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Global Climate Change agenda and Processes: Scouting for Traditional Grassroot Adaptation Strategies in Arid and Semi-Arid Agriculture of India

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International Crops Research Institute
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Abstract

The paper attempts to explore how a global Climate Change agenda and processes (covering concerns, debates, negotiations, research-based projections, impacts and actions broadly collectively termed as "global discourse" in this paper), can help enhance the farmers' adaptations against impacts of climate change in arid and semi-arid regions of India, which is potentially more vulnerable to climate change.

After a brief introduction to these dryland agricultural regions, the paper looks at the main thrusts of largely macro level focused global discourse on climate change. This is followed by a discussion on relevant features of farmers' traditional adaptation strategies against climatic variability in the above-mentioned regions captured through longitudinal village level studies by ICRISAT, and supplemented by other studies focused on farmer responses to weather induced risks. Based on the above, we look at the extent of match or mismatch between the two to identify the limitations and potential of the macro-level global discourse on climate change, for enhancing farmers' adaptation strategies against the negative impacts of climate change.

Information on mainstream global discourse is picked up from a variety of reviews and critiques of the specific components of global discourse on climate change. The information on farmers' adaptation strategies is provided by a number of studies on farmers' vulnerability and risk management conducted during the last thirty years in different parts of arid and semi-arid areas in India.

The important concerns about usability of global discourse relate to highly aggregative and macro level focused information, projections, modeled scenarios, etc, along with their current information gaps and uncertainties. Consequently, they do not offer apparent concrete contexts at micro levels to which dryland farmers respond by way of adaptation measures. Besides, the global discourse largely focus on mitigation as against adaptation to climate change, which does not help dryland farmers' adaptations to climate change. Finally, the farmers' adaptation-responses are not directed exclusively to weather induced risks and uncertainties, but they address the other sources of risks such as market and other calamities. Since the global discourse on climate change has highly skewed perspectives (reflected by its focus mainly on climate change with little attention to other linked global changes), it may not offer inspiring lead lines, even in the perspective sense to dryland farmers to evolve holistic coping strategies against risks.

Based on the evidence and understanding of farmers' traditional and present adaptation strategies against weather variability, the paper attempts to explore some indicative possibilities to benefit from macro level global discourse on climate change. They include the indicative approaches to harmonize the elements of traditional adaptation approaches and potential field oriented (micro level focused) new approaches guided by imperatives of climate change, using new technological and institutional options. Their involved facilitative interventions, however, are largely product policy programs initiated and promoted by the governments. In some way, one of the most significant contributions of global discourse on climate change is generating information and concerns of policy makers about potential risks created by climate change and need for promoting measures against them including the above-mentioned interventions, which

ultimately help in making development steps climate sensitive. However, promotion of such steps will be greatly facilitated if some downscaling of current global approaches, by way of focusing on regional and local/landscape situations, is promoted.

1.0 Introduction

This paper looks at the global discourse (broadly covering concerns, debates, projected impacts and potential adaptation responses) on climate change through the lens of indigenous / traditional adaptation strategies against climatic risks evolved and followed by the farmers in arid and semi-arid regions of India. The latter are largely guided by farmers' experience based perceptions of weather variability and its consequences rather than formal meteorological information. These regions referred to as dry regions of India, belong to the regions likely to have very significant impacts of climate change, which may further aggravate their poverty and related problems.

Since the climate-linked risks are as old as agriculture in these regions, the farmers have learned to live with them by evolving various coping measures to minimize the impacts of climatic variability. Based on village, farm and plot level information from different studies during the last 30 years in different parts of arid and semi-arid areas of India, the paper synthesizes the attributes of the said adaptation strategies. The paper looks at their relevance in the context of evolving potential responses to impacts of climate change in the dry regions of India. We also look at the relevant components of global discourse on climate change for their ability to help farmers for enhancing their adaptation strategies.

The short and long term, as well as individual and collective coping measures against risks form a part of the overall adaptation strategies of dryland farmers. Based on the intra- regional biophysical and socio-economic differences, the adaptations show considerable diversity and flexibility as well as gradual change in their contents with the changing constraints and opportunities. Besides, three points that are central to our discussion on adaptations to climate change can be noted.

First, the highly variable weather (or climate) conditions in the dry regions have shaped the farmers' responses or adaptations in the past. They may offer some insights and clues for evolving place based adaptation strategies to climate change for the future. Second, the farmers' adaptation strategies (with some intra-regional differences) are not directed to weather variability exclusively. They are addressed to multiple constraints and opportunities including those having links with climatic variables. Third, the farmers' adaptations measures not only have significant diversity and flexibility, but tendency to evolve (change) with the emergence of new opportunities and constraints. The implications of the above in the context of changing climatic conditions in the dry regions would include (i) possibility of harnessing the potential complementarities between traditional, farmer-evolved measures and those generated through modern technologies and management systems, (ii) designing and harnessing of micro-macro links-based policy-program interventions to make dryland agriculture and rural development climate sensitive, (iii) re-orientation of institutions and overall support systems for dryland agriculture to enhance capacity of dryland communities to withstand the negative impacts of climate change.

Different sections of the paper address the above issues by focusing on: constraining features of global discourse on climate change, specially its missing links with micro level situations; dryland agricultural context along with the traditional adaptation experiences; quantified

field observations about adaptations at grassroot levels to illustrate diversity and dynamics of farmers' adaptation measures; farmers' experience based perception guiding adaptation strategies and indicative implications and imperatives of the above issues, mainly in terms of making dry agriculture and rural development climate sensitive.

2.0 Global Discourse on Climate Change: Searching Contexts for Adaptation responses

Impressive results from climate science research, significant progress in the mobilization of opinions, efforts and resources to deal with the problems of climate change and associated risks and vulnerabilities and enhanced understanding and awareness of the impacts (specially the negative consequences) of climate change, have been achieved. However, some gaps continue to characterize the mainstream discourse on climate change in terms of addressing micro-level, spatial situation to facilitate adaptations through clear and realistic thinking and action to facilitate development of adaptation strategies against climate change. The broad areas of the gaps or imbalances relevant to the present discussion are elaborated below:

(i) Continuing uncertainties and information gaps characterizing the projected extent of changes in different climatic variables particularly at micro (landscape) levels. Notwithstanding the progress in terms of relatively more certain and definite information including macro-level projections of different climatic variables generated by research at global levels, there is a lack of information at the micro-levels, where actual adaptation (or even some mitigation) responses to climate changes are to be designed and implemented. This is more so in the context of the subject covered by this paper, namely, adaptation to climate change in arid and semi-arid regions of India. Reducing information and knowledge gaps, through systematic place based data collection and analysis should be the first step in this context (Nelson in "Development and Cooperation D+C", 2009). In the absence of this, the farmers would continue to prefer their traditional, culturally and environmentally rooted approaches to assess the weather variabilityies and other climatic processes (including extreme events) and respond to the same, in place of accepting/using undependable and uncertainty-dominated information to guide their decisions (Crate and Nuttal 2009). Based on their practical and usable knowledge on natural phenomena (including climatic variables), the communities have, over the generations developed adaptation measures, to serve their sustenance and development needs (Berkes and Folke 1998, Jodha 2001, Jodha et al. 2009). To sum up, due to associated information gaps and uncertainties (in the micro level contexts), the climate change projections and scenarios do not provide basis for adaptation strategies in the micro level contexts in dry regions of India (Kumar et al. 2010).

