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Making Trans-disciplinary Science Work for Resource-poor Farmers

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Abstract

The paper draws on three strands of experience: the authors' involvement in a trans-disciplinary research project in Africa, their role as writers in the IAASTD, and their tenure as social scientists in agricultural universities. The paper reports major *propositions* and the *conclusions* that follow. Making trans-disciplinary science work for resource-poor farmers requires addressing issues at the global, regional, national and local levels. The impediments are largely institutional. A supply-driven approach to technology development has limited scope because of the small windows of opportunity that farmers face. A more demand-driven approach requires rethinking the global economic system and its premises. The authors draw conclusions for research institutes and universities, which seem to be neglecting their key mandate: dealing with the disruptive anthropogenic future and designing agricultural and food systems that take into account the multi-functional nature of farming. Farmer First remains a true entry point if farming is viewed not just as commodity production but ensuring (global) ecological services, including the sustainable and equitable generation of livelihoods.
167

1. Introduction

The rising prices of food as a result of increased demand for high-energy and protein foods and the diversion of resources to bio-energy, combined with prolonged droughts in production areas such as Australia, threaten global food security. Agriculture potentially is a major contributor to mitigation and mediation of climate change, but it now is a major source of the gaseous emissions implicated in global warming, the largest user of potable fresh water, a leading contributor to pollution, a source of actual and potential pandemics, and land clearance for agriculture is a major cause of loss of habitat and biodiversity. Farmer First remains a priority.

The paper is based on three strands of experience. (1) A major research programme in Benin and Ghana, Convergence of Sciences (CoS), that started in 2002 and ended with a bang in October 2006 with the simultaneous graduation under Wageningen and host university procedures of eight African and one Dutch PhD students in respectively Accra and Cotonou, who had carried out research with groups of small-scale African farmers on integrated management of pests and weeds, soil fertility and genetic diversity, and a study of the 'pathways of science' required to develop and execute 'winning ideas'. Each student was supervised by a multi-disciplinary team, including at least one natural and one social scientist from each of the African countries concerned and from Wageningen University. The fact that each research project was carried out with a selected group of small-scale farmers and other stakeholders added a trans-disciplinary component to this inter-disciplinary collaboration. The research process included a

period of zeroing in on the problems experienced and prioritised by small-scale farmers by means of a technography and a diagnostic study that included farmer selection and stakeholder group formation. A sequel to this project focuses on Innovation Systems (in the sense of World Bank 2007) in Benin, Burkina Faso, Ghana and Mali.

(2) The second strand comprises the long-standing experience of both authors as social scientists in agricultural universities.

(3) The third strand derives from the authors' participation in the ongoing International Assessment of Agricultural Science and Technology for Development (IAASTD) (completion January 2008). This Assessment is the latest in a series of recent global assessments (bio-diversity, ecosystems, climate change). It is not the product of experts, as is the World Bank's 2007 World Development Report on agriculture, so much as the outcome of interactive multi-stakeholder knowledge processes including civil society organisations, private industry and governments operating under tri-partite governance and with the final summary and synthesis reports submitted to governments for approval. The IAASTD assesses agricultural knowledge, science and technology (AKST) by looking at history, challenges and the options for action, informed by explicit normative goals: nutritional security, livelihoods, human health, and environmental sustainability and takes a short- and long-term perspective (now to 2050). At the time of writing, the outcomes of the IAASTD remain contested; the controversies highlight some of the key issues that arise in trans-disciplinary science involving multiple stakeholders.

The paper draws on these strands to present ideas that can hopefully guide efforts to make trans-disciplinary science work for resource-poor farmers. The exercise is strongly biased towards agriculture in sub-Saharan Africa (SSA).

The paper deals with two arenas: (1) resource-poor farmers, the outcomes of their farming and the opportunity context within which these outcomes are generated, and (2) agricultural science in interaction with resource-poor agriculture. For each arena, the paper formulates propositions that are followed by conclusions for action.

