Green Jobs for a Revitalized Food and Agriculture Sector

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January 2012

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Acknowledgments

The authors whish to thank Nadia Scialabba and Noémi Nemes at the FAO for their consistent and valuable support in the preparation of this report. Thanks also to all other reviewers for their comments and constructive criticism.

1. Introduction:

This report presents an overview of opportunities to create "green jobs" by encouraging and investing in the implementation of a global transformation of the agriculture sector into a sustainable, productive and environmentally balanced 'green agriculture' paradigm. In the context of this report, "green agriculture" is broadly defined as "the use of farming practices and technologies that simultaneously: (i) maintain and increase farm productivity and profitability while ensuring the provision of food on a sustainable basis, (ii) reduce negative externalities and gradually lead to positive ones, and (iii) rebuild ecological resources (i.e. soil, water, air and biodiversity "natural capital" assets) by reducing pollution and using resources more efficiently. A diverse, locally adaptable set of agricultural techniques, practices and market branding certifications such as Good Agricultural Practices (GAP), Organic/Biodynamic Agriculture, Conservation Agriculture and related techniques and food-supply protocols represent the various forms of "green" agriculture" (UNEP, Green Economy Report: Agriculture Investing in Natural Capital. 2011). Fishery and forestry are also mentioned, but with a lower level of detail. This is due to the nature of interventions needed to support a transition to greener fishery and forestry, which primarily focuses on resource conservation and the rebuilding of stocks.

We define green employment to cover the full spectrum of decent jobs that are created by green agriculture farming practices (see Text Box 1). This view encompasses not only on-farm job creation; it also includes input supply chains and post harvest field-to-market value added food sector operations. These green jobs would include: unskilled manual field labor; sustainable input production jobs; skilled agriculture extension service agents; community scale food storage and processing operations; university researchers and educators; entrepreneurs in sustainable agriculture related enterprises; and other employment categories. By considering the potential for creating green jobs, we explore the opportunities and outlook for transitioning to a greener agriculture and food sector.

This assessment is based on a high level overview of the main elements of potential green agriculture employment. An integrated dynamic modeling approach has been employed that simulates expected production outputs; increases in farmer income; and impacts on the quality and quantity of natural capital ecosystem assets. A particular focus is placed on job creation potentials. This paper also discusses and analyzes policies that could encourage and support the transition to greener farming and livestock husbandry practices and help create millions of rural farm and non-farm jobs. This introductory section provides an overview of the current challenges facing agriculture, including mentions of forestry and fisheries and the farm-to-market supply chain food sector. It sets the context in which the analysis is embedded and serves as the foundation for the innovative modeling and policy analysis work presented in this paper.

Issues and opportunities

Global and national food and nutrition security are facing critical challenges in the decades ahead. It is expected that global food demand will increase by nearly 70% by 2050. This increased demand will be driven by population growth, changing dietary demands of a more affluent and increasingly urban population, and increased competition for resources between food, feed, fiber and biofuel feedstock production. Prospects for achieving these increases in agricultural output will be impaired by deteriorating soil quality, decreasing availability of fresh water, and industrial farming's high dependence on fossil energy sources for mechanization, pesticides and fertilizers (IAASTD, 2009). The agriculture sector will need to affordably nourish nine billion people worldwide by 2050.

There is evidence suggesting that a successful green transformation of the agricultural sector could meet global food needs while also contributing to the mitigation of GHG, improving the conservation of biodiversity, water and land resources, slowing the pace of rural to urban migration and improving farmers' adaptation to climate change impacts (Pretty et al., 2006). The transition to more sustainable agriculture practices is needed to support our growing population and should also serve as an economic development engine to create jobs and prosperity in the now impoverished and depopulating rural areas.

The global agriculture sector, including forestry and fisheries currently provides over 1 billion jobs (ILO, 2009) and 3% of the global GDP (WDI, 2009). In many developing countries, agriculture provides between 20% to more than 50% of national GDP (WDI, 2009). There is a wide disparity between developed and developing countries with regards to the proportions of their work force that are involved in agriculture (e.g. 6% in the EU versus 56% in Africa)(FAOSTAT, 2010). The majority of the world's poor live in rural areas and their incomes are predominantly based on agriculture. It should also be recognized that most small holder farmers are primarily focused on producing sufficient food for their families, and, once subsistence has been achieved, on marketing any surplus production for cash income. In considering the full impact of agriculture on GDP it is necessary to recognize that the value of food directly consumed by farmers and their families is often not taken into account when evaluating agriculture's contribution to national GDP and overall economic output levels.

Significant investments are needed to make the transition from both the industrial farming practices of the developed world and from the more traditional, low productivity practices common in the developing world to more sustainable and equitable food production systems. Neither industrial nor traditional farming practices are projected to be sustainable over the long term (i.e. through the end of this century). This paper intends to provide an initial investigation of whether the implementation of greener farming practices (including, among others, organic and ecological agriculture) would result in a productive and sustainable agricultural sector that also creates new and rewarding jobs across the entire food system.

2. Potential for Creating Green Jobs in Sustainable Agriculture

While a number of studies have been conducted on sustainable development by international agencies, there are very few published reports that specifically reference employment issues[1] – green or otherwise. These studies inventoried various approaches for practicing green agriculture and forestry, identified potential employment-intensive green technologies, analyzed the role of organic agriculture as a robust employer in comparison to the conventional alternative and analyzed the role of green agricultural employment in improving conditions for climate change mitigation and adaptation. In preparing this paper, many reports of relevance to the food and agriculture sector (mostly regional or global) were analyzed. Several of the reports of particular relevance to green jobs in agriculture are summarized below and specific job impacts driven by selected intervention are presented in the following sections.

The FAO report, "Comparative Analysis of Organic and Non-Organic Farming Systems: A Critical Assessment of Farm Profitability (Nemes, 2009) reviewed various methodologies to assess the impact of organic agriculture practices that are representative of green agriculture methods and found that "the overwhelming majority of cases show that organic farms are more economically profitable, despite frequent yield decreases" (where such yield reductions may be encountered in the early years of organic implementation). The reduction of production input costs, increased variety of total farm products and organic premium market prices all contribute to more profitable operations. This report also determined that organic farming generally offered greater rural employment with higher returns for hired and family labor inputs, particularly if off-farm labor incomes were included in the analysis. The report acknowledged that care should be taken in analyzing specific circumstances, as organic farming performance is highly determined by specific local conditions.

The UNEP and ILO report, "Green Jobs: Towards Decent Work in a Sustainable Low Carbon World" (UNEP, 2008) assembles evidence on currently existing green jobs in key economic sectors and presents estimates for future green employment in general. A number of policy measures and funding options are suggested with regards to their potential application in the agriculture and food sector. The opportunities for green job creation proposed by UNEP include: natural resource management, reducing harmful inputs, managing intensive livestock systems, payment for environmental services, climate change mitigation and adaptation, organic farming, urban agriculture, smallholder farming, sustainable retailing, and reducing food waste.

The UNDP (2009) discussion paper, "Green Jobs for the Poor: A Public Employment Approach" explores the potential for governments to create green jobs for the poor in developing countries by funding public employment programs for environmental conservation and rehabilitation. By drawing on some national experiences, the report argues for the important role of government leadership in these programs and identifies major investment opportunities and funding options for these activities.

The GHK report, "Links between the Environment, Economy and Jobs" (2007) shows strong links between the economy and the environment, and evaluates the broad impact of environmental policies on jobs, outputs and the added value of environment rehabilitation and conservation activities. Policies to ensure the protection of our environment should not be viewed as imposing a depressing

1 See, for instance: OECD, 2004. Agriculture and the Environment: Lessons Learned from a Decade of OECD Work; So Far, 2006. Integration Between Social Farming and Third Activities in Multi-Functional Farms; FAO, 2007. The Roles of Agriculture in Development: Policy Implications and Guidance; World Bank, 2008. World Development Report: Agriculture for Development; World Watch Institute, 2009. State of the World: Confronting Climate Change; World Bank 2010. World Development Report: Climate Change.

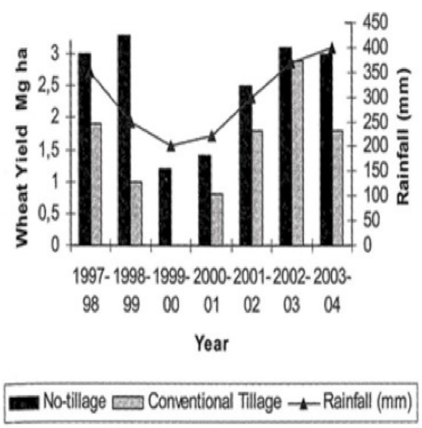
effect on the economy. In fact, they may to be a source of new jobs and innovation that help increase economic health and social wellbeing. In particular, the study estimates that in the entire EU-27 economy there were 500,000 full-time equivalent jobs in organic farming as of 2000: 300,000 direct (directly engaged in farming), 151,000 indirect (indirectly engaged through employment in organic agricultural supply chains), and 48,000 induced (additional jobs generated by the expenditure of incomes earned by direct and indirect labor). This study provides direct, indirect and induced output and gross value added data for the sector as well, from which Type I (i.e. direct) and Type II (i.e. indirect and induced) multipliers are calculated to reflect the relationship between direct impacts and the consequential indirect or induced effects. Using these multipliers, the scenario of a 10% demand shift from conventional to organic farming is expected to have a net gain of 43,834 jobs (66,012 direct jobs less 22,718 indirect) jobs lost in the agrichemical input supply chain) in EU 27 countries.

These studies indicate the agricultural productivity gains and economic benefits that are possible with the adoption of more labor intensive green farming practices. It is important to recognize that the benefits described were primarily in terms of increased farmer net incomes and crop productivity. There were also valuable external benefits that were realized with respect to reduced environmental pollution, reduced pest pressures, reduced consumption of fossil fuel based inputs and other positive economic externalities. If there were means by which these farmers could be compensated for their contribution to improved environmental conditions that are shared by the broader community (i.e. financial mechanisms for *payments for environmental services*), the enhanced value of additional skilled labor inputs for green agriculture practices could be more clearly recognized and included in the overall return on investment.

