the existing productive water needs of the communities in the village. They were found to be raising trees in their homesteads, and raising kitchen gardens, apart from dairy production.

In Varoshi village, since the poor HHs do not have the independent tap connections and are dependent on common stand posts, it is important to create water distribution infrastructure, which include individual tap connection. This would enable the poor HHs to raise kitchen gardens, apart from covering their human and livestock needs.

Marathawada Region

In the Marathawada village, the communities are entirely dependent on groundwater abstracted from bore wells. The surface water resources are extremely limited in this region. The traditional ponds and tanks in the region dry up completely by the end of winter. The shallow aquifer, which is of basalt origin, has poor groundwater potential. But after the rains, the water level rises significantly, and often the aquifer does not have sufficient storage capacity to accommodate the water which infiltrates. Overflowing of wells in years of good monsoon is a common phenomenon. But with the withdrawal of water soon after the monsoon, water levels start declining very rapidly. Besides pumping for agriculture, one of the major sources of discharge of water from the shallow aquifer is the outflow into streams and rivers. This basically means that the domestic water sector faces severe competition from irrigation.

The best way to effective allocation of water from a common pool like aquifer for domestic uses during lean season is to create a pumped storage of the water from the aquifer. Here again, like in the case of western Maharashtra, water required to meet demand for two months can be pumped out when the aquifer is fully replenished. This allows for further infiltration of rainwater, though this would mean reduced stream flows into local ponds and streams and rivers. The water pumped out of the aquifer through bore wells can be stored in surface-sub-surface storage tanks. The tank can be lined using HDPE (High Density Poly Ethylene) sheet to prevent seepage and percolation of the stored water.

The storage capacity of the tank can be worked out in such a way that it takes care of the entire HH water demand for domestic and productive needs. Hence, it will be on the basis of: 1] the size of population; 2] the per capita water demand for domestic and productive uses; 3] the number of months for which the water shortage is felt; and, 4] the amount of water tapped daily from the two public open wells during the months of shortage. But, unlike in the case of Varoshi, the productive water needs of the population here would cover only water for cattle drinking. It is to be kept in mind here that dairy production is a major source of livelihood and income for majority of the village households. This essentially means that greater the degree of water deficit (between the demand during the lean season and the amount supplied though open wells), higher would be the storage capacity required for the tank.

The only design variable is that total number of bore wells, which during the monsoon can sustainably yield the water, which is needed during the lean season. Since the water table would be very high during monsoon with no significant abstraction for agriculture, the well yield would be generally high.

Vidarbha Region

Chandrapur district of Vidharbha region is characterized by moderate to high annual rainfall (1050mm), steep slopes, high density drainage and hard rock geology. The region forms the upper catchment of the only water-rich river basin flowing in the South Indian peninsula, i.e., Godavari. But, the public water supply systems built in the villages of this region are based on groundwater resources, which are extremely scarce due to the crystalline geology. The wells in this area go dry in summer, and there is acute shortage of drinking water. The only way to augment water supplies for domestic purpose is to harness the surface runoff generated in the region and store it on the surface. Storing water underground won't make much sense because of three important reasons. First, recharging the aquifer would be extremely difficult because of the crystalline geology. Second: once water percolate down to the local aquifer, the agricultural users would be the main beneficiary of the recharge water and it would be difficult to enforce any control over agricultural pumpers, with the result that water will be made available for use in summer months; and even if agricultural users do not pump out the recharged water, the water might not remain in the local geological formations due to high groundwater flow gradients and outflow of groundwater into the streams.

The water from small hilly catchments in the forest area can be harnessed using small dams and reservoirs. The storage efficiency would be good because of crystalline strata. This water can be pumped into the over-head reservoirs along with the groundwater during summer months to supply to the individual household connections. Since there would be excessive stream flow during monsoon months, one of the ways to increase the effective storage of the small dam would be to also divert water from the small reservoir during the times of inflow. This strategy can reduce the amount of groundwater pumped from the local aquifer thereby reducing the pumping costs.

The actual storage capacity (live storage) of the small dam can be estimated on the basis of the following: 1] the size of population in the village; 2] the per capita water demand for domestic and productive uses; 3] the number of months for which the water shortage is felt; and 4] the amount of water tapped daily from open well and hand pumps during the months of shortage. It is to be kept in mind that the productive water needs of the population here would include water for livestock (cattle, buffaloes, goat and sheep) drinking and kitchen garden. This essentially means that greater the degree of water deficit (between the demand during the lean season and the amount supplied though bore wells), higher would be the storage capacity required for the tank

The number of small dams to be constructed will have to be decided on the basis of the maximum storage that can be created at a site, the total storage requirement and the number of economically viable sites available in the vicinity of the village settlements. The storage capacity of the reservoirs created by the small dams will have to be decided by the rate of runoff (dependable) from the catchment and the catchment area. Water from the small dams can be pumped into the overhead tanks, which then can be distributed among the HHs through the individual tap connections, which already exist.

8.3 Selection of Alternatives on Financial Feasibility Considerations

The MUWS models were selected on the basis of technical viability considerations. They were later on examined for cost effectiveness, by comparing the estimated cost with the costs of various rural water supply interventions, which can become alternatives in these special settings, wherever possible. On subsequent examination, it was found that GSDA would not be able to take up these pilots for implementation due to high cost, and non-availability of schemes which fit into the type of interventions suggested. Doubts were also raised about the feasibility of land acquisition required in one case (Chikhali for building the small dam). Therefore, less costly interventions were finally chosen for interventions. They all based on the strategy of artificial recharge of groundwater (using the existing water impounding structures or new ones) and strengthening of the existing groundwater based sources of water supply in the village.

Table 52 provides the details of the existing water sources and additional water demand during summer months in the three project villages. Thus, the MUS models suggested as per the feasibility report were to increase the effective availability of water for household water supply, in order that the water supply system which is being retrofitted is able to meet various domestic and productive needs of the localities in question round the year. Based on these suggestions and subsequent discussions between IRAP, GSDA, PRIMOVE and UNICEF, DPRs' for three locations were prepared.

Table 52: Village-wise details of water sources and additional water demand

Particulars	Project Villages		
	Varoshi	Chikhali	Kerkatta

No. of Water Sources				
Spring		1		
Public bore wells	Functional	3		
	Non-functional			
Public dug wells	Functional		6	3
	Non-functional	1		1
Hand pumps (Public)	Functional	3	5	1
	Non-functional		1	4
Detail on the piped water supply in the village:				
Type	**Source**			
Individual scheme	Spring	1 functional scheme		
Individual scheme	Dug/Open well		1 functional scheme	2 functional schemes
Regional scheme	River	Scheme not in operation		
Additional water demand during summer months (in cu. m)				
Current (2011)		2,084	2,596	5,243
Projected (2028)		3,095	3,590	7,020

Details of interventions proposed in three project villages are given village-wise below:

Village Varoshi

The primary objective of the proposed interventions was to augment the supply levels in summer and retrofit the existing water supply distribution system for ensuring water supply to all the village households through private tap connections. To achieve these objectives, following interventions were proposed by GSDA: 1] strengthening of the existing non-functional public well by augmenting the availability of ground water in the strata which the source taps; 2] retrofitting of the existing water supply and distribution system to provide individual household tap connections; 3] capacity building of the village community for better use of supplied water for kitchen gardens and other domestic purposes; and 4] capacity building of GP/VWSC to improve O&M of water supply system and water quality management. In additions, following interventions were proposed to promote environment friendly sanitation practices: 1] awareness and capacity building for scientific management of solid liquid waste; 2] promotion of kitchen gardens where liquid waste can be used; and 3] repairing of existing gutters.

The drinking water source strengthening activity was taken up after thorough geo-hydrological and geo-physical investigation in the area to locate the fractures in the formations, which could be used to induce recharge to the defunct water supply source (public well) from the water impounding structure. The public water supply source well is being deepened up to a depth of 12 m under NRDWP; hence the cement nalla bund has been suggested to recharge the aquifer both vertically and laterally.

The budget for all the construction and repair activities (hardware work) was estimated to be around Rs 27 lac. It was proposed that the money required for hardware purpose will be sourced from NRDWP, Eco-village and SLWM schemes, whereas, funds for undertaking capacity building activities will be sourced from UNICEF/GSDA.

