



# Extreme Risks, Vulnerabilities and Community- Based Adaptation in India (EVA)

A PILOT STUDY

**Final Report on WP2.3  
Mapping of drought vulnerability and risk**

Line Barkved (NIVA), Karianne de Bruin (CICERO),  
Bård Romstad (CICERO)

Research partners



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**Authors:** Line Barkved (NIVA), Karianne de Bruin (CICERO), Bård Romstad (CICERO)

**Contributors:** TERI, AFPRO, NIBR

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**Photo credits (cover):** Line Barkved

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**EVA team members:**

AFPRO: D. K. Manavalan, S. G. Salunke, Nikhil Kusmode, Sham Deshpande, Sandeep Gade, B. T. Sangle, Mangesh Bopache, Vinod Doke, Yugandhar Mandavkar (GRASP)

CICERO: Karianne de Bruin, Armando Lamadrid, Bard Romstad

NIBR: Trond Vedeld, Guro Aandahl

NIVA: Line Barkved, Isabel Seifert-Dähnn

TERI: Suruchi Bhadwal, Saurabh Bhardwaj, Vrishali Chaudhuri, Prodipto Ghosh, Sambita Ghosh, P. K. Joshi, Ulka Kelkar, Prutha Lanjekar, Richa Mahtta, Arabinda Mishra, Divya Mohan, Anjali Parasnis, Veerabaswant Reddy, Shivani Wadehra

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## Abstract

Climate change will increase the vulnerability of societies around the world. Changes in the frequency and magnitude of extreme events, such as droughts and floods require measures to reduce the vulnerability of communities particularly in developing countries.

The report is part of the deliverables from a two-year Indo-Norwegian research and capacity development project, 'Extreme Risks, Vulnerabilities and Community-Based Adaptation in India (EVA): a pilot study' (2012–2014). The drylands of Maharashtra, the region of study, offers an interesting context for studying how drought-prone ecosystems and rural communities in India are able to withstand and respond to extreme drought risks and adapt towards future climate change.

In this report we describe the process of participatory mapping of drought and use of Normalized Difference Vegetation Index (NDVI) for study of drought impacts and vulnerabilities. The report is to be seen as a technical report, complementing the other reports of the project, summing up the main steps and reflections in the application and testing of the approach. It may be of relevance for development practitioners, researchers and policy makers interested in approaches on how to engage local communities in climate change adaptation and rural development challenges in Maharashtra and/or in general.

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# 1 Introduction

In this report we present and discuss the outcomes of Work Package 2, task 2.3 on drought maps under the project ‘Extreme Risks, Vulnerabilities and Community-Based Adaptation in India (EVA): a pilot’. The EVA-project a two-year pilot project (2012–2014) under an Indo-Norwegian collaborative programme funded by the Norwegian Embassy, New Delhi. The overall project has assessed the impacts of and responses to extreme events on agriculture and water resources in nine villages in the drought-prone drylands of Jalna District, Maharashtra, India.

Drought is a complex phenomenon to manage and predict, and this is a point of departure for the EVA study. On the overall level the EVA project aims to understand the enabling and constraining conditions for Community Based Adaptation (CBA) to climate change and extreme events; and to develop pilot approaches to research on and capacity-building for CBA (Aandahl et al. 2014). The project is based on a mixed-method approach, combining analysis of climate risks with participatory assessments of human and natural vulnerability and has involved extensive fieldwork at village and district levels, semi-structured interviews, household surveys, policy and institutional analysis and participatory workshops.

In this report we describe the work done on drought mapping—experienced impacts and vulnerabilities through participatory mapping and mapping of NDVI-index by use of satellite imagery. We explore the potential for participatory mapping of drought and drought mapping combined with secondary data in a climate change adaptation context.

## *1.1 The objective of the report*

The purpose of this report is to describe and document the drought mapping as a project deliverable output 2.3. This report is to be considered as a technical report, complementing the other EVA reports. The report is based on scientific presentations made during the project period. Specifically it describes:

- Key aspects of drought and mapping of drought
- What is participatory mapping of drought? Why is this needed? And how did we conduct the participatory mapping process?
- Drought indexes: focusing on use of NDVI-index as part of understanding drought
- What did the maps help us understand in terms of different vulnerability to drought?
- How can mapping be helpful for the local communities in climate change adaptation?
- What were some of the methodological challenges?
- What are suggestions for the future?

## 1.2 The EVA-project and study area

The Jalna District is located in the central part of the state of Maharashtra (see Figure 1) in what is known as the Marathwada region, a semi-arid part of the Deccan Plateau. The district has provided an opportunity to explore the impacts of climate change and extreme weather on water and agricultural resources and the responses at community and district levels. Fieldwork was carried out in nine villages in three blocks in Jalna District, which was severely affected by the 2012–13 drought.

The EVA case villages were chosen as highly exposed and vulnerable communities to drought and water scarcity given their location in the monsoon shadow belt and drylands of Marathwada. Nine villages were surveyed altogether in the blocks of Badnapur, Bhokardan and Jafrabad (see Figure 1). The villages included in the study are Asarkheda, Niwdunga, Dongaon, Kadegaon, Malegaon, Warudi, Palaskheda Pimple, Pimpalgaon Thote and Pimpalgaon Barav. The case villages illustrate different kinds of impacts of drought depending on a set of local circumstances - farming system, access to water resources and land, eco-landscape, market admission, local leadership, right to external institutions and the type of interactional relationship the local people have with external actors and the different kinds of responses that such relations evoke. Since this was a two-year pilot project, participatory mapping activities were fully only carried out in some of the villages, mainly in the Badnapur and Jafrabad blocks, including the villages of Kadegaon, Malegaon, Warudi and Asarkheda (located in Badnapur) and Niwdunga, Dongaon (located in Bhokardan).

Agriculture is the primary source of livelihood for a majority of the rural communities. Cotton is the main cash crop, while pulses, pearl millet (*bajra*), sorghum (*jowar*), maize and wheat are important grain crops (as shown in the EVA WP 2.1 report). Most crops are under dryland farming in the area, but a majority of the farmers have and use open dug wells for irrigation (during the winter season). Average annual rainfall is about 725 mm, of which more than 90% falls during the southwest monsoon season from June to September. This means that there is a seasonal deficit of precipitation during the remainder of the year; so double cropping is contingent on irrigation.

Observations from the field indicate that the vast majority of irrigation is from shallow open dug-wells. Also some of the larger farmers (according to landholding size) have invested in drip irrigation and/or sprinkler irrigation. In 2012, low precipitation rates created widespread agricultural and domestic water scarcity in the district. Although 2012 was the most extreme drought to hit the region since 1972, drought is nonetheless a normal phenomenon in the Marathwada, where a dearth of rainfall is expected to occur approximately once every 6 to 10 years.



Figure 1. Study area in Jalna District, Maharashtra state

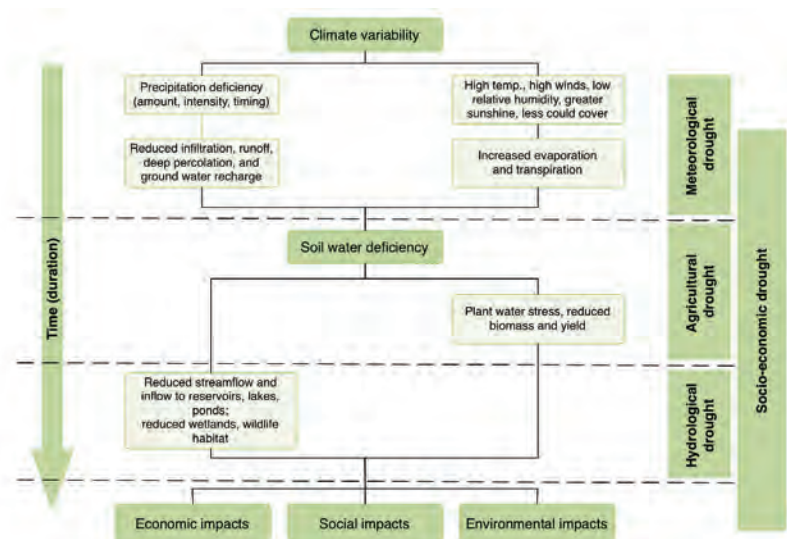
## 2 Drought and mapping of drought

The occurrence and impacts of droughts are expected to increase in the future as climate change may alter the frequency, intensity and magnitude of droughts (IPCC 2012: 13) in addition to other pressures such as population growth and urbanization. Especially ‘arid or semi-arid regions will be most impacted as the availability of water is already low under normal conditions, the demand often is close to or even exceeds the natural availability and societies adaptive capacity to cope with droughts is low’ (Dai 2011 in Van Loon 2013: 4). Hence, managing future drought impacts through increasing the adaptive capacity of local communities will be important.

Drought is most commonly associated with lack of rainfall, and is generally defined as a temporary meteorological event, which comes from a deficiency of precipitation over an extended period of time compared to some long-term average conditions. Furthermore, drought is a natural event and a normal part of the natural system and climate of all regions, regardless of how arid or humid they are (Eriyagama et al. 2009). Yet, no common definition of drought exists.

There are several types of drought associated with different spatial and temporal processes. Compared to, for example, floods, drought develops slowly and is difficult to detect and have many facets in any single region. Droughts are generally defined in terms of meteorological, agricultural, hydrological and socio-economic drought (Mishra and Singh 2010). Thus, there are complex spatial, temporal and social dimensions to drought, which complicate the responses to drought.

On a general level, drought always starts with a shortage of precipitation, compared to normal or average amounts, but it may or may not, depending on how long and severe it affects streams, soil moisture, groundwater, etc. The magnitude of these impacts is determined by the level of development, population density and structure, demands on water and other resources. This is represented in Figure 2.



**Figure 2. Different types of drought.**

*Source:* National Drought Mitigation Center, University of Nebraska-Lincoln, USA)

For reasons of analysis drought is from a natural systems perspective commonly defined as having three critical but inter-related components (as taken from the US National Drought Mitigation Center’s definition<sup>1</sup>), namely:

<sup>1</sup><http://drought.unl.edu/DroughtBasics/TypesofDrought.aspx>



- **Meteorological drought** which is defined mainly by deficiencies in precipitation. Along with deficient rainfall, conditions during drought may be accompanied or intensified by high temperatures, strong winds, low relative humidity, stronger sunshine and less clouds.
- **Agricultural drought** occurs when plant water demands cannot be met due to soil water deficiency resulting from dryness brought on by meteorological (or hydrological drought). In such cases plant water stress may be evidenced from reduced biomass and plant yield, as plants are highly dependent on stored soil water.
- **Hydrological drought** can be considered a third stage in the evolution of drought conditions evidenced by significant reduction in surface reservoirs, drying of dams and wetlands. In this phase of drought, livestock may be severely impacted and other sectors begin to feel the devastation.

Furthermore, there is a fourth type defined as socio-economic drought which associate the supply and demand of some economic good with features of meteorological, hydrological and agricultural drought. Furthermore, it looks into how some sectors and/or groups are impacted more or less than others. It is different from the other mentioned types of drought because its occurrence highly depends on the time and space processes of supply and demand to identify or classify drought. The EVA WP3.2 report looks especially into issues of social vulnerability.

Vulnerability to drought may be defined as economic, social and environmental characteristics and practices of the communities that make it susceptible to the effects of a drought. Vulnerability is reduced by the ability to effectively plan for, anticipate, cope with, and recover from droughts (IPPC 2012). Drought risk can be understood as the potential adverse effects of droughts viewed in relation to their frequency and severity combined with the vulnerability of population determining the risk to such events. Drought risk for the purposes of this analysis is considered as having two contributing factors, namely: 1) recurring environmental or meteorological events or natural physical characteristics beyond the control of man 2) human practices (policy or land use) that make the population vulnerable to natural events and characteristics. In this study, we focus mainly on vulnerability, which again has implications for risk.

In EVA we approached drought widely by considering several definitions and leaving it open for the local villagers to also describe what they perceive as drought. Based on this, we approached drought as to how it was experienced by the local system in terms of impacts on agriculture, vegetation, soil and water resources. Thus, we focus largely on *experienced drought*. Here, reference is made to the meteorological, hydrological or agricultural drought as appropriate. We have addressed the drought mostly from the local levels perspective in this study. A scientific definition of drought may not (always) match public recollection and perception of drought.

## ***2.1 Indicators of drought***

Currently, there are several biophysical variables used to quantify drought (Bhuiyan et al. 2006). However, several of these conceptualizations bypass social, economic, cultural and political influences on the lives of local community members and how they perceive the state of their physical environment (Agrawal 1995). Hence, using only these variables may not be sufficient or particularly useful when it comes to explaining local people's knowledge and perception of drought (Crease 1997 in Slegers 2008). In this report we describe the process of participatory mapping of drought and use of Normalized Difference Vegetation Index (NDVI).

## *2.2 Mapping of drought*

With the participatory drought mapping, we aimed to learn more about vulnerabilities and risks in particular at the local level and how this could then set the scene for adaptation and adaptation measures. Participatory mapping has a tradition for applications within resource mapping (e.g., Carter 1996; Mbile et al. 2003, Kalibo et al. 2007) and to some extent in mapping of floods (e.g., López-Marrero and Tschakert 2011; Senanayake et al. 2012). Less is found in literature on participatory mapping of drought.

In this project we conducted mapping both as a participatory process - the participatory mapping - and also a mapping based on secondary data and indicators, namely, the use of NDVI-index to tell us something about vulnerability to drought in the study area. More details on the two respective approaches are mentioned in subsequent chapters.

### 3 The participatory mapping of drought

It is anticipated that impacts of climate change will be most felt by marginalized and resource dependent communities through a multitude of impacts cascading through natural and social systems (Adger 2003). While top–down methods such as climate modelling give indications about how climate extremes will impact Earth’s future environment, bottom–up, participatory methods have the potential to enhance communities’ ability to understand, plan for and manage adaptation to these extremes (Moser and Ekstrom 2010).

Understanding vulnerabilities and risks are an important component of the adaptation process. Studies do, however also show that hazard impact assessments of vulnerability to climate change inherently fail to provide the context-specific understanding required for informed development of adaptation policies and actions (Park et al. 2012). It is both necessary and potentially difficult to gain consensus amongst parties attempting to define and measure vulnerability (ibid.). Hence, vulnerability assessments play an important role, but there is a need to move beyond ‘mere’ vulnerability assessments and build participatory processes that helps local communities adapt. A central part of CBA is based on the well-established principle of utilizing local participatory processes to ensure that chosen projects meet a local priority need (Magee 2012).

Participatory mapping on a general level is a term used to define a set of approaches and techniques that combines the tools of modern cartography with participatory methods to represent the spatial knowledge of local communities. Participatory mapping is particularly useful in eliciting local perceptions, experiences and knowledge within a spatial context (Chambers 1997). Significant principles of participatory methods in general entail the behaviour and attitudes of outsider facilitators, including not rushing, “handing over the pen”, and being self-critically aware (Chambers 1994).

Participatory maps are produced for a particular purpose, which includes management of natural resources, assessing territorial rights, mapping vulnerabilities, etc., and are intended to be used by those who made them (Million 2012). The maps made by the communities can be combined with other data sources, such as geographical and remote sensing data, to support the participatory adaptation planning processes. Corbett et al. (2006: 14) lists a number of participatory mapping methods that are used in practice. These participatory mapping tools include: ephemeral or ground mapping, sketch mapping, transect mapping, scale mapping, participatory 3 dimensional modelling (P3DM), GPS mapping, photo-mapping (i.e., using aerial and remote sensing images), multimedia mapping, participatory GIS (PGIS), internet mapping.

#### **The participatory drought mapping process and results**

Best described for our case study is that we used case photo-mapping combined with GIS, taking steps towards participatory GIS (PGIS). Photo maps are printouts of geo-referenced satellite or aerial photographs and participatory photo-mapping is a process that can be used to generate a series of outputs to be transferred into a GIS, as part of a PGIS process. See the Annex for more details.

Field research was conducted in Jalna between September 2012–February 2014 and the first session of participatory resource mapping was held in eight communities in September 2012 in order to understand how the residents viewed the resource situation of their villages. This was only done in a selection of the villages (in the Badnapur and Jafrabad clusters mainly).



**Figure 3. First session of participatory mapping, Warudi village, September 2012 (photos: L. Barkved).**

The mapping exercises were conducted with local community members in groups of about 8–15 participants with facilitation. Large-scale (A0) printouts of high-resolution satellite images of the villages were used as base map. For each mapping sessions there was a facilitator, a note taker and addition observer(s), and each session lasted about 45 minutes–1 hour.

In September 2012, during the first mapping session the base maps were presented to the participants as a ‘blank’ map to facilitate discussion and mapping of specific features. The community members mapped out, by drawing on a translucent overlay paper, different relevant features in the communities, e.g., village boundary, water resources, wells, irrigated areas and marked also roughly areas that they perceived to be most vulnerable to drought. These maps were brought back with the research team and the results were digitized. This was again brought back for validation with the community to ensure an overall common understanding; the goal was not to get all details specifically right at fine scale. In February 2013 the second session of participatory mapping was conducted, focusing specifically on mapping of drought. The participants were asked to identify and draw zones where they experienced high, medium and low impacts of drought and areas that more or less frequently affected. Participants took turns drawing different elements of the map.

We observed that usually 2–3 persons would do most of the drawing on behalf of the group, but there were a discussion among the participants and all helped with locating and identifying important areas/zones or features. Since the mapping activity was meant to also encourage dialogue the role of the facilitators was to encourage the participants to talk about, e.g., why they identified areas in a specific way. Examples of issues that were discussed are: soil quality, location within the watershed, usages and locations of wells, irrigated land and implications for agriculture of water scarcity. The agricultural drought-prone communities in Jalna have a strong connection living with their land and water resources as it makes the livelihood basis for most of them. Hence, the participatory spatial mapping was found relevant as it related to the vulnerability, the various dimensions of drought and also the livelihood of the communities.