No-Till cultivation

Improvements in agricultural land management, such as conservation tillage, multiple crop rotations, agro-forestry, integrated plant-animal systems and rehabilitation of degraded crop and pasture land, can improve soil productivity (Mrabet et al, 2005).

Figure 7: Tillage effect on wheat grain yield at a semi-arid Moroccan farm with medium depth clay soil on sloping land. Source: Mrabet and El Brahli, 2005.



As *Figure 7* indicates, over the seven year period that these Moroccan farms applied no-till (NT) cropping practices; aggregate yields were forty-two per cent higher than conventionally tilled farms. The superior returns from no-till were particularly high during low rainfall drought conditions. Of specific relevance to employment impacts, most no-till farm operations have lower labor requirements per productive unit of output and per unit of land. Several studies indicate that NT cultivation requires between twenty to fifty percent less labor than conventionally tilled farms in the same area (Pieri et al, 2002; Sorrenson et al, 1998; GTZ, 1998). As yields from NT farms were consistently greater than from conventional farms; the economic return to NT farm labor was significantly higher. For example, Paraguayan NT farmers effectively earned $16.50 per day, more than double the returns of $8.20/day earned by conventional farmers (Sorrenson et al, 1998). Such higher income farm jobs could be considered a more 'decent' and greener job relative to the less economically rewarding jobs on conventionally tilled farms.

'Push Pull' Farming

One of the most effective agroecological farming practices is known as "Push Pull." This technique combines several crops (i.e. maize, desmodium and napier grass) in an integrated, intercropping arrangement that provides a natural barrier to insect and weed infestation while simultaneously enriching the soil.

An economic study of the performance of "Push Pull" farming in Kenya concluded that its innovative multi-cropping practices provided both stem borer and Striga weed control, natural nitrogen fixation in soils, improved maize yields, provided fodder for livestock and utilized manure as an organic fertilizer. These evocative green agriculture techniques required between 20 and 30 per cent higher labor requirements than conventional local farming practices (Khan et al, 2008a). However, the significantly higher crop yields and total farm outputs resulted in higher earnings per day of labor on the Push Pull farms.

An economic analysis of a "Push-Pull" field trial in East Africa with 21,300 farmers found that they achieved higher net returns on their land and labor (Khan et al, 2008a), with an average economic gain a factor of 2.5 relative to cost. Even when considering the increased level of labor inputs for Push Pull, the income returns for labor was 3.7 USD/man day with Push Pull as opposed to 1 USD/man day with their previous maize mono cropping practice. The gross revenues range between 424 and 880 USD/ha under Push Pull and 81.9 to 132USD/ha in maize mono crop. Similar systems are being field trialed for other cropping systems and it is likely that comparable rates of return will be realized.

Implementation of Push Pull in eastern Africa has significantly increased maize yields and the cultivation of N-fixing Desmodium has provided both nutrients to the soil and forage crops for livestock. With increased livestock operations, the farmers are able to produce meat, milk and other dairy products and they use the manure as organic fertilizer that returns additional organic nutrients to the fields. In smallholder farming operations, the ability to support livestock for meat, milk and draft animal power is an important added benefit of this plant and animal health management (PAHM) strategy (Khan et al, 2008b).

In Nigeria, maize yields for farmers participating in the Push Pull field trial have more than doubled in comparison to their previous conventional farming practices (Asiabaka et al., 2008). The main costs of implementation are additional labor requirements for farmer education and adopting more complex intercropping methods. Additional investments are needed to purchase desmodium seed and livestock. The returns on investment have been immediate and are increasing as soil fertility is re-established and crop and livestock productivity levels rise.

Skilled Labor Pest Management

The value of local labor inputs for enhanced agricultural productivity can be seen in the experience of a farmer field school project for integrated pest management of cocoa in southern Cameroon. In this case study ("Socio-economic impact of cocoa integrated crop and pest management", STCP/IITA, 2006), cocoa farmers were trained in pruning, shade adjustment and phytosanitary harvesting methods that effectively maintained yields comparable to conventional practices that relied on multiple applications of fungicides. The farmers who practiced these techniques were able to reduce their use of fungicides by 39%. Although their costs for labor inputs increased by 14%, their total production costs decreased by 11% relative to conventional practices. By introducing more skilled labor inputs, a larger share of the total costs of cocoa production was paid to workers within the local community. In addition, Cameroon reduced its foreign exchange expended to import fungicide chemicals. Additional benefits were realized with reduced health costs and environmental pollution resulting from the decreased use of hazardous fungicides.

Another example of effective and more labor intensive biocontrol of pests is a low technology method of controlling millet head borer infestations in Sahelian countries (Figure 8). Beneficial predator insects are reared in locally made jute bags that are filled with millet grains, infested with a rice storage moth pest and then inoculated with a parasitoid wasp (Habrobracon hebetor). These small bags function as very low cost incubators for the beneficial wasps. The adult parasitoid wasps emerge from these bags and attack tunneling larvae of the millet head borer that infests nearby millet fields. Preliminary estimates of the efficiency of this delivery system indicate that 16 release bags installed in a village were able to cover a circular area of 5km radius, corresponding to 7850 ha, with approximate costs of 0.004 US$ per hectare treated (Baoua et al., 2008).

Figure 8: Community biological pest management techniques in Niger (McKnight Foundation)

Organic farming

Of particular interest is the expansion of organic farming, which relies on ecological processes, biodiversity and cropping cycles that are adapted to local conditions and generally excludes or strictly limits the use of agrichemical inputs. Whereas positive impacts on the environment are evident in the form of soil quality, ecosystem services, ground and surface water, organic farming will also benefit the economy in terms of greater employment and business diversification (GHK, 2007). Positive-sum employment gains are expected in organic farming and local food systems, as these farms are often more labor-intensive than industrialized farms (UNEP, 2008). In addition, there are also incremental positive impacts on job creation in both on-farm processing (e.g. quality sorting and special handling) and non-farm production of organic agricultural inputs (e.g. natural fertilizers) and post harvest farm-to-market supply chains. Therefore, rather than displacing the agricultural workforce, a greener agriculture safeguards livelihoods by keeping people on the land and realizing a broad range of livelihoods on the basis of its enhanced productivity. Additionally, according to some recent studies, organic farming has demonstrated that it can yield more total food produce than does conventional farming on the same amount of land (Badgley et al., 2007).

There are several studies that indicate the relatively higher labor demands of organic agriculture as compared with conventional and traditional farming. A comprehensive field survey of organic farming in the U.K. and Ireland (Morison et al. 2005) found higher labor intensity per organic farm (i.e. 97% and 27% respectively) relative to conventional farms. Comparisons were complicated by a variety of factors such as different sizes of farms, variations between grain, horticulture and livestock farming, the inclusion of on-farm organic marketing activities, etc. The U.K. Soil Association analyzed the survey data and found that on a weighted basis, organic farms averaged 32% higher labor requirements than comparable non-organic farms (Green et al. 2006).

The University of Cambridge (2002) evaluated the Organic Farming Scheme (OFS), also in the UK. By conducting cost-benefit analyses, the study examines the rationale behind the public assistance provided by the Scheme for organic farming, and justifies its effectiveness and efficiency in meeting the conversion objectives, and makes recommendations for future improvements to the Scheme. In terms of the impact on employment, the conversion of the sample farms has led to evident gains in on-farm employment, especially in casual labor and employed part-time labor inputs.

There are additional studies that indicate the higher labor requirements of organic agriculture (e.g. UNCTAD and UNEP's "Organic Agriculture and Food Security in Africa," 2008). The determining factors for the increased labor intensity of organic and sustainable farming practices are generally the increased manual and mechanized labor inputs for more diverse cropping rotations; integration of crops and livestock in order to recycle organic wastes into soil nutrients, maintenance of crop residue and 'green manure' ground covers to reduce soil erosion, greater reliance on biological processes for pest and weed management and many other agroecological farming methods.

The shift from conventional to organic farming will require higher training and extension costs, as well as investments in organic research. There is also the need for investments in the fixed and variable costs of organic cultivation systems during the conversion phase, (e.g. alternative machinery and organic seeds/breeds that are better adapted to low-external input conditions respectively) (GHK, 2007). However, the situation could change considerably with energy prices increasing in the future. If organic market price premiums remain at current levels (or perhaps even rise in the short term) such conditions would indicate that there is a higher demand for organic products than there is supply. These market signals would encourage more farmers to convert to organic farming. Such transitions to organic production methods would be particularly stimulated if the transaction costs of organic certification are reasonable (e.g. enabling more economical group certification) and there is improved access for small holder farmers and their associations to growing domestic and global markets for premium priced organic produce.

As more farmers shift to organic production practices and current organic farmers expand their operations, the supply of organic produce would gradually converge with demand. Under these conditions, the prevailing premium market prices are likely to fall or at best stabilize. It will be very important that as organic prices eventually approach parity with 'conventionally grown' agriculture products the benefits of relatively lower costs for organic inputs (compared to fossil fuel based inputs) and higher productivity yields due to enhanced soil fertility would justify continued green agriculture practices. A discussion of a successful organic agriculture transition is seen in the example of Uganda's growing organic farm sector (UNEP, 2010) in terms of its economic, social and environmental benefits.

Certification and branding for organic and sustainable produce

The labeling of sustainably produced food and organic certification systems provides consumers with information to make responsible purchasing decisions. As consumer demand for such products increase, food manufacturers will be encouraged to market more eco-friendly products. Most importantly, these certification and branding activities are essential for enabling consumer awareness and confidence in the higher quality and ecologically beneficial food (and other agricultural) products that result in *premium prices* for such product, especially in the developed world. If there are no price premiums in local and domestic markets, and in view of the difficulties smallholder farmers often encounter in supplying organic export markets, many farmers may not be motivated to undertake the more complex and diverse practices of a more labor intensive green agriculture.

