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Policy Brief for Parliamentarians

Climate Change and Sustainable Agriculture: Securing the Small and Marginal Farmer in India

Introduction:

The sustainability of the agricultural and allied sectors is threatened by climate change. While mitigation and adaptation measures are urgently needed to try and combat climate change in all sectors of the economy, the agricultural sector should take precedence. This sector supports the livelihoods of millions of small and marginal agricultural labourers who have only limited insight and understanding of coping mechanisms that can help them to combat the effects of changing temperatures and erratic rainfall patterns (Howden et al 2007). These farmers are vulnerable and exposed to many risks associated with climate change, including droughts, floods, disease of both crops and animals and unpredictable market irregularities.

> The latest report from the Inter-Governmental Panel on Climate Change (IPCC) recognised the importance climate change has for agriculture and food security by identifying the extensive impact that rising temperatures, subsequent glacial melts and erratic rainfall is having in India. The IPCC further highlight the impact of these rising temperatures using case examples from 2004, in particular the affect on the yield of wheat and the implications this has for food security. Additionally, the Panel identified that an increase in cyclones and floods has had a huge impact on agricultural practice and led to greater emphasis on the need for further research towards mitigation and adaptation measures to cope with climate change.

With over 80% of the agricultural sector in India consisting of small and marginal farmers, it is absolutely vital to identify and evaluate cost-effective strategies to allow farmers to mitigate and adapt to the effects of climate change. Furthermore, due to the diverse agricultural production practices found throughout India in response to climatic variability, soil irregularities and socio-economic factors, these strategies will need to take into account a broad range of farming conditions. It is also important to acknowledge that there is uncertainty as to how many of the mitigation and adaptation measures developed to address climate change could be easily adopted by such small scale and marginal farmers who are most vulnerable, due to their limited adaptive capacity, poor socio-economic backgrounds and unfavourable policy conditions within which they are forced to operate.

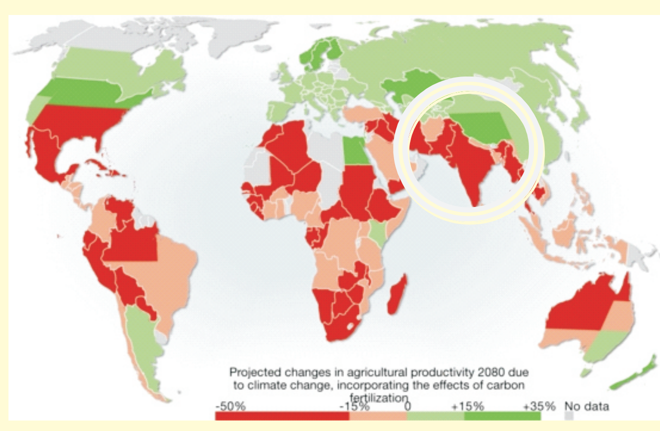
This brief has sought to collate and evaluate some of the methods and processes that have been developed to aid farmers in the battle against rising temperatures, changing sea levels and erratic rainfalls. Furthermore, this brief makes a series of policy recommendations, with the aim to influence government legislation that can in the long-term help to reduce the devastating impact climate change will have on the agricultural sector in India.

Adaptation and Mitigation:

The two most widely recognised and adopted approaches to combat the effects of climate change are strategies of MITIGATION and ADAPTATION:

> **MITIGATION:** All human interventions which reduce the sources of greenhouse gases (GHGs) or which enhance the sinks of GHGs
>
> **ADAPTATION:** A response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities

In the context of small and marginal farmers, adaptation measures are most tangible. Mitigation strategies should be the government's priority. The main areas in which small and marginal farmers can contribute to mitigation efforts are Integrated Nutrient Management (INM) and Site-Specific Nutrient Management (SSNM). Demonstrated benefits of these technologies are increased rice yields and thereby increased net CO_2 assimilation and a 30-40% increase in nitrogen use efficiency. These systems offer important potential for decreasing GHGs linked with



This map presents a rough idea of changes in agricultural output from increased temperatures, precipitation differences and also from carbon fertilization for plants. Note that by 2080, India's productivity will have decreased by 50% unless we act now to combat the effects of climate change.

