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Review

How agro-biodiversity conservation can rebuild CARICOM small-farming systems

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ABSTRACT

There are two perspectives on climate change that govern our response in terms of the sustainability of small-scale food production. The familiar perspective focuses on the expectation of deteriorating environmental conditions. The second perspective, which sees climate change also as a global geographic shift in climate occurrences, broadens this expectation to concerns of new geographic coverage, biological connectivity, resilience, resource management, local area governance and equity in benefit from adaptation/mitigation. A more comprehensive scope of the climate change challenges requires sustainable agriculture with more practical policy actions and greater applicability of knowledge of agro-ecology. Agro-biodiversity Conservation presents an investment strategy to increase the volume of options available to the small-farming community in CARICOM Member States. A policy of on-farm conservation of agro-biodiversity holds the key to building resilience in CARICOM Agriculture. This approach will not only reinforce the perception that farmers are the most important custodians of climate-change adaptation, but also that their collective local knowledge can become an irreplaceable element in managing the inter-links in our farming system.

Keywords: Climate change, CARICOM small farms, agro-biodiversity, farming options.

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INTRODUCTION

There has always been a tension in small-scale farming between utilizing highly specialized chemical inputs which represent the bane of commercial agriculture and a dependence on traditional farming practices. Both of these practices are coming under pressure with the expected impact of climate change on agricultural production in the islands of the Caribbean Community (CARICOM)[1]. Agrobiodiversity can provide all stakeholders with a coping strategy that bridges the natural and the social science perspectives of a viable framework against agricultural risks in an uncertain future.

The narrow definition of agrobiodiversity emphasizes variety and variability of living organisms that contribute to food and agriculture in the broadest sense and the knowledge associated with such judicious use. The broader definition extends this vision to the full diversity of organisms living in the agricultural landscapes, including soil microbes and fauna, weeds, herbivores, and carnivores. Employing all of these factors should result in colonizing the agroecosystem through local management and environment-friendly farming practices. To promote agrobiodiversity within the broader definition, however, implies making the small-farm a coherent unit of agricultural activity, spatially and functionally. That will

[1] The Caribbean Community and Common Market (CARICOM) consists of 20 countries in the Caribbean. The 15 full-fledged member states are: Antigua and Barbuda; Bahamas; Barbados; Belize; Dominica; Grenada; Guyana; Haiti; Jamaica; Montserrat; St. Lucia; St. Kits and Nevis; St. Vincent and the Grenadines; Suriname; Trinidad & Tobago. The 5 Associate Members are Anguilla, Bermuda, British Virgin Islands, Cayman Islands, and Turks and Caicos Islands.

include the living and nonliving components in a reinforcing cycle of farm interactions.

There are challenges in this approach that must be overcome. The social values of agrobiodiversity differ within farming cultures and more importantly market signals and subsidy policies do not always properly monetize these values. For example, the agro-chemical technology which has some attraction for small farmers, has the appeal of “keeping it simple” because it is better and easier to manage. This supports the commercialization of the farming system with more dependence on off-farm inputs and a reduction in the potential of recycling processes. This has more credibility for farming practices that remain as appendages to monocultural practices, such as in the production of banana and sugar for exports and foreign exchange earnings, or even for biofuels as source for energy substitution.

As a policy goal, agrobiodiversity has the potential to force a paradigm shift in the way research and support systems for small-farms are pursued. Formal scientific investigations should continue to look at how current on-farm practices can be upgraded for greater yields, pest resistance and adaptation to stress conditions within the context of traditional practices. This strategy, however, will also need to accommodate small-farmers opting for some traditional methods because they meet multiple needs in addition to the marketability option, or because they perform better under low levels of external outputs.

Climate-change impact

Agriculture is the second most important source of employment and foreign exchange earnings in the CARICOM islands. In spite of the fact that most of these islands import food, local production is still critical to meeting subsistence needs and ensuring the food security of a significant proportion of the local population. The impacts of climate change on the agricultural sector, therefore, are amplified due to the limited adaptive capacity of the small farming systems and the occupation of low-lying coastal areas. Indeed, the research of the Caribbean Community Climate Change Centre (CCCC, 2009) strongly cautions that the expected impact of climate change can threaten the very existence of the CARICOM countries.