Although organic certification expenses are relatively minor in comparison to the added market valuation of organic produce; these costs generally represent between two and ten percent of the total costs of organic products in well managed operations. However, there are cases where these inspection and certification costs have been as high as more than half of total costs. Studies indicate the importance of certifying at the right scale in order to effectively manage certification costs (Markandya et al., 2010). These transaction costs cover the additional reporting efforts and third party certification auditors' field work to verify farmers' claims. The higher level of literacy and special skills involved in such certification efforts suggest that these market oriented tasks represent new, 'decent' jobs that extend beyond manual farm labor employment.

Agroforestry

Agroforestry, mainly practiced in Africa, Asia, and Latin America, integrates tree growing with traditional cropland farming. One of this practice's most important contributions to agriculture productivity are instances where nitrogen fixing tree species (e.g. Faidherbia albida, Acacia and Tephrosia) are intercropped with maize and other cereals. Field trials in Malawi indicate that, once the beneficial tree cropping method has been established (which is usually within the third or fourth year of tree growth) maize yields have increased between 54-76% compared with traditional practices (Garrity, et al. 2010). The adoption of agroforestry practices create employment opportunities with regards to management of seedling farms for the recommended tree species, increased labor for pruning and harvesting of firewood and other products from the tree stands.

Improved post harvest storage and handling practices

There are significant opportunities for job creation in the area of reducing post harvest losses of food. It has been reported that very substantial portions of agricultural produce is lost or destroyed by pests, moisture, fungal contamination, spoilage and other conditions (UNEP, 2011b). These losses are particularly severe in many developing countries, where a frequent cause for these losses is the lack of safe and secure storage facilities (e.g. grain silos, poor packaging and handling of produce in transit from the farm to distribution outlets, lack of affordable crop drying or refrigeration facilities). Technologies and materials are available to greatly improve post harvest storage and handling practices in developing countries, but their adoption and use will require focused public and private encouragement and financial support for local farmer associations and small enterprise initiatives to build and operate such facilities.

There are encouraging examples of post harvest reduction initiatives that have had significant economic and employment benefits for farmers in the Developing World. The FAO has conducted programs that domestically manufacture and distribute metal grain silos for family and community scale storage of cereals (Household Metal Silos, FAO, 2008). These inexpensive silos enable farmers to both reduce their grain losses and extend the time frame over which they can sell their grain for higher prices that occur months after harvest peak supply periods. The resulting income gains enable these farmers to fully recover their initial investment costs for the silos in the first year of use.

Similar high returns are being achieved by farmer cooperatives that have implemented an innovative triple bagging system (i.e. the Purdue Improved Cowpea Storage system) that protects cowpeas and other legumes and grains from insect contamination for four to six months (Baributsa et al., 2010). Both of these simple yet effective crop storage technologies could be manufactured in many developing countries. Although such manufacturing operations have not been studied, it is certain that the incremental non-farm jobs involved in producing and marketing these systems would offer sustainable employment in those regions that widely adopt such measures, despite potentially reducing farm jobs.

Farm-to-Market Food Systems

In terms of the local food distribution systems, a more sustainable agriculture would address food security issues through improvements of transport infrastructures and facilities that reduce post harvest losses (e.g. market feeder roads, grain and produce storage and distribution and ag-related information services). According to UNEP (2009), global food loss accounts for more than 56% of total edible crop harvests, leaving less than half available for household consumption. Additional development involves enhancement of small scale farmers' linkages with local, urban and regional markets, as well as participation in green markets by enhancing regional market integration, and better compliance with regulations and standards for product safety and quality. Trading equity should be improved by supporting such approaches as fair trade, so as to provide more favorable and stable returns to farmers. Innovative technologies in food production, post-harvest treatment, food processing, packaging, preservation and overall improved sanitary conditions throughout the field to market system are also playing a more important role.

There are increasing examples of major global food companies that have begun innovative reformation of their supply chains with the intention to improve both their operations and their brands with regards to corporate social responsibility. These initiatives are designed to improve the sustainability with which their raw agricultural products are produced; and to enable a more equitable participation of producer farmer organizations in the value added revenue potential for their outputs. In many of these projects, the transnational firm helps finance farmer training and capital equipment that enables poor farming cooperatives to apply quality improving processes to their raw produce and enter into long term supply contracts at much higher farm gate prices than traditional practices. In these cases, farmers often increase their incomes by 20% or more and become more sophisticated and experienced supply partners in a global food supply chain that extends from the farm to the market (KILICAFE project in Tanzania).

Livestock management

Adoption of crop and livestock diversification strategies is one of the most significant opportunities for achieving sustainable agricultural productivity. This is particularly suitable for many developing world regions that have not yet widely adopted large scale confined animal feedlot operations (CAFO's). The regional co-location of cropping and livestock farming operations would facilitate a more efficient organic nutrient cycle that is enabled by manure recovery and reuse to help fertilize fields that grow feed, fodder and other agricultural products. Effective diversification practices should be matched with location-specific agro-climate conditions and could create balanced and possibly self-regulating cycles. Achieving this symbiotic balance could optimize economic returns for all harvested products and enable overall farm productivity gains.

Animals feed on crop residues, which would otherwise be wasted. The recycling of livestock manures as organic nutrients for soil is also an essential element of greening agriculture. Furthermore, to a certain extent, small and medium scale livestock operations can also invest in biogas production systems that produce clean methane gas for cooking, process heating and even power generation uses. Such systems (e.g. anaerobic digestion plants) also produce organic effluents that could be converted into nutrient and fiber rich soil amendments (Integrated Farm Energy Systems, FAO, 2010). Draft animal power for farm mechanization in low income countries is also an important benefit of crop/livestock biodiversity on the farm.

Livestock husbandry provides higher value food products (e.g. meat, milk, poultry and eggs) if farmers can effectively market these perishable products with limited losses due to waste. Furthermore, livestock is a critical asset that can be leveraged as collateral for loans and can also be quickly converted to cash to meet important needs of poor farming families. With the benefit of farmer dairy cooperatives, value added food products (e.g. cheese, yogurt, etc.) may be produced with associated new revenues to the members.

The implementation of improved livestock management, coupled with green agriculture practices can create synergies that would therefore allow generating sustainable additional jobs.

Capture Fisheries

An increasing amount of wild fish stocks are being depleted due to overcapacity and damaging fishing methods. Such depletions are widespread, with only 25% of the commercial fish stocks (mostly low priced species) currently viewed as being underexploited (FAO, 2008). It was reported that some 27% of the world's marine fisheries had already collapsed by 2003 (Worm et al., 2006). As overfishing conditions are widely recognized (UNEP, 2011), there is a need to rebuild fisheries where ever possible (FAO, 2008). Achieving sustainable fisheries will require the reduction of excess fishing capacity by decreasing the numbers of particularly large-scale marine vessels which have higher negative impacts on the survival and regeneration of fishing stocks. The reduction of fishing fleets would need to be supported by training and education of displaced fishery workers in order to help them find employment in other livelihoods. In some less developed areas, especially those dominated by artisanal fishers, such retraining efforts and possibly even household relocation assistance may actually improve their incomes. Improving fish resource management is also essential for recovery of the aquatic ecosystems. These initiatives would create employment in fish stock assessment, monitoring, control and protection, as well as supporting additional research positions in relevant technologies.

Aquaculture

Similar opportunities are available for diversification with aquaculture practices. Various farm waste streams could be used as inputs for raising fish and aquatic edible plants. Aquaculture offers high conversion efficiencies of biomass nutrient inputs into fish protein and may be able to use brackish (saline) water in areas where fresh water is scarce. To increase rural and national food and energy security, fish production can be incorporated into Integrated Food Energy Systems (IFES) –which simultaneously produce food and bioenergy and adopts closed loop agricultural systems with optimal utilization of by-products from all systems including aquaculture–. In such a system, farmers could divide the work and specialize in complementary farming activities including aquaculture, thus increasing efficiency and productivity through collaboration. This is especially effective for small-scale farmers who can benefit from the economies of scale (FAO, 2010). A recent FAO estimate of aquaculture employment indicates that the sector provides over 30.5 million full-time-equivalent jobs, including about 21.5 million on-farm and nearly 9 million off-farm positions (FAO, 2010). However, though most of these jobs are produced in developing countries where most of the production technologies are generally environmentally-friendly, it is still difficult to tell how many of these jobs are green and how many are not. However, the aquaculture of filter feeders and extractive species (e.g. bivalves and seaweeds respectively) offer great opportunities to produce food in coastal marine areas with a very low or nil carbon footprint. On the contrary, the farming of these species, very suitable for rural and small farmers, have great potential regarding carbon credits and for the ecosystem service of extracting excess nutrients from coastal waters.

Forestry and Agroforestry:

The forestry sector is closely associated with the agricultural sector and rural livelihoods. According to projections discussed at FAO's special event "Impacts of Global Economic Turbulence on the Forest Sector" in 2009, future targeted investment in sustainable forestry could possibly generate 10 million new jobs. Such new green jobs could include establishing and managing urban and peri-urban green spaces, improving watersheds, protecting forests from fire and building roads and trails for recreation sites. These jobs are generally characterized by low capital requirements and high diversity, and have multiplier effects of generating additional 1.5- to 2.5-fold local employment gains in the economy. (Nair and Rutt, 2009).

Afforestation and reforestation are expected to offer the greatest scope for job creation, particularly where rural unemployment is high and vast tracts of degraded land are available (Nair and Rutt, 2009). While it may seem obvious that these new jobs would be considered green employment, the large numbers of jobs in planting trees are often informal, part-time, seasonal, and low paid with long working hours. Ensuring the creation of decent green jobs will require more rigorous labor regulations and requirements standards, such as improved basic working conditions and above-poverty wage level incomes (UNEP, 2008).

Sustainable forest management strategies mimic the natural forest ecosystem processes to preserve forest resources and assure a diverse, long-term supply of timber and other forest products. Regarded as a practical application of the Ecosystem Approach (FAO, 2004), Sustainable Forest Management aims to create a balanced stewardship of forest resources that also serves to maintain healthy forest ecosystems. In some cases, the necessary limitations on timber production that are advanced by these strategies could cause immediate reduction in the number of jobs (Cashore, 2006; UNEP, 2011). However, over a longer period of time the adoption of these approaches are likely to have positive overall impacts on both the employment and income of rural communities. It is the combination of these benefits that presents rural communities with the incentive to support conservation initiatives, particularly in specially designated 'protected areas' (UNEP, 2008; FAO, 2004).

