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Vulnerability Assessment Of The Agricultural Sector In Yadgir District, Karnataka: A Socio-Economic Survey Approach

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VULNERABILITY ASSESSMENT OF THE AGRICULTURAL SECTOR IN YADGIR DISTRICT, KARNATAKA: A SOCIO-ECONOMIC SURVEY APPROACH

Sarishti Attri[1] and Sunil Nautiyal[2]

Abstract

The agricultural sector is affected by multiple stressors. One of them is climatic change. Its impact is visible in the form of rise in temperature and sporadic rainfall. The non-climatic stressors, evident in the form of price fluctuations, are controlled by market forces and social, economic and political factors. The vulnerability of agriculture to climate variability is also aggravated by the cultivation pattern practiced in a particular area. If a crop contributes heavily in increasing GHGs (Green House Gases), by intensive use of fertilisers and irrigation, it makes the region twice as vulnerable to the impact of climate change. Therefore, an understanding of vulnerability of this sector is critical for the immediate implementation of remedial policies. This study includes a survey of the district to assess the reasons behind the change in the cultivation patterns in last few years and an assessment of carbon footprint contributed by each crop grown in the region. It aims to highlight the crop type that could increase the vulnerability of the region in the long-term. The key findings show the sequential events of how people have shifted from one crop to other and how climatic as well as non-climatic stresses, perceived to have taken the form of overexploitation of land, have affected the fertility of the soil. Water availability has been altered by the changed rainfall patterns and as a result, people have shown more inclination from rain-fed rather than irrigated agriculture. Low productivity from traditional varieties has increased dependency on hybrid seeds, which in turn has further increased their problems. Variability in climate has led to further changes in agricultural practices as it has caused changes in the periods of growth and harvest of crops. This study compiles the climatic variability experiences of the district for the last 10 years along with non-climatic interventions, and analyses how together have they contributed in changing the cultivation patterns of the region.

Keywords: Agriculture; Rainfall; Temperature; Vulnerability; Double exposure

Introduction

The regions that already are vulnerable to harsh climatic conditions and the intervention of intensive agriculture in semi-arid regions pose a novel challenge to the current as well as future residents of that area. It may provide short-term benefits, but eventually, the sustenance of people in such a system becomes questionable. Farmers are bound to make alterations in their cropping patterns in response to the extreme events of climatic variability. The response to the different consequences may vary based on the resilience of the system. Still, the response to these stresses may affect the system both positively as well as negatively.

The study discusses the case of district Yadgir that forms a part of the North-Eastern Dry Zone of Karnataka and has historically suffered many dry spells. This has affected the agriculture of the region and the effect has largely been felt more intensely because agriculture is the main sector on which economy of the district survives. People in the region have made a drastic change in their cultivation patterns and are opting for more water and fertiliser intensive crops.

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The purpose of the study was to assess the vulnerability of the region's agricultural sector to the impact of climate variability and to assess as to how the shift in cultivation patterns in response to the changes has further increased the vulnerability of the region – made it double-exposed.

Aim: To assess the vulnerability of the agriculture sector to the impact of climate variability in Yadgir district (Karnataka). This includes a socio-economic survey analysis and carbon footprint estimation of each crop to assess how the region has been double-exposed to different climatic and non-climatic stresses.

Objectives of the study

- To identify vulnerable crops of the region, find indicators of low productivity in the past 10 years using survey/interview method and validate the survey to identify gaps by using meteorological data
- To approximately estimate the carbon footprint of each crop grown in the region
- To assess the impact of climatic as well as non-climatic stresses on agricultural production

Literature review

"Agriculture in past few decades has significantly expanded along with the increase seen in the demands for the basic resources like water, energy as well as fertilizer consumption, imprinting a considerable footprint on the environment" (Tilman, 1999; Tilman *et al.*, 2001). "If this continues, it would introduce larger uncertainties for climate projections of irrigated agricultural regions as well as cause huge water stress" (Bonfils and Lobell, 2007). "Lower than expected crop yield with rising CO_2 (Carbon-dioxide) concentrations will create further uncertainty" (Long *et al.*, 2006). "In certain semi-arid areas where rainfall is already unpredictable, this might have severe impacts on crop production" (Mendelsohn *et al.*, 2007b). "Thus, these pressures are likely to magnify the environmental footprint of agricultural production on ecosystem productivity and services" (Scanlon *et al.*, 2007).

The drawbacks of agricultural intensification carried out in any region for years becomes evident in the form of depletion of natural resources, deterioration of soil quality and low productivity which leads to rising demands but poor ability to supply. Hence, it affects the economy of the region with its other social impacts included both at individual as well as at system's level as a whole (Pearson et al., 2011).

The study area faces a similar situation where experiences of intensive agriculture have affected the natural resources. Rainfall in the region has become highly uncertain. Irrigation facilities have been provided and earnings have improved but it has brought forth a novel challenge because the people have initiated a shift in their cultivation patterns. This has put more pressure on the land as well as natural resources.

Study Area

Yadgir is known as the "Daal bowl" and the second smallest district after it was carved out from Gulbarga district as the 30th district of Karnataka in 2010. Highly fertile black soil (30%) stretches along the belts of the rivers that flow through Yadgir district. It and is known for bumper red gram, cotton and jowar crops. Apart from this black soil, a mixture of red and sandy soil (70%) is also found in the region.

Yadgir district is located at latitude of 16° 43'N to 16° 28'N and longitude of 76° 42'E to 77° 08' E. It is surrounded by Gulbarga district in the north, Raichur district in the south, Bijapur district in the west and Mahbubnagar district of Andhra Pradesh on the east. Two main rivers, i.e., the Krishna and Bhima along with a few tributaries flow in this region. The Upper Krishna project, built on the River Krishna, stretches through the district in the form of canals to provide irrigation to theentire district.

Yadgir is primarily an agricultural district and is divided into two agro-climatic zones namely Eastern Transition and the North-Eastern Dry Zone. The district has been divided into 3 main blocks – Shahapur, Shorapur and Yadgir. Both, Shahapur and Shorapur come under the North Eastern Dry Zone whereas Yadgir falls under Eastern Transition Zone. The district lies at a height of 389 meters above mean sea level. These zones indicate the preponderance of rain-dependent dry agricultural land. The climate of the region is dry, drought-prone with average rainfall of 777 mm and normal 46 rainy days in a year. During summer, temperature reaches up to 48-50°C with day temperature around 42°C in summer and 26°C in winter. December to May is the driest part of the year and no major agricultural activity is carried out during this time.

The major crops grown in this district are paddy, cotton, jowar, bajra, red gram, green gram, Bengal gram, chillies and groundnut. In terms of productivity, the yield of the principal crops is less than the State average. The variations in rainfall and widespread pest attacks have affected agricultural productivity in the region.

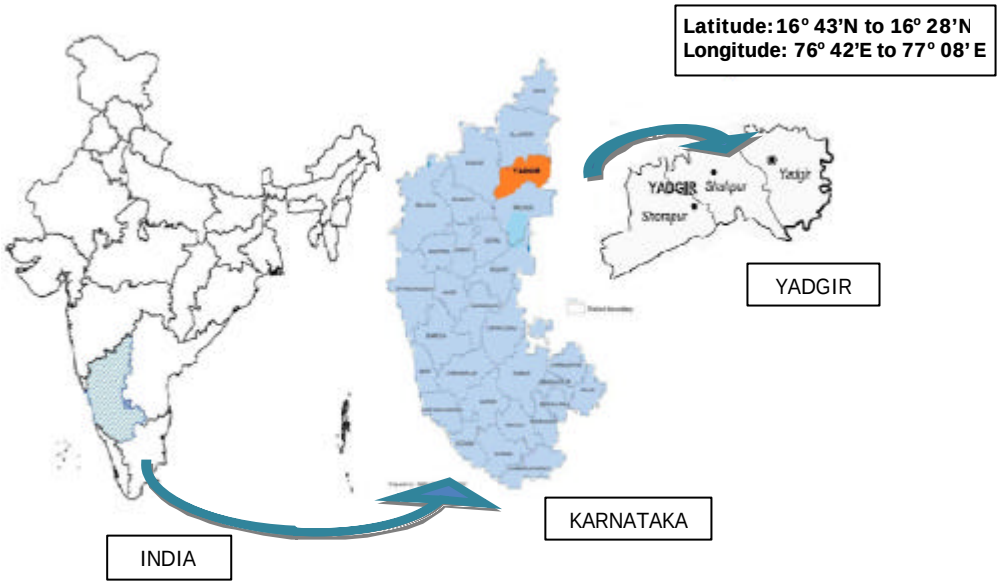
'Mainly Krishna and Bhima rivers flow in the district. The medium irrigation projects in the district are Hattikuni and Soudha Ghar. There are 36 lift irrigation schemes and 445 minor irrigation tanks in the district. Both, Shahapur and Shorapur Taluks/blocks have been fully irrigated. While, Yadgiri taluk has 65 per cent irrigated area' (Ground Water Information Booklet, Gulbarga district, Karnataka, 2007).

'Though 18.73%of men and 25.86% of women are agricultural laborers, they do not have year-long employment, as they remain unemployed from March to June, due to lack of rainfall, irrigation facilities and extreme temperature which reaches 48° to 50° during peak summer season. Road is one of the basic means of transport which requires to be developed in the district. All indicators pertaining to roads in the district are below the State average' (Gulbarga district-Yadgir taluk, Industrial perspective plan, 2008).

As per Census 2001, "The total population of the district is 31.25 lakh, which constitutes 5.93% of State population. The domestic decadal growth is 21.02%, which is higher than the state average of 17.25%... 33.85 per cent of the families (1,26,586) in the district are BPL families. The literacy rate of the district had increased by 12.11% in 2001. The male and female literacy has also increased by 10% and 13.91% respectively."