The case for Climate Change impact on CARICOM Agriculture is usually framed within the expectations of a continuous flow of adverse events such as global warming, rising sea-levels and more severe tropical storms. This perspective sees climate change purely in terms of its projected short and long-term effects. While such knowledge heightens an awareness of what to expect, it still begs the question as to whether we are building policy options on projections of a limited zero-sum game. This model paints a portrait of a linear trend of increasing ecological change and stress in Earth's biosphere, with many plant and animal species facing increasing competition for survival. It is not uncommon to see a response which appears more like a natural reaction to an inevitable deteriorating situation.

The fact is that climate change can be measured in a variety of ways, reflecting distinct dimensions of change with unequal spatial patterns across the world (Garcia et al., 2014). There is the perspective which, while not denying the grave potential of such events unfolding, takes its cue instead from the behavior of other species in nature, such as birds, butterflies, mammals. This perspective comes from the review of studies which have investigated the divergent responses to climate change in precipitating geographic shifts in tree-born species in 86 tree species/groups across the eastern United States spanning the last three decades (Fei et al., 2017). The data showed that more tree species have experienced a westward shift (73%) than a poleward shift (62%) in their abundance. Such an incidence could lead to changes in composition of forest ecosystems, while putting the resilience and sustainability of various forest ecosystems in question. We humans, on the other hand, tend to stay in place because of social and economic constraints. However, would this perspective give us a different response for Caribbean Small-Scale Agriculture in an age of rapid climate-change? Are some species in nature forecasting that their habitats are failing; or are they long-term migrants directly on the lookout for new and more suitable locations as they follow a geographic shift in the climate they have known?

The expression of climate-change as a representation of a “geographic shift in climate occurrences” reflects much more than the simple migration of species. There has also been some scientific explanation for this phenomenon. A study out of Denmark, has shown that slight variations in Earth's orbit have historically led to changes in the seasonal distribution of sunlight reaching the Earth and as a consequence, a change in local climate (Blosser, 2015). This geographic redistribution perspective of climate-change has two perceivable affects. The first is a degree of permanence in the very long-term geographical and seasonal re-distribution of climate events. The second is the short-term perceptible movement of some species to more accommodating habitats. All of this tends to pull us out of the box that defines climate-change only as an intensification of current adverse conditions that provoke an involuntary reaction.

This perspective raises as many new issues as it does new visions. One of the least apparent issues is that the impact of a geographic re-distribution of climate conditions can come upon us faster than our responses anticipate. A study in 2013 indicated that the melting ice caps have caused the geographic North Pole to drift slowly southward (Oskin, 2013). However, in terms of the pace of change, it is also a fact that the polar ice caps have melted faster in last 20 years than in the last 10,000 years. Such warming, as has already occurred, is affecting the biological timing (phenology) and geographic range of plant and animal communities. Relationships such as predator-prey interactions are affected by these shifts, primarily when such changes do not occur evenly among species (University of Michigan, 2019).

The geographic shift in climate occurrences can also lead us into a vast array of complex causations. However, within it, we can find a validity for the methodology of forecasting by analogy. If the climate we are beginning to experience has shifted from somewhere else, then we can learn a lot from the experiences in locations that have already witnessed some of these phenomena. More importantly, the forecasting by analogy approach provides a platform for a structured approach to a sound response in agriculture. It allows us to include strategies and tactics to increase *the volume of options* available to our farming community. In essence, it is the scientific interpretation of the institutional realignment that the former President of Guyana sought from the Caribbean's agricultural research and support facilities, when he implored them to move… "*away from traditional structures and organisational forms towards smart public-public, private-private and public-private sector partnerships and alliances*" (Jadeo, 2007).