As part of the process, the data was later integrated in GIS for additional spatial analysis and to facilitate their representation and comparison. The participatory maps were, however, not meant to be highly geographically precise, but rather to reveal indications of patterns, interconnectedness and overlay of different issues. The participatory mapping helped us (the project team) to understand the local perspectives and for participants together to discuss challenges. In terms of photo mapping as a method we found that applying satellite imagery as a base map added a useful visual element that provided a form of familiarization and intuitiveness. The mapping process helped to engage the villagers in discussions on natural resource use, vulnerability to the spatial dimensions of drought, how the communities are connected to their lands and also planning and management. However, as EVA was a pilot study more follow-up would be needed for concrete implementable adaptation measures as a direct result.

## 4 NDVI-index mapping

In EVA we also approached the issue of drought mapping from a more secondary data and technical side, focusing on how vegetation is affected when a drought emerges.

Normalized Difference Vegetation Index (NDVI) is commonly used to determine the density of green on a patch of land, and for this satellite data is used. An NDVI-index value defines the health condition of the vegetation cover. An NDVI value, over time, can be averaged to establish the 'normal' growing conditions for the vegetation in a given region for a given time of the year. Therefore, a region's absorption and reflection of photosynthetically active radiation over a given period of time can be used to characterize the health of the vegetation there, relative to the norm (Bhuiyan et al. 2006).

In general terms, NDVI is calculated from the visible and near-infrared light reflected by vegetation with the following formula:  $NDVI = (NIR - VIS) / (NIR + VIS)$

For Landsat mosaic image (which we used), NDVI is calculated from visible red (TM Band 3) and near infrared (TM Band 4). Since healthy green vegetation has low reflectance in the visible red part (RED) of the electromagnetic spectrum but a very high reflectance in the near infrared (NIR) part, the following ratio yields an index (between -1 and 1) that indicates the amount (and health) of vegetation on the ground:  $NDVI = (NIR - RED) / (NIR + RED)$

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1). NDVI values close to zero or below means no vegetation. Values close to +1 indicates the highest possible density of healthy green vegetation. Commonly vegetation with index over 0.6 would be considered healthy. However, in dry land ecosystems this might be different and we did observe relatively healthy looking vegetation in the field even if the index were below this.

To make the NDVI maps we collected Landsat scenes covering our area from <http://glovis.usgs.gov>. It is only in the dry season we can get a long series of scenes taken at the approximately same time of the year. We were able to collect scenes and calculated NDVI from the last 11 years the following dates—02.01.2003, 22.12.2004, 25.12.2005, 28.12.2006, 31.12.2007, 02.01.2009, 05.01.2010, 23.12.2010, 26.12.2011, 28.12.2012. So we had an 11-year time series of winter images taken a year (+/-14) days a part (except for the 2003/4 winter season where no image was available within the timeframe). The maps are presented in the appendix.

By looking at the NDVI images it is clear that there are large variations in the NDVI values between the different years and we assume that this is related to drought. Yet, it is important to note that the NDVI does not give the reason for a low NDVI-index (reduced plant health/growth). It may be due to lack of precipitation, but changes in the type of crops farmed, and the time of harvest may also cause significant variations in the NDVI values. From the maps we do also see that there is seasonal variation and that this variation is different between dry and wet years. In the dry years, the NDVI decreases throughout the season while in the wet years it increases again in the Rabi season.

## 5 Summary and recommendations

As climate change poses new challenges in developing countries, small incremental adaptation steps may not be enough. Capacity building for adaptation is needed, entailing planning for deliberate adjustment and change in communities' activities and goals. Bottom-up, participatory methods have the potential to enhance communities' ability to understand, plan for and manage change for adaptation.

We have explored how using participatory mapping of drought may serve as a valuable tool to combine expert-driven and participatory approaches with the potential of enhancing capacity for climate change adaptation. Participatory mapping as such is nothing new, yet it has been less used in the context of drought than for example floods and general natural resources management.

As part of the mapping process, we applied satellite imagery to map vulnerability with communities and the process served as a method to facilitate a collective dialogue and learning about drought impacts and drivers of vulnerability. It helped bring in local knowledge about vulnerability and impacts, which is invisible to top-down assessments. As this has been a pilot study we can only conclude on preliminary findings, our case study on CBA to drought in Jalna rural India. We found that visualizing community members, spatial knowledge provide insight of local variations in perceptions and experienced impacts and vulnerabilities to drought and using satellite imagery as a base map provides a form of familiarization and intuitiveness.

A community-based, participatory planning approach aims at fine-tuning adaptation strategies and actions to the needs of the local communities. However, CBA does not entail that local communities have the sole responsibility of adapting to climate change. According to White (foreword in Magee 2012) community-driven approaches need to be implemented within an institutional framework that combines community-based priorities and skills with outside expertise and skills. Dialogue based on visual aids like maps may be useful in such a context. We also acknowledge mapping as a *process*, in particular in participatory mapping where it is about more than the map itself. The mapping process provides a space and setting for dialogue. The mapping process can help initiate discussion on dynamics of vulnerability over time, encouraging learning and anticipation for adaptation. Participatory mapping have, according to literature, the potential to create cohesion in local communities that may translate into collective action (Di Gessa et al. 2008; IFAD 2009), which is important for CBA.

Yet there are also some challenges to be aware of; participatory mapping is time consuming, good facilitation is needed, GIS knowledge may be lacking, and it may be challenging to get all to participate and engage and design for all to have a say ('hold the pen'). It is also important to take note of that maps are not neutral objects separate from the social context; with this comes also reflections around ethics, the power of maps and the role of facilitation.

In EVA we also applied NDVI data as part of the drought mapping. This is relatively easy available data that can be downloaded for free. There may be limitation of which images are available for what times (as it needs good weather/no clouds), but the data represents a valuable source of information. We found that it helped us get an overview of the natural conditions in the area and also the historical development. Furthermore, in a system highly dependent on agriculture drought indexes related to vegetation is of high importance. Yet, it is important to keep in mind that the NDVI-index does not give the definite reason for any changes in vegetation cover that might be observed (it may be due to other reasons than drought).

Key points:

- Participatory approaches in the context of CBA can help build understanding, plan for and manage change. Participatory mapping helps to understand the perspectives of the communities, and local communities get a voice in defining which problems are important and it can aid the discussion on implications of adaptation options.
- Depending on the overall objective, the mapping process may be more important than the output; it serves a dialogue tool that promotes co-creation of knowledge and learning.
- Since drought is a spatial and temporal complex phenomenon and local communities tend describe and perceive it in terms of impacts (on water, soil, agriculture), rather than scientific meteorological definitions, participatory mapping can help elicit this knowledge and also integrate it into drought assessments and adaptation planning.

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## Annex – the maps

- A. Maps produced and the mapping process
- B. The Participatory maps
- C. The NDVI-index maps
- D. List of data sources for different data layers (GIS)

## A. Maps produced and the mapping process

During the process of conducting the participatory mapping we went through several steps and visited the communities in the field several times. The mapping exercise has traits of both participatory mapping (as a tool of Participatory Rural Appraisal (PRA<sup>2</sup>) and Participatory GIS (PGIS) (and photo-mapping<sup>3</sup>).

A basic assumption for the activity is that a map is an essential planning instrument in general and also suitable to facilitate (steps towards) the identification of adaptation and risk reduction measures. In our mapping process we have applied so-called photo-mapping where we used satellite imagery as base map for the activity. We have then taken main parts of the mapped information further into GIS. Hence, the work described here also builds on GIS capacities.

### The approach include the main components

- aerial photographs/satellite images
- geographic information systems (GIS)
- narratives and focus groups
- global positioning system (GPS) technology (not strictly needed, but recommended)

### The approach used consists of two main steps:

1. Firstly, data and satellite imagery is acquired and taken to the community members as a 'blank' base map to facilitate discussion and the mapping of specific features. "A photo-based community mapping exercise"
2. Secondly, the data is being integrated in a GIS and analyzed through additional spatial analysis.

### Resources required to conduct the activity in the field:

- print-outs of the satellite map, we used size A0 on strong photo paper
- maps from older exercises and/or especially prepared maps. We had additional A4 print-outs
- markers/pens in different colors for each group (preferably two-three of each color)
- tape to affix the map
- transparent overlay-paper that can be used on top of base-map. We used overlay paper for the first mapping, for the second mapping drawing was done directly on the map print outs
- photo camera to make photos
- GPS device if you want to "ground truth" - make certain reference points (coordinates) while in the field
- additional pens and paper that can be used for notes etc.

### Facilitators' guides

Below are the facilitators' notes that the whole EVA project team developed together and used as guide for the exercises.

## Community Resource & Drought Hazard Mapping – Guiding Instructions for the field, EVA Project – September 2012

**Objective:** For the community to take charge and map the issues below, for which the research teams are the *facilitators* for. This activity is meant to be a general exercise, not to get lost in details.

### STEP1:

- Activity 0: Present briefly the map to the group and purpose of the map. E.g. "here you see your village...". "Here you see the neighbouring village..." "This mapping exercise is meant to show the village, the important land and water resources, the relationship of caste to land and water sources, and how drought impacts the community"
- Activity 1: Start a discussion around the spatial aspect of the village and broader area. Ask them to draw the village boundaries. **Draw a line with black marker.** General aspects of the village: do you have households that are more scattered?
- Activity 3: Mapping of water sources: community-owned water sources for starters and later privately owned sources (i.e. check-dams, tanks, wells, springs, etc). Use **blue marker** and record what symbols for different types of sources are used.

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<sup>2</sup> [www.iisd.org/casl/caslguide/pr.htm](http://www.iisd.org/casl/caslguide/pr.htm)

<sup>3</sup> Sometimes photo-mapping is also used to describe when photos are made in the field/communities and these are portrayed on a digital map with coordinates. Here we mean photo-mapping in the capacity of using a satellite image as a base map for the participatory mapping in the communities.

- Activity 4: Mapping of land type. Indicate distribution of different land-holding sizes (large, medium, small). The legend may/will be different for each map, so take notes on what each symbol means. **Symbols should be used in case illiterate participants are present.** Marking land distribution plot by plot will be too tedious, so where possible general areas should be outlined and shaded (again, legend assigned should be recorded).
- Activity 5: Mapping of infrastructure: indicate if possible where markets, health centres & education centres are located and how far.

**STEP2:**

- Activity 6: Refer to the information gathered during the timelines, venn diagram, seasonal calendars and notes Identify the 2 or 3 most important impacts (i.e. drought, etc.), and start a discussion about the implications of these for water resources, land, and people. For instance, which areas are affected first in a drought, and who it impacts as well as which areas are the most resilient to drought, and who benefits are important considerations. This discussion of impacts should be represented in a spatial manner, either through drawings, shading, symbols, etc. in order to start developing a narrative. The meaning of symbols, shading, drawings, etc. should be recorded in detail.

Take photos of the maps, both before and during the production and of the final map.

**CLOSING REMARK:** These maps will contribute to later mapping for planning and managing of drought and extremes.

## Participatory drought zone mapping – February 2013

**Rational behind activity:** The aim of this activity is to bring back the resources maps that were made during the September 2012 fieldwork and ground truth the resources that were then mapped. The community perceptions drought maps will be input into the overall mapping activities of the project.

The community will be asked to identify, draw and define areas of high, medium and low impacts to droughts within each community. Additional follow-up questions will be asked on agricultural practices, water and livelihood.

This activity will be conducted in smaller groups of the people from each specific village that drew the maps.

*Note to facilitator:*

- In the participatory mapping exercise, the facilitator's role is of great importance and energy should be put into noting down the process, dialog and context of the mapping, rather than just producing the end result itself—the map. How the stakeholders arrived at the mapping result, whose voices were involved and the discussions around the elements included are important details that must be noted down and are crucial for documenting our methodology. So, make sure to take rich notes, always reflecting on the process of the mapping in addition to what is produced at the end. Furthermore, make sure that a diverse array of participants is present, both young and old, men and women, powerful stakeholders and not, and make sure everyone gets a chance to “hold the pen” and lead the discussion/give input.
- Make sure that the participants draw areas/zones not points. If hesitant acknowledge that boundaries may not be strict, but encourage them to draw areas. Explain that this is just to get an indication.

*Note to notetaker:*

- Describe the process of the drawing and the discussions of the participants in as much detail as possible

**Step 1: Introduction to Activity 2 (15 minutes)**

1. Introduce yourself and ask the participants to introduce themselves (guiding format , see step 1.1)
2. What we will do now is:
  - a. Discuss the September 2012 maps
  - b. Expand the September 2012 maps with further questions regarding drought, agriculture and water
3. How information will be used: The information provided will be used to characterize how your community experiences drought and its impacts on your agriculture, and water resources and livelihood. This will be used to look at possible adaptation options.
4. Are there any questions before we start?

5. Show and briefly explain *the drawn* community resource maps from September 2012 for orientation of what has been done. Briefly mention what was mapped (i.e. village boundaries, roads, water sources, agricultural lands, . . . , droughts)

### Step 1.1: Description of Participants

1. Village, Cluster: \_\_\_\_\_
2. Date: \_\_\_\_\_
3. Names of participants
4. Position in community (*panchayat* member, committee member, farmer, etc.)
5. Gender
6. Approximate age (young, adult, elderly)
7. Land holding size (small, medium, large)

### Step 2: Introduce the Digitized Maps from September 2012 (approx. 30 min)

1. Explain that the September 2012 maps as shown in the introduction (Step 1) were digitized for our analysis of their agriculture and water in a drought situation
2. Recap the questions that were asked that guided the drawing in September 2012, and step by step talk through the things presented on the maps (the digitalized elements).
3. Explain that we have digitized their drawing and have made a summary on this map and emphasis that this is our interpretation, with a focus on agriculture, water and drought.
4. Are there any corrections and/or additions to be made on major village landmarks?
  - a. Community boundary
  - b. Nalas
  - c. Percolation tanks
  - d. Check dams
  - e. Other watershed development structures (not mapping individual wells)

See legend to use on separate paper. Use **black** marker to make correction.

*[e.g. if nala direction was wrong, cross out and redraw. To add landmarks, use existing legend on map]*

### Step 3: Detailed Mapping of Drought Zones (45 minutes, including step 4)

1. Warm-up: Set the scene by asking the group about how they would describe/define a drought (5min max)
2. Earlier we have been talking about rainfall: Which areas in your village received less rain in the last 10 years? (spatial variation within the village, if any mark this on a separate small map)
3. Now we will move to impacts on agriculture and water resources
4. [drought frequency]
  - a. In the last 10 years, in which areas are the water resources/wells most often affected by drought? *[participant draws boundary with BLUE SOLID LINE – Facilitator labels areas]*
    - i. Have participants draw these area(s) and mark with
      1. Most often - “III”
      2. Moderately - “II”
      3. Least often - “I”
  - b. In the last 10 years, in which areas are the crops most often affected by drought? *[GREEN SOLID LINE]*
    - i. Have participants draw these area(s) and mark with
      1. Most often - “III”
      2. Moderately - “II”
      3. Least often - “I”
5. [drought severity]
  - a. In the last 10 years, in which areas are the water resources/wells most **strongly** affected by drought? *[RED SOLID LINE]*
    - i. Have participants draw these area(s) and mark with
      1. Most strong - “III”
      2. Moderately - “II”

3. Least strong - "I"
- b. In the last 10 years, in which areas are the crops most **strongly** affected by drought? [*BLACK SOLID LINE*]
  - i. Have participants draw these area(s) and mark with
    1. Most strong - "III"
    2. Moderately - "II"
    3. Least strong - "I"
6. Ask participants *why* they make these divisions
7. In this drought (2012) which areas are *most* affected by the drought? [*RED SPARSELY DOTTED – Water / BLACK SPARSELY DOTTED - Crops*]

#### **Step 4: Specific water and agricultural questions**

1. In which area are the most wells located? Mapping of zone(s) with high well density. [*BLUE DASHED LINE*]
  2. Which are irrigated areas? *Mapping* [*GREEN DASHED LINE*]
    - a. *Have participants draw these area(s) and mark with Irrigated - "Irr"*,
  3. In the irrigated areas: What is used most drip or sprinkler irrigation? (noted/not mapped)
    - 3a. In previous 10 years, if less water in well, for which season was the water used? Use it for Kharif or save it for Rabi?
  4. Which parts of your village are single cropped areas? (Kharif) Map. List the main single crops (max 3)
  5. Which parts of your village are double-cropped (sequential) areas? (Rabi). List the main double crops (max 3) [*RED DASHED LINE*]
  6. In the last 10 years in which parts of your village have the highest density of perennial crops? (indicator of water availability) [*BLACK DASHED LINE*]
- Extra in case of time:**
7. In the last 10 years which double-cropped area could not plant the second crop? (noted/not mapped) [*GREEN SPARSELY DOTTED*]
  8. In the last 10 years which single-cropped area remained fallow? For how many years? Why – indicate 2 or 3 reasons? (noted/not mapped) [*BLUE SPARSELY DOTTED*]
  9. Have people made changes in cropping due to this years (2012) drought? (noted/not mapped) Kharif? Rabi?
    - 9a. Have you planted fodder crops?

