1 Introduction: Changing Perspectives on Agricultural Intensification, Economic Development and the Environment

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Introduction

Growing concerns over the sustainability of agriculture and natural resource management in the developing world have, in recent years, focused attention on the multiple challenges confronting growth-promoting development strategies and have broadened the expectations of those strategies. The Green Revolution of the 1960s and 1970s was considered a success by most observers, in that it achieved major gains in food production and food security in many low-income countries where population growth had previously outstripped the growth in crop yields. Concerns about equity and environmental impacts were raised by some, but the consensus view was that these were secondary to alleviating hunger and malnutrition through increasing food production and agricultural productivity.

Over the past two decades, however, this production-centred view of agricultural development objectives has been challenged from a variety of sources. Agricultural and rural development strategies are still widely expected to intensify agricultural production and enhance rural food security through food production and income growth. In addition, however, development strategies are now commonly expected to address a broader range of concerns, such as poverty reduction and employment generation, and to be environmentally sustainable – that is, not unduly compromising the natural resource base of future generations of users. One prominent contribution to this debate has, for example, posited a 'critical triangle' of development goals: agricultural growth, poverty alleviation and sustainable resource use (Vosti and Reardon, 1997). The continuing debate over achieving sustainable growth has at times emphasized one objective over another, but a widely held view is that agricultural and rural development strategies should contribute, at one level or another, to the enhancement of these multiple objectives.

The broadened agenda of economic and environmental sustainability has had many sources and has been evidenced in a variety of ways. A series of major global policy initiatives in the 1980s and 1990s have highlighted the broad set of concerns facing rural development in both developing and industrialized countries. A range of approaches taken in different academic fields – ecoregional analysis, farming systems analysis, bioeconomic modelling, systems ecology – have contributed to basic and applied research, emphasizing systemic approaches to solving agricultural and environmental problems and the linkages tying agricultural production to economic and ecosystem outcomes. In applied development circles, heightened concerns that development strategies, in order to be successful, must be relevant to the circumstances faced by local people have intensified interest in decentralized strategies that are accountable to households and communities. This has stimulated interest in participatory development, local institutional development and community-based natural resource management, and is one of the factors contributing to the paradigm represented by integrated conservation and development projects (ICDPs).

As we review in greater detail below, the notion that there exist important synergies, rather than tradeoffs, in efforts to advance food production, economic growth and environmental sustainability has been central to much recent thinking about the mechanisms used to address these goals. In a wide-ranging set of high-profile international conferences, international policy and planning documents and institutional mission statements, complementarity among these multiple goals is widely presumed. Often, however, the existence of synergies appears to be accepted on faith, rather than concluded as a result of careful analysis, research and observation. Yet economic intuition and an increasing base of research and applied work in developing countries suggest that – at least in the short to medium run – tradeoffs often, although not always, characterize the simultaneous pursuit of development goals. 'Win–win–win' opportunities exist and must be pursued, to be sure, but they are less ubiquitous than is often assumed, and, in the shorter term, hard choices must typically be made in the allocation of resources among multiple desired objectives. A central theme of this volume is that agricultural intensification is a necessary condition for satisfying economic growth, environmental sustainability and poverty alleviation goals in most developing countries, but it is by no means sufficient. A host of factors condition the complementarity or competition between these objectives. The chapters that follow describe and explore these linkages in considerable detail. But, first, it is useful to briefly consider the origins of current thinking on the 'tradeoffs versus synergies' debate.

The 'Tradeoffs versus Synergies' Debate: a Brief Review

Policies for sustainable development

In the 1960s and early 1970s, policy-makers, development scholars and practitioners grew increasingly aware of the interactions between economic development and environmental quality. This interaction, however, was widely deemed to be rife with tradeoffs – development practitioners believed that environmental protection would lead to reduced growth, while conservationists generally opposed economic development initiatives and were primarily concerned with alleviating the pollution and environmental degradation associated with economic growth. The impetus for the 1972 United Nations Conference on the Human Environment, for example, came from representatives of high-income nations concerned with environmental quality, yet representatives from low-income nations made a point of emphasizing that environmental protection was a luxury they could not afford (Sandbrook, 1992).

Starting in the mid-1970s, however, policy-makers and practitioners began to question the existence of such tradeoffs. An increasingly common viewpoint was that environmental conservation objectives could only succeed if human needs were attended to, and human needs could not be met in the long run with continuous degradation of the environment. To cite one prominent example, after originating in the 1970s as a programme focused chiefly on biodiversity conservation and protection, the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Man and the Biosphere Programme increasingly encompassed human development priorities in buffer zones, where extractive and other economic activities were permitted (UNESCO, 1987). Efforts were begun to identify 'win–win' scenarios that could promote both environmental protection and economic development.