In Costa Rica, the national government's National Forestry Financing Fund (FONAFIFO) has implemented a payment for environmental services (PES) program that has paid an average of US$433 per hectare of forest land over a five year period (ranging from US$205 to US$816 depending on the particular type of forest management practice) to land owners for forest protection, forest management, reforestation and other conservation techniques. FONAFIFO is funded by a national tax on fossil fuel use in Costa Rica. Between 1997 and 2008 FONAFIFO distributed US$206 million, the majority of which were for forest protection (73%), covering 460 thousand hectares of forest, indicating an average annual cost of $327 per ha (FONAFIFO, 2010). Besides PES, Costa Rican private companies could invest in forest conservation (mainly for emissions mitigation) with Certificates of Environmental Services (CES). FONAFIFO (2010) estimates a CES value of US$285 per ha for 7,000 hectares of forest conservation work in the Guanacaste region.

SFM and Certification standards represent only a fraction of the total global wood market and forestry sector, but have been growing especially rapidly in the last few years, and could provide the potential of long-term employment for rural communities. It also supports higher market transparency that improves private firms' compliance with contracts and helps combat illegal logging that relies on cheap labor and provides poor working conditions (UNEP, 2008).

Certain certification schemes require compliance with specific standards for employment. For example, the Program for Endorsement of Forest Certification (PEFC), the Forest Stewardship Council (FSC), and the Malaysian Timber Certification Council (MTCC) promote employment standards for complying with national labor laws and agreements at national or international levels for minimum health and safety rules and equipment to protect workers, guaranteed workers' rights, training and education programs, and prohibition of child labor, among others terms (UNEP, 2008). These certification standards contribute not only to the potential long-term increase in the number of green jobs, but also to their quality. Nonetheless, past experiences show mixed employment consequences of these certification schemes – possible short-term job losses due to a decline in the amount of land available for harvesting and layoffs from adoption of certification, and yet more stable and decent jobs in the longer run (UNEP, 2008, 2011).

Biofuel production

With rising pressure to mitigate the impacts of climate change, the growing biofuel sector is projected to create 12 million jobs in related agriculture and industry processes by 2030 (UNEP, 2008).

Currently this industry accounts for about half of all jobs registered in the renewable energy sector (UNEP, 2008, 2011). The job creation for agricultural workers producing biofuels, particularly if at small and medium capacity scales, would offer opportunities for rural development and poverty reduction in developing countries. In these regions, biofuels could be locally used for cooking, process heating, and mechanical and electric power generation. Most poor rural communities in developing world regions rely on firewood or inefficiently produced charcoal or animal dung for their energy needs, as the vast majority of households lack access to electricity or affordable fossil fuels. Locally produced biofuels could help increase rural access to modern energy resources that are essential for mechanized farming and irrigation applications.

However, there are concerns that the rapid development of biofuels could impose environmental, social and economic costs. The benefits of existing and projected new jobs need to be carefully considered in the context of labor standards and broad impacts on rural communities. The bulk of such jobs, especially those created in landscape scaled liquid biofuel plantations can hardly be described as decent employment, as these agricultural workers are usually low-skilled and suffer from stagnant wages, the risk of intermittent unemployment and poor working conditions (UNEP, 2008). Child labor and forced labor have also been found in these market segments. In addition, the rapid expansion of biofuel production may also increase the risks of further destruction of ecosystems, displacement of poor communities and food insecurity. While biofuel production could bring benefits to rural livelihoods, many large-scale projects focus on exporting to energy-intensive economies rather than serving local community demands in poor countries where employment and other benefits may be more pronounced (Rossi and Lambrou, 2009).

To overcome these challenges and avoid possible consequences, development of biofuel production must ensure coherence with the nation's overall strategies and efficient use of available resources (UN Energy, 2010). The implementation of Integrated Food Energy Systems (IFES) provides a promising solution to national food and energy security, resource efficiency improvements and local poverty reduction. Such farming systems combine production of food and biofuel crops on the same land, or maximize synergies between the production of food crops, livestock and fish and generation of renewable energy. The minimized waste and negative environmental impacts and enhanced resilience of these systems further contribute to climate change mitigation and adaptation capacity (FAO, 2010). As the logistics of handling biofuel feedstocks are a major challenge for economically viable biofuel production, the capacity of local and regional areas to produce on-farm biogas and community scaled biodiesel fuel could help resolve these supply chain problems. Bioenergy supply for transport and heat and power provision tends to gain more attention due to their attractiveness to foreign investors. However, it is particularly important that sufficient emphasis is placed on the traditional biomass sector and the agricultural sector which are the basis for rural livelihood. Locally produced biofuel and biopower could also enable value added food processing and other enterprises that could provide farmers and rural communities with additional incomes from rural non-farm job opportunities (UN Energy, 2010; IEA, 2010).

Farm mechanization

The introduction of technologies that mechanize farming operations will significantly increase agricultural productivity by enabling greater output per unit of land and human labor. By substituting machine and fossil fuel power for muscle power, farm mechanization enables larger areas of arable land to be cultivated in less time. Use of pumped irrigation enables farmers to extend the length of their growing season where ground water resources are available. These improved labor efficiencies could enable farmers to cultivate a second or third crop during the year. In *Figure 9* an innovative, integrated green agriculture practice in Kenya known as Push-Pull farming is demonstrated. Push

Pull uses several agroecological techniques and appropriate mechanization to achieve higher productivity through improved crop and livestock yields.

Figure 9: Push-Pull farming: intercropping for pest control, soil fertility and higher yields (H. Herren)

Farmers that invest in equipment systems powered by fossil fuel energy inputs have significantly reduced their need for farm labor while substantially increasing crop yields. While mechanization reduces the drudgery of manual farm labor, it also reduces the absolute levels of on-farm employment. By enabling a single farm worker to cultivate more acreage than is possible with manual labor or the use of draught animal power, fewer workers are needed to produce food requirements. In this situation, rural economic diversification with the growth of non-farm enterprises will be critically important to build and maintain employment levels. Mechanizing the local production of organic fertilizers, building water catchments, handling post harvest produce and other off-farm enterprises (e.g. maintenance and repair services) would greatly compensate for the loss of menial field farm labor jobs. It should also be recognized that as productivity increases per worker, there should be greater opportunities for family labor, especially that of children to be able to attend school instead of spending many hours working in the fields.

With the notable exception of draught animal power, mechanization cannot be implemented without reliable and affordable access to liquid fuels and electric power. Supplying modern energy resources to rural areas with poor transportation infrastructures and limited connectivity to national electric power grids is a major challenge.

It is technically feasible for rural communities to produce the quantity of liquid biofuels (e.g. biodiesel or ethanol) needed to support farm mechanization. Local organizational capabilities needed to finance, own and operate biorefineries and to supply required biomass feedstocks should be established in advance of the mechanization investments. Similar investments in rural power utility infrastructures must also occur for the ag sector to gain access to electricity for irrigation pumps and food processing and handling systems.

Draught animal powered mechanization

Draught animal mechanization in many areas of the developing world can be an important factor for increasing crop yields in many small holder farms. While animal power is not comparable to the work output of engines, its primary distinction is that farm communities could cultivate both food and feed crops to support livestock and draught animals. Intercrop rotation or co-planting strategies that cultivate N-fixing feed crops could both contribute to soil fertility enhancements and support draught animals. However, a major drawback with draught animals is the need to feed them throughout the year, even though their use as field power is highly seasonal, with extended periods of little or no productive input to farm operations.

While trade-offs between allocating some portion of their land to growing fodder versus more food crops must be carefully addressed; the expanded use of draught animals could provide a degree of self sufficiency in farm mechanization while avoiding the risk associated with volatile fossil fuel price increases or supply disruptions. There will continue to be an important role for draught animal power in poor farming areas. This requires that improved veterinary health services should be made available to smallholder farmers as part of a comprehensive diversified crop and livestock production strategy.

Eco-tourism

For several areas of the world, agro-ecotourism, eco-forestry and sustainable forest management (off-farm activities) offer additional sources of employment and income to the rural population. The rural landscapes of many rich biodiversity areas, such as small-scale farms could attract tourism based on the pristine nature, or traditional agricultural practices, or a combination of both. If reasonable means of accessing such areas are available, significant new employment and income may be gained from these activities as well as the sale of sustainably harvested products. This would, in turn, possibly provide strong financial incentives for the rural communities to conserve the natural resources and high levels of biological diversity, thus benefitting these areas socially, economically and environmentally.

According to the FAO (2004), past experience has demonstrated ecotourism as one of the most effective approaches for financing biodiversity protection. Moreover, tourism has strong economic multiplier effects on the local prosperity of destinations due to tourism service workers and related suppliers (e.g. farmers producing food for tourists) who predominantly spend their wages and incomes on locally sourced goods and services (UNEP, 2011). These tourism expenditures also generate additional indirect jobs in associated activities such as artisanal crafts that are often produced by farming households. In particular, foreign visitors' expenditures in developing countries help to create much needed positive foreign exchange for these countries that also helps to reduce economic disparities and poverty (UNEP, 2011). Worth mentioning, tourism activities should be managed sustainably, as the negative impact of tourism in several parts of the world is highly documented and clearly visible.

Further brief descriptions of green agriculture interventions and their potential impacts on soil, water, crop and livestock diversity and pest management are presented in Appendix 2.

3. Integrated dynamic analysis of a greener agriculture sector

Given the high number of employment-generating interventions introduced in Section 2 of this report and the complex interconnections existing across them, this section focuses on analyzing the potential synergies on job creation resulting from coordinated action. In this respect, an integrated simulation model was employed to support the quantification of impacts and the relevance of delays and feedback loops existing in the agriculture and food sector. It is acknowledged that this approach and model are not all encompassing. The model per se is relevant because it attempts to identify how many green jobs could actually be created. On the other hand, despite data limitation, several factors (mostly on the supply side) were integrated in a single framework and analyzed in concert.