#### **Wrap-up activity:**

- Provide a short summary of what we did during the activity.
- What the next step is with the maps made now

*These facilitator guides are considered as guides, adjustments were made (e.g. in use of specific markers) according to need when we were in the field.*

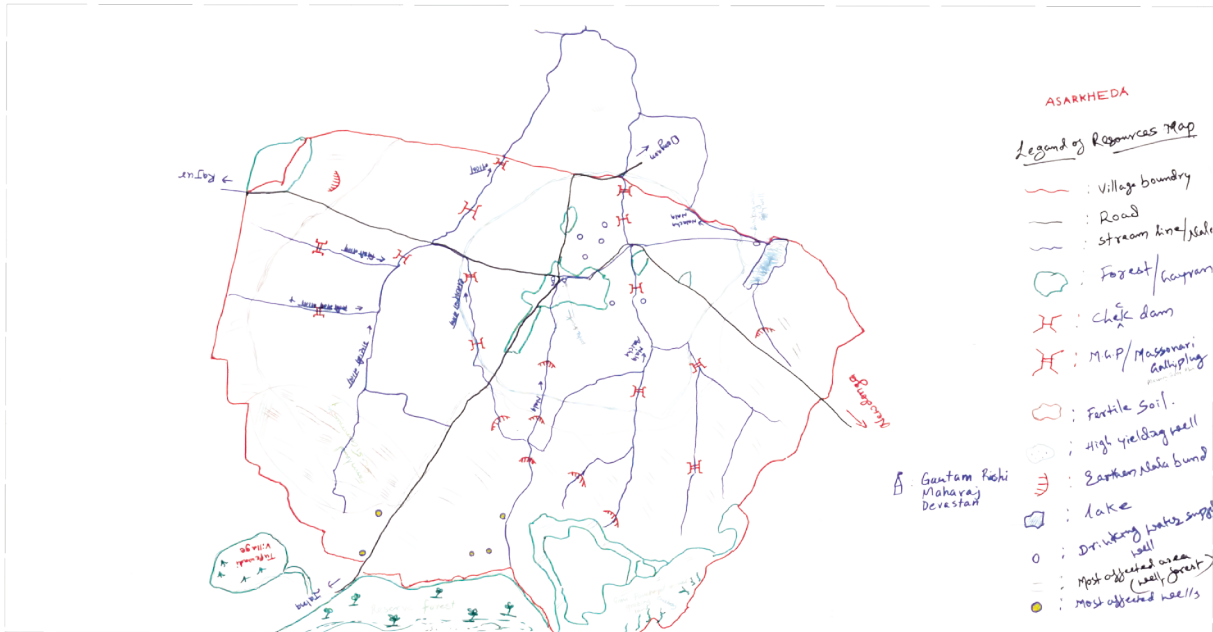
## **Processing and combining with GIS**

The information gathered through the mapping and dialogues in the field were brought back by the research team and the information was digitized and geo-referenced. We scanned the maps and then brought this information into ArcGIS. Alternatively, if one is not able to bring back and or/scan the maps, a possibility is to project the maps using a beamer and then draw after this and make sure one has good reference points (geo-referenced points in the field). The information was then as described in the report combined with other layers of information (see Annex D), in particular the elevation in the mapped area (derived from a Digital Elevation Model (DEM)), as presented in the maps in the next section.

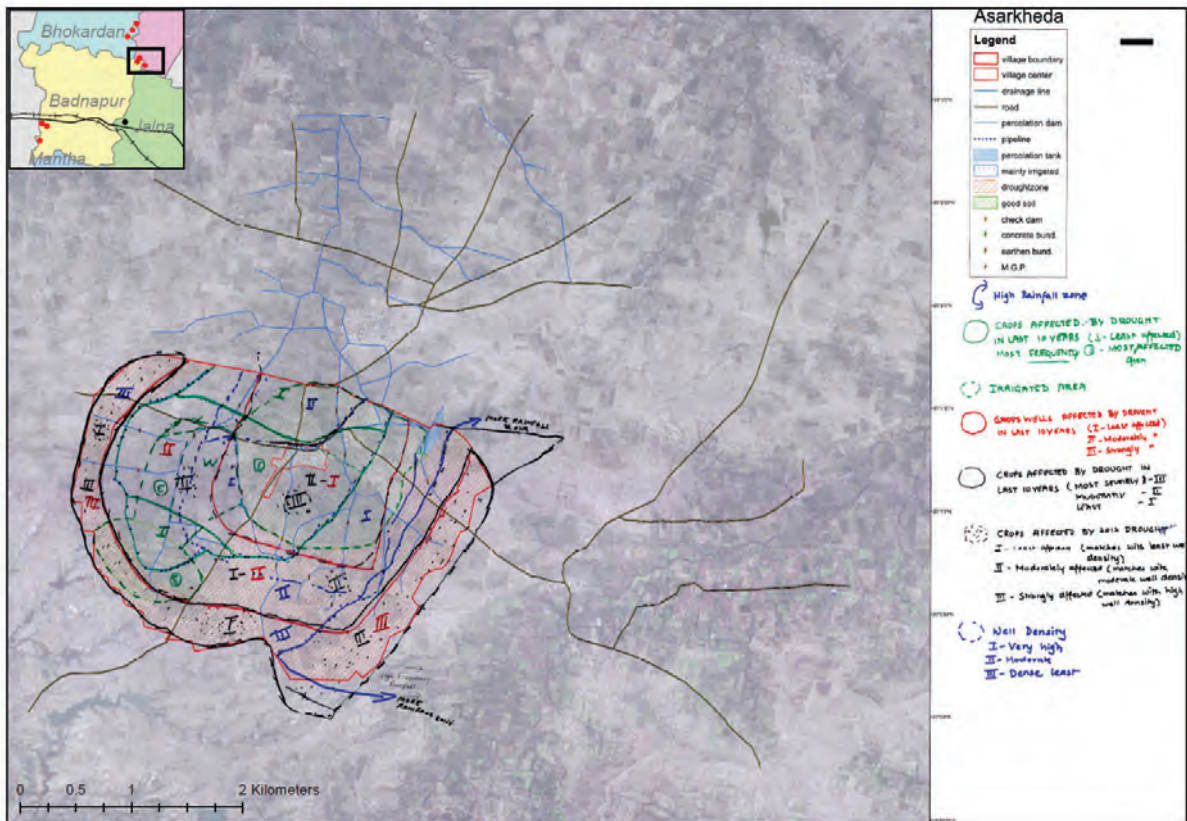
## B. The Participatory maps

### Asarkheda (Badnapur block)

Community mapping in September 2012

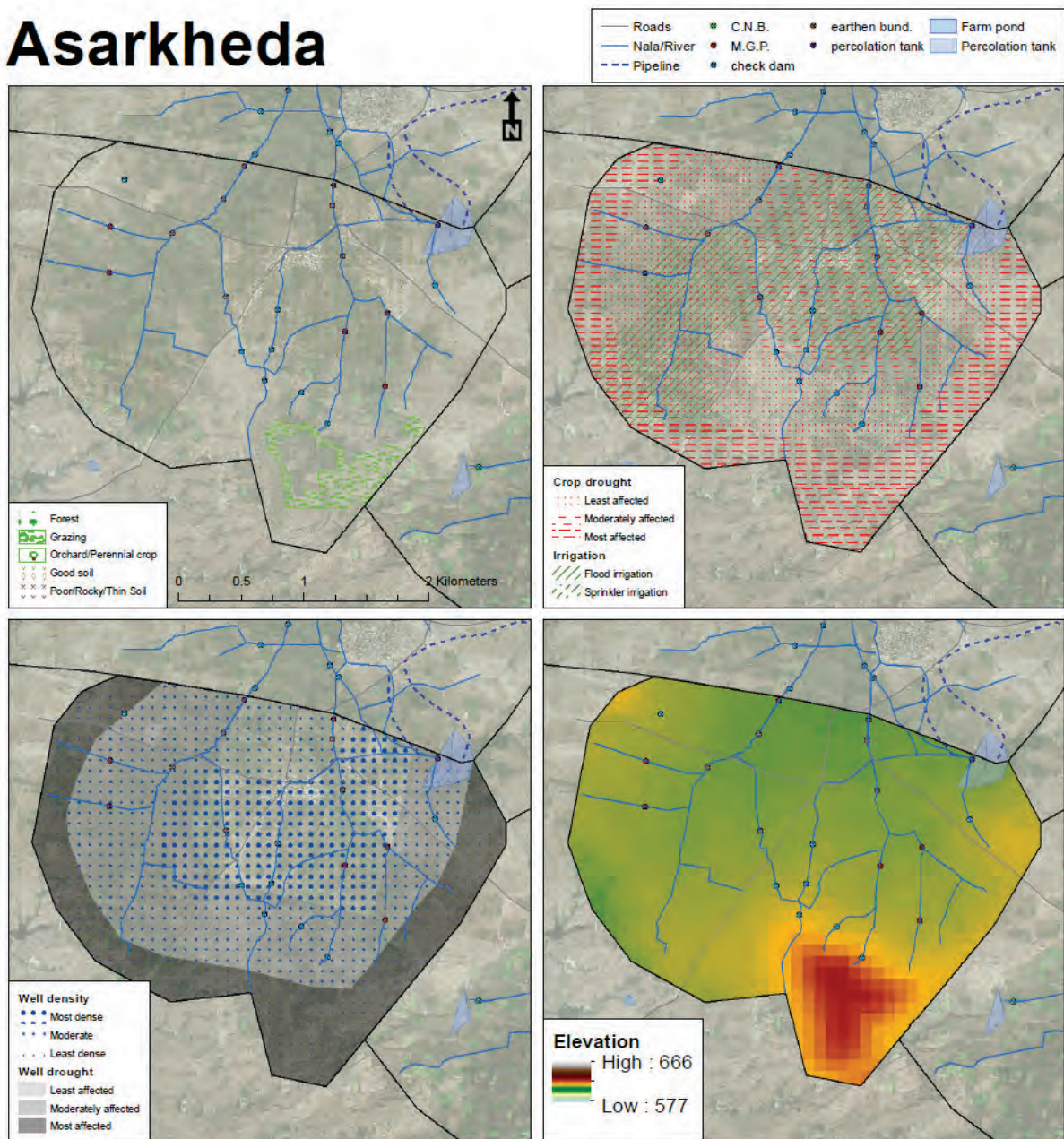


Drought zone mapping in February 2013





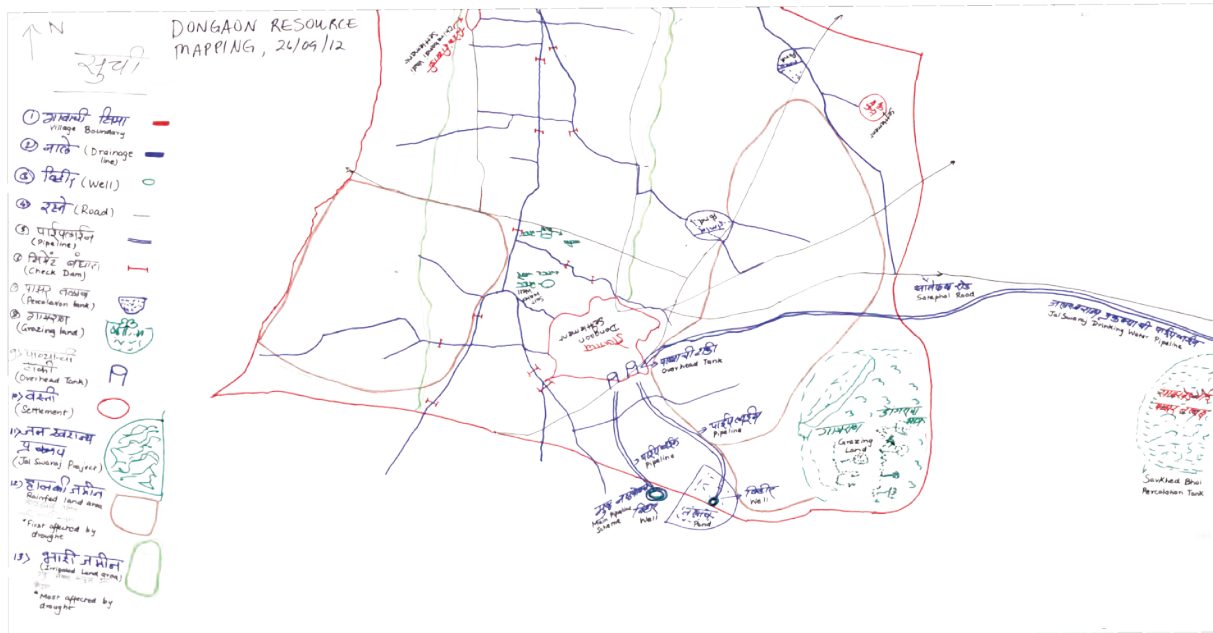
# Asarkheda



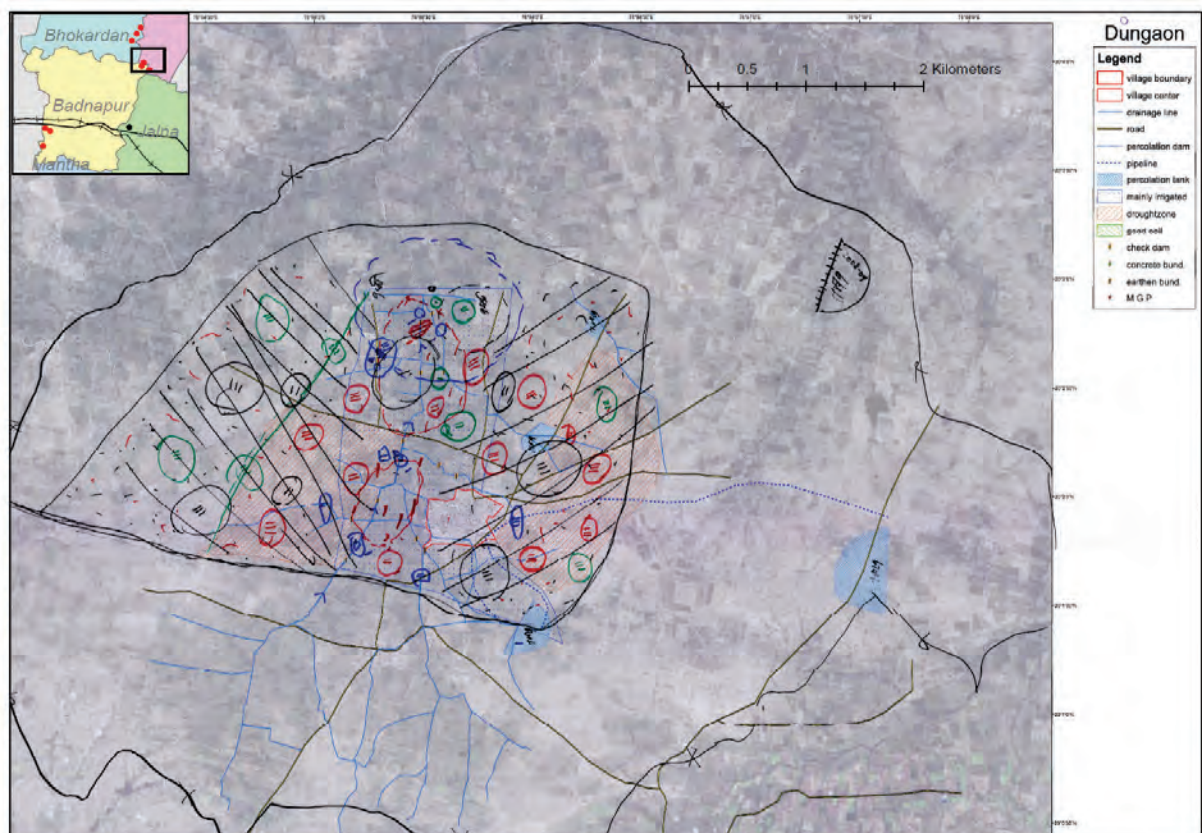
What can be highlighted from the maps for Asarkheda is that areas marked as highly affected by drought are in the higher areas (ridges) of the village. Crops are mostly affected in the lower central areas around the streams. This is also the area where most crops are grown and wells established.