Village Chikhali, district Chandrapur

Following interventions were proposed by GSDA to improve the water availability during summer months in the six settlements of village Chikhali: 1] de-silting of existing small concrete check dams to improve surface water storage and groundwater recharge; 2] Fracture Seal Cementation at a distance of about 110 to 120 metre (in North-east direction) from the hand pump in Rengeguda-2 settlement; so as to restrict the sub-surface groundwater outflow. 3] deepening (up to 3 metre) of the existing well in Rengeguda settlement and drilling of horizontal bore holes of 30-40 m in North-east and North-west direction[4]; 4] **s**trengthening of public wells (construction of water absorption trench and deepening of percolation well including provision for water wheel on two public wells) and thereby, augmenting the well yield; 5] retrofitting of the existing water supply and distribution system to provide individual household tap connections; 6] capacity building of the village community for better use of supplied water for kitchen gardens and other domestic purposes; and, 7] capacity building of GP/VWSC to improve O&M of water supply system and water quality management.

Additionally, following interventions were proposed to promote environment friendly sanitation practices in the village: 1] awareness and capacity building for scientific management of solid liquid waste; 2] development of NADEP type compost pits; 3] promotion of kitchen gardens where liquid waste can be used; and, 4] cleaning of existing gutters. The budget for all the construction and repair activities (hardware work) was estimated to be around Rs 15.6 lakh. It was proposed that the money required for hardware purpose will be sourced from NRDWP, MNREGS, Agriculture Department, Eco-village and SLWM schemes, whereas, funds for undertaking capacity building activities will be sourced from UNICEF/GSDA.

Village Kerkatta, district Latur

For improving the water supply situation in village Kerkatta, following interventions were proposed: 1] Fracture Seal Cementation (FSC) in an area of 30 meters towards South of Kalidas Shinde well; 2] Bore Blasting (BBT) in half Jacket area towards North of newly developed source well under Jalswarajya programme[5]; 3] de-silting and provision of a water wheel on the well located near Hanuman temple; and 4] repairing of parapet and platform of a well located near Prahlad Ingle's house. For promotion of environmentally safe sanitation practices, following interventions were proposed: 1] awareness and capacity building for scientific management of waste; 2] repair and cleaning of solid waste management facilities (NADEP type compost pits, vermi-compost and biogas facilities); 3] promotion of kitchen gardens; and 4] cleaning of gutters.

The budget for all the construction and repair activities (hardware work) was estimated to be around Rs 2.9 lakh. It was proposed that the money required for hardware purpose will be sourced from NRDWP, Agriculture Department, and SLWM schemes, whereas, funds for undertaking capacity building activities will be sourced from UNICEF/GSDA.

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[4] The aquifer gets recharged locally from the foot hill area, which is situated in the northern part. Hence, horizontal bore holes were suggested to connect the upstream fractures and to make way for the groundwater to move towards the well. This has been decided based on the detailed Hydrogeological survey followed by drawing the water table contour maps.

[5] This has been proposed to connect the fractures located in upstream and downstream side of the well and to establish the connectivity with the surface water body

9.0 Institutional Models for Implementing MUWS

9.1 The Review of Micro level Water Institutions

Here, we have reviewed a wide variety of institutions from different parts of India, managing water-related services. These are broadly classified as "local management institutions", and their management regime is either a village, or village service area or chak of a canal irrigation system, i.e., the area under the distributory outlet or minor outlet, respectively (as found in many Indian states); command area of a diversion weir (as in the case of *Phad* in Maharashtra) or the command area of a tube well (Mehsana district of north Gujarat); or service area of a village drinking water supply scheme (Kerala, Karnataka and Maharashtra); or the subsystem of a regional water supply scheme, serving a village (Saurashtra in Gujarat); or a watershed area within a village (Ahmednagar in Maharashtra, Uttarakhand and Himachal Pradesh); or the command area of a surface irrigation tank (Pune, Maharashtra, Andhra Pradesh and Tamil Nadu).

The nature of institutions also vary significantly--from community based organizations (as found in the case of watershed institutions and pani samities for rural drinking water supply), to organizations of landed farmers (as found in the case of groundwater irrigation organizations, WUAs of canal and tank commands) to organizations of both landed and landless farmers (in case of *Pani Panchayats*) to irrigation department in the case of Phad in Maharashtra. The WUAs in canal commands of many states are legal entities registered under Societies Act. The groundwater irrigation organizations are informal organizations.

The pani samities, promoted by NGOs under the aegis of the government agencies (as found in Kerala, Karnataka and Gujarat) are legitimate organizations, recognized by the village Panchayats. The watershed institutions (watershed committees) are also legal entities, recognized by the rural development department for undertaking various watershed management activities. The WUAs under tank commands of South India are enjoy great legitimacy in the traditional village Panchayats, but many of the new ones are promoted by the state minor irrigation departments with the help of NGOs and are legally registered.

Performance of the various micro-institutions has been analyzed vis-à-vis their outcomes and impacts on access to water, food security and livelihoods. Based on the performance of these micro-institutions, and a review of institutional design principles prescribed by scholars working on institutional aspects of sustainable water management, ideal intuitional characteristics that can be introduced into the local MUWS institution have been identified (refer section 8.2).

Water Institution	Location	*Type of Service Provided*	Design Features & Operating Principles	Administrative Structure	Rules and Regulation	Outcomes	Impact
Community Based Water Services	Kerala, Karnataka and Maharashtra	*Domestic Water*	# Demand-responsive approach for joint effort by community members and government staff in service design, construction, and operation & maintenance (O&M) of water supply systems. # Community members participate in the design process: in particular, to choose collectively the type and the level of service based on their willingness to pay. # Water services are fully financed through government grant funds	# Management Committee and User Group	# Users, in collaboration with government officials and NGO staff, craft rules and practices about user participation in: a) decision-making, design, construction, and O&M; b) monitoring of participation and usage; and, c) sanctions to deter non-compliance # In most cases communities carry out responsibility for O&M. # In some cases, communities may be asked to contribute cash or labor to construction, and take care of operation and maintenance.	# Reliable access to potable water # Time Savings, Better Health	# Improved personal and environment hygiene practices # Increased domestic water security
Groundwater Irrigation Organizations	Northern Gujarat	*Groundwater based Irrigation*	# Mostly comprised of shareholders who constitute the general body of the organization. # The value of each share is calculated by dividing the system cost by the potential command area under which can be irrigated by tube well. # Each share gives the right to irrigate one *Vigha* of land.	# Consist of Management Committee and General Body. # The number of members in the management committee (including President and secretary) range from 7 to 11.	# Water is distributed as per the set schedule # Every farmer is entitled for as much water as required to irrigate his share, irrespective of the crops grown # The extra water can be given to the non-share holders but at higher price. # In *Bhagidari* system, the price	# Improvements in: a) timeliness of water delivery; b) equity of water delivery; c) quality of maintenance; d) collection of water charges; and, e) amount of area irrigated.	# Better System Performance. # Improved crop yields & farm incomes (especially for small farmers).

			# In another pattern (*Bhagidari* system), every member has equal share holdings irrespective of the size of the holding member has in the command. # Most of the irrigation is during winter and no irrigation is provided during monsoon season # The water delivery pattern changes periodically to maintain equity in water allocation. # Underground pipelines are used for water distribution thus nullifying any water loss	# Operator (employed by organization) oversees the irrigation and makes sure every farmer gets watering as per the schedule. # Secretary collects the water charges #The general body meets annually and discusses matters like the constitution of the management committee, water charge fixing, water distribution pattern etc. # Annual accounts are also presented in the meeting.	of water is the same for both shareholders and non-shareholders. # There is a provision of discount and interests for early and delayed payment respectively. # Those who do not pay the water charges are denied irrigation service in the next winter. # Any repairs or replacements of system is carried by the management committee. The funds are allocated from the net income generated by the organization.		
Irrigation Assets Rental Market	Indo-Gangetic and Hard Rock States	*Groundwater based Irrigation*	# Informal contract system # These are rental markets for irrigation assets such as wells and pump sets. # Result of: a) increasing value of irrigation water as well as land; and, b) resource-related bottlenecks for private investment in irrigation assets.	# Buyer purchases irrigation asset from seller on pre-determined price.	# Informal water markets requiring sufficient number of sellers and buyers. # If farmers do not pay, their future supplies will be cut. # If a seller does not deliver, the buyer can use another supplier	# Allow farmers to irrigate their farms by renting the irrigation assets from their neighbors	# Contributes both to equity in water use and better utilization of irrigation assets

