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Decision Making Tools (Approaches) for Adaptation of Agriculture to Climate Change*

- N.S. Jodha**

Introduction

This paper deals with the indicative approaches to identify and promote options for adaptation of agriculture to climate change in developing countries. After elaborating on the factors constraining the search for adaptation options, it discusses the potential search areas which can help in promotion of adaption strategies for agriculture in the face of climate change. To identify adaptation options, it is essential to understand the attributes of agriculture (its components, support system etc.), to be affected by climatic changes on the one hand and the nature and extent of changes in climatic variables along with their spatial and activity - contexts on the other.

Viewed in terms of primarily nature-dependent and natural processes-driven activity, (historically all over the world and currently in several developing countries), agricultural transformation can be seen as a result of two-way adaptation process supported by informal trials and errors or formal scientific experimentation. This implies adapting agricultural activities (e.g. choice of crops and crop attributes, crop combinations etc.) to bio-physical environment (including climatic variables) on the one hand and amending/adapting the latter (through irrigation, terracing, conservation and drainage management etc.) to the needs of agriculture (representing societal needs) on the other. Understood this way, adaptations to climate change is a part of the dynamic process characterizing agricultural transformation. However, the major difference is the projected speed and pervasiveness of the change in the bio-physical environment following green house warming and associated disruptions (Jodha 1996). This, unlike in the past, not only shortens the available lead time to adjust to the projected environmental changes, but requires unusual capacities and preparations for quick readjustments to warming led rapid and subsequent changes, as the latter may make the past adaptations and their support systems quickly redundant. On the other hand amending and adapting the environmental resource base (e.g. climatic variables) to suit the agricultural needs is a task that falls far beyond the capacity of the agricultural researchers, farmers and policy makers alone. Yet in order to explore agricultural adaptions to climate change, one should look at (i) the relevant components or features of agriculture which are vulnerable to climatic changes and related variables, on which the adaptation options could be focused; and (ii) understand the attributes of climate change itself in the context of which adaptions are to be evolved. The changes in the variable under (i) and (ii) provide the specific contexts for exploring the need and types of adjustment measures and required capacities for the latter.

Adaptation – contexts

Such change-contexts for agriculture termed as first, second and third order impacts of climate change, elaborated and illustrated elsewhere (Jodha 1988, 1989), are summarized under Table 1. The table also lists the relevant climatic factors. Accordingly, the climate change in the concrete, operational sense (affecting agriculture) would be manifested in terms of changes in temperature, evapotranspiration, atmospheric humidity, precipitation, soil moisture etc. (Table 1, col. 1). The above changes will have impact on variables ranging from growing season and ground water to photo synthesis patterns and disease/pest complexes, listed as first order

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** Policy Analyst, ICIMOD, Kathmandu, Nepal

Table 1: Indicative variables to understand potential vulnerability developing country-agriculture to climatic and related changes: The first, second, third order impacts

(1) Climatic and other variables affected by GHW (greenhouse warming)	(2) First order impacts due to (1), covering major components of bio-physical resource base and production environment	(3) Second order impacts due to (2), covering components/features of farming systems	(4) Third order impacts due to (1-3) covering agricultural support systems and activities at macro-level
• Temperature • Solar radiation • Precipitation • Soil moisture • Runoff • Evapo-transpiration • Atmospheric humidity • Weather cycle etc.	• Moisture regime/flows • Ground water • Growing season • Micro-climatic stresses • Frequency of aberrant weather • Seasonality • Disease/pest complex • Bio-mass complex, productivity, potential • Photosynthesis pattern • Plant-input interaction • Chemistry/biology of soil • Soil erosion hazards etc.	• Adapted cultivars • Diversified/interlinked agril. enterprise • Moisture management systems/structures • Input-schedule-types • Agronomic practices • Risk management mechanisms • Production flows/yields • Costs, returns, profitability, investment • Livelihood security etc.	• Irrigation systems, strategies • Relief strategies • Infrastructure • Input supply systems • R&D strategies • Marketing, trade, food systems • Inter-sectoral linkages • Agril. planning, strategies • Employment, income distribution strategies etc.
Factor causing high vulnerabilities in developing countries:	<u>High first order impacts due to</u>: • Agri. a dominant sector, with greater direct dependence on nature • Larger marginal areas, substance orientation • High degree of diversity in natural resource base and levels of development obstructing "uniform" interventions	<u>High second order impacts due to</u>: • Inadequate support systems (banking/ insurance) • Weak physical infrastructure • Low risk absorption and scope for spreading risk-by forward-backward links • Reduced efficacy of: traditional diversification-based adjustments, informal institution to insure against risk • High degree of diversities of farming systems	<u>High third order impacts due to</u>: • General state of under development (specially in marginal areas) • Low investment-resources for agricultural infrastructure, R&D etc. • Vast gaps between commercial and subsistence centred agriculture • Limited protection through irrigation/ physical support systems; innovative technologies • Differences in third order impacts due to diversities
Focal context (level) for adaptation exploration and decisions	Agrl. R&D, planning with input from science and farm-level experiences	Farm level decisions with support from R&D and public programmes	National agricultural policies, strategies and support programmes