# Dongaon (Jafrabad block)

Community mapping in September 2012

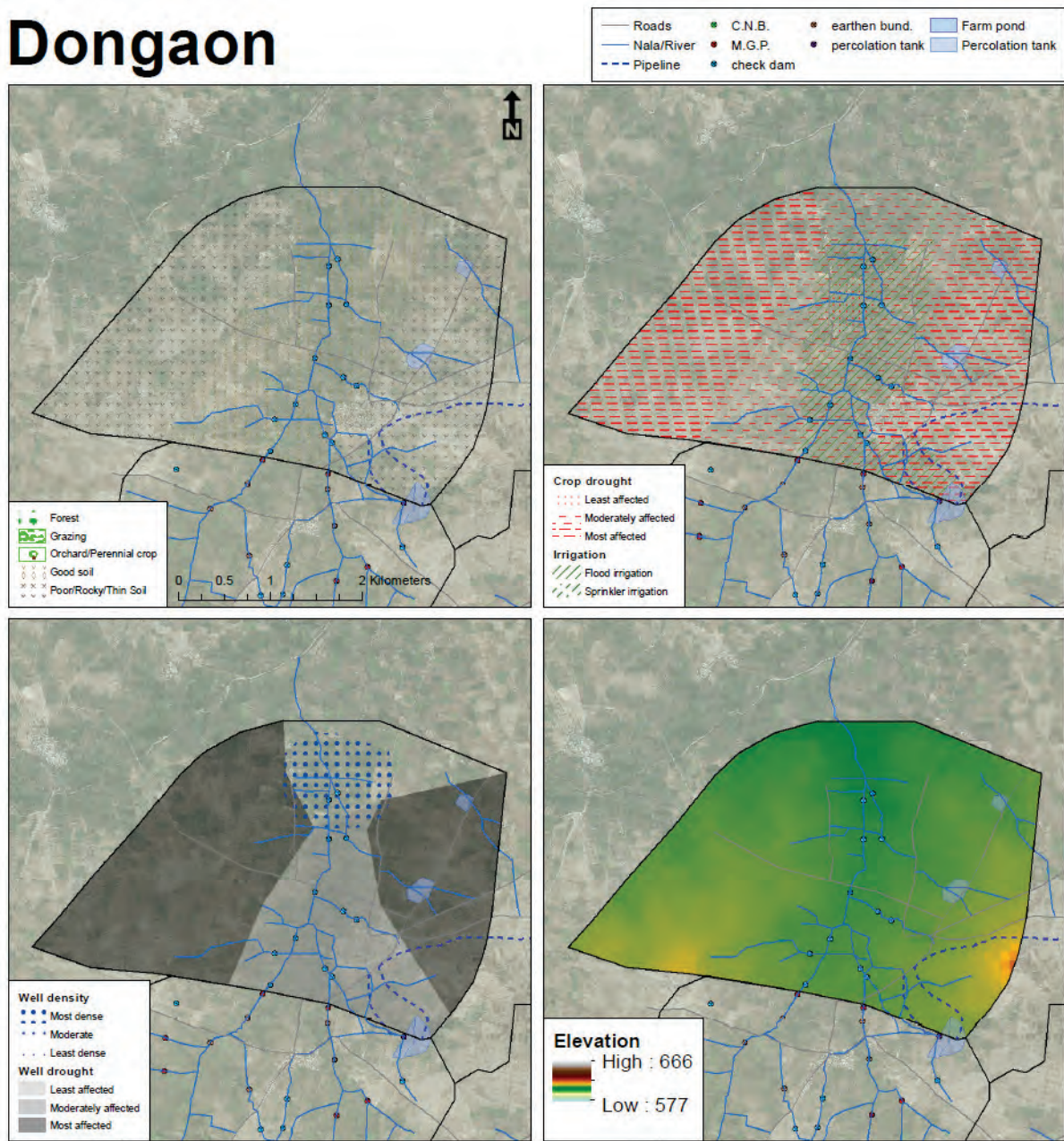


Drought zone mapping in February 2013



Processed maps

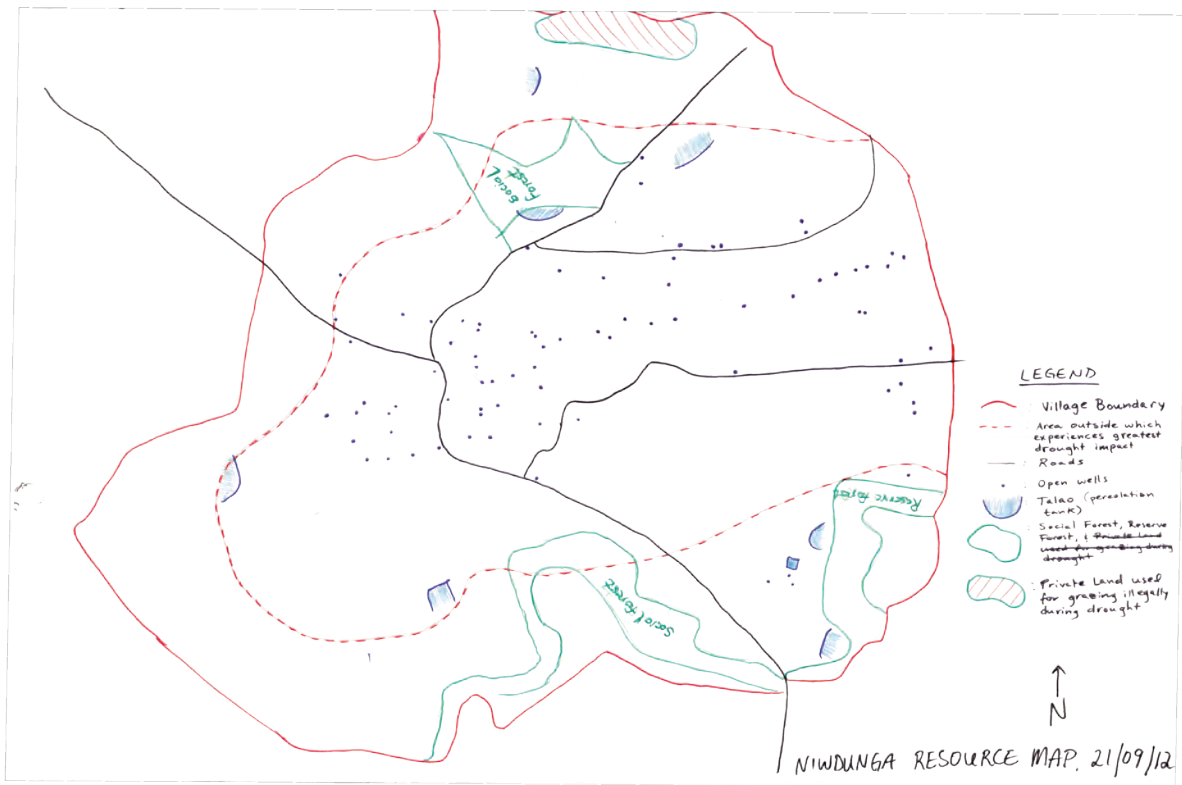
# Dongaon



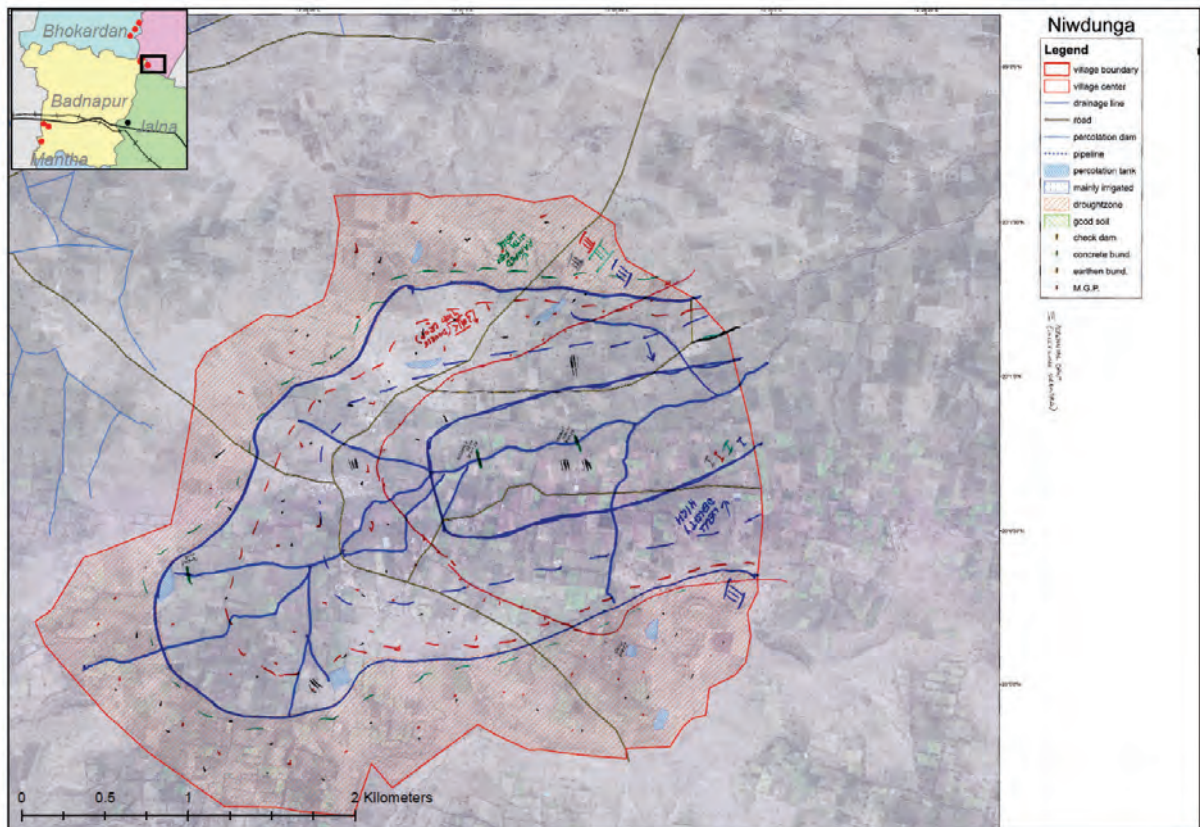
What can be highlighted from the maps for Dongaon is that areas marked as highly affected by drought – both in terms of crops and wells- are in the outer ridges of the village, away from the streams (valley). The elevation gradient is not so large (or at least what can be detected from the DEM) but this pattern is still dominant. The categorization was based primarily on the soil quality - the villagers felt that better quality soils are less impacted by droughts. The village has a Nala that runs through almost the center of the village. The area surrounding the nala is made up of soft rocks, which retains more water as compared to the areas farther away from the nala, which are composed of hard rocks, which does not allow the water to stay.

# Niwdungu (Badnapur block)

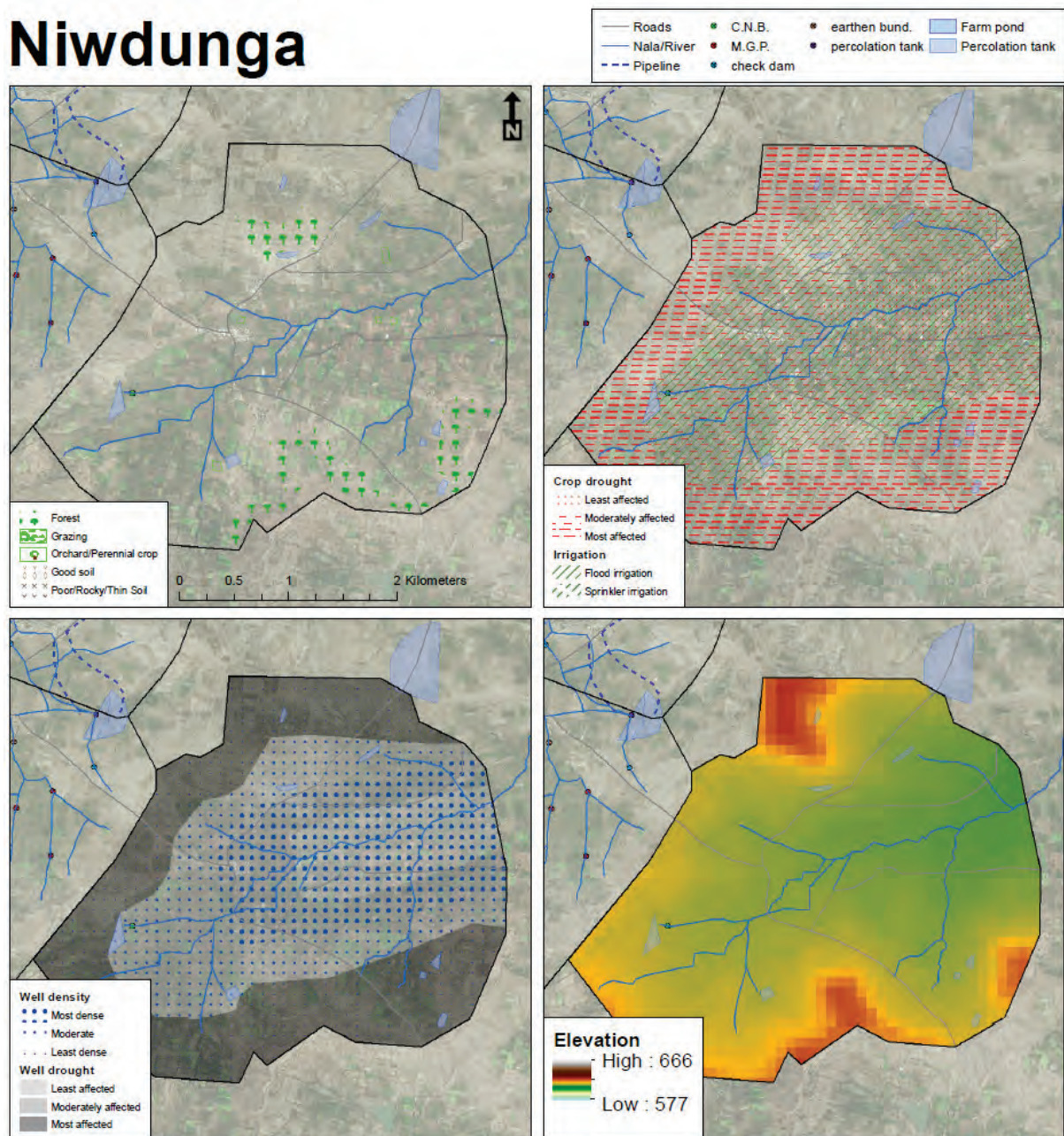
Community mapping in September 2012



Drought zone mapping in February 2013



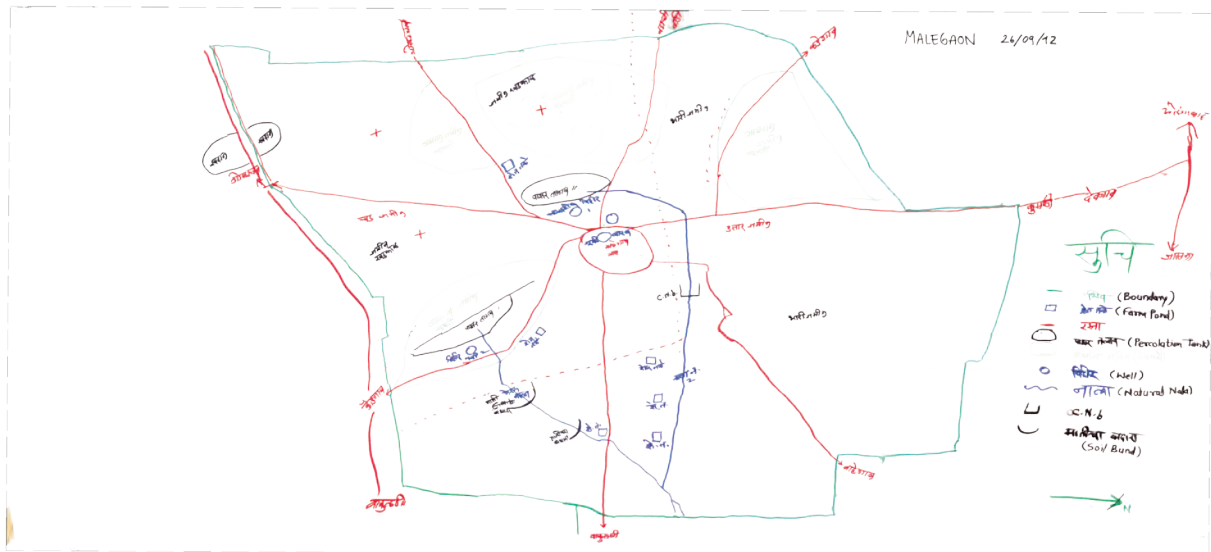
# Niwdunga



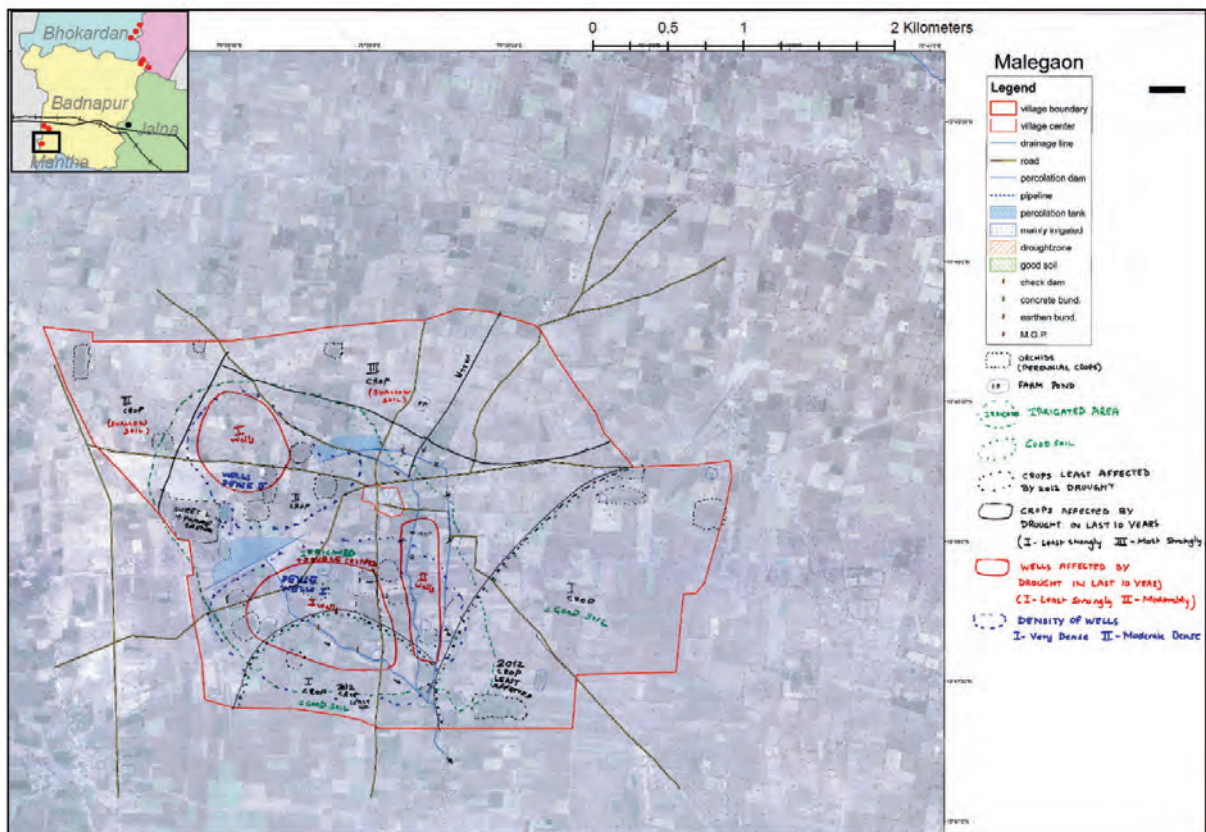
What can be highlighted from the maps for Niwdunga is that also here the areas marked as highly affected by drought – both in terms of crops and wells- are in the outer ridges of the village, away from the streams (valley). Thus the most highly affected areas were along ridge where soil depth and quality is low. The grounds for the participants marking of the zones were done on their experience of soil type, crop yield and wells’ water retention period. Most wells are located in the areas close to the streams where the water levels are higher, than in the more elevated areas, as the water moves towards the streams. On the discussion with respect the drought of 2012, this year they said, the expanse of zone-III (most affected) increased reducing the area under zone-II. The water retained in wells falling in zone-I also affected because of less than 50% rainfall.

