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CRIDA

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PREFACE

The impacts of changing climate on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the large population depending on agriculture and excessive pressure on natural resources. Rainfed agriculture is likely to be impacted severely in view of its' high dependency on monsoon, the likelihood of increased extreme weather events due to aberrant behavior of south west monsoon. While reducing the green house gas emissions holds key in addressing the problem, successful adaptation to changing climate is important to stabilize the productivity. Adapting to changing climate is a continuous process and communities have wealth of information. As a first step, there is a need to document all the indigenous practices farmers have been following over time for coping with changing climate. An effort has been made to document the perceptions of the communities towards changing climate in three most climatically challenged districts of Andhra Pradesh and the common adaptation practices they resort to. I congratulate the efforts of Dr. Ravi Shankar and his team for bringing this important work in usable form. A better understanding of the farmers' perceptions towards changing climate, the practices they adopt and the factors that contribute to the decision making help in formulating policies and programs aimed at minimizing the losses and reducing the risk due to changing climate and variability. The results of the study will be useful while planning climate change adaptation programs.

B. Venkateswarlu

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PREFACE

1. Introduction

Indigenous knowledge is generally defined as the "Knowledge of a people of a particular area based on their interactions and experiences within that area, their traditions, and their incorporation of knowledge emanating from elsewhere into their production and economic systems". It is culturally appropriate, holistic and integrative. Incorporating indigenous knowledge is less expensive than bringing in aid for populations unprepared for catastrophes and disasters, or than importing adaptive measures, which are usually introduced in a top- down manner and difficult to implement, particularly because of financial and institutional constraints. Indigenous people that live close to natural resources often observe the activities around them and are the first to identify and adapt to any changes. The appearance of certain birds, mating of certain animals and flowering of certain plants are all important signals of changes in time and seasons that are well understood in traditional knowledge systems. Farmers have been confronted with changing environments for millennia and have developed a wide array of coping strategies, and their traditional knowledge and practices provide an important basis for facing the even greater challenges of changing climate. Participatory research and farmer-back-to-farmer models of technology transfer are examples of attempts towards establishing a bridge between traditional knowledge and scientific knowledge. The increasing attention to adaptation to changing climate has not come with sufficient emphasis on the local nature of climate adaptation and on the role of local institutions and local governance in shaping adaptation practices (Agrawal *et al*., 2009). Local knowledge is therefore a major priority in the planning of adaptation (Allen, 2006). Indigenous knowledge systems can facilitate understanding and effective communication and increase the rate of dissemination and utilization of climate change mitigation and adaptation options. While the importance of indigenous knowledge has been realized in the design and implementation of sustainable development projects, little attention has been drawn to their incorporation into formal changing climate mitigation and adaptation strategies (Nyong *et al*., 2007).

Changing Climate is becoming a major driver of disasters, with increasingly frequent and intense floods and storms affecting more people globally. Increased forced displacement is an extremely likely consequence of such events. Heightened drought risk, desertification, sea level rise and changes in the availability of water and fertile land, coupled with reduced access to basic resources, will also fuel longer term migration and forced displacement.

2. Changing Climate: Impacts on Agriculture in India

Agriculture is one of the largest contributors to India's Gross Domestic Product (GDP), approximately 20%. It is the main source of livelihood for almost 60% of the country's total population. The impacts of changing climate on agriculture will therefore be severely felt in India. It has been projected that under the scenario of a 2.5^0C to 4.9^0C temperature rise in India, rice yields will drop by 32%-40% and wheat yields by 41-52%. This would cause GDP to fall by 1.8%-3.4% (GOI, 2011; Guiteras, 2007; OECD, 2002). Despite the gloomy predictions about the negative impacts for India's agricultural sector, changing climate is expected to bring opportunities as well e.g.: production gains through the CO_2 fertilization effect or the expansion of cultivated land to higher altitudes and northern latitudes. However, it must be noted that to date all climate change projections have been accompanied by uncertainty-not primarily concerning trends but extent (IFPRI, 2009; UNFCC, 2009).