2. Resource-poor agriculture

Proposition 1: The principle of Comparative Advantage, when applied to global agricultural trade and markets, causes poverty of resource-poor farmers and degradation of their resources.
Resource-poor farmers face unfair competition from farmers in industrial countries and emergent economies. These lucky few (typically 3% or less of the working population) are highly professionalized, embedded in networks of services, and highly capitalized in terms of machinery and other resources. Their land, water and soil fertility have been significantly modified to accommodate farm intensification dependent on heavy through flows of fossil fuels. Their labour productivity far outstrips that of farmers in developing countries, so that, even if their labour costs are twenty or more times higher, they can out-compete small farmers any time (Bairoch 1997). Value Added per Agricultural Worker in 2003 (const. 2000 US$) in developed market economies was 23,081 with an annual growth in 1992-2003 of 4.4%. For SSA, the figures are respectively 327 and 1.4% (FAO 2005). Emerging urban (super) markets in developing nations are captured by imports. In these conditions, to accept comparative advantage as a design principle for global agricultural trade condemns the 60% of Africans who live by farming to poverty, and their land and other resources to degradation. This historical legacy of unlevel playing fields probably is more important than the OECD agricultural subsidies in disadvantaging small farmers. Pitting resource-poor farmers against farmers who have during the past century or so managed to capture economies of scale as a result of government assistance, good governance, science and extension support, developed farmer organisations and commercial institutions, pre-empts the opportunities of the former.

Conclusion: Market protection, accompanied by measures to create access to remunerative markets, credits, inputs and other essentials, is a necessary condition for improving the opportunities of resource-poor farmers.
Yet, in our experience, protection is anathema to economists, let alone to people who benefit from the current situation (e.g., exporters of chicken wings, a worthless by-product that prevents the growth of a sustainable African poultry industry). ECOWAS has tried to place the matter on the agenda but so far has not succeeded in the face of EC opposition. The success of Asian countries, such as Malaysia, which faced similar conditions to those in e.g., Kenya in the 1960s, is attributed to weak governments in Africa and their lack of attention to and protection of agriculture, as well as to their inability to stand up to the pressure for market liberalisation by the IMF (NRC/Handelsblad 21 October 2007: 46).

Proposition 2: There is a strong contradiction between the interests of urban consumers and resource-poor farmers under current trading conditions.
Urban consumers make up an important electorate. Even if the majority of the population depends on farming, as is the case in most SSA countries, African governments tend to favour urban electorates and import cheap food, even if this means that the national farming industry does not develop. In countries with few mineral resources, farming and rural communities are a source of revenue and rent seeking for different tiers of government and others. Major African agricultural export industries, such as cotton and cocoa, feed huge bureaucracies and patrimonial networks. In Benin, pesticide sellers refuse to make available equally effective but cheaper chemicals because that would eat into their profits (Sinzogan et al., 2007). Ghana only increased the percentage of the FOB price that cocoa farmers receive from 40 to 70% under international pressure. As a result, in recent years cocoa production has doubled without any significant change in technology (Ayenor et al., 2007; Dormon et al., 2007). Most export industries lack a coherent marketing chain that seeks to strengthen its competitive position in the world market.

Conclusion: Development requires policies that maintain a careful balance between prices domestic farmers receive and urban consumers pay. Attention to this issue is an indicator of good governance.

Proposition 3: African resource-poor farmers are innovative and enthusiastically embrace anything that they see as an improvement of their situation. In policy documents (i.e. IAC 2004) African agriculture is depicted as 'stagnant' because food production per ha or per head of the population has not increased during the past 20 years. But such low productivity should not be a source of wonder. It is not rational for resource-poor farmers to produce surpluses (as we experienced during our project in Benin and Ghana when farmers accused our researchers of helping them to produce surpluses which they could not sell). But that does not mean African agriculture is stagnant. During the past decades, African farmers have managed to keep up with rapid rural population growth, notwithstanding the collapse of shifting cultivation and the need to develop more permanent land use, and the need to cope with the emergence of pernicious herbaceous weeds, the loss of soil fertility, the reduction of farm sizes, and in many cases the feminisation of agriculture, not to speak of the HIV-AIDS pandemic, wars and conflicts, and reduced rain fall in parts of West Africa. Because the opportunities for commercial food production are small, resource-poor farming largely remains (adaptive and innovative) subsistence farming. This means that money outlays for school fees and farm inputs must be paid for by the local sale of surpluses or by off-farm income. In Benin, our farmers continue cotton production even if is no longer profitable, because it gives them access to fertilisers for their maize. Calculations of the profitability of e.g., the use of synthetic fertilisers rarely take this aspect into account, but focus on gross-margins per hectare.

