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Enhancing integrated approaches in agricultural learning systems using experiences from agroforestry

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Small-scale farmers integrate biophysical factors with social, economic, cultural and environmental considerations in their day-to-day decisions to manage complex farming systems. This approach contrasts with the traditional organization of knowledge and institutional structures at universities, where reductionist approaches prevail, leading to production of graduates with insufficient competence in the analysis of complex systems. Three decades of agroforestry research has developed a series of tools for understanding integrated systems: The landscape analysis framework is used by the alternatives to Slash-and-Burn initiative; participatory domestication of tropical fruits in Africa; and modeling tools such as WANULCAS that enable us generate future scenarios of integrated land use systems. Although new agroforestry education programmes in the tropics are putting such tools into use in learning systems, there are still constraints to their adoption. The rising demand for food, fibre, energy and environmental services is likely to lead to transformation of farming landscapes into complex mosaics, shaped by farmers through agroforestry. Universities need to pay increased attention to understanding integrated systems. Our experiences in Africa and Southeast Asia show that agroforestry education contributes to better understanding of integrated approaches in the learning system. This innovation prepares future graduates to understand, and advise farmers on integrated production systems.

Key words: Agricultural education, integrated systems, agroforestry research, curriculum development.

INTRODUCTION

Small-scale farmers throughout the tropics and sub-tropics tend to integrate crops, animals and trees in their farming systems. Their livelihood strategy may mix on-farm and off-farm work, where they extract timber and non-wood forest products (including fodder) from nearby forests and/or communal lands. They produce for their own consumption as well as for the market. Some key features of such integrated livelihood systems include risk mitigation, labour distribution, intimate links between agriculture and social and institutional factors, use of traditional knowledge, and customary tenure systems. According to Dixon et al. (2001), farming systems are characterized by structural complexity and interrelation-ships between various components of a small-holding, which are also influenced by the external environment, including policies and institutions, markets and information linkages.

Tools such as Participatory Rural Appraisal (PRA) have emerged which take such complexities into account, and involve local people in the analysis, learning and action (Chambers, 1994). Such participatory research and development, acknowledges the complexity of rural livelihoods, the dynamic changes of rural landscapes, the importance of local knowledge and local institutions, and provide joint learning opportunities between farmers and scientists, among other benefits.

At the level of public institutions, however, segregation prevails. For instance, there are usually separate ministries and separate university faculties for the two 'sectors' of agriculture and forestry. Similarly, social aspects are handled independently in administrative structures and in education programmes. Conventional mono-disciplinary curricula present units of specialized

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knowledge, without challenging students to explore how this new knowledge fits into the context of a whole system (Salomonsson et al., 2008). Such approaches tend to foster a fragmented view of reality, making it difficult for learners to integrate knowledge and skills to resolve real-life issues (Wals et al., 2004). This artificial divide has left universities poorly equipped to develop students' competence to work effectively in a reality, which is complex, dynamic, and where 'ready-made' answers are becoming less meaningful.

However, these statements do not denigrate the importance of specialization and depth of science. Temu (2004) indicates that it is intellectually stimulating to specialize, because it enables scientists to unravel complex systems into simple elements. He further argues that it is as important to see the individual elements separately as it is to see them together and at different scales. This is particularly important as we deal with complex production systems, as in agroforestry or in agricultural biodiversity management.

Agroforestry, which emerged as a science since 30 years ago, has been at the fore-front of bridging agriculture and forestry disciplines, and in bringing scientists and farmers together in joint action research and development (Garrity et al., 2006). Other examples of integrated approaches include, for example, farming systems research (Norman et al., 1995) or integrated soil and water management.

The bridging of sectors has also taken place in higher education: Two university networks in Africa and Southeast Asia – the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE) and the Southeast Asian Network for Agroforestry Education (SEANAFE) – have since 1993 and 1999, respectively, been working with more than 200 universities in the two regions to enhance the content and delivery of agroforestry and natural resources education.