Throughout the 1980s and early 1990s, international institutions and coalitions of development and conservation practitioners published high-profile policy and planning documents that advocated synergies between environmental protection and economic development (IUCN, UNEP and WWF, 1980, 1991; WCED, 1987a,b; World Bank, 1992). Not surprisingly, for rural areas of the developing world heavily dependent on agriculture for food production and employment, agricultural intensification played an important role in the 'win–win' scenarios outlined in these documents. Perhaps the best-known example is the 1987 Report of the World Commission on Environment and Development (WCED, 1987b) – commonly known as the Brundtland Report – in which the authors emphasized that '[n]ew technologies provide opportunities for increasing productivity while reducing pressures on resources' (p. 144). In its report to the United Nations, the WCED identified 'increasing yields and productivity' (WCED, 1987a, pp. 26–27) as one of three essential strategies for achieving a sustainable world agricultural system. The report noted that increasing productivity was critical, among other things, to 'halting indiscriminate deforestation'. The World Bank's 1992 review of the status of the global economy and environment echoed a similar theme: 'If more food can be grown on the same land, that will ease the pressure to cultivate new land and will permit the preservation of natural intact areas' (p. 134).

Among groups with more explicit conservation agendas, similar themes were emphasized. In *Caring for the Earth* (IUCN, UNEP and WWF, 1991), a policy document published by three prominent international conservation organizations, the authors wrote: 'There are no great unused resources of cultivable land that can safely be taken from nature. Consequently, the land now used for agriculture will need to be cropped more intensively' (p. 33). In reference to land degradation, the same document stated: 'Today's losses of soil and productivity through erosion, salinization, desertification and misuse are intolerable [in poor nations]. The development of techniques for more intensive, more sustainable agriculture applicable at the local level in the lower-income countries has highest priority' (p. 35). At the field level, these themes are echoed in myriad project work plans and similar documents written by project managers and conservation and development practitioners. In the African rainforest, for example, a conservation project listed agricultural intensification as one of its priority tasks, noting that intensification would 'decrease the pressures on the protected area by reducing the need for upland agricultural surface area' (Conservation International, 1993, p. 77)

While policy-makers and practitioners over the past two decades have widely asserted that environmental and development goals are complementary, it is useful to consider the evidence upon which these assertions are based. In particular, how has the perceived relationship between agricultural intensification and associated economic development goals and environmental objectives been transformed from what was often an antagonistic relationship to a more cooperative one? The literature from several different traditions over the past three decades is useful for understanding this process and is briefly reviewed here.

Endogenous intensification and policy-led intensification strategies

Boserup (1965) began an important path of enquiry in the study of agricultural intensification by arguing that population growth was a major determinant of technological change in agriculture. In the Boserupian framework, population growth in a given area leads to growing demand for agricultural products, land degradation and the disappearance of the frontier. These conditions exert pressures on farmers to intensify (reduce fallow length, double-crop, etc.) by using more labour or capital per unit of land. Until some constraint to land extensification is reached, it may not be profitable for farmers in an area to switch from extensive practices to more intensive practices (Boserup, 1965; Holden, 1993b).

The Boserupian perspective suggests that intensification can be viewed as an endogenous outcome – e.g. that soil fertility is a 'dependent variable' – in a development process stemming from forces affecting agricultural communities. Such intensification, while consistent with high external input use, does not necessarily help to stem the disappearance of natural ecosystems, since the intensification process does not begin until land and ecosystem services are limited in supply.[1] The Boserupian perspective is also generally silent on issues related to off-site agricultural externalities (e.g. nutrient runoff), although some authors (Edwards and Wali, 1993; Tiffen *et al*., 1994) have attempted to connect population growth to the protection of productive agricultural resources (as opposed to environmental amenities).

Most proponents of the positive links between agricultural intensification and the environment, however, do not advocate that less developed nations simply wait for a gradual change from extensive to intensive systems as population grows and agriculture expands at the extensive margin. Boserup herself recognized that this shift may, in fact, not occur in those densely populated communities characterized by a very high rate of population growth and limited ability to change tenure regimes and make investments in intensification (Boserup, 1965, pp. 77–111, 118). As emphasized in the WCED's United Nations report (1987a), the linkages between agricultural intensification and the environment suggest that '[n]ational and . . . provincial governments will have to develop a package of incentives and disincentives to promote conservation-based development' (p. x).