"Yadgir district is one of the most backward districts in the State and occupies a low position in economic as well as in human development. The district is drought-prone, which further adds to the vulnerability of the poor" (Institute of Human Development, 2008).

Figure 1: Block map of District Yadgir, Karnataka



Source: GIS Unit, RDS, ICRISAT, Government of Karnataka

Framework

This study adopts a place-specific approach to understand the vulnerability through mutual learning and exchange of information with the affected stakeholders (Kelkar *et al.*, 2008). The district has been divided into three different blocks or *taluks*. The study concentrated on two of these three blocks where the people have experienced a rapid change in the yield of crops and which has led to change in the cropping patterns in recent years. Hence, they are representative of the district. The climatic and non-climatic stressors were studied as part of a larger context.

The definitions of vulnerability adopted for this study are: "The degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, either a perturbation or stress" (Turner *et al.*, 2003). "Various factors shape the differences in vulnerability of individuals or groups like entitlements, personal heterogeneity, variations in social obligations, environmental location, livelihood diversification strategies, support networks, empowerment or power relations, access to knowledge, information, and technology" (Noronha, 2003). "A combination of factors may increase vulnerability or enhance resilience to stresses (i.e. the capacity to cope or respond to stress in different ways). Within the context of climate studies, the most vulnerable are considered to be those who are most exposed to perturbations, who possess a limited capacity for adaptation and who are least resilient to recovery" (Kelkar *et al.*, 2008). "Exposure refers to the character, the

magnitude and the rates of future climate change a system is or will be facing. Sensitivity refers to the degree to which a system is affected by climate stimuli" (McCarthy *et al.*, 2001).

Methodology Followed

Fourteen villages were selected for community-level interactions with the main focus on the changes perceived by the farmers in the production of various food crops as well as commercially important crops. Methodology given by (Mary *et al.*, 2009) was followed for conducting the survey. Primary and secondary data were collected to fulfill the objectives of the study. Past and present statuses in the yield of the different cash crops were assessed using data collected from the agriculture department Indicators of low productivity were determined through a preliminary survey. A semi-structured interview/survey was conducted for the determination of crops vulnerable to the impact of climate variability and the change in cropping patterns. Statistical analysis using correlation and qualitative content analysis (cross tabulation) using SPSS (Statistical Package for Social Sciences) were recorded by assigning binary codes to the responses. The survey was validated with the secondary data collected from the meteorological department. To identify double exposure of agricultural sector to multiple stressors (O'Brien and Leichenko 2000; O'Brien *et al.*, 2004) and to assess how these stresses get further reinforced due to the intensive agricultural practices, a carbon footprint estimation of each crop was done by calculating carbon footprint values per kg of each crop (Cheng & Pan, 2011) grown using SimaPro7 software.

Site Selection

For the study, 14 villages were selected in the Shahapur and Shorapur blocks of Yadgir district. A qualitative household survey was conducted to gather information on livelihood strategies and perception of climate risks and adaptation practices at the household level.

The selected study area was typical in terms of economic importance of crops like jowar, red chilli, paddy, cotton, groundnut, red gram, bengal gram etc. It is in the semi-arid areas where recent shifts in cultivation patterns have been observed in the past few years. This district falls under the least developed regions in Karnataka. It is within the project area of the "Baseline Study of Flora and Fauna around village Gogi, Karnataka" project approved by BARC, Mumbai. Villages from these blocks were selected on the basis of purposive sampling according to time and resource accessibility of the villages.

The main villages considered were Gogi, Sahidapur, Diggi, Diggi Tanda, Singanahalli, Hothpet, Sirwal, Harengera, Shakapur, Ingalige, Banaknahalli, Maktapur, Lakshampur, Bijapur and Kongandias. Exercises were held in each village in February, 2012, to gain insight into the community perceptions about climate changes and learn about factors affecting agricultural livelihoods over time. Open-ended semi-structured interviews were conducted in these villages to elicit information on agricultural practices and non-agricultural responses to climatic stress events (Fischer *et al.*, 2005).

To explore factors influencing the vulnerability of the regions where agriculture is practiced and coping measures employed by the stakeholders, case studies were carried out in the different villages of the study area. This section reports insight gained through a few focused group discussions, interviews with individual as well as key informants' (*sarpanch*) in different villages.

There are at least 30 to 35 households per village with 63 per cent having small land holdings (2 to 5 acres), 22 per cent with medium holdings (up to 15 acres) and 15 per cent with large landholdings (above 15 acres). In all, 60 interviews were conducted, four focus group discussions and a few expert opinions were collected in the study area.

These villages in the study are can be accessed to some extent by roads and further by walking. For drinking water, the people in these villages depend on bore wells. Almost all the villages are connected by road. The region has a few health centers and the people have knowledge of curing with indigenous herbs. Education beyond primary school level is also possible because a few high schools and Degree colleges are situated in Shahapur. Nevertheless, the **literacy rate is very low** compared to other districts in the State. Out of all the 60 respondents, almost 57 per cent were illiterate while only 3 per cent were graduates.

Almost all the households in the villages use *chullas* while only a few households have LPG (Liquefied Petroleum Gas) gas stoves. According to the respondents no initiative has been taken by the government to provide subsidised LPG connections. The efforts made by the government are not evident because the households lack basic facilities.

In the recent years, there has been a **massive migration** of the population in this area to the cities, specifically youngsters, who prefer to work in factories and construction sites as laborers in the nearby major cities like Mumbai, Bangalore and Pune, instead of farming. They sense insecurity when it comes to taking up farming as their main occupation. This semi-arid region is highly prone to droughts. Water for irrigation has been provide by the government under the Upper Krishna Project but still problems exist in getting access to canal water. The government has provided free access to electricity for the motors (up to 10 Hp) used for extracting the water out of the canals but availability and usage varies according to the proximity to the canal. Agriculture here is mainly rain-fed but rainfall in the region is becoming highly unpredictable in recent years. It is the reason for farmers shifting to canal irrigation. Farmers also cannot depend only on irrigation supply because it also reduces in the event of less rainfall. This makes the agricultural sector in the region highly vulnerable.

Figure 2: Water obtained through canal irrigation in the study area

Farmers reported crop failure due to less rainfall last year. Moreover, very few people are employed under NREGA (National Rural Employment Guarantee Scheme). Many are not even aware of such schemes and if they are, they have stopped working because investing much time in small jobs affects their agriculture. The younger generation practices farming as a secondary source of income and prefers jobs in the cities that are much more economically reliable.

These communities have polyandrous patriarchal system. The families are large and own small landholdings. Only a few nuclear families – 3 to 4 people per family – exist in this region. The larger families comprise, at the most, 15-20 members each. Due to the poor literacy rate, the people are not aware of family planning concepts and such parents have five or more children. People in these villages have barely completed their schooling and only a few have passed PUC-II (Pre-University College).

Farming is the main occupation of the males of households (almost 87%) with other activities like poultry as an alternative employment. One person had taken up a small government job and a few were shopkeepers apart from doing farming. These people remain unemployed (almost 80%) or take up small jobs for between February and June in the peak summer season when temperature rises to more than 48°C and is not suitable for cultivating any crop. Most of the farmers in both the blocks had small land holdings. The main occupation for women is farming besides doing household chores. Some women do take up poultry as an alternative employment.

Results and Discussion

Climatic and Non-climatic stresses: Community perception

Almost all the households interviewed in Shahapur and Shorapur blocks felt that variability in rainfall and the annual average temperature had increased in the last few years. They could not rely on the timely onset of the monsoon because they had observed delays by a month or two in last few years. The respondents noted a decrease in scattered light rainfall and an increase in sudden intense rainfall, which affected the crops drastically. Some of the indicators mentioned by respondents were:

- **Climatic stress:** Past events of sporadic rainfall has led to a change in the cultivation pattern of the region. There has been a shift from rain-fed to irrigated agricultural practices. Earlier, they used to grow jowar, bajra and pulses but have now shifted to cotton and paddy. In fact, paddy is the most cultivated crop.. It is an irrigated crop and requires huge inputs but a secure option for the farmers because it ensures huge productivity. It has benefitted the farmers, especially after the implementation of the Upper Krishna Project. However, according to agricultural experts it is not suitable for the kind of soil in the region. In spite of constant warnings from the agricultural department, people are doing **intensive cropping in this region**.
- **Temperature variability has increased** in past few years in this region. An abrupt rise in mean annual temperature to 32.97°C - the highest observed in the last 10 years – was recorded in 2006. There was a rise of about 5.4°C. The recorded normal temperature in the region is 27.57°C.
- New hybrid varieties have led to an increase in production and many crops like paddy and cotton are now being recognised as important cash crops of the district. An increase in temperature and humidity has increased the **vulnerability of these new varieties to new diseases, insects**

and pests. New hybrids also come with new inborn diseases. This makes it mandatory for the farmers to spray pesticides once in four or five days, which poses a threat to the quality of soil.

In addition, the **soil of the study area shows a huge variation** from black, red to sandy. Therefore, the suitability of a particular variety of seed to a particular region can be totally opposite from any other region. Farmers have incurred loss sometimes due to this reason also.

- **Change has been perceived at the time of growing and harvesting**. About one or two months' delay in sowing, especially of cotton, paddy and chilli, has been noticed. Rainfall has become highly unpredictable in the region and the people adapt by growing red-gram and green-gram if the region receives rainfall in June. When there is a delay in the monsoon, they grow cotton.