Through faculty training, educational policy changes advocacy and cross-disciplinary dialogue, ANAFE, has facilitated the adoption of integrative teaching of land use sciences at 67 colleges and universities in Africa (Temu, 2004). Similar milestones were made by SEANAFE in Southeast Asia (Rudebjer et al., 2008). These outcomes were strongly influenced by training events and the publication of a methodology for developing agroforestry curricula (Rudebjer et al., 2005a). The networks have learned important lessons from this mainstreaming, which can provide a framework for broader innovations in education.

This paper aims to review lessons learned and explore future options for accelerated sector-integration in higher education. Work on Alternatives to Slash and Burn (ASB); Participatory Tree Domestication; Water, Nutrient and Light Capture in Agroforestry Systems (WANULCAS) and Rewarding Upland Farmers for Environmental Services (RUPES) are reviewed to demonstrate the integrated nature of land-use systems under Agroforestry. Our hypothesis is that such integrated knowledge and skills would be an asset in addressing future challenges such as developing sustainable agricultural practices that can adapt to and mitigate the effects of climate change.

MISMATCH BETWEEN PRACTICE AND LEARNING SYSTEMS

Farmers' knowledge is acquired through life experience and often starts at a very young age. Growing up in a farm and interacting daily with a farming community, the landscape gives an intuitive sense of how the integrated system works, and how to make decisions. Logically, agricultural universities should produce graduates who are able to analyze these complex production systems and conceptualize, implement and guide appropriate integrated interventions.

Scientific knowledge, in contrast, tends to un-pack the system into components, which are studied separately, in great detail. Agricultural universities typically teach forestry, agriculture and livestock sciences in separate faculties or departments. Within each faculty, there is further subdivision into departments or sections. The notion is that the different bits and pieces must be learned first, before synthesis courses can be taught. Often, the first few years of an education programme contain a great number of small courses, but with little connection between them. Towards the end of a programme, there might be some larger synthesis oriented courses, such as Forest Management; Animal Production and Crop Production.

Upon graduation from these segregated programmes, the graduates start working in a likewise segregated professional system. They are equipped with scientific knowledge within their chosen discipline, but have limited understanding of other sectors that are part and parcel of the farming systems. They have little exposure to farmers' traditional knowledge system, which is neglected in most curricula. This linear, reductionist paradigm fails to prepare graduates for a reality which is dynamic, complex and uncertain.

The mismatch between small-scale farmers' practices and university learning system, leads to situations such as:

1. Bias towards linear, top-down solutions as opposed to joint learning and action.
2. Sectorized approach to extension, causing overlaps or conflicting extension messages.
3. Lack of understanding or ignorance of other 'sectors', leading to lost opportunities for win-win inter-disciplinary collaboration.
4. Inefficient knowledge sharing between sectors (e.g. between forestry and agriculture, or between health and agriculture).

5. Inexperience in using tools that analyse complex innovation systems.
6. Lack of awareness of the trade-offs involved.
7. Competition for research resources among the sectors.
8. Difficulties in formulating and implementing holistic policies and strategies for agricultural development.

An illustrative example of the segregated approach is the development of the Comprehensive Africa Agricultural Development Programme (CAADP) (NEPAD, 2003). The initial focus was on crops, leaving out other natural resource management sectors (including forestry, fisheries and livestock). Only a few years later, after realizing the significance of such links, these three sectors were captured in what was called a companion document (NEPAD, 2006). However, no tools or structures were developed to fully integrate them into 'the agriculture' programme. To date, forestry still lies outside the agricultural research and development initiatives under CAADP. Recently, forestry emerged as important, but peering in from the climate change and environment perspectives. In most literature on CAADP, forestry is still treated as an environmental issue, rather than one that contributes to food security and poverty alleviation. The reality on the ground is quite different. Still there is no integration in sight. Yet, CAADP is a high profile framework document approved by the Africa Union Commission.

How could such an oversight occur? The segregation emerges from learning systems and is propagated by institutional structures. In the case of CAADP, food security is the main driver, and leaders tend to focus on the cultivation of a few major crops, oblivious of the underlying threat to agriculture arising from unsustainable use of natural resources.

If learning systems were designed to first project and understand the holistic interactions among sectors, we could reduce such oversights. A mindset of change is imperative.