# Malegaon (Badnapur block)

Community mapping in September 2012

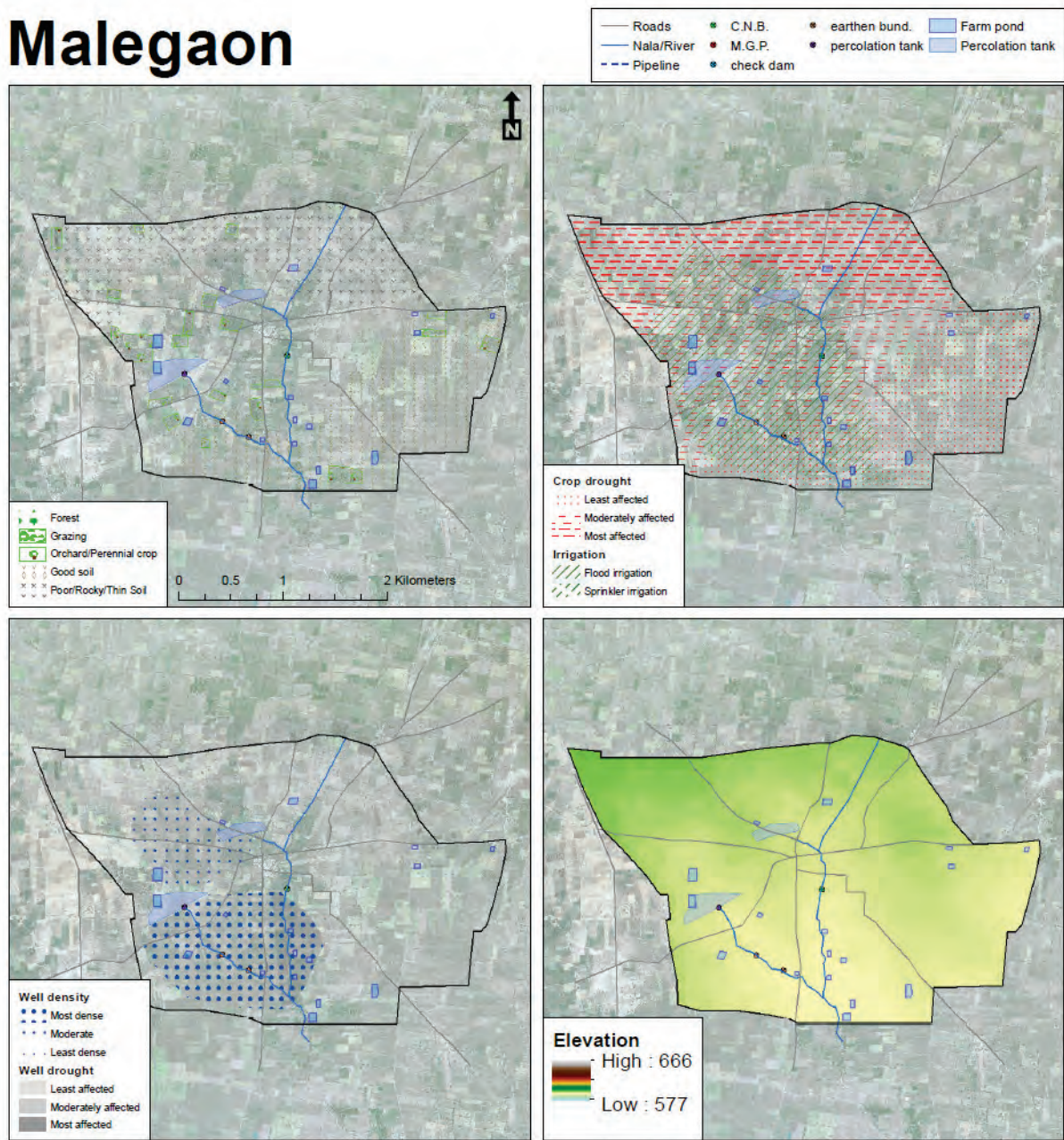


Drought zone mapping in February 2013



Processed maps

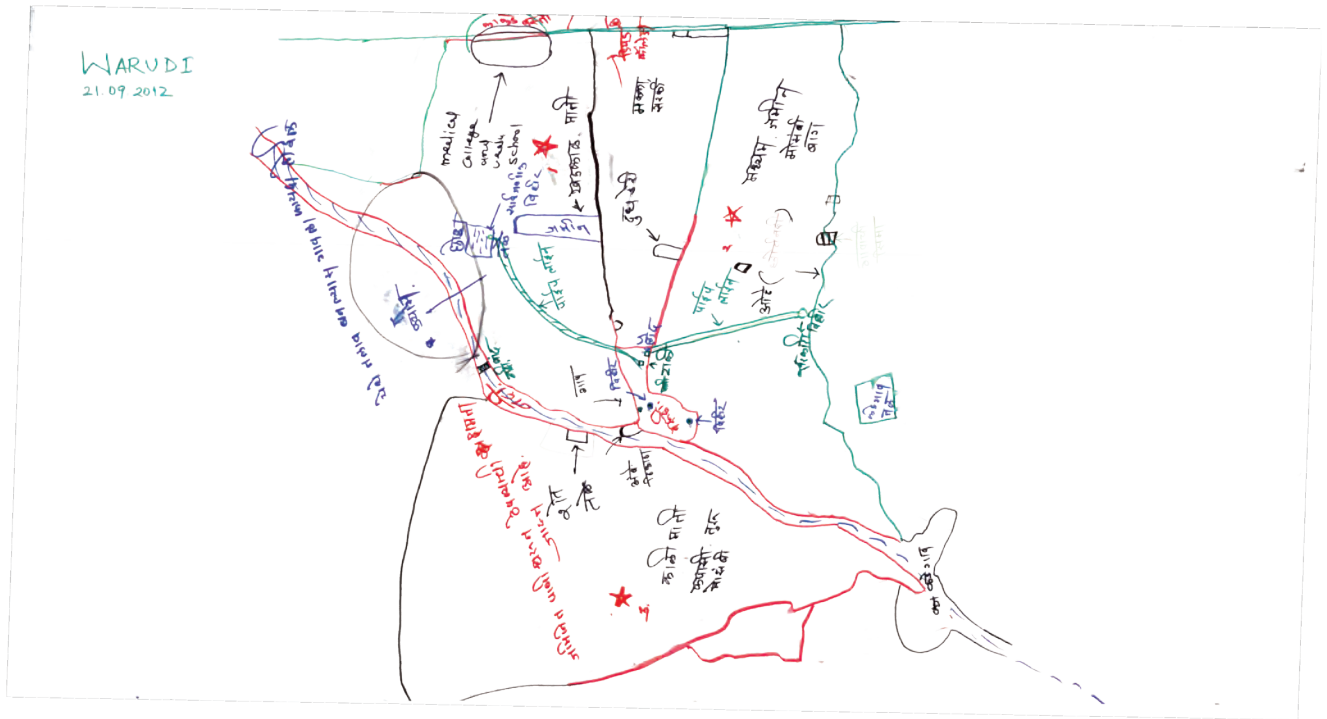
# Malegaon



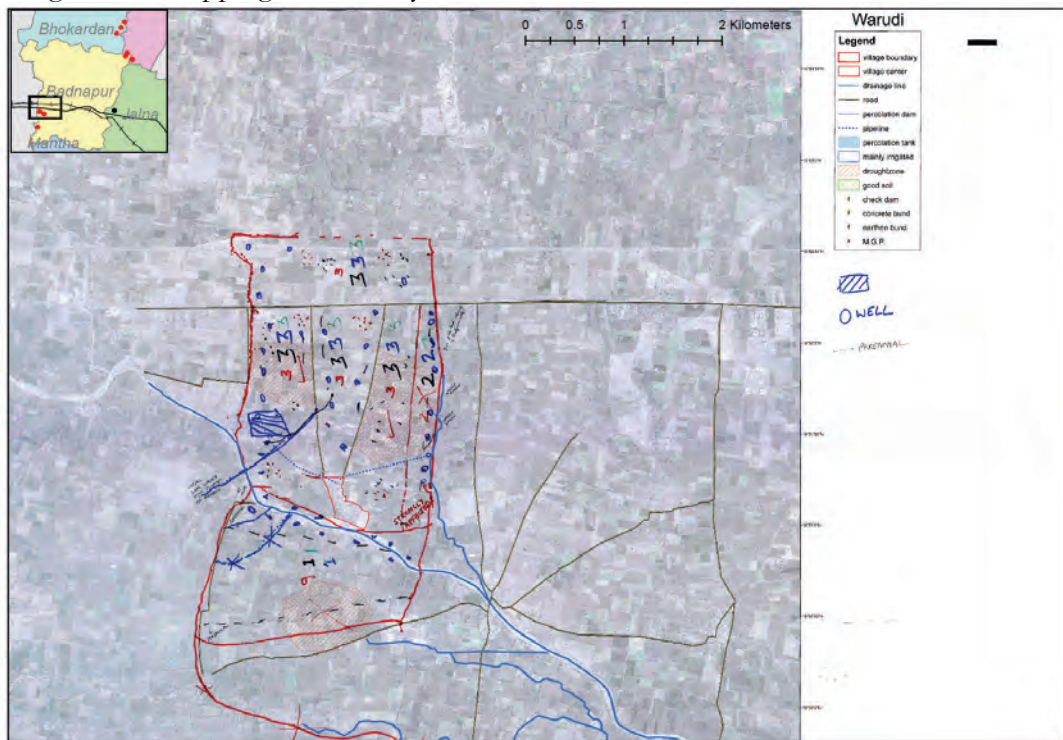
What can be highlighted from the maps for Malegaon is that also here the areas marked as highly affected by drought – both in terms of crops and wells- are in the outer ridges of the village, away from the streams (valley). The elevation gradient (or what can be derived from the DEM) is not large. We can however observe from the maps that the areas marked as most affected by drought are the more elevated parts of the village. Again, confirming the interplay and importance of the topology.

# Warudi (Badnapur block)

Community mapping in September 2012

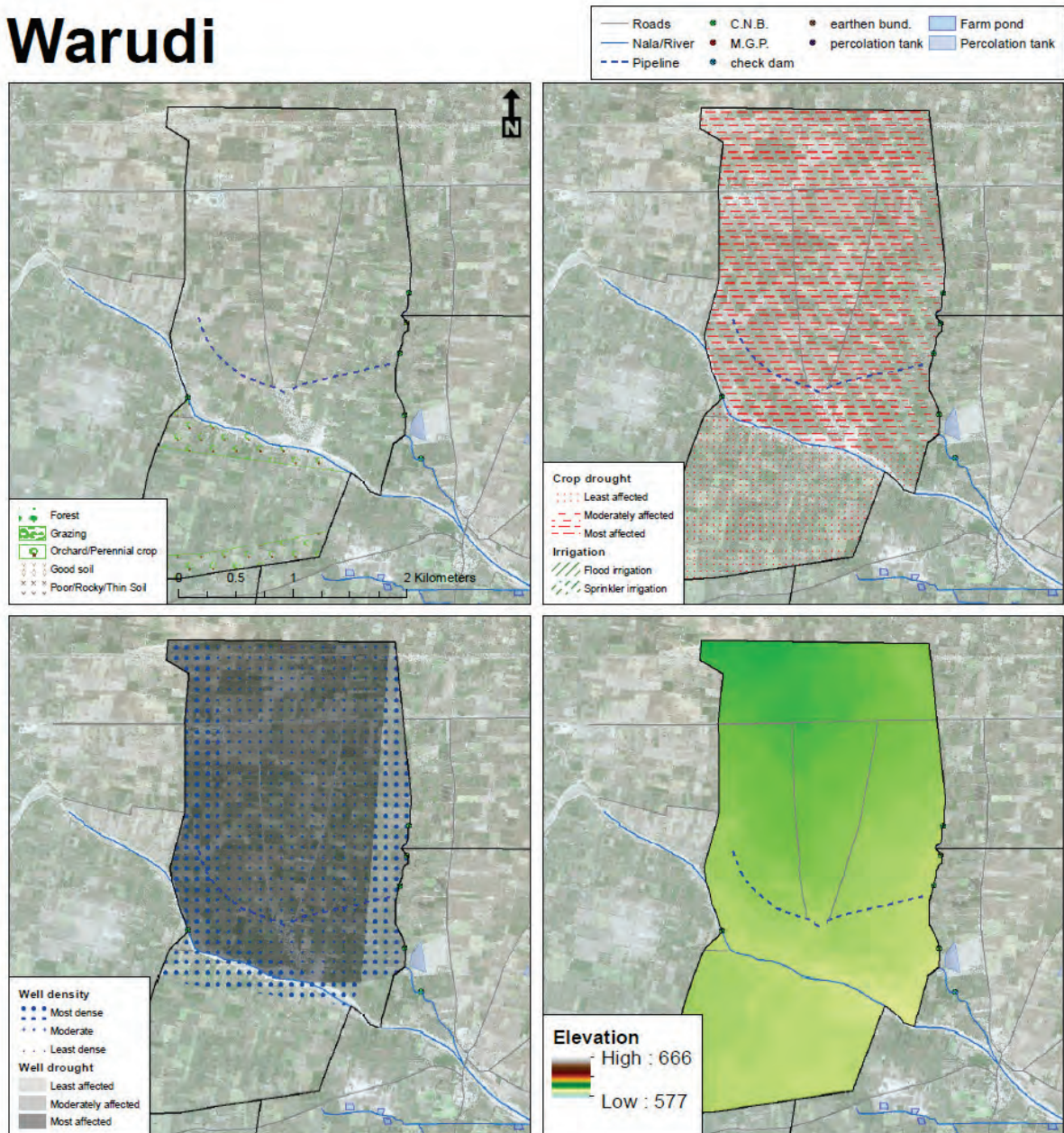


Drought zone mapping in February 2013





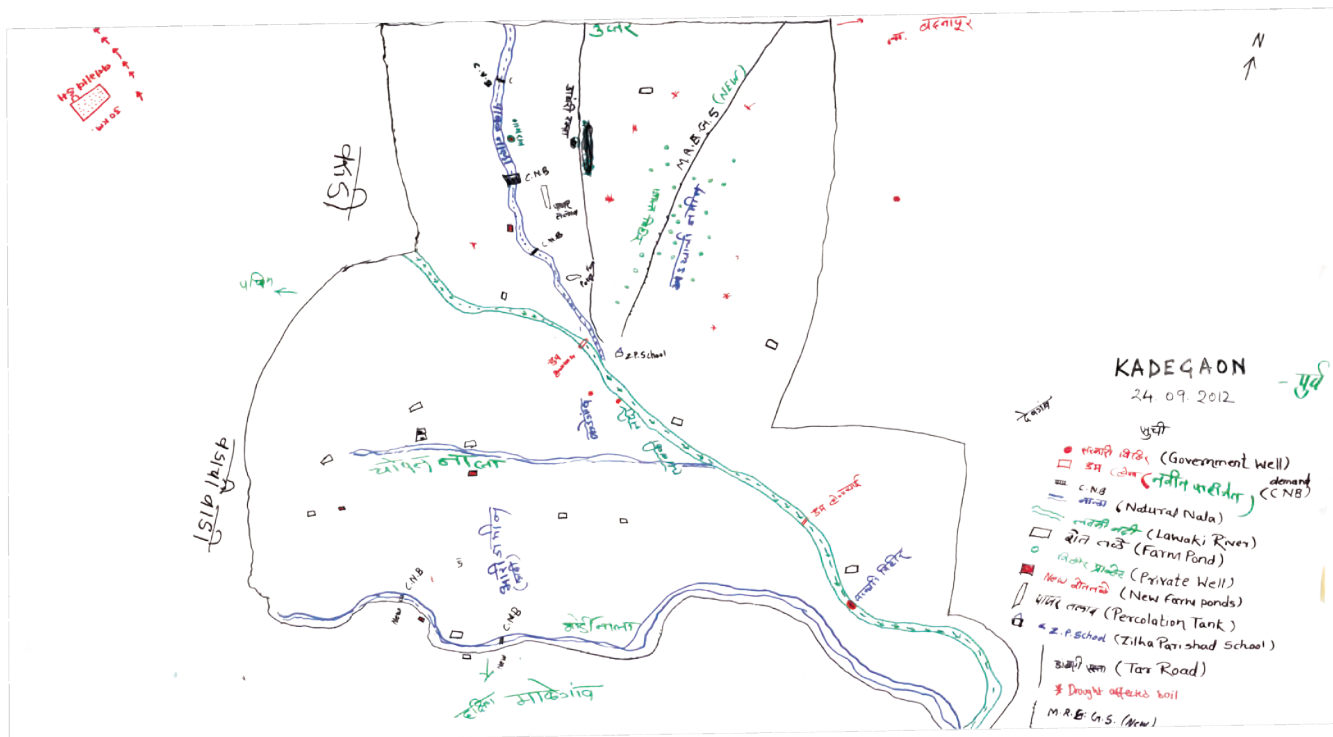
# Warudi



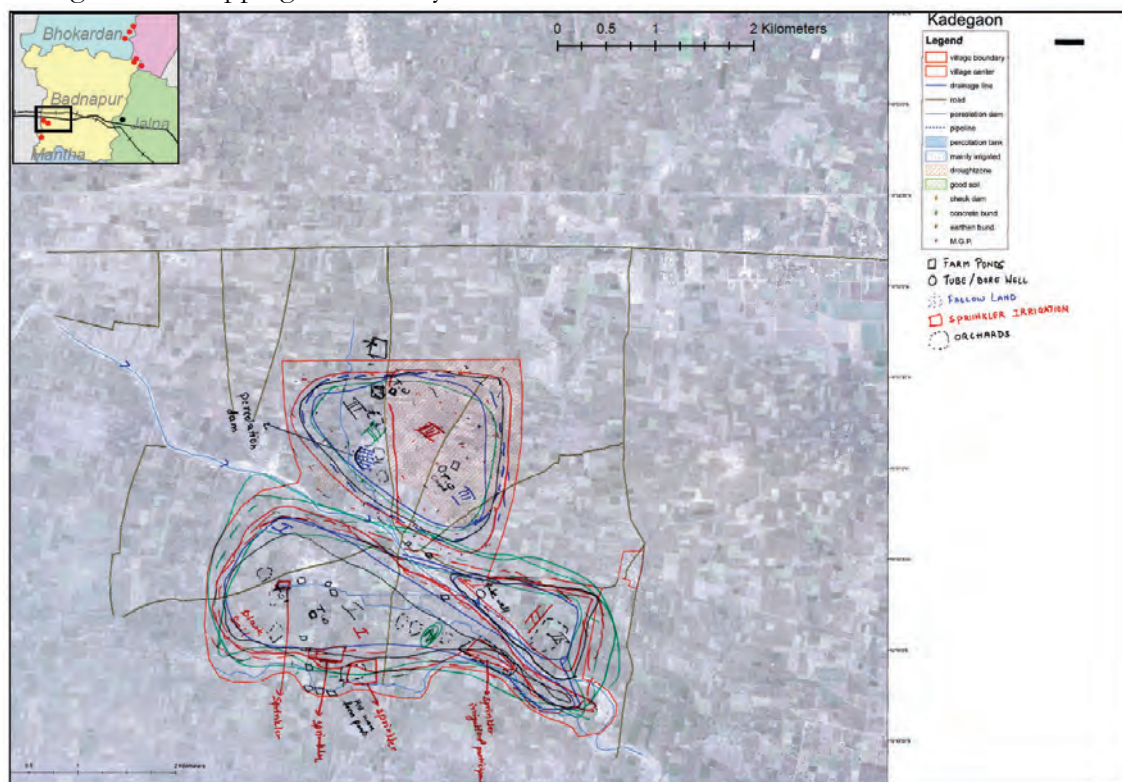
What can be highlighted from the maps for Warudi is that there were marked quite larger distinct zones of most affected versus least affected by drought. Warudi is also generally flat village; there is slight elevation gradient down towards the lower parts by the season river Laukhi (that was completely dry in 2012-13). Wells are established in the upper areas, due to need for irrigation of crops. They were reported to fill quickly when it rains, yet also drain /dry out quicker. Water is being brought from the upper areas to lower. In the lower areas the water retention capacity of the soil is better; it is black soil, which is richer.