In order to avoid serious environmental degradation and habitat loss, the logical and commonly voiced policy prescription is, then, to promote a process of intensification before these losses are realized through Boserupian intensification and induced technological innovation (which may lag behind changes in relative factor prices that do not fully reflect social costs). Such 'policy-led intensification strategies' can play a role in 'speeding up the natural evolution of intensification' (Lele and Stone, 1989) and may forestall resource degradation stemming not only from rapidly rising agricultural populations but from rising food demands from the non-agricultural population (Pingali and Binswanger, 1984). This process typically implies interventions by outside agents, including policy changes (WCED, 1987a), investments in research and extension (Aldy *et al.*, 1998) and local investments (Wells and Brandon, 1992). These interventions aim to increase agricultural productivity by introducing, or facilitating access to, external inputs and improved agricultural practices – improved crop varieties, inorganic and organic fertilizers, pesticides, credit, conservation agriculture practices, irrigation, crop diversification, improved market access and a variety of other inputs and investments.

To be successful, however, such interventions typically require money and the ability to coordinate resources at large scales. Thus, it should not be surprising that, by the early 1990s, the largest global development aid organizations had also become the largest global environmental organizations. Between 1988 and mid-1995, for example, the World Bank committed US$1.25 billion in loans, credits and grants for projects with explicit objectives of conserving biodiversity. This money leveraged an additional US$0.5 billion (Jana and Cooke, 1996). Moreover, much of the Bank's broader agricultural development portfolio has also explicitly involved conservation and natural resource management objectives (e.g. 10% of projects have included biodiversity conservation objectives). Among bilateral donors, the US Agency for International Development (USAID), in particular, has also become an important financial and intellectual leader in international conservation, spending US$650 million each year on its environmental portfolio during the early 1990s (USAID, 1994).

The environmental Kuznets curve

Another tradition, that associated with the 'environmental Kuznets curve' (EKC) hypothesis, has also played an important role in research and policy debates regarding development and the environment. The EKC hypothesis posits that there is an inverted U-shape relationship between environmental degradation and per capita income similar to the original Kuznets relation applied to income inequality. This suggests that, as economic development proceeds from very low income levels, pollution, resource use and waste generation per capita increase rapidly. Then, '[a]t higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures, result in leveling off and gradual decline of environmental degradation' (Panayotou, 1995, p. 13).

The EKC hypothesis implies that economic growth will eventually redress the negative environmental impacts associated with the early stages of economic development. Rather than being a threat to the environment, economic development is complementary to – or necessary for (Beckerman, 1992) – the maintenance or improvement of environmental quality. The logic behind the EKC hypothesis had an important influence on the sustainable development arguments of the WCED's *Our Common Future* (1987b) and the World Bank's *World Development Report 1992*. The latter report noted that:

> The view that greater economic activity inevitably hurts the environment is based on static assumptions about technology, tastes and environmental investments. . . As incomes rise, the demand for improvements in environmental quality will increase, as will the resources available for investment.
>
> (World Bank, 1992, pp. 38–39)

After a decade of debate, however, the empirical evidence for the EKC hypothesis is decidedly mixed. First, the inverted U-shape relation appears to apply only to a subset of impacts, mainly airborne pollutants (Arrow *et al*., 1995). Secondly, the assertion that environmental quality is a 'luxury good' has not been conclusively demonstrated (Barbier, 1997). Thirdly, the relationship between income and the environment is not static but can be influenced by policy changes (Panayotou, 1995; Barbier, 1997). Finally, it is not at all clear why the posited relation should necessarily hold to begin with (Rothman, 1998; Suri and Chapman, 1998). The EKC hypothesis makes no explicit arguments about the role that growth in agricultural productivity can play in environmental protection. Proponents of a positive synergy between intensification and the environment infer a synergistic relationship based on known correlations between increases in productivity and increases in per capita income (e.g. WCED, 1987b). To date, there have been relatively few studies on the EKC hypothesis in the specific context of agriculture and environmental degradation. Studies that could be considered relevant tend to focus on deforestation or water quality and their results do not consistently confirm or disconfirm the EKC hypothesis. Panayotou (1995), for example, finds support for the notion that industrialization is linked to declines in deforestation, while Koop and Tole (1999), using a comprehensive data set on more than 70 developing nations, find no support for an inverted U-shaped relationship.

Technology-driven intensification and environmental effects

Despite the ambiguous results derived from empirical tests of the EKC hypothesis, there are other studies in the literature that attempt to more explicitly link agricultural intensification with improvements in environmental quality. These studies have often turned to the experiences of industrialized countries, particularly the USA, and the Green Revolution in Asia, both of which suggest that increases in agricultural productivity can relieve pressure on natural ecosystems.