- The government has helped in better adaptation to the changing conditions by providing subsidised electricity – ? 1.5 to 2 up to 10 hp of electricity used and beyond that at ? 8 per hp. In addition, improved seeds are available for small and marginal farmers at 50 per cent subsidy. It is 10 per cent for the other farmers. Nevertheless, most of farmers who were interviewed did not prefer buying seeds from the government centres. According to them, only 10 per cent of what is given by the government through the subsidised schemes reaches the farmer. The problem is in the lack of awareness among the people regarding the government's schemes. According to a senior official, only selected people from some villages are trained and are made aware of schemes like NFSM (National Food Security Management), RKBY(Rashtriya Krishi Bima Yojana), NPDP(National Pulse Development Program), sprinkler irrigation (75% subsidised but still not implemented), Krishi Yantrikaran Yojana and Bhoo Chetna. This points to the **lack of proper implementation of the policies made by the government.**

- **Dependency on chemical fertilisers has increased** because of the reluctance of the State government to organise awareness campaigns to guide the farmers on what to use and how much to use. This has led to **over-exploitation of the soil** and the condition is such that the population of earthworms in the soil has reduced drastically.

- Rainwater harvesting is not practiced in the region, probably due to the scattered distribution of the rainfall. Special efforts have not been made by the local communities as well as the government to create awareness about water conservations methods. Their **reliance is totally on canal water as well as bore wells,** which has **increased pressure on the ground water.**

- Another major reason that makes the region more vulnerable to the changing climatic conditions is the **low rate of literacy** and awareness. The region is recognised as one of the most backward and least developed areas in Karnataka. This reason for this backwardness, one of the farmers living in the region explained, is because the farmers living within the first 25 kms of the canal exploit the canal water (*nirawari*) to the maximum extent possible by practising flood irrigation, which leads to **problems of siltation** and the soil becomes barren within five years.

  Farmers in regions far away from the canals suffer the repercussions of **improper canal water distribution** in the event of low rainfall. The canal water that they receive is not adequate for

cultivation. Huge tracts of land become barren and farmers are forced to abandon such lands. Small and marginal farmers are the major victims.

- **Deforestation activities** are rampant in the region and make it more vulnerable. Only a small area (10-15%) is covered by forests, and that too shrub forests, in this region. The people have converted most of these forests into agricultural land and currently just three to five per cent of forest area exits that can give them fodder and fuel in the region. So, reduced forested area, reduced the grazing area has resulted in reducing population of cattle in the region, which today is fed with the residue of the crops grown. This further had reduced the chances of the villagers of taking up poultry as their main occupation. However, it is taken up as an alternative employment by a few households during the 5 months of dry season – from Feb to June – when no cultivation is carried out.

- According to a senior official of the Agricultural Department in the district, the region comes under the command area of Upper Krishna Project. Hence, the reports mention that 80 per cent of the area that needs to be irrigated but in reality only 40 to 42 per cent of the area is irrigated. In Shahapur, a taluk that comes under the study area, out of the total area of 1,59,492m^2, only 1,41,988m^2 comes under cultivated area, out of which only 55,945m^2 – less than 50 per cent – is irrigated while 86,043m^2 is left un-irrigated.

- **A shift has been observed in the growing time of the crops** due to delay in the rains. In case the region does not receive any rainfall in June (monsoon season), as has been the case from past few years, they are bound to grow crops in August or else rely on the controlled supply of water from the canal, which is also not well managed.

- For the last few decades the people depended on forests for herbs and a **rich knowledge** existed among them in the use of such herbs to cure ailments. However, this **is gradually being lost** because almost 83 per cent of the households covered did not have any knowledge of these **indigenous herbs.** Those who had were not making any effort to share their knowledge with the younger generation. The younger generation too is reluctant to acquire this precious knowledge.

- Agricultural experts confirm that paddy was not suitable for the kind of soil that existed in the region. After canal irrigation started, farmers were advised to carry on with the cultivation of crops grown earlier but paddy being a food crop was considered less risky without adequate irrigation facilities. The case with paddy is that it gives bumper crops initially but constant high input of chemical fertilisers and improper irrigation, as was the case in Yadgir, affects the soil drastically and it deteriorates in quality and brings down the production. It may give excellent short-term benefits but eventually paralyses the economy, especially in a semi-arid region like Yadgir, which comes under northeastern dry zone of Karnataka. In a few villages of Shorapur district, covered in the study, people reported that about 5,000 acres of land where paddy as well as other crops were grown extensively had been affected drastically and was almost barren. In one village, around 1,500 households are surviving on water from four to five bore wells because **water supply from the canals in the region is inadequate**. In another village, the people do not get water often so

they have constructed pipelines between two villages and borrow water in the events of water scarcity. **Legal pluralism** is evident in a few villages.

Figure 3: Huge acres of cultivable land became barren in the study area

- According to the villagers, the government had taken initiatives to build **tanks** but due to **poor water supply** these tanks dried up and are **not maintained properly**.
- Changing cropping patterns have brought new problems – paddy is mostly affected due to irregular water supply, **chilli and cotton,** which are also new crops in the region, are most **prone to attacks by pests.**
- **The quantity of fertilisers used increases every year** because 10 years ago the farmers used fertilisers or sprayed insecticides and pesticides 8 to 10 times per crop. Currently they do so at least 10 to 15 times per crop. **Constantly rising prices of the inputs** in such situations is another burden on the farmers. According to the farmers of the region, the price has risen from ? 100 per quintal a few years ago to ? 1000 per quintal today.
- After canal irrigation commenced, **the dependency of farmers on rainfall reduced drastically**, and contributed to the change in their cropping patterns. They have more or less stopped growing the traditional crop varieties and **agriculture in the region has become more fertiliser and irrigation intensive**, which cannot be supported for long by the soil of the region.
- The agriculture in the region has become more driven by economy and the **land is being exploited more than it can support**.
- **The population of a few indicator species of the region like peacock, white-breasted kingfisher and wild boar (it used to feed on bajra) has reduced.** As, the forest area reduced so has the production of *Sitaphal* (custard apple) which used to grow in abundance in the forests a few years ago. Experts confirm, "Climate change and land use change are the key drivers of biodiversity change (Chazal and Rounsevell, 2008)." These changes in dimate might have different

effect on different species and varieties of animals and plants, which might disturb the ecological balance of any particular ecosystem (Omann *et al.*, 2009).

- A few affluent farmers have collectively invested in growing vegetables like tomato, brinjal, onion and spinach. They have their own bore well and share the benefits.
- Cultivation of paddy has overtaken jowar in past eight years in the study area.
- **Alternate yet frequent occurrences of drought and heavy rains** during ripening stage have affected production in the region.
- An increase in the number of bore wells reduced **the level of the water table has reduced beyond the depth of 200-300 feet**.
- Initially paddy was grown for 2 seasons, i.e. Kharif (July to Dec) and Rabi (Dec to March) as the canal water was available for five to six months. However, due to reduced rainfall, the water is available for one season and it has affected productivity.
- LPG in not available at subsidised rate and the use of wood as fuel varies from 1.5 to 2 quintals per month. The area under forest cover is less, yet the people are forced to collect more fuel for wood from the trees grown their fields and in village commons.
- The quality of the produce has also deteriorated after canal irrigation was introduced in the region. Earlier crops were grown for one season and the quality of the produce was good. Today the quantity produced may have improved but the quality has reduced, especially in kernel size for the cereals because the same crop is grown twice a year. The quality of the soil has also deteriorated.
- **Market pressures** are quite evident in case of the price of chillies, which crashed from ? 6000 per quintal in 2010 to ? 4000 per quintal in 2011

Table 1: **Ranking of vulnerability indicators of the agriculture sector (higher the ranking of the indicator, larger the number of farmers consider it responsible)**

Indicators of low productivity	Ranking
Sporadic rainfall	1
Improper canal water distribution	2
Deterioration of soil quality due to intensive agriculture practices	3
Increased pressure on ground water	4
Rise in the no. and type of insects, pests and weeds	5
High price of farm inputs	6
Shortage of labour	7
Market stresses	8
Deforestation	9
Low rate of literacy	10
Lack of awareness	11
Increased GHG emissions from paddy cultivation in semi-arid area	12
Loss of indigenous knowledge	13

Estimation of Carbon Footprint of Production of Each Crop Grown in the Region

Modern agriculture depends on fertiliser intensification but poor utilisation leads to unproductive results. It further leads to emission of methane, carbon dioxide, nitrous oxide etc., which pollute the environment and gradually contribute to global warming (Smith *et al.*, 2008).

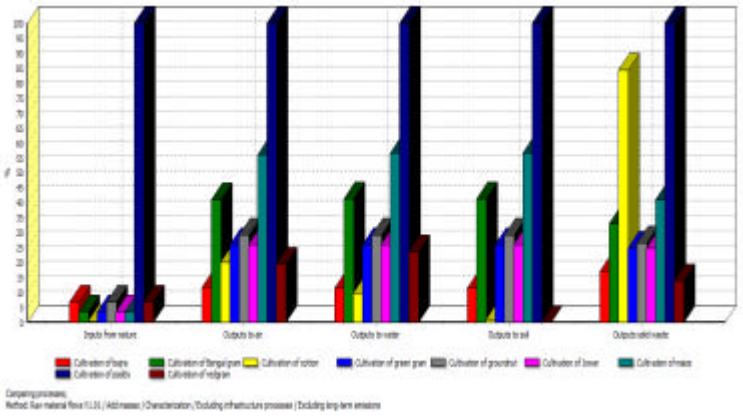
'Greenhouse gases are those that absorb infrared radiation in the atmosphere, trapping heat and warming the surface of the Earth. The three greenhouse gases (GHGs) associated with agriculture are carbon dioxide (CO_2) released largely from burning of plant litter, methane (CH_4) mainly from the livestock, and nitrous oxide (N_2O) mainly from the soil' (Snyder *et al.*, 2009). According to the US Inventory Report, "methane is produced during flooded rice cultivation by the anaerobic (without oxygen) decomposition of organic matter in the soil. These soils are ideal environments for methane production because of their high levels of organic substrates, oxygen-depleted conditions and moisture. The level of emissions varies with soil conditions and production practices as well as climate." Estimating the extent of the carbon footprint of the cultivation such crops may help in formulating strategies to reduce it by using improved technology and efficient management (Cheng & Pan, 2011).

