Connecting the Dots

Evolving Practical Strategies for Adaptation to Climate Change

Towards Resilient Agriculture in a Changing Climate Scenario

– Building Response Capacity of Small-Holder Producers

WOTR

Towards Resilient Agriculture in a Changing Climate Scenario

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Acronyms

ASSOCHAM	Associated Chambers of Commerce and Industry of India
AWS	Automated Weather Stations
CGIAR	Consultative Group on International Agricultural Research
CRIDA	Central Research Institute for Dryland Agriculture
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
ICRAF	International Centre for Research on Agriculture and Forestry
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IGWDP	Indo-German Watershed Development Programme
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
IT	Information Technology
IWMP	Integrated Watershed Management Programme
KVK	Krishi Vigyan Kendra
LEISA	Low External Input Sustainable Agriculture
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MPKV	State Agricultural University
NABARD	National Bank for Agriculture and Rural Development
NAPCC	National Action Plan on Climate Change
PBR	People's Biodiversity Register
PPCP	Public Private Community Partnership
SAPCC	State Action Plans on Climate Change
SAPPLPP	South Asia Pro-Poor Livestock Policy Programme
SCI	System of Crop Intensification
SDC	Swiss Development Cooperation
SHG	Self Help Group
SMS	Short Messaging Service
SRI	System for Rice Intensification
WOTR	Watershed Organisation Trust

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Foreword

Climate change is already happening and its effects, especially on rural communities in India, are particularly adverse. The need is to highlight the key issues and understand the practical challenges that must be addressed if India is to build the capacities of rural communities to robustly adapt to climate change and realise the National and State Action Plans on Climate Change (NAPCC and SAPCC).

For the last four years, WOTR has been implementing a large-scale integrated project on climate change adaptation in rural Maharashtra, Andhra Pradesh, and Madhya Pradesh, in collaboration with the National Bank for Agriculture and Rural Development (NABARD), the Swiss Development Cooperation (SDC), the Indian Meteorological Department (IMD), the Central Research Institute for Dryland Agriculture (CRIDA), the World Agro-Forestry Council (ICRAF), and the State Agricultural University (MPKV).

This experience has catalysed insights, lessons, and experiences from multiple stakeholders which we have formulated as Position Papers across 12 thematic areas: Watershed Development, Water, Food and Nutrition Security, Agriculture, Livestock, Biodiversity and Ecosystem Services, Disaster Risk Reduction and Risk Prevention, Alternate Energy, Economics and Livelihoods, Health, Gender, and Governance.

It is predicted that for every two-degree rise in temperature, the agriculture GDP of India will reduce by five percent. In this context the worst hit are small-holder producers, as their ability to cope with the speed and intensity of climate events as they are happening, is an issue of concern. The need for a climate resilient approach to agriculture is critical for India with 60 percent of Indian agriculture being rain fed and more than 80 percent agriculturists are small-holder farmers.

Within this context, the current paper attempts to capture the ground realities that small-holder producers face, from the experiences gathered by WOTR in projects across Maharashtra, Madhya Pradesh, and Andhra Pradesh and the impacts of various programmes being implemented by the government and other agencies. The paper presents WOTR's approach to climate-resilient agriculture and suggests recommendations for **policy that will help increase the response capacity of farmers and the resilience of the ecosystem, and reduce their risks to climate change.**

Key Messages

- Indian agriculture today faces a multipronged set of **challenges** pressured simultaneously by several sectoral and non-sectoral demands. All this is further aggravated by the extreme weather variations that are being experienced.
- The majority of farmers are **small and marginal landowners** who are resource-poor. They are most affected due to their low adaptive capacity and risk-taking ability. By incorporating various adaptation measures in the agriculture system one can increase the resilience and adaptive capacity of the small land holders.
- Agriculture in a climate change context requires a **multi-sectoral and multi-agency approach**. Government policies, and the various departments and development agencies need to synchronise their efforts towards achieving sustainable agriculture productivity and food and nutrition security, particularly for the small and marginal farmer.
- **Assessing vulnerabilities** of villages for climate variations is essential for building resilience of the people and their livelihoods.
- **Integrated and participatory watershed development** should be the **centre-point activity** for agriculture as it improves the natural resource base around which other development initiatives are founded, particularly in semi-arid and arid regions of the country.
- For building the response capacity of farmers, especially the small land holders, the model advocated promotes agriculture for the market while it simultaneously ensures **food and nutrition security and ecosystem resilience**.
- Hand-holding is urgently required to build the confidence of farmers in **improved farming practices**. Capacity building for application of a crop-specific **'package of practices'** will enhance the ability of farmers to respond to the challenges facing them.
- **Preparedness for weather variations is critical**. To better equip farmers to respond appropriately to climate variations and minimise risks, **local automated weather stations** at appropriate distances will help generate locale-specific crop-weather advisories; together with **Contingent Crop Plans** specific to the sub-agri-climatic zone, they will increase the response capacity of farmers and will minimise losses.
- There is an urgent need to **promote/revive indigenous crop varieties** and reverse the loss of agro-biodiversity caused due to market drivers. Indigenous crops are more resilient to climate variations, farmers have better knowledge of handling them, and traditional crops generally meet the food preferences of communities, making it all the more important to create measures to promote and revive them.
- **Reduction of waste of agriculture produce** at all stages – from farm to plate – is essential, especially during the post-harvest stage. Decentralising the storage facilities and improving storage possibilities along with localised value addition to perishable goods is essential and will reduce the carbon footprint simultaneously.
- Adaptation is always a local phenomenon. Hence, there is a need to **integrate traditional knowledge with the scientific** to develop locally suited adaptive strategies for agriculture.

1. Introduction

Agriculture plays an important role in the social and economic life of people in India, and will continue to do so in the foreseeable future. Today agriculture accounts for about 14 percent of the Gross Domestic Product (GDP) and 11 percent of exports (Sharma, 2007; Ministry of Agriculture, 2013). It faces many challenges. Some of the *sectoral challenges* since the last decade or so are: a slowdown in growth, increased exposure to world commodity price volatility, degradation of the natural resource base, rapid and widespread decline in the groundwater table, land fragmentation, lack of extension services, and the indebtedness of farmers. Further, *non-sectoral challenges* that are stressors for agriculture are: population growth, expanding urbanisation, demographic transition (larger sections of society becoming affluent) with increasing incomes, improving life styles and changes in food habits, globalisation, and the demand for bio-fuels. Added to the latter is the increasing absorption of agricultural land into Special Economic Zones and townships, large industrial and irrigation-cum-power projects, and mining.