In the US context, it has been argued that technological progress has made it possible to limit US land conversion to agricultural uses, thereby protecting natural habitats and biological diversity (Goklany and Sprague, 1992; Waggoner *et al*., 1996). The USA has doubled its harvests over the last 50 years while keeping the area under cultivation steady (Raloff, 1997). Waggoner *et al*. (1996), for example, note that the clearing of forest for agriculture had largely stopped in the USA by 1920 and state that intensification over the last 50 years has 'spared' 90 million ha for nature. Goklany and Sprague (1992) use observed correlations between agricultural productivity and farmland area to make a similar case with respect to agriculture in New York and the north-east. In the same vein, attention has also been given to increases in the area of forests (MacCleery, 1993) and wildlife (Kolbert, 1986) in the USA. Sedjo (1995), in examining forest cover increases in the north-eastern USA in the period 1850–1990 and deforestation and reforestation patterns across the world, concludes that 'economic development promotes forest stability through well-defined and recognized property rights, the enforcement of property rights, the absence of government subsidies to encourage land clearing, and high levels and growth rates of agricultural productivity' (p. 205).

It is with respect to the Green Revolution, particularly in the Asian context, that the 'land-sparing' argument is most frequently made. For example, in extending earlier estimates by Borlaug (1987), Waggoner *et al*. (1996) maintain that Green Revolution technologies increased wheat production in India five-fold between 1961–1966 and 1991, while acreage only expanded by about three-quarters. Had traditional low-input technologies not been supplanted by modern technologies, 42 million additional hectares would thus have been required to generate the same levels of production as occurred in 1991. It is argued, then, that the exploitation of many millions of hectares of land was spared through technological improvements and crop intensification.

Elsewhere in the developing world, complementarities between intensified agriculture and environmental indicators have been reported in many places. Studies from Africa have reported that, when fertilizer prices increased or fertilizers became more scarce, farmers changed from sedentary farming to shifting cultivation, leading to more land degradation and more deforestation (Ferraro *et al*., 1997; Holden, 1997). In Honduras, Bunch (1988) reports that agricultural intensification has led to positive environmental effects, such as air and water quality improvements through reductions in biomass burning and increases in the farm demand for manure formerly dumped into rivers. Forest area and quality increased through reductions in erosion, migration, forest fires and turpentine collection. Similarly, regression analysis using household data from Honduras (Godoy *et al*., 1997) indicates a positive association between increased productivity per hectare and low levels of agricultural expansion. Other empirical models have found similar associations in other areas of the world and at larger scales (see Kaimowitz and Angelsen (1998) for an excellent review).

Inspired by historical data and field experimentation, numerous scientists have emphasized the potentially positive impacts of using existing, but thus far non-adopted, agricultural technologies in developing nations. Based largely on experimental work in Latin America (Sanchez *et al*., 1982), soil scientists have argued that, for every hectare converted to more productive, sustainable technologies, 5–10 ha of tropical rainforest are conserved (Sanchez *et al*., 1990). A similar argument has been made for the intensification of Amazonian pastures (Serrao and Toledo, 1990).

Despite the many empirical examples suggesting a positive relationship between agricultural intensification and environmental quality, it is difficult to argue *a priori* that one should expect the relationship to be positive. Where agricultural intensification has enjoyed widespread success, this has not occurred without environmental degradation, ranging from a loss of native ecosystems to waterlogging and salinization due to improper irrigation and water pollution resulting from the use of pesticides, fertilizers and animal wastes. In the case of the Green Revolution in South Asia, for example, Pingali *et al*. (1997) and other scientists have documented widespread environmental problems which threaten future production (see also Pingali and Rosegrant, Chapter 20 of this volume). Even the use of basic intensification technologies has been demonstrated to have mixed effects. Reductions in (inorganic) fertilizer prices, for example, can have both substitution effects (as farmers substitute fertilizer for land) and output effects (as all input use increases because farming is more profitable). The total use of land may rise, even though land use at the intensive margin falls. In a recent empirical study of agricultural assistance in low-income countries, Lewandrowski *et al*. (1997) found that the coefficient of the fertilizer price variable in an equation explaining arable land use in eight nations was negative and significant, suggesting that the output effect may dominate the positive substitution effect. A study in Brazil (Ozorio de Almeida and Campari, 1995) found that, when the prices of inputs other than fertilizer increased, there was a decrease in land clearing.