Pani Panchayat	Maharashtra	*Surface water based Irrigation*	# Initiated by *Gram Gaurav Pratisthan*, Pune, Maharashtra, it is a community-based water council. # An innovative collective management of water for both harvesting and equitable distribution in order to improve economic condition # It has an inbuilt device to control the demand as per availability of water and ensure equity in water use # The available water would be allotted to beneficiary members at the rate of half acre of irrigation (1000 cubic meter) on a per capita basis with a maximum of 2 ½ acres (1 hectare) of irrigation per family.	# Typically a five-member *Panchayat* of the villagers manages the project # Groups of people share water equitably on per capita basis under non-transferable water agreement.	# Access to water is based on the number of persons in the family and not in relation to the land rights. # All the members contribute 20% of the capital cost in cash initially. # Water intensive crops like sugarcane, banana, turmeric etc. are not eligible for irrigation in water scarce area. In such areas, cropping patterns are restricted to seasonal crops with low water requirements. # The water rights are not tradable. # Landless persons can get access to water on the basis of which he could enter into informal lease in arrangement for exchange of land with somebody who has more land.	# Increased availability and equitable distribution of irrigation water # Sustained crop yields	# Formation of Sustainable Irrigation System # Improved Livelihood
Pani Samities	Saurashtra, Gujarat	*Domestic Water*	# Pani samitis are sub-committees of village Panchayats # They are created in all WASMO (Water and Sanitation Management Organization) projects and are responsible for drinking water	# Consist of Management Committee and General Body. # Each pani samiti has 10-15 members. At least one third of the members are women,	# The Government of Gujarat Resolution (2004) specifies how to involve communities in sustainable and equitable water management through pani samitis. # Communities shares cost of capital investments for water	# Improved access and availability of water for domestic purpose # Time Savings, Better Health	# Improved personal and environment hygiene practices # Improved rapport between government

			and sanitation in villages. # With the help of WASMO and NGO's, they carry out the following: a) Preparation of village action plan for water supply and sanitation; b) construction of water harvesting and sanitation structures; c) Monitoring of construction work; d) O&M of newly-created structures; and, e) Ensuring equitable and optimal distribution and use of water.	while weaker sections of society are also proportionally represented. # The term of a pani samiti is two years and its chairperson is elected by the members.	supply scheme (10% of total estimate) and Operation & Maintenance. Remaining cost on capital investment contributed by government. # Appropriate systems for monitoring water supply; tariff collection; power supply are in place. # Pani Samities collect water charges (as decided) from community and after paying tariff to government, keep the remaining for O & M activities.		functionaries, NGOs and the village community # Increased domestic water security
Phad	North-western Maharashtra (Tapi River Basin) Phad system	*Surface water based Irrigation*	# Weir is constructed to divert the river water for agriculture use. # The command area of a diversion weir is divided in to four equal parts, called as *Phad*. # Each Phad grows only one type of crop in a season. # Rotational Cropping pattern is followed. The first Phad may have a perennial crop, second may have a two seasonal crop, third may have a one seasonal crop and forth may be kept fallow. # Each Phad has a provision to	# Farmers contribute in terms of labor and money for Phad preparation. # Irrigation to the crops in the fields is given by the appointed staff.	# Farmers are not allowed to interfere in irrigation operation. # Farmers need not worry about the irrigation and guarding the crops in their field. The irrigation staff put in their best effort as they have to get share from the individual field produce. # Maintenance is a group responsibility. All farmers contribute equally both in labor and leadership. # Discipline is observed strictly.	# Improved access to water for irrigation # Sustained crop yields # Fertility of land maintained	# Formation of Sustainable Irrigation System # Improved Livelihood

			raise perennial crop in every four years.				
Shejpali	Canal command of Western Maharashtra	*Surface water based Irrigation*	# The canal authorities issue 'water passes' on the basis of an application from farmers in the command on a 'first-come, first-serve' basis.	# Arrangement between the Water Users and the irrigation administration	# The duration of the water passes varies from six years to a single crop season. # Their priority varies directly with their duration i.e. longer duration passes have seniority over shorter duration passed. # This pass system closely resemble the water permit system practiced in the mid-western state of US but they are non-transferable & quantity specific.	# Improved access to irrigation water	# Contribute significantly to increased crop yields
Tank Irrigation Associations	Southern India, mostly Andhra Pradesh & Tamil Nadu	*Surface water based Irrigation*	# Under the direction of the management body, water is distributed to the various fields. # Water distribution takes place as per specific turn system, which is strictly followed. # The statement in the turn	# Consist of Management Committee and General Body # Management of tanks is in the hands of the beneficiaries. They nominate a respective person in the village as the in	# The turn schedule is clear, but still followed. Time, however, could be mutually adjusted by the farmers. # Fundraising through collection of dues, fines and/or taxes. # Additional fundraising is possible, i.e. by sale of	# Improved availability of water for irrigation. # Increased crop yields # Alternate source of income	# Favorable Impact on livelihood and food security

			sketch gives the extent of the irrigation from Monday through Sunday. It also specifies the time of irrigation to a certain areas of the field.	charge of the irrigation under the tank. # The in-charge has irrigation assistants, called *Neerkattis*, who monitor the distribution of water.	common property resources such as fish and trees.		
Water Based Contracts	Gujarat and Andhra Pradesh	*Groundwater based Irrigation*	# Informal contract system # They can be of three types: (a) a two-party contract where water sellers provide irrigation, and receive payment from the farmer. (b) a two-party contract where water sellers provide irrigation, share 50 percent of cash expenses (except labor costs), and claim 50 percent of output (c) a three-party contract where water seller, land owner, and laborer share equally the cash expenses as well as crop output.	# Arrangements between Buyers and Sellers	# If farmers do not pay, their future supplies will be stopped. # If a seller does not deliver, the buyer can purchase water from another supplier.	# Allow farmers to irrigate their farms by purchasing the water from resource rich farmer	# Improved crop yields and farm incomes
Watershed Institutions	Uttarakhand, Himachal, Madhya Pradesh & Maharashtra	*Soil and Water Conservation.*	# Initiated with the purpose of integrated resource management for livelihood enhancement of the poor. # Involvement of all sections of society in planning and management.	# Consist of multiple users' committee, such as: a) water users committee (if any storage structures); b) forest protection committees; c) fodder	# Empowered to: a) execute the watershed management programme; b) resolve problems within the community to fulfill their basic needs; and, c) enable government to play a complimentary role.	# Increased availability of irrigation water # Increased employment opportunities # Improved	# Improvement in the quality of lives of most villagers # Greater inclusiveness of lower landholding

			# Focus on use of simple but effective technology. # Cooperative system of irrigation water access and use # In certain areas (e.g. Ralegaon Siddhi and Hiware Bazar) Watershed Management was based on five principles: a) restrictions on free grazing; b) ban on tree felling; c) ban on alcohol; d) adoption of family planning; and, e) voluntary labor	development committees; d) seed distribution committees; e) self-help groups (women and men); and, f) social-cultural committees (All under the broader umbrella of *Gram Panchayat*).	# Adoption of strict rules regarding use of water: a) ban on bore wells for agriculture; and, b) ban on cultivation of water-intensive crops (except farmers using drip or sprinkler irrigation)	drinking and household water availability # Improved education and health facilities	classes and marginalized sections of the society # Livelihood enhancement
WUAs	Many Indian States	*Surface water based Irrigation*	# MOU between state administration and farmers for transfer of irrigation system (minor, distributory or main canal level) under end user based management. # Mainly involves farmers/end users as a supplement to government management. # In most cases, control and ownership of system with state machinery. # Comprehensive legislation is made in several states as a sequel of irrigation reforms.	# Consist of Management Committee and General Body of end users # In some cases, government representatives becomes members in the WUA's committees # In most cases, NGOs are involved to facilitate the transfer of irrigation system to farmers	# Mobilize community to contribute cash or labor for the purpose of maintaining and repairing the field channels. # Have formal system of fundraising through a system of dues, fines and/or taxes. # WUAs can decide their own water rates for irrigation water (subjected to some regulation). # After payment of water rates to irrigation department, remaining fund is kept for WUA administration and O & M of irrigation system. # In some states, the WUAs	# Improvements in: a) timeliness of water delivery; b) equity of water delivery; c) quality of maintenance; d) collection of water charges; and, e) amount of area irrigated. # Reduced cost of irrigation for government	# Better System Performance. # Improved crop yields & farm incomes.

					have to claim their share for O & M from the government.		