(ii) Mitigation versus Adaption Strategies: Imbalances. In the mainstream work on climate change, there is greater emphasis on mitigation strategies wherein efforts are concentrated more on factors and processes leading to climate change (eg, deforestation, excessive use of fossil fuel, etc) as compared to adaptation strategies (ie, measures enhancing capacity to minimize risks associated with climate variability covering institutions, technologies, other traditional practices, etc). The latter helps in building the farmers' resilience to climate change.

Such unbalanced approach tends to over-emphasize the more uncertain, long-term exploration and modeling-centered future rather than the relatively easier to perceive and act-upon issues at the community/household levels. Consequently, discourse and decisions on mitigation measures against climate change are pushed to higher, macro levels, where despite well-articulated arguments, the formal steps towards agreements between the parties are difficult. A critical assessment of the Kyoto Protocol and staggering process of consensus building on important issues, debated at Conferences (at Bali, Copenhagen and Cancun) on climate change, would bear this out (Harmeling and Bals 2008, Narain 2008, Dutt and Gaioli 2008). This is largely because the proposed options, including reduction in use of fossil fuels and other potentially development constraining measures, rarely go beyond the formal debates and non-implementable resolutions. These and other related factors put serious brakes on the rapid and effective actions on mitigation measures against climate change, unless they are closely linked to place-based adaptation measures.

In contrast to the constraining factors against largely debated mitigation approaches, the adaptation approaches to climate change have high doable potential, greater field action and implementation possibilities, through participation by place-based stakeholders, including participation by state, NGOs and multiple funding agencies. Besides, a number of natural and manmade circumstances, constraining the promotion and use of mitigation strategies as alluded to above, have much less obstructing role in adaptation strategies to climate change. However, despite potentially greater feasibility and contributions of adaptation strategies, which partly build upon the conventionally and historically known elements of resilience to climate variabilities and associated uncertainties and risks, they seem to get relatively lower status in the mainstream thinking and debates on the problems of climate change (Kerr and Sanghi 1992, Crate and Nuttal 2009, IFAP 2009). Besides, they also have significant potential as "dual purpose" strategies (ie, besides addressing current livelihood/development needs they contribute to the fight against the climatic risks, as indicated by the role of community forestry (Banskota et al. 2007) and other land use practices (Nelson 2009) as well as diversified farming systems (Shah 1993, Walker et al. 1983, Jodha 2001). The World Development Report (WDR) and the The Economics of Climate Adaptation Working Group (ECA) have proposed a decision making framework for "Shaping Climate Resilient Development", by emphasizing the need for incorporation of neglected aspects (including traditional practices) in the strategies against climate change.

Additionally, a number of potential "adaptation options" specially in the case of the Indian dry regions under discussion, and many other areas in the developing countries, have their predecessors in the form of traditional adjustment measures and practices evolved over generations to protect against climate variability and natural hazards (Jodha and Mascarenhas 1985, Crate and Nuttal 2009, Arnold and Dewees 1995, Bantilan et al. 2002, Green Peace International 2009). Their rationale, if not the forms, can help in developing adaptation strategies against risks associated with climate change in the dry areas.

(iii) Skewed perspectives: Almost exclusive focus on climate change***, ignoring other linked global changes.*** The other rapidly emerging changes at global levels relate to key drivers of global change including economic integration (or economic globalization), border-insensitive

E- technology (eg, internet) and communication systems, and relatively inclusive approaches to international agricultural research (eg, through CGIAR and others), jointly designed or agreed governance and development approaches under the UN System as reflected by MDG, international initiatives relating to biodiversity conservation, global food security and health issues.

A closer look at the involved processes and drivers of the above and other global level changes indicates a variety of direct or indirect links between them and their consequences (O'Brien et al. 2004). However, most of these links and their imperatives, due to subject-wise fragmented perspectives, generally remain unaddressed. For instance, how the process of economic globalization affects or gets affected by indicators of climate change in short or long run contexts, hardly gets significant space in policy-program discourse and strategies, notwithstanding the recent increased concern for this aspect (Kumar 2007).

In this context one may also refer to a number of documents by The World Bank, FAO, UNEP, IHDP, ODI, Oxfam International, ADB, various universities and research institutions that look at the impacts of climate change on food security, poverty, health, migration, etc, as affected by climate change and emphasize the need for "climate smart" development interventions (WDR 2010). By way of a brief digression, it may be stated that the research focus on adaptation to climatic risks at micro-farm level has also largely over-shadowed the other sources of risk, quite prevalent in dryland settings to which farmers try to adapt. The implication of the above issues is that adaptations to changing climatic conditions in arid and semi-arid areas will involve multiple facets including harnessing of potential and complementaries between traditional, farmer-evolved measures and those generated through modern technologies and management systems, as well as micro-macro links characterizing policies and institutions for dryland agriculture.

3.0 Climate Change and Dryland Agriculture

3.1 Contexts and Adaptation Experiences

As stated earlier, despite the gaps, global discourse on climate change has been able to promote awareness and concerns of policy makers about potential risks and needed response to the problems. The new advocacy for evolving climate sensitive interventions is one consequence of the same. Understanding of this aspect will be enhanced with the following discussion covering relevant features of the dryland farmer's adaptations against climatic variability.