3. Adaptation to Changing Climate

Agriculture in developing countries is one of the most vulnerable sectors of the global economy to changing climate (Kurukulasuriya *et al.,* 2006; Seo and Mendelsohn 2008c). Farmers whose livelihoods depend on the use of natural resources are likely to bear the brunt of adverse changing climate impacts. Farmers will be hard hit if they do not adjust at all to new climates (Mendelsohn *et al*., 1994, Rosenzweig and Hillel 1998; Reilly *et al*., 1996). Adaptation to changing climate requires that farmers first notice that climate has changed, and then identify useful adaptations and implement them (Maddison, 2006). Adaptation is widely recognized as a vital component of any policy response to changing climate. Studies show that without adaptation, changing climate is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced (Easterling *et al*., 1993; Rosenzweig and Parry 1994; Smith 1996; Mendelsohn 1998; Reilly and Schimmelpfennig 1999; Smit and Skinner, 2002). The degree to which an agricultural system is affected by changing climate depends on its adaptive capacity. The adaptive capacity of a system describes its ability to modify its characteristics or behavior so as to cope better with changes in external conditions. Adaptive capacity is determined by various factors including recognition of the need to adapt, willingness to undertake adaptation, and the availability of, and ability to deploy, resources (Brown, 2010). Recent empirical studies indicate that farmers have already adapted to the existing climates that they face by choosing crops or livestock or irrigation

(Kurukulasuriya and Mendelsohn 2007, 2008; Nhemachena and Hassan 2007; Seo and Mendelsohn 2008a, 2008b) ideal for their current climate. The adaptation strategies must not be used in isolation. For instance, the use of early maturing crop varieties must be accompanied by other crop management practices such as crop rotation or the use of cover crops. This, however, requires additional institutional support, such as credit, access to input and output markets and information.

The objective of the present study was to identify farmers' knowledge perceptions towards changing climate along with their farm-level adaptation measures with a view to suggest appropriate research/policy issues which help in facilitating farmers' adaptation to changing climate. Role of extension in facilitating adaptation to changing climate is discussed.

4. Methodology

A sample of 180 farmers @60 each from Anantapur, Mahbubnagar and East Godavari districts of Andhra Pradesh in South India was selected randomly. Data was collected using a pre-tested interview schedule from the farmers. Percent analysis, correlation and regression, and composite index developed in the study were used for analyzing data.

5. Results and Discussion

a) Farmers' perceptions and Adaptation Measures towards Changing Climate:

Table 1 : Farmers' Perceptions regarding Changing Climate in Anantapur

S. No.	Farmers' Perception	Number*	%	Rank
1.	Rise in temperatures	57	95	I
2.	Decrease in rainfall	56	93	II
3.	Advanced onset of monsoon	54	90	III
4.	Middle, long dry spells	53	88	IV
5.	Terminal heavy rains	50	83	V
6.	Uneven distribution of rainfall thereby, affecting length of growing season	49	82	VI
7.	Prevalence of pests and diseases	47	78	VII
8.	ITKs for weather forecast failing	41	68	VIII

*Multiple responses

Table 2 : Farmers' Adaptation Measures towards Changing Climate in Anantapur

S. No.	Farmers' Adaptation Measures	Number*	%	Rank
1.	Buy insurance	56	93	I
2.	Change in planting dates of groundnut (go or early sowings may be between May end to early June)	55	92	II
3.	Intercrop with red gram in 8:1 or 12:1 ratio.	48	80	III
4.	Intercrop with castor contemplated	47	78	IV
5.	Construct water harvesting structures under MGNREGA	45	75	V
6.	Require quick maturing, drought resistant varieties	42	70	VI

From table 1, it is clear that rise in temperatures followed by decrease in rainfall, advanced onset of monsoon, middle long dry spells, terminal heavy rains, prevalence of pests and diseases and ITKs for weather forecast failing are the major farmers' perceptions in that order of magnitude regarding changing climate in Anantapur. Bryan *et al.,* (2009) in their study in Ethiopia and South Africa reported that farmers experienced increased temperature and decreased rainfall. Similar observations were reported by Vedwan and Rhoades (2001), Hageback *et al.,* (2005), Maddison (2006), Gbetibouo (2009) and Dejene (2011) in their studies. Results of a study conducted in Bundi district of Rajasthan, India revealed farmers' perceptions to changing climate as increase in temperatures, decreased rainfall and long dry spells. The chief adaptation measures followed by farmers' are change in planting time, intercropping, soil and water conservation and planting drought tolerant crops (Dhaka *et al*., 2010).