Source: Cline, W.R. 2007. Global Warming and Agriculture: Impact Estimates by Country. Washington D.C., USA: Peterson Institute.

nitrogen (N) fertiliser use in rice systems. It is critical to note here that higher CO_2 concentrations in the future will result in temperature 'stress' for many rice production systems, but will also offer a chance to obtain higher yield levels in environments where temperatures are not reaching critical levels.

One of the key emerging technologies to reduce GHG emissions from rice fields is the use of zymogenic bacteria, acetic acid and hydrogen-producers, methanogens, CH_4 oxidizers, and nitrifiers and denitrifiers, which help to maintain the soil redox potential in a range where both N_2O and CH_4 emissions are low (Hou et al 2000). The use of neem coated urea is another simple and cost-effective technology which can be practiced in South Asia by farmers with small holdings.

Strategic Research in Adaptation:

Within the agricultural sector, adaptation techniques include the use of biotechnological tools like marker assisted selection and whole genome expression analysis that lead to molecular mutation. The efficient use of conventional breeding and molecular/mutation breeding by the use of such tools and their subsequent elucidation and gene finding by bioinformatics, will form the basic and strategic approach to counter climate change for increased food grain production. The indirect effects such as decline in water resources, increased pest and disease incidence and loss of soil organic carbon, should be tackled by conservation and efficient use of water, Integrated Pest Management (IPM) and conservation farming.

Cropping System Based Technologies:

This adaptation strategy is centred on the promotion of crop varieties that have adapted to suit changing climatic conditions. Newly developed crop varieties are able to withstand temperature and rainfall extremes, while other crops are being developed to thrive under increasing CO_2 atmospheric conditions or possess greater tolerance to coastal salinity.

Agricultural biodiversity and the development of efficient **crop germplasms** is an area for further research that will drastically help marginal farmers with rural small holdings to adapt to climate change. Crop breeding research must be furthered through collection and analysis of seeds and plants demonstrating tolerance to temperature, water and atmospheric irregularities, while in-depth investigation of wild relatives/strains, landraces, extant varieties, modern varieties and breeding stocks will further aid this research.

Genetic resources could prove to be the most important cost-effective raw materials that can allow agricultural practices to adapt to the effects of climate change. In India considerable progress has been made in the genetic dissection of flowering time, inflorescence architecture, temperature, and drought tolerance in certain model plant systems and by comparative genomics in crop plants. The Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, has come out with a transgenic *Sorghum* incorporated with a bacterial gene which can confer tolerance to drought and salinity (Maheswari et al 2008). Germination potential of these transgenic seeds is much higher when exposed to salt and water stresses. In addition, they have remarkably robust root systems in terms of root biomass and length.

Strategies for genetic enhancement of heat tolerant genotypes (especially in pulses), by identifying and validating markers for high temperature tolerance coupled with yield potential, is one of the key technological advances that can prove to be a significant strategy for adapting to climate change. An additional strategy is to capitalise on those advances which have produced plant varieties that thrive in higher temperatures, for example the *rabi* rice which is insensitive to photoperiod and temperature. Improved and newly developed agronomic se-induced spikelet sterility, can be used to reduce yield instability by preventing flowering during the hottest months (Gadgil 1995).

Farmer Participation in Adaptation:

Adaptation strategies need to strengthen farmers' abilities to manage the risks they face. Such measures to reduce the negative effects of climate change in arid and semi-arid tropics can include changing the cropping calendar to take advantage of the wet period and to avoid extreme weather events during the growing season. In addition, improved crop management through crop rotations and intercropping, integrated pest management, supplemented with agro forestry and afforestation schemes, are important strategic interventions that enable farmers to adapt to cope with the effects of climate change in India.

