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Role of extension agencies in climate change related adaptation strategies

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ABSTRACT

The croplands, pastures and forests that occupy 60 per cent of the earth's surface are progressively being exposed to threats from increased climatic variabilities. Abnormal changes in air temperature and rainfall are resulting in increasing frequency and intensity of drought and flood events that in turn have long-term implications for the viability of the ecosystems. As climatic patterns change there comes change in the distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests, fish populations and ocean circulation patterns which can have significant impacts on agriculture and food production. The main cause of climate change has been attributed to anthropogenic (human) activities such as the increased industrialization in the developed nations which led to the introduction of large quantities of greenhouse gases (GHGs) including carbon-dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) into the atmosphere. The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. In order to sustain the agricultural sector that plays pivotal role in human existence in terms of the provision of food, fibre, fuel and income strategies of change need to be urgently initiated to cope with the changing climate. Agricultural system has key role to play in initiating this change. This is because adaptations to climate change require changes in knowledge, attitudes, resilience capacities and skills of the people and agricultural extension system can bring this change. There is need to strengthen the extension system that can put forward the adaptive strategies to mitigate the climate effects. The strategies required include training of extension staff to acquire the new knowledge and skills in climate risk management, setting up of emergency management unit by extension agencies, dissemination of innovations strategic research on best practices and building resilience capacities of vulnerable people in climate risk management, providing feedback to government and interested agencies with situation reports on various causes of climate change and its effects, use of technology demonstrations in farmer trainings on the measures used to mitigate or adapt to the effects of climate change, organizing seminars, exposure visits, workshops and field days on climate risk management, use of farmer-to-farmer extension strategy to promote awareness and adoption of best practices such as adoption of zero or minimum tillage, use of weather forecasts etc, use of information communication technologies eg Kisan Mobile Advisory Services (KMAS), ICTs to create awareness on the climate change issues, formation of Young Farmer Clubs (YFC) and organize farmer field schools to educate and encourage farmers in learning about climate change issues with a view to reduce human causes and improving adaptation options.

Keywords: Climate change; extension; agriculture; strategies

INTRODUCTION

The croplands, pastures and forests that occupy 60 per cent of the earth's surface are progressively being exposed to threats from increased climatic variabilities. Abnormal changes in air temperature and rainfall are resulting in increasing frequency and intensity of drought and flood events that in turn have long-term implications for the viability of the ecosystems. As climatic patterns change there comes change in the distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests, fish populations and ocean circulation patterns which can have significant impacts on agriculture and food production. The global average surface temperature is likely to rise by 1.8-4°C in this century if further action to reduce greenhouse gas emissions is not taken immediately. Climate change is affecting all aspects of the climate making rainfall very unpredictable, changing the pattern of seasons, raising sea levels due to melting of glaciers and increasing the severity of extreme weather events like floods, landslides and droughts. The main cause of climate change has been attributed to anthropogenic (human) activities such as the increased industrialization in the developed nations which has led to the introduction of large quantities of greenhouse gases (GHGs) including carbon-dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) into the atmosphere. The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. The estimate for Africa is that 25–42 per cent of species habitats could be lost affecting both food and non-food crops. Habitat change is already underway in some areas leading to species range shifts and changes in plant diversity which includes indigenous foods and plant-based medicines (McClean et al 2005).

Agriculture and climate change are inextricably linked. Nelson (2009) stated that "Agriculture is part of the climate change problem, contributing about 13.5 per cent of annual greenhouse gas emissions (with forestry contributing an additional 19%) compared with 13.1 per cent from transportation. Agriculture is however also part of the solution offering promising opportunities for mitigating emissions through carbon sequestration, soil and land use management and biomass production. Climate change threatens agricultural production through higher and more variable temperatures, changes in precipitation patterns and increased occurrences of extreme events like droughts and floods". Agriculture accounts for more than 70 per cent of global water use (Anon 2006, Anon 2008). According to projections there will be increasing challenges in terms of increased water stress and areas suitable for agriculture along the margins of semi-arid areas and arid areas are expected to decrease significantly (Falkenmark 2007). Seasonal variability in water availability is

also critical for agricultural production. For instance a comparatively small decrease in rainfall during one season may have more severe consequences than a much larger precipitation decrease in another season. Population changes could in fact nullify any increases in precipitation/available water. The situation will be aggravated by overdependence on natural resources (Raleigh and Urdal 2007). Overdependence on surface water especially for irrigation will aggravate the impacts of climate change and variability on agricultural development. The predicted impacts of climate change must be introduced into development planning including land-use planning, natural resources management, infrastructure design and measures to reduce vulnerability in disaster reduction strategies. According to Falkenmark (2007) the array of adaptation options is very large ranging from purely technological measures to managerial adaptation and policy reform. For developing countries availability of resources and adaptive capacity building are particularly important.