Table adapted from Jodha 1989 where the above details are elaborated and illustrated.

impacts of climate change. Summarized under Table 1, col. 2, these components represent the bio-physical resource base and production environment of agriculture. The second order impacts (Table 1, col. 3), representing changes in the farming processes and practices to be affected by changed climate variables via first order impacts, would relate to well adapted cultivars, moisture management practices, proven agronomic measures, farmers' risk management devices, on farm infrastructure etc. The third order impacts (a consequence of changes in climatic variables and some variables under first and second order impacts) largely relate to macro-level arrangements designed to support agricultural performance and development. They include physical and institutional infrastructures such as irrigation systems, R&D strategies, policy-planning measures etc. focused on agriculture and farm economy in general.

The indicative details summarized under Table 1 can help in identifying the areas and the levels at which the adaptation options are to be focused in specific country or regional context. They can also help in identifying the agency or activity levels at which option decisions and search efforts have to be initiated. For instance the systematic responses to the first order impacts (e.g. changes in seasonality, photo synthesis patterns etc.) have to begin at agricultural R&D level. The variables covered by Table 1, once related to agricultural situation in specific region/country can also help in assessing the vulnerability of agricultural components to climate change in terms of extent and intensity of impact of climate change and required responses in specific situations (Dinar et.al. 1998). For instance based on the inventory and analysis of variables under Table 1, one can assess the degree of direct dependence of agriculture on the nature alone or on nature plus man made systems, which in turn could help in determining the scale and intensity of vulnerability of agricultural systems to climate change. A systematic inventory and analysis of details indicated by Table 1, col. 3 and 4 can help in understanding the capacities of developed and developing countries to adapt to climate change. Finally, details under Table 1, col. 2 (i.e. first order impacts) can also help in identification of functional variables (e.g. growing season, crop yields etc.) potentially exposed to the impact of climatic change and facilitate work priorities of agricultural R&D to address the problems created by climate change. However, to be useful for identification of adaptation options, the above information on agriculture needs to be supplemented by understanding of the nature and degree of changes in climatic variables themselves. Hence, the key requirement for evolving adaption options for agriculture is the firm information about changing climate component in local contexts.

Agriculturally relevant attributes of climate change

Any changes in climate related variables (Table 1 col. 1) can affect agriculture or its different components, particularly in developing countries due to the former's higher and direct dependence on nature. However, the nature and degree of the impacts (against which adaptation would need to be evolved) would depend on the magnitude and speed of climate change in concrete local/regional contexts, where the agriculture and its support systems are physically located. In this context a quick look at the attributes of projected climate change will be helpful.

Green house warming induced climate change is a global phenomenon. It is a long term phenomenon as well. The emerging change is well recognized, monitored, documented, and also projected in future context. It is a matter of global concern and a source of a major scare that induces increased funding for further scientific work and sustained global discourse on the subject but limited effective action on abatement and adaptation fronts. One of the crucial factors responsible for the limited progress on the above fronts is the complex of uncertainties and information gaps on the regionally disaggregated extent of impacts of climate change. As

revealed by work of different analysts, there is a wide range of suggested impact scenarios depending on the use of baseline, assumptions, scale of analysis, and method or models employed (Downing et.al. 2000). In the context of present discussion the scale issues are highly critical. For this reason projections of climate change impacts at regional and affected activity levels are highly uncertain.

To elaborate, these uncertainties relate to differences in: the extent of countries or areas and the population groups (including their nature-based activities) within countries, vulnerable by climate change; direction and speed of (negative or positive) impacts; dynamic context of change i.e. change having a linear or non-linear patterns, how it could be positively or negatively affected by socio-economic change processes, and finally the levels of confidence in the projected change-impacts.