The cumulative effect of global warming and land degradation caused by intensive agricultural activity affects the yield drastically.

SimaPro7 software was used for the present study, which is mainly used for doing Life Cycle Assessment (LCA) – "Analysis of contribution of life-cycle stages of a process/product to the overall environmental load, usually with the aim to prioritize improvement on these products and processes" (SimaPro7, An introduction to LCA, 2008). It was used for calculating emissions to the air, water and soil, i.e., calculation of carbon footprint of the production stage. Data for the requirement of fertiliser, manure, irrigation, electricity and fuel for production of 1 kg of a crop were fed to the software and the output in the form of emissions incurred through the process was generated.

Results Generated for Carbon Footprint Estimation of the Production Stage of Each Crop

Figure 4: Comparative account of inputs as well as outputs for different crops



The above figure clearly depicts the comparative account of both inputs as well as outputs of cultivation of all major crops in the region. It is quite evident from the figure that paddy requires maximum inputs in the form of irrigation, fertilisers, manure and pesticides as well as contributes maximum to air, water and soil in the form of emissions. The inputs for the production of paddy are almost 10 times higher than production of other crops and generate thrice as much emission generated by other cereals and pulses. Hence, paddy has the largest carbon footprint, as far as production is considered. This contributes to making the region twice as vulnerable because the soil has been affected by stagnation of water (O'Brien and Leichenko 2000; O'Brien *et al.,* 2004). In next few years, the soil may lose its fertility and huge investment would be required to restore soil fertility.

Comparative Analysis of Paddy V/s Red Gram

Figure 5: Inputs as well as outputs to the air, water and soil on cultivation of 1Kg of Red gram

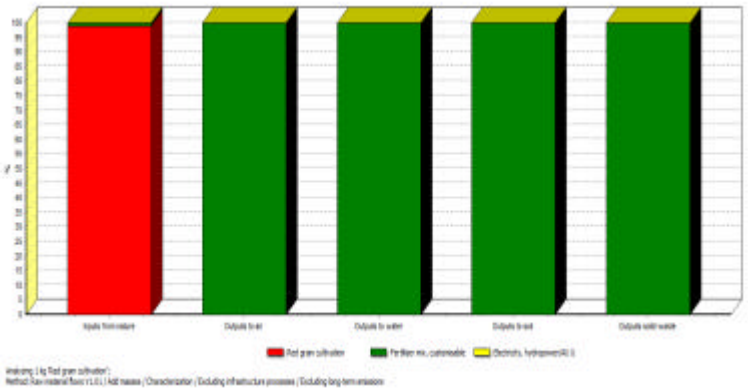
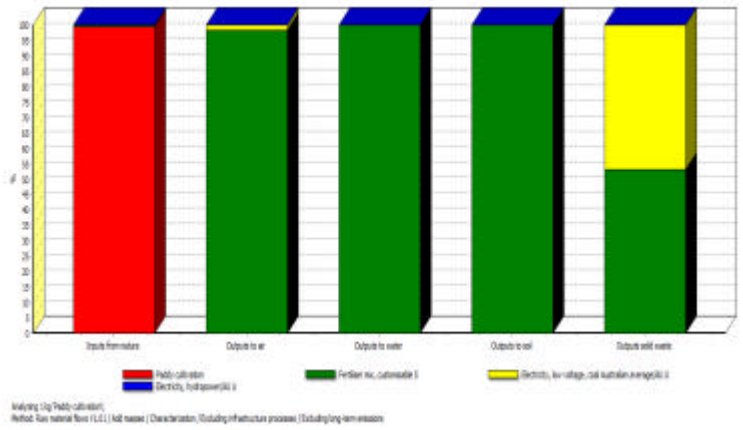
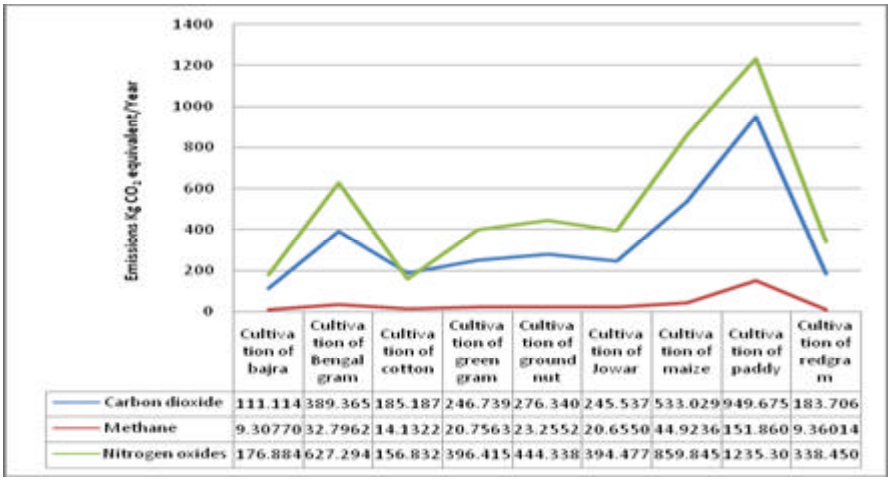


Figure 6: Inputs as well as outputs to the air, water and soil on cultivation of 1Kg of Paddy



Figures 6 and 7 bring out the comparison between the two major crops cultivated in the region. Paddy is preferred in the region by the farmers. Red gram was once held as a representative crop of that region because it was suited best to the prevalent dry climatic conditions. It requires minimum inputs of fertilisers and irrigation and, hence, a smaller carbon footprint. Paddy on the other hand, is huge water, energy and fertiliser intensive crop and leaves a bigger carbon footprint. Hence, cultivating paddy in this region is not a sensible option.

Figure 7: Relative contribution of each crop to emissions of CO_2, CH_4 and NO_2



	Cultivation of bajra	Cultivation of Bengal gram	Cultivation of cotton	Cultivation of green gram	Cultivation of ground nut	Cultivation of Jowar	Cultivation of maize	Cultivation of paddy	Cultivation of redgram
Carbon dioxide	111.114	389.365	185.187	246.739	276.340	245.537	533.029	949.675	183.706
Methane	9.30770	32.7962	14.1322	20.7563	23.2552	20.6550	44.9236	151.860	9.36014
Nitrogen oxides	176.884	627.294	156.832	396.415	444.338	394.477	859.845	1235.30	338.450

Figure 8 clearly presents the carbon footprint of each crop grown in the region. The values have been converted to Kg CO_2 equivalent per year. The highest emissions were observed in the case of paddy in the form of CO_2, NO_x (Nitrous-oxide) and CH_4. High NO_x emissions could be the result of intensive use of fertilisers. The contribution of other food crops and pulses was almost negligible compared to paddy (Pathak *et al.*, 2010). A study of the rice soils of North India focuses on a similar concept (Bhatia, *et al.*, 2011). Being a semi-arid region, it is already vulnerable to the impact of climate variability and further cultivation of paddy makes the region more vulnerable. Hence, cultivation of paddy in the future will make the region doubly vulnerable to the impact of future climate changes.

The above figures for methane and nitrogen oxide were obtained by multiplying the concentrations with their global warming potential.

GWP is a relative measure that compares the amount of heat trapped by a gas to the amount of heat trapped by a similar quantity of carbon dioxide. It is compared for a specific lifetime of 20, 100 and 500 years. In this study a lifetime of 20 years was considered, i.e., the 20-year GWP of nitrous oxide is 289, which means that if the same mass of nitrous oxide and carbon dioxide was introduced into the atmosphere, nitrous oxide will trap 289 times more heat than carbon dioxide over the next 20 years (Walsh *et al.*, 2009).

One of the limitations of using the above software is that, when emitted CH_4 takes multiple paths, there can be chances of double counting.

Table 2: List of GWP's for different gases

Global Warming potential of the different GHG's(Lifetime 20 years)	
CO_2	1
CH_4	72
NO_2	289

Results Obtained from the Data and the Survey

Figure 8: Productivity (Kg/hectare) of paddy (2000-2010)

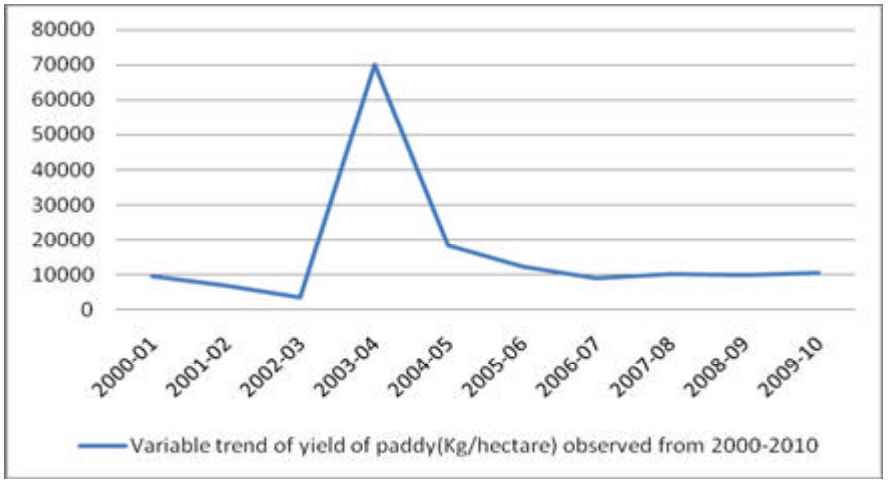


Figure 9 depicts high yield for irrigated paddy cultivated in the region in 2003-04, but in the following years, the yield decreased and has been almost constant, since then. The probable reason could be deterioration of soil due to intensive cultivation because the soil in the region cannot support prolonged paddy cultivation.