The linkages between intensification and tropical deforestation have been the focus of perhaps the greatest body of work in this area. The ‘land-saving’ arguments associated with the Green Revolution in Asia are commonly cited (Waggoner, 1994), but recent empirical analysis of deforestation in India, rather than confirming a positive relationship between intensification and reductions in deforestation, suggests that agricultural technology improvements have promoted deforestation in India by pushing up the value of land for growing crops (Foster *et al*., 1999). In an evaluation of four case studies of agricultural intensification in Africa, Wiersum (1986) concluded that the adoption of intensified cash-cropping systems did not necessarily lead to forest conservation due to increases in the demand for land, widespread land speculation and cultivated area. In another case study review, the adoption of more productive technologies was found to be correlated with the expansion of market opportunities, leading to an increase in the use of all factors of production, including land (Barraclough and Ghimire, 1995). Kaimowitz and Angelsen's (1998) extensive assessment of 148 economic models and empirical studies of tropical deforestation finds contradictory conclusions regarding the effects of higher agricultural productivity on deforestation. Conclusions and results vary with model specification, assumptions and the nature and source of the data employed. The principal general conclusion reached is that the relationship between intensification and deforestation is indeterminate.

The argument that land-sparing technological change is unambiguously beneficial for the environment is not clear-cut even in the context of high-income nations. In the USA, although some eastern states have experienced a return of their native ecosystems, the prairie ecosystem of the Midwest has been largely lost (Bultena *et al.* (1996) document this for Iowa, for example). In Australia, a similar evolution has taken place in the central-western region of New South Wales, one of the most productive farming areas in the world, where the only remaining woodland is confined mainly to areas unsuitable for agriculture (Goldney and Bauer, 1998).

Even if developed countries do offer some clear examples of the long-run synergies between agricultural intensification and environmental quality, it is not clear that these cases are necessarily transferable to low-income countries. The USA and other developed countries have increased agricultural productivity, but they have also increased their land–labour ratios (Hayami and Ruttan, 1985; Thirtle, 1985). Although the area under cultivation in the USA has remained steady over the last 50 years, the number of farmers has shrunk by more than two-thirds. While excess rural labour has been successfully absorbed into growing manufacturing and service sectors (Sedjo, 1995), it is not clear whether these sectors in low-income countries can fully accommodate the large rural populations looking for agroindustrial and urban employment opportunities.

The point of this brief review is not to take issue with the important role of technological change in agriculture or with the enormously beneficial effects of agricultural intensification in increasing food production and farmers' incomes around the world. Indeed, the record of technology change in agriculture has been highly impressive on these (and other) scores; consequently, hunger and malnutrition among millions of rural and urban poor have been reduced and food security enhanced. Rather, the point is simply to indicate that the empirical evidence does not support the argument – sometimes made explicitly, sometimes implicitly – that agricultural intensification and the economic growth associated with it are *necessarily* beneficial for the environment, particularly in the short term. As *Caring for the Earth* (IUCN, UNEP and WWF, 1991) concludes, 'The pressures on agricultural land . . . can be partly relieved by increasing productivity. But short-sighted, short-term improvements in productivity can create different forms of ecological stress' (p. 57).

Integrated conservation and development projects (ICDPs)

During the 1980s and early 1990s, conservation practitioners also began to embrace the 'synergy' perspective on agricultural intensification and the environment. They added large community development initiatives to their portfolios, initiated partnerships with development-oriented organizations and hired more social scientists to facilitate their work with communities (Wells and Brandon, 1992; Western and Wright, 1994). A new approach called the 'integrated conservation and development project' (ICDP) became a popular vehicle for channelling conservation funds into community development initiatives.

Unlike conservation projects in the 1960s and 1970s, ICDPs tend to focus their efforts on lands outside, rather than within, protected areas. More importantly, 'people' were explicitly identified as part of the solution. *Caring for the Earth* (IUCN, UNEP and WWF, 1991), a revision of *World Conservation Strategy* (IUCN, UNEP and WWF, 1980), emphasized that economic development was not necessarily antithetical to nature conservation and that local communities should be given a significant role in the design and management of integrated conservation and development activities.

An important element of many ICDPs was the introduction of technologies that offered substitution possibilities for the existing production methods that were leading to deforestation. Proponents argued that farm-level interventions in the 'buffer zones' around protected areas could improve the productivity of agriculture and thereby reduce the incentives for local residents to expand cultivation and animal husbandry into the protected areas or to engage in resource extraction through activities such as fuelwood collection or wildlife poaching (see McNeely and Brandon, Chapters 21 and 22, respectively, of this volume).