Using the preceding discussion as background, we look at the situation in arid and semi-arid tropical areas in India, with a focus on (broadly defined) dryland agriculture with its risk related features and how farmers adapt to the same through spatially and temporally differentiated measures. This is based on the synthesis of field based quantitative evidence on farmers adaptations reported by Jodha et al. 2009. For this, farmers' experience based perceptions rather than formal climate change related information provide the basis. Accordingly, through a mix of close observation based descriptive accounts and quantified details we reflect on various dimensions of diversity of the farmers' adaptations, their changes over time, their institutional and technological dimensions and their policy dimensions. For reason of paucity of quantified information on various climatic variables (such as temperature, humidity, intra rainy season breaks in rainfall, hot and cold winds and their velocity), the seasonal or annual extent of rainfall in the areas is used as primary indicator of climatic variability, which acted as a primary context for the farmers' adaptation responses. However, subconsciously the farmers understood the role and extent of other above-mentioned variables that often compelled mid-season changes/ correction in farmers adaptation actions. They formed an important element in shaping farmers' perceptions as discussed later.

I. Responding to bio-physical constraints and opportunities

To begin with, the farmer's adaptations are focused on overall features of their natural resource base as a source of potential risks and opportunities. Climatic conditions (variability) constitute one of the components of the same. Table 1 illustrates this phenomenon. Details under Table 1 capture the general situation of arid and semi-arid regions but may not fully cover some exceptions with relatively better resource endowments within these regions. The associated spatial differences in this context constitute the determinants of diversity of risks generated by climate change and farmers adaptations to the same. Table 1 provides a generalized illustrative picture of these diverse issues and farmers' responses.

For example, with the help of Table 1, one can have indicative view of different aspects of the farmer's adaptation profile. Table 1, col.1, helps to provide an indicative, integrated view of the complexity of risk generating factors and processes affecting dryland agriculture; Table 1, col.2 indicates the diverse community responses to the same to harness opportunities and guard against constraints and risks; Table 1, col 3 covers the dynamic aspects of adaptations indicating positive and negative changes in the coping measures. The variables covered by Table 1 include technical and institutional as well as collectively or individually adopted measures.

Table 1. Dominant biophysical features of natural resource base (NRB) including climatic conditions), associated situations and community adaptation-response measures in drylands.

A. Features of NRB and associated situations	B. Traditional situation and responses to col. A	C. Emerging changes in A & B
Water/moisture scarcity and instability, frequent droughts and scarcities	Water harvesting, moisture conservation (bunding, trenching, etc), limited groundwater harnessing, focus on crops (mixed crops) with varying drought tolerance; seasonal migration during droughts, focus on annual-perennial plants complementarities	Moisture conservation/water harvesting measures requiring group action declined due to increased social differentiation. Rapid increase in groundwater exploitation. Reasons: Drilling technology, govt. subsidies and high prices of irrigated crops, lost collective concerns of communities for local resources.
High fragility, erodibility of land, not suited to high intensity uses	Overall land use and folk agronomic practices focused on combining production and conservation needs; focus on practices such as shallow tillage, terracing, bunding, strip farming crop-fallow rotations; more marginal lands allocated to animal grazing, common property resources (CPR)	Gradual discard of conservation-promoting land use systems; enhanced land use intensity, rapid degradation of land for both cropping and grazing. Reasons: Population growth, backlash of R&D-based modem technologies on traditional ones; decline of collective stake in local resources and community norms replaced by government rules.
Scarce and slow growing/ regenerating vegetation, frequent shortage of natural biomass supplies	Traditional agro forestry/farm forestry, periodical long fallows, regulated and collective efforts to maintain CPRs, provisions of protected areas, eg, water bodies, religious sites etc; seasonal closure/rotational use of grazing space	Traditional farm practices and institutional provisions facilitating vegetation protection/growth discarded; new initiatives such as JFM, agro forestry with new components yet to pick up at large scale Reasons: Reduced collective concerns/efforts; increased dependency on government subsidy programs, socioeconomic differentiation.
Soils with low nutrient and low potential for biomass and crop productivity	Farming systems focused on crop-livestock complementarities, local organic inputs, periodical resting (fallowing) of croplands, cereal-legume rotation or mixed cropping.	Decline of sources and usage of practices/systems helping soil fertility; increasing use of chemical inputs. Reasons: Extension services and subsidy on chemical inputs, formal R&D indifferent to traditional practices.

Continued

Table 1. Continued

A. Features of NRB and associated situations	B. Traditional situation and responses to col. A	C. Emerging changes in A & B
Overall high degree of marginality of NRB offering limited, high risk, low productivity earning options to communities	Accepting "inferior earning options"; stabilize and enhance opportunities using the practices mentioned above; collective risk sharing during crisis; external links through migration; petty trade; relief and charity.	Gradual discard of traditional approaches due to availability of new options through development intervention (including new technologies), rising dependence on public support, diversification of sources of livelihood including public relief, out-migration, earning through urban jobs, etc. Reasons: Emerging new phase of adaptation strategies.

a) Table adopted from Jodha (2005), based on evidence/inference from Arnold and Dewees 1995, Bantilan et al. (2002), Dasgupta and Karl-Goran (1990), Jodha (2001, 1992a, 1992b), Jodha and Mascrenhas (1985), Kerr and Sanghi (1992), Shah (1993), Walker and Jodha (1985), Walker and Ryan (1990), Reddy et al. (1993), Gadgil et Al. (1988).

By way of digression, indicative possibilities as to how global discourse in climate change can facilitate the adaptation process enhancement can be indicated. It may be mentioned that global discourse on climate change, as of now, does not readily offer usable contexts to multiply or enhance the range of adaptations exhibited by Table 1 covering diverse (micro level) situations in dry regions of India. The skewed perspective of discourse on climate change (besides other limitations) obstructs the same. In such situations, the role of global discourse in enhancing micro level adaptations can take place through promotion of policy maker's awareness and concerns about climate change risks and consequent government interventions directed to issues indicated by Table 1. Thus, contents of Table 1 particularly col.3 also indicate several intervention areas that can promote adaptations strategies against climatic risks.

Some of the changes, that weaken the traditional adaptation options such as inappropriate intensification of land use, weakening of collective arrangements against crisis situations, mining of groundwater, side effects of new technologies and generalized public intervention, increased pressure on lands, etc, indicated by Table 1, col. 3 would call for approaches to protect against risks created by them. Sensitization of policy makers as well as pressure groups/NGOs, etc, through global discourses can induce varieties of interventions. Similarly, the changes such as promoting access to off farm jobs, other livelihood promoting measures, use of new location specific conservation technology and public supported innovative institutional measures, adding new options for the dryland farmer, too could be encouraged and multiplied through information and scare generated by global discourse to reduce risks and vulnerabilities. To sum up, Table 1, col. 3 can help in identifying indicative options to help make the development approaches climate sensitive in the dry regions of India. This can also help in identifying the steps having potential for mitigation along with adaptation to climate change at micro/ community levels. Thus promotion of dual purpose steps, besides reducing impact of current risks, can help in reducing the extent of future risks from climate change processes (eg, through community forestry, various conservation measures, etc).