Figure 9: Productivity (Kg/hectare) of different pulses grown in the region (2000-2010)

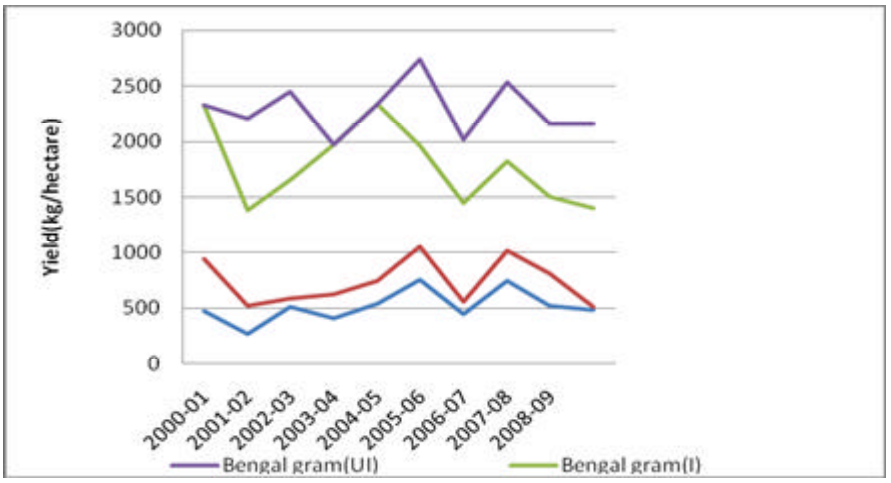


Figure 10 reveals a variable trend in the productivity of the pulses grown in the region. Pulses are famous dry land crops, but variability could be due to variable rainfall experienced in the region. In addition, cultivation of paddy as a major cash crop, made the farmers take a step back for the cultivation of pulses, which they found less lucrative and less productive in comparison to paddy and cotton. Hence, these pulses lost their importance in following years.

Figure 10: Productivity (Kg/hectare) of different food crops grown in the region (2000-2010)

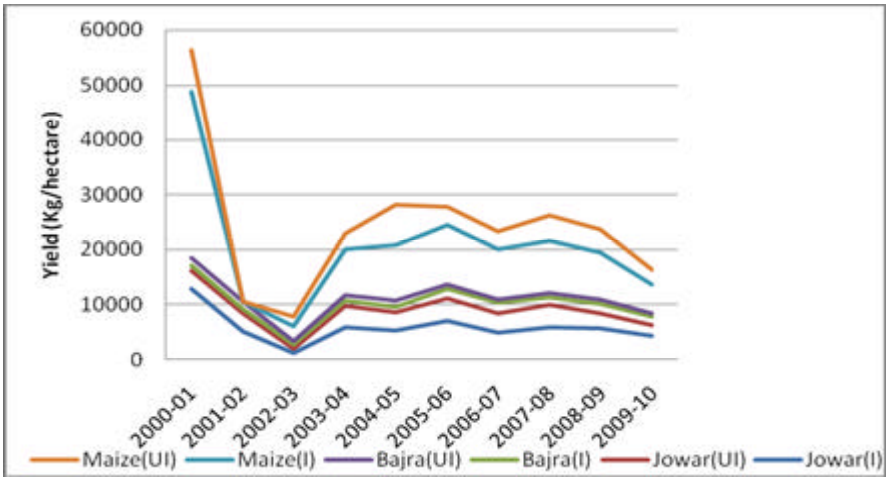
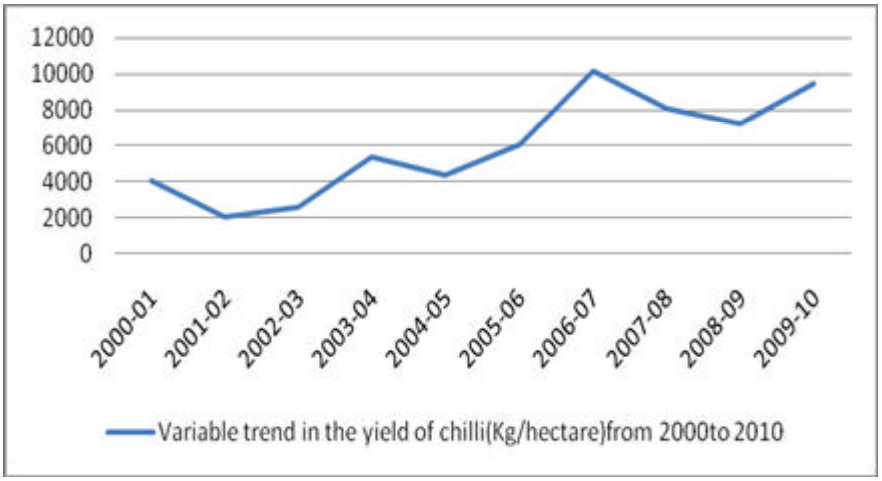


Figure11 depicts that productivity has fallen for all three crops – jowar, bajra and maize – compared to productivity in 2000. Most of the farmers replaced these crops with paddy after canal irrigation started because canal dependent villages grow paddy.

Figure 11: Productivity (Kg/hectare) of chilli grown in the region (2000-2010)



The yield of chilli increased gradually in past few years in spite of variable temperature and rainfall in the region. It has been recently taken up on a larger scale and can be considered as a favorable cropping option for the region (Figure 12).

Figure 12: Correlation between yield and rainfall from year 2000-2010
(I-Irrigated, UI-Un-irrigated)

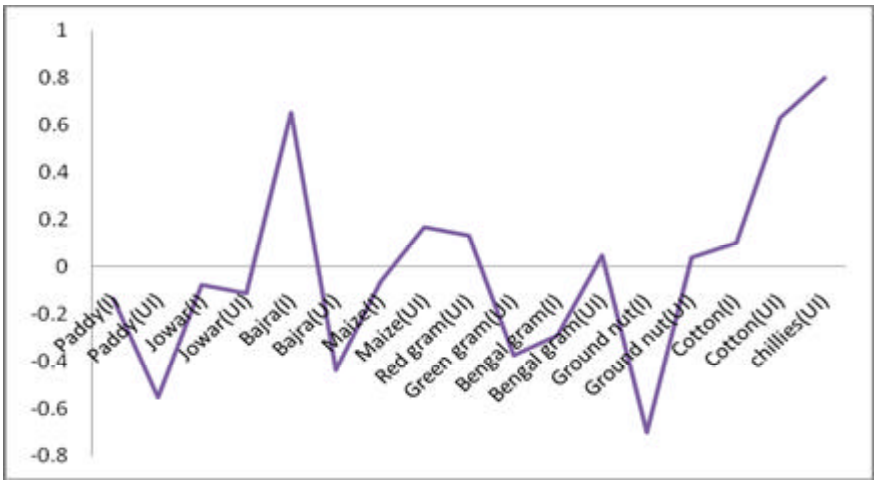


Figure 13 shows that mostly dry land crops, which are not irrigation dependent are least affected in the event of variable rainfall. So, either most of them show zero correlation or are negatively correlated. Chilli shows a positive correlation with rainfall. In addition, its production has shown a gradual increase in the past few years.

Figure 13: Correlation between yield and average temperature from year 2000-2010
(I-Irrigated, UI-Un-irrigated)

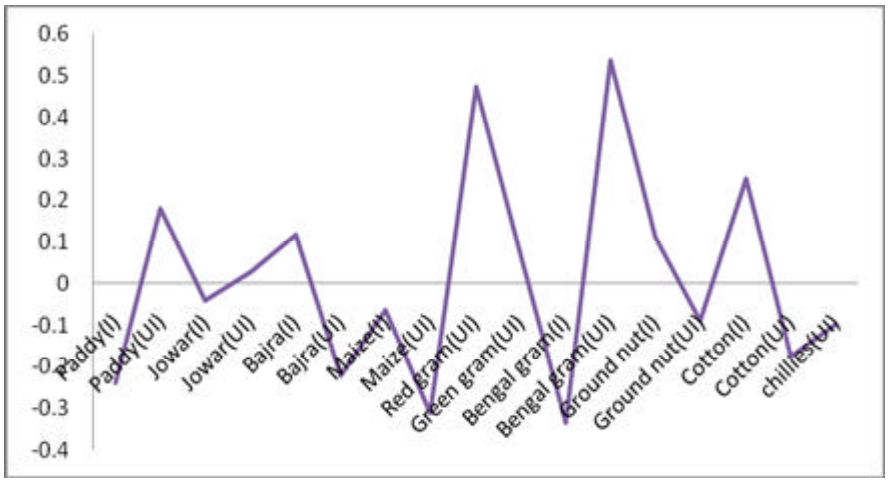
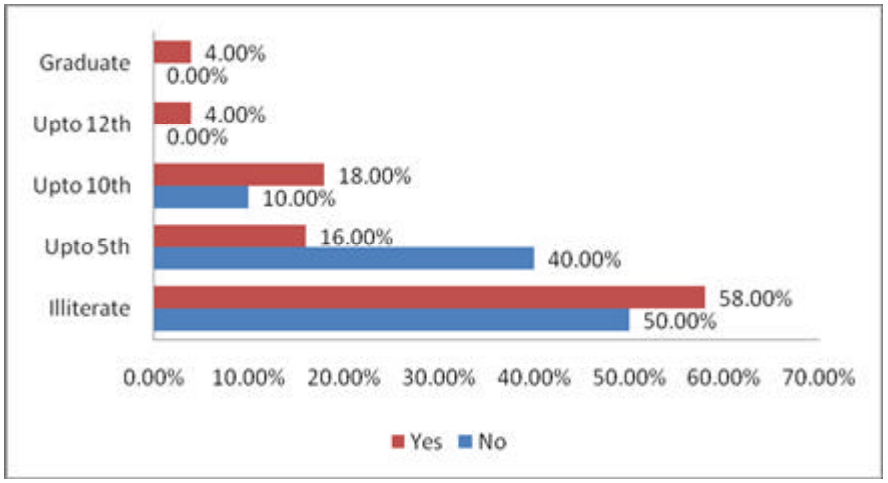


Figure 14 depicts that the yield of pulses (both red and bengal gram) has been positively affected due to change in temperature, i.e., the yield shows a positive correlation with variability in annual average temperature.