It is clear from table 2, that buying insurance, changing planting dates of groundnut, intercrop with red gram, construct water harvesting structures, and require quick maturing, drought resistant varieties in that order of magnitude are the major adaptation measures followed by farmers' towards changing climate in Anantapur. This finding is consistent with that of Swanson *et al*., (2008) who reported that crop insurance was widely used by farmers in Foremost and Coaldale regions of Canada and the common feeling was that even though it might not provide sufficient returns for losses incurred it does offer some protection. It has allowed them to continue farming. Agricultural insurance can help people to cope with the financial losses incurred as a

result of weather extremes. Insurance supports farmers in their adaptation process and prevents them from falling into absolute poverty. Apart from stabilizing household incomes by reducing the economic risk, insurance can also enhance farmers' willingness to adapt, to make use of innovations and invest in new technologies (Ilona *et al*., 2011). Agricultural adaptation involves two types of modifications in production systems. The first is increased diversification that involves engaging in production activities that are drought tolerant and or resistant to temperature stresses as well as activities that make efficient use and take full advantage of the prevailing water and temperature conditions, among other factors. Crop diversification can serve as insurance against rainfall variability as different crops are affected differently by climate events (Orindi and Eriksen 2005; Adger *et al*., 2003). The second strategy focuses on crop management practices geared towards ensuring that critical crop growth stages do not coincide with very harsh climatic conditions such as mid-season droughts. Crop management practices that can be used include modifying the length of the growing period and changing planting and harvesting dates (Orindi and Eriksen, 2005).

Table 3 : Farmers' Perceptions regarding Changing Climate in Mahbubnagar

S. No.	Farmers' Perception	Number*	%	Rank
1.	Rise in temperatures	55	92	I
2.	Decrease in rainfall	53	88	II
3.	Advanced (some places timely) onset of monsoon	51	85	III
4.	Middle long dry spells accompanied by cloudy weather during flowering	48	80	IV
5.	Terminal heavy rains	46	77	V
6.	Prevalence of pests and diseases (powdery mildew, mold in castor; smut and jassids in paddy)	41	68	VI

From table 3, it is clear that rise in temperatures followed by decrease in rainfall, prolonged dry spells in between rains, terminal heavy rains and prevalence of pests and diseases (powdery mildew, mold in castor; smut and jassids in paddy) are the major farmers' perceptions in that order of magnitude regarding changing climate in Mahbubnagar. It is striking that farmers across the world show a remarkable unanimity in observations of seasonal change, particularly regarding rain falling in most intense bursts; and generally higher temperatures and longer hot, dry spells within rainy seasons, with effects on soil moisture (Jennings

and Magrath, 2009). Kemausuor *et al*., (2011) reported that a large percentage (93%) of farmers was of the opinion that the timing of the rains is now irregular and unpredictable.

Table 4 : Farmers' Adaptation Measures towards Changing Climate in Mahbubnagar

S. No.	Farmers' Adaptation Measures	Number*	%	Rank
1.	Staggered sowings (dry paddy, castor, red gram and cotton in kharif), (groundnut, paddy, chillies and tobacco in rabi)	50	83	I
2.	Change in Planting dates and planting different crops	49	82	II
3.	Require drought resistant varieties	45	75	III
4.	Water harvesting structures started under MGNREGA	41	68	IV

It is clear from table 4, that staggered sowings, change in planting dates, require drought resistant crops, and construct water harvesting structures are the major adaptation measures followed by farmers' towards changing climate in Mahbubnagar.

Also, the farmers' in Mahbubnagar are accustomed to observe the rainy season and if the season is favourable with good rains, they will continue farming. Otherwise, they migrate and work as construction labour at Gangavati, Hyderabad and Bangalore. Higher temperatures, pest and disease attack on crops were the chief perceptions of farmers towards changing climate, while, planting different crops and water conservation were the main adaptation strategies of farmers in Ogbomosho agricultural zone of Oyo state in Nigeria. (Ayanwuyi *et al*., 2010).

Table 5 : Farmers' Perceptions regarding Changing Climate in East Godavari

S. No.	Farmers' Perception	Number*	%	Rank
1.	Rise in temperatures.	54	90	I
2.	Decrease in rainfall.	53	88	II
3.	Pest and disease incidence is high for kharif paddy like BPH, BLB and stem borer (at transplanting stage).	51	85	III
4.	Terminal heavy and unseasonal rains.	49	82	IV
5.	ITKs for rain forecasts are failing.	45	75	V

From table 5, it is clear that rise in temperatures, followed by decrease in rainfall, incidence of pests and diseases, terminal heavy cyclonic rains, and ITKs for rain forecasts failing are the major farmers' perceptions in that order of magnitude regarding changing climate in East Godavari.