Methodology

Green agriculture, by definition, should enable the provision of food, feed, fiber and some portion of fuel to meet humanity's current and future needs in a sustainable manner that is in balance with available renewable ecological resources. As the main source of employment in rural areas and income for the poor, a green agriculture transition is expected to create more job opportunities in the next few decades, especially green jobs than would be created if Business As Usual (BAU) trends continue. An integrated approach is employed based on the System Dynamics "T21-World" model to analyze the prospective productivity of the green agricultural sector and opportunities for creating green jobs.

The key components shaping the T21 analysis of the agricultural sector and the definition of scenarios are presented in more detail in Appendix I. The following model diagram (*Figure 12*) covers the key factors involved in agricultural production. The performance and interaction of factors shaping post harvest and field-to-market food supply chains are not explicitly simulated by this model at this time due to the lack of data. The model captures some of the factors that impact reductions of post harvest losses and food processing and point of sale wastes when it calculates the population's nutrition levels in relation to total food production. *Figure 12* illustrates the main feedback loops that influence agricultural yield and options for green investment in the agriculture sector (crop production) in T21-World. Acknowledging the fact that only certain variables can be comfortably quantified, this diagram shows only the quantifiable key –not all– agricultural indicators and their interrelations in the model.

Figure 12: Causal Loop Diagram of the main factors influencing agriculture crop yields in T21. *While acknowledging that several variables are missing from this diagram (such as the overall resource base: land, water and air), the diagram is simplified and includes only variables that could be estimated and simulated with confidence.*

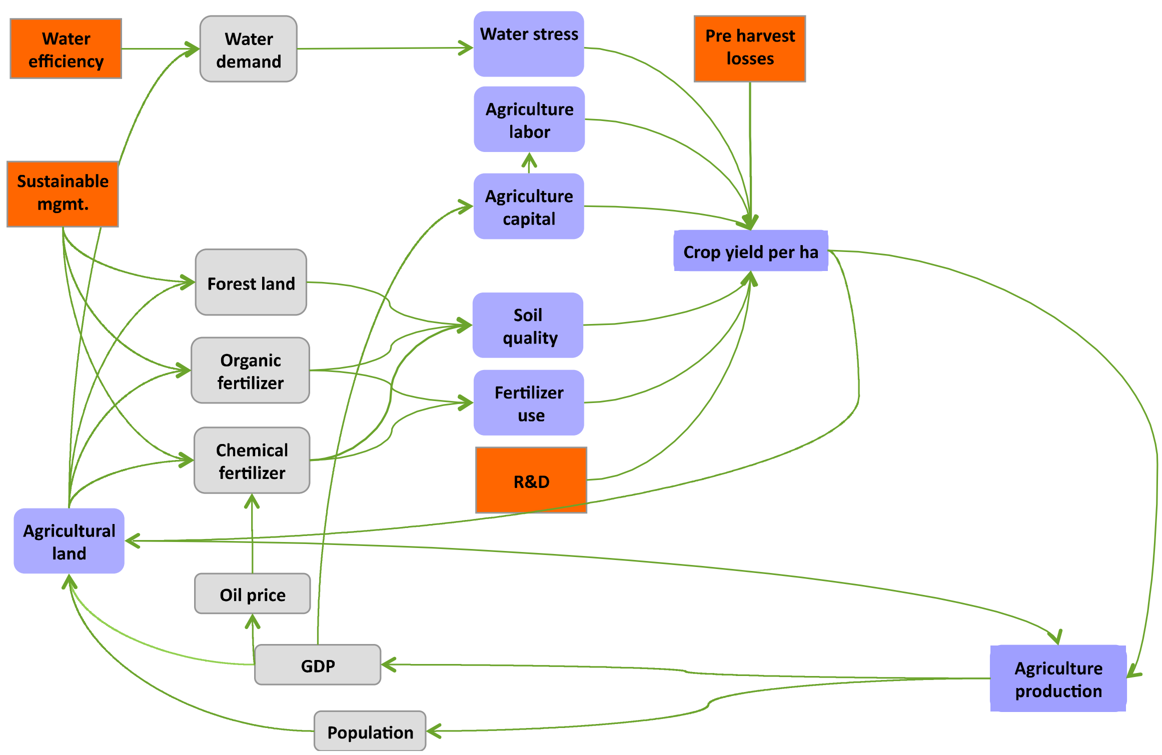


Diagram Key:
Colors:
- orange: policy variable
- blue: direct factors affecting production (first order)
- grey: other factors affecting production (second order)

Lines:
- solid: positive correlation & causality (when A goes up, B goes up -- when A goes down, B goes down)
- dotted: negative correlation & causality (when A goes up, B goes down -- when A goes down, B goes up)

Analysis of Employment Impacts

In this study, two scenarios were set up to analyze the impact that several interventions would have on primary sector employment. These actions include sustainable (more ecologically balanced) management practices (e.g. no-till cultivation, expanded natural fertilization practices), research and development, integrated pest control and rural value-added food processing, but also conservation and reconstruction of forest and fish stocks (through, for instance, afforestation and reforestation as well as fish stock management measures and the expansion of aquaculture). Investments -catalyzed through subsidies, shifts in taxation, contributions to capital investments, etc.- are estimated for two scenarios, reaching respectively $100 Bn per year and $180 Bn per year (or approximating 0.12% and 0.2% of annual world GDP on average over the next 40 years). This total investment is assumed to be invested in two ways: in green agriculture interventions (green agriculture: GA1 and GA2) and in more conventional industrialized agriculture practices (conventional agriculture: CA1 and CA2). Finally, climate change impacts are assumed to be the same for all scenarios.

With these assumptions, the projected additional agriculture and food employment (that could be considered green if the interventions are implemented correctly) ranges between 1,650-1,730 million in 2050 in GA1 and GA2 (i.e. 8-13% higher than business as usual -BAU; 3% higher than CA1 and CA2 scenarios; and 52-59% above today's level). Green agriculture jobs tend to rise slowly over time, as more practices are adopted. Net short-term declines in employment are projected for fishery and forestry (in the range of 2 to 5 million jobs), where the effects of reduced production (driven by conservation measures) offset the gains in natural resource management and stock rebuilding. On the other hand, in the longer term higher natural stocks support the creation of new and additional jobs relative to BAU (n the range of 5 to 15 million jobs). In particular, adoption of sustainable management practices accounts for 362-630 million of employment gains in CA1 and CA2.

Of relevance, the production of second generation biofuels is projected to reach 250-844 billion liters of gasoline equivalent per year in 2050. This level of production is projected to require between 12%-37% of annual agricultural and forestry residues as feedstocks and creates between 330,000 and 1 million jobs. This figure could increase up to 3 million if a mix of agricultural residues and conventional, purposely grown biomass feedstocks are used.

Worth mentioning, by 2050, the GDP of the primary sector would reach $1,835-1,850 billion in green scenarios (i.e. 20-21% above BAU and 19-20% higher than CA1 and CA2). Of this total production, the crop production segment ($554-586 billion) would outperform the BAU and CA1 and CA2 cases by 11-17% and 6-10%. Per capita income, if distributed in a just manner, would therefore increase among farmers even without considering relevant price premiums for greener produce. Also, this result indicates that –at least a portion of the- existing subsidies to conventional agriculture could be reallocated to finance the transition to green agriculture, as the gains would outweigh the costs.

In both the GA and the other scenarios, we observed a *decline* in the aggregate global *agriculture employment to GDP ratio* after 2010. This is due to a combination of factors that increase productivity for the sector (i.e., more value added is produced by each worker). Nevertheless, the green agriculture scenarios result to be more labor intensive than the CA and BAU scenarios. This is caused by the synergies existing across the various interventions simulated, which allow increasing soil quality, reducing water stress and pushing yields, while requiring more labor (as mentioned in Section 2). Social development also plays an important role in the GA scenarios. In fact, with better nutrition and an increase in income, which in turn –among others- effectively increases life expectancy and education levels (especially for girls in rural areas), an improved access to appropriate farm mechanization technology becomes possible, practically increasing labor productivity.

4. Policy Analysis: Balancing public and private responsibilities

This section analyzes important social, economic and environmental policy proposals that could help stimulate job growth in the green agriculture sector. There is a growing recognition that governments will have to take the initiative in encouraging and supporting private sector efforts to adopt green agriculture practices (UNEP, 2008). Once these are embraced and begin spreading, increasing yields and value added in combination with higher employment would support the transition to a more self-sustaining sector.

The policy options analyzed for intervention include both financial and regulatory measures such as subsidies, taxes, public R&D, international assistance and regulated standards; and marketing processes and voluntary efforts (e.g., eco-labeling and certification programs).

Public and private investments

With the social, environmental and economic challenges ahead, there is an opportunity to re-connect agriculture with its "green" roots. However, the pace of such a transition will be determined by the degree to which individual countries and the international community are able to stimulate widespread adoption at an unprecedented pace and scale. This transformation towards green agriculture practices and the creation of millions of green jobs will require significant investments in the development and implementation of efficient, productive and sustainable agricultural practices. As green agriculture is relatively more labor intensive and also requires greater application of appropriately scaled farm mechanization capital, the present levels of investment are not commensurate to the task. Many of these investments could be funded by public and private partnerships, as the benefits would accrue to both sectors.

In the developed and industrialized countries, the key areas that require public financial support include reducing the expense of sustainable production equipment, farmer training and extension services and perhaps temporary compensation assistance for farmers during the early transition years when there might be yield reductions. In developing countries, green investment is primarily required for immediate soil improvements by increased organic and mineral fertilizer applications, improved seeds for food and fodder crops and also for the purchase or hire of minimum tillage farming implements. A radical change in policies as well as investments is needed to change the prevailing trends in these regions (IAASTD, 2009). For all farmers, both in developed and developing countries, training is the single largest investment need. In developing countries in particular, such training will also improve the quality of agricultural jobs and help reduce rural out-migration.

However, the lack of functional markets that could monetize valuations of the 'avoided externality costs' that are provided by environmental services reduces the potential of such beneficial programs to attract sufficient private investment. Without such markets, the private sector may be less enthusiastic about many green investment opportunities due to the longer time frames often required for productivity improvements to deliver competitive economic returns on such investments. Private capital investing has the tendency to be 'impatient.' Given the uncertainty of payments for environmental services becoming a valid incremental revenue stream for green agriculture efforts, it will be critical to undertake policy initiatives that mobilize public sector funding through a variety of fiscal policies and regulatory frameworks order to fund investments that support the creation of green jobs.