9.2 The Characteristics of Ideal Institutions MUWS Management

The ideal institutional characteristics for sustainable resource management and multiple water use services are identified from an extensive review of the range of effective micro level water institutions in India, with the purpose of understanding the key design features that contribute to their robustness; and, institutional design principles for sustainable water management prescribed by scholars internationally (see for instance, Frederiksen, 1998).

1. Inter-Sectoral allocation of water from the river basin should be the responsibility of RBO, whose functioning to be regulated by a State level water resources regulatory agency (here in this Case Maharashtra State Water Resources Regulatory Authority).
2. The various agencies engaged in managing water-related services (line agencies) such as irrigation, and water supply in rural and urban areas would be allowed to appropriate water from within the basin on the basis of the basin-wide allocation for respective sectors.
3. Apart from enforcing water allocation, the RBO will also undertake water resource management function, including water quality management.
4. Size of MUW system should be such that it can be easily managed by the village community. The village community chooses the location, design and size of the MUWS system on the basis of their needs and priorities.
5. Framing operational rules for the MUWS, including rules for allocation of water across different segments of the socio-economic strata must be the responsibility of the local community institutions managing MUWS.
6. Drinking water and water for personal hygiene should be given top priority in water allocation from MUWS.
7. Access equity should be the underlying principles for the water allocation across households.
8. The local institution managing the MUWS will decide the levels of service, i.e., the per capita supply norms, the quality of water; and the frequency & duration of supply.
9. Water prices to be fixed by the local institution need to reflect the scarcity value of the resource to encourage efficient use. Nevertheless, it should be sufficient to cover the cost of O & M, including the management costs. The prices being charged from the users should reflect the volumetric consumption.
10. The local MUWS institution needs to be an autonomous entity, with representation of all primary stakeholders of water, for better coordination among users, and management of MUS.
11. Individual with good leadership qualities, and integrity need to be the entrusted with the responsibility of governance of the institutions at the local level.

9.3 Institutional Set up for Management of MUWS, and Roles and Responsibilities of various Institutions

As per the Maharashtra Water Resources Regulatory Authority Act (2005), River Basin Agencies issue bulk water entitlements based on the category of use (irrigation water supply, rural water supply, municipal water supply or industrial water supply) and subject to the priority assigned to such use under State Water Policy (MWRRAA, 2005). Further, it was stipulated that the existing Irrigation Development Corporations should function as River Basin Agencies. But currently, IDCs are only responsible for survey, planning, design, construction and management of Major, Medium and Minor Irrigation Projects, and irrigation water services. Hence, the new arrangement is likely to protect the entrenched interests of irrigation Corporations to over-allocate water for the sector it is concerned with, which is against the principle of sustainable water resources management in the river basin. Researchers for long have argued that for sustainable water resource management, the agency responsible for water allocation should not be same as the agency using the water (Frederiksen, 1998; Kumar, 2006). Separating out the water resource management functions from water service functions would create conditions under which the utility (the water supply agency) would be confronted with opportunity cost of using the water (Arghyam/IRAP, 2010).

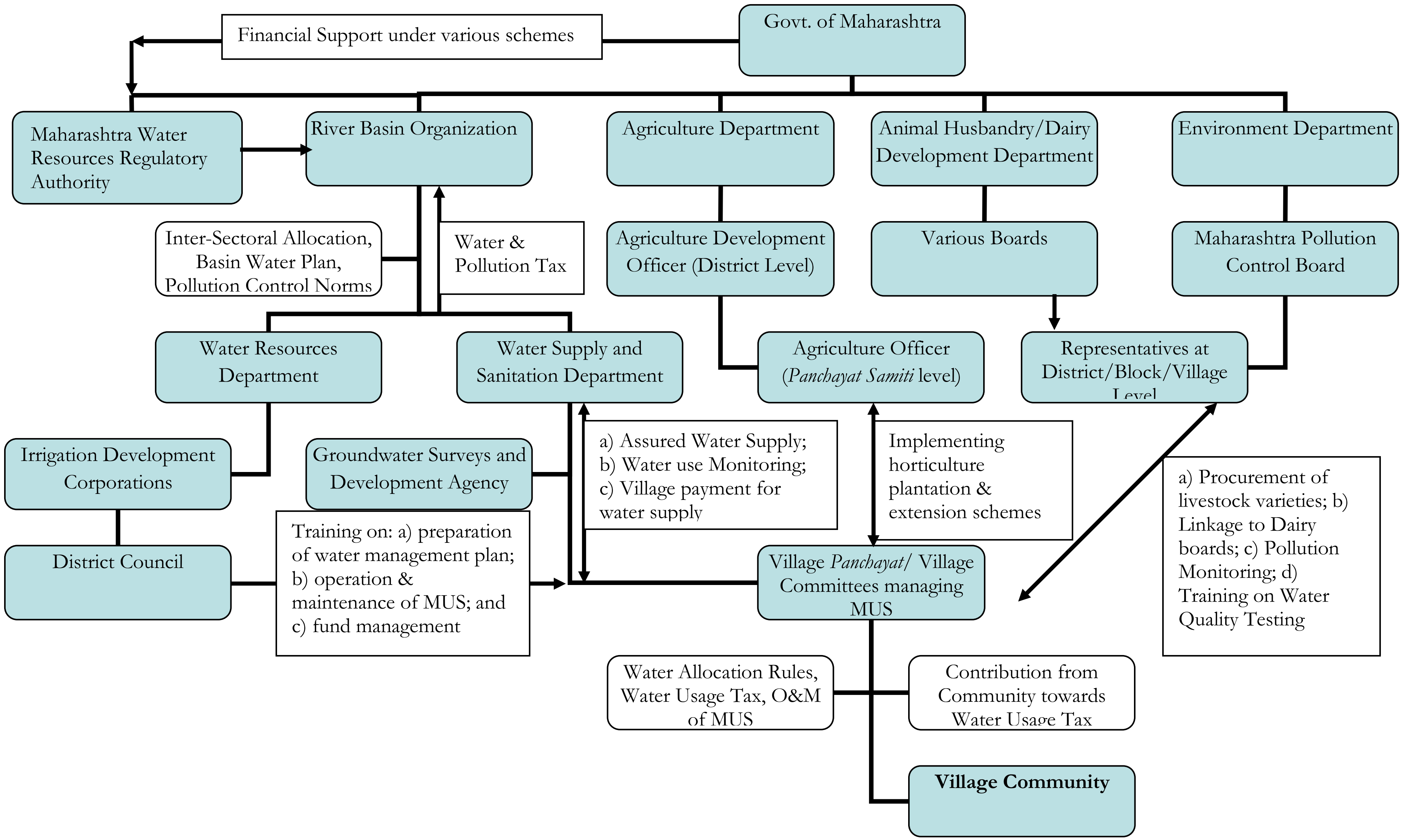
Thus, we propose the River Basin Organization (RBO) to be responsible for regulating water resource development, performing water resource management functions, managing inter-sectoral allocation, as per the regulatory framework provided by the Maharashtra Water Resources Regulatory Act. The concerned RBO can share the basin water allocation plans with all concerned departments including the Water Resources Department (WRD) and Water Supply & Sanitation Department (WSSD) and Groundwater Survey and Development Agency so that planning of schemes by these utilities adhere to such allocation plans. The GSDA and district council should make sure that there is no violation of water rights by putting effective regulatory mechanisms in place. The RBO shall charge for bulk water allocation to various water utilities on the basis of volume supplied to cover the resource cost. The presence of formal water markets would encourage the RBOs to manage the resource efficiently and sustainably (Sibly and Tooth, 2007).

Under this institutional paradigm, pollution monitoring can rest with the State Pollution Control Authority, while enforcement of pollution control norms, and water quality management would rest with RBOs. The institutional design principle being followed here is that the agency responsible for monitoring pollution and the agency enforcing pollution control norms, including treatment measures are not the same.