AGRO-BIODIVERSITY AS STRATEGIC POLICY

There appears to be some validity to the claim that the climate of the Caribbean region is already changing in ways that seem to signal the emergence of a new climate regime (Taylor, 2017). Such a geographic shift in climate conditions can have adverse consequences for Caribbean Agriculture. One of particular concern to agriculture is the change in the geographic distribution of pathogens. The emergence of pathogens is the outcome of dynamic processes involving host availability, abundance and susceptibility of the target organisms and of course the suitability of climate conditions. The implication of a geographic-shift perspective is expansive. It brings into focus both the intensity of pest/disease problems and the geographic range of their occurrence. It is also filled with questions of biological connectivity, resource management, local area governance and equity in benefit distribution. Under the perspective of a geographic-shift in climate occurrences, our farming environment is no longer naturally protected by our island status. The sea around us is not a delimiting factor.

If plant-pest/disease is a challenge to our agriculture, this perspective alerts us to be concerned with the quantitative estimates of the magnitude of such an impact. In a study of the pathogen phenomenon, the authors have argued that at present, the uncertainty in predictions of change in the geographic distribution of pathogens is so great, that the essential adaptive response is to monitor such changes and to retain the capacity to innovate (Shaw et al., 2011). This is in stark contrast to the technological response which presumes that a *"Roundup-Ready"*[2] approach can eliminate most unwanted species whenever and wherever they may surface. Herein lies a potential re-direct to agricultural research, in pursuing the *Conservation of Agro-Biodiversity* as a policy strategy to stabilize the small-farming capacity.

A basic tenet of Agro-Biodiversity is its accommodation of variety and variability of animals, plants and micro-organisms within an integrated farming system. It points us towards establishing an agriculture and food production system that includes crops, livestock, forestry and fisheries. It weaves a coherence within the diversity of non-harvested species that support crop production (soil micro-organisms, predators, pollinators), as well as those in the broader environment that support agro-ecosystems i.e., agricultural, pastoral, forest and aquatic systems (World Bank, 2008).

In attempting to recreate the cultural practices in small-farm production, Agro-Biodiversity Conservation provides farmer extension services with the need to integrate value propositions in four areas of support to local farmers and the local farm system:

a) Natural Resource Management: Small farmers have at their disposal (smart phones, etc.) the capacity to understand how the genetic diversity in the ecosystem can provide the basis for new breeding programs, improved crops species, enhanced agricultural production, and food security, as well as the mitigation of risks to natural disasters. There is no need to pretend that this is beyond their comprehension;

b) Farm Operations: As more attention is given to the economic viability of small farms, a biologically diverse farm will offer more lessons for risk management, cost avoidance, stability in production and profit maximization. This is probably the best opportunity to change the potential vision of the next generation of small farmers;

c) Businesses links: As a business proposition, the level of agro-biodiversity provides a sound evaluation of the potential risks to others in the supply chain. This is a lucrative link for allowing the more innovative farmers to adapt to changing source costs and to gain a competitive advantage from first-adapter status;

d) Climate Change Adaptation Policy: On the policy level, for those who wish to support small-farm production, a knowledge about agro-biodiversity is crucial to understanding which policies can support resilience to the economic, environmental, and social challenges that will accompany a changing climate.

[2] Round-up is the brand name of a weedicide that was considered easy to use and effective, but has now been linked to the emergence of cancer in the body.

POSITIONING SMALL-FARM PRACTICES IN SCIENTIFIC KNOWLEDGE SYSTEMS

It is not uncommon to hear Caribbean agricultural policy advisors speak of an approach to increasing agricultural productivity, in terms of a dichotomy based on input use. In high-input agricultural enterprises, productivity gains are achievable through increasing use of high-yielding seeds, propelled by chemical fertilizers and protected by chemical pesticides. On the other hand, in the low-input rain-fed agriculture, we tend to focus on the low level of external inputs as a limiting factor to raise the average productivity of such farms. This is not a meaningful dichotomy because the diversity of crops and diversification of crop management strategies are both valid working alternatives for both farming systems. Both of these are options within the armory of cultural knowledge that farmers can employ with or without external inputs. We can easily modify this approach by considering how Caribbean small-farm practices can contribute to the role of Plant Genetic Resources for Agriculture (PGRFA) as the building blocks of agricultural production.

