

Diversity and efficiency: The elements of ecologically intensive agriculture

A six-year study in Cuba has shown that increasing a farm's diversity, for example with a mixed crop-livestock system, increases its overall productivity, energy efficiency and nutrient management. Equally important, it reduces risks, in particular when compared to simplified and homogeneous systems. Mixed systems draw various ideas and lessons from traditional farming systems found in many parts of the world. The Cuban case, at the same time, provides many lessons, especially when regarding the design and management of diverse systems.

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Whether we look at small-scale farming or at large commercial enterprises, designing a sustainable and equitable agricultural system poses continuous challenges. The farming model most commonly promoted throughout the world, based on simple and homogeneous systems, has notoriously failed in terms of sustainability and equity. Where it hasn't failed, but has increased total agricultural production in some countries, it is because this production has been subsidised in one or more ways. Subsidies, whether monetary, or in terms of over-exploitation of resources, absorb the costs of reducing the agroecosystem diversity. At the same time, aspects like environmental pollution, land degradation or rural poverty are disregarded.

Small-scale family farmers have not benefited much from this model. Attempts to improve the performance of small-scale agriculture based on simplified, homogeneous and subsidised systems have often failed due to, among other reasons, limitations of scale. Small-scale farming, therefore, still comprises a diversity of livelihood strategies, diverse land use, management and marketing strategies, the integration of different types of activities (e.g. crop-livestock interactions), intercropping and rotating crops and crop cultivars, or the maintenance of agro-diversity on the farm. Efficient use of the natural, economic and social resources –which goes beyond the efficient use of only a certain input– relies on one or more of these diversification strategies.

There is plenty to learn from small-scale production systems, particularly in terms of the role that diversity plays in making them more productive, reliable and efficient (see Box). Some of these lessons are being taken up in Cuba, where the agricultural sector has been moving in a “different” direction for almost two decades. This change in direction was initiated by the sudden disappearance of subsidies after 1990. After that, a severe energy crisis created the conditions for coming up with a new model of agriculture that relies heavily on agrodiversity. This emerging model may contribute to the design of sustainable systems around the world.

Cuba's path towards diversity

The economic crisis that started in 1990 in Cuba had a big impact on agriculture. Various alternative systems were proposed in order to tackle the difficulties which agricultural production

was facing. However, they all showed a common characteristic: they followed an input substitution scheme, in which high-input industrial practices were substituted with organic inputs. These early attempts then led to a new approach, based on the systems seen in Mexico and elsewhere: converting specialised (monoculture) and often centrally-managed farming systems into mixed, diversified (and small-scale) farming systems.

Mixed farming systems are now presented as an effective step towards implementing sustainable practices in Cuba. They aim to maximise the systems' diversity, emphasise soil fertility conservation and management, optimise the use of energy and the locally available resources, and are highly resilient. In short, they are based on three main principles: (a) diversification, by including crops, trees and animal species, (b) integration, considering the dynamic exchange and recycling of energy and nutrients among the different components of each system, and (c) self-sufficiency, referring to the extent to which the system is able to satisfy its own needs without requiring considerable external inputs.

A six-year study followed the transition from “conventional” farming systems to mixed systems, looking at the opportunities for improving productivity while at the same time enhancing sustainability and equity. This started at the Pastures and Forage Research Institute in western Havana, where two prototype mixed farms of one hectare each were established within a 15 ha dairy farm, with 25% and 50% of the total area devoted to crops. The study used different indicators to assess aspects

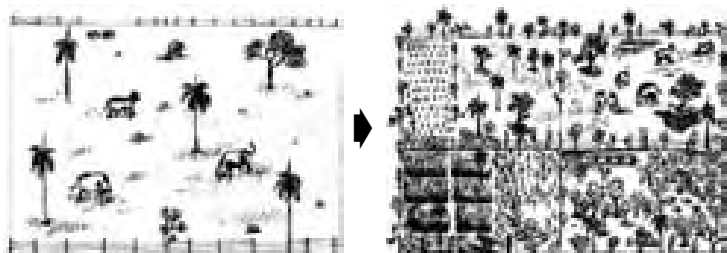
Lessons from elsewhere

As in many other countries, policies and development programmes in Mexico have encouraged the simplification of agricultural systems. Nevertheless, diverse farming systems are very common, and they contribute to the livelihood of the rural population and to the country's overall food production. For example, in the highlands of Michoacan, the Purhepecha people have relied on diverse agro-silvo-pastoral schemes for thousands of years. Each household has a diverse herd, including horses, chicken and dual purpose cattle. Livestock is partially fed with crop residues and, in return, manure is used in the fields where crops are grown, to restore soil nutrients and organic matter. The cropping sub-system is normally based on two fields, of about 3 to 4 hectares each, with alternating fallow. In the fallow field, cattle graze maize stubble after harvest during the dry season and, in the cropped field, a mixture of maize varieties, beans and squash are grown together in a mixed cropping pattern known as *milpa*.