Conclusion: The decision that low productivity per ha is THE problem of African agriculture and that therefore intensification must be promoted through a Green Revolution for Africa, as is currently assumed, is based on an erroneous diagnosis and means in effect, more-of-the-same and more wasted years. In an analysis of a number of cases in West Africa to test the hypothesis that soil mining is the key problem of farming, Mortimore and Harris (2005) concluded that it is not

so much the supply side that is the problem as the demand side: improve farmers' opportunities and they are capable of taking care of soil fertility themselves. The question for policy is not: how do I improve farm productivity in SSA, but how can I create opportunities for resource-poor farmers to make some money by farming?

Proposition 4: The reproduction of subsistence farming, under the rain fed, highly diverse and variable conditions faced by the resource-poor farmers in developing countries, is under severe pressure everywhere. In China the emigration of cheap labour from rural areas to cities is fuelling phenomenal economic growth. In Africa, masses of disenfranchised youths who cannot reproduce the cultural repertoire, or marry, are fuelling conflict and war (Richards 2002). Subsistence farming seems to be losing its resilience, yet it will need to absorb more people in the near and medium term.

Conclusion: Neglecting the development of rain fed subsistence farming seems increasingly untenable. The Chinese Government is under severe pressure to redress the huge inequities between rural and urban areas and is faced by thousands of peasant rebellions and revolts every year. The refugee problems in Africa and the pressure exerted by unregulated emigration to Europe ask for urgent action. We cannot afford to let the huge resources now under shifting cultivation slide towards further disarray and degradation. Farmer First has become a matter of global survival.

Proposition 5: Institutional development is a necessary precursor to economic growth (North 2005). A common approach to agricultural development in SSA argues that population is increasing, land productivity is static if not degrading, therefore agricultural intensification with science-based technology must improve farm level productivity. Two Dutch scientists, Bindraban and Rabbinge (2005), put it thus: 'In combination with close and remote sensing, geographical information systems and robots, the progressive precision in agriculture increases the efficiency and productivity of mono-crop cultivation. In an increasingly liberalised world this far-reaching specialisation, accompanied by increases in scale, would appear to be the only economically feasible development trajectory. The environmental impact of this system is low per unit of produce and, as such, environmental-friendly'. Yet Dutch agriculture, one of the top three exporters of agricultural products by value, has reached its position as a result of painstaking attention to and support of institutional development: auctions providing low threshold access to markets; publicly financed land re-adjudication and land and infrastructure development; cooperative banking and input purchasing; land tenure laws protecting the tenant and making investment in land attractive; product quality controls; subsidised credit interest; a huge public apparatus for agricultural research, extension and education; price and export subsidies; market protection; tax deductible investment; strong farmers' organisations (for years they provided the Minister of Agriculture); and a Ministry of Agriculture that acted as a support organisation for farmers. In Africa, Structural Adjustment has meant tearing down whatever institutional development in support of agriculture had taken place, 'incorrectly assuming that market forces would jump-start agricultural growth' (article in The New York Times of October 15 2007 reporting on an internal evaluation of the World Bank's agricultural lending).

Conclusion: The current emphasis on science and technology as the entry point for agricultural development in Africa must shift to an emphasis on institutions that create the conditions that allow resource-poor farming to become more productive and sustainable. Technology availability is not the most constraining factor, opportunity is. The sequel to CoS will test an innovation system (IS) approach (World Bank 2007) to the interaction of stakeholders around perceived opportunities in an effort to stimulate institutional development across aggregation levels. CoS demonstrated that developing technology *within* farmers' very small windows of opportunity is not as effective as *stretching* those windows through institutional development. The stakeholder groups' institutional experiments included: multi-stakeholder agreement at the District level to carry out random checks of weighing scales of Licensed Produce Buyers (of cocoa) (Dormon et al. 2007); agreements among land owners and immigrant settlers about tenure arrangements as a condition for sustainable soil fertility management (Adjei-Nsiah et al. 2007; Saidu et al. 2007);

and a marketing chain for organic cocoa - which failed because of resistance by the Cocoa Board (Ayenor et al. 2007)[1].