# Kadegaon (Badnapur block)

Community mapping in September 2012

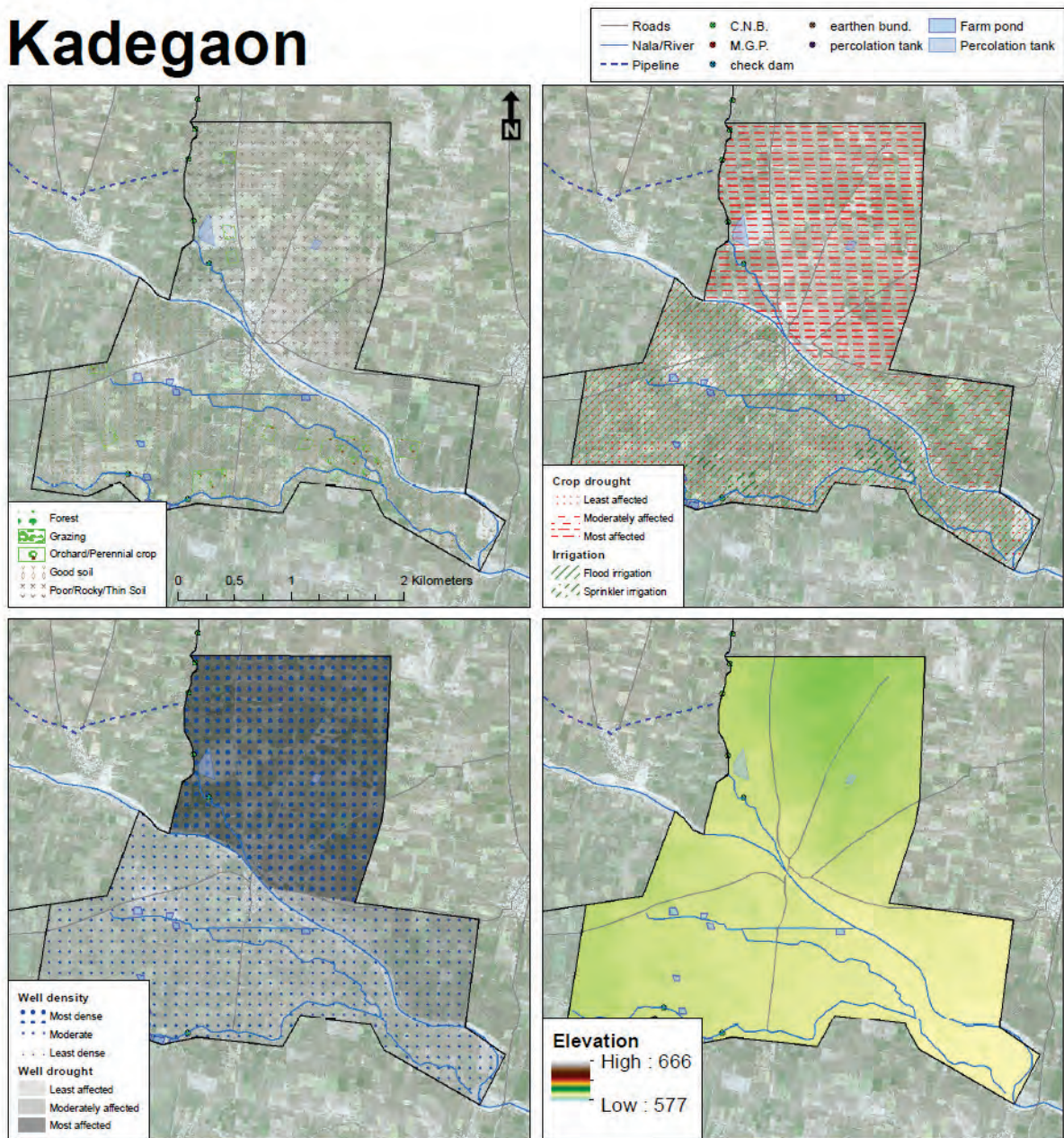


Drought zone mapping in February 2013



Processed maps

# Kadegaon



What can be highlighted from the maps for Kadegaon is also here larger distinct zones of most affected and less affected. The most affected area is relatively more elevated, away from main drain and has reportedly poor soil quality while the others fall along the main drain where water is more available and soil is good. An interesting observation made during the mapping was that the participants marked that most wells were located in the upper zones (corresponding with the most drought affected) not just because of having area (to cultivate) but also because of necessity of more frequent irrigation due to poor soil quality having poor water holding capacity.

## C. The NDVI-index maps

The method of deriving the NDVI is explained in the report itself.

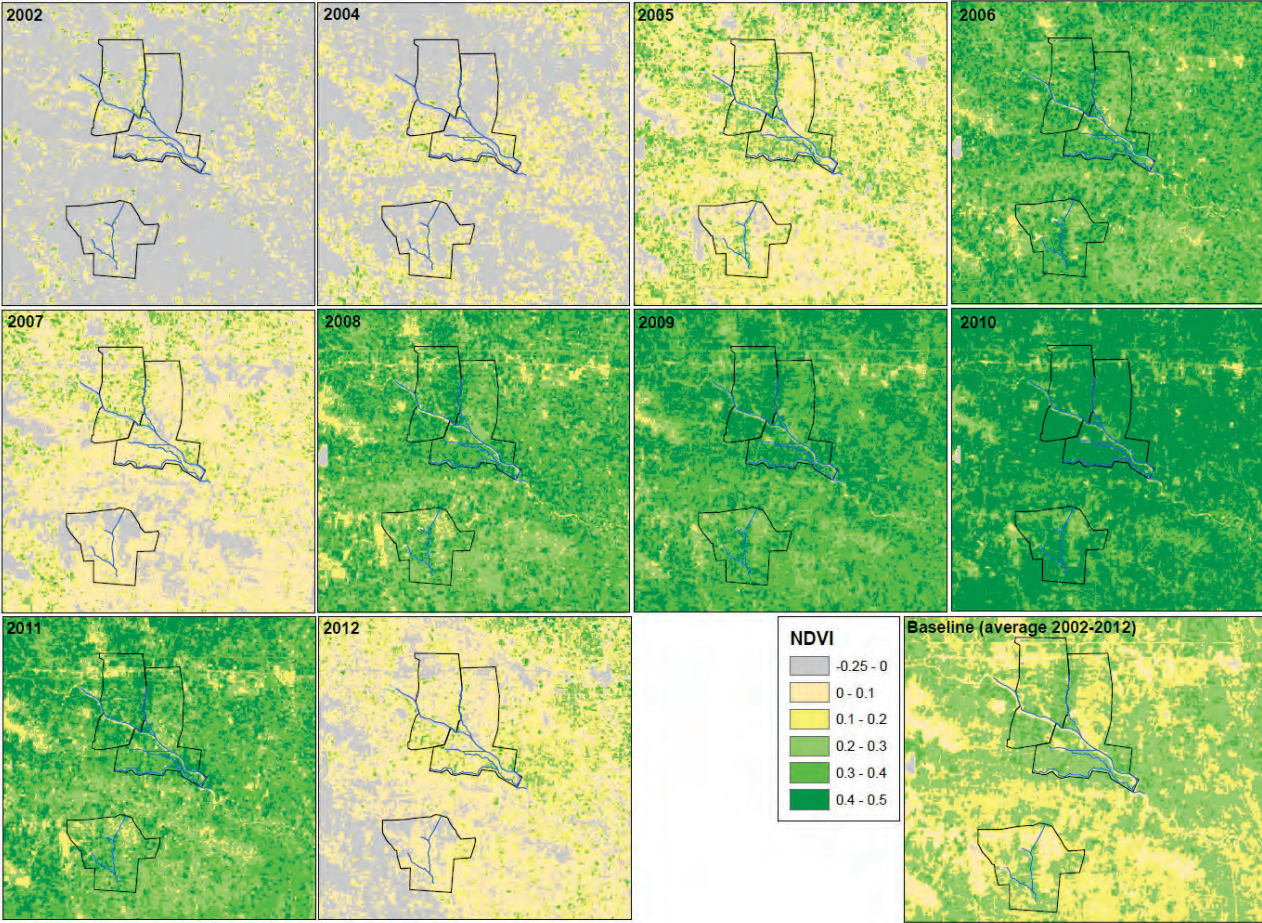
Data was downloaded for the period 2002-2012 and prepared. Data was not yet available for the 2013 at the time of study. 2002 was also a drought year so we want to include this in our study.

As one part of the study, maps for the three study clusters were put together and calculations for December month. December was chosen due to availability of data for all years and also to be sure that harvesting had been done. In September/October crops may or may not be harvested yet. The NDVI-index does not say anything about why an area may show less green for a certain time. See these maps on pages 38-40. The maps distinctly show the difference and response in the vegetation between a low rainfall year (e.g. 2002) vs a high rainfall year (e.g. 2009). Furthermore, the vegetation is, according to the NDVI-index, most healthy longest around the water streams, not unexpectedly.

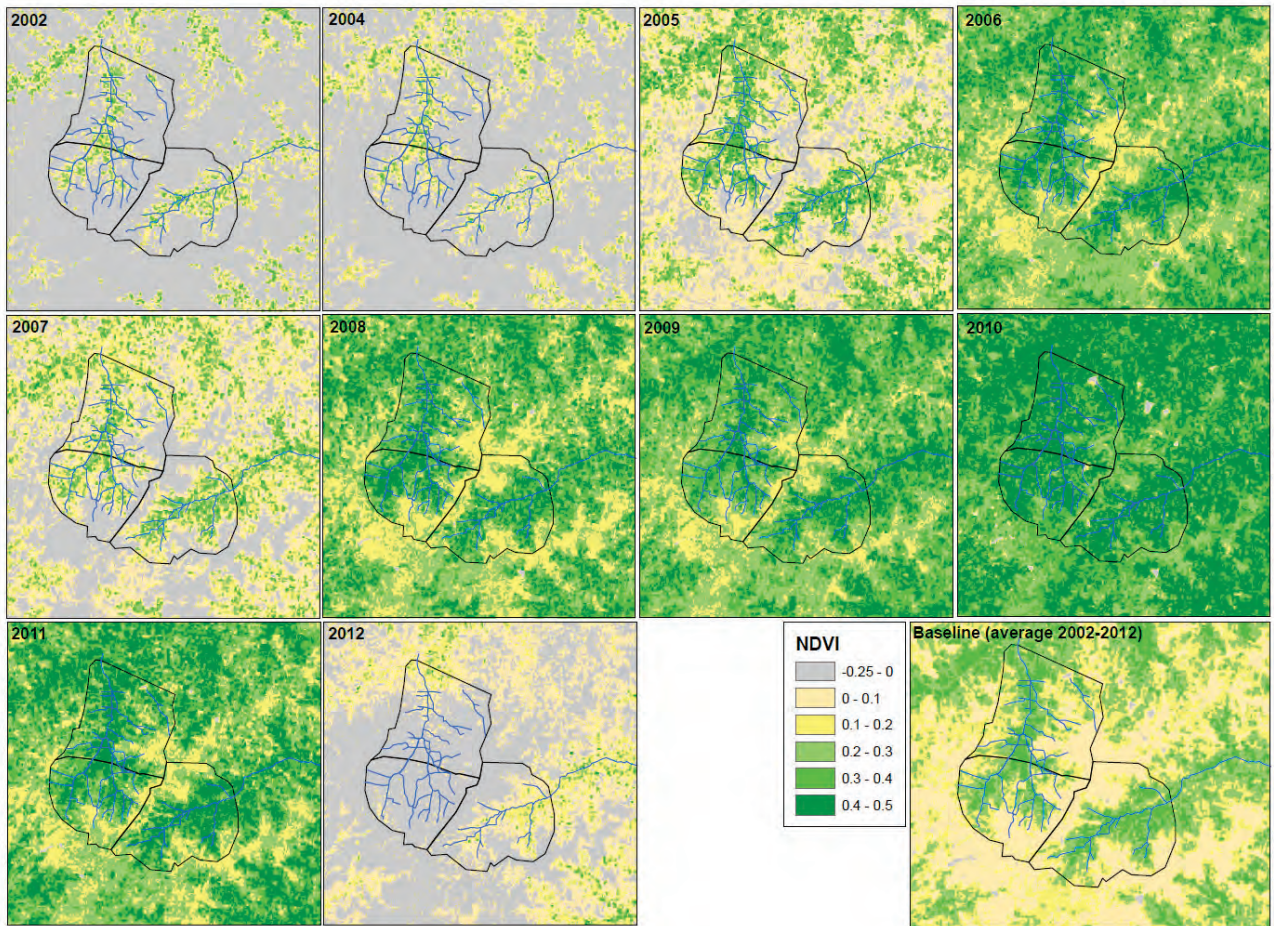
As another part of the study, we zoomed in both in scale and time. Three images were downloaded and calculation made for three different points in time for the respective villages areas. See these maps on pages 41 and onwards. Each column represent one year in these map-matrixes. Data is missing for Sept/Oct 2006. In some areas one would see white areas, these are clouds (blocking the satellite, hence no calculations can be made).

These maps shows how the NDVI changes from the end of the rainy season (Sept/October) to end of December in two dry years (2002 and 2012) and two normal/wet years (2006 and 2009). To these maps we also added the drought zones from the participatory mapping, and we can observe that there on the maps is a correspondence with the terrain and where participatory mapped drought zones. Generally, also the NDVI-index is lower in areas marked as areas highly affected by drought.