Given this complex of uncertainties, expecting most of the developing countries to spare their scarce resources to address the issues of adaptation to climate change in the context of agriculture and other sectors, may not prove a realistic view. More importantly even if the resource issue is ignored, the above uncertainties seriously constrain the identification of adaptation strategies and options against climate change impacts. It is easier to convince the decision makers about any intervention, if its target area (or context) is well defined and understood. The above mentioned uncertainties do not make the "Climate Change Impact" a definite and concrete context for the decision processes.

In the light of the above uncertainties characterizing climate change scenarios, identifying and implementing any adaptation options is similar to firing at a shifting target. In such a situation, to ensure that one hits the target, one has to resort to multiple shots, where one or the other shot might hit the target. Though this add to the cost and effort to achieve the goal. When translated in to "adaptation options generation" for agriculture, this means an attempt to evolve and apply multiple and diverse measures to address the problems caused by climatic and related changes, with full understanding that some of the measures will be redundant.

Thus the first and foremost implication of the uncertainties and complexities of climate change impacts in the context of agriculture in the developing countries, is a need for evolving a range of multiple options (with varied spatial and activity contexts). However, as mentioned earlier, due to these very uncertainties it is not easy to ensure applicability and usability of the part of the options at any stage. This in other words mean, attempting, more options (based on conception of likely but uncertain change situations) than the ones which could be actually used. This obviously has major cost dimension, which may discourage serious effort on the subject, unless some prioritization for adaption-search (within the uncertainty framework) is done.

One way to facilitate the prioritization of option search is the analysis of the uncertainties themselves in terms of their relevance in the context of time, space and activity f(i.e. agriculture). The work on impact indices and their combinations to help in this regard is already in progress (Downing et.al. 2000, Moss 1999).

Impacts of Globalisation

The key inference of the above discussion is that while attempting to evolve adaptation strategies against climate change impacts, one should be alerted to the complex of constraints created by the uncertainties of projected climate changes. However, in today's changing context one should also be alerted to additional set of constraints manifested by the impacts of rapid economic globalisation spreading to all countries and regions. Accordingly, the gains of adapting agriculture (specially crops and other products) to climate change may not accrue or

sustain, if they do not have competitive advantage in the globalised markets. Accordingly, the governments' liberalized trading policies (under the compulsion from WTO) may expose the newly adapted crops/agricultural products to open competition with products from well endowed areas. Thus the adaptation options suited to changed bio-physical environment (due to climate changes) are not enough to help agriculture in the affected areas. Examples on this aspect are already available. For example gains of break-throughs facilitated by agricultural R&D and other support systems for oilseed crops in dry areas and apple and flower crops in hill areas in India, were washed out once governments trade policies allowed liberal imports of these products under OGL (open general license). The new adaption options (against climate change), therefore, will have to be compatible with emerging economic changes associated with globalisation. This puts still greater pressure on agricultural R&D efforts devoted to identify and evolve adaptation options against climate change. They will have to satisfy duel goals.

Furthermore, globalisation has not only increased the challenges before national and international R&D for agriculture, but has reduced their capacities to meet those challenges. With unprecedented primacy accorded to the market forces and marginalized role of state/public sector under globalisation (due to structural reforms etc.), the states are left with reduced resources and initiatives to help R&D and other measures for marginal areas and groups exposed to risks and vulnerabilities. The enhanced stock market volatility under globalisation has also eroded the research support for agriculture from various foundations and charities. The declining financial support to agricultural R&D at national and international levels in the recent years would bear this out. Under the changed situation, private sector agencies can afford the level of support needed for agricultural R&D to help adaptation to climatic as well as economic changes. However, their priorities driven by corporate profitability are quite different from public supported R&D. This is a major area requiring serious attention of the policy makers dealing with agricultural R&D.

Search for adaptation options

With full recognition of the above constraining factors and processes, we try to suggest some indicative approaches to search for appropriate adaptation options against climate change impacts (and globalisation induced risks). To begin with, in the light of the above mentioned constraints, the central focus of adaptation strategies should be on (i) the multiplicity and diversity of adaption options to address uncertainties ; (ii) economic viability of options, to accommodate the relevant imperatives of economic globalisation and (iii) involvement or partnership of private sector in research effort directed to (i) and (ii) above. The rationale behind the such orientation of adaptation strategies is clear from the above discussion.