Currently almost 46 percent of India's geographical area is under agriculture. A large percentage of this land falls in rain-fed regions generating 55 percent of the country's agricultural output, providing food to 40 percent of the nation's population (Ahmad et al., 2011; Planning Commission, 2012). More than 80 percent of the farmers are small-holder producers, with very poor capacity and resources to deal with the vagaries of weather and changes in climate.

For the farmer, climate is the seasonal temperature and rainfall pattern expected in their area, based on experience over decades. Weather, on the other hand, is the actual temperature, rainfall, and other climatic conditions experienced from day to day, for which they need adaptation or coping strategies to deal with these variations. With approximately 60 percent of Indian agriculture being rain fed and dependent on the vagaries of the monsoons, the climate will be *a major determinant of agricultural production.* Temperature, rainfall, and seasonal weather variations will thus aggravate the existing agricultural challenges.

The Intergovernmental Panel on Climate Change (IPCC) report of 2007 predicts an increase in rainfall over the Indian subcontinent by 6–8 percent (Ministry of Environment and Forests, 2009). Goswami et al. (2006) predict substantial increase in hazards related to heavy rainfall over Central India in the future. Overall in India, some physical impacts of climate change will be seen as: (1) increase in the average surface temperature by 2°C–4°C; (2) changes in rainfall (distribution and frequency) during both monsoon and non-monsoon months; (3) decrease by more than 15, in the number of rainy days; (5) increase in the intensity of rain by 1–4 mm/day; and (6) increase in the frequency and intensity of cyclonic storms. It is predicted that for every two-degree rise in temperature, the GDP (Gross Domestic Product) will drop by five percent. Climate assessments of the agriculture sector, however, focus on the impacts of crop yields, while little emphasis is given to the inter-connected sub-systems of the agriculture production systems as a whole (Ranuzzi and Srivastava, 2012).

Today groundwater is the major source of water utilised for irrigation, accounting for about 65 percent, while 15 percent of India's food is produced by mining non-renewable groundwater (Brown, 2009). Hence the rapidly declining groundwater because of over-extraction is a major cause of concern. Current trends estimate that 60 percent of India's groundwater sources will be in a critical state of degradation within the next twenty years (World Bank, 2010). According to the IPCC, in the changing climate scenario, the demand for irrigation in arid and semi-arid regions of Asia is estimated to increase by at least 10 percent for an increase in temperature by 1°C (Bates et al., 2008).

Small-holder producers across the world have always faced the vagaries of nature. However, their capacity to cope with the speed and intensity of current climate events is of concern (IFAD, 2011). With over 60 percent of Indian agriculture being rain-fed and more than 80 percent farmers being small-holder producers, the need for a climate-resilient approach to agriculture is critical. Therefore adaptation measures must not only build the response capacity of small-holder producers, but it is crucial to also maintain the resilience of the ecosystem from which they derive a living.

In this context, the paper captures some ground realities that small-holder producers face in selected pockets[1] of Maharashtra, Andhra Pradesh, and Madhya Pradesh. This paper presents an approach to climate-resilient agriculture[2] that will help increase the response capacity of farmers and the resilience of the respective ecosystem.

2. Key factors and issues affecting agriculture today: Emerging insights from the grass roots

2.1 Modern Agriculture: Reducing resilience of small-holder farmers

India has come a long way from being a food-deficit country to having food sufficiency. The Green Revolution[3] was a major step towards achieving this feat. However, in recent times we have begun experiencing its downside.

Vulnerability assessment studies conducted by WOTR in ten watershed villages in the states of Andhra Pradesh, Madhya Pradesh, and Maharashtra, have revealed the following:

- Triggered by a demand for cash flow, small-holder farmers have shifted from low-water-requiring food crops (e.g. sorghum, millets, pulses) to market-driven water-intensive mono-cultivation cash crops (particularly vegetables). This choice has led to the loss of good practices such as crop rotation, inter-cropping, and mixed farming, while soil health deteriorates. Furthermore, the shift has a huge negative impact on the food and nutrition of the poor farmer. The trend of repeated mono-cropping, with the increasing requirement of chemical fertiliser sand pesticides, has been cited as the cause of the deteriorating soil quality, poor water-retention capacity, decline in productivity, and ever-increasing input costs, by farmers in Maharashtra.

- Farm bunding is an essential operation that reduces soil erosion and water runoff, retains soil moisture, and improves ground water levels by increasing filtration. However, the larger land-holding farmers in

[1] Experiences are from 49 villages in seven clusters of villages where WOTR is working. In WOTR's data base (of 3,713 HH from 25 villages), 6.2 percent HH are large farmers, 15.4 percent are medium farmers with some irrigation, 65.5 percent are small and marginal farmers, and 12.9 percent are landless.

[2] WOTR's adaptive sustainable agriculture strategy (referred to below).

[3] The Green Revolution is an example of modern 'high-input, high-output' agriculture which needs a complete package for success – the use of high-yield hybrid seed varieties, extensive irrigation, chemical fertilisers, pesticides, and mechanisation.

particular prefer using tractors for land tilling operations due to the rising cost of labour. This choice in turn requires removal of farm bunds and increase in irrigations per crop, pushing farmers to invest in more bore wells or deepening the existing ones. However, investments in bore wells show huge losses due to the fast-declining water tables. To save the horticulture plantations and vegetables in summer, some farmers invest in purchasing tankers of water.

- The shift in crops from sorghum and millets to wheat and vegetables contributes to fodder scarcity, decrease in the number of livestock, and a reduced amount of manure. Decreasing grazing lands (dwindling common property resources and the ban on grazing in forests) are also contributing factors. Reduction in farmyard manure has increased the need for chemical fertilisers.

Agriculture, with its changing patterns and declining profitability, is proving a non-remunerative occupation, especially for small-holder farmers.

2.2 Livestock, an integral part of the agriculture production system: The dying link

In the harsh and unproductive environments of the arid and semi-arid rain-fed systems, livestock rearing goes beyond the purpose of mere milk and meat production and supporting rural livelihoods (Ashley et al., 1999): it plays a critical role in providing draught power for agriculture and transportation, biodiversity regeneration and maintenance, and most importantly, manure for agriculture. This is a low-carbon system.