II Responding to Long and Short term risks

The contents of Table 1 dealing with overall risks can be supplemented by adaptation/ adjustment to climatic variability in short and long term contexts, as manifested by different features of farming systems in arid and semi-arid regions and briefly alluded to earlier. Based on detailed farm and village level data from different districts during different years, a quantitative picture of the same has been presented by our paper (Jodha et al. 2009). Based on the same, we can summarize the relevant adaptation/adjustments to climatic variability in the dry regions. The broad features of farming systems covers major resource management measures and agricultural practices such as crop-livestock-farm forestry integration, with their spatial and temporal changes like planting/harvesting crops, organic recycling and a variety of salvage operations in farming during crisis periods. These measures are resorted to according to short and long term rainfall situations and attributes of resource base. Their extent does vary between areas with different extent of aridity and man-made support systems such as water harvesting facilities, access and use of modern technologies and public support system, which inject spatial-temporal diversities into adaptations and coping strategies. They cover several folk engineering measures, folk agronomy measures and institutional arrangements such as provision of common property resources and other group initiatives (Jodha 1992a, Walker and Ryan 1990). The number and complexity of the indicated measures have also changed in recent periods with availability of more and diverse options. This change reflects the dynamic aspect of traditional adaptation strategies evolved by farm communities. Over time, changes in farming and resource management practices and choice of new adaptation measures to climatic situations in revisited areas including ICRISAT's VLS also reflect this phenomenon. This could be further enhanced by making development interventions climate change sensitive in the dry regions of India.

Equally important is visible differences in type and extent of adaptation responses in different areas manifesting the diversity of adaptation strategies. This should alert the decision makers against the emphasis on uniform approaches and programs to address adaptations against climate change for the region as a whole.

3.2 Experience Based Perceptions: guiding adaptation responses

Despite general lack of ready access and understanding of formal meteorological information the dryland farmers do possess some experience and understanding of climatic happenings (at times captured through natural indicators such as the behavior of birds and other creatures as well as growth stage-based performance of some plant species), to guide their decisions and actions especially where perception and ground level situations tend to converge. The following discussion elaborates the same. These perceptions of climatic variability serves as important contexts and guides for adaptation responses as elaborated below (Kanani 2004).

The relevance of such approach can be understood by the fact that dryland agriculture is largely a nature-shaped and nature-driven activity, which offers greater opportunities to identify contexts or processes, through which impacts of changing weather conditions (particularly rainfall) could take place (Jodha 1996). Following Kates (1985), we put these contexts in three

categories. This can help in understanding the issues and areas (contexts) requiring attention to handle the problems associated with projected climate change vis-à-vis micro level situations; who could be responsible for addressing underlying issues and gaps; and finally where could the farmers' traditional practices and support systems be of some help in evolving adaptation strategies against climate change.

A. The three categories of direct or indirect links between agriculture and climate variability (and hence its impacts) are put as first, second and third order impacts (Kates 1985).
B. The first order impacts of climate change relate to the agricultural resource base and production environment.
C. The second order impacts of climate change cover affected components or features of farming systems due to already impacted resource base and production environment (covered by "A")
D. Third order impacts cover macro-level aspects of agricultural systems and their links with macro level (secondary and tertiary level) processes and activities linked to agriculture as influenced through already impacted components of farming systems (covered by "B").

The involved variables and processes as per the farmers' perceptions and practices, captured through different studies in arid and semi-arid areas of India, are summarized below. The structures of variables and their linkages indicated may look quite crude and simplistic, but they capture the processes through which the farmers, exposed to weather variability, relate their production and resources use decisions and actions to face climatic risks. The information supporting the above was generated through repeated visits and interactions with farmers and field observations during the already mentioned studies in dry regions at CAZRI, ICRISAT and AERC. The fieldwork also included detailed discussions with farmers on interpretation of spatial and temporal differences in the status and performance of agricultural activities covering different fields and spatially differentiated locations in their own villages and some neighboring villages. Based on the synthesis of the above information (Jodha 1989, Jodha et al. 2009), we summarized the farmers perception based adaptations to climate variabilities. The Table 2 below puts together the major components/related activities to illustrate the process.

Table 2. Important Features of Farmers' Response to 1st, 2nd and 3rd Order Impacts of Climate Variabilities and their Implications for Future Adaptations.

1st Order Impacts: on Biophysical Environment	2nd Order Impacts: on Farming Systems	3rd Order Impacts: on secondary and tertiary levels
1. Farmers have functional knowledge of local climate variability	1. Farming systems with features and contents are adapted to climatic variabilities and stresses	1. Adaptations involving secondary and tertiary level links and processes with key focus on disaster management.
2. The formal modeled climate change related information is often neither available nor usable as this model-based aggregative knowledge do not relate to ground level, micro-level spatial diversity	2. Current measures/ practices can provide rationale (if not form) for future adaptations, but "the contexts" should be clearly known, which are largely missing	2. Impacts of negative side effects of public policies and support system, market forces, etc, and weakening of traditional adaptations without providing effective alternatives.
3. The above (2) provides no concrete context to evolve, amend response measures by the farmers, despite potential for the same	3. Of late traditional adaptations to climate change are weakened due to side effects of increased role of other factors: policies, market forces, demographic changes, etc	3. New problems with transformation process of dryland agriculture, requiring new adaptations covering multiple aspects involving long learning time.
4. Yet to sensitize farmers to modeled climate change; awareness generation can be helpful.	4. New adaptations or strengthening of the traditional ones call for action on multiple fronts.	4. Adaptation strategies to have integrated approach involving focus on change agents and process.
5. Awareness generation, sensitization approaches to climate change through public agencies are needed.	5. Needed adaptation strategies for "transformed" agriculture are a key task.	5. Needed policy and institutional changes to combine adaptations with development interventions.

The important "impact-route" characterizing the first, second and third order impacts of climatic variability on dryland agriculture are portrayed in boxes below:

Box I. First Order Impacts of Climate Variability in the context of Climate Change.