**Badnapur cluster NDVI december 2002-2012 (Villages: Kadegaon, Warudi, Malegaon)**

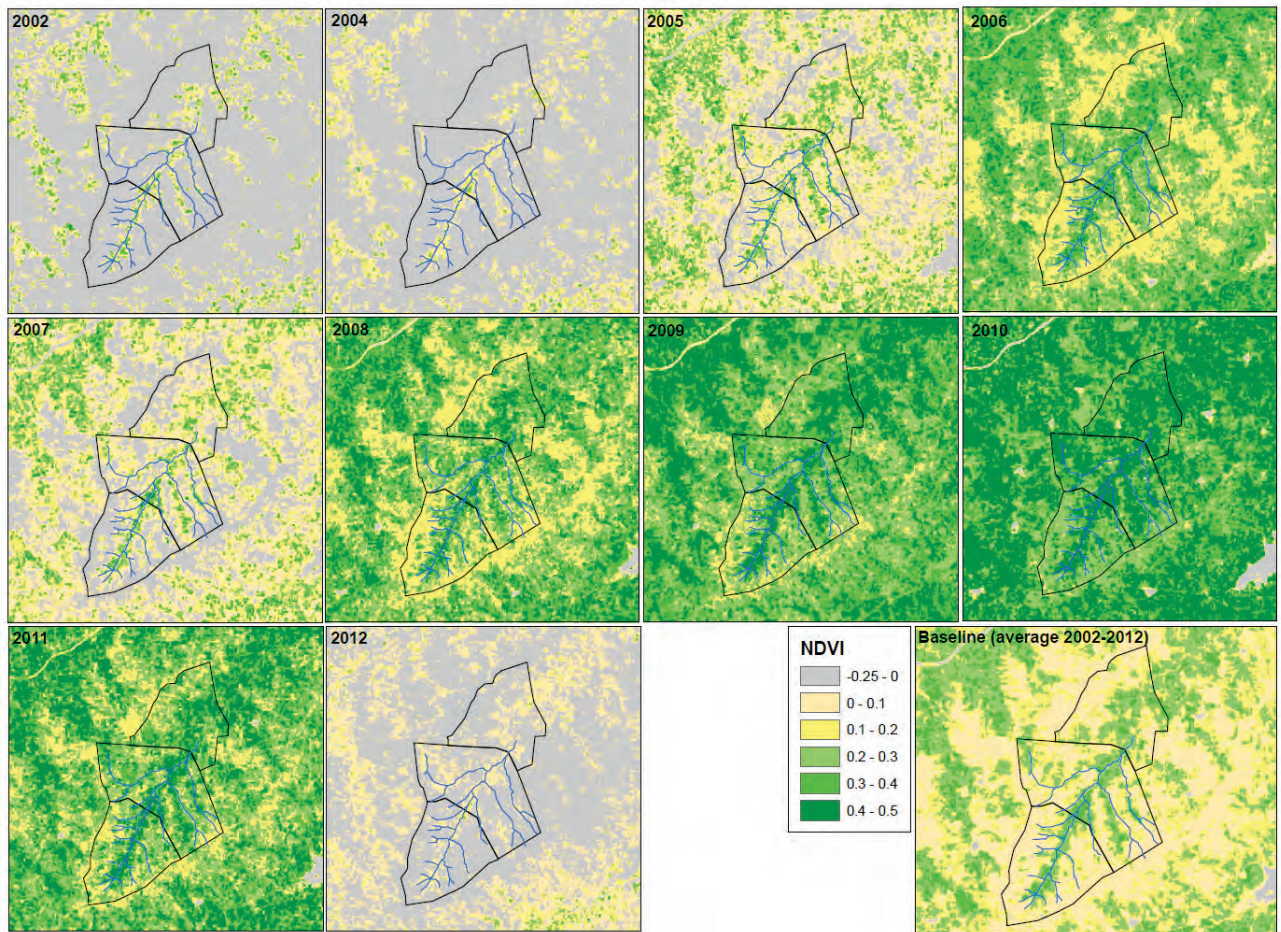


**Jafrabad cluster NDVI december 2002-2012 (Villages: Dongaon, Asarkheda<sup>4</sup>, Niwdunga)**

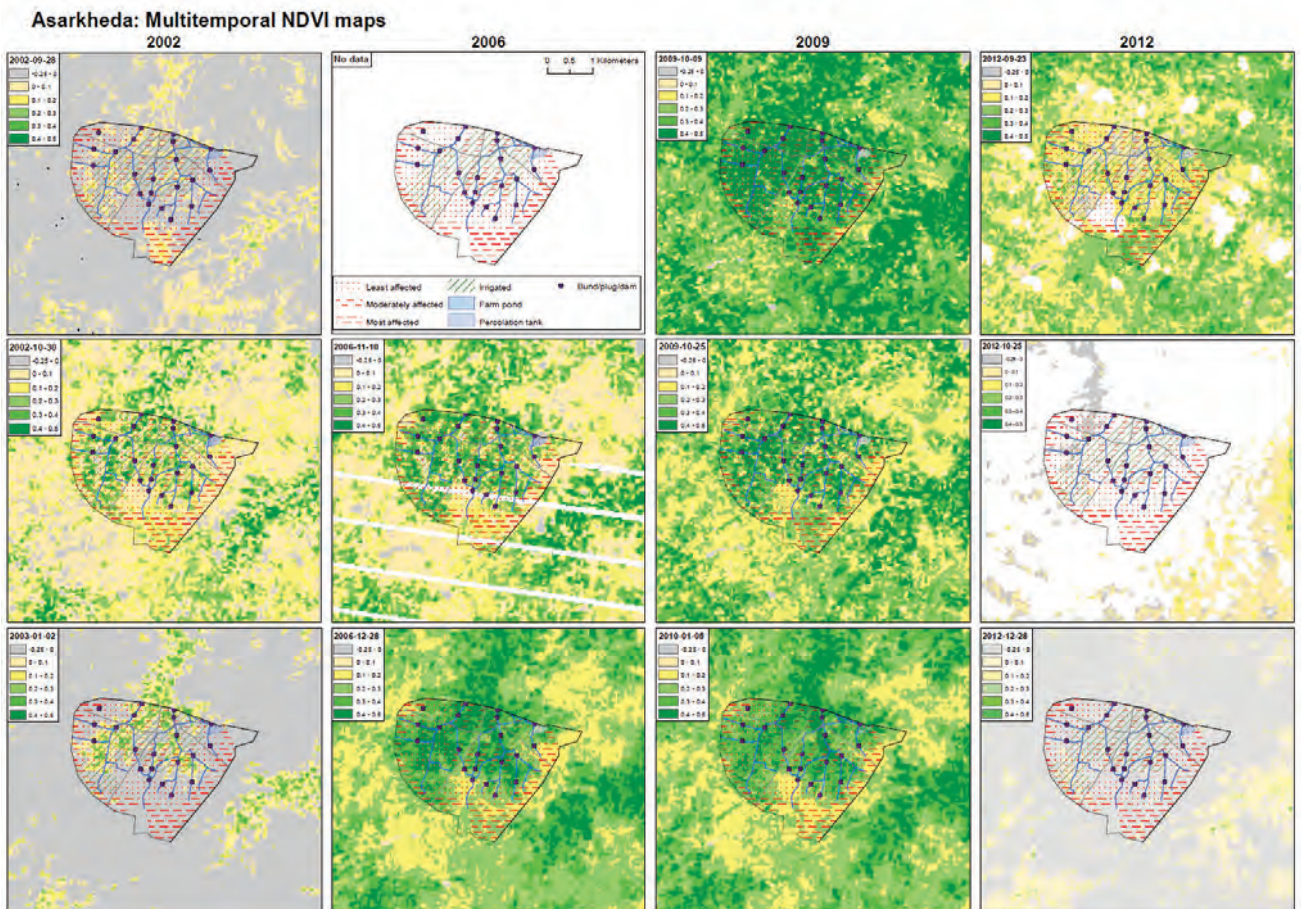


<sup>4</sup> In terms of administrative boundaries Asarkheda is located in the Badnapur block. In the EVA project the cluster with these three villages is sometimes referred to as the Jafrabad cluster or EVA 2 cluster