The source of funding for green investments cannot be explicitly defined at the global and regional level unless financing mechanisms are approved through international agreements. As various national governments may prefer to rely on different policies and strategies to support the transition to a green economy, projecting aggregate investment levels for a region can only be done with the use of scenario modeling assumptions. With specific national analyses, the source of funds can be explicitly defined and analyzed and more credible results would be determined based upon specific policies and funding sources.

Determining both the gross and net cost of moving toward a greener agriculture sector has various purposes. These include the need to estimate and disaggregate present costs and future benefits for the key participants involved, both in economic terms and as expressed by the preservation of natural resource stocks. It also supports evaluation of the impacts of policy options in light of their opportunities and risks. For instance, if a government has set an environmental goal (e.g. reducing emissions below 1990 levels) and decides to rely on incentives (e.g. tax breaks or discounts) to support the shift to lower emission levels, the buy-in of households and the private sector will be a key factor that will define the success or failure of the policy. In this case, the government risks missing its emissions reduction targets if the private sector does not participate as expected.

This policy option normally targets negotiated goals to mitigate the economic burden on households and the private sector. As an alternative case, when governments set mandates, the buy-in of households and private sector is assured by law, and the economic cost is either shared (if public incentives are offered) or fully allocated to households and the private sector. In this case an emphasis is put on reaching the policy target through mandates and the costs can be more easily estimated knowing that both public and private economic actors will have to assume the full costs of complying with the mandate.

A good example is PES, concerning public-private partnerships. Successes of developed countries may not necessarily be easily extended to developing countries due to the potential lack of reliable funding. Sources include the domestic market, the national government and international donors. Being the market often small in these contexts, funding should come from the government or donors. This could be the case when the externality created by a traditional form of production in a developing country also amounts to an externality for a developed country (global externality). Perhaps the most prominent example is the willingness of rich countries to pay for a lower carbon footprint of production in developing countries through the CDM (note that GHG emissions and CC are global externalities, i.e. also externalities for rich, developed countries). The same holds for payments that help maintain tropical rainforest (e.g. the Yasuni ITT initiative in Ecuador), protect global biodiversity or provide other general societal benefits.

Financial and fiscal shifts

Subsidies

Governments should phase out subsidies for unsustainable farming methods that rely on the intensive use of fossil fuel based inputs as these practices have resulted in negative feedbacks in conventional agricultural systems. In parallel, public agriculture policies should encourage and support efforts to restructure farming production methods to adopt more sustainable ecological agriculture practices. In many developed countries, large scale commodity crop agriculture is heavily subsidized or supported. These policies encourage the monoculture production of selected crops (e.g. corn, wheat, rice, soybeans, sugar and cotton) and raise the level of risk to those farmers who cultivate a more diverse variety of grains, vegetables and fruit. Such domestic crop price support subsidies or income support payments for commodity farming in OECD countries are distorting market signals and result in unfair competitive conditions relative to farmers in countries that do not offer such crop production subsidies. This public investment in high volume commodity crop production has been a key factor in the rapid growth of international trade in these commodities and has undoubtedly reduced private sector motivation and incentives to invest in developing countries' agriculture sectors for decades. The continuation of these subsidies is certain to hinder needed investments in the transition to green agriculture.

However, it remains controversial whether the reduction, removal or reform towards such decoupling would help developing countries. Ideally, with the gradual elimination of such 'perverse subsidies' for fossil fuel based inputs, governments would reapportion some of these funds to support the development of sustainable agriculture (as indicated in Section 3, which shows that higher returns would be achieved when investing in a green agriculture). It would be particularly useful if special consideration were given to those actions that create green jobs. Such areas include infrastructure construction (e.g. local water catchment facilities) and the purchase of equipment and application of products (e.g. minimum tillage equipment, local/regional organic compost production, adequate animal housing). Subsidies could also promote the dissemination of agroecological knowledge for sustainable agriculture through extension services and other means. Government initiatives could be instrumental in helping to create employment in the supply chains of these products and in providing temporary compensation assistance for farmers (especially during early phases of the transition when crop yields might be depressed). Such policy linkages can be complicated, as past experience in with the opening of OECD markets and their decoupling of subsidies have indicated that these reforms may favor conventional agriculture in both non-subsidizing OECD countries (e.g. Australia, New Zealand, etc.) and developing regions (e.g. in Latin America and East Asia). Care should be taken in defining transitional mechanisms for funding and trade.

In Europe, the recent reforms of Common Agricultural Policy (CAP) programmed aim to, among others, completely decouple agricultural subsidies from production, and award farmers according to their contribution to environment conservation and farm employment (Ventura-Lucas, 2002; IAASTD, 2009). There has been some criticism that the schemes do not deliver all of the environmental and biodiversity benefits for which they were designed, especially as the scale of implementation becomes too small and fragmented (Whittingham, 2007). One option that avoids this situation is the adoption of regional planning approaches (e.g., the OECD environmental farm plan programs) to generate more coordinated land use patterns across larger landscapes (Manderson et al., 2007).

Payments for ecosystem services (PES)

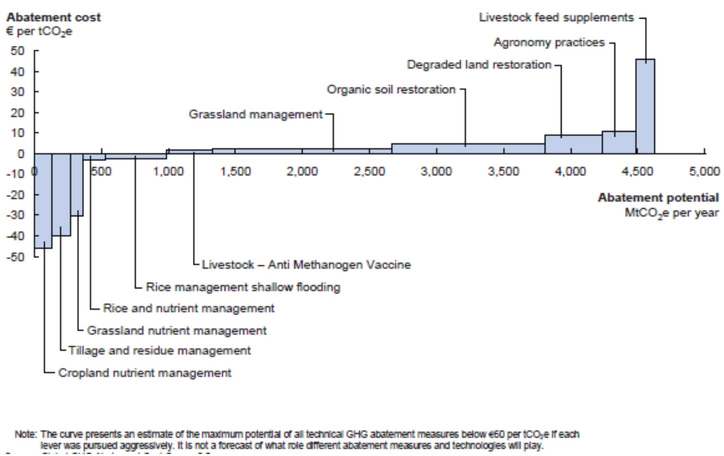
Many policy makers are beginning to consider the long term economic and environmental benefits of establishing programs that would recognize and financially reward farmer and forester efforts to restore and sustainably maintain the health of local rural ecosystems. These initiatives, known as Payments for Environmental Services (PES) would monetize the value of reduced GHG emissions, increased carbon sequestration in soils, improved forest and watershed resources, conserved fresh water resources, reduced sedimentation of lakes and reservoirs, pollination and pest management by enhanced biodiversity, and other positive 'externalities' that are now 'freely' provided by sustainable agriculture practices. An excellent overview of PES project initiatives can be found in the USAID report, "Lessons and Best Practices for Pro-Poor Payment for Ecosystem Services" (Jindahl, R. et al. 2007).

One of the pioneering efforts in this area is the recently announced "Kenya Agricultural Carbon Project," in which the World Bank's Carbon Finance Unit entered into an Emissions Reduction Purchase Agreement (ERPA) with the NGO, Vi Agroforestry for their coordination of approximately 40,000 small holder farmers' adoption of a variety of sustainable agriculture practices (e.g. compost management, crop rotations and agroforestry) on 45,000 ha in western Kenya. Over the duration of the nine year ERPA, it is anticipated that the farmers would earn nearly $2 million (US) in PES payments that would complement the economic returns that are expected from gains in crop yields and other agricultural products.

Local capacity building and training for local farmers will initially be the primary tasks of this project. During the project's first phase, there will be nearly 70 field officers and another 20 supporting technical and management staff employed to execute this project in two Kenyan provinces. These new jobs would be incremental to the additional labor required to implement the sustainable agricultural farm and forestry activities.

The global potential to apply PES financial compensation for farmer and forester efforts to improve watersheds, restore soil quality and other actions is substantial. In considering whether efforts that mitigate GHG emissions and levels could be eligible as PES actions, a study of global GHG abatement costs (Figure 14) found that a wide range of green agriculture practices (e.g. organic soil restoration and grassland management) offer significant abatement opportunities that would pay back themselves in a few years of cost less than ten Euros per CO_2 equivalent ton (McKinsey & Co. 2009).

Figure 14: Global GHG Abatement Cost Curve for the Agriculture Sector (McKinsey & Co. 2009)



In spite of the limited application of PES to date, efforts are needed for further promotion. A key objective of PES schemes is to generate stable revenue flows that help reward farmers for reducing environmental pollution and other ‘externality costs’. In addition to protecting the ecosystem and creating employment, these initiatives also provide the opportunity to reduce the rate of rural-to-urban migration. In order to encourage the move towards a greener agriculture, such PES arrangements should be structured so that small-scale farmers and communities, not just large landowners, are able to benefit.

While most applications of PES have been in developed regions, these programs in developing countries, primarily supported by the government, have also established long-term win-win situations with both environmental protection and employment creation especially for the rural poor – such as the Working for Water initiative in South Africa (Lieuw-Kie-Song, 2010) and National Rural Employment Guarantee Scheme in India (Government of Maharashtra 2006; Lieuw-Kie-Song, 2010). Thus, PES in developing countries has a significant potential to generate socio-economic benefits by providing productive employment for poor and marginalized rural populations. However, general assumptions that PES programs will assist the poor or stimulate employment should be tempered with a recognition that determining who are the primary beneficiaries is highly dependent on who holds the rights to the natural resources that are being managed and who has land ownership rights for the areas that are subject to PES incentives (FAO, 2007).

Many parts of the world are in acute environmental distress with extremely low productivity. In the extreme case of Haiti, due to severe deforestation, soil erosion and flash floods in many areas, the land productivity is already too low to sustain healthy livelihoods. PES programs could help finance long-term investments in restoring natural capital required in these areas; and subsequently help create opportunities for sustainable employment. In addition, people in many areas are engaged in natural capital destruction under very poor occupational conditions, such as deforestation in the Amazon region in Brazil. While they do this generally for a lack of better options, PES programs could offer alternative employment with better working conditions in environmentally sound activities like reforestation or other agro-forestry activities.