Intercropping is an efficient strategy that can be followed with desirable outcome. Grain-legume intercrops have many potential benefits such as stable yields, better use of resources, weeds, pest and disease reductions and increased protein content of cereals as compared to sole cropping systems. The establishment of seed banks is of crucial importance in highly variable and unpredictable environments. This facility provides a practical means to re-establish crops obliterated by major disasters and extreme climate events. This will also help in plant community dynamics, as differential plant germination strategies to buffer against inter-annual variability in growing conditions.

The promotion of **scientific agro forestry** forms another key component. Agro-forestry systems buffer farmers against climate variability, and reduce atmospheric loads of GHGs. Agro forestry can both sequester carbon and produce a range of economic, environmental, and socioeconomic benefits. For example, trees in agro forestry systems improve soil fertility through control of erosion, maintenance of soil organic matter and physical properties, increased N accretion, extraction of nutrients from deep soil horizons, and promotion of more closed nutrient cycling.

Resource Conservation Based Technologies:

Vital resource conservation based technologies primarily aim to improve moisture conservation, rainwater harvesting and recycling, efficient use of irrigation water, conservation agriculture, energy efficiency in crop production and use of poor quality water. The suggested strategies for adaption include characterisation of bio-physical and socio-economic resources utilising GIS and remote sensing; integrated watershed development; improving rainwater use efficiency through run-off harvesting, storage, and reuse and contingency crop planning to minimise loss of production during drought/flood years (Kapoor 2006).

Zero-tillage has effectively reduced the demand for water in rice-wheat cropping systems in more than a million hectares of land on the Indo-Gangetic Plains. Zero-tillage is a process whereby seeds are planted into soil that hasn't been tilled after the harvest of the previous crop. Advantages of this technology are increased water-use efficiency, reduced water-logging, better access for inter-row cultivation, weed control and banding of fertilizers, better stand establishment, less crop lodging and reduced seed rates. Overall, farmers can realise higher yields and reduce production costs. In addition, zero-tillage has a direct mitigation effect as it converts GHGs like CO_2 into oxygen in the atmosphere and carbon, and enriches soil organic matter. **Bed-planting,** widely adopted in the Indo-Gangetic Plains, has also proven to be a successful conservation technology. The main advantages of this technology are increased water-use efficiency, reduced water-logging, better access for inter-row cultivation, weed control and banding of fertilizers, better stand establishment, less crop lodging and reduced seed rates.

In case of coastal salinity, the **Doruvu/Kottai technology** for managing sea water intrusion in coastal areas has been practised effectively in the states of Andhra Pradesh and Tamil Nadu. This technology involves the creation of extended, open wells that allow for the horizontal flow of underground water through pipes. This adaptation strategy enables farmers to pump non-saline, underground water to irrigate their crops in areas where previously their crop production was hindered by poor water quality.

System of Rice Intensification (SRI) has key benefits under the present changing climatic conditions. This new technology keeps rice fields moist rather than continuously saturated, thereby minimising anaerobic conditions and improving root growth and diversity of aerobic soil organisms. Rice plants are spaced optimally to enable full growth of roots and canopy, thus keeping all leaves photosynthetically active. Furthermore, to minimise root trauma and transplant shock, rice seedlings are transplanted quickly and carefully when young. SRI offers a potential strategy to adapt to climate change related risk because it uses less water. The resistance of SRI rice plants to lodging, caused by wind and/or rain given their larger root systems and stronger stalks, is an important feature to enable their resistance to flooding. Such SRI methods can reduce the agronomic and economic risks that farmers have to face with the increasing effects of climate change.

Promotion of **integrated farming systems** for marginal farmers will also be a viable and effective alternative in combating climate change. Multiple-enterprise agriculture, whereby farmers invest in a combination of crops, livestock, poultry, fish farming or trees in a single unit of land, will minimise risk by supplying farmers with several potential sources of income should one farming process be affected more significantly by the affects of climate change. **Small farm mechanisation** is also an important step towards combating the affects of climate change as such technology facilitates 'precision' agriculture: reducing waste and increasing energy efficiency in crop production. Small and suitable field production machinery for precision planting, nursery industry and efficient use of water for small farms will inevitably improve the management of farming systems. In addition, post harvest mechanisation for the processing of agricultural produce in rural industries should be encouraged and financial credit given to support the process.