Table 6 : Farmers' Adaptation Measures towards Changing Climate in East Godavari

S. No.	Farmers' Adaptation Measures	Number*	%	Rank
1.	Go for early (June) sowings to avoid November cyclones coinciding with harvests.	56	93	I
2.	Salt water spray for harvested paddy stalks to avoid discoloration and regermination. For paddy in field, tying with rope and sticks on four sides to keep them erect and not falling down.	55	92	II
3.	Strengthening of river banks and improved drainage.	53	88	III
4.	Survey number wise insurance covering low lands.	50	83	IV
5.	Loans to tenant farmers though introduced, falls short of actual requirements in terms of coverage.	48	80	V

It is clear from table 6, that early sowings, salt water spray for harvested paddy stalks, strengthening of river banks and improved drainage, survey number wise insurance, and loans to tenant farmers are the major adaptation measures perceived by farmers' towards changing climate in East Godavari. Migrate as construction labour if monsoon fails, particularly in rainfed areas of the district is another common phenomenon (Ravi Shankar *et al*., 2013).

Improving the adaptive capacity of disadvantaged communities requires ensuring access to resources, income generation activities, greater equity between genders and social groups, and an increase in the capacity of the poor to participate in local politics and actions (IISD 2006). Thus, furthering adaptive capacity is in line with general sustainable development and policies that help reduce pressure on resources reduce environmental risks, and increase the welfare of the poorest members of the society.

Since most smallholder farmers are operating under resource limitations, lack of credit facilities and other inputs compound the limitations of

resource availability and the implications are that farmers fail to meet transaction costs necessary to acquire the adaptation measures they might want to and at times farmers cannot make beneficial use of the available information they might have (Kandlinkar and Risbey 2000). Lack of access to credit has been observed in previous studies (Nhemachena and Hassan, 2007) to be a barrier to responding to changing climate. A better understanding of how farmers' perceive changing climate, ongoing adaptation measures, and the factors influencing the decision to adapt farming practices is needed to craft policies and programmes aimed at promoting successful adaptation of the agricultural sector (Bryan *et al*., 2009).

b) Computation of Adaptation Index to assess the Extent of Farmers' Adaptation to Changing Climate:

Each farmer was scored for adaptation by assigning scores of 0, 1, and 2 for non, partial and full adaptation of a measure respectively. In case of drought and floods, total adaptation measures were 8 for each respectively, and hence maximum adaptation score that can be obtained is 16, while minimum adaptation score that can be obtained by a farmer is 0. Adaptation indices were computed for assessing the adaptation.

Adaptation index = Adapted measures/Total recommended measures x 100.

The adaptation indices for the three districts along with their SD and CV values are presented in table 7.

Table 7 : Adaptation indices of farmers for Drought and Floods

Statistic/ Category	Ananthapur (Drought)	Mahbubnagar (Drought)	East Godavari (Floods)
Mean	11.90	11.65	12.13
S.D.	2.14	2.22	1.97
C.V.	17.96	19.02	16.23
Max.	15	15	16
Min.	6	6	6

c) Village wise and Practice wise Adaptation Scores of farmers:

Adaptation to climate change is the adjustment of a system to moderate the impacts of climate change to take advantage of new opportunities or to cope with consequences (Adger *et al*., 2003).

Table 8 : Village wise Adaptation scores of farmers for drought in Anantapur district of A.P.

S. No.	Village	Minimum	Maximum	Mean	SD	CV
1.	Bhadrampally	6	15	12	3.2	26.4
2.	Siddharamapuram	6	15	11.1	2.5	22.3
3.	Nagasamudram	9	15	12	2	16.7
4.	Chenne Kothapalli	12	12	12	0	0
5.	Podarallapalli	12	15	13.2	1.5	11.7
6.	Mangalamadaka	9	15	11.1	2	18.2

Table 9 : Village wise adaptation scores of farmers for drought in Mahbubnagar district of A.P.

S. No.	Village	Minimum	Maximum	Mean	SD	CV
1.	Machanpally	9	15	12.6	1.9	15.1
2.	Appaipally	6	15	11.1	2.5	22.3
3.	Nirven	12	15	12.3	0.9	7.7
4.	Palem	6	15	11.7	2.6	22.5
5.	Penchikalapadu	6	12	9.9	2.8	28.7
6.	Aragidda	12	15	12.3	0.9	7.7

Table 10 : Village wise adaptation scores of farmers for floods in East Godavari district of A.P.