RESEARCH EXPERIENCES ON INTEGRATED APPROACHES

Bridging the forestry and agriculture sectors, agroforestry research have in the past, three decades been among the front-runners in studying complex ecological, social and economic systems. The integration of trees into farming systems addresses several high level goals. These include increasing and sustaining food production, improving environmental services, conserving natural resources (especially soils, biodiversity and water) and raising incomes.

The world agroforestry centre (ICRAF) and its partners have addressed these challenges through several integrated research initiatives and programmes, including:

1. The Alternatives to Slash-and-Burn (ASB) initiative, with a focus on tropical forest margins. The ASB system applies an integrated natural resource management (INRM) approach to analysis and action. It engages scientists with local communities and policymakers at various levels. Through participatory research and policy consultations, ASB has developed combinations of policy, institutions, and technological reform options to raise productivity and income of rural households in the humid tropics without increasing deforestation or undermining environmental services (ASB, 2008).
2. Participatory tree domestication of indigenous fruit tree species. In this work, farmers learn tree selection and on-farm cultivation by applying simple techniques. Several indigenous fruits (e.g. *Dacryoides edulis* and *Irvingia gabonensis*) are now cultivated in humid West Africa, effectively increasing the range of alternative crops available to farmers (Tchoundjeu et al., 2008).
3. The development of modeling tools, such as WANULCAS – Water, Nutrient and Light Capture in Agroforestry Systems (Martin and van Noordwijk, 2009). This model was developed to represent tree-soil-crop interactions in a wide range of agroforestry systems where trees and crops overlap in space and/or time. The model can be used for exploring positive and negative interactions for different combinations of trees, crops, soil, climate and management by the farmer.
4. Rewarding upland farmers for environmental services (RUPES), is a collaborative research programme in Southeast Asia, established in 2002. The purpose is to explore 'ways to make it more worthwhile, in financial and livelihood terms, for poor farmers and communities in the uplands of South East Asia to maintain, rather than degrade natural resources' (Swallow et al., 2008). By definition, RUPES is a realistic, voluntary, conditional and pro-poor mechanism for rewarding ecosystem stewards for legitimate actions foregone or positive actions undertaken beyond social expectations. For example, in watershed services, payment for environmental services range from subsidies of forest owners paid from levies on water or hydropower users, through trade in certificates of rights to pollute (based on certified emission reduction elsewhere), moral incentives to plant trees and eco-tourism, to outcome based contracts to reduce sediment loads of streams and rivers.

Other examples of integrated approaches in agriculture R and D include integrated pest management (IPM), integrated soil and water management, and farming systems research, among others.

In social sciences, Participatory Rural Appraisal and a related family approaches emerged since late 1970s. These methods seek to empower local people to analyze, plan and take action, thus combining local knowledge with that of outsiders (Chambers, 1994).

For each of the examples cited, a significant body of tools and methods are available for analysing integrated

systems at multiple scales.

MAINSTREAMING AGROFORESTRY IN HIGHER EDUCATION: SOME EXPERIENCES

In spite of the availability of an increasing body of tools and methods, the systematic inclusion of integrated approaches in higher agriculture education is uneven and slow. Most examples refer to revisions of existing courses or programmes within current institutional frameworks, rather than attempt to create new innovative programmes.

Agroforestry, commonly perceived as 'falling in the cracks' between the established forestry and agriculture sectors, has been taught for at most only three decades. In the past fifteen years, the mainstreaming of agroforestry into education programmes in Africa and Southeast Asia has been further enhanced by two networks, ANAFE and SEANAFE, respectively. Between them, they bring together more than 200 universities and technical colleges (Temu et al., 2003; Rudebjer et al., 2005b). The networks have used several techniques to support the institutionalization of agroforestry education, including:

1. Developing and facilitating the implementation of creative and participatory curriculum designs and reviews.
2. Enhancing faculty capacity to participate and guide curriculum development and review.
3. Enhancing faculty capacity in social and technical areas of agroforestry.
4. Providing access to new tools and source materials for faculty to develop its own teaching and learning resources.
5. Providing research opportunities in an international context to graduate students and faculty.
6. Strengthening networking among institutions including the exchange of faculty and students.
7. Supporting policy advocacy and strategies that lead to greater integration of disciplines.

