

identify specific aspects of mixed farming systems. At the same time, certain practices seem to transcend the whole territory and relate little to the activities that dominate a zone. To be able to organize a follow-up of these promising complex systems at farmer and experimental level situation a first evolutionary assessment grid was sketched to enable the selection of the situations. This should allow a more detailed study of the functionality of farms where estimates can be made on the the performances and robustness of systems in terms of sustainable development.

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## Systemic Vulnerability vs Resilience in Small Island Territories: Keys for a Viable Adaptation of the Agricultural Sector

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### Introduction

The devastating effects of the environmental changes on humanity and on Earth will increase and will be coupled with spatial and social inequalities that imply not only a higher exposure level of some population groups and some countries to these risks, but also a more unsteady ability to face them. Consequently, it is admitted that poor populations, developing countries and island micro-regions are and will be the most vulnerable. In this context, crucial questions for these territories are asked: how to limit the extent of the climate change and its impact on Small island developing states (SIDS)?, how to mitigate the SIDS (economic, social and environmental) vulnerability and how to make these small island entities resilient? Since Rio Earth Summit (1992), SIDS constitute a particular group of countries which declared their willness to include environmental aims within their development plans. This was fully detailed during the Barbados Global Conference (1994) which was the first conference to translate Agenda 21 into a programme of action for SIDS. This programme set forth specific actions and measures to be taken at the national, regional and international levels in support of the sustainable development of SIDS. Many reports dealing with SIDS emphasize the impact of agriculture on the environment and crucial state of their vulnerability. Agriculture and its main characteristics are pointed out (Atkins et al., 2000 ; Guillaumont, 2006): low number of products, concentration of exports and foreign dependence. The aim of this exploratory work is to analyse and assess the contribution of agriculture to macroeconomic vulnerability versus resilience in the SIDS.

### Objectives

Questioning the contribution of agriculture to SIDS' macroeconomic vulnerability vs resilience, it can be argued that some alternative farming systems can contribute to the resilience of SIDS. This paper analyses the specificities of these farming systems (diversified, mixed and integrated one (complementarities and interactions between animal and crop productions) and discusses the conditions under which they promote sustainable agriculture and augment the resilience of small islands. The analysis, carried out from a multidisciplinary viewpoint that associates economics, mathematics and agrarian sciences (systemic agronomy and zootechnics), also aims at providing efficient decision-making processes to emerge and public action to be implemented.

### Hypothesis

The approach assumes that alternative farming systems (opposite to the usual and historically predominant agro-export production scheme) present strong options to promote resilience. The general hypothesis is that alternative farming systems (opposite to the historically predominant agro-exporting systems) which still exist in SIDS have an intrinsic resilience which is likely to be transferred to the whole agricultural sector if it grows from these viable endogenous bases.

### Method

The research links quantitative measurement tools (mathematical theory of viability, economic modelling, simulation) and qualitative approaches (analysis of institutional, market, edapho-climatic contexts and its repercussion on farm production choices from surveys in the field) in order to estimate and differentiate the role(s) dedicated to agriculture in SIDS. A numeric simulation tool is provided based on the mathematical viability theory that allows modelling the spatiotemporal evolution path of farming systems in SIDS. The reasoning unfolds in three steps. Firstly, a robust (generic and reliable) methodology is targeted to identify ad hoc decision rules that would allow course of actions to mitigate the vulnerability of SIDS. Secondly, a systemic and aggregated procedure from agro-technical knowledge is produced for the

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computation of resilience/vulnerability indices at the farming system scale. Thirdly, the consistency of the computation method is tested to produce results by defining the test of optimal decision rules considering the effective contexts where decisions are made (external shocks, institutional design etc.). The necessary conditions for actions and policies in favour of SIDS' resilience to emerge are then explained.

### Insight on the method suggested in the viability theory

Since late 1980, viability theory has focused on the study of constrained discrete or continuous dynamic systems (partly controlled by humans or regulated by nature), partly subject to known but unpredictable perturbations or to systemic approximate assessment and for which qualitative objectives may be prescribed such as reaching a target in finite time or optimizing some overall criteria. Viability tools can handle complexity which avoids the use of classical methods such as optimal control theory or Monte Carlo as in statistical methods. Typically viability analysis answers the question: starting from a given initial situation, does it at least one viable evolution exist? Above all viability analysis provides the decision rules which when applied will sustain viability.

### Expected results

The research contributions are theoretical, empirical as well as practical. Theoretically, a re-foundation of the agricultural sector analysed as a determinant of the SIDS vulnerability is expected. On the empirical viewpoint, a robust protocol that determines the viable evolutions of the agricultural sector should be built. At the practical level, the interpretation of measurement results should provide the rules of decision the different stakeholders (from the producer to the politician) have to follow using a guidebook, in order to generate resilience in SIDS from an agricultural development viewpoint in line with the new requirements of adaptability and sustainability.

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## Productivity veterinary services and milk marketing through communities increase milk production and farmers income

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Bangladesh has the largest population density in the world and most of its population is rural, with per capita incomes being among the lowest in the world. This population is continually growing, increasing the demand for food, including animal products. Agriculture has evolved in an attempt to meet this demand. The purpose of rearing cattle has been shifting from traditional utilisation as traction animals to milk and meat producers. Artificial insemination (AI) was introduced in 1969, to help to increase productivity, but growth rates in production lag behind increases in consumption.

To increase productivity, crossbreeding in cattle through artificial insemination has been continued since 1969. There are about 3 million crossbred cattle in Bangladesh, representing 13% of the animal population. Crossbred animals generally perform well, assuming that veterinary services are included in the AI programme and milk marketing opportunities are made available. Veterinary services are required because the crossbred cattle tend to suffer more health and reproductive problems than local animals. Crossbred cows also require more inputs in feed and health care, so an accessible market is necessary to allow the farmer to obtain better returns to cover these increased costs. A project funded by USDA and IAEA-FAO has been working in Bangladesh since 2001 and has developed a model for delivering comprehensive services that address the issues mentioned. The service is called the Community-based Dairy Veterinary Service (CDVS) and is delivered through farmers' groups and associations. An individual veterinarian makes a scheduled farm visit to perform preventive and emergency cattle health care and reproduction and feed management. This has led to the formation of a foundation that aims to make the programme self-financing. It is called the Community-based Dairy Veterinary Foundation (CDVF). At the same time, a milk processor, BRAC Dairy and Food Projects has installed milk chilling tanks in the community. The impact of such programmes were evaluated in two districts of Bangladesh, Satkhira and Chittagong.

In Satkhira, three farmers associations collect about 9000 litres milk every day and transport them to five BRAC milk chilling centres. BRAC pays 1.65 Bangladesh Taka for each litre of milk (US\$ 2.4/100 litres milk) to CDVS in addition to the milk price paid to producers, yielding a yearly income to the foundation of US\$ 80 000. This amount of money is sufficient to pay the salary of three veterinarians, two field assistant, rents for three veterinary offices and the cost of vaccines and anthelmintics for all animals of the farm community. In addition, 69 men are employed to collect the milk and transport it to the BRAC chilling centres. Each man earns US\$ 45–65 per month. The programme generates a large amount of off-farm employment, which is very important in a country like Bangladesh where unemployment is a big problem.

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