S. No.	Village	Minimum	Maximum	Mean	SD	CV
1.	Gollaprolu	12	16	**13.9**	1.7	12
2.	Chendurthi	9	15	11.7	2.2	18.9
3.	J. Thimmapuram	6	12	11.1	2	18.2
4.	Kattamoru	9	16	12.7	2.1	16.2
5.	Narsapuram	9	12	11.4	1.3	11.1
6.	Dora Chintalapalem	9	15	12	1.4	11.8

Table 11 : Practice wise Mean Adaptation scores of farmers for drought in Anantapur district of A.P.

Statistic	A1	A2	A3	A4	A5	A6	A7	A8
Mean	1.12	1.0	1.97	1.97	0.85	1.20	2.00	1.80
SD	0.52	0.64	0.18	0.18	0.36	0.40	0.00	0.40
CV	46.90	63.78	9.20	9.20	42.36	33.61	0.00	22.41

Table 12 : Practice wise Mean Adaptation scores of farmers for drought in Mahbubnagar district of A.P.

Statistic	A1	A2	A3	A4	A5	A6	A7	A8
Mean	1.05	0.97	1.92	1.92	0.83	1.13	2.00	1.83
SD	0.47	0.55	0.28	0.28	0.38	0.34	0.00	0.38
CV	44.45	57.03	14.54	14.54	45.10	30.25	0.00	20.50

Table 13 : Practice wise Mean Adaptation scores of farmers for floods in East Godavari district of A.P.

Statistic	A1	A2	A3	A4	A5	A6	A7	A8
Mean	1.02	1.18	1.85	1.85	2.00	1.20	1.20	1.83
SD	0.22	0.43	0.36	0.36	0.00	0.40	0.40	0.42
CV	22.12	36.46	19.46	19.46	0.00	33.61	33.61	22.83

Adaptation practices for drought in Anantapur and Mahbubnagar

A1 - Improved irrigation
A2 - Minimize irrigation loss
A3 - Construct water harvesting structures
A4 - Drought resistant crops
A5 - Timely supply of inputs
A6 - Contingency crop planning
A7 - Crop management by adjusting planting dates
A8 - Soil management by mulching, conservation tillage

Adaptation practices for floods in East Godavari

A1 - Water storage
A2 - Strengthening of river banks
A3 - Flood forecasting and early warning systems
A4 - Drainage aspects
A5 - Better soil and crop management practices
A6 - Credit
A7 - Insurance
A8 - Community based water management

Inference:

- From table 7, the mean adaptation index value for floods (12.13) (East Godavari) is greater than that for droughts (11.90, 11.65) (Anantapur and Mahbubnagar respectively).
- From tables 8, 9 and 10, the villages namely *Podarallapalli* in Anantapur (13.2), *Machanpally* in Mahbubnagar (12.6) and *Gollaprolu* in East Godavari (13.9) showed highest mean adaptation values for droughts and floods respectively.
- From table 11, practices A3 (construct water harvesting structures), A4 (drought resistant crops), A7 (crop management by adjusting planting dates) and A8 (soil management by mulching, conservation tillage) showed highest adaptation in Anantapur. This amply illustrates the need for water harvesting, storage and reuse.
- From table 12, practices A3 (construct water harvesting structures), A4 (drought resistant crops), A7 (crop management by adjusting planting dates) and A8 (soil management by mulching, conservation tillage) showed highest adaptation in Mahbubnagar. This amply illustrates the need for water harvesting, storage and reuse.
- From table 13, practices A3 (flood forecasting and early warning systems), A4 (drainage aspects), A5 (better soil and crop management practices) and A8 (community based water management) showed highest adaptation in East Godavari. The problem here is managing excess water.

d) Correlation and Regression Analysis:

Table 14 : Correlation between selected Socio-economic Variables and extent of farmers' adaptation to Changing Climate

Independent variables	'r' value
Age	0.007
Education	0.182*
Family size	0.071
Farming experience	0.506**
Farm size	0.201**
Annual income	0.327**

Correlation between extent of farmers' adaptation to changing climate and selected socio-economic variables was computed and compared.

Three variables namely, farming experience, farm size and annual income were found to be positively significant at 0.01 level of probability while, education was positively significant at 0.05 level of probability.