**Bokhardan cluster NDVI december 2002-2012 (Pimplegaon Barav, Thote Pimplegaon, Palaskheda Pimple)**

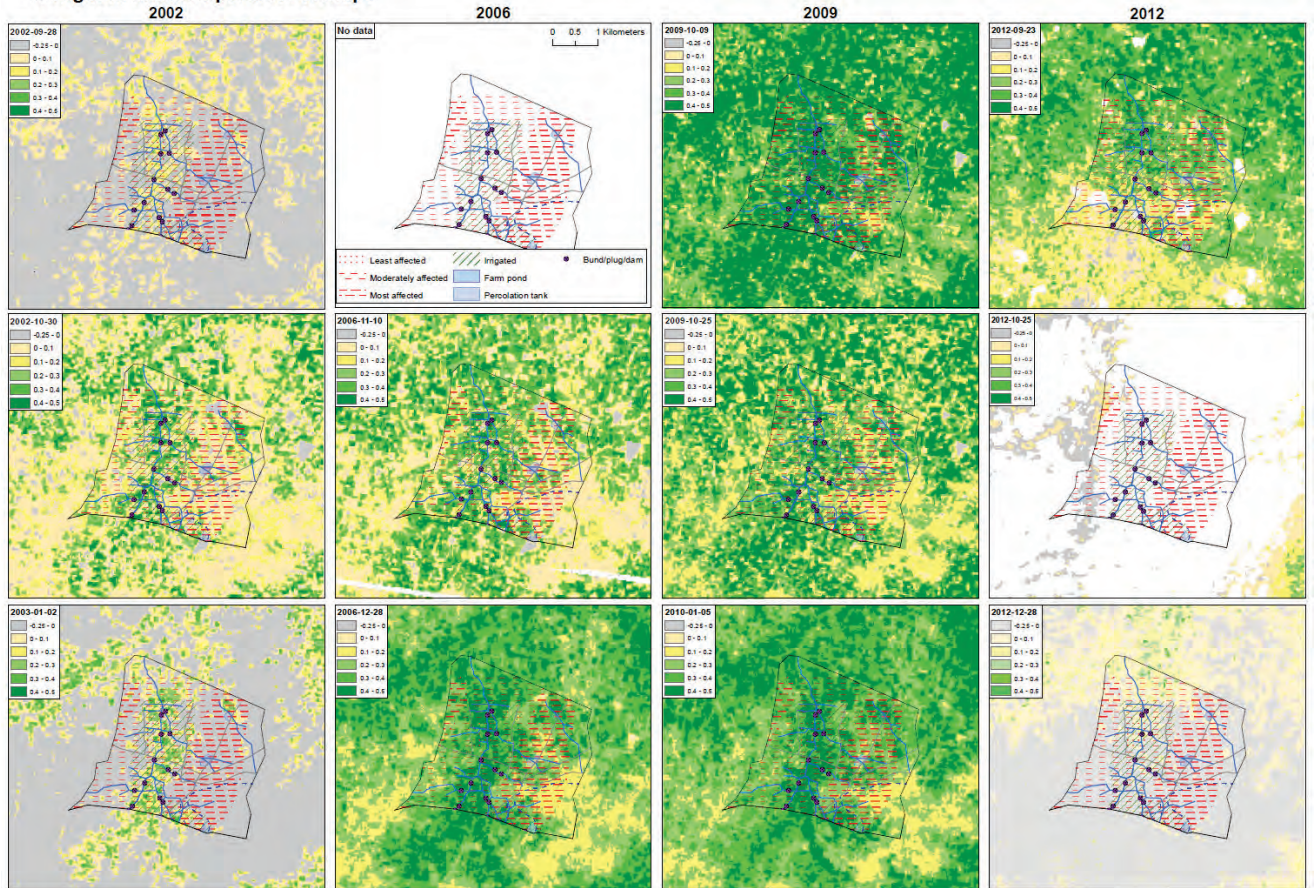


# Village level NDVI maps combined with participatory drought mapping

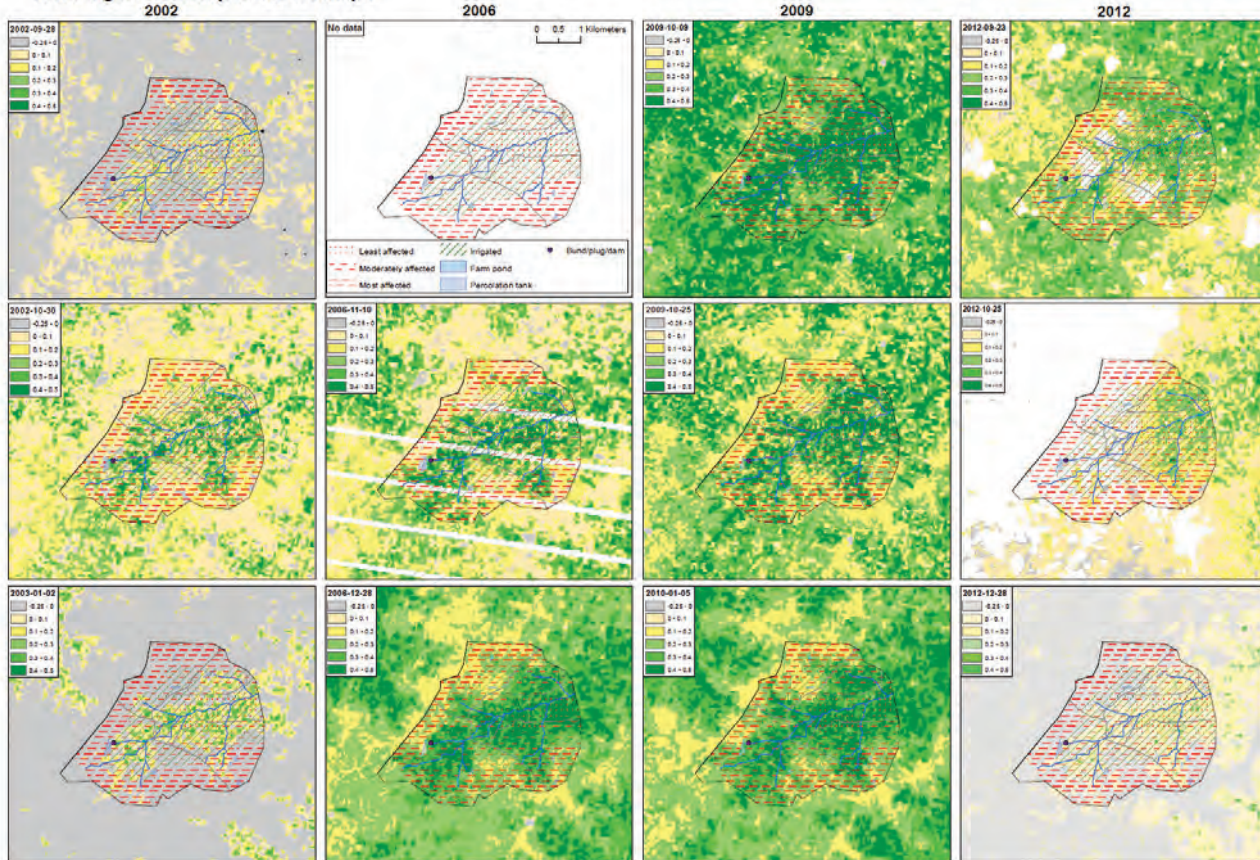




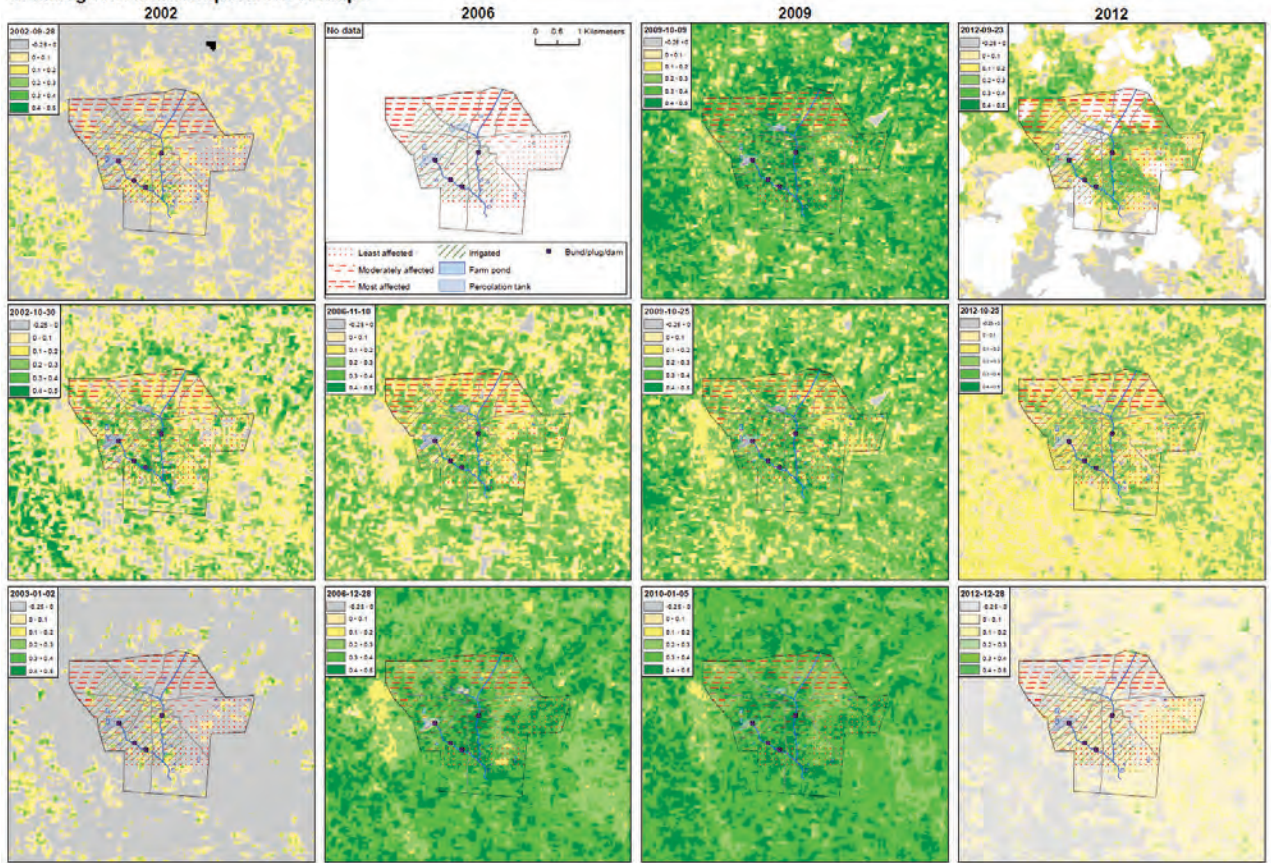
# Dongaon: Multitemporal NDVI maps



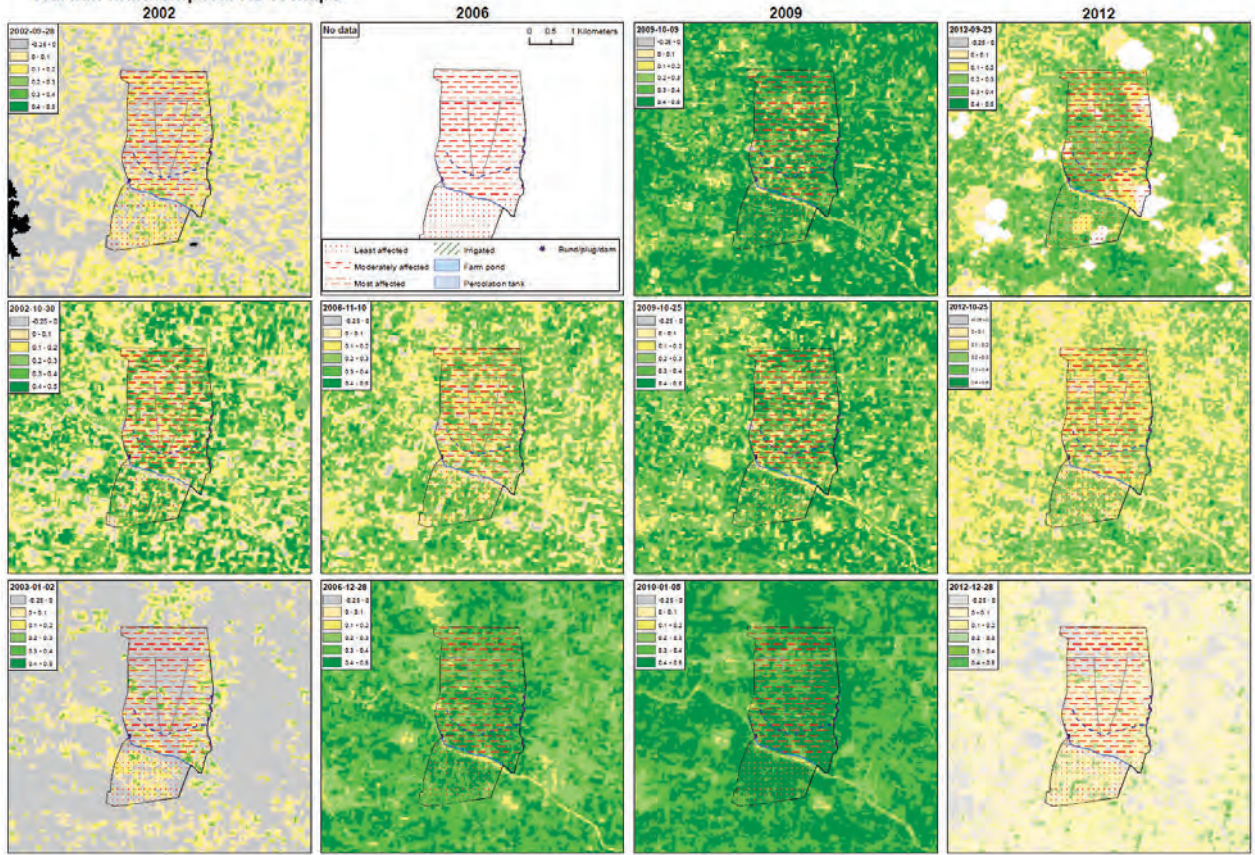
Niwidunga: Multitemporal NDVI maps



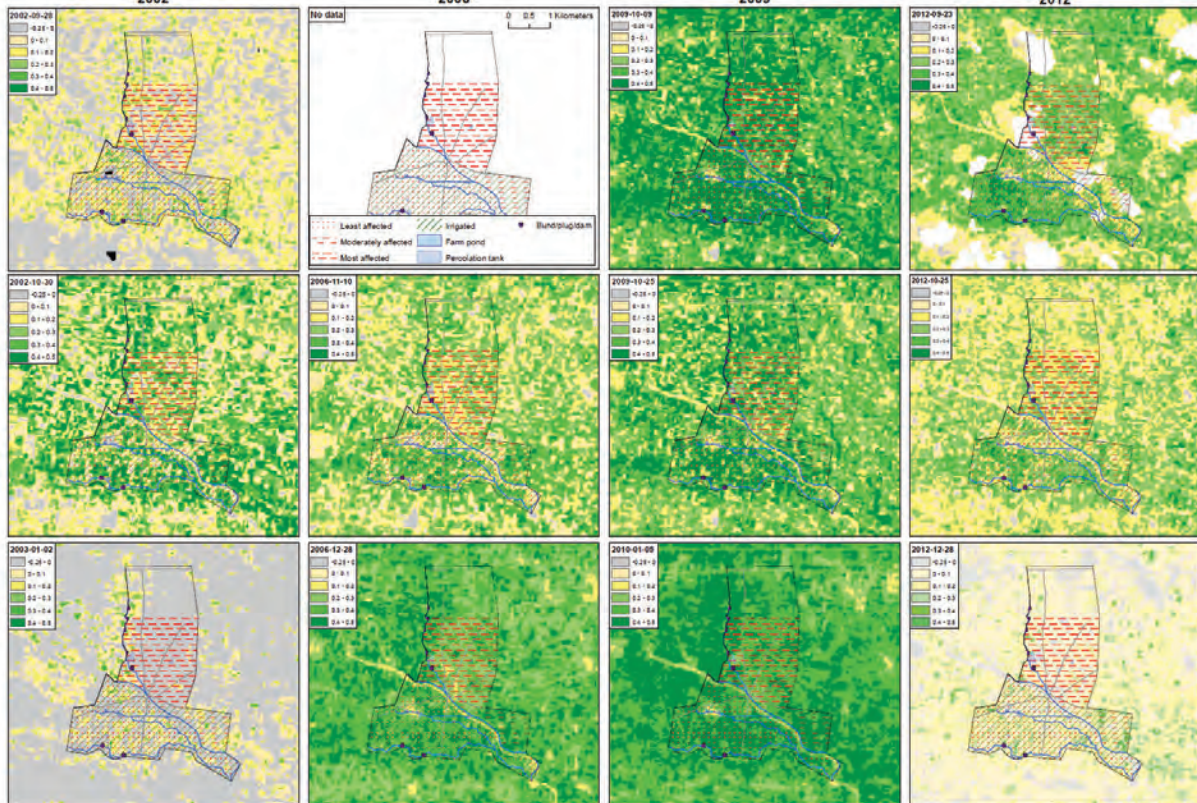
## 2. Malegaon: Multitemporal NDVI maps

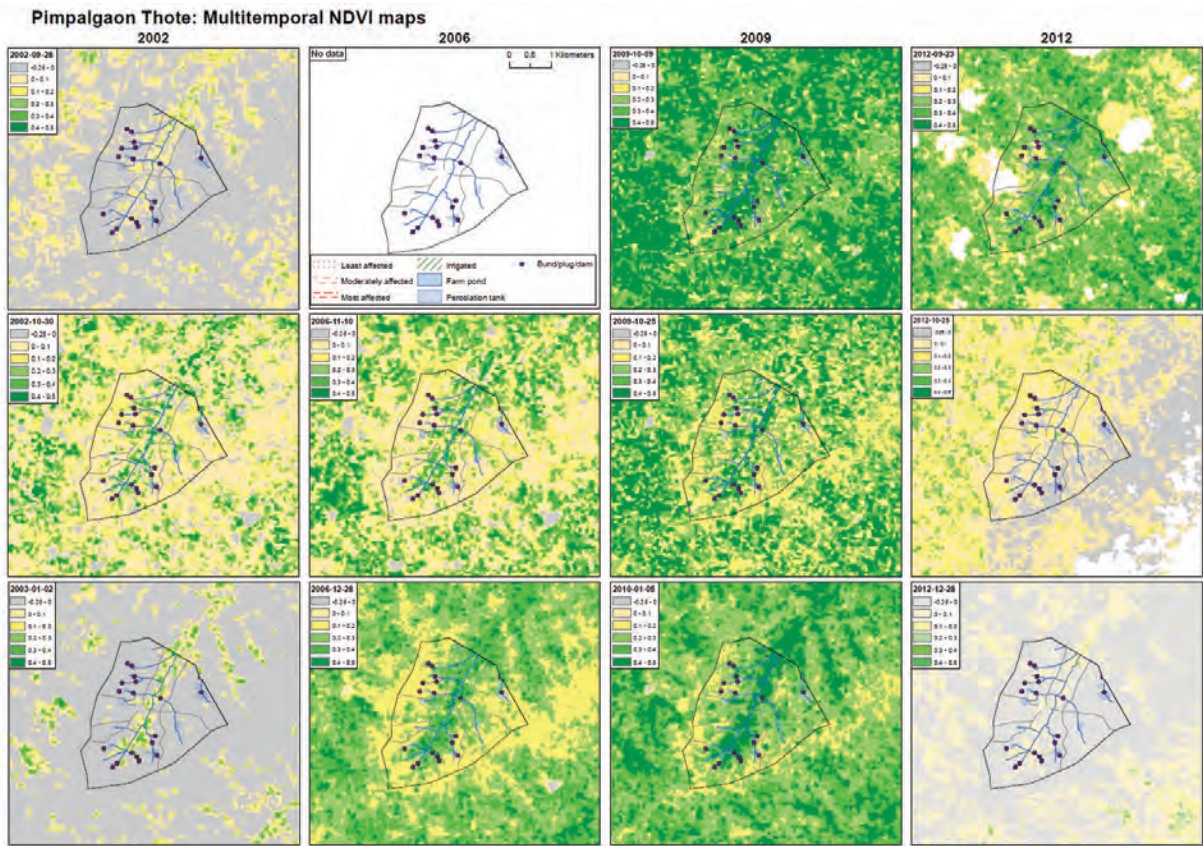


Warudi: Multitemporal NDVI maps



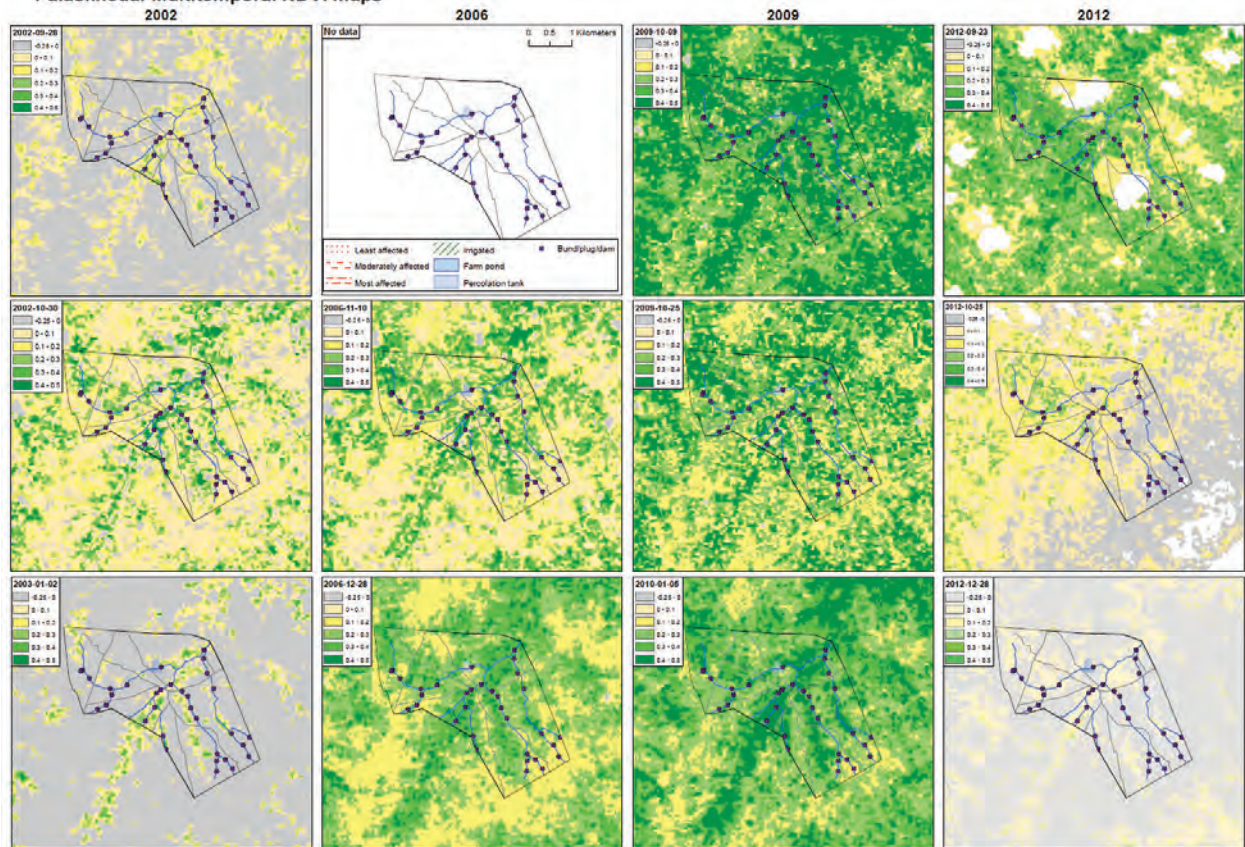
**Kadegaon: Multitemporal NDVI maps**  
2002





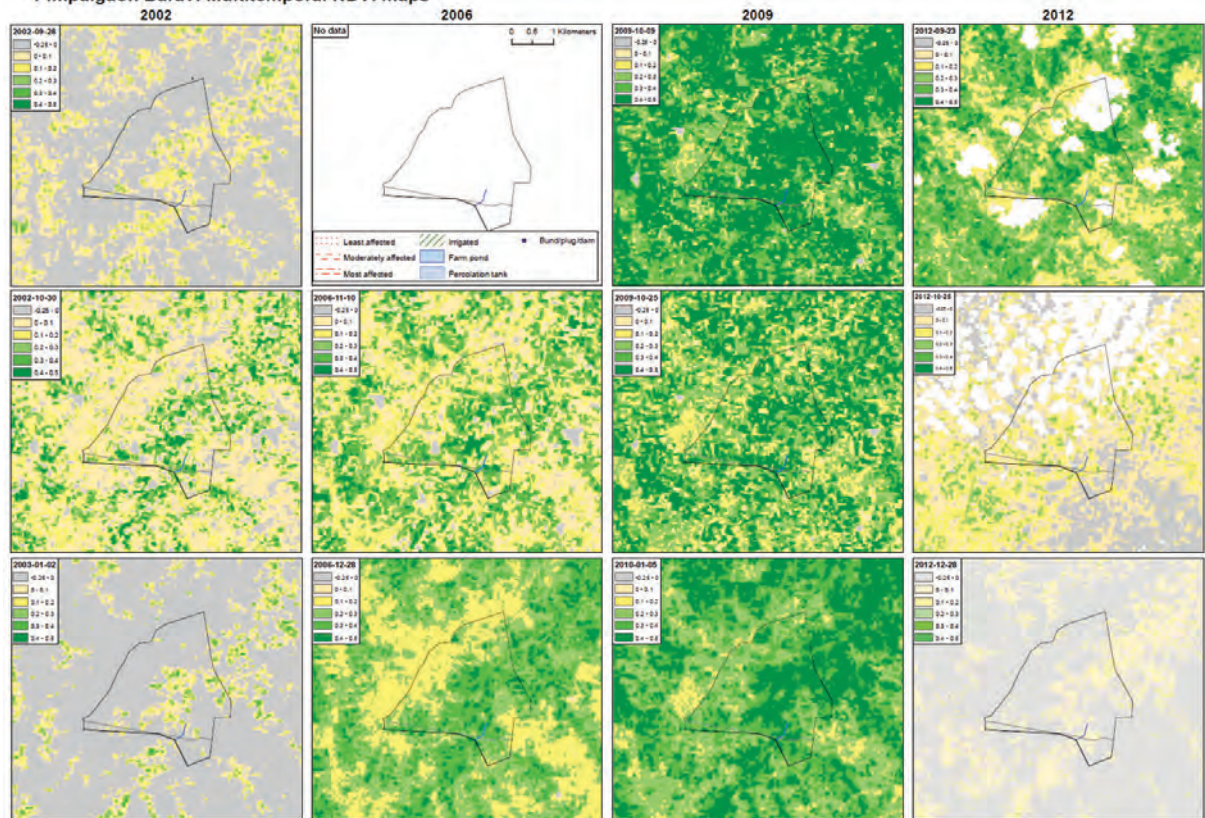
*Only first step of our participatory mapping (resources mapping) was conducted here.*

Palaskheda: Multitemporal NDVI maps



Only first step of our participatory mapping (resources mapping) was conducted here.

Pimpalgaon Barav: Multitemporal NDVI maps



*Only first step of our participatory mapping (resources mapping) was conducted here.*



## D. Table of data sources (for GIS)

What	Source
Polygons with Jalna districts (for overview map)	shapefile provided by TERI
Polygon with Maharashtra state (for overview map)	Natural Earth 10m (manually simplified to match NE110m)
World country polygons (for overview map)	Natural Earth 110m
Lines with main world river centerlines (for overview map)	Natural Earth 50m
Polygons with village boundaries/mapped area from the PGIS exercise.	PGIS 2013-2 (except for Bhokardan villages where revenue maps are used)
Polygons indicating how severely crops are affected by drought in different areas	PGIS 2013-2
Polygons with crop type (only orchard/perennial crop is indicated).	PGIS 2012-9 + 2013-2
Polygons indicating irrigation practice in different areas.	PGIS 2012-9 + 2013-2
Polygons indicating soil quality in different areas.	PGIS 2012-9 + 2013-2
Polygons with water retention structures ( <b>ponds and percolation tanks</b> )	PGIS 2012-9 + 2013-2
Polygons indicating <b>well density in different areas</b>	PGIS 2013-2
Polygons indicating how severely wells are affected by drought in different areas.	PGIS 2013-2
Lines indicating pipelines (as mapped by some villages)	PGIS 2012-9
<b>Lines indicating roads/tracks</b>	PGIS 2012-9
<b>Lines indicating hydro features (mainly nalas)</b>	PGIS 2012-9 + 2013-2
Points indicating position of water retention structures ( <b>bunds, dams</b> ).	PGIS 2012-9 + 2013-2
Ndvi images (grids) derived from Landsat for the date indicated.	LandsatTM images ( <a href="http://glovis.usgs.gov/">http://glovis.usgs.gov/</a> )
Raster DEM	SRTM ( <a href="http://www2.jpl.nasa.gov/srtm/">http://www2.jpl.nasa.gov/srtm/</a> )
Polygons with village boundaries from the revenue maps	Revenue maps were obtained from the District collectors office, scanned, digitized and geo-referenced



## About the Project

The EVA project focuses on the state of Maharashtra. More than 30 % of the state of Maharashtra falls under the rain shadow area and about 84 % of the total cultivated area is rainfed. Drylands in Maharashtra face the combined stress of human pressures and drought. Communities within these drylands are poor and face extreme conditions of water stress. This pilot project aims to assess the extreme risks and vulnerabilities to climatic extreme events in the drylands of Maharashtra and their impacts on agriculture and water resources, and the implications for community-based adaptation in response to these extreme events.

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