The Conservation of this Agro-Biodiversity offers a systematic and comprehensive approach to protecting the stock of genes, species, and ecosystems in the global as well as the local environment. What we need to understand is just how climate-change will impact on such options as viable methods of maintaining productivity and increasing total output. We need to understand why PGRFA (high yielding inputs) can function best when we create a third mechanism in our production culture, namely *Facilitation*.

Plant Genetic Resources[3] for Agriculture (PGRFA) provide the essential raw materials for helping farmers respond to climate change. However, there is a structure which we need to overcome. It is the "*Patents and Property Rights*" that accompany the scientific research into such new material. The world of plant breeding and plant genetic research is not only a world of investigative inquiry, but also a world of commercializing such results and rewarding the inventors (patentability). The extent to which we can control and utilize such innovations really depends on what we consider *the paradigm fit* of its property rights (who owns its use). This is important because the patent systems, while necessary to incentivize research and development, do not readily support public facilitation in terms of local adaptation and innovation.

In the fields of facilitation, Transgenics and Molecular Plant Breeding are the most protected because these are patentable material. They may accommodate upstream applications limited by broad claims and negotiated licenses, but they can also block new uses and allow supply companies to use patents as bargaining chips.

[3] Plant genetic resources have been defined as the genetic material of plants, which is of value as a resource for present and future generations of people.

Conventional plant breeding and mass selections however, are areas in which the paradigm of patent rights and royalties partially breaks down (Figure 1). Here we can find an absence of strong patent production, trade secrets, plagiaristic breeding and more open competition. Mass selection refers to a method of crop improvement in which individual plants are selected on the basis of phenotype from a mixed population. These selected seeds are used to grow the next generation. This is a common practice among small farmers, especially those who have accumulated valuable information from years of observations in their particular environment. They just have limited opportunities for sharing these experiences.

The ultimate goal of managing plant genetic resources is to ensure that the maximum possible genetic diversity of a taxon is maintained and available for utilization (Maxted and Kell, 2003). Conservation can now become the dynamic form of "*plant genetic resources management*" being built on natural farmer selection. More importantly, such a policy will reinforce the perception of farmers as relevant custodians of agro-biodiversity and their local knowledge as the unique element of agro-biodiversity conservation. Clearly the issues of biodiversity conservation, plant genetic resource management and building resilience in our agricultural systems are nested issues that give us the opportunity of improving agricultural productivity at both the farm and the landscape level.

Agro-biodiversity conservation methods are usually focused at the macro level of the eco-system, not at the micro level of the farm as many conservation practices take years to demonstrate their worth in trials which can be readily adopted by farmers. The necessary conclusion is that while plant genetic resources are the cornerstones of increasing small-farm production, the promotion of sustainable resource use needs to be integrated into the broader landscape through land management practices and planning at different scales. We do have some experiences in integrating these two levels. Agro-biodiversity conservation policies allow us to prioritize land uses in what we call "**High Nature Value Environments**" (Williams, 2011). The experience of the High Nature Value Index (HNVI) as a bio-diversity approach, draws our attention to a policy tool that can address landscape fragmentation by patches of agricultural activity, reverse habitat loss, forest fires and a loss of critical ecosystem services such as soil maintenance and water retention.