These efforts have contributed to curriculum outcomes, such as new or revised agroforestry courses, and new or revised agroforestry programmes. Yet, these changes have by and large, taken place within the existing institutional structures, rather than through the creation of new offerings. For example, a university might offer agroforestry courses independently in their faculties of agriculture and forestry, respectively (Rudebjer et al., 2008). The historic separation between forestry and agriculture faculties tend to prevail, in spite of the scientific progress in understanding integrated, complex systems.

The alternative option, to create integrated cross-faculty programmes seems to be rare, although some attempts have been made. Sokoine University of Agriculture in Tanzania introduced an MSc Natural Resources Management programme in the late eighties. However, the programmes', graduates had challenges in finding employment that fits into their new qualifications because employment criteria were tied to traditional disciplines. The programme was discontinued.

CONSTRAINTS TO MAINSTREAMING INTEGRATED EDUCATION PROGRAMMES, AS ILLUSTRATED BY AGROFORESTRY EXPERIENCES

What are the constraining factors that hinder the knowledge of small scale farmers from being internalized in higher education systems? The experience of ANAFE and SEANAFE in Africa and Southeast Asia, respectively, provide some lessons. The constraints relate to: (i) The external environment, including policies; (ii) Institutional structures and behaviour; (iii) Educational and research processes; and (iv) Human capacity.

Constraints related to the external environment

1. Job markets and career pathways are rigid. Clear disciplinary career pathways prevail with defined criteria for entry and promotion. For example, employment as a forester in the public sector in the Philippines, requires a board exam, issued by the Professional Regulation commission (PRC). This in turn requires that the education programmes and institutions follow certain defined minimum standards. This system is a disincentive for innovative, integrated fields of learning, such as agroforestry or agricultural biodiversity management.
2. Policies are often a restriction to change. Land use policies may not be conducive to accepting new concepts such as agroforestry, and education policies may be hindering the offering of new programmes. For example, Vietnamese universities which operate in a policy environment conducive to agroforestry have been quicker to mainstream agroforestry in their programmes, compared to their counterpart universities in Thailand which face policy constraints to such introductions (Rudebjer et al., 2008).
3. Sectorized professional networks, e.g. on soils and root crops tend to emphasize the segregation between sectors and also among working professionals.

Constraints related to institutional structures, mandates and attitudes

Professional boundaries

Governments and private sector adhere to traditional disciplinary boundaries such as agriculture, forestry,

live-stock management and rarely have integrated departments or programmes.

Territoriality

In actual land distribution we have designated agriculture and forestry lands, but there is no land set aside for agroforestry.

Conservatism

Many institutions and individuals resist changes especially where they involve crossing disciplinary boundaries.

Constraints related to educational and research processes

1. Rigid frameworks for curriculum change can delay or hinder the introduction of new approaches in educational programmes.
2. Segregated, reductionist research programmes which emphasize bio-physical sciences dominate agriculture and forestry sectors. There is inadequate experience in research that blends bio-physical and socio-economic sciences.
3. Researchers have difficulties to find publication outlets that appreciate integrated approaches to science.

Constraints related to human capacity

1. Low competence in 'soft skills' (social sciences) among biophysical faculty is common, and vice versa.
2. Very limited acquaintance with integrated tools and methods for research and teaching.

FACILITATING FACTORS: OPPORTUNITIES FOR INTEGRATION

In spite of the constraints noted, some progress has been made. Universities in the ANAFE and SEANAFE networks have used three main approaches for mainstreaming agroforestry in education programmes:

Incremental inclusion of agroforestry courses and topics in existing educational programmes is the most common approach. Typically, a new integrative subject, such as agroforestry, is first taught opportunistically, within existing courses. Later, during curricula reviews, a new course is included. A major may also be offered, especially at MSc level. Programmes are gradually transformed or oriented towards more integration of agroforestry.

A second approach is to offer agroforestry as an alternative discipline. In this approach, predominantly used in the Philippines, agroforestry is seen as a new professional area, and is in a way, a competitor with agriculture and forestry.