Farmer's perception of variabilities as a part of conventional knowledge

a. The conventional knowledge continues to govern farmers' practices.

b. Reasons for (a), despite climate change research and debate:

   i. Climate change is not sudden, but gradual hence broadly similar to climate variability known and responded through adaptations;

   ii. New elements in traditional adaptations through new technologies, public support systems, market, etc.

c. Limited scope for and use of climate change research affecting farmers' adaptations:

   i. Non-usability of modeled results and scenarios that focus on large aggregates, with little space for place-based adaptation options.

   ii. Scientific/climatic information through scenarios not structured as per farmers' perceptions of climate and its impacts

   iii. Climate change issues/implications have not yet reached the information and awareness stage relevant to the dryland farmers' decisions. A large gap yet to be negotiated.

Box II. Second Order Impacts of Climate Variability in the Context of Climate Change.

a) Formal climate change indicators at landscape/ micro farming systems levels are, as yet neither known nor shaping adaptations by farmers.

b) Conventional adaptations against climatic variability still guide farming systems.

c) Emerging primacy of multiple non-climatic factors (technology, market, public policies-programs, population changes, etc) in transforming the dryland agricultural systems.

d) As negative side effects of (c), the traditional adaptation measures are weakened.

e) Responding to the above (d) adaptation strategies have to focus on multiple drivers and their interactions to rehabilitate the traditional adaptations and complement them by new ones.

f) Elements for (e) have to be searched at macro level links of agriculture, and different inter-sectoral activities and organizations.

g). The above (f), links 2nd order and 3rd order variables.

Box III. Third Order Impacts of Climate Variability in the Context of Climate Change and Enhanced Macro-Level Links of Agricultural Systems.

a) Visible transformation of dryland agriculture, role of macro-level links/ processes

b) Affected by (a) visible fragmentation of "dryland agriculture" in

   i. Areas with greater extent of change due to public policies, market forces, technologies, etc.

   ii. Areas still having dominance of traditional farming systems.

c) Overall, the impacts of macro-level factors and processes have marginalized the traditional adaptation strategies against climatic variability in many cases.

d) Hence, need for conscious and proactive role of agencies governing multiple processes affecting agriculture along with the agencies facilitating adjustment to weather risks only, ignoring other risks.

e) Due to d) responsibilities and capacities to be evolved for future adaptation strategies (including against impacts of climate change) have largely shifted from dryland farmers to those dealing with policy-programs, market links, infrastructure, technology promotions, etc.

Under the first order impacts, the farmers' perceptions cover the broad changes (experienced if not measured in most cases) in (a) variables such as temperature, solar radiation, precipitation, humidity, soil moisture and run-off on the one hand, and their effects on the following variables on the other. The latter includes (b) soil moisture situation, length of growing season, micro-climatic stress, weather aberrations/extreme events, seasonality, disease-pest complex, biomass productivity, potential, effects of plant-nutrients and plant growth, soil productivity and erosion.

Under second order/level of impacts, the farmer focuses on items covered under (b) above and their likely effects on (c) ie, various aspects/features of farming systems. They include moisture management devices, adapted/popular cultivars, farm enterprise combinations, etc, in the medium and long term contexts, as well as risk management practices, seasonal crop activity calendar, input use and levels, production flows and yield levels as well as overall returns from agriculture.

At the third order impacts, the farmers, based on past experience and emerging circumstances looks at the possible effects of changes in (c) above on the secondary and tertiary level activities and processes having links with agriculture and its support systems.

These are the activities that help agriculture to integrate and interact with the overall economic systems. Some of these activities and processes put under (d) include the following – 'irrigation' support, relief strategies, agricultural infrastructure, collective action and cooperation, credit

and other input services, marketing, trade and links with other agencies whose services/support depends on crop surplus production), migration and external dependence, different inter-sectoral linkages, employment-income generating alternatives, agricultural planning, R&D and support systems.

3.3 Imperatives and Present Situation of Farmers' Perceptions and Adaptations

Despite limitations of the approaches summarized above, they can offer useful clues for realistic thinking and action on approaches to adaptation strategies against climate change in the dry area context. During the field visits, the validity of the above processes as a part of farmers' perception based adaptations to climate variability was verified, though it took longer time and frequent interaction with the farmers individually and in groups. The role and process of perception based understanding and consequent choice of responses to climatic variability by the dryland farmers has two significant implications.

The first relates to mainstreaming this approach to understand the farmer's perceptions based responses to climatic variability. This calls for long-term information gathering on farmers' perceptions and relating them to actual adaptation decisions/actions. This forms part of ICRISAT's longitudinal village studies conducted since 1975 to date. Besides gathering and analyzing perception-capturing information, an equally important aspect relates to the psychological dimension of the perception formation and its manifestation. This 'capturing' also involves circumstances and factors that shape the perceptions. This needs focused effort to identify and strengthen the process. Interactions with village elders can greatly help in exploring this process. ICRISAT village level studies have attempted this process.

The second implication of the above discussion on perception based adaptations is the list of variables and links under a,b,c,d categories of variables under first, second and third order impacts of climate change. These variables in a way represent the experience based inventories of options from which the farmer picks up while responding to first, second and third order impacts rooted in climatic variability led changes affecting the farm enterprises and livelihoods. Just to illustrate, these options may relate to crop and resource management technologies, public support systems, institutional set up and services, a variety program helping dry land agriculture, etc. Multiplications of diverse inventories of such options constitute the policy and program imperatives to strengthen and enhance farmers' perception based adaptation. Multiplication of such options as part of agricultural development would mean making development climate sensitive.

To better understand and reinforce the status and dynamics of farmers' adaptation strategies against climatic variability and their policy program imperatives, it will be helpful to summarize the key issues emerging from this paper and their action related implications. To avoid repeated elaborations, we put the key issues in textual tables. Accordingly, we begin with listing the factors and processes affecting (particularly weakening) the traditional/indigenous adaptation measures and practices in Table 3.

Table 3. Factors and Processes Affecting Traditional Adaptation/Adjustment Strategies against Drought and Uncertainty in Dry Tropical Regions of India[a].