Table 15 : Regression of selected Socio-economic Variables with extent of farmers' adaptation to Changing Climate

Independent variables	Regression coefficient	't' value
Age	0.492	1.498
Education	0.212	2.327**
Family size	0.132	0.990
Farming experience	0.250	2.219**
Farm size	0.482	2.202**
Annual income	0.016	0.186

R^2=0.423

*Significant at 0.05 probability level
**Significant at 0.01 probability level

Further, in order to determine the affect of selected socio-economic variables on extent of farmers' adaptation to changing climate, multiple linear regression analysis was carried out and results were presented in table 15. From table 15, it is clear that education, farming experience, and farm size were contributing significantly at 0.01 level with farmers' adaptation to changing climate. Evidence from various sources indicates that there is a positive relationship between the education level of the household head and the adoption of improved technologies (Igoden *et al*., 1990; Lin, 1991) and adaptation to climate change (Maddison, 2006). Both farming experience and farm size had a positive and significant relationship with adaptation to changing climate. Similar findings were echoed by Ayanwuyi *et al*., 2010 who reported that farm size, education, and farming experience had positive and significant relationship with adaptation strategies of farmers in Oyo state of Nigeria. Education, farming experience and extension contact had a positive and significant relationship with farmers' adaptation to climate change (Dhaka *et al*., 2010).

6. Role of Extension in Adaptation and Mitigation to Changing Climate

Today's understanding of extension goes beyond technology transfer to facilitation, beyond training to learning, and includes helping farmers form groups, deal with marketing issues, and partner with a broad range of service providers and other agencies. Agricultural extension can thus be defined as the entire set of organizations that support people engaged in agricultural production and facilitate their efforts to solve problems; link to markets and other players in the agricultural value chain; and obtain information, skills, and technologies to improve their livelihoods. Extension has proven itself to be a cost-effective means of bringing about greater economic returns for farmers with significant and positive effects on knowledge, adoption, and productivity. Studies of extension productivity report rates of return from 13 to 500 percent. A recent study demonstrated that receiving at least one extension visit in Ethiopia reduced smallholders' likelihood of being poor by 10 percent and increased consumption growth by 7 percent. Extension is thus a cost-effective tool that can play an important role in dealing with changing climate while at the same time helping to increase productivity and reduce poverty (Kristen, 2009).

Extension can help farmers prepare for greater climate variability and uncertainty, create contingency measures to deal with exponentially increasing risk, and alleviate the consequences of changing climate by providing advice on how to deal with droughts, floods, and so forth. Extension can also help with mitigation of changing climate by providing links to new markets (especially carbon), information about new regulatory structures, and new government priorities and policies. Mitigation strategies are procedures or activities that help prevent or minimize the process of climate change (Nyong *et al*., 2007). It is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (UNFCC, 2011). According to Fussel (2007), mitigation and adaptation are complementary rather than mutually exclusive. The capacity of farmers to cope with such different forms of risk will become ever more crucial, and extension efforts must pay special attention to educating farmers about their options to enhance resilience and response capacity. Increasing the availability of extension officers is critical to transfer the knowledge necessary for farmers to respond to changing climate. Training is required in crop production technologies and innovations appropriate to the changing climate, such as new, early

maturing seed varieties. Extension workers also need to be made aware of climate variability and trained on how to communicate it and what to do about it. The spread of mobile telephony is a significant opportunity for farmers and extension workers to work together more effectively (Katharine Vincent et al., 2011). Extension agents can introduce locally appropriate technologies and management techniques that enable farmers to adapt to changing climate by, for example, developing and disseminating local cultivars of drought-resistant crop varieties with information about the crops' advantages and disadvantages. They could educate farmers regarding carbon credits and markets; assist in forming community groups; link farmers to governmental, nongovernmental, and private organizations at the national and international levels. Additionally, extension staff can share with farmers their knowledge of cropping and management systems that is resilient to changing climate conditions such as agroforestry, intercropping, sequential cropping, and no-till agriculture. It is important to provide farmers with information about how the various options will potentially increase income and yields, protect household food security, improve soils, enhance sustainability, and generally help to alleviate the effects of changing climate. Supporting farmers with the skills they need to choose the best option to deal with the climate uncertainty and variability and to make informed decisions about if and how to engage in new markets for carbon emissions. For example, tree planting can also help to improve soil, prevent soil erosion, and increase biodiversity. Recent innovative extension activities include the adult education and experiential learning approaches utilized in farmer field schools, an extension and education approach already working with farmers on issues of changing climate. Climate Field Schools (CFSs) have been established in West Java, Indonesia, to deal with changing climate in agriculture. Another example is a multimedia campaign planned by True Nature Kenya and the World Agroforestry Centre that will show films and offer educational follow-up by extension agents to publicize grassroots solutions to the problems of changing climate.