A study conducted by WOTR in 2012 in four watershed villages in Maharashtra revealed that over the last twenty-five years, two levels of drivers have emerged as responsible for triggering changes in the crop-livestock production systems. At the national level, key drivers of change are the animal husbandry policies that promote adoption of high-input-output production systems and animal breeding programmes focussed on increasing productivity (of a single productive trait – milk). The driver on another level that forces a decline in rearing of indigenous cattle is the conversion of common

property resources (grazing lands in particular) into agricultural lands. In terms of pressures, communities reported that the ban on grazing in forest areas, and the restrictions to grazing in natural resource conservation and management programmes, have caused reduction in rearing indigenous cattle and non-dairy livestock. The simultaneous promotion of dairy cooperatives and related infrastructure, subsidies, poverty alleviation programmes, and animal husbandry schemes/programmes that promote crossbred cattle for improving economic returns through increased milk production have accelerated a shift towards rearing crossbred cows. The same is seen in sheep where fast-growing meat breeds are promoted rather than local breeds that are more suited to the agro-ecological zone (e.g. the 'Nellore Red' is promoted in Andhra Pradesh rather than the local *Deccani* sheep). Besides these, fluctuations in market prices, the demand for agricultural products, and repeated crop losses due to the vagaries of climate, are pressures that greatly influence decisions the rural poor make. The need for regular cash flow to meet their daily needs is a key pressure for the small-holder farmers. It influences cropping patterns, seed selection, and the type of livestock they rear.

The drivers and pressures have induced a clear shift from low-input farming to cash-oriented high-input-output, water-intensive, dairy-based farming. This change has deep impacts, affecting agriculture and livestock production, the ecosystem, and the communities. There is a significant reduction in indigenous cattle and non-dairy livestock in villages over time. In the ecosystem, the main impacts observed are rapid ground water depletion, decreasing soil quality and fertility, and loss of biodiversity. For the communities, agriculture input costs are on the rise, while crop yields are decreasing, lowering incomes, with a significant drop in animal protein in their diets. (Rao, 2010; SAPPLPP, 2012).

A lack of understanding of the role of livestock in dryland farming systems has resulted in serious unintended consequences in the name of better economic development and environment conservation.

2.3 Declining agro-biodiversity and traditional knowledge

Market economy and globalisation have resulted in a trend of increasing monoculture cropping, enticing farmers to abandon the diverse indigenous crops they grew earlier. The Food and Agriculture Organisation (FAO) states that since the 1900s, some 75 percent of plant genetic diversity has been lost worldwide, generating 75 percent of the world's food from only 12 plants and five animal species (FAO, 2004).[4] It cites the rapid expansion of industrial and Green Revolution agriculture, globalisation of the food system, and market demands as the main reasons for the erosion of genetic diversity. Along with this, the rich traditional knowledge, culture, and skills of farmers are lost.

Being local, indigenous crop varieties have a higher degree of resilience to the vagaries of nature. They are a buffer against starvation in times of stress, especially for the poor.[5] At the local level, communities need to be encouraged to preserve the heirloom varieties of seeds in seed banks, while rotating their stock each year to ensure that adaptability is retained. Simultaneously, traditional knowledge of communities, aptly called 'reservoir of adaptations' (Tengo and Belfrages, 2004), need to be revitalised. Revival of these neglected and

[4] International Plant Genetic Resource Institute (IPGRI) states that at least 7000 plant species could be cultivated for food, but only 150 crops are grown commercially. See http://www.scidev.net/es/features/para-combatir-el-hambre-regreso-a-cultivo-abando.html. Accessed on 6 January 2012.

[5] One of the cases can be accessed at www.underutilized-species.org/documents/publications/millet_mssrf.pdf. Accessed on 6 January 2012.

underutilised crops[6] will help provide familiar dietary diversity to address problems of food security and hidden hunger.[7] In fact, these crops acted as 'famine food' for tribal and rural communities during times of bad weather conditions and crop failures. Some 'weeds' (locally called *darad*) that were earlier used during times of food shortage are not used anymore.

Field experiences from WOTR's climate change adaptation project implemented in the states of Maharashtra, Andhra Pradesh, and Madhya Pradesh have revealed that there are significant changes in agriculture practices. Food crop diversity has reduced. In the Akole block of Ahmednagar district Maharashtra, eleven indigenous varieties of rice and two of wheat were cultivated even ten years earlier. Besides these, finger millet, french millet, niger seeds, little millet, sorghum, maize, and horse gram were also grown extensively. Today, the area under cultivation of these crops has drastically fallen, being replaced by new-to-the-region crops like groundnut, Bengal gram, field beans, soyabean, and a variety of vegetables and pulses. Villagers recall that in the past, pest attacks were insignificant. Today with the changed cropping pattern and the use of hybrid seeds, there are increased incidents of pest attacks. The use of *shenkhat* (cow dung), *lendikhat* (pellets of sheep-droppings), and leaf litter as farmyard manure, have been replaced by chemical fertilisers.

Similar findings have been obtained from the baseline studies of project villages in Andhra Pradesh. Farmers in Mahabubnagar (average annual rainfall of 692 mm) now grow sugarcane, rice, cotton, sunflower, hybrid maize, vegetables, green fodder, and fruits such as sweet lime, watermelon, and papaya. Cotton occupies the first place at 43 percent of total cultivated area, followed by maize (27 percent), paddy (20 percent), and groundnut (6 percent), followed by 4.5 percent for vegetables, fruits, millets, and

[6] Underutilised crops: crops which were once more widely grown but are today falling into disuse for a variety of agronomic, genetic, economic, and cultural factors. Neglected crops are those grown primarily in their centres of origin or centres of diversity by traditional farmers, where they are still important for the subsistence of local communities. Some species may be globally distributed but they remain inadequately characterised and neglected by research and conservation. See http://www.cropsforthefuture.org/publication/Articles/Underutilized-crops-trends-challenges-and-opportunities-in-the-21st-century.pdf. Accessed on 6 January 2012.

[7] A nutritional deficiency caused by lack of balance in an otherwise full diet.

pulses combined. These crops have replaced the indigenous millets, local varieties of maize, sorghum, etc., which are less water-intensive and more suitable to the agro-ecology. Rice is not native to this region. However, over time, the area under repeated rice cultivation has increased, resulting in the soil becoming highly saline, and unsuitable for other crops.