Proposition 6: *Brokered Long-term Contractual Arrangements (BLCAs) are perhaps the only proven way to effectively put money into resource-poor farmers' pockets.* A BLCA can be arranged, for instance, by a farmers' cooperative, or a private commercial company, a parastatal, or a state trading enterprise that puts together a package that allows small farmers to engage in the production of a marketable commodity, such as tea, cotton, coffee, cocoa, organically grown fruits, or other product that farmers cannot easily sell elsewhere. The package typically includes inputs such as planting materials or animal stock (e.g., day-old chicks), marketing services (quality control, grading, certification, (pre-) processing, transport, export and payment of farmers), credit and knowledge in terms of extension, training and gap-filling research. Sometimes the package also includes some price stabilization. The package has been tested as attractive for the farmers targeted. The relatively high costs of servicing the package are deducted from the revenues. Supervised credit schemes are a special form of BLCA. Small farmers act as out-growers by adopting the package, becoming clients of the central agency and subscribing to the conditions set by it. BLCAs were first developed by colonial agencies. After independence, these schemes were mostly taken over by government agencies or parastatals, and subsequently often abolished and privatized under Structural Adjustment. New models based on cooperative or commercial value-chain approaches are emerging. BLCAs, when properly managed, can be very effective. An example is the Kenya Tea Development Authority, which has, over the years, provided opportunities for thousands of small-scale farmers, who now produce a larger share of the tea exported from Kenya than the commercial planters. With IFAD support, farmer field schools for KTDA outgrowers are currently strengthening sustainable production skills and market quality standards. In Ghana, out-grower schemes have made pineapple the second export crop that allows thousands of resource-poor farmers some income from sales to overseas supermarket chains. In recent years, a public-private partnership has allowed the sweet MD2 variety to replace the traditional Cayenne and so saved this export industry (Elizabeth Acheampong, pers. com., June 2007).

The BLCA is sensitive to management quality. It requires high dedication, professionalism and inputs of resources. For example, seeds and fertilizers need to be delivered in time (and not after the rains). Farmers need to be paid in time lest they lose interest. The arrangements for transport, delivery of materials, contracts, etc., are sensitive to management failure and shortage. Nationalizing the schemes opened them up to misuse. In Western Nigeria, after Independence, the ruling party grabbed the Cocoa Marketing Board's price stabilization fund to buy vehicles. In many SSA countries, the government used the BLCAs to extract revenue from agriculture and systematically undermined the countervailing power of the farmers. But…it is one thing to say an instrument is useless, another thing to say that a good instrument is wrongly applied. The evidence points to the latter, as many BLCAs successfully tie small-scale farmers into lucrative markets by creating the appropriate institutional conditions.

Conclusion: BLCAs offer part of the solution because they can create the institutional conditions for enlisting at least some farmers and their resources in expanding market opportunities.
It is proving difficult for resource-poor farmers to organize to effectively cater for the demands of supermarkets and their "Good Agricultural Practice" standards (Berdegué 2001). Yet supermarkets are capturing an increasing share of the market for food in developing countries (Reardon, et al. 2003). The BLCA is a tested approach for creating the mix of institutional and technical support that allows resource-poor farmers to access export opportunities and domestic supermarkets. The important point is to improve the transparency and accountability of the BLCAs and the influence farmers have on them.

3. Agricultural science

Proposition 7: Agricultural research aims to establish what works and why, at best it establishes what is technically possible in a certain agro-ecological zone. However, working with resource-

poor farmers also requires establishing what is feasible and desirable for farmers in terms of their labour, land, off-farm work, market opportunities and prices, gender divisions, etc. (Tekelenburg 2001; Van Schoubroeck 1999). The only way to do this is through involving farmers directly in the research. When scientists make assumptions as to what is useful or desirable, the result is often that the new technologies are not used and remain 'on the shelf' (as is the case with the NERICA rice varieties, for example). Even when technologies are developed during a process that ensures that farmers' feasibilities and desirabilities are taken into account, it is very difficult to refrain from creating special conditions, such as access to timely inputs or credit, that cannot be replicated in normal circumstances.