Maize production, however, shows a negative correlation with the change in annual average temperature. When the temperature has risen, the production has been negatively affected and vice versa. The other crops are either positively affected by the change in annual average temperature or do not show any correlation with it.

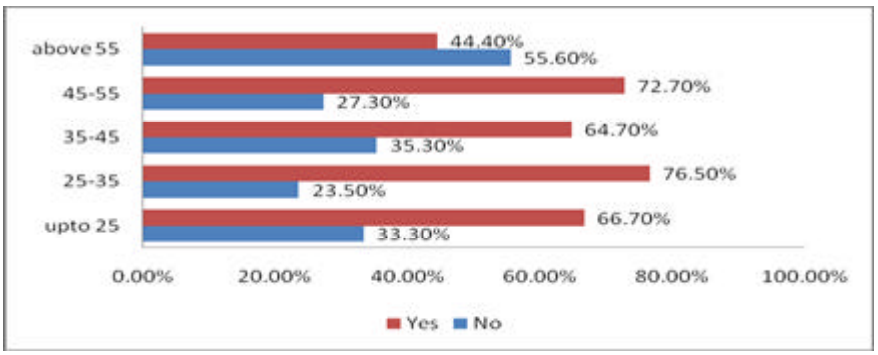
List of Bar Charts Depicting the Survey Results Based on Farmers Response

Figure 14: Economic reasons behind current crop selection



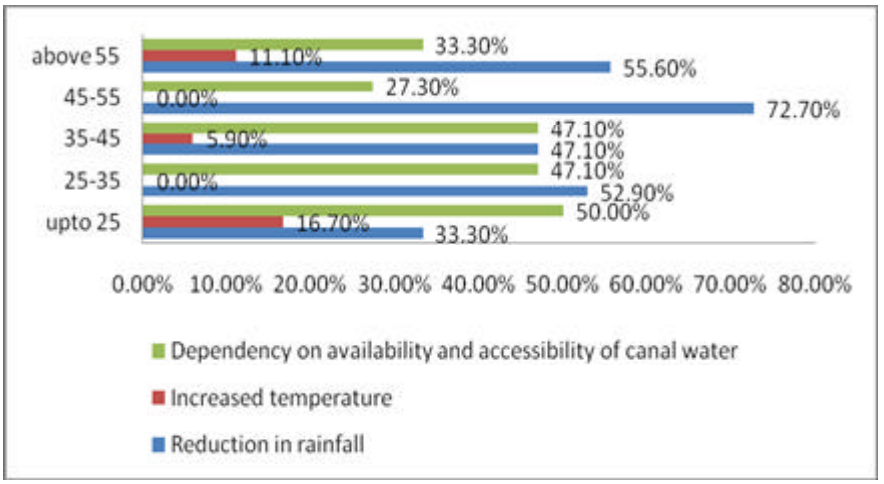
Almost 58 per cent of the respondents who were illiterate believed that they have shifted to paddy cultivation purely due to economic reasons – on the same land the productivity of paddy was much higher than that of pulses. Hence, illiteracy contributes a lot in making this region vulnerable to any future events of climate variability.

Figure 15: Soil degradation in the study area



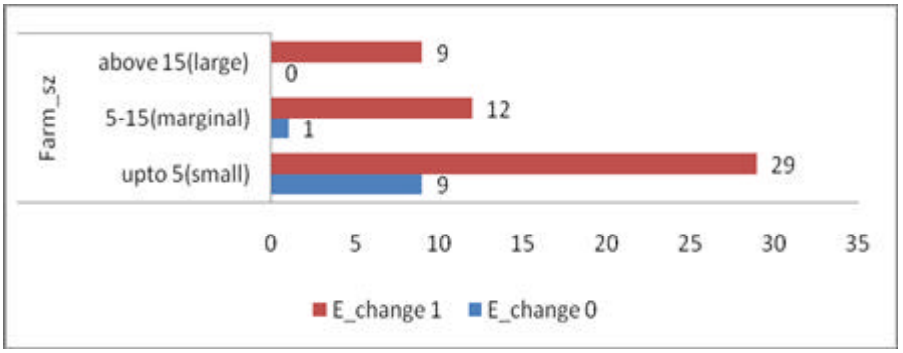
Almost all the age groups (25 to 55 years, i.e. the major working class) reported that the quality of soil in the region has deteriorated in past few years. Intensive cropping and immense stress on the ground water resources has made the soil less productive.

Figure 16: Reasons behind the shift in cultivation patterns



A major chunk of the population considers availability and accessibility of canal water to be the reason behind the shift in the cultivation patterns. They shifted because they found paddy to be a more lucrative option, in terms of productivity.

Figure 17: Variability observed in the climate in past few years



Farmers with small land holding – less than 5 acres – have experienced the impact of variability in the climate. They are relatively poor and have had faced huge losses in the past due to such variability experiences. Hence, this increases their vulnerability to future climate variability.

Other Findings Include the Following:

- Evident variability in climate leading to low productivity was experienced mainly by farmers aged 25 - 45 years (94.1%), i.e., the middle age group which constitutes the major working class involved in farming. They believe that region's soil quality has degraded because of the changes made in cropping patterns to overcome low productivity. They point to the increase in agricultural land-use, removal of forests and intensive cropping to reap economic benefits as the major reasons for the loss of species that existed in this region.
- Almost all age groups (25-55 years) considered reduction in rainfall and availability of canal water as the main reasons behind change in cultivation patterns.
- The dependency of the villagers on forests for NTFP (Non-timber Forests Produce) collection is very low.
- Not many people are aware of medicinal plants and their utility and those who are aware are not making efforts to pass on this rich indigenous knowledge to the younger generations.
- Majority of the illiterate people (68% of those total interviewed) believe that variability in climate has led to the change in their cultivation patterns. In addition, this class (85.7%) shifted to cultivation of jowar, bajra and pulses to paddy and cotton mainly due to economic reasons. They are least aware of efficient use of water.
- Production increased for farmers (36.4%) who had access to irrigation facilities in command area of the Upper Krishna Project.
- For around 85% of the population, agriculture is the main occupation with no major alternative employment.

Other Non-climatic Factors that Contribute to Vulnerability

Expert views

Crops like groundnut and cotton are not only vulnerable to agronomic risks but also **exposed to global market volatility** (Galab *et al.*, 2009). Continuous negative returns from cotton and jowar are primary factors responsible for increased cultivation of cash crops and extensive adoption of HYV has required heavy doses of fertilisers and pesticides. As a result, the cost of cultivation has plunged agriculture into a crisis.

The study area is under the command area of the Upper Krishna Project and is being gradually transformed into an irrigated area. Once an area is irrigated, it demands more inputs. The cultivation of paddy increased the use of fertilisers in the region. It is less compared to other irrigated areas in the country but high for the region because the soil is not that suitable for paddy cultivation. Hence, the productivity of the soil has declined.

According to a senior scientist at ISEC, Dr Parmod Kumar, another reason behind the change in the cultivation patterns is that **in dry land farming** the **price hike is more** for the crops produced, **but the productivity is low**, so the farmers are unable to get good returns. Paddy demands huge input of fertilisers, irrigation and labour but the price hike is low compared to jowar, bajra and pulses like red gram, green gram and bengal gram. It is productivity that shoots up and that is what the farmers want to invest in – no doubt the cost of cultivating paddy is excessively high. An irrigated area

demands more agricultural inputs compared to a dry area. According to Dr. Chinnappa Reddy, Agricultural Economist, GKVK, paddy being a food crop that involves least risk and maximum yield, it is robbing the current market of a number of crops. Moreover, overuse of fertilisers and excessive irrigation adversely affects the soil. It gradually loses its water-holding capacity, starts demanding more inputs that are artificial, becomes less productive and finally turns barren.

"With CO_2 emissions bound to increase to meet the developmental needs of the region, enhancements of carbon stocks in degraded forests can be one of the effective strategies to temporarily restrain the increase in atmospheric carbon dioxide concentration and buy time to build up technologies without hampering the progress during this period. NTFP's can provide lucrative employment during the lean periods of income (Singh, 2008). "

In case of pulses, prices have increased because the area in which these crops were grown has increased but still there is no such increase in yield. Price may increase for the crops, but until farmers have the surplus, it is not beneficial.

"Water harvesting in dry land areas, which means previously abandoned and degraded lands can be cultivated, and additional crops can be grown on small patches of irrigated land owing to better rainwater retention((Pretty, 2008)), and improving water productivity of crops" (Pretty, 2008).

The study was conducted to gain an insight into the vulnerability of the agriculture sector through mutual learning and exchange of information with the affected communities. The survey conducted in the different blocks of the district revealed that cultivation patterns have shown a major shift from jowar, bajra and pulses to paddy and cotton. This has taken place because of access to canal water and high variability in rainfall in past few years. Almost similar observations were made by Chandrashekhar (2012). Both high and low rainfall has affected production. In 2010, the yield reduced for almost all the crops except chilli, which shows a positive correlation with rainfall. Moreover, during this year the region received heavy rainfall – 910mm – much higher than what is normally received. As such, no data gaps were identified in the secondary data.