In Madhya Pradesh today, farmers mainly grow hybrid wheat, chickpea, and paddy, along with small proportions of kodo millet (*kodo*), little millet (*kutki*) and niger (*ramtila*). Farmers prefer the hybrid varieties that have market demand over the many local varieties of wheat (*mundi, pahadi, katanga, narmada, chare, misri,* etc.) that were cultivated earlier. Currently just 10 percent of farmers still cultivate these local varieties.

2.4 Services of agriculture universities – Krishi Vigyan Kendras (KVKs), and the block agriculture services: A demand yet to be adequately met

Agriculture universities, **Krishi Vigyan Kendras[8] (KVKs),** across the country are located in every state, catering to the broad agro-ecological zones. These centres have the responsibility to extend services to farmers in their extensive jurisdiction. However, many farmers, small-holder producers in particular, prefer to seek out a nearby one-stop centre that provides them with guidance in seed selection (according to market priorities), the fertilisers and pesticides required for the variety and the related know-how. The unavailability, within reach, of a KVK to provide all agricultural needs compels the small-holder producer to turn to local private service providers. The increasing dependence on these private service providers has translated into experimentation with new

seed varieties, fertilisers, and pesticides without adequate guidance, which has resulted in less-than-expected crop yields and never-ending debt cycles. The small farmer is the loser, with high input investments, reduced crop productivity, and declining soil fertility over time, rendering agriculture unviable. During field interactions, small-holder producers expressed their preference for supplies and inputs from KVKs and universities; however, they report that these institutions are too distant and have inadequate supplies to meet all the needs of the region. The block agriculture offices have a great opportunity here to hand-hold farmers, besides promoting the various schemes of the government. Clearly, improving access through extension service mechanisms is critical for small-holder agriculture to remain viable.

2.5 Agriculture, climate change, and vulnerability

Various studies indicate that climate change will negatively impact the production of major crops like rice, wheat, and sorghum (*jowar*). Others indicate that there might be improvement in yields of winter (*rabi*) maize, sorghum, and millets. A report by IFPRI (Gerald et al., 2009) states that South Asia will be hard-hit by climate change and yields of almost all crops will

[8] The Krishi Vigyan Kendras (KVKs) are district-level Farm Science Centres established by the Indian Council of Agricultural Research (ICAR), New Delhi, for speedy transfer of technology to the farmers' fields. Their aim is to reduce the time lag between generation of technology at the research institutions and its transfer to the farmer's field for increasing productivity and income from agriculture and allied sectors on a sustained basis. Generally there is at least one KVK per district.

Impacts of Climate Change on Agriculture:

1. If temperatures rise by 4°C, vast areas of drylands will have their growing seasons cut by more than 20 percent.
2. Temperature and water stress affects leaf formation, flowering, and growth.
3. Temperature increase of 3.5°C by 2050 will lead to a decline of yield in water-intensive crops such as rice by 8–9 percent and wheat yields by 2–6 percent.
4. There will be negative impacts on sorghum productivity due to reduced crop durations, if temperatures increase by 3°C.
5. As the climate becomes warmer, the response of crops to added fertilisers will be lower.
6. Increase in temperature affects the quality of cotton, fruits, vegetables, tea, coffee, and medicinal plants.
7. Increased temperature leads to loss of moisture from the soil and soil organic matter which will affect soil fertility and decrease yields.
8. If rainfall reduces by 10 percent, there will be decrease in yield of groundnut.
9. There will be increased risk of pests and diseases due to change in the pattern of host and pathogen interaction.

Source: CARDA/CCAFS, 'Strategies for Combating Climate Change in Drylands Agriculture: Synthesis of dialogues and evidence'. Devendra, C., (2012); 'Climate Change Threats and Effects: Challenges for Agriculture and Food Security', Academy of Sciences, Malaysia; and IPCC.

decline significantly. With climate change, new combinations of pests and diseases will emerge; geographical spread and incidences of pest attacks will increase (CGIAR, year not known). The existing hybrid crop varieties may not be able to withstand local climate variations. The current pest management strategies may not be effective, leading to crop losses.

The experience of WOTR in its project villages indicates that climate variability is already hitting crop production, causing economic losses for the farmers[9] despite the tangible benefits of participatory watershed development.

In view of this, new strategies to support agriculture in general and the small-holder producers in particular, are vital.

3. An approach towards making agriculture production systems climate resilient, within the Participatory Watershed Development context

Watershed development is crucial to build resilience in agriculture. Large parts of India's drylands regularly suffer from water scarcity in summer and droughts, exacerbated by the dropping water tables due to the reasons outlined above. The best way to illustrate the situation is to demonstrate by comparison: villages that did not implement watershed development and those that did. To address land degradation and water scarcity, watershed development has been implemented

[9] See films produced by WOTR, available at http://youtu.be/oix3rXQyHO4, http://youtu.be/ZnoRdrXMhJM, http://youtu.be/75z6UlDK9Oc.

Climate variability experienced in WOTR project locations

In Maharashtra's Akole block of Ahmednagar district, the people of Khadki-Khurd, Khadki-Budruk, Pimpri, Purushwadi, Satewadi, Umarewadi, Palsunde, and dozens of nearby villages woke up on 9 February 2012 to see small ice crystals gripping the tender leaves of their crops. Some farmers said that the whole area was covered with what looked like ash.

February is the fag-end of winter in Maharashtra. A cold wave at the height of winter, i.e. from late December to mid January is actually beneficial for the *rabi* crop. But such extreme cold in February, after the summer crop has been planted, was an aberration the young seedlings could not bear. The leaves of the summer millet, maize, beans, and groundnut were destroyed. Approximately 25 percent crop loss due to the frost was reported by the farmers.

In Amangal block of Mahabubnagar district, Andhra Pradesh, drought was declared in 2011 and 2012. The major impact of the drought was on dual-purpose crops such as maize (food for humans and fodder for livestock). Farmers shared that they could not harvest even half-grown crops for fodder, as the investment in labour was far too high. Thus, crop loss was total.

In Mandla district of Madhya Pradesh, in January 2011, there was frost for three or four days continuously, which resulted in heavy loss of the *rabi* crops. About 60 percent of chickpea and pigeon pea, and 15 percent of wheat, was lost, which obliged the government to provide compensation packages to the affected farmers.