CREATING A PRODUCTIVE MICROCOSM WITHIN SMALL-FARMS

We have used the term "***Facilitation***" in adapting advanced technologies to small-scale farming. Facilitation can be described as the cultural practices that will maintain a compatible microcosm within the production cycle. Geo-physical conditions do bring new

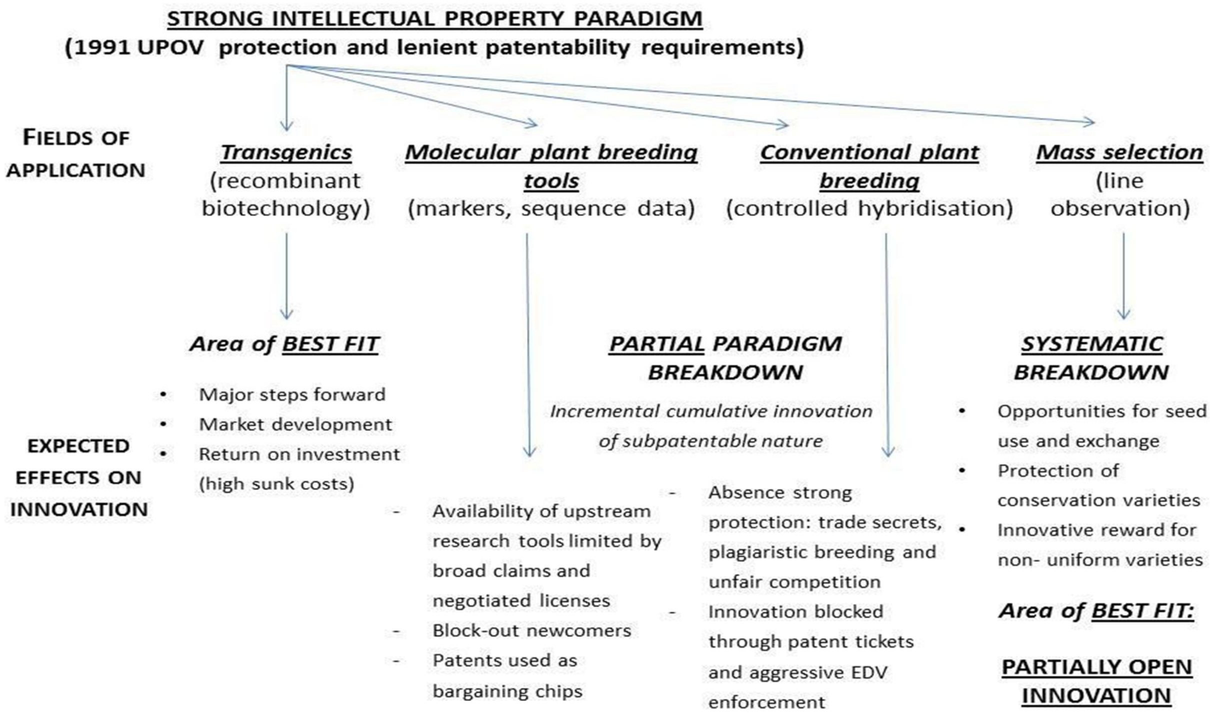

Figure 1. The intellectual property paradigm. Source: Batur and Dedeurwaerdere (2012).

variables into the viability of our farming system that go beyond the productive capability of the soil and the plant species. In describing the ecology of inter-cropping, Vandermeer (1989) notes that its major benefit is that it provides a system whereby certain species help or allow other species to grow by modifying the environment in a way that is favorable to co-occurring species. We need to move beyond the goal of trying to increase the uptake of external inputs into the arsenal of farm tools. It is within that extra step that we introduce the concept of a "***Cosmos within the smallest farm***", suggesting that its composition should represent a mini-universe that is orderly, harmonious and diverse.

In the actual process of growing crops, farmers usually take the genetic claims of seed producers for granted. However, the success factor for most farmers, resides in their tactics for changing the micro-climate on their farms in an effort to modify and maximize the results from the simple application of the external inputs.

In our aging traditional cultural solution of rain-fed agriculture, crop production goes directly into the domestic food consumption system. This is the correct orientation, but it is not always protected by the legal and trading regimes that dominate these local systems. Solutions of increased irrigation systems, crop rotation, non-chemical crop production all achieve minimal goals but fail to rise to the challenge of a growing local food demand. The feedback from the local seller's market does not incentivize the aging farming population to innovate, nor attract new younger farmers into this pattern of production. There is a lot of innovative potential to be harnessed in making Caribbean Agriculture attractive to a new generation of farmers by creating microcosms or "micro-climates" within small land spaces.