The other factor involved is pricing Farmers do not get good surplus for pulses and there is, no appreciable hike in prices. Hence, farmers have shown a shift towards a high surplus generating and secure crop like paddy. Apart from this, highly intensive and expensive agriculture practices have made agriculture more vulnerable and deteriorated the soil quality. These practices include excessive use of water, which leads to siltation and huge fertiliser usage resulting in high GHG emissions. "The 41 per cent increase in wetland rice production since 1951 has increased methane releases (Neue, 1993). Emissions from natural wetlands and rice paddies are particularly sensitive to temperature and soil-moisture changes and these might get easily affected by future climate changes" (Dale, 1997).

The carbon footprint estimation carried out for the study reveals that paddy has the highest carbon footprint among all the crops grown in the region.

"Cultivated wetland rice soils emit significant quantities of methane (Yan *et al.*, 2003). Emissions during the growing season can be reduced by many practices (Yagi *et al.*, 1997; Wassmann *et al.*, 2000; Aulakh *et al.*, 2001). For example, draining the wetland rice once or several times during the growing season effectively reduces CH_4 emissions (Smith & Conen 2004; Yan *et al.*, 2003), although this benefit may be partly offset by higher N_20 emissions and the practice may be constrained by water

supply. In the off-rice season, methane (Aulakh *et al.*, 2001) emissions can be reduced by improved water management, especially by keeping the soil as dry as possible and avoiding water logging (Cai *et al.*, 2000, 2003; Kang et al., 2002; Xu *et al*, 2003)" (Smith *et al.*, 2008). The farmers should be made to understand that excessive paddy cultivation may be providing bumper crops today but in the end, they may become responsible for the loss of productivity of the soil.

Crop choice of most of the farmers has been motivated mostly by economic rather than cultural or social factors. The survey shows a decline of almost 55-60 per cent in the production of conventional crops. In addition, pulses and crops like jowar and bajra are identified as vulnerable crops of the region. Paddy has been identified as the most carbon intensive crop, which in this changing climate regime contributes the most in making agriculture in the region more vulnerable. There is a need to pursue low carbon emitting agriculture because improved yield of paddy shows a correlation with carbon intensity. On the other hand, red gram and cotton show the faintest carbon footprint. Pulses demand least amount of any agricultural inputs. Hence, they may not be lucrative enough even though they are more favorable for the region. It would take huge investments to improve energy as well as water use efficiency in order to reduce these environmental footprints. The implementation of improved cropping methods, like reduced tillage and water conservation may also be considered as sustainable options.

Farmers are highly dependent on canal irrigation but there is need to tap new improved irrigation options, like drip irrigation, which may help them adapt to the changing environment. It could help people adapt to the changing climate and prevent them from migrating and taking up non-agricultural jobs in the city where they will become more vulnerable.

The survey reveals very low level of education and relatively poor economic status of farmers in this region. These farmers do not have any alternative employment and remain unemployed for nearly 6 months in a year. All these factors expose this region twice over to the impact of future climate variability and further increase uncertainty (O'Brien et al., 2004).

"Despite great progress in agricultural productivity in the past half-century, with crop and livestock productivity strongly driven by increased use of fertilizers, irrigation water, agricultural machinery, pesticides and land, it would be over-optimistic to assume that these relationships will remain linear in the future" (Pretty, *et al.*, 2002). New approaches are needed for the sustenance as well as development of productive agriculture in the study area because many acres of land have become barren. The only way to reclaim the land in few years is by building small channels and having a more controlled supply of water. Switching back to crops that are less water intensive and performing mix cropping may help. There is a need to generate awareness among individuals about proper utilisation of the resources. The government should take the initiative to provide subsidy and encourage people to take up floriculture, animal husbandry (can be sustained on dry fodder, as the area is semi-arid and not much area is available for grazing) and bee-keeping, which will be a support system in the event of crop failure (Simões et al., 2010).

"Sustainability in agricultural systems would incorporate concepts of both resilience (the capacity of the systems to buffer shocks and stresses) and persistence (the capacity of the systems to

continue over long periods), and these might address many wider economic, social and environmental outcomes" (Pretty, 2008).

Biotechnology scientists should be encouraged to develop better quality of drought-resistant seeds that can be made available to farmers at subsidized rates. Most people believe that agriculture in these changing economic times is not a viable employment option for the future generations. Though many technical interventions are being promoted by the Government of Karnataka, the interactions with the people clearly highlights a mismatch between top-down policy recommendations and ground level conditions. This calls for appropriate and systematic planning to help this region to cope with these unavoidable stresses.

References

Below, T B and K D Mutabazi (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables. *Global Environmental Change*, 22 (1): 223-35.

Bhatia, A, A Ghosh, V Kumar, R Tomer, S D Singh and H Pathak (2010). Effect of elevated tropospheric ozone on methane and nitrous oxide emission from rice soil in North India. *Agriculture, Ecosystems and Environment*, 86: 413-24.

Bing, Y and C Guosheng (2011). Research and development of carbon footprint analysis in human province. *Energy Procedia*, 5: 1210-17.

Central Ground Water Board (2008). *Ground water information booklet, Gulbarga district, Karnataka*. [online] Available at: <http://cgwb.gov.in/District_Profile/karnataka/GULBARGA_brochure.pdf> [Accessed on 28th Feb, 2012]

Chandrashekhar, H and K N Ninan (1993). Green Revolution, Dryland Agriculture and Sustainability: Insights from India. *Economic and Political Weekly*, 28: 12-13.

Chazal, J, M Rounsevell (2009). Land-use and climate change within assessments of biodiversity change: A review. *Elsevier: Global Environmental Change*, 19: 306-15

Cheng, K and G Pan (2011). Carbon footprint of China crop production-An estimation using agro-statistics data over 1993-2007. *Agriculture, Ecosystems and Environment*, 142: 231-37.

Dale, V (1997). *The relationship between land-use change and climate change*, Ecological Applications, Vol. 7: 753-69.

District Planning Authority (2007). *Gulbarga district – Yadgir Taluk Industrial perspective plan*. [online] Available at: <www.karnatakaindustry.gov.in/content/Gulbarga/YADGIR_Taluk.doc> [Accessed on 13th Mar, 2012]

Fischer, G and M Shah (2005). Socio-economic and climate change impacts on agriculture: An integrated assessment, 1990-2080. *Philosophical Transactions: Biological Sciences*, 360 (1463): 2067-83, Food crops in changing climate.

GIS Unit, RDS, ICRISAT and Government of Karnataka (2008). Block map of district Yadgir, Karnataka.

Institute for Human Development (2008). *A Baseline Survey Of Minority Concentration Districts Of India, Gulbarga, Karnataka*. [online] Available at: <http://www.icssr.org/Gulbarga%20final[1].pdf> [Accessed on 25 Jan, 2012]

Kelkar, U, K Narula, V P Sharma and U Chandna (2008). Vulnerability and adaptation to climate variability and water stress in Uttarakhand State, India. *Elsevier: Global Environmental Change*, 18: 564-74.

Khan, S and M A Hanjra (2008). Footprints of water and energy inputs in food production-Global perspectives. *Food Policy*, 34: 130-40.

Mary, A L and A E Majule (2009). Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania. *African Journal of Environmental Science and Technology*, 3(8): 206-18.

O' Brien, K L and R Leichenko (2000). Double Exposure: Assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change*, *Part A: Human and Policy Dimensions*, 10: 221-32.

O' Brien, K L, R Leichnko and U Kelkar, H Venema, Guro Anandahl *et al.,* (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global Environmental Change*, 14: 303-13.

Omann, I, Stocker, A, Jäger J (2009). Climate change as a threat to biodiversity: An application of the DPSIR approach. *Elsevier: Ecological Economics*, 69: 24-31.

Pathak, H, N Jain, A Bhatia, J Patel and P K Aggarwal (2010). Carbon footprints of Indian food items. *Agriculture, Ecosystems and Environment*, 139: 66-73.

Pearson, J, R Nelsonc, S Crimp and J Langridge (2010). Interpretive review of conceptual frameworks and research models that inform Australia's agricultural vulnerability to climate change *Environmental Modelling & Software*, 26: 113-23.

Pretty, J (2008). Agricultural Sustainability: Concepts, Principles and Evidence. *Philosophical Transactions: Biological Sciences*, 363 (1491): 447-65, Sustainable Agriculture I.

Pretty, J N, A S Ball, L Xiaoyun and N H Ravindranath (2002). The role of Sustainable Agriculture and Renewable-Resource Managemant in Reducing Green house Gas Emissions and Increasing Sinks in China and India. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences*, 360 (1797): 1741-61, Carbon, Biodiversity, Conservation and Income:An Analysis of free market approach to Land use change and forestry in developed and developing countries.

Simoes, A F, D C Kligerman, E L L Rovere, M R Maroun, M Barata and M Obermaier (2010). Enhancing adaptive capacity to climate change: The case of small holder farmers in the Brazilian semi-arid region. *Environmental Science and Policy*, 13: 801-08.

Singh, P P (2008). Exploring biodiversity and climate change benefits of community-based forest management. *Global Environmental Change*, 18: 468-78.

Smith, P and P Kumar (2008). Greenhouse Gas Mitigation in Agriculture. *Philosophical Transactions: Biological Sciences*, 363 (1492): 789-813, Sustainable Agriculture II.

Snyder, C S, T W Bruulsema, T L Jensen and P E Fixen (2009). Review of greenhouse gas emissions from crop production systems and fertilizer management effects. *Agriculture, Ecosystems and Environment*, 133: 247-66.

Walsh, C and B O' Regan (2008). Incorporating methane into ecological footprint analysis: A case study of Ireland. *Ecological Economics*, 68: 1952-62.