On 4 December 2010, the weather station in Darewadi village (in a semi-arid region of Maharashtra) recorded 272 mm of rain. That year farmers re-sowed the *rabi* crop between late December and early January. Poor quality wheat was harvested in mid-April under temperature conditions of 42°C.

extensively across the country, particularly in semi-arid regions. When area and drainage line treatment is systematically constructed with the participation of the local community, the impacts show tangible benefits in increased water availability and agriculture productivity. The summer of 2013 witnessed a severe drought, of a degree not experienced in many years. In Maharashtra 15 districts were declared drought-hit, the worst being in Marathwada and the rain-shadow area of Western Maharashtra. However, within these regions, villages where integrated watershed development had been implemented were more resilient as compared to neighbouring villages where no similar programme had been done. Field data collected during the drought period highlighted this.[10] Kachner village in Aurangabad district (Marathwada region) had sufficient water for people, agriculture, and livestock. They even supplied drinking water to three neighbouring villages, while Adul and Jodwadi, just a few

[10] *Drought – The Litmus Test for Watershed Development* (WOTR 2013 – under print).

kilometres away, faced a water crisis. Gyansingh Nemane of Adul village, lost 500 trees of sweet lime and an investment of about Rs. 75,000. People attributed the water availability at Kachner to the watershed work carried out in their village. The ex-sarpanch of Kachner said, *'It is simple really – we followed a ridge-to-valley approach and built various structures that slowed and stopped the water. This recharged our groundwater.'*

Kasarwadi village in Jalna district, Maharashtra, where watershed development was implemented, is a similar case. Neighbouring Bantaakli was reeling under severe drought and had to depend on two water tankers each day to meet basic needs. People sent their livestock to fodder camps. Kasarwadi however, had sufficient water for both agriculture and livestock. Some farmers started drip irrigation for horticulture, reducing the water requirement by nearly half, thus ensuring water availability even during the drought. One farmer reported having surplus water which he provided to several families from neighbouring villages.

In Kumbharwadi village of Ahmednagar district, the drought of 2012–13 provoked an interesting response from farmers – crop diversification. Sixty-four percent of the households had diversified crops much more as compared to the previous year. They grew 24 crop varieties (small quantities on a reduced area) as compared to the 15 crops grown in 2011, a year of normal rainfall. Farmers prioritised household food security and fodder needs rather than market demands. They said that *the benefits of watershed development – water availability and land productivity – gave them the confidence to make judicious decisions and take calculated risks during adverse conditions*.

In all watershed project villages implemented by WOTR and in the Indo-German Watershed Development Programme (IGWDP), farmers were more resilient in the face of drought. Distress migration for wage labour, that took place after Diwali each year, has greatly reduced, as farmers have sufficient water to cultivate *rabi* and even summer crops.[11]

Experiences and findings that emerge from the semi-arid regions (both rain-fed and irrigated areas) detailed in section 2 above, bring up important concerns for agriculture as a whole and for the farming community, particularly small-holder producers.

It is in this light that WOTR has reoriented and reorganised its approach so as to build the adaptive capacities of rural communities and increase their resilience to climate-related shocks. For WOTR, climate-resilient agriculture is not necessarily about adopting/inventing new methodologies/products, but about appropriate strategies/approaches that consider extreme weather variations. With climate change, we are in a domain of complexity that is not very amenable to analysis. While the relationship between cause and effect exists, it can only be perceived in retrospect, not anticipated. As conditions change rapidly, analysis just cannot keep up at the same pace; hence, best/good practices cannot be replicated everywhere. The only possible approach would be to *probe, sense, and respond*. From an implementation

[11] Project Completion Reports of WOTR and the IGWDP (source: WOTR, NABARD).

technologies. The process is iterative. Successful experiments get further amplified, while the not-so-successful ones provide lessons for the future.

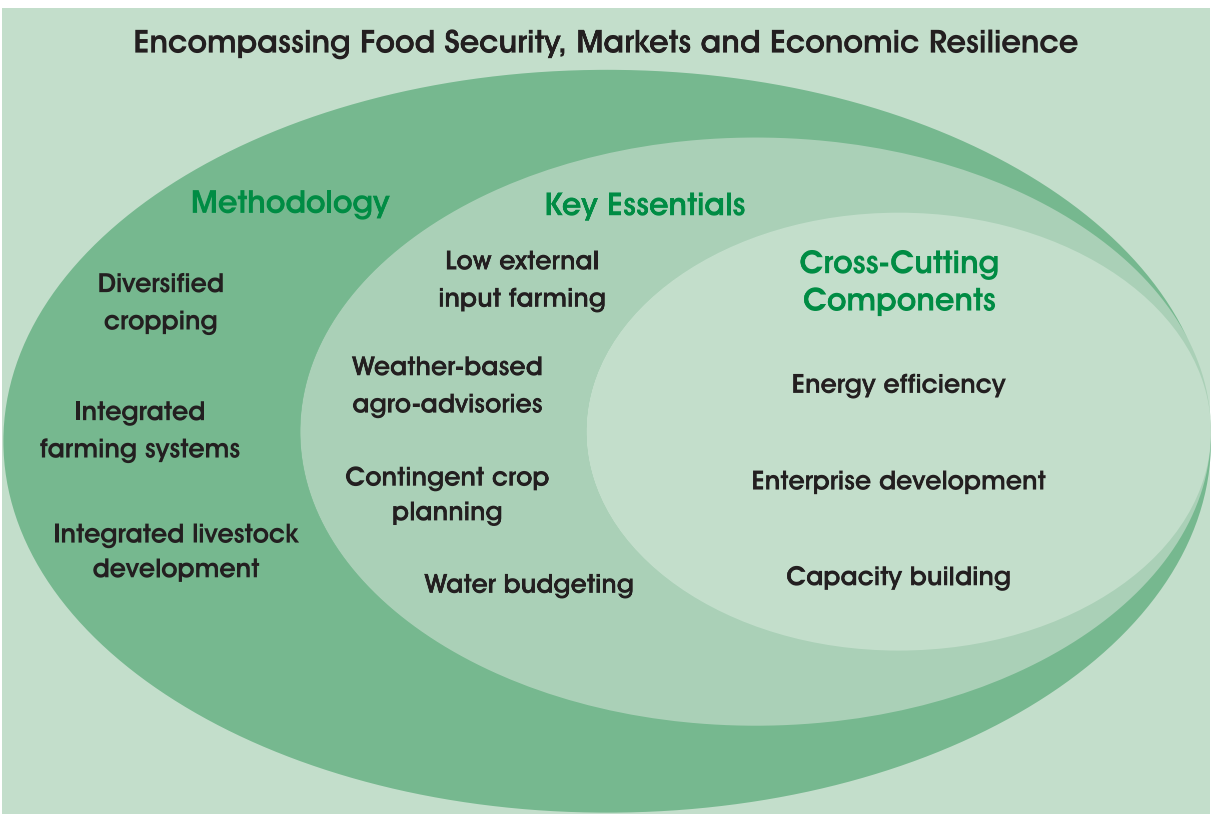
perspective, it means testing through many small experiments, using varied alternate agricultural

This section explains WOTR's current approach and the various components aimed at making agriculture production more climate resilient, within a participatory watershed development context.