However, it is well known that the introduction of new technologies and practices in rural environments can be a challenge. Rotational crop–fallow land use with slash-and-burn methods remains widespread in the tropics, despite decades of agricultural research and technical assistance (Weischet and Caviedes, 1993). A review of over 450 articles on agroforestry and other intensified cropping systems published between 1972 and 1989 found some 'promising technologies', but few clear successes (Robison and McKean, 1992).[2] The same source reviewed more than 85 soil conservation technology studies, and concluded that promoting the adoption of these technologies is difficult and, even when they are adopted, they do not always have the desired effects.

It is perhaps not surprising, then, that several recent comprehensive surveys of the experiences of conservation projects with explicit development objectives have suggested that ICDPs are characterized by numerous problems in design and execution, are complicated to manage effectively and have typically not fared any better than projects with a strict development focus (Wells and Brandon, 1992; Brandon *et al.*, 1998; Larson *et al.*, 1998; Oates, 1999; see also Brandon, Chapter 22 of this volume). Although substantial resources continue to be allocated to ICDPs, the role that agricultural intensification can play in helping to achieve their conservation objectives is still inconclusive.

Conclusions

The relationship between agricultural intensification and the environment is an important one, and not simply because 70% of the total land surface of the earth is in agriculture or managed forests (Pimentel *et al*., 1992) and the impact of agriculture on the environment is expected to grow in the future (FAO, 1993a). It is also important because many policy-makers, international organizations and influential policy and planning efforts have appeared to accept on faith the assumption that agricultural intensification and accompanying economic growth in rural areas will necessarily lead to improvements in environmental quality. Guided by this critical assumption, international donors and development and conservation organizations have allocated, and continue to allocate, significant resources to encouraging agricultural intensification strategies, with the expectation of achieving progress not only in food production and income generation, but also in poverty reduction and environmental goals.

Our brief survey of the past literature on agricultural intensification and the environment, however, suggests that the question of ‘tradeoffs versus synergies’ is a complex one with few easy answers or unambiguous conclusions. Simple assertions of complementarities in the realization of multiple goals have, in many instances, been shown to be unrealistic and overly simplistic or, at best, to pertain to mostly long-run and aggregate-level relationships. This is demonstrated time and again in the rethinking that has occurred in areas as diverse as assessing the impacts of green-revolution technologies, the environmental Kuznets curve, agriculture and deforestation linkages and ICDPs. The conclusion one draws from the mass of theoretical and empirical evidence is that, in most developing-country circumstances, while agricultural intensification is generally necessary for achieving conservation objectives in concert with rural economic growth and poverty alleviation goals, it is by no means sufficient. Further critical consideration regarding the relationship between agricultural intensification, economic development and the environment in developing countries is clearly warranted. The chapters that follow offer important contributions to the extension of that discourse.

Outline of this Volume

The central objective of this volume is to review and consider a range of evidence on the ‘tradeoffs versus synergies’ theme as it pertains to the multiple objectives of agricultural intensification in low-income countries. This evidence is wide-ranging and includes theoretical and conceptual analysis, numerous empirical examples and case studies from Asia, Africa and Latin America and synthetic analyses of selected technology, policy and institutional issues. The intention is to directly address the ‘tradeoffs versus synergies’ question and related issues this question engenders.

Part I considers a number of cross-cutting themes and background issues relevant to the empirical studies discussed later. In Chapter 2, Conway addresses the enormity of the global challenge of generating adequate food supplies for the estimated 800 million people around the world who are hungry or malnourished, while at the same time ensuring equitable access to food and mitigating the many negative environmental externalities associated with agricultural production. He suggests that a 'Doubly Green Revolution' – exploiting scientific developments in biotechnology and ecology as well as more participatory development strategies – is required, which will repeat the successes of the Green Revolution and do so in a manner that is equitable, sustainable and more conserving of natural resources.

Bilsborrow and Carr, in Chapter 3, consider the dynamics of population size, movement and density in relation to changes in forest cover and trends in agricultural intensification and extensification, principally in Latin America. While population pressures (mainly rural–rural migration) are found to result in some of the expected consequences for land use consistent with Boserup, they find that population pressure is generally a secondary factor in driving land clearing, with road construction and economic, market and political factors dominant. They also find substantial variations in the nature of the driving forces behind land-use trends in different countries and different environments.

In Chapter 4, Perrings addresses the biodiversity implications of agricultural development in developing countries, and identifies the major economic factors behind biodiversity loss in agriculture, forestry and fisheries. He contrasts the benefits realized in these sectors with the costs of biodiversity loss, principal among them being the reduced resilience of agroecosystems in confronting environmental and market shocks. He posits an 'optimal level' of biodiversity that mediates benefits and costs, and highlights the role of poverty and market failures in reducing the effectiveness of economic instruments in stemming biodiversity loss.