The greatest impact will continue to be felt by the poor who have the most limited access to water resources. In developing countries 11 per cent of arable land could be affected by climate change including a reduction of cereal production in up to 65 countries, about 16 per cent of agricultural GDP (Anon 2005). During the past fifty years agricultural development policies have been remarkably successful at emphasizing external inputs as the means to increase food production. This has led to growth in global consumption of pesticides, inorganic fertilizers, animal feed-stuffs and tractors and other machinery. These external inputs have however substituted for natural processes and resources rendering them less powerful. Pesticides have replaced biological, cultural and mechanical methods for controlling pests, weeds and diseases; inorganic fertilizers have substituted for livestock manures, composts and nitrogen-fixing crops; information for management decisions comes from input suppliers, researchers and extensionists rather than from local sources; fossil fuels have substituted for locally generated energy sources. In order to sustain the agricultural sector that plays pivotal role in human existence in terms of the provision of food, fibre, fuel and income strategies of change need to be urgently initiated to cope with the changing climate. The most profound impacts of climate change in India will be in agriculture and food security, water resources, water induced disasters, biodiversity changes and human health. Increasing the resilience of communities to cope with climate change demands some effective strategies in state or national level and practical implementation and integration of those strategies in India's long term development plans. Practising policy through the implementation of different projects, encouraging vulnerable

communities to take part in decision making processes on climate related adaptation strategies, revising climate change policy to enable local-level action, continuous monitoring and analysis of predicted climate change by agriculture, energy, health and water departments of government and empowerment of community to prepare themselves for climate-induced hazards should be focused at the moment. Therefore the overall purpose of this paper is to ascertain the role which agricultural extension can play in building adaptive/ resilience capacities of vulnerable people to climate change impacts.

Role of extension agencies

Climate change will certainly affect agriculture but agriculture can also be harnessed to mitigate greenhouse gas (GHG) emissions. A key element in supporting agriculture's role is information. The costs of adapting agriculture to climate change can be large and the methods not always well known. Mitigation efforts will require information, education and technology transfer. Agricultural extension and advisory services both public and private thus have a major role to play in providing farmers with information, technologies and education on how to cope with climate change and ways to contribute to GHG mitigation. This support is especially important for resource-scarce smallholders who contribute little to climate change and yet will be among the most affected. Support from extension for farmers in dealing with climate change should focus on two areas: adaptation and mitigation.

How can extension help with adaptation and mitigation?

There are several ways that extension systems can help farmers deal with climate change. These include adaptation and contingency measures for what cannot be prevented. 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 climate change by providing advice on how to deal with droughts, floods and so forth. Extension can also help with mitigation of climate change. This assistance may include providing links to new markets (especially carbon), information about new regulatory structures and new government priorities and policies. Discussed below are different ways in which extension can help with adaptation and mitigation related to climate change:

(i) Technologies and management information

Extension traditionally has played a role in providing information and promoting new technologies or new ways of managing crops and farms. Extension also links farmers to researchers and other actors in the innovation system. Farmers, extension agents and researchers must work together on farmers' fields to prioritize, test and promote new crop

varieties and management techniques. While extension must now go beyond such methods there is still a need for simple technology transfer in order to increase resilience to climate change and mitigate GHG emissions. Today's farmers will need to be able to quickly respond to climate change and adeptly manage risk. This will be especially challenging for extension in terms of knowledge and information systems. Farmers need to have access to this kind of information be it climatic information, forecasts, adaptive technology innovations or markets through extension and information systems. Extension agents can introduce locally appropriate technologies and management techniques that enable farmers to adapt to climate change by for example developing and disseminating local cultivars of drought-resistant crop varieties with information about the crops' advantages and disadvantages. Additionally extension staff can share with farmers their knowledge of cropping and management systems that are resilient to changing climate conditions such as agroforestry, intercropping, sequential cropping and no-till agriculture. Some of these practices have the added advantage of improved natural resource management. Tree planting can also help to improve soil, prevent soil erosion and increase biodiversity. 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 climate change. At the same time extension staff can play an important role in transferring indigenous technical knowledge to help farmers worldwide. A core challenge for extension in the future is to shift from providing 'packages' of technological and management advice to instead 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. Some farmers will also need access to new technologies and management options in those areas where climate change renders their current farming systems inviable.