The GSDA, which is concerned with rural drinking water supply, should guarantee that the village community is able to access the required amount of water, by investing in the necessary infrastructure for diversion/storage and transportation of water, wherever necessary. Since in the case of Multiple Use Water Systems, water is also being supplied for uses other than drinking water supply, the cost will have to be shared by agencies concerned such as the GSDA, animal husbandry department, the fisheries department, the horticulture department etc. depending on the actual situation in the field vis-à-vis water services.

In return, local MUS institutions shall pay for the water services, which cover the cost of production & supply of water in addition to the resource cost. At village level, local MUS institutions should frame operational rules for the MUWS, including rules for allocation of water across different segments and pricing or tax structure for the water services. Water price or tax should reflect the volumetric consumption. Since metering may not be a viable option in the village water supply due to the small volumes of water handled, the local institution can evolve some simple mechanisms for estimating the water drawn by individual households from the system.

Local MUS institutions will also be responsible for water quality testing at use point. For the purpose, required training can be provided by the block/village level representatives of Maharashtra Pollution Control Board (MPCB). GSDA and district council should also arrange required number of trainings (related to O&M of MUS, village water plan etc.) for the smooth functioning of local MUWS institutions. Considering the proposed multiple use of water (also for livestock and kitchen garden purpose), block/village level representatives from agriculture, horticulture and animal husbandry department should be involved for providing necessary extension and support services.


Govt. of Maharashtra
Financial Support under various schemes
Maharashtra Water Resources Regulatory Authority
River Basin Organization
Agriculture Department
Animal Husbandry/Dairy Development Department
Environment Department
Inter-Sectoral Allocation, Basin Water Plan, Pollution Control Norms
Water & Pollution Tax
Agriculture Development Officer (District Level)
Various Boards
Maharashtra Pollution Control Board
Water Resources Department
Water Supply and Sanitation Department
Agriculture Officer (*Panchayat Samiti* level)
Representatives at District/Block/Village Level
Irrigation Development Corporations
Groundwater Surveys and Development Agency
a) Assured Water Supply; b) Water use Monitoring; c) Village payment for water supply
Implementing horticulture plantation & extension schemes
a) Procurement of livestock varieties; b) Linkage to Dairy boards; c) Pollution Monitoring; d) Training on Water Quality Testing
District Council
Training on: a) preparation of water management plan; b) operation & maintenance of MUS; and c) fund management
Village *Panchayat*/ Village Committees managing MUS
Water Allocation Rules, Water Usage Tax, O&M of MUS
Contribution from Community towards Water Usage Tax
Village Community

9.4 Status of Implementation of the DPRs

Village Varoshi

The status of implementation of the interventions which were proposed for Varoshi village is given below:

1. A cement dam (bhandara) was constructed to strengthen the existing non-functional public well. It is expected that this intervention will augment the availability of groundwater in village Varoshi, in the non-monsoon period.

2. The main storage tank of the spring based water supply scheme was repaired. It is expected that this repair will lead to availability of water to all households in the village.

3. The work of deepening of existing public well is under way and extension of water supply distribution network is yet to be completed.

4. Capacity building activities for GP/VWSC/Village community were undertaken.

5. Proposed works relating to promotion of environmentally safe sanitation practices were yet to be initiated.

Table 53 provides component-wise details on the work status, budget estimates, actual amount spent and source of funding.

Table 53: Details on the work status and amount spent on various interventions in village Varoshi

Work Undertaken	Estimated/ Sanctioned Cost (Rs)	Actual Expenditure (Rs)	Source of Funding	Work Status
Construction of cement dam	11,84,518.0	10,86,714.0	NRDWP	Completed
Repair of spring storage taken	25,830.0	10,332.0	NRDWP	Completed
Deepening of existing public well and retrofitting of water supply distribution system	33,69,821.0	Not available	ZP, Satara	In progress
Capacity building of GP/VWSC/village community	Not estimated	31,617.0	MUWS Project (UNICEF)	Completed
Works related to promotion of environmentally safe sanitation (cleaning and repairing of gutters,	91,000.0	-	SLWM	Not taken up

compost pits)				
Promotion of kitchen gardens	Not estimated	-	Agriculture Department	Not taken up

A drawing showing the location of the new structures built in the village along with that of the public water supply scheme is given in Figure 7.

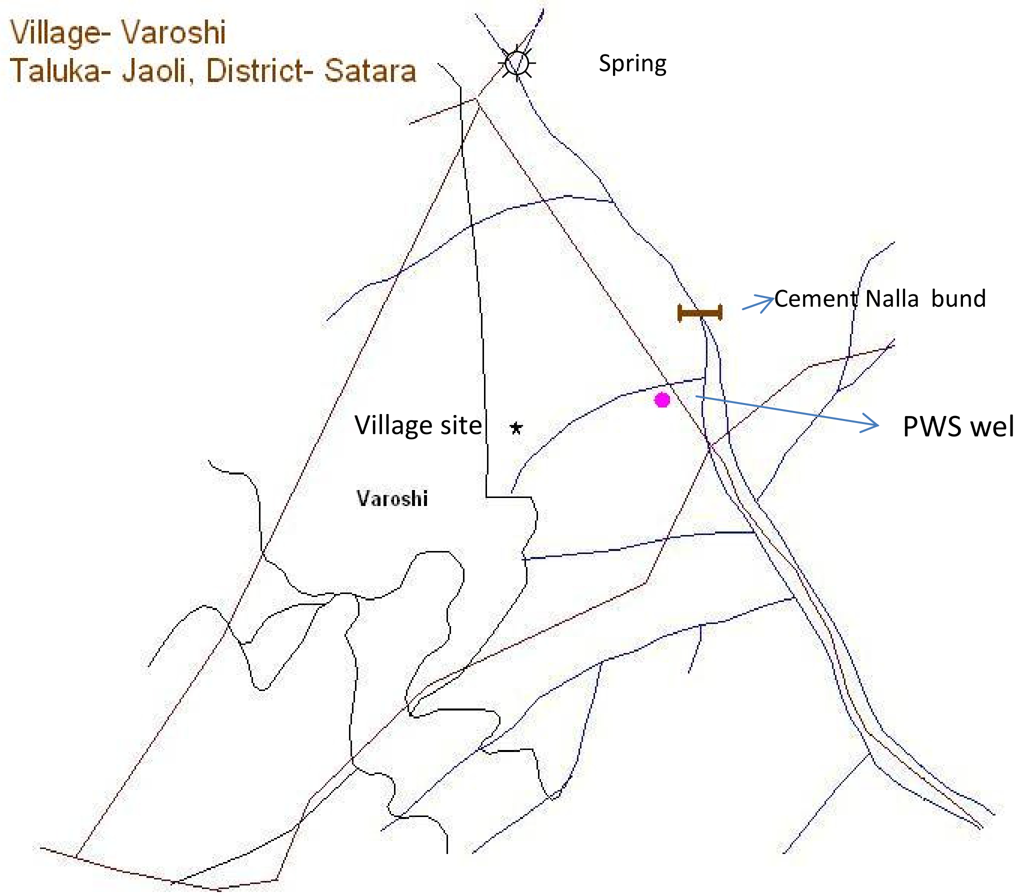


Figure 7: Diagram showing the details of interventions done in village-Varoshi

Village Chikhali

The status of implementation of the interventions which were proposed for Chikhali village is given below:

1. FSC downstream of Gaothan settlement PWS source (at a distance of about 500mt) and near hand pump at Rengeguda-2 settlement has been completed. This intervention is expected to arrest sub-surface run off in the area.

2. Bore blasting near the public well at Rengeguda-1 settlement is completed. This is expected to improve the sustainability of the drinking water well by connecting it with the existing surface storage body through artificial fractures created by the technique.

3. Construction of 5 new cement dams has been completed, while work on other 2 dams is in progress. The completed dams are expected to contribute around 15.7 thousand cubic metre of water for groundwater recharge.

4. De-silting and deepening of 3 out of existing 7 cement dams is also in progress, while work on remaining 4 has not started.

5. Water supply and distribution system for Nadamguda settlement is completed and a new percolation well is also under construction.

6. Provision of water wheel on the wells at Rengeguda-1 and Gaothan settlements has not been taken up.

7. Water absorption trench near the wells of Rengeguda 1 & 2 was not constructed.

8. One cattle trough was constructed.

9. Seeds distribution for promotion of kitchen gardens is in progress.

Table 54 provides the component-wise details on the work status, budget estimates, actual amount spent and source of funding.