In the following two chapters, Pagiola and Holden (Chapter 5) and Angelsen and Kaimowitz (Chapter 6) develop the theoretical basis for farm households' decisions regarding intensification and extensification of agricultural production. Pagiola and Holden develop a stylized model of farm household decision-making that illustrates the roles played by clearing efficiency and the productivity of newly cleared lands, output prices, labour costs and the household's rate of time preference in determining household land-use strategies. The analytical model developed by Angelsen and Kaimowitz highlights households' subsistence versus profit-maximizing behaviour, capital- versus labour-intensive technological change and product market characteristics in accounting for deforestation outcomes. Both chapters conclude that *a priori* theoretical results are ambiguous and that intensification–income–environment outcomes are essentially empirical questions.

Chapters 7 and 8 together illustrate the benefits of using ecoregional and bioeconomic models jointly to address economic and environmental objectives. Ruben *et al.* (Chapter 7) discuss the advantages and disadvantages of different types of bioeconomic models that can be employed in joint economic and biophysical analysis. They then employ three variants of a bioeconomic model developed for southern Mali to address the tradeoffs and complementarities among production, economic welfare and sustainability indicators that result from a simulated fertilizer subsidy. Crissman and co-authors (Chapter 8) present the conceptual framework and structure of a model that explicitly addresses tradeoffs among economic, biophysical and health outcomes in an application to the potato–dairy system of the Andean highlands. They highlight the economic–environmental and economic–health tradeoffs that stem from policy alternatives and stress the importance of making the results of research on tradeoffs understandable by and accessible to policy-makers.

Part II of this volume encompasses a series of empirical studies which, using different analytical approaches and models, address issues of tradeoffs and synergies among multiple development goals under different developing country circumstances. In Chapter 9, Hazell and Fan analyse contributions to agricultural productivity growth in high- versus low-potential areas in India. They find that investments in rural infrastructure, agricultural technology and human capital are at least as productive (and typically more so) in many rain-fed areas as in irrigated areas, and reach the important conclusion that 'win–win' strategies for addressing productivity and poverty problems may thus be possible in the case of India.

Pender and co-authors (Chapter 10) analyse 'pathways of development' in a set of diverse communities in central Honduras, where economic restructuring and land-use changes have been particularly great since the 1970s. They identify the characteristics and determinants of six distinct pathways, which differ substantially in cropping practices and resource management strategies, and suggest that a 'one-size-fits-all' approach to technical assistance is unlikely to be successful. Poverty reduction in these communities, rather than being dependent on natural resource management strategies, is found to be highly dependent on the provision of public services.

Chapters 11–13 report empirical results from the three principal benchmark sites of the Global Initiative for Alternatives to Slash-and-Burn (ASB) of the Consultative Group on International Agricultural Research (CGIAR). Coordinated by the International Centre for Research in Agroforestry (ICRAF), the ASB programme is using common research strategies and methodologies to: (i) develop and test alternative technologies for smallholder farms; (ii) examine policies that may create disincentives for deforestation; and (iii) promote sustainable alternatives to slash-and-burn agriculture. Specific cropping-system alternatives are evaluated, using the 'ASB matrix' approach, according to a wide set of indicators of agronomic and environmental sustainability, economic viability and indicators of interest to policy-makers (e.g. food security). 'Best bet' alternatives are identified which merit further attention by researchers and development practitioners.

In the first of the ASB studies, Gockowski and co-authors (Chapter 11) analyse economic and environmental tradeoffs characterizing resource use alternatives in the rainforest of the Congo River basin in Central Africa. In Chapter 12, Tomich and colleagues apply the 'ASB matrix' of indicators to a series of crop monoculture, agroforestry and forest management land uses on the island of Sumatra, Indonesia. Vosti and colleagues (in Chapter 13) also employ the ASB matrix approach in their evaluation of alternative cropping systems facing small-scale agriculturalists in the western Brazilian Amazon. In each case, 'best bet' farming systems are identified, often based on diversified agroforestry or perennial cropping systems. These systems appear to offer considerable scope for the joint realization of farmers' economic and agronomic goals, as well as addressing national- and international-level environmental and food-security goals.

Using a bioeconomic modelling approach, Schipper and colleagues, in Chapter 14, analyse land-use alternatives in northern Costa Rica, giving explicit attention to the incorporation of local labour markets, product markets, crop and animal production and environmental indicators. Their model is used to analyse the effects of technology and policy alternatives, including a pesticide tax and forestry subsidies. Labour and product market conditions are found to substantially influence the outcomes.