THE TACTICAL APPROACH: AN OPTIONS-RICH SMALL-FARMING SYSTEM

A decade ago, the United Nations conference on Trade and Development (UNCTAD) warned that the agriculture sector has the potential to transcend from being a problem to becoming an essential part of the solution to climate change. Its report suggested that this can be achieved through a "rapid and significant shift from conventional, industrial, monoculture-based and high-external-input dependent production towards mosaics of sustainable production systems that also considerably improve the productivity of small-scale farmers" (UNCTAD, 2010). Today, CARICOM Agriculture continues to be viewed as a choice between a techno-scientific model of chemical-based, **high import content** production system and the more traditional cultural system of rain-fed "**low-input**" production system. The current state of food production in this region suggests that both of these approaches are struggling to meet our expectations of ***stability*** in agricultural production output and ***efficiency*** in agricultural resource use.

In our search for policies and strategies to build resilience to climate-change in Caribbean agriculture, stability and efficiency must become the most common watch words. It is clear that Caribbean agriculture will need strong support from the local scientific community. Most of the inputs from the techno-scientific solution are already available to Caribbean farmers. The issue is whether a perspective of climate-change allows us to believe that biological diversity conservation will provide us with more options to overcome uncertain events?

The concept of an "***Options Rich Agricultural System***" says three things, Firstly, in the dynamic world of changing climates, farmers need a more comprehensive range of options to respond to the local challenges; secondly we must respond to the challenge of climate change at a level commensurate with the magnitude of the need for adaptation; and thirdly the new farming practices can best promote climate-change resilience when they are flexible, multi-functional and environment enhancing.

From a farmer point of view, accepting technological change is a single point adoption. Adapting to climate change is an ongoing process that requires an enabling environment. The scope of the climate change challenge requires a sustainable agriculture based on more practical policy actions and greater applicability of knowledge of agro-ecology. Here we can conceptualize at least five (5) cogent policy guidelines:

1. The new "golden rule" for helping small-farming is that the support structure must respond *at a level commensurate with the magnitude of the need for adaptation;*
2. In traditional agricultural knowledge systems, the word "culture" refers to the tried and tested methods of using the complexity and diversity of the environment to grow crops, raise animals and harvest marine species for food. These need to be shared more widely.
3. If climate change is the visible indication of a shift in the stability of the ecosystem, then the current generation of farmers has to produce the new "culture" of growing our food, for our survival and as a lasting legacy to future generations. They have the experience from observations and mass selection.
4. The cultural solutions already exist in the biodiversity of the environment, so agro-biodiversity conservation is the process that safeguards the environment for future solutions.
5. A "climate-smart" agriculture is not achievable by a single-purpose technology transfer (drought-resistant seeds; roundup-ready GMO species). It has to reach a level that is commensurate with the complexity of climate-change. This is only achievable by increasing the cultural options in our farming practices (Options-Rich).

QUALITY SOILS: A NEW PRODUCTION GOAL

Soil quality defines the capacity of the soil to sustain agricultural production. The standard expectation is that the continuous growing of crops does contribute to a degradation of this capacity. What is seldom appreciated is that a policy of promoting agro-biodiversity does have the capability of maintaining a nutrient balance in the soil through its recycling processes (Kaihura et al., 2001). A "Quality Soils" production goal is aimed at incentivizing cultivation practices that simultaneously produce crops and improve the quality of the soils, (nutrient recycling, utilizing the complexity of biological interdependence, etc.). The guiding principle is that we can improve the quality of our soils while at the same time producing on it.

Here are some tactical options:

1. Promoting farmer-driven innovations

Farmers innovate when they are working on the edge of what is "known" and feel the necessity to introduce system-wide changes that challenge the logic of existing practices. 90% of farmer-driven innovation is soil-based methods to change their micro-climates. A quality soil policy can become the appropriate focal point for incentivizing such innovations.