(ii) Capacity development

One of extension's major activities over time has been adult and non-formal education. This role continues today and is even more important in light of climate change. In addition extension is also responsible for providing information using techniques ranging from flyers and radio messages to field demonstrations. 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 climate change. Climate Field Schools (CFSs) have been established in West Java, Indonesia to deal with climate change 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 climate change. Climate change will initiate extreme events like sudden onset disasters and new vectors of human and livestock diseases. Evidence is emerging that the biggest impacts will be in the form of small droughts, floods and other events that cause severe hardship but do not attract the attention of the international community. 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. There is a need for capacities to engage new sets of actors including humanitarian agencies. Education must thus move beyond technical training to enhance farmers' abilities for planning, problem solving, critical thinking, prioritizing, negotiating, building consensus and leadership skills, working with multiple stakeholders and finally being proactive. Capacity development is important within extension as well. Extension agents have traditionally been trained only in technical expertise and often lack 'soft' skills such as communication, development of farmer groups, systems thinking, knowledge management and networking. To improve outcomes in rural development, farmers and extension agents need new skills that will require agricultural education and extension curriculums to include valuing and understanding the knowledge and experiences of rural people and co-learning (that is farmers and extension agents learning together rather than extension agents training farmers in a one-way information transfer). There are many different ways to inform and educate farmers about adaptation options. Climate change 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 climate change effort and on increasing the capacity of extension agents and farmers where needed.

(iii) Facilitating, brokering and implementing policies and programs

Another role of extension which will be critical for climate change issues is that of acting as an honest broker bringing together different actors within the rural sector. Traditionally this has meant linking farmers to transport agents, markets and inputs suppliers among others. With climate change it will be increasingly important for the extension system to link farmers and other people in rural communities directly with voluntary and regulated carbon markets, private and public institutions that disseminate mitigation technologies and funding programs for adaptation investments. Increased access to meteorological information will be imperative. Extension also has an enormous

challenge in bringing together farmers' concerns and those of other actors as they address both climatic and market uncertainties together. Extension has the chance to make a significant contribution to overcoming this gap through enhanced farmer decision making. Extension agents may also play a role not only in brokering but also in assisting farmers in implementing policies and programs that deal with climate change mitigation. For instance regarding carbon credits extension agents could be employed to educate farmers in their area; assist in forming community groups; link farmers to governmental, non-governmental and private organizations at the national and international levels and perhaps assist with proposal preparation or negotiations with other players.

(iv) Coordination

Agriculture development system presents a complex coordination phenomenon inter-institutional and inter-disciplinary. Coordination is required within the disciplines/specializations, between institutions and departments and in functional areas like research, extension and training. The old concept of people's participation and new thrust on participatory research and development bring farmers also in the framework of interactions at all levels. More allied agencies have to be brought together to serve the farmers on the line of farming systems approach.

(v) Infrastructures/institutions

Keeping in view the local conditions the village extension workers and farmers ratio of 1:700 has to be reduced to 1:500 for covering larger areas and scattered population as also for more personalized approach. Rural institutions especially village cooperatives must function to meet the local needs of inputs-small and marginal farmers cannot afford to spend a lot of time in searching for the inputs. 'Village Resources Development Societies' being promoted in watershed areas under the Operational Research Projects of the ICAR involving local institutions and people in planning and implementation needs promotion and strengthening for sustainable rainfed agriculture. Krishi Vigyan Kendras may be established in rainfed districts on priority basis.

According to Ozor (2009) there is need for change in roles and capacity in the extension system so as to accommodate the new dimensions brought about by climate change. In order to provide practical solutions to hazards and sudden uncertainties in agricultural production there is need to establish emergency management units within every extension agency that will be trained to take charge of victims of disasters emanating from climate change risks such as flooding, erosion, acid rains, drought, submergence and poisoning from agricultural chemicals (insecticides,

pesticides, herbicides, fertilizers etc). The role of extension in emergency management is advocated because they work very closely and live with the rural farmers and can provide at least the best first aid assistance before the arrival of experts. It therefore makes it important for extension to be linked to the state emergency services, health workers and the police. The primary role of extension is in the dissemination of innovations to targeted clientele ranging from farmers, pastoralists, fisher-folks, hunters, foresters, wine-tappers and other rural residents who depend on agriculture in one way or the other. Therefore it behaves on extension to disseminate the best practices and innovations currently being developed by numerous research efforts across the globe on how to boost the adaptive capacity and resilience of vulnerable people to the effects of climate change.