Conclusion: Zeroing in on the constrained possibilities for technological change that most resource-poor farmers face requires a carefully crafted 'pathway of science' that is kept open-ended by minimising the 'pre-analytical choices' (Giampietro 2003; Röling et al. 2004*) made before the experimental programme* (Nederlof, et al. 2007**).** Making pre-analytical decisions, such as selecting certain disciplines to be involved and not others, defining desirable dependent variables (such as tonnes per ha), picking crops and issues to work on, cut off avenues of potentially greater relevance and pertinence. But if one keeps all options open, one initially needs a procedure to zero in on what works, is feasible and desirable for the 'ultimate users' who have to live by the results. In CoS we used two procedures to do this: technography and diagnostic studies[2]. The *technography* looked at pre-selected themes, including IPM in cocoa, cotton, soil fertility and weeds, and genetic diversity in sorghum and yam, on the basis of explicitly declared pre-analytical choices. The idea was to scan these themes to identify major opportunities and constraints for innovation that the research should take into account. A technography also identifies the major stakeholders who should play a role in the research. In hindsight, we made the mistake of not including marketing or economics in the disciplines involved, therefore the technography did not pay enough attention to market conditions. The *diagnostic studies* were carried out by the PhD students. Within the broad theme of for example weeds, the researcher established the major issues, problems and areas where research and experimentation could have a pay-off in farmers conditions. In the case of weeds (Vissoh et al. 2007), *Imperata cylindrica* and *Striga* species were found to cause major problems and to contribute significantly to poverty. Formal research had neglected weeds until recently and farmers were struggling to develop effective weed management or adaptations to weeds. The diagnostic study identified two local areas and groups of farmers who were willing to engage in experimentation with the researcher to find better weed controls. In this manner all of our researchers established working partnerships with groups of stakeholders and were successful in developing technologies with them. But except for the two researchers who worked with cocoa farmers (who were benefiting from recent price rises), all ran into the very limited opportunities that farmers face and hence the very limited options for technology development to deliver worthwhile outcomes.

Proposition 8: The dominant model for agricultural development emerged in the American Mid-West in the 1950s and assumes a market-propelled diffusion of technological innovations, which enables surviving farmers to capture economies of scale. This model is called the 'agricultural treadmill' (Cochrane 1958; Rogers 1961 and 1995; Röling 2006). Very briefly, the model assumes farms to be small firms engaged in the production of the same commodity. Since they are each too small to affect the price, they are all price takers and try to produce as much as possible against the going price. A new technology allows early adopters to capture a windfall profit, but soon others follow and this squeezes the price to a point where those who have not yet adopted see their incomes drop. This forces them to adopt or eventually drop out. Their resources are taken up by the 'stayers' and so it goes in an endless rat race that creates economies of scale and puts a downward pressure on commodity prices. Evenson et al. (1979) have shown that investment in technology development and extension that drives the treadmill has a very high internal rate of return.

Conclusion: The treadmill has been the explicit basis for agricultural policy in the EU, the US, Australia, etc. The combination of a free global market and strong (international) agricultural research institutions that produce the technologies seeks to replicate the treadmill at a global

scale. However, this approach, though still favoured by many, obviously has not been effective in reducing rural poverty, especially in Africa. What is required is an all out effort on the part of agricultural economics and policy institutions to develop a better model (Jiggins et al. 1996). Such a model would not look at agriculture as being in the business of producing only tradable commodities, but would recognise agriculture's place-based multi-functionality in ensuring the continuation of the ecological services on which all life depends, including hydrological cycles, food systems, biodiversity, climate stability, etc., as well as its role in local food systems, cultural landscapes and community life[3]. It would look at ways to internalise the high social and environmental costs of agriculture. It would further take food sovereignty seriously and not only focus on productivity per ha, but on creating fair access to the scarcest good in agriculture: remunerative markets.