Component of Traditional Strategies	Affecting Factors and Processes			
	Technology	**Policy/Program**	**Population**	**Market Forces**
Moisture Security	In pockets improved access to irrigation, water harvesting; (-)well boring/ blasting/water lifting technologies and mining of groundwater	Infrastructure and support for irrigation development (-) misallocation of scarce water (-)due to water price policies, missing usage-regulation	Crop intensification to meet rising demands (-)Insensitive of resource capacities, conservation needs	(-)[b] Concentration on high water usage, high value crops, backlash on dry/coarse crops
Biomass stability	(-) Reduced biomass due to concentration on grain crops and grain yields; neglect of resource centered technologies	(-)General neglect of biomass in R&D; decline of CPRs; pasture, forest, development dominated by 'technique' without institutional focus	(-)Decline of land extensive biomass oriented practices, eg, land fallowing; CPRs privatization	Rise of fodder/ fuel marketing, (-) draining of rural areas, reduced local storage and recycling, availability
Collective sustenance	(-) Promotion of individual oriented (crop, livestock) technologies; missing institutional component in resource centered (watershed, rangeland) technologies	(-)Public relief/ support systems replacing mutual self-help; formal legal, administrative norms replacing social sanction; decline of common property resources	(-)Increased socio-economic differentiation, promoting factionalism, indifference to group action, collective concerns, CPRs	(-) Market orientation and growth of individualism, erosion of group initiatives, neglect of low pay-off but dependable options
Diversification	(-) Over emphasis on grains (HYVs), with backlash on minor crops, mixed cropping, extensive cultivation, neglect of non-crop, conservation activities	Relief, employment schemes, special programs (DPAP), (-) Dependency on public relief, marginalization of traditional diverse occupations	(-)Decline of land extensive activities, increased land fragmentation, negative attitude to some traditional occupation, self provisioning	Integration with wider market economy, (-) Operational rigidities, new sources of risk, unfavorable terms of trade and local scarcities.
Flexibility	(-) Reduced range of promoted crops, technological rigidity of options, practices	(-) Dependence on public programs and their logistic norms/rigidities and indifference to local realities	(-) Land constraint reducing flexibility of options (eg, crop fallow rotation, mixed farming)	(-) Decline of self-provisioning and control over own decisions; market rigidities.

a. For further details and some quantitative evidence see, Jodha (1975, 1978, 1991, 2001), Gadgil et al. (1988), Walker and Ryan (1990).
b. The items beginning with (-) indicate negative change.

The Table 3 above is self-explanatory to need elaboration. However, the insight and understanding generated by this table in association with Tables 1 & 2 can be synthesized to outline the enabling process to promote adaptation options for the future under the next section.

4.0 Enabling the adaptation process

The understandings generated by the above discussion have indicated a number of potential approaches and options to facilitate adaptation strategies against Climate Change in the dryland context of India. The issues involved (despite unavoidable degree of repetition) are discussed below in Table 4. It primarily focused on issues central to evolving future adaptation strategies in dryland agriculture such as those dealing with crop technologies, natural resource management, and rural development programs covering community centered and infrastructure related programs. For a matter of ease, we have put in the textual form Table 4, which is self-explanatory.

Table 4. Possible Approaches to Generate Option to Revitalize Farmers' Adaptation Adjustment Strategies against Climate Risks and Uncertainty in Dry Regions.

Parameters	Aspects to be focused on to generate relevant adaptation option
Area of Intervention	
Crop Technologies	Crop range: Multiple crop choice, incl. minor crops, diverse cropping system, varieties besides hybrids without destroying local biodiversity Crops with: Variable maturity, variable range and date agronomy, high temporal and spatial adaptability, compatibility (for inter cropping, agro-forestry), drought resistance, high stalk component, suited to organic recycling. Products with: High storability, recyclability, local processibility
Resource centered	Conservation measures with multiple objectives (productivity, etc), scale and group action neutrality. Mix of short and long maturity and possibility of mid-season corrections.
Perennials	Fast growing, high restorability, non-competing and non-toxic type, suited to cut and carry system, complementarities between perennials and annuals: Focus on biomass processing/storage/recycling techniques
Development programs	
Resource/Community centered	Silvi pastoral/ social forestry related initiatives: de-emphasis on less known techniques; formal administration and subsidy: focus on" user group action" involvement. Equity of access and again: incentive for group's action, usage regulation of CPRs, involvement of different stakeholders.
Irrigation/ soil water aspects	Focus on low water requiring crops, arrangement for equitable access to water; water use regulation, localized water harvesting.
Relief operations	Strong productivity component, multiple activities, emphasis on matching contribution in any form, incentive for voluntary action, involvement of NGOs. Reduced domination of formal agencies, create accountability mechanisms, focus on links between development and relief components specially adaptation enhancing ones

Note: for further details and some quantitative evidence see, Binswanger et al. (1980), Jodha (1979, 1980, 1988a), Jodha et al (1988), Walker and Jodha (1985)

While the details under Table 4 indicated the potential ways to strengthen dryland agriculture to withstand the impacts of climate change, the following Table 5 deals with: (i) the factors and processes weakening the traditional adaptation mechanisms that need to be strengthened, (ii) the multiple driving forces and change agents (besides climate change) creating risks and vulnerabilities for farmers and rural communities in general in dry regions of India. The table lists the role of different forces and agents responsible for the change and how to respond to them to enhance their positive contributions and responsibilities in reducing the risks and vulnerabilities faced by the dryland farmers. Table 5 in a way replaces long elaboration, is also self-explanatory and does not need elaborations except some introductory notes.

Accordingly, the focused driving forces or processes and change agents covered by Table 5 include: (i) Rising population causing resource degradation and scarcities; (ii) Increased socio-economic differentiation reducing the collective stakes and efforts in sustainable use of natural resources; (iii) Increased integration of dryland economy into mainstream economy with little attention to control the negative side effects of the change; (iv) Limited technological space and relevant capacities of dryland agriculture; (v) Rehabilitation of dryland economy with focus on current status and possibilities; (vi) Economic globalization and dryland communities with emphasis on adapting to potential risks and opportunities; (vii) Policy concerns for dryland agriculture/economy: harnessing the opportunities without negative side effects.

Through collective thinking and interactions between different stakeholders, detailed operational measures briefly indicated by Table 5, can be designed and planned using the lead lines indicated by the Table 5.

Table 5 also lists the (a) contributions of the above forces and processes towards resource degradation and risk/vulnerability enhancement; (b) needed potential responses to address them; (c) roles and responsibilities as well as needed support to the change agents as a part of potential responses.

The issues and items listed under Tables 4 and 5 can help to build lead lines to initiate thinking and action to address the processes generating risks/vulnerabilities (besides the ones linked to climate change) and how to control them.

Table 5. Key driving forces to be addressed for evolving future adaptations in dry tropics.