Table 54: Details on the work status and amount spent on various interventions in village Chikhali

Work Undertaken	Estimated/ Sanctioned Cost (Rs)	Actual Expenditure (Rs)	Source of Funding	Work Status
FSC and bore blasting	10,64,210.0	9,84,014.0	NRDWP	Completed
Construction of 7 new cement dams	1,75,00,000.0	70,58,023.0	MNREGS	5 Completed and 2 in progress
De-silting and deepening of existing 7 cement dams	1,00,00,000.0	24,75,567.0 24,99,353.0	DPDC	In progress on 3 dams and not taken up on other 4 dams
Water supply and distribution system for Nadamguda	Not available	Not available	NRDWP	Completed
New percolation well	10,75,575.0	Not available	NRDWP	In progress
Provision of water wheel for 2 community well	6000.0		Eco-village	Not taken up
Water absorption trench	1,44,600.0		NRDWP	Not taken up

1 Cattle trough	20,000.0		Eco-village	Not taken up
Capacity building of GP/VWSC/village community	Not estimated		MUWS Project (UNICEF)	Completed
Works related to promotion of environmentally safe sanitation (cleaning of gutters, compost pits, soak pits)	2,49,790.0		Eco-village, MNREGS	Not taken up
Seeds for kitchen gardens	6000.0	Not available	Agriculture Department	In progress

Drainage map of village Chikhali with the location of water sources and works undertaken is shown in Figure 8.

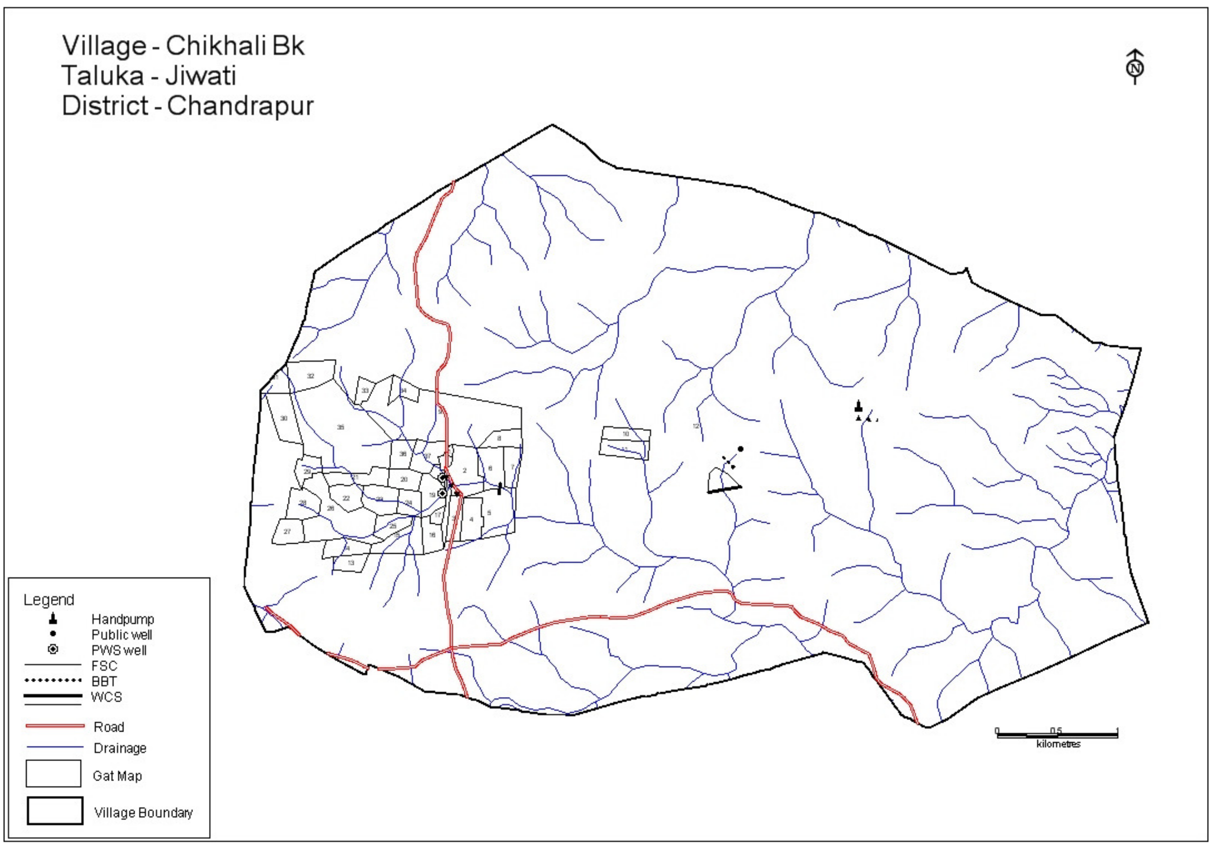


Figure 8: Drainage map of village Chikhali showing location of water sources and interventions undertaken

Village Kerkatta

The status of implementation of the interventions which were proposed for Kerkatta village is given below:

1. Fracture Seal Cementation (FSC) near the source well of old piped water supply scheme is completed. It was reported that there was a rise in well water level immediately after the completion of FSC work.

2. Bore blasting in half Jacket area on the north side of source well of Jalswarajya piped water supply scheme is completed. It is expected that the interventions will improve the availability of water for groundwater recharge.

3. Works related to: de-silting and provision of a water wheel on the well located near Hanuman temple; and repairing of parapet and platform of a well located near Mr Prahlad Ingle's house, are yet to be taken up.

4. Seeds distribution for promotion of kitchen gardens is in progress.
5. Proposed works relating to promotion of environmentally safe sanitation were yet to be initiated.

Drainage map of village Kerkatta with the location of water sources and works undertaken is shown in Figure 9.

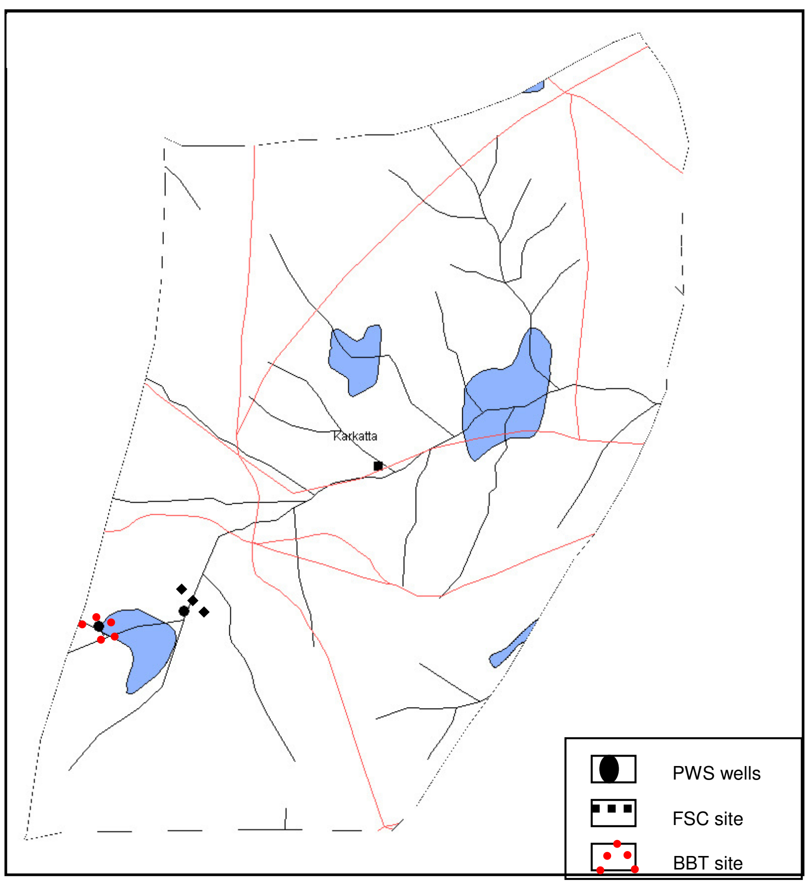


Table 55 provides component wise details on the work status, budget estimates, actual amount spent and source of funding.