Proposition 9: In agricultural research and academic institutions, one can discern three 'blood groups': natural scientists, agricultural economists and (to some extent) social scientists (anthropologists, rural sociologists, social psychologists, management scientists, etc.). The *agricultural economists* tend to look at the market as a natural phenomenon and at their own field as 'the profession', which translates all that is useful in agricultural science into policy. The ensuing policy is based on the dominance of free market thinking. The New Institutional Economics (e.g., North 2005), which considers institutional development as a precursor to economic growth, has made limited headway. Ecological economics remains a sideshow. Agricultural economists usually undervalue the social sciences. They claim to know all about people as rational choice makers, and eschew the margins of equivocation and contrariness where decisions are actually formed. The opportunities for collaboration between social scientists and economists in the area of economic and market institutions remain unused. *Social scientists* are not making much headway in taking up the challenge posed by Jane Lubchenco (1998): 'humans have become a force of nature'. That is, we live in the 'anthropocene' and the future depends on human behaviour. Humans will have to engage in concerted action across all scale levels because a sustainable future for our species cannot emerge from greedy individuals seeking to optimise their utility functions, as the methodological individualism of economics leads us to believe. The social scientists who have been working on this issue have not made much headway. A recent special report on innovation in *The Economist* of October 13th 2007 does not mention innovation in the design of the global economy, and says nothing about climate change or poverty. The *natural scientists*, by their number and status as scientists and technology developers, usually dominate agricultural research and academia. They publish in magazines that deal with crops, insects, trees, soils, etc., and tend to be rewarded for designing technologies and systems that work. People are not a necessary part of their mandate: individual and societal management, learning processes and behavioural change are relegated to applied domains beyond the research gate. Yet in our experience, water management, forestry, entomology, animals sciences, and to some extent soil science and agronomy, are capable of a 'beta/gamma' perspective, i.e. they are open to the integration of natural and social science, even if many natural scientists continue to assume the global treadmill as the context within which their findings will be utilised.

Conclusion: Agricultural research institutes and universities increasingly have become driven by market thinking, and dependent on third party financing. They have not, as a rule, opened up a discourse about the core of their mandate: how to manage the largely anthropogenic future of ecosystems across all system levels. It is becoming clear that sustainable management cannot automatically emerge from aggregating the individual pursuit of utility and cannot be understood or designed on the basis of the methodological individualism of conventional economics. Hollling (1995) concluded that the cyclic nature of ecosystems and the linear nature of economies do not sit well together. He identified resilience as the desirable dependent variable and social learning as the road to get there. The poverty of resource-poor farmers, and especially their lack of prospects and the continual degradation of the resources they depend on, especially in SSA, is part of the anthropogenic predicament. It is the mandate of agricultural research institutes and universities to create fresh perspectives for sustainable futures, and move beyond the mental models have proven inadequate or downright dangerous.

4. Final reflection

Making trans-disciplinary science work for resource-poor farmers is an issue that requires a global perspective. The persistence of resource-poor farming is the outcome of systems that stack against them. At the global level, they are deprived of opportunities for farm development and off-farm work by unfair trading arrangements. At the national level they lose out from urban electorates, rent seeking patrimonial networks and revenue-starved local and national governments. And at the village level, they are reaching the end of the tether in terms of access to land, water, labour, health, cash income, education for their children, and in terms of their resilience to shocks, be they economic, climatic or political. Technology supply-push under prevailing drivers and institutional arrangements will make the already negative trends worse and create risks that may prove unmanageable as instability increases.

We take heart from recent signs that the world is taking stock. At its 2007 autumn meeting, the IMF has apparently concluded that privatisation, indiscriminately opening up countries to monetary and trade flows, and restrictive monetary and budgetary policies, have not only been unpopular measures, but they have failed to realise their purported purpose of fostering growth. Countries where growth has taken place, such as China, have not followed the policies prescribed by the IMF (based on Mark Weisbrot, Deputy Director Centre for Economic and Policy Research, Washington, reported in NRC/H'bld 20 October 2007: 19).

An internal evaluation concluded that the World Bank's push for the public sector to pull back from agriculture, incorrectly assumed that market forces would jump-start agricultural growth. 'In most reforming countries, the private sector did not step in to fill the vacuum when the public sector withdrew' (Reported in the New York Times, October 15, 2007).

Finally, we are heartened by the fact that the international community has instigated the IAASTD. This multi-stakeholder process has led to major mutual learning. In the final reports inconsistencies, contradictions and inclusion of both conservative and forward-looking positions remain. But for those who want to find it, there is space for change.
4733

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[1] The studies and experiments relating to institutional development are reported in a special issue on CoS in *IJAS*, the International Journal of Agricultural Sustainability Vol. 5 (2&3), 2007

[2] The technographies and diagnostic studies were published in a special issue of *NJAS,* Wageningen Journal of Life Sciences, Vol. 52 (3-4), 2004

[3] Multi-functionality is a key point in IAASTD though contested all the way. The IAASTD Summary for Decision Makers (SDM) and the Synthesis Report can be found on website www.agassessment.org