I. Rising population related implications	**(a) Contribution to resource degradation process and risk** • Create land scarcity • Promote land use intensity • Reduce conservation –promoting diversification/extensive land use **(b) Potential responses** • Pressure reduction on land by effective population control measures • Off –farm activities • Agro-processing, value adding activities • Diversified high value land use options • Expansion of infrastructure facilities and equitable rural –urban links • Productive migration • Livestock management with focus on quality/productivity, not number of animals • Market oriented product-processing **(c) Role, responsibility and support issues** • Reorienting the approach/activities of State, communities, NGOs, technologies and management specialists
II. Increased socio-economic differentiation: reducing collective stake in sustainability of local resources	**(a) Contribution to resource degradation process and risk** • Decline in culture of group action • Social indifference to community resources and management practices • Decline of collective risk sharing, natural asset building and group-based agricultural practices **(b) Potential responses** • Building upon the successful experiences of participatory group action initiatives • Promotion of resource-specific grouping of stakeholders • Bottom-up, local level group initiatives and their up-scaling **(c) Role, responsibility and support issues** • Provision of policy–program support and incentives • NGOs and community mobilizers with bottom up approach • Focus on demonstrating gains of group actions • Promotion of such grouping as a part of mandatory activities at different levels for NR management

Continued

Table 5. Continued.

III. Closer integration of dryland economy into mainstream economy: How to protect against negative side effects	**(a) Contribution to resource degradation process and risk** • General paradigm, making resource use systems demand-driven rather than supply determined. • State, market forces insensitive to specific vulnerabilities of dryland • Extension of generalized intervention to dry areas **(b) Potential responses** • Mandatory provisions for assessing capacities/limitation of resources before initiating development interventions; • Higher priority to resource upgrading, conservation while designing measures • Focus on harnessing niche opportunities/resources • Interventions to match the internal diversities of landscapes • Ensure equity of dryland's links/interaction with mainstream system **(c) Role, responsibility and support issues** • Most responses suggested fall in policy-program area, hence greater responsibility of state • Involvement of local communities in identifying and implementing interventions • Restriction on free play of market forces.
IV. Limited technological space and relevant capacity development for drylands	**(a) Contribution to resource degradation process and risk** • Negative side effect on health and productivity of resources • Successful interventions in selected pockets , pushed to larger unsuitable areas • Technologies enhancing farmers' capacity to over -exploit resource (eg, groundwater) • Dominance of crop-centered rather than resource-centered technologies • Disregard of traditional technologies **(b) Potential responses** • Option with closer understanding of diversified landscapes • Controlled location specific trial before extension • Development involving formal R&D and elements of traditional technologies • Technologies that help in product processing /value addition • Making dryland products competitive **(c) Role, responsibility and support issues** • R&D agencies • Research planners and supporters • NGOs and community organization for projecting worth of traditional technologies /products • Policy and incentive environments

Continued

Table 5. Continued.

V. Current status and possibilities of rehabilitation of dryland economy	**(a) Contribution to resource degradation process and risk** • No incentives for resource users to improve heavily depleted resources • Mutual reinforcing of natural resource vulnerabilities and social vulnerabilities • A vicious cycle of degradation promoting degradation • Lack of investment resources and group initiatives **(b) Potential responses** • Incentive and simple technological options for resource users • Promotion of collective action for rehabilitation • Leasing of degraded lands to specialized conservation agencies • Specific conservation technologies • Learning from experience of successful initiatives in the past (eg, JFM, watershed development projects), receding of CPRs **(c) Role, responsibility and support issues** • R&D establishments, government, NGOs and farmer groups • Development agencies and investors • Specific development agencies such as wasteland development authority, rain fed farming agency, employment guarantee scheme, etc.
VI. Economic globalization and dryland communities: adapting to potential risk and opportunity	**(a) Contribution to Resource degradation and risk** • Globalization led potential risk of further marginalization and neglect • Unregulated market focus – favoring profit earning, competitive activities products services etc, while most drylands generally focus on diversity of activities. • Missing support system/structure/ capacities to respond to globalization • Globalization-led process favors resource intensification and discourages diversification **(b) Potential Response** • Reorientation of resource use focus with space for niche and diversification • Focus on product processing, value chain, better infrastructure and equitable market links • Local skills and capacity building for new tasks **(c) Role, responsibility and support issues** • R&D for identification and promotion of niche product and services • Institutional support for building capacities/ organization • Public Private Sector-farming community collaboration

Continued

Table 5. Continued.

VII. Policy concerns for drylands: harnessing opportunities without negative side effects	**(a) New opportunities** • Enhanced awareness of poor status of natural resource and poverty • Emerging new scientific/ technological possibilities • Rising voices of civil society and farming communities • NGOs, academics projecting value of indigenous system • Emerging space for drylands in policy-program, creating new opportunities • Sustainability-focused research/extension by R&D institutions (b**) How to harness the opportunities** • Build a committed and informed lobby of people for effective policy, program dialogue and advocacy of drylands • Mobilize problem-specific, area specific resource support • Combine bottom up approach with top down approaches • Involve interventions with focus on diversity • Upscale the results of past successful initiatives to larger areas **(c) Role, responsibility and support issue** • Major reorientation in policies and program • Greater role and responsibilities for government, development planner and field agencies • Advocacy groups
Final issue: climate change-risk and responses	Linking risks of climate change and above mentioned change processes and identification/promotion of integrated responses.

The implementation of the above suggestions emerging from Tables 4 and 5 would need both enhancement and reorientation of the capacities of not only farmers and rural communities but the institutions and public agencies working with them.

The central message conveyed by Tables 4 and 5 as well as Boxes I, II and III could be stated as follows.

(i) The farmer's adaptation strategies in different contexts are weakened by the negative side effects of new developments such as policies, market forces, population growth, etc.

(ii) The same changes have potential to strengthen and enhance the scope and effectiveness of adaptation strategies provided the convergence between attributes of adaptation and elements of new developments is identified and promoted.

(iii) The progress on (ii) is slow because the integrated approach to development interventions and adaptation strategies is slow and is still unstable.

A number of operational ideas and steps directed towards the above gaps are listed for different contexts under the above mentioned tables and boxes. Put differently, action on these aspects can help in making diversifications part of a dynamic process and enhance convergence between development and adaptation strategies.

5.0 Learnings from grassroot adaptations: key features

Despite the above features obstructing usability of global approach to climate change to enhance farmers' adaptations in dry regions, some potential possibilities could be explored, where along with the other factors the global discourse on climate change can also offer some lead lines to enhance traditional adaptations. For doing so, one has to look at the relevant features of the farmers' adaptation measures and identify their components that could be supported or complemented by learning from experiences of climate change related work in different contexts. Accordingly,

(i) *Adaptation needs concrete contexts at micro levels:* The global approach at the present stage is not able to provide this. However, the advocacies and attempts are ongoing for downscaling climate change projections and strategies from world-region level to lower levels. In due course, this might reach needed micro levels.