Table 55: Details on the work status and amount spent on various interventions in village Kerkatta

Work Undertaken	Estimated/ Sanctioned Cost (Rs)	Actual Expenditure (Rs)	Source of Funding	Work Status
FSC for old PWSS well	1,51,840.0	1,64,350.0	NRDWP	Completed
Bore blasting for new well	1,17,240.0	1,80,828.0	NRDWP	Completed
De-silting and provision of a water wheel on the well located near Hanuman temple	6,800.0	-	GP	On going
Repairing of parapet and platform of a well located near Mr Prahlad Ingle's house	15,020.0	-	GP	Not taken up
Capacity building of GP/VWSC/village community	Not estimated	-	MUWS Project (UNICEF)	Completed
Works related to promotion of environmentally safe sanitation (cleaning of gutters, compost pits)	13,310.0	-	Eco-village	Not taken up
Seeds for kitchen gardens	16,200.0	Not available	Agriculture Department	In progress

9.5 Impact of MUWS Interventions on Household Vulnerability

The interventions discussed in the previous section were carried out prior to the onset of the monsoon in 2012. The following interventions were made to augment the existing water sources in the villages: 1] repairing the storage tank of the spring based water supply scheme in Varoshi; 2] Fracture seal cementation of PWS source, bore blast technique for public well and construction of 5 new check dams in Chikhali; and 3] Fracture seal cementation near the source well of old piped water supply scheme, bore blast technique in half jacket area on north side of the source well in Kerkatta. As discussed earlier, the interventions primary centered on augmenting groundwater resources in the pilot villages and strengthening the existing water supply sources. After the monsoon, a survey of the sample households, whose vulnerability was assessed during the initial research phase, was undertaken (in November, 2012) to see how their water access and use situation changed post implementation. The survey included collection of primary data from the sample households on various physical and socio-economic attributes, which are critical to changing their vulnerability, and which are likely to be influenced by the project interventions. Finally, vulnerability indices were computed for all the 300 sample households from the pilot villages, and compared against the corresponding pre intervention values.

Computation of Vulnerability Index

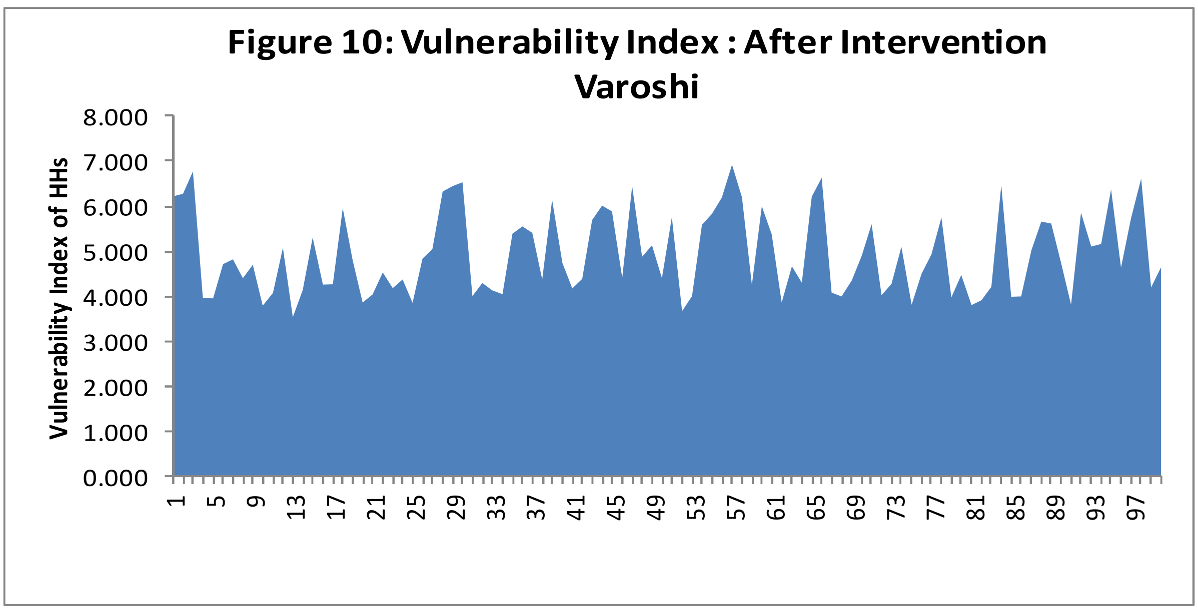
It was observed that in Varoshi village, the minimum value of the vulnerability index increased from 3.31 (before intervention) to 3.52 (after intervention) and the maximum value of vulnerability index also increased from 6.58 (before intervention) to 6.92 (after intervention). In Kerkatta and Chikhali villages too the changes in number of minimum and maximum values of vulnerability index were observed as in Varoshi village.

Table 56: Highly Vulnerable HHs before and after interventions

Location	Vulnerability Index Range		Highly Vulnerable HHS	
	Before Intervention	After Intervention	Before Intervention	After Intervention
Varoshi	3.31 - 6.58	3.52 - 6.92	67	58
Kerkatta	2.21 - 6.32	3.05 - 6.53	81	58
Chikhali	3.15 - 6.37	3.39 - 6.53	30	29

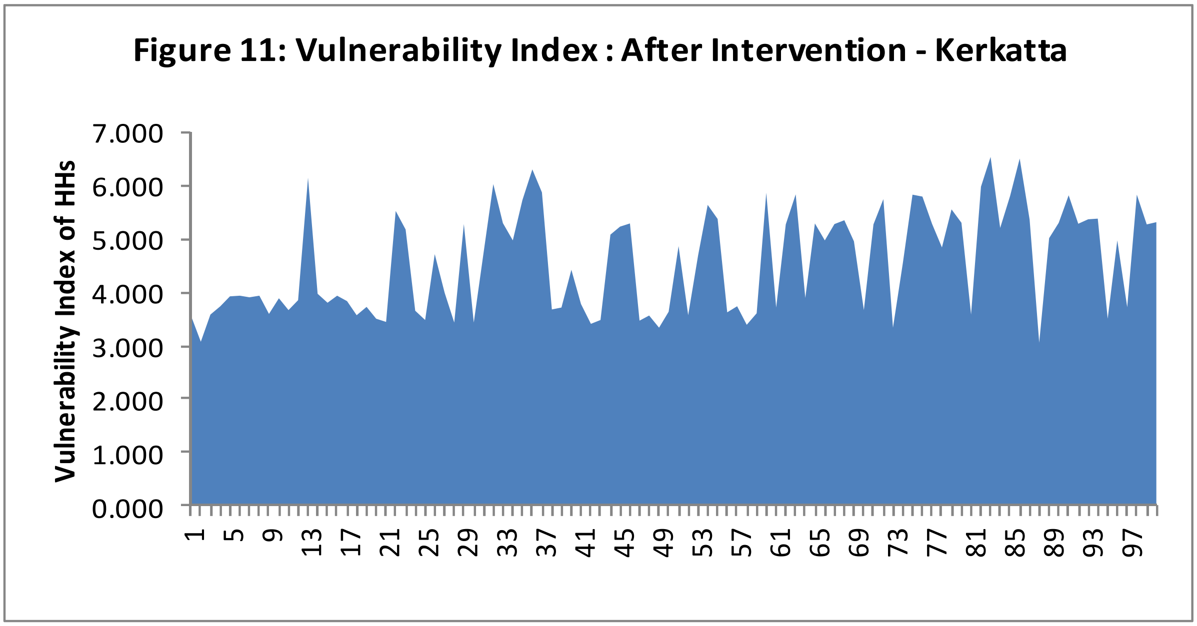
Vulnerable Households in Varoshi Village

In Varoshi village, after intervention, the number of highly vulnerable households came down to 58 from 67 (before intervention). In terms of percentage, the vulnerable households decreased by 13%. This can be attributed to more number of households gaining access to improved water supply during period of shortage. A graphical representation of the values of the vulnerability index for the sample households of the village is given in Figure 10.