3.1 Building response capacity, particularly of small-holder producers: An integrated approach

A comprehensive model which addresses food security, markets, and ecosystem resilience (Figure 1) is advocated. The model focusses on promoting diversified cropping and farming systems and possibilities of income from more than one source, so as to reduce the risk of crop loss from both market and climate variations, while providing dietary diversity and food and nutrition security to the extent possible.

Figure 1: Climate-Resilient Agriculture: An Approach



Key essentials include enhancement of soil health, low external inputs (favouring organic and minimising chemical agriculture and integrated nutrient and pest management), use of indigenous and composite seed varieties, localised agro-meteorological advisories with contingent crop plans, and agriculture-allied enterprises.

Moving towards climate-resilient agriculture in a watershed development framework requires water- and energy-efficient systems and integrated, mixed, tree-based farming and livestock development. These hold the key to enhancing the capability of the farming community to adjust and adapt. It ensures dietary diversity and food security. The promotion of alternate non-farm livelihoods for small-holder producers reduces the burden on agriculture and the natural resource base of being the only sources of income.

a) **Linkages and Partnerships:** Collaboration with experts is essential to address the complex issue of building resilience to climate change. Partnerships with local, national, and international institutes such as the state agriculture universities, the Indian Meteorological Institute (IMD), Central Research Institute for Dryland Agriculture (CRIDA), International Centre for Research on Agriculture and Forestry (ICRAF), and others bring in a wide relevant range of expertise essential for building the resilience of farmers towards sustainable agriculture. With the support of these mandated institutes, locale-specific weather-based crop-specific advisories and block-specific contingent crop plans that consider likely extreme meteorological events are disseminated to farmers. An IT-assisted platform for content management, AGRIMATE, is being developed by WOTR and populated with knowledge packages which would be available to farmers on demand.

   Linkages are made with government programmes, e.g. Integrated Watershed Management Programme (IWMP), National Rural Employment Guarantee Scheme (MGNREGS) and NABARD. In addition, public-private-civil-society partnership (PPCP) projects are taken up with the corporate sector and various donors that bring in financial resources. For on-site guidance, the Farmer Field Schools provide opportunities for linkage with the block agriculture unit and experts. This helps communities avail of the various government programmes and other support towards sustainable agriculture.

b) **Farmer Field Schools:** This outreach strategy (Figure 2) fills the gap of inadequate extension services, currently experienced by small-holder producers. It provides **on-site guidance** and **participatory documentation**, engaging farmers in discussions and studies of their own and neighbours' plots, applying indigenous knowledge and scientific data. Women farmers are given special attention for they play a major role in agricultural operations. This 'action research' includes documentation in the People's Biodiversity Register (PBR) of traditional farm management practices, skills, and knowledge along with heirloom seeds varieties. Lessons from the field contribute to experiential learning for practitioners and decision-makers.

3.1.1 Package of agriculture-related services that build response capacity of farmers

As small-holder producers are vulnerable in the face of climate variations, work with such farmers has helped establish a series of interventions, which when implemented as a 'package of practices', help enhance their response capacity in managing the vagaries of the weather.

- **Weather-based locale-specific agro-advisories:** With the support of data from Automated Weather Stations (AWS) located in villages,[12] three days' weather forecasts provided by the Indian Meteorological Department help generate *locale- and crop-specific agro-advisories* that are sent through SMS to farmers[13] every three days. The pilot SMS service has been launched with six crops – sorghum, gram, onion, rice, wheat, and groundnut, and feedback loops have been set up. A weekly *'Krishi Salla'* (agri-guidance) wall newspaper (for the main crops grown) is also displayed in villages. This helps farmers to respond appropriately to local climatic variations. Crop calendars have been prepared for different crop varieties and crop growth stages for various meteorological conditions and soil types. The crop calendar helps prepare real-time, crop-specific agriculture advisories based on local weather conditions and in accordance with crop growth stage. Crop mapping helps in monitoring yearly seasonal changes in the cropping pattern at plot level.[14]

- **Contingent Crop Planning:** Monsoons are critical for India's dry land agriculture. The

Farmers' Experiences with Agro-Advisories

Manjula Lohate cultivates her three acres of land single-handedly. She grows pearl millet, gram, wheat, onions, and tomatoes. On 30 *guntas* she grows pomegranate, using drip irrigation. She has constructed a small farm-pond of 10x10 m^2 which serves to irrigate the pomegranate plot. She found the *Krishi Salla* (the weekly wall newspaper) very useful. Based on the advisory given, she applied mulch on her pomegranate plot. This reduced the evaporation rate considerably and lowered the water requirement by 50 percent. 'Earlier I used the drip for two hours every day. Now I use it only for one hour,' she says. She also began to use *amritpani* – an organic fertiliser/pesticide preparation using cattle manure and leaves which has greatly reduced the incidence of pests and diseases: 'I have completely stopped using chemical sprays.' She is the first farmer in her village, Bhojdari, to see the merits of composting and has prepared four tons of compost for the next season.

In the kharif season of 2013, in Bhojdari village, Sangamner block, Ahmednagar district, about 35 percent of the farmers followed the ago-advisory provided by WOTR and sowed pearl millet in the first week of June, earlier than usual. These farmers harvested their crops in the first week of September. However, the remaining 65 percent of farmers followed their regular plan and sowed the crop late in the fourth week of June. The heavy rains of the second week of September caused an infestation of pests and diseases to the crop, which was in the grain-filling stage, leading to heavy losses.

[12] There are 51 AWS located in Maharashtra, Madhya Pradesh, and Andhra Pradesh.
[13] The SMS service was availed of by 1,500 farmers during the *kharif* and *rabi* seasons in Sangamner and Akole blocks, Ahmednagar.
[14] GPS documentation of 25 crops on 1552 ha in eight villages by WOTR.