(ii) *Adaptations have extent of diversity and flexibility, not uniformity:* Farmers' adaptations are characterized by high extent of diversity, flexibility as required by spatial and temporal variations affecting the farmers' responses. With availability of several present days technological and management related options, the diversity and flexibility aspects can be addressed if the decision makers and planners are conscious of such possibilities.

(iii) *Adaptations are not static but dynamic:* The farmers' adaptations are not static. They change depending on emerging opportunities and constraints. This offers the scope for enhancing the traditional adaptations by incorporating new elements. An important implication of this possibility is to make new development components in dry regions climate sensitive.

(iv) *Understanding of complex adaptation requires long-term farm level information:* For effectively addressing the above issues, it is essential to understand how farmers understand and respond to climatic and associated risks. To capture this, detailed and long-term studies at farm and village levels (as tried by ICRISAT) are essential. This will help us understand the farmers' decision and action processes based on their experience based perceptions of impacts of climate variability and needed responses to the same.

(v) *Harmonious mix of traditional and modern practices is a pragmatic approach:* The above steps would help in harmonizing the traditional adaptations and the new ones, based on use of modern science and technologies as well as varied insights and understanding generated by research induced by global discourse on climate change.

(vi) *Enhanced capacities and re-orientation of stakeholders:* The most crucial requirement to effectively address the above issues is enhanced capacities and changed orientation of different stakeholders in the process, right from the relevant institutions, responsible functionaries and the farmers. Approaches to effective adaptations to climate change will finally change when agencies potentially responsible for the same change.

(vii) *Sensitization of policy makers towards issues raised by global discourse:* The final (and foremost) issue relates to enhanced awareness and concern to climate change generated by global discourse.

6.0 Mainstreaming local level adaptations to climate change in the macro context

The central purpose of this paper has been to explore the possibility of global approaches to climate change (ie, Projected impacts and protective responses) helping in enhancement of traditional adaptation strategies against climatic variability and associated risks, evolved and used by farmers in the arid and semi-arid regions of India, the region, which as per the projected scenarios will have very high negative impact of climate change.

A closer look at the global discourse or approach despite substantial work and its role in sensitizing the policy makers, researchers, media and informed citizenry revealed its limitations, which tend to obstruct its direct relevance and applicability to micro-level dryland farmers' adaptation strategies.

(i) For instance, its largely aggregative, top down, highly macro-level focused approach along with the continuing uncertainties and information gaps do not help in presenting concrete, place based climatic contexts to which the dryland farmer responds as a part of the overall strategy against climatic and related risks.

(ii) Similarly, the main thrust of global approach/ work on climate change is addressing climatic issues ie, change and impact scenarios largely ignoring the other global issues such as biodiversity, economic globalization and population (with some scholarly work as exceptions). The elements of this skewed approach may percolate to relatively lower level work, and its results may not help the dryland farmer, as his adaptation strategies are addressed to the multiple sources of risk rather than climate/ weather variability alone. An associated issue in this context is that unless the multiple aspects of risks complementing climatic risks are addressed, one cannot think of making rural development in dry regions climate sensitive.

(iii) Global discourse and formal concerns about climate change indicate significant imbalances, favoring mitigation against adaptation aspects of potential approaches against climate change. Depending on the spatial and temporal contexts, the dryland farmers' adaptation strategies cover both mitigation and adaptations.

7.0 Conclusions

The paper aimed at deepening the understanding of grassroot adaptation strategies and processes to climate change/variability in arid and semi-arid transect. As a prelude, the global discourse and its specific attributes obstructing the enabling adaptations and risk adjustments of the farmers were highlighted. These will facilitate the identification and promotion of effective adaptation to climate change in the micro-macro context.

The farmers' perceptions and practices are largely governed by local/landscape/village level variables influenced by weather conditions, socio economic settings and several farm- and household-level attributes that not only influence the assessment or extent of climatic risks but also other risks as well, calling for an integrated approach to address the risk and vulnerability concerns with bottom up approach. An attempt was made to synthesize the village, farm and

plot level information collected through different studies in arid and semi-arid regions of India during different years over a period of nearly twenty years. The discussion was broadly centered on Adaptation practices focused on (i) risk generating features due to natural resource base; (ii) long and short-term weather patterns; and (iii) extreme events such as severe droughts. Further, the farmers' perceptions about climate (weather) variabilities and their potential adaptation practices were elucidated. The adaptation measures thus obtained were categorized in terms of (a) First order adaptations focusing on the farmers' bio-physical resource base and micro environmental situation affected by different climatic conditions; (b) Second order adaptations covering responses to adjustments in their farming systems and practices; and (c) Third order adaptations covering links of farming systems to factors falling under secondary and tertiary level arrangements.

The paper attempts to put the farmers' adjustments to changing situations that includes factors other than weather conditions as well. Accordingly, unless climate change related information and advocacy fulfill the conditions that guide the farmers adjustment approaches, their indifference or disregard towards the advocacy and acceptance of messages by mainstream discourse on climate change is likely to continue.

To facilitate effective adaptation to climate change (with all its uncertainties and information gaps in the micro-level spatial contexts) the following aspects need to be recognized.

1. Adaptation strategies should have element diversification, both horizontal and vertical
2. Since income sources, options and opportunities to adapt are increasingly recognized, adaptation strategies have to have strong dynamic orientation.
3. In keeping with the emerging evidence on convergence between development and adaptation processes, adaptation should be an integral part of the development strategy.
4. Requisite space for grassroot level understanding of adaptation strategies that help in institutionalizing effective and pragmatic bottom up approaches. This understanding is reinforced by details from field studies (like ICRISAT VLS Panel data).
5. Adaptations to be effective not only call for individual households' understanding and capacities, but a strong element of collective action and institutional support on the one hand and a proactive approach of the formal public and private agencies on the other.
6. Finally, the development policies for diverse agro-climatic regions need to have explicit and effective support for integrated adaptation strategies. The purpose of this paper is also to sensitize and induce the same.

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The **International Crops Research Institute for the Semi-Arid Tropics** (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, of whom 644 million are the poorest of the poor. ICRISAT innovations help the dryland poor move from poverty to prosperity by harnessing markets while managing risks – a strategy called Inclusive Market-Oriented Development (IMOD).

ICRISAT is headquartered in Patancheru near Hyderabad, Andhra Pradesh, India, with two regional hubs and five country offices in sub-Saharan Africa. It is a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

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