Annexures

Annexure- I

a) Rainfall (mm) data from the year 2001 to 2010

Rainfall	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
January	10	0	0	2.4	7	0	0	0	0	0
February	0	1.6	2.6	0	0	0	1.4	1.4	0	6.23
March	0	0	205.5	0	1.6	20.4	122.2	122.2	0	4
April	12	5	17.2	28	39.4	20.2	18	18	14.2	8
May	2.4	64	0	46.6	15.8	88.8	0	0	25.8	49.7
June	84.5	46.4	44	30.8	72.4	145.4	63.3	63.3	141.5	104.6
July	6.2	80.6	158.2	196	173	45.8	166.6	166.6	29	129.4
August	232	299.08	134.8	63.4	125.4	131.4	150.4	150.4	279.2	299.4
September	278.6	109.2	74.8	218.8	255.6	140	142	142	230.6	131.07
October	69.4	68	14.2	112.4	67.6	79.2	103.2	103.2	26.1	56.6
November	7.4	0.8	0	0	2	23.8	11	11	46	27
December	0	0	0	0	0	0	0	0	0	94
Sum	**702.5**	**674.68**	**651.3**	**698.4**	**759.8**	**695**	**778.1**	**778.1**	**792.4**	**910**

Source: Department of Economics and Statistics, district Gulbarga/Yadgir, Karnataka

b) Mean Temperature(^{o}C) data from the year 2001 to 2010

Monthly Average Temperature	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
January	26.17	23.39	28.67	23.3	23.85	23.53	24.19	24.19	22.61	23.27
February	27.22	26.11	31.82	26.09	26.76	26.39	24.09	24.09	25.71	25.34
March	28.61	31.23	30.5	29.13	28.03	32.61	27.34	27.34	26.37	26.98
April	31.31	34.66	34.25	29.91	28.15	36.36	28.66	28.66	31.21	33.31
May	31.47	33.19	35.34	27.95	30.18	34.39	34.77	34.77	32.71	33.33
June	25.83	26.65	30.45	26.63	26.52	30.49	27.06	27.06	29.33	30.41
July	27.08	24.13	28.04	25.72	23.71	29.56	25.04	25.04	27.65	26.48
August	25.78	25.22	26.45	25.78	23.64	27.85	25.28	25.28	27.7	26.65
September	29.18	26.28	27.2	25.99	23.56	28.59	29.41	29.41	26.34	26.52
October	24.91	25.85	29.09	26.33	23.68	66.56	27.53	27.53	26.16	26.14
November	23.55	25.4	25.04	26.07	23.64	31.61	25.03	25.03	24.29	25.68
December	23.17	25.2	23.39	23.76	20.27	27.72	23.58	23.58	22.95	22.02
Mean	**27.02**	**27.28**	**29.19**	**26.39**	**25.17**	**32.97**	**26.83**	**26.83**	**26.92**	**27.18**

Source: KSNDMC, Bangalore, Karnataka and University of Agricultural sciences, District Gulbarga/Yadgir, Karnataka

Annexure- II

a) Cost of cultivation of the crops grown in Karnataka, 2010

Crop		Cotton	Paddy	Red gram	Green gram	Bengal gram	Maize	Jowar	Bajra	Ground nut
Production per hectare (in Kg/hectare)		961	4538	747	132	874	1765	890	639	471
Total Cost of production (`/Kg)		24.57	8.1118	23.9	63.552	17.819	6.399	11.08	10.73	38.52
Total Cost of cultivation (`/hectare)		22239	35859	16529	7868.6	14370	20672	10662	7249	17404
Variety	Traditional	0	0	0	0	0	0	0		0
	HYV	1	1	1	1	1	1	1		1
Amount of HYV used (In Kgs./hectare)		3.37	79.55	9.27	12.59	62.95	16.52	7.62	3.45	89.38
Seed rate (In `/Kg)		724.1	11.63	33.28	34.97	25.65	69.27	30.62	117	40.54
Fertilizer amount (in Kgs./hectare)		130.9	227.81	59.81	59.27	94	129	58.98	26.25	66.48
Fertilisers price(in `/Kg)		14.79	14.15	16.23	17.14	15.17	14.13	15.48	15.55	15.32
Manure (in quintals)		19	6.67	6.82	11.09	0.25	7.88	3.24	0	4.97
Price (`/quintal)		42.78	62.93	58.74	36.23	80	62.22	37.7	0	56.41
Irrigation (in `/acre inch)		100	300	100	100	100	100	100	100	100
Electricity used (varies)	1.S I (canals) in command area 2.Borewell	` 300-400/crop ` 100-300/crop	` 600/crop ` 600/crop	300-400/crop and 100-300/crop						
Electricity price(in `/unit)	Subsidised till 10Hp-` 1.5 to 2/unit	>10 Hp-Rs.800/Hp consumed								
Human labour (in no. of man hours)		676	1070	397.9	290.13	387.17	599.5	408.4	302.7	502.4
Price (`/man hours)		9.45	11.87	11.93	9.3	9.71	10.03	9.43	8.92	11.05
Bullock labour (pair hours)		71.57	83.81	68.65	44.62	42.35	82.41	65.15	42.75	67.46
Bullock labour (price/pair hours)		24.13	27.87	28.32	26.42	30.7	26.39	24.29	26.61	29.35
Petrol/diesel charges	varies	10 Hp diesel set- 8 litres diesel/hr.								
Price		Petrol- ` 73.60 and diesel- ` 40								

b) Cropwise Actual Productivity Figures for All Major Crops Grown in the Region From 2000 to 2010(Kg/Hectare) of Yadgir/Gulbarga district, Karnataka

Year	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Paddy(I)	9609	6709	3510	69994	18284	12201	9088	10291	9958	10584
Paddy(UI)	4195	3613	1099	2661	2838	3701	1597	1336	2494	601
Jowar(I)	12967	5081	1215	5963	5242	7036	5032	5845	5784	4421
Jowar(UI)	3159	3378	809	3711	3255	4134	3283	4131	2642	1804
Bajra(I)	930	754	800	984	1135	1559	1973	1281	1633	1574
Bajra(UI)	1412	1404	570	1013	1170	910	664	847	837	578
Maize(I)	30258	0	2710	8436	10011	10839	9075	9551	8624	5232
Maize(UI)	7664	0	1816	3013	7518	3503	3421	4700	4254	2805
Red gram(UI)	472	269	507	411	540	752	450	742	520	479
Green gram(UI)	471	252	76	213	208	299	106	276	285	33
Bengal gram(I)	1383	863	1068	1350	1590	916	890	807	703	889
Bengal gram(UI)		820	802	0	0	773	572	713	656	763
Ground nut(I)	1852	1978	2112	2355	1842	1913	1247	2000	1816	1360
Ground nut(UI)	648	532	533	506	338	453	238	2541	489	322
Cotton(I)	501	406	538	542	512	709	695	797	723	445
Cotton(UI)	259	162	292	214	277	244	302	415	513	372
Chillies(UI)	4076	2075	2582	5384	4373	6052	10160	8088	7203	9505

Source: Fully revised estimates of Principle crops of Karnataka, Directorate of Economics and Statistics, Bangalore, Karnataka (2010)

Annexure- III

Questionnaire

Vulnerability Assessment of Agriculture sector, district Yadgir, Karnataka: A Socio-Economic survey approach

Name of the block/taluka..... Main crops grown in the region

Name of the village.....

.....

.....

1. Name.....
2. Age.....
3. No. of years of schooling.....
4. Household size.....
6. Major occupation of male of the house..... Female.....
7. Alternative employment of the

males.....Females.....

8. Farm size.....
9. No. of plots.....
10. Amount of crops produced

Food grains	Vegetables
1.	1. .....
2.	2. .....
3.	3. .....
4.	4. .....
5.	5. .....
6.	6. .....

11. Is there any change in the kind and number of crops being grown today, than were grown a few years back?
12. Any climatic stresses experienced due to high/ low rainfall or temperature.....
13. Reason behind current land use/selection of the crops (drivers behind the change in cropping patterns)
    1. Economic
    2. Social
    3. Geographic
    4. Cultural
    5. Climatic
14. Role of Men and women in production and collection of the produce

    Men –

    Women –
15. Reduction in the yield experienced due to any insect, pest, weed, disease or climate .....
16. Any change perceived in the shift in the time

	Crop Type	Growing	Harvesting
1.	.....		
2.	.....		
3.	.....		

17. Dependency on the forest as a resource for fuel, fodder, fruits, medicines and how much do they contribute to the economy of the region .....

18. Any change perceived in NTFP (Non-timber forest produce) collection, in last few years.....

19. Any specific species' whose population may have shown an abrupt rise or fall in the recent past (indicator species).....

20. Any change in any agriculture practice which may have caused deterioration of the soil .....

21. Any change in the demand of the fertilizers required for the main crops grown (manure or chemical fertilizers) in past few decades.....

22. Dependency on rainfall 1.High 2. Medium 3. Low 4. No dependency

23. Dependency on grasslands for cattle feeding (overgrazing) 1.High 2. Medium 3. Low 4. No dependency

24.Has there been increase in non-agricultural jobs/or the people who move out have increased.....

.....

25.What has been the impact of various developmental programs on agriculture.....

26. How well any improved technical systems been installed, if any, for improved agriculture e.g. rainwater harvesting storage tanks, irrigation channels.....

27. Have they perceived any change in climate and whether it has led to increase or decrease in production of any crop .....

28. Whom do they consider as the sole responsible for their good or bad produce, climate change or land use change (anthropogenic factor), which has affected the cropping pattern the most? .....

Adaptive strategies taken

29. Any role played by the government, such as, in better availability of the seeds, improved crop varieties or any other schemes like:

1. Mahila Kisan Sashaktikaran Yojna
2. Rashtriya Krishi Bima Yojana(RKBY)
3. Farmers Self Help Groups

and have they helped in better adaptation in the events of crisis

.....

30. Efforts made by the local communities in:

1. Integrated land/water management activities
2. Passing on the indigenous knowledge

.....

21. Any change in the demand of the fertilizers required for the main crops grown (manure or chemical fertilizers) in past few decades.....

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