2. On-farm biodiversity conservation

On-farm conservation of agro-biodiversity holds the key to building resilience in Caribbean agriculture. This can be done through the movement of germplasm or the breeding of new varieties and seeds exchange in the partial open innovation paradigm that does not attract patentable claims. This approach will reinforce the perception that farmers are the most important custodians of agro-biodiversity and their collective local knowledge is the unique element in managing the inter-links in their farming system.

3. Incentivizing farm practices

The most prevalent incentive structure directed at farmers, seeks to lower their production costs by subsidizing some inputs. A Quality Soils programme will call on us to ***subsidize farming practices*** that demonstrate stability and efficiencies (at all farm sizes). Here are some examples:

- combining inter-cropping, crop rotation and other practices to create and use the full range of micro-environments within the farm (soil, water, temperature, altitude, slope, fertility);
- maintaining closed cycles of materials and wastes through effective recycling practices; and
- innovating with the complexity of biological inter-dependencies, in order to achieve some meaningful

degree of biological pest and weed suppression.

4. Leveraging quality soil investments

We can create a "debt/innovation swap" in which farmers, who have received loans for quality soil improvements, can swap part of their loan payments for demonstrated innovative practices. An accumulation of such practices can be collected and used by the Extension Division of the Ministry of Agriculture as knowledge information transfers, complementing or replacing technology transfer that may be prohibitively expensive.

5. Landscape Indexation of farm practices

The High Nature Value Index (HNVI) (Williams 2011) is a monitoring tool that scores the compatibility of farming practices with the environment. An HNVI ranking can become the basis for providing incentives, credit and other infrastructural support. Furthermore, indexation exercise can be used to map the landscape and see where land-use practices (in agriculture) are defaulting.

6. Occupy the landscape and seascape

HNVI mapping also allows communities of actors to occupy the landscape and promote its judicious use through legal structures such as "*land designations*", programme actions such as "*local area concept plans*" and local area control through participatory *natural resource utilization authorities.*

7. Plan ecological coherence in the landscape

Climate-change poses the highest risk to sustainability in areas in which we source our local food supply. Flooding, salt-water seepage and drought are the most commonly exposed risks. This constellation of risks cannot be mitigated solely with on-farm technology. Landscape approaches provide the framework to work beyond the farm-scale to support food production, ecosystem conservation and human livelihood in an integrated manner.

CONCLUSION

The impact of climate-change on small-scale farming is a complex issue that requires an adequate response at multiple levels. Agro-biodiversity Conservation is the agricultural investment strategy that is required now to reduce the uncertainty of future outcomes. This approach can identify solutions to emerging performance risks among small-farmers and bring into the culture of food production new innovations, supported by scientific research, with longer-term strategic needs. It has implications for various factors in agricultural production namely:

- Nature: continuously rewriting the genome of its fauna and flora;
- Species: diversity of species in a system;
- Genetic: variability of genetic information in the system;
- Spatial Distribution; Vertical or horizontal;
- Structural Factors: number of niches/habitats;
- Functional Content: number of species which serve different compatible roles;
- Time-Based Responses: cyclical changes (daily, seasonal) in the system.

Setting up the framework for agro-biodiversity conservation at national and local levels requires more than State action. There is much room for the NGO community and even local groups of concerned citizens to act.

- Agriculturalists, ecologists and economists need to start cooperating in identifying and establishing adequate assessment strategies (including valuing eco-system services);
- Anthropologists, nutritionists and ecologists should extend their work to the community level to observe, record and preserve ethno-biological species (plants and organisms) and functions (in health and nutrition);
- Conservation biologists and agriculturalists can begin exchanges aimed at finding common ground for policy initiatives to manage genetic, species and ecosystem diversity in agricultural landscapes.

The response to this complexity is as global as it is local, with the uniform recognition that these issues are nested within each other.

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