In view of the uncertainties characterizing the projected climate change and diversities of agricultural components potentially vulnerable to the former, the diversity and multiplicity have to be the key feature of adaption options. The potential sources of search for diverse options could include the following.

(i) Inventories of agricultural patterns and practices from agro-climatically different regions/ areas, which may have elements for potential transfers to areas vulnerable to climate change. This possibility is supported by the past experiences of inter-eco-regional exchanges of crops and farming practices in different parts of India. Such transfers between agro-climatically different areas is, therefore, not unusual. For instance a look at the inventory of farming practices and crop varieties with specific attributes (used as and when the annual weather fluctuations demand) in dry areas of Rajasthan and Gujarat, shows that they have been built up on the elements and experiences learned from agro-climatically different areas in central India (M.P.) and Punjab. With the

availability of modern R&D facilities and data base/data management systems covering farming systems or cropping typologies, potential for relevant exchanges can be identified and enhanced. Specially in the countries with a range of different agro-climatic zones this could be an important approach to search for adaptation options.

(ii) Quite related to the above, there is yet another source of building inventory of adaptation option. This relates to indigenous knowledge and production/resource use systems in different regions, which embody several diverse elements designed to support the farmer's coping mechanisms to respond to weather induced uncertainties. The product and resource centred elements from farmers' strategies could be identified, upgraded and incorporated in the modern R&D based adaptation options. However, a key imperative of learning from the traditional farming systems is the need for dismantling of "compartmentalization" of organically interlinked land based activities (e.g. crop, livestock, forest etc.), which otherwise tends to erode the adaptation potential of agriculture.

(iii) Besides learning from the traditional wisdom, the understanding of the present intelligent layman's perception of climate change and his responses is yet another source that could be tapped for identifying adaptation options. For instance, following the changes in flowering season and reduced flowering in fruit crops such as apple due to impacts of climate change (perceived by the farmers in Himachal Pradesh), they have either moved to other fruits such as plum or discarded fruit farming (involving higher investment and longer gestation period with possibility of impacts of further increased warming) and replaced it by high value (niche) crops such as garlic and ginger. In the process they have met the imperatives of both climate change and globalisation. This underscores the value of promoting awareness about climate change among the farming communities, who can evolve through trials and errors some adaptations to the change.

(iv) The most important source of adaptation-options (which also includes the elements from the above mentioned sources) is the agricultural R&D that could systematically focus on climate-agriculture interaction, under different scenarios. This involves preparedness to respond to any situation by building large inventories of agricultural technologies vis-à-vis different crops, activities and the projected climate change scenarios. This approach to building inventories may require spatially and farming systems wise differentiated priorities, to save at least a part of enormous cost of evolving technological options, part of which may not be finally used or become obsolete quickly (due to the unabated increase in global warming). Apart from using the high science inputs (e.g. bio-technology etc.), the R&D efforts to build adaptation options, should put increased emphasis on use of indigenous knowledge systems and farmers' innovativeness reflected through various agricultural practices designed to meet diverse problems (Jodha 1996, 2001).

(v) The above option needs significant enhancement of regionally focused resource allocation to agricultural R&D. However, to make R&D based options a success, the latter will have to address the economic aspects in the globalisation context. This also implies changing the orientation of agricultural R&D that promotes focus on agricultural niche (in terms of agricultural products with comparative advantage) in specific areas, and helps in enhancing and harnessing the niche. This may also involve research on agricultural processing aspects to enhance niche. One examples in this context may include emphasis on organic food; products with medicinal value etc. However, "extent" of export market for such niche products supplied by millions of small farmers is a big question that needs proper exploration. The above suggestion may also require looking

beyond "crops only" and focus on integrated, diversified land based activities (e.g. perennials and annuals, crop-livestock-forestry links etc.). Similarly, focus on off-farm opportunities and promotion of agro-based micro-enterprises are important complementary approaches to enhance capacities of farming groups to face the vulnerabilities created by climate change and globalisation.

(vi) Finally besides agricultural R&D led option search, the infrastructural development and other support systems to help (climatically affected) marginal areas and groups, constitutes another area to be focused for enabling communities to adapt to changing situation both climatically and economically. In fact in view of the crucial importance of the above factors (e.g. support systems etc.), it will not be wrong to say that a significant part of the capacities for agricultural adaptations to climate change falls outside agriculture.

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