In Chapter 15, Otsuka and Place summarize the results of an extensive comparative study of land tenure and land and forest management in seven Asian and African countries. They identify a number of key factors that account for deforestation and poor forest management, including farming on marginal lands, weak individual land rights and major deficiencies in state ownership and communal tenure regimes. They discuss several policy and institutional changes which may enhance the incentives for tree planting and the adoption of agroforestry systems.

In Chapter 16, Kerr and co-authors examine factors contributing to incentives for improved agricultural productivity and natural resource management across a broad sample of watershed management projects in India's semi-arid tropics. A variety of factors are found to affect these incentives, including population density, infrastructure, social organization and agroclimatic conditions. Importantly, participatory projects that focus as much on social organization as on technology transfer are shown to be generally the most successful.

Part III addresses a series of technology, policy and institutional concerns that affect the joint realization of intensification, environmental and development objectives. In Chapter 17, Sanchez and colleagues discuss factors contributing to what they argue to be the critical factor limiting sustainable agricultural intensification in Africa – declining soil fertility. They outline a detailed strategy encompassing specific technological and policy measures to address problems of soil fertility and agricultural intensification, focusing largely on soil fertility replenishment and diversification into high-value crops.

In Chapter 18, Staal and co-authors address the problems associated with livestock intensification in developing countries, particularly in Africa. They identify the significant potential that successfully intensified livestock systems can play in contributing to smallholders' goals and discuss a series of factors that have thus far limited the success of these systems. Strategies are outlined to redress these problems, including better integrated crop–livestock systems, improved manure management and improved soil fertility management.

Still with a focus on Africa, Chapter 19 turns to the realm of policy. Reardon and colleagues review a wide set of factors that have limited sustainable agricultural intensification in African agriculture. The limitations of past macroeconomic, sectoral, marketing and credit policies are identified and applications to a number of diverse settings in sub-Saharan Africa are reviewed. A strategy of capital-led intensification and selected public investments, accompanied by continued policy and market reforms, is proposed to generate successful intensification in African agriculture.

Chapter 20 treats a dramatically different situation – the intensified agricultural systems of Asia and the factors contributing to recent declines in productivity growth in the important rice and rice–wheat systems of the Indo-Gangetic plains of South Asia. Pingali and Rosegrant identify a host of agronomic and soil-related constraints (salinity, waterlogging, soil nutrient deficiencies, etc.) which have contributed to these productivity problems. These are accompanied by policy and institutional constraints that have distorted input markets (notably groundwater for irrigation) and exacerbated intensification-related problems. A range of technology and policy solutions are suggested for improving environmental outcomes while increasing the likelihood of continued growth in food production.

Chapters 21–23 shift the focus of the book to institutional strategies for enhancing the joint realization of intensification and economic objectives. In Chapter 21, McNeely outlines the critical institutional issues faced by those seeking to jointly promote agricultural development and biodiversity conservation. He emphasizes the contributions provided by ecosystem services and protected areas for agricultural development and rural communities. Alternatives, including economic alternatives, for involving local communities in protected area and buffer-zone management are stressed as mechanisms to make the conservation of natural resources attractive to local people and thus ensure the availability of natural resources for the future.

In Chapter 22, Brandon provides an overview of goals, underlying assumptions and operational issues characterizing ICDPs, which, as we discussed earlier in this chapter, have been a popular mechanism in seeking to jointly accomplish economic development (including agricultural intensification) and conservation goals. She finds that successes have been rare, due to a host of problems related to project design and execution, and suggests that the current movement toward ‘ecoregional’ or ‘landscape’ approaches to integrated development and conservation projects may address some of the fundamental limitations encountered in ICDPs to date.

Highlighting the theme of community-based approaches identified in earlier chapters, Uphoff (Chapter 23) emphasizes the fundamental need to involve local people and communities in the design and execution of projects with development and environmental goals. He describes a number of developing-country case studies where community-based natural resource management strategies have been a cornerstone of local development efforts. He further argues that addressing critical social and community-related aspects of development – that is, those beyond purely individual economic motivations – is essential to making local development efforts successful. The volume then concludes with a summary chapter (Chapter 24), which synthesizes some of the important results of the chapters of this book.

Notes

1 Boserup highlights the island of Java as an important example of endogenous intensification. The Javanese, however, largely removed the entire extent of natural forest cover on the island; most modern forest cover on Java is in the form of plantations and secondary forest (Gillis, 1988).

2 The vast majority of the successes were systems developed endogenously by local populations, with little or no outside technical assistance. Their development was more akin to a Boserupian notion of intensification.