Raising Awareness:

The emphasis on 'risk management' towards crop production should be shared with farmers on the measures they can take to manage risks associated with the effects of climate change. Farmers must be made aware of the measures they can take to manage risks associated with the effects of climate change. Such a proposed programme for raising awareness should include the following information on:

- How weather and climate extremes, variability and change will impact on farm operations
- Weather and climate processes, including the causes of climate variability and change
- Historical insights towards weather patterns and climate variability for farmers wishing to locate suitable agricultural land to farm
- Analytical tools to describe the weather extremes and climate variability
- Forecasting tools that can give early warnings as to severe or variable climatic conditions and methods farmers can use to translate awareness of these early warnings into informed decisions that will enable them to take action and protect crops and livestock

Conclusions:

To make all of the proposed changes and advancements addressed in this policy brief attainable for small and marginal farmers across India, there should be an established policy framework backed by strong political will on the part of the government. Such a framework should address the issues of redesigning the social sector with focus on vulnerable areas/ populations, introduction of new credit instruments with deferred repayment liabilities during extreme weather events, and weather insurance as a major vehicle to transfer risk.

Governmental initiatives should be undertaken to identify and prioritise adaptation possibilities in key sectors i.e. storm warning systems, water storage and diversion, health planning and infrastructure needs. Focus on integrating national development policies into a sustainable development framework that complements adaptation, should further accompany technological adaptation methods. Policies to reduce environmentally detrimental agricultural subsidies, or at least to redirect these subsidies to sustain environmentally friendly forms of agricultural production, can help to further reduce GHG emissions. Climate change adaptation could be facilitated through greater use of market-based instruments such as efficient water pricing and water markets, and risk-based insurance for floods and droughts. In addition, the role of local institutions in strengthening capacities i.e. self-help groups, banks and agricultural credit societies, should be promoted and encouraged.

There must be a political will to implement economic diversification in terms of risk spreading, livelihood strategies, migration and financial mechanisms (Schneider 2007). Policy initiatives that address access to banking, micro-credit/insurance services (before, during and after a natural disaster) and access to communication and

Information services are also absolutely imperative in order for India to cope with the predicted effects of climate change.

Moving Forward:

The effects of climate change in India are becoming a witnessed reality with further predictions of impending widespread devastation. More detailed research and assessment of these impending risks is still needed, as such an assessment has the potential to offer an in-depth insight as to the potential impact and vulnerabilities that will be encountered through changing climate patterns.

Furthermore, an in-depth impact assessment with particular reference and emphasis on small and marginal farmers should be conducted in order to establish the extensive effects that climate change will have on this sector. Once the full extent of the potential impact has been realised, the development of appropriate technology to enable mitigation and adaptation should be a priority, coupled with appropriate government policies to offer continued long-term support to small and marginal farmers in India.

Suggestions for Key Policy Initiatives:

- Mainstreaming adaptation strategies by considering the impact on all major development initiatives
- Facilitate greater adoption of scientific and economic pricing policies, especially for water, land, energy and other natural resources
- Consider financial incentives and package for improved land management and explore CDM benefits for mitigation strategies
- Establish a "Green Research Fund" for strengthening research on adaption, mitigation and impact assessment
- Credit input for small farm mechanization and rural post harvest industry
- Interventions for adaptation should be more strongly supported by agro-meteorological services for marginalised agricultural producers
- Capacity building must be integrated into adaptation measures for sustainable agricultural development strategies
- Policy should focus on integrating local risks, needs, and capacities, with international markets, tariffs, subsidies and trade agreements so that marginalised farmers have the information and ability to compete in global markets.

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