In Sangamner in 2012, after an early start, the monsoon had a gap of about six weeks. Based on the contingent plan developed, farmers were advised to cultivate pearl millet instead of the usual tomato and onion. As a result, farmers harvested the assured bajra, which contributed to their subsistence.

amount of precipitation received during the main cropping season influences the annual crop production plan of the area. This in turn affects farmers' incomes, triggers ground water utilisation and ultimately impacts the national economy. Climate variability in terms of the frequency and quantum of rainfall and temperature regimes varies across the country, as also within the same agro-ecological zone. Hence, having a contingent crop plan well in advance for the main cropping season helps prepare farmers for weather aberrations during the particular year. WOTR has prepared a Contingent Crop Plan for the Sangamner block in collaboration with the Central Research Institute for Dryland Agriculture (CRIDA).

- **Promotion of low external input technology:** Between now and 2050, the world's population is projected to increase by one-third with the major growth being in cities and in developing countries. For such growth in income and consumption, FAO estimates that agricultural production will have to increase by 60 percent to meet these demands. The current agriculture production system would need a major overhaul encompassing enhanced food security, mitigating climate change, and preserving the natural resource base (FAO, 2013).

  Besides the extensive application of organic compost (*amrutkhad, vermicompost, amrutpani*) and integrated nutrient and integrated pest management, WOTR promotes a System of Crop Intensification (SCI). This low-input crop production methodology enhances productivity and uses inputs more efficiently, while maintaining the resource base. It appears to withstand some shocks due to climate variability. Derived from the now successful System of Rice Intensification (SRI), SCI has been modified and adapted to various crops. It is a four-pronged approach that is implemented systematically, more so in the case of poor soils. It involves soil preparation and management, crop spacing, systematic application of locally available organic inputs supported with micro-nutrient foliar spray and basal applications to support the plants' enhanced growth. Field trials[15] were conducted across WOTR project locations for various crops, namely maize, groundnut, sunflower, turmeric, wheat and

[15] http://wotr.org/wp-content/uploads/2013/08/SCI-System-of-Crop-Intensification-Booklet.pdf.

a variety of vegetables. Almost all field trials have shown significant impacts in increased agricultural productivity ranging from 30–80 percent, while reducing the cost of production by 40–50 percent.

Through **crop demonstrations with regular on-site technical handholding**, farmers were encouraged to have small demonstration plots beside their regular fields. In this manner, the difference in the crops between the two methods was immediately visible.

- **Water Budgeting:** As water is basic to living, it is essential to ensure its optimum and efficient use. This is particularly important in semi-arid regions following participatory watershed development. It requires local data of the water available, to plan its use to meet the community's various needs – domestic, livestock, agriculture, and livelihoods. Water is a sensitive resource in that people who own its sources need to use it judiciously, while ensuring that the needs of the community are met. There is better acceptance of water budgeting when it is participatory, with data displayed, accompanied by appropriate crop planning and micro-irrigation with agricultural guidance. Adaptive capacities are built to face summer months and years of drought. School children are engaged in data collection and water-use planning (budgeting) as a school activity, thus reaching its application to homes, while preparing the next generation for water management.[16] It thus ensures water availability for future generations.

[16] WOTR is implementing an action research on promoting equitable and sustainable groundwater use in rural communities in two villages of Aurangabad and Ahmednagar district. As a part of this project, water budgeting is being promoted by two schools of these villages. The objective is to make them aware of the need for water management, build and strengthen their confidence and leadership qualities, and effectively utilise children's ability and enthusiasm to sensitise the community about these issues.

- **Diversification for livelihood security:** When dependence of farmers for their sustenance is solely on agriculture, they will use any and all means to earn for their survival, even if it means extracting every drop of water, or increasing the application of chemicals, cultivating cash-pulling mono-crops, and taking huge loans for agriculture. Therefore, diversification of crops,[17] agri-allied activities, and alternate livelihoods are imperative for increasing resilience, ensuring economic security, and protecting the natural resource base. It thus reduces the burden of productivity from agriculture, particularly in a climate change context.

  With this in view, WOTR has been promoting dryland horticulture, sale of surplus organic manure through traditional livestock keepers and SHGs, bee-keeping for enhancing agriculture and honey production, and development of various agriculture-related enterprises, besides non-farm interventions. The latter reduces the dependence on climate-affected activities. Livelihood promotion is enhanced through value addition, food processing, and marketing, making agriculture more lucrative. Value addition and food processing will reduce wastage, while providing additional income to farmers and village level organisations.

- **Conservation and promotion of indigenous varieties:** Village elders have often shared that indigenous crop varieties have beneficial properties and are useful in times of drought. Indigenous rice varieties such as *raibhog, khadkya*, and *ambemohor* in Maharashtra are considered to have medicinal values. The *khadkya* rice is drought-resistant, and grows when merely scattered in the fields in times of low rainfall. Little millet (*sava*) is a sturdy crop that can survive in low rainfall. Finger millet (*nachni*) is grown on the slopes, with barely any care. It is the general opinion among village elders that crop yields of the indigenous varieties used in the past produced low quantities, but the ability to satisfy hunger, the taste, and the quality of grains was good. They comment that though crop yields with hybrid varieties have increased substantially, they lack quality, particularly in taste and the energy derived from it.[18] They feel that chemical fertilisers affect the growth and health of people. The elders quote a local proverb in this regard,'खतानउकलेलआणगिरिणीतबुजेल' (literally translated,'grown with chemicals and ground in a flour mill') implying that the grains now consumed have lost their nourishment and energy-providing properties. The findings have spurred WOTR to document this knowledge and promote production of indigenous crop varieties, before we lose our heritage. However, research to assess the drought-resilient characteristics of indigenous varieties is necessary.[19]

3.2 Other important issues related to sustainable agriculture

- **Crop insurance:** There are many experiments in progress, besides those promoted by the government. The fundamental premise of adaptation is risk reduction. Adaptation for climate-sensitive agriculture requires continuous effort to prevent damage/loss at every stage. When left on their own, farmers attempt to get whatever crop production is possible, the operative assumption being, 'getting partial benefits from investments made, is better

[17] Refer to study done by WOTR available at http://weadapt.org/knowledge-base/vulnerability/agriculture-in-a-rain-scarcity-zone-in-a-drought-year
[18] Refer to: http://wotr.org/wp-content/uploads/2013/05/14.Gender-Dimension-of-Climate-Change-Adaptation.pdf.
[19] WOTR's position paper on biodiversity available at http://wotr.org/wp-content/uploads/2012/10/Biodiversity-Position-Paper.pdf.

than complete loss'. However, it appears that the current paradigm of insurance rewards failure and punishes partial success. Therefore the **design of insurance products should be such that they contribute to adaptation**. They should necessarily incentivise success, risk reduction (payment of premium is not the same as overall risk reduction), adaptive behaviour and application of methods geared towards sustainability, and reward ecosystem-based (low-input low-risk) agriculture.