(vi) Materials

Mobility is the first requirement for the extension work in different areas. To economize on travels motor-cycles may be used instead of jeeps, station wagons etc. low cost indigenous audio-visual aids may be preferred over expensive communication gadgets. Village library may be promoted where extension publications in local language could be available for atleast those who can read and write; the latter can function as extension agents for others. The concept of mini-farmers fair in villages can be promoted. Mobile exhibition van and soil testing kits can prove useful and effective for promoting different agriculture systems approach. Extension staff should not suffer for want of simple common requirements like papers, pencils, pens, typing facility and other stationeries for effective bottom-up communication and reporting.

(vii) Training

Poor resource farmers have to be trained more for they are less enlightened mostly illiterate and neglected from the mainstream of development. Because of their background trainings have to be based on the principles of 'training by doing' and 'learning by doing' like being followed by the Krishi Vigyan Kendras. Most of the trainings have to be in situ, off-campus/ village based for such farmers cannot afford to come for residential courses; they have to be one or two day courses. The training strategy should be to reach farmers, farm women and young farmers including boys and girls with special priority to school dropouts. We must build training infrastructures/institutions nearer to the farming situations as best as possible. KVKs being promoted in India for each districtis a good example in this respect.

(viii) Use of technology demonstrations

Extension agents can use various extension teaching approaches including method demonstration, result demonstration, print media (for example, posters, leaflets etc) and computer/ telecommunication media (for example

internet, television, cinema, radio, computer, etc) to further inform and educate farmers on various issues of climate change. Farmers learn by doing and practices learnt during a demonstration session could lead to adoption of the technology. Farmers perceive the use of demonstration methods as a significant role of extension in disseminating the coping and adaptive measures that could reduce climate change risks among vulnerable communities.

(ix) Climate change and conservation agriculture

Lal (2005) suggested that by adopting improved management practices on agricultural land (use of NTand crop residues) food security would not only be enhanced but also offset fossil fuel emissions at the rate of 0.5 Pg C yr^{-1}. Climate change is likely to strongly affect rice–wheat, rice–rice and maize-based cropping systems that today account for more than 80 per cent of the total cereals grown on more than 100 Mha of agricultural lands in South Asia. Global warming may be beneficial in some regions, but harmful in those regions where optimal temperatures already exist; an example would be the rice–wheat mega-environments in the IGP that account for 15 per cent of global wheat production. Use of resource conservation technologies such as Happy seeder technology for sowing wheat in the standing paddy straw, direct seeded rice (DSR), laser leveling, tensiometer etc can help in improving the soil structure along with carbon sequestration as well as saving of groundwater resources. While intensive soil tillage reduces soil organic matter through aerobic mineralization, low tillage and the maintenance of a permanent soil cover (through crops, crop residues or cover crops and the introduction of diversified crop rotations) increases soil organic matter. A no- or low-tilled soil conserves the structure of soil for fauna and related macrospores (earthworms, termites and root channels) to serve as drainage channels for excess water. Surface mulch cover protects soil from excess temperatures and evaporation losses and can reduce crop water requirements by 30 per cent. Special attention must be given to the situation of indigenous communities, risk-coping production systems resilient to land and water modifications require diversified structures in space and time such as crop rotations, agroforestry, crop-livestock associations, crop-fish systems and the use of hedges, vegetative buffer strips and other farm landscaping practices. Accomplishing this can have an enormous impact on adaptation to drought, heavy rains and winds.

Agronomic and crop management practices have to aim at reducing CO_2 and other greenhouse gas emissions by reducing tillage and residue burning and improving nitrogen use efficiency. In the IGP resource-conserving technologies continue to expand in the rice–wheat cropping systems and save 50–60 l of diesel ha^{-1} plus labour and

significantly reduce release of CO_2 to the environment. Methane emissions that have a warming potential 21 times that of CO_2 are common and significant in puddle anaerobic paddy fields and also when residues are burnt. This GHG emission can be mitigated by shifting to an aerobic, direct seeded or NT rice system. A review of the other benefits of direct seeding and NT in RW areas of South Asia can be found in Grace et al (2003). Nitrous oxide has 310 times the warming potential of carbon dioxide and its emissions are affected by poor nitrogen management. Sensor-based technologies for measuring normalized differential vegetative index and moisture index have been used in Mexico and South Asia to help improve the efficiency of applied nitrogen and reduce nitrous oxide emissions.