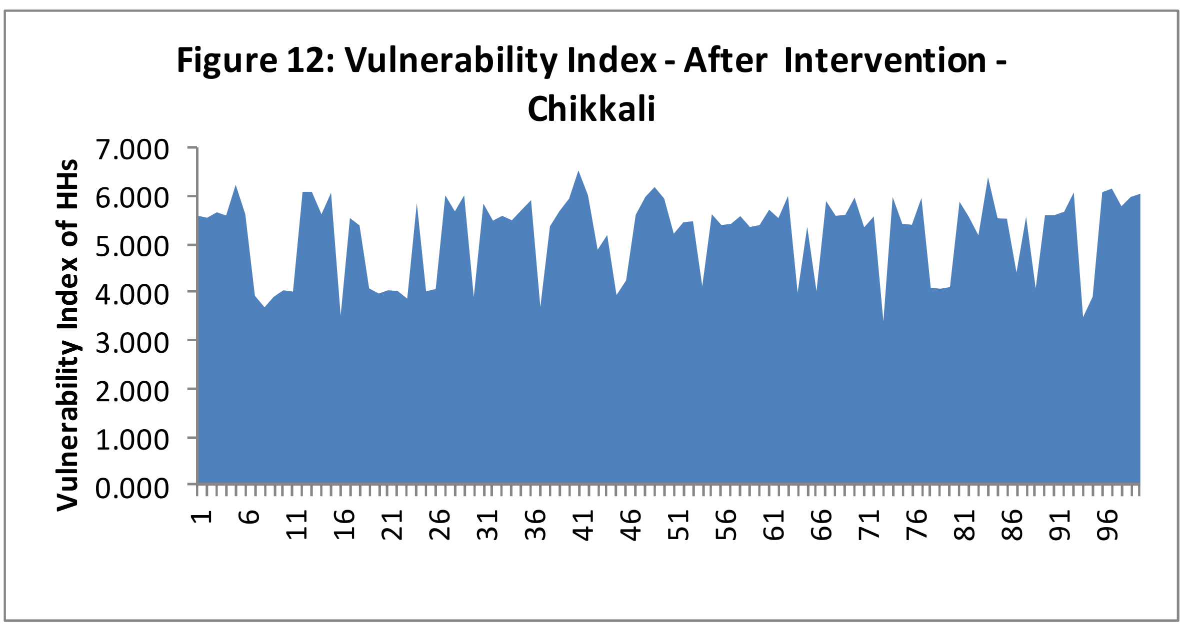
Vulnerable Households in Kerkatta Village

In Kerkatta village, after interventions like bore blast technique and fracture seal cementation near the primary water source wells, more water was made available for domestic supply. As a result of this, the number of highly vulnerable households came down to 58 from 81 (before intervention), which is reduction by 28%. A graphical representation of the values of the vulnerability index for the sample households of the village is given in Figure 11.



Vulnerable Households in Chikhali Village

A graphical representation of the values of the vulnerability index for the sample households of the village is given in Figure 12. In the case of Chikhali village, not much change was observed in the number of highly vulnerable households as the number of highly vulnerable households reduced by merely 3%. Here, one of the reasons could be that the works related to check dams, de-silting are still under progress. The vulnerability may still decrease further once the interventions are completed.



Out of the three pilot villages, Kerkatta village had shown a drastic change (reduction) in the number of highly vulnerable households. Apart from this, it was also observed that the minimum and maximum values of the composite vulnerability index increased in all the three villages. As a result, the overall vulnerability also decreased.

10. Conclusions

This report covered the key outcomes of a pilot project undertaken on developing and implementing a multiple use water systems in different villages of Maharashtra.

The research phase consisted of the following: i] a detailed survey of sample households in the villages to assess the different domestic and productive water needs of the households, to analyze various dimensions of water to and use of water, and to assess their socio-economic and livelihood dynamics, with particular reference to the impact of climate variability on the same; ii] to assess the multiple use vulnerability of the households; iii] an extensive review of various multiple use models available from around the world with particular reference to the study of features that contribute to their good performance; iv] design multiple use water systems that suite each one of the three agro climatic and socio-economic settings; v] an extensive review of effective water institutions from around India; and, vi] developing institutional arrangements for managing multiple use water systems in the pilot villages.

Developing a multiple use vulnerability index at the household level was one of the exercises carried out under the research phase. Six broad sub-indices constitute the composite multiple use vulnerability index developed by us. They are: 1] water supply and use; 2] family occupation and social profile; 3] presence of social institutions and ingenuity; 4] water resource endowment; 5] climate and drought proneness; and, 6] financial stability. These sub-indices broadly capture the key parameters like capital assets (natural, physical, social, financial), sequencing & time, institutional linkages, and knowledge environment.

Analysis of primary data from the sample households in the three villages showed the following. The households in all three villages had domestic and productive water uses, viz., drinking & cooking; bathing, washing and toilet use; livestock drinking; and, watering of kitchen gardens. Nevertheless, the number of households using water for kitchen garden and homestead was much less for Kerkatta and Chikhali. This is because, lesser number of families own livestock in these villages. Again, the average number of animals they keep is lower as compared to Varoshi, owing to shortage of drinking water, and green and dry fodder. Further, lesser number of households maintains kitchen gardens. Those who have kitchen gardens, practice it in much smaller areas as compared to Varoshi. Again, water shortage is the major reason for this. Only one household each from two villages, viz., Varoshi and Kerkatta was found to be using water for small scale industrial unit. In all the villages, water use for domestic and productive needs was found to be influenced by the overall economic of the households with higher values of economically better off households.

Based on the understanding of the different domestic and productive water needs of the sample households covered during primary survey, and the data obtained on various physical and socio-economic parameters influencing their MUS vulnerability, the vulnerability indices for the sample households were computed. The values for the three locations showed the following. In the case of Varoshi village in Jawali taluka of Satara district, the MUS vulnerability of the HHs varies from 3.31 to 6.58. Sixty seven families were found to be most vulnerable as per the estimates, with values of the index falling below 5.0. In the case of Kerkatta in Latur taluka of Latur district the values range from 2.16 to 6.14. Of these, 81 households were found to be most vulnerable. In the case of Chikhali in Jivati taluka of Chandrapur district, the values range from 3.14 to 6.32, and 31 households were found to be most vulnerable. Hence, Kerkatta had the maximum percentage of household vulnerable to problems associated with inadequate water supply for multiple uses.

The analysis of socio-economic data of the sample households showed the following. In all the villages, the cropping systems under irrigated conditions were different from that under rain-fed conditions. But, farmers without irrigation facilities also grow crops after monsoon season. This is by virtue of the very high rainfall the region receives. Nevertheless, those farmers with irrigation facilities are able to take up some high valued crops. The returns from these irrigated crops are much higher than that from rain-fed crops. In Varoshi, where crops are grown by farmers under both irrigated and rain-fed conditions even during drought years, the yields decline under drought conditions. But, the decline was found to be quite remarkable under rain-fed conditions. As regards the net returns, the drop was very significant under rain-fed conditions. In Kerkatta and Chikhali, no crops were grown by the farmers during drought years. Also, unlike in the case of Varoshi, only farmers with irrigation facilities grow winter crops.

The design of MUWS involved an extensive review of MUWS models from around the world, which included countries as diverse as India (south and north India), Nepal, Bangladesh (south Asia), Ethiopia, South Africa, Zimbabwe and Morocco (African countries); Bolivia, Colombia and Brazil (South America); and Vietnam and Thailand (South East Asia). The MUWS displayed wide heterogeneity vis-à-vis their technical features, size and the services they provide. Based on identification of features which contribute to their effectiveness as MUWS, understanding of the physical and socio-economic characteristics of the regions in question and the type of water supply systems existing there, models of MUWS were developed for all the three locations. Subsequently, the institutional arrangements for their management were also worked out. The institutional structure suggested involves a four-tier hierarchy of institutions from the state water resource regulatory authority to the river basin organization (RBOs) to the line agencies concerned water supply services to the local village level institution for managing multiple water use services.

However, the models chosen through research could not be taken up for implementation due to financial constraints faced by GSDA, which in this case is the implementing agency. Alternative interventions were chosen, which were technically feasible and financially viable, though theoretically less effective than the interventions chosen as model MUWS. The selection of these interventions involved some geophysical investigation in the village for their technical efficacy, and community consultation for their utility and appropriateness. The DPRs for the same were prepared and their specific components were implemented before the onset of monsoon.

The household vulnerability index computed post the interventions showed some reduction in the vulnerability of the households to problems associated with lack of water for multiple needs. The highest reduction was found in the case of Kerkatta village, which had the highest number of vulnerable households prior to the intervention. However, to what extent these interventions are really useful in improving the household supply situation in the villages and thereby reducing the HH vulnerability would be known only during summer when the water sources, which are now augmented through the technical interventions, get dried up.

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