Tax reforms

Another policy to address agriculture's environmental externalities is to advance an ecological tax reform, which makes more sense than merely imposing a new tax. By scaling-up and expansion of eco-taxes (e.g. taxes on carbon and pesticide use), governments have a better chance of meeting their tax revenue targets, increasing employment and helping clean up the environment at the same time (Elkington et al., 1998). For instance, revenues from eco-taxes can allow the reduction in payroll taxes that stimulates employment and economic activity, or tax exemptions for biocontrols to promote integrated pest management.

Some OECD countries adopted environmental taxes on agricultural inputs as a part of a policy package to reduce the environmental impacts of pesticides, fertilizer, manure waste as well as energy use. Denmark, Norway and Sweden, for example, have introduced taxes on pesticide use, as incentives to reach pesticide use reduction targets. Similarly, the Netherlands imposed an excise manure tax (IAASTD, 2009). Unfortunately, eco-taxes are frequently weakened by granting a variety of exemptions, such as lower tax rates to energy-intensive firms (UNEP, 2008).

There have been positive results with such taxing policy, as seen in Germany where an eco-tax levied on different forms of energy consumption has successfully helped avoid emissions of more than 7 million tons of carbon dioxide between 1999 and 2002. Reductions in social security contributions made possible by these funds helped create 60,000 additional jobs by 2002 and possibly as many as 250,000 by 2005 (Umweltbundesamt, 2002 and 2005). However, in many low-income countries such taxes may be hard to collect, particularly with large informal sectors (Panayotou, 2000; Bhagwhati, 2005) unless private companies are taxes directly.

Research and extension

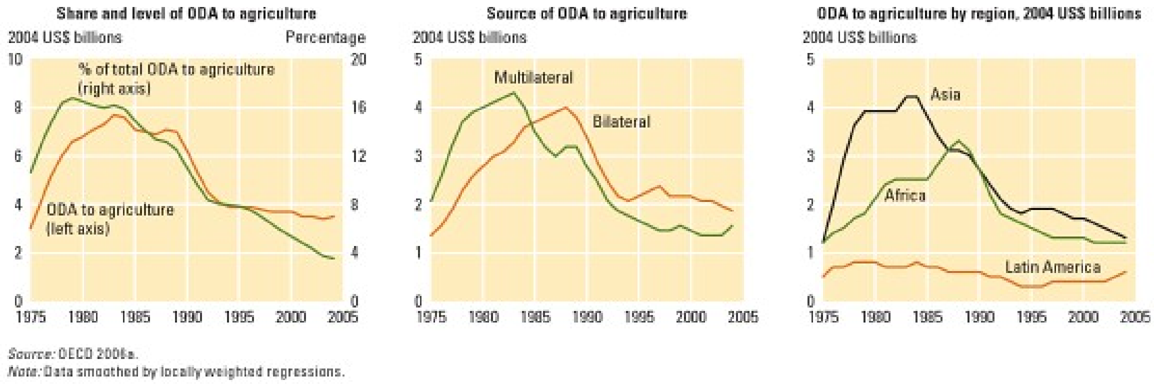
High-productivity sustainable farming is knowledge and science intensive and requires both site-specific research for adaptation to different farming environments and widespread training of extension specialists and farmers. A shift towards a sustainable agriculture will depend upon many disciplines including soil biology and fertility; water management; biodiversity conservation; food systems; integrated pest and vector management; and covering many cross cutting socio-economic issues. Investments in strengthening these activities would create new and decent employment opportunities and would lay the foundation for more sustainable rural livelihoods.

There are significant knowledge gaps in rural labor markets with regards to green job opportunities. A large portion of agricultural workers has limited access to education and training, which directly contributes to the labor market's poor wages. As the promotion of decent work is integral to green job creation, policy interventions are needed to support the investment in research and knowledge generation for all rural groups; including females, youth and subsistence level farmers. Historic attitudes that "small farmers need to be taught" have led to frequent failures of some extension service programs. A greener agriculture needs a more integrative and participatory learning process in which farmers and professionals in agro-ecological sciences work together to determine how to implement best practices and make new discoveries. Therefore, their adoption requires the education of specialists. This could also include the regular collection, interpretation and use of age and sex disaggregated data (ASDD), in both the formal and the informal economy.

International development assistance

There has been a disturbing trend over the past several decades of continual reductions in wealthier nations' Official Development Assistance (ODA) aid that has been provided to support agricultural development in the developing world. Despite the central role played by the agriculture sector in most of these nations, other economic sectors and various social institutional programs have been the greater beneficiaries of foreign aid. This trend needs to be reversed if green agriculture transitions are to be given the stimulus needed to progress forward in these countries.

Figure 15: Agriculture's declining share of Official Development Assistance (WB, 2008)



Reorienting the priorities of national and multilateral development assistance agencies as well as export credit agencies away from unsustainable projects and toward greener alternatives is an urgent need. The EU, for example, has signed preferential treatment for agricultural producers in sub-Saharan Africa, though it was unable to reverse unsustainable trends in these areas (European Commission, 2008).

Regulatory measures

Targets and mandates

Mandatory regulation and standards, especially related to animal and plant health and food safety need to be better integrated on an international basis to more effectively utilize the limited national resources that may be allocated for these activities. Stronger mandates for natural system conservation are needed in both developed and developing countries (IAASTD, 2009). Regulatory tools such as land-use policies should be reformed; with particular attention to establishing farmers' legal rights to the land that they cultivate in order to ensure that they are the prime beneficiaries of their investments and labor that are committed to restore and sustainably manage these natural assets through green agriculture practices. However under some circumstances where related markets exist, such as in the case of the organic farming scheme in UK, cautions should be taken on whether to set targets for organic conversion, as an arbitrarily set target has the danger of disconnecting the industry from the market. In such cases, responsive manners to the requirements of the market may be suggested (University of Cambridge, 2002).

Stronger regulatory oversight of farm labor occupational health and safety conditions are recommended, with particular attention to the proper handling and disposal of pesticides and herbicides. Improved attention to mitigating these occupational health risks would also have the indirect effect of demonstrating the value and cost benefit returns of biological practices for managing pest and weed threats to farm productivity. Similar attention should be given to improving food safety and food processing quality in order to improve small holder farmers opportunities to participate in the supply chain for higher value food products and to supply urban domestic and foreign export markets.

Certification

Certification programs are intended to enable access to higher value markets for producers who can provide objectively verified evidence that the production methods that they have useed comply with specific environmental and to some extent social and ethical standards (e.g. USDA certified organic products). The veracity of such products' quality claims are determined through both third party certification and to a lesser extent by participatory guarantee processes.

As is presently implemented in the US, third party certification of organic products requires that an authorized, credible party other than the producer audits the individual farmer's production process and detailed records of input use. These assessments follow an array of requirements that have been standardized by government regulations in order that such products are deemed eligible for whatever premium prices may be assigned by the consumer market.. The US organic soybean and milk certification, for instance, remains critical to producers, without which they would be subject to the same competitive pressures that have lead to lower prices that are faced by conventional producers (UNEP, 2008). While there are examples of developing country farmers who have benefited from third party certification (Hatanaka et al., 2005), arguably these standards discriminate against resource poor farmers who cannot afford the high costs of participation (IAASTD) but could potentially be addressed through group certification processes. Internationally, the private sector in developed countries, which is driving third party certification, should promote the harmonization of private sector standards and streamline accreditation, especially where these apply to plant products produced in developing countries (Jaffee, 2005).

The alternative approach, participatory guarantee systems (PGS), involves less administration and relatively lower costs, members of a cooperative organization inspect each others' farms, share information on improving their crop production and agree to farm in accordance with international organic farming standards. In the developing world, for example, the International Federation of Organic Agricultural Movement (IFOAM)'s PGS programs help small producers to adhere to organic farming standards via social networking, e.g. knowledge sharing and mutual monitoring (IFOAM, 2010).

The certification programs may also provide a stimulus for the development of off-farm employment opportunities through the provision of services such as accreditation of farms or production systems (IAASTD, 2009).

However, certification may face several problems that are typically associated with niche markets and may face limited prospects for market expansion. Furthermore, accreditation and control systems are essential to enforce organic standards and regulations to meet general quality requirements. It is also warned in some studies (IAASTD, 2009) that the system is extremely expensive and unless charges can be passed onto consumers the ability of poor producers to comply with such regulations will be doubtful. There are efforts underway to develop group and 'participatory' organic certification processes that could reduce the transaction costs incurred by individual farmers. By coordinating organic practices, and input procurement record keeping activities within farmer cooperatives and grower associations, more farmers may be encouraged to begin the multi-year process of gaining organic certification and the costs of doing so would be commensurate with the additional earning potential for premium priced crops (Khosla, FAO. 2006).

Land reform support

In order for farmers in the developing world to significantly invest their labor and capital in green agriculture transition efforts, major land rights reforms will have to be implemented. As many of the green practices improve farm productivity over a period of several years, farmers need to have confidence that they and their families would enjoy the longer-term benefits that are gained from the work they do now. Unless there are improvements in land tenure and ownership rights for poor farmers, it is unlikely that they would make the full measure of investments that are justified by the economic returns over time.

It is particularly critical to address and rectify current conditions where women farmers are denied equitable participation in the natural capital assets that they tend and manage. For real global progress to be made, it will be essential that women are legally conferred land rights and rights to water to provide a strong foundation for their work in applying green farming practices. Much work has been done to reform land rights, particularly in the NGO community. There are promising examples of national and provincial government actions; such as West Bengal's recent revision of property deed registrations to include women spouses as co-owners (see Landesa.org) that are beginning to resolve this challenge. This is without a doubt one of the more difficult issues that must be resolved in order that many countries could begin a transition to green agriculture.