(x) Information and communication technology (ICT)

The role of ICT to enhance food security and support farming cannot be ignored. Its role in agriculture which includes use of computers, Internet, geographical information systems, mobile phones, radio and television was endorsed at the World Summit on the Information Society 2005. A number of factors influence the decision whether or not to invest in ICT: higher costs, lack of competition, lack of relevant skills for effective use of ICT could be inhibitors (Caseli and Coleman 2001).The use of mobile phones has been found to reduce information asymmetries, enabling users to access arbitrage, marketing or trade opportunities (Jensen 2007). Agricultural decisions on timely land preparation, planting, weeding, irrigation, harvesting, storage and marketing have always been central concerns to agricultural stakeholders. ICT especially mobile telephones can speed the way farmers in rural areas get, exchange and manipulate information. They rework the way farmers interact with markets and cities. A variety of innovations that integrate ICTs into the dissemination of agricultural information to farmers (Farmers Information Services FIS) have been developed at local, national and regional levels. They have currently demonstrated a promising field of new research and application in e-agriculture whilst bringing new sources of information and new tools for local knowledge dissemination. They are increasingly enabling farmers to focus, search and extract useful and up-to-date market information. Because of its potential to ameliorate this old rural farming problem an evaluation of its usage among farming communities becomes necessary. The use of Kisan Mobile Advisory services (KMAS) by Krishi Vigyan Kendras in which the farmers get message for the relevant crop pest attack or use of various technologies during growth stage of the crop is the example in this respect.

(xi) Crop yield forecasting

The knowledge and technology required for adaptation includes

understanding the patterns of variability of current and projected climate, seasonal forecasts, hazard impact mitigation methods, land use planning, risk management and resource management. Adaptation practices require extensive high quality data and information on climate and on agricultural, environmental and social systems affected by climate with a view to carrying out realistic vulnerability assessments and looking towards the near future. Vulnerability assessment observes impacts of variability and changes in mean climate (inter-annual and intra-seasonal variability) on agricultural systems. However agricultural production systems have their own dynamics and adaptation has a particular emphasis on future agriculture. Early warning and risk management systems are obvious and efficient contributors that can facilitate adaptation to climate variability and change including:

- a historical climate data archive, an archive on climate impacts on agriculture,
- monitoring tools using systematic meteorological observations,
- climate data analysis (to determine the patterns of inter-annual and intra-seasonal variability and extremes),
- information on the characteristics of system vulnerability and adaptation effectiveness such as resilience, critical thresholds and coping mechanisms (this information is required to identify opportunities for adaptation measures and the potential of particular practices) and
- crop weather insurance indices to reduce the risk of climate impacts for lower-income farmers.

(xii) Feedback role to government and other interested agencies on climate change issues

Extension agents live and work with the people in rural areas. This affords them the opportunity to be knowledgeable on issues that border on climate change in their areas of coverage. During the fortnightly meetings (FNTs) and block meetings (BMs) extension agents are expected to give situation reports on their duty stations. From this government and non-governmental bodies can become aware of climate risk situations in the rural areas and then be able to render assistance, make policies or execute programmes to manage the challenges identified by agents. In this circumstance challenges such as flooding, drought, pest and diseases infestation, submergence by water and other catastrophic effects of climate change can be reported promptly. Similarly local practices which have helped a particular individual or community to adapt to the effects of climate change can also be reported and advertised thereby creating the avenue for such practice(s) to be replicated and up-scaled in other vulnerable areas.

Why extension rather than another institution for climate change?

Gathering information is expensive. 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 per cent. A recent study demonstrated that receiving at least one extension visit in Ethiopia reduced smallholders' likelihood of being poor by 10 per cent and increased consumption growth by 7 per cent. Extension is thus a cost-effective tool that can play an important role in dealing with climate change while at the same time helping to increase productivity and reduce poverty.

Recommendations

Extension has a major role to play in helping farmers adapt to and mitigate climate change. To capture this potential role adaptation and mitigation funds could be used to support extension efforts that deliver new technologies, information and education about increasing carbon sequestration and reducing GHG emissions. Traditionally extension has worked to promote new technologies and management techniques, educate farmers and act as a facilitator or broker for rural communities. Now too extension can help link practice in the field to new policies regarding climate change. Considerable 'expert judgment' or accumulated experiences are available in farming communities who live with climate risks over time. The availability of usable science-based climate prediction information needs to be tailored to farmer needs by matching it with traditional practices and incorporating existing local knowledge. To facilitate this process science-society integrators who orient climate modelling research to meet farmers' need and vice versa can provide feedback to the climate science community on the application value of their research. These integrators need to be part of the initial institutional set-up with specific responsibilities and terms of reference. An important aspect in the above is to analyse the dimensions of climate change impacts and adaptation patterns on gender and the implementation of human rights including issues such as: how does climate change aggravate existing problems in the areas of food and water security; does this affect women's and men's lives differently; what are women's needs for improving their access to education, labour markets and participation in decision making. All of these roles can be exploited in a cost-effective way to help resource-poor smallholders deal with the issues of climate change that will so radically affect their livelihoods. Perhaps 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 climate change.

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