In other words, risk reduction should be rewarded upfront. Responsible behaviour for continuous and sustained risk reduction measures and the efforts of individual households and communities should be rewarded. Any residual risk should be covered in a manner that creates no moral hazard, but builds the adaptive capacities of the individual and the community.

- *Population, markets, food consumption, and wastage*: There is sufficient evidence to conclude that declining yields and fluctuations in food production will increase food prices. A report by the International Food Policy Research Institute (IFPRI) (Gerald et al., 2009) predicts substantial rise in food prices in a climate change scenario. The same report states that the consumption of cereals will fall, resulting in reduced calorie intake and increase in child malnutrition. With India's current population of 1.21 billion projected to rise to 1.53 billion by 2030 (Mamanshetty, 2012), there is much that India needs to do to meet the food and nutrition security needs. This is particularly important as India is a climate change hotspot.

As large proportions of India's population become affluent, there will be major changes in food habits. In the food chain from farm to plate, there is a need to reduce wastage of agricultural produce, particularly post-harvest losses. A study by ASSOCHAM (ASSOCHAM, 2013) states that about 30 percent of perishable foods produced in the country are rendered

unfit for consumption due to spoilage after harvesting. The report states that in India the maximum amount of post-harvest losses are in West Bengal (ranking first with annual losses worth Rs 13,657 crore), followed by Gujarat (losses of about Rs 11,398 crore), while Maharashtra ranks fifth with losses of Rs 10,100 crore.

The procurement of food grains (wheat and rice) by government has increased substantially from 36.2 MT in 2006–07 to 59.2 MT in 2010–11 (Planning Commission, 2011). However, quality storage space available in the country is insufficient to meet the stocks of grains procured. As a result, huge quantities of food grains are stored in 'cover and plinth storage' resulting in massive losses. The Eleventh Five Year Plan reported that lack of processing and storage facilities for fruits and vegetables result in huge wastages estimated at about 35 percent of the total production in the country. The working group report on warehousing development and regulation for the twelfth plan period (2012–17) (Planning Commission, 2011) indicates that about 65–70 percent of total food grains produced in the country are stored at farm level. It estimates that substantial quantities of food grains (6–10 percent of total production) are damaged due to moisture, insects, rodents, and fungi. As individual farmers (particularly the small-holder producers) have no proper storage facilities, they are forced to sell their perishable produce immediately, fearing losses. What has also been observed at the farm level is the huge amount of losses when the market prices fall. Farmers then find it makes better sense economically to leave the produce by the wayside, rather than accept the low prices the market offers.

When food losses are reduced from production and along the distribution chain, it will greatly contribute to conservation of precious resources (water, energy, soil health, etc.) and will simultaneously decrease the carbon footprint of agriculture.

4. The Way Forward

India being a hotspot for climate change and having 15 broad agro-climatic zones and 127 sub-zones, the presentation of climate change and its effects will vary from region to region. Hence a 'one size fits all' approach will be detrimental to the agriculture and food security of the country. Given the multiplicity and inter-connectedness of possible solutions, these will necessarily have to be selected and tailored to fit the geographic and socio-economic characteristics and needs of the local community. Solutions should address the twin challenges: adaptation to climate variations and sustainability of the resource base with increase in productivity, to meet future food security demands.

Climate-Smart Adaptive Sustainable Agriculture is the way forward:

1. **Stabilisation and management of the natural resource base** (land, water, and biodiversity) is important for all, particularly the semi-arid and rain-fed, regions. An ecosystems-based approach to **Participatory Watershed Management** as a central point of activity is essential for building the adaptive capacities to climate change.

2. **Assessing Vulnerability** of a cluster of villages/sub-region to climate change is essential for developing a road map for building locale-specific resilience of the people and their land to varying weather extremes.

3. It is imperative that we integrate a package of **climate-smart agriculture**

practices into ongoing programmes which includes **weather-based locale-specific agro-advisories, contingent crop planning, promotion of low-external-input technology, water budgeting, livelihood diversification, and promotion of local agro-biodiversity**. These, together, would build the resilience of the farming community, while simultaneously **improving the quality of the resource base** (details in Section 3.1.1 above).

4. **Reduction of wastage of agriculture produce** from farm to plate, especially during the **post-harvest** phase, will greatly contribute to conservation of precious resources (water, energy, soil health, etc.), while decreasing the carbon footprint of agriculture. Decentralised good quality **storage facilities** would greatly reduce losses. Simultaneously, the promotion of village/household level storage facilities and **value-addition** would protect the income of small-holder producers.

5. **Capacity Building** of the farming community right through, is essential at all stages and for all aspects. This is essential for sustainability of agriculture.

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About WOTR

Aware of the fragility of ecosystems and our symbiotic link with it, WOTR has since 1993 applied a systems-based approach to watershed development, focusing on people-centric participatory interventions. With more-than-normal weather variations now being experienced, WOTR has moved into an Ecosystem-Based Adaptation (EBA) approach that helps vulnerable communities build resilience of their degraded ecosystems and livelihoods threatened by climate change impacts. This approach generates significant benefits, social, economic and cultural.

WOTR is now oriented and equipped to specifically address the challenges (and opportunities) posed by climate change to vulnerable communities. In the process, WOTR has introduced a bottom-up, holistic and integrated approach towards Adaptation and Resilience Building.

Constantly learning from experience, WOTR has been revisiting conventional development. Systems Thinking and Complexity Analysis have been incorporated in program design leading to formulation of new tools and frameworks while adapting the existing ones. This helps us shift to a Framework-Based Management, in contrast to activity focused project.

At WOTR, Applied Research is a constant companion. Our team, guided by experts, helps local communities become researchers - observing, measuring, and assessing for themselves problems as also improvements that a project brings about. Having tested methodologies, WOTR disseminates the learning through Capacity Building Events to implementers and donors, far and wide, so as to benefit rural communities across India and to countries in the South.

WOTR has carried out developmental work in over 2,500 villages in six states. Its program on Climate Change Adaptation project is currently being implemented in over 70 villages in Maharashtra, Madhya Pradesh and Andhra Pradesh.

For more information visit us at www.wotr.org

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