By contributing to building resilience and strengthening adaptive capacity, Information and Communication Technologies (ICTs) have the potential to tackle changing climate uncertainty not only by providing access to information and knowledge**,** but also by fostering networking, personal empowerment and participation**,** facilitating self-organization, access to diverse resources and learning**,** among others, which ultimately contribute to better preparedness and response, including the possibility

of transformation in the face of the unknown. Providing relevant information for long-term planning, building on multi-level and multi-sect oral synergies, linking both new and traditional knowledge, and facilitating more inclusive processes, are some of the areas in which ICT tools can contribute to local decision-making, helping farmers to adapt more effectively to the impacts of changing climate. Adaptation funding should focus on extension systems and programs that incorporate a good understanding of what practices and skills are needed to best promote activities that help in the changing climate effort and on increasing the capacity of extension agents and farmers, where needed. Adaptation and mitigation funds could be used to support extension efforts that deliver new technologies, information, and education about increasing carbon sequestration and reducing green house gas emissions (Anthony Hogan *et al*., 2011).

7. Conclusion

Lack of resource rights and insufficient access to markets, finance, information, and technology are often greater determinants of vulnerability for the poor than changing climate itself (Schipper 2007, Ribot 2009). Adaptation to current vulnerability is the most urgent task to implement in the process of adaptation to changing climate (Bohle *et al*., 1993); because as emphasized by Locatelli *et al*. (2008), a community less vulnerable to the current problems could more adapt to future changes.

Capacity building at local, national and regional levels is vital to enable developing countries like India to adapt to changing climate. Capacity building, for example to integrate changing climate and socio-economic assessments into vulnerability and adaptation assessments, helps to better identify effective adaptation options and their associated costs. Education and training of stakeholders, including policy-level decision makers, are important catalysts for the success of assessing vulnerabilities and planning adaptation activities, as well as implementing adaptation plans. Enhanced funding is required for adaptation projects in developing countries and needs to be increased in national budgets as well as in multilateral funds. It is also important to ensure integration of changing climate risks into national development policies. For example, in Cuba, hurricane and disaster risk reduction is taught in schools and training is carried out for the entire population every year (Cuba, 2001).

Collaboration between educational, training and research institutions would help to enable the formal exchange of experience and lessons learned among different institutions of the respective regions. There are a number of actions that can help facilitate adaptation and integration of adaptation into policy, including actions at the local level (e.g. strengthening coping strategies and feedback to national policies), the national level (e.g. inter-agency coordination in the water sector and legal provisions for mainstreaming) and the regional level (e.g. incorporating changing climate risks in projects of regional development agencies and the creation of intersect oral committees to be engaged in the formulation of adaptation plans). The most fundamental changes required to support ongoing food production in the context of a changing climate are modifications to agricultural policies to enable and support adaptation, and directing more resources towards agriculture, especially to small-scale farmers (Katharine Vincent et al., 2011). The different policy options include raising awareness about changing climate and the appropriate adaptation methods, facilitating the availability of credit, investing in yield increasing technology packages to increase farm income, creating opportunities for off-farm employment, conducting research on use of new crop varieties and livestock species that are better suited to drier conditions, encouraging informal social networks, and investing in irrigation. Additional information about farmers' awareness of changing climate and current adaptation approaches would assist policymakers in their efforts to decrease the country's vulnerability to the adverse impacts of changing climate (Temesgen Deressa *et. al*., 2008). Extension can make a significant contribution through enhanced farmer decision making in the light of changing climate. The most important purpose for extension today is to bring about the empowerment of farmers, so that their voices can be heard and they can play a major role in deciding how they will mitigate and adapt to changing climate.

Recommendations :

- As national and international policy makers turn their attention to changing climate adaptation, they should keep in mind that constructing an enabling environment that minimizes these vulnerabilities will be central to any meaningful and lasting increase in the adaptive capacity of the rural poor.
- Govt. policies designed to promote adaptation at the farm level will lead to greater food and livelihood security in the face of changing climate.

- Extension's role is in providing knowledge related to adaptation to changing climate and communication, so that farmers' can make informed decisions.

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