When evaluated, these traditional systems display many advantages, especially when compared to “simplified” systems. They require few external inputs (occasionally some fertilizer and labour for specific tasks such as maize harvest). Although the production of maize, milk, meat and wood might be slightly lower than on specialised farms, resources such as land, labour and inputs are more efficiently used. Nutrient cycles are more efficient, allowing their capture and assimilation by different components of the system and in different forms. Just as important, a diverse system provides the household with various goods for consumption or market, ensuring food self-sufficiency and a reliable and resilient production of cash income in the long term.

such as biodiversity, productivity, energy use or financial performance. While all measurements showed clear results (a more intensive use of the available resources through diversified systems contributes to food self-sufficiency and to the efficient production of marketable products), we wanted to see if similar results could be attained on real farms. So we looked at 93 farms, varying in size, proportion of area allocated to arable crops, and in the stage of “conversion” to mixed farming. These farms were found in five different provinces, representing the country’s major agro-ecological zones.

A thorough evaluation showed that mixed farms are more productive, more energy-efficient, and manage nutrients better, than farms specialising in dairy products or a certain crop. There were, however, many differences between these cases, mostly depending on the percentage of the area used for crop production in each farm. The farms with the highest proportion of land under crops achieved the highest values of productivity in terms of milk yield per unit forage area, energy output and protein output. Farms with more land under crops demanded three times more human labour, but the overall energy cost of protein production was lower, energy use efficiency was higher, and a more intense use of organic fertilizers was needed. This was mainly due to including crops in systems which were previously pasture-based, which was a precondition to further increases of energy outputs.



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The conversion from a specialised farming system into a mixed farming system follows three principles: diversification (by including crop, tree and animal species), integration (by dynamic exchange and recycling of energy and nutrients among systems components) and the achievement of food self-sufficiency.

Higher proportions of farmland dedicated to cash crops also resulted in higher values for the agrodiversity indicators (such as “diversity of production” or “reforestation index”). Under the conditions of low inputs and high uncertainty in which these farms have to operate, this higher diversity greatly contributed to reducing risk and increasing productivity. Both internal and scarce external resources were used more efficiently in the mixed farms than in the specialised ones, and the diversified farms were more efficient in the use of energy, lowering the energy costs of protein production.

These results showed that when comparing different systems, the issue is not only one of high or low inputs, specialisation or diversification. Equally important is how the specific characteristics of each farming system, the necessary inputs and its agro-diversity are interrelated and managed – in particular, by farmers themselves. In deciding on the proportion of the farm area to be used for crop production, for example, farmers considered factors such as land availability, stocking rate and animal feed balance on the one hand, and soil characteristics, productivity of forages and availability of crop residues, on the other. Market constraints, sales contracts with the state, as well

as other socio-economic factors also played a role in deciding the degree of conversion from specialised to diverse farming systems. Managing higher levels of agrodiversity also required design skills and more dynamic decision-making, which led to the empowerment of farmers. In addition, the better allocation of feeds and labour throughout the year contributed to improved resource use efficiency.

Lessons of global relevance

Optimal use of resources for both crop and animal production helps to achieve food self-sufficiency while at the same time yielding marketable products that contribute to household income – without degrading the environment. After only a few years, these highly diverse, heterogeneous and complex small farms are already proving to be substantially more productive and efficient than specialised crop or livestock systems. About 65% of the food produced and marketed locally is grown nowadays by small-scale farmers who cultivate half of the total land in use by agriculture in Cuba.

The many forms and scales of diversity associated with family agriculture play an important role in sustaining rural livelihoods. A quick examination of the many different traditional farming systems shows how agrodiversity is always inherent, and contributes importantly to their sustainability. It guarantees a more efficient use of the local resources, reduces dependence on external inputs while conserving biological resources, and reduces risks. Agrodiversity also plays an important role in the preservation of local knowledge and empowerment of farmers, as diverse agricultural systems are knowledge-intensive and require complex, dynamic and adaptive decision making. These systems need to be thoroughly analysed for their potential to provide services of global relevance, such as carbon sequestration or biodiversity conservation, or for preserving our cultural heritage. Mixed farming systems should be the primary target for protection and subsidies.

But the potential benefits of agrodiversity are not only limited to traditional, smallholder family agriculture. The lessons learnt from the conversion of Cuban agriculture show the opportunities that diversity offers in the design of more sustainable agricultural systems at a much broader scale. The unique position of the Cuban agricultural sector, both nationally and internationally, provides lessons that are highly relevant to the rest of the world. The instability of oil prices, climate change, or the ever-increasing prices of food in the international markets, combined with national awareness of the necessity to substitute food imports for nationally-grown food, opens up a wide spectrum of possibilities for disseminating alternative systems at a nation-wide scale. Diversification, decentralisation, and the movement towards food self-sufficiency, are the response of Cuban agriculture to the current local, international and global context: the very same context that threatens agriculture and food security worldwide today.

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