A third opportunity for integration is emerging during institutional re-structuring. Mergers between faculties or departments would then bring together subject areas which have earlier been taught separately. This has occurred in many universities in the developed countries where, for economic reasons, faculties have been forced to merge. Over the last decade, faculties of forestry have been collapsed into agriculture faculties, and although there are tensions on how the merger would work, there are also opportunities for closer professional integration.

Whichever approach is used, we have observed the key success factors as:

1. Having a refreshed vision regarding the goals of the education programmes.
2. Applying a consistent effort towards change, which sometimes takes several years. Curriculum change is a slow process, and timing with the regular curriculum review process which is important. A champion is needed for this to happen.
3. Effectively using opportunities that arise, such as working within existing rules and regulations and enriching the learning content with integrative knowledge
4. Reinforcing the knowledge and skills of faculty and institutional leaders. For instance, public lectures at colleges and universities can help introduce new topics and learning materials into existing courses, or securing the participation of institutional leadership in curriculum reviews.
5. Participation of external stakeholders in the curriculum development process can help to identify competencies required in graduates, and suitable learning methods/tools.
6. Identifying and using opportunities available within the national policy framework.

CONCLUSIONS

In future, it is likely that education programmes will need to change more quickly to respond to powerful drivers such as the need for mitigation and adaptation to climate change, and risk management. Other drivers include sustaining biodiversity conservation and the threat of land conversions to produce biofuels. Such drivers can push both towards more segregated systems, or towards more integrated ones, or both (Table 1).

While these drivers may push changes towards both integration and segregation, there is no doubt that future graduates will need more competence in dealing with integrated, dynamic and complex systems. For education systems to adjust, actions are required at several levels:

Table 1. Factors that may push towards integrated or segregated systems.

Global trends	Push towards integration	Push towards segregation
Pressure to increase cereal production	Intensified use of legumes like *Sesbania sesban* and *Gliricidia sepium* can triple outputs	Increased use of high-yielding modern crop varieties
Enhanced food nutrition	More diverse food and agriculture systems	Genetically enhanced commodity crops
Biofuels	Incorporating biofuel crops into farming systems	Use of monoculture biofuel crops on large areas
Expanded markets for agriculture products	1. Demand for 'new' and previously underutilized species 2. Demand for high-quality crops (e.g. speciality shade coffee, cacao)	Clearing forest areas for more crop cultivation or pasture
Biodiversity conservation	1. Ecosystems conservation 2. Landscape approach to biodiversity conservation	Separate conservation and production areas
Adaptation to climate change	1. Agriculture that emphasize resilience and risk mitigation 2. Better land management in watersheds and riparian zones 3. Using inter- and intra-specific diversity in crops and trees on farms, to mitigate risk	Push for few resilient and/or genetically modified crop varieties, possibly leading to a reduction in genetic variation
Climate change mitigation	1. More trees on farms to store carbon 2. Better management of below-ground biodiversity	Monoculture tree plantations under the Clean Development Mechanism

1. Universities and their institutions of learning should consider:

(i) Setting goals that acknowledge complex, dynamic systems and support curriculum development that meet such goals.
(ii) Teaching innovation systems approaches.
(iii) Using problem-solving as a learning approach – how to state, structure and analyse a problem, in participation with stakeholders
(iv) Dealing both with the depth and breadth of a problem, such as drivers that influence change.
(v) Putting more emphasis on understanding trade-offs and feedback mechanisms of interventions.
(vi) Creating more publishing opportunities for integrated science.

2. Policy makers should consider:

(i) Options to recognize integrated knowledge and skills in educational policies and in job markets.

(ii) Reviewing institutional structures and processes to facilitate multi- and inter-disciplinary problem solving.
(iii) Recognizing and measuring/monitoring the benefits of integrated approaches to farming, especially the promotion of environmental services.
(iv) Helping to improve the capacity for integrated approaches to farming.
(v) Establishing ways and means to reward farmers for the public benefits accruing from integrated farming systems.

Our experiences show that a networking approach can play an important role in catalyzing the mainstreaming of integrated subjects into education, research and development initiatives.

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