Branding and Marketing Initiatives

Eco-labels could be adopted for all consumer products to ensure that consumers are more aware of the environmental conditions and impacts incurred in the production of the products that are being marketed. Such access to this type of information would be needed to enable consumers to make more responsible purchasing decisions with regards to the direct and indirect impacts of their consumption behaviors. It is anticipated that as consumers become more knowledgeable of the 'ecological footprint' of their own actions; there would be an associated increase in market demand for more eco-friendly products, which would encourage manufacturers to adopt more sustainable practices.

It is also critical to address the need for better public awareness and understanding of the relationships between eating habits; health impacts and the wide range of ecological and resource pressures created by consumers' food choices. The disparity between continued malnutrition among more than a billion people throughout the world; and the growing 'epidemic' of obesity and diabetes among millions of people whose diets are heavily skewed towards animal fats and highly processed foods is cause for great concern. Policies are needed to inform consumers of the health and environmental implications of their diets.

One of the most comprehensive eco-labeling programs, Germany's "Blue Angel" has been in existence for twenty five years, covering nearly 100 products in 1981 and now more than 3,600 today. Another eco-label, developed in 1992 by the Swedish Confederation of Professional Employees (TCO) now covers more than 7,000 products and 100 manufacturers worldwide. Many developing countries (e.g. India, Indonesia, Thailand, Philippines, etc.) have also adopted or are developing eco-labels. However, as these labeling programs proliferate, there are emerging problems of vague claims or low performance standards that may result in discredit of such labeling schemes. Thus, regulatory instruments or qualified certification bodies may be needed for verification (OECD, 2002).

Moreover, many export-oriented economies rely on cheap and exploited labor. Public policy and private market sourcing strategies should be cautious to not only be concerned about a single-minded focus on 'greening' products and their underlying business practices. Social equity and fairness are also important issues that need to be included in the broad category of eco-labeled goods. Future jobs need to be not only green but also decent with regard to wages, labor conditions and workers' rights.

Decent Work and Equity

In addition to absolute number of jobs created, it is important that green job opportunities should qualitatively be for decent work, i.e. "under conditions of freedom, equity, security and dignity, in which rights are protected and adequate remuneration and social coverage is provided" (UNEP, 2008). While much of the employment in green agriculture should generally support environmental goals, such as biofuel feedstock plantations in Latin America, many of these jobs may be of lower quality, with low wages and long working hours under extremely poor working conditions. There is also the potential for labor problems concerning conditions of forced or child labor, especially in developing countries. While enormous decent work deficits exist for both smallholders and a large portion of the waged agricultural workforce, women and children are the most exposed to these challenges. Thus government policies and strategies are necessary to promote decent jobs and address equity issues, as these will be critical to facilitate a green transition, reduce poverty and achieve inclusive and sustainable development (UNEP, 2008).

Gender equality is an integral cross-cutting theme in the decent work agenda. Women are disproportionately affected by extremely poor working conditions, and they are less likely to benefit from green agriculture improvements because they represent a majority of the world's poor and have less access to agricultural resources (such as land) and education. Active labor reform policies, job standards and broad social protections are essential to ensure the rights of workers and their communities. It may be useful to link the green subsidies and tax incentives that are provided to private enterprise with requirements that they provide decent pay, benefits and safe working conditions to their workers. Legislation should also support adequate training and educational opportunities in order to create green jobs skills with a specific emphasis on promoting gender equality. It is also important to promote the participation of both women and men in decision and policy-making processes (UNEP, 2008; ILO, 2010).

Young people are also facing critical challenges in finding gainful work in rural areas (UNEP, 2008); they currently account for 47 percent of the total unemployed globally (FAO/ILO, 2010). In order to promote youth employment, major rural development policies and investments should specifically address the views and needs of young people and include technical and vocational education training as integral elements of funded programs (FAO/ILO, 2010).

Other enabling conditions

Enabling conditions are a broad set of factors that impact more economic sectors than exclusively agriculture. These conditions must also be addressed in order that the specific investments in green agriculture initiatives are actionable and have successful outcomes. Key enabling conditions for transitioning toward a green agriculture sector are briefly discussed in the following section.

Construction of roads for transport of inputs and outputs to and from farms

Rural road networks must be extended and improved to provide more farming communities with reliable access to regional markets and urban centers. The need for such investments is greatest in Africa (IFPRI, 2009); although other regions also have significant needs that must be addressed. When improving rural transportation, we should also consider railways and waterways that could serve many common needs in an environmentally sound and energy efficient manner. This improvement will provide work in construction, maintenance and operations of transport systems.

Rural electrification and internet access

In addition to building a good transportation network; making rural areas attractive enough to dissuade rural populations from migrating into urban areas will need to assure affordable and reliable power supplies to farms, villages and small towns. It is important that sustainable energy and power services are made available to the small and medium enterprises that would be provided farm related inputs, products and services. Such AP supply chain operations will help create many non-farm jobs that are necessary for the maintenance and establishment of vibrant and prosperous rural communities.

Trade regulation

Trade can be both, very positive and negative for agricultural development. It is therefore very important that the trade policies are adjusted to promote local production even if this has to be done with subsidies, until the local agriculture has reached a level that is competitive with the rest of the world. The Doha Round of trade negotiations, which encompasses also agriculture, is therefore important for LDC agriculture and the LDC need to make their interests prevail.

Rural village and small town development

The above amenities are only part of what is required to develop rural centers that are attractive for people and businesses to settle in a rural environment. There is a need to invest in education institutions at all levels as well as in health sector facilities. It is also important to develop local food systems, both in terms of more self-reliant food economies and urban/rural networks through short supply chains. These in turn will create new local jobs, reduce food-millage and propel the green economic development in the rural areas. For this to happen, investment in agro-processing and agro-input and products manufacturing and maintenance will also be required.

Strengthening small producers' access to green job opportunities

Strengthening small producers' access to green job opportunities requires removing the barriers that smallholder farmers traditionally face, with lack of land access being particularly essential to agricultural activities (UNDESA, 2007). Another notable challenge is the obtainment of credit and thus capital from traditional financing institutions compared to large-scale producers (UN Energy, 2007). In such cases, governments can either provide these producers with favorable policy and technical support to reduce the perceived risk, or directly offer loan guarantees, soft loans or alternative credit delivery systems such as microcredit (CFC, 2007).

Small farmers also traditionally lack of access to technology, equipment and training, making so that the role of governments is critical in supporting them and providing assistance in terms of technologies, products and equipment, and capacity building, including training of farmers and transfer of technical and managerial skills. In particular, access to agricultural extension services should be ensured for small-scale farmers, and for both male and female producers, in order to disseminate best practices, facilitate farmer-to-farmer participatory learning, and encourage and address farmers' requests for technical advice (UNDESA, 2007; UN Energy, 2007). This intervention, if correctly implemented, could also increase the quality of employment.

The small farmers' lack of access to markets also needs to be addressed. They can be organized in cooperatives that could more effectively link independent growers to these large groups, allow them to benefit from the economies of scale to meet more easily and efficiently the feedstock production volume and reliability requirements for conversion facilities (Rossi and Lambrou, 2009).

Within support to sustainable small farming and local food systems, essential opportunities lie in the promotion of greener farm non-farm linkages and establishment of local markets for agribusiness. Potential creation of non-farm jobs include the production of green agricultural inputs (e.g. organic fertilizers, watershed management infrastructures) and farm equipment, sales and technical services, and post harvest supply and distribution chains. Non-farm enterprises associated with agricultural activities are important for creating more and higher paid jobs in rural areas as farm productivity increases. Additionally, the development of local food systems, such as expansion of retail outlets, could contribute to the reduction of farm-to-market distance, effectively reducing costs and mitigating emissions from transportation. Such development may further be enhanced through charges to internalize social and environmental externalities of transport, such as "food mile" taxes (UNEP, 2008).

Medium and long-term development roadmaps

It would be very useful for individual countries and multi-nation regional organizations to invest in building their own capabilities to develop medium and long-term roadmaps that define 'green agriculture' milestones for meeting the country's MDGs or other development goals. Such a capacity would allow governments and private sectors to measure their progress; evaluate the impact of their investments; and guide policy makers in making needed adjustments to stay on their selected development path.

5. Conclusions

The global agriculture sector is in need of a fundamental paradigm shift towards more sustainable practices and underlying input technologies. This transition is projected to create more employment (over 200 million full time jobs in 2050), particularly more decent green jobs across the entire food production system. This employment growth would include more labor intensive green farming practices operations, management and preservation of ecosystems, research and development and training of rural populations in the use of green agriculture technologies (Pretty et al, 2006; UNEP, 2008; UNDP, 2009; FAO, 2007; WB, 2008). Job losses in some sectors may occur, especially in the short term if current levels of post harvest food losses are considerably reduced and resource use efficiencies are consistently increased. On the other hand, additional jobs would be created in localized production of inputs, manufacture of mechanized farm systems and construction and maintenance of local and rural infrastructures, as they must necessarily accompany the transition. The direct employment in green input supply chains would increase in line with the increased farming sector demand for these products. Finally, with the benefit of farm mechanization and improved rural social conditions, there would be lower labor intensity per unit of agricultural output that would lead to higher per capita incomes (i.e. rising GDP per capita) due to increases in yields beyond those projected for continued business as usual (BAU) investment decisions.

In fact, the transition to green and more sustainable farming practices is expected to enhance agricultural production and improve the quality and quantity of food supplies (with the GDP of the primary sector rising to over 20% above BAU in 2050). It would also curb the excessive use of natural resources such as fresh water and gradually replace inorganic inputs with ecologically sourced alternatives. This transition would be catalyzed by R&D that is focused on agroecological sciences and be driven by a widespread emphasis on farmer field schooling and associated extension services. These economic gains would be further complemented by significant reductions of GHG emissions, especially those that are avoided due to reduced use of mineral fertilizers and the reduced pressures of deforestation land use changes.

The resulting restored ecosystems would improve biodiversity and contribute to much higher levels of agricultural adaptation and resilience to climate change impacts. With the combined gains in employment and productivity, a greener and more sustainable agriculture sector would bring solutions to the currently worsening hunger-poverty-environment nexus. While achieving this envisioned green agriculture transformation is feasible, such a shift will require substantial new investments in the actions and policies discussed in this report. It must also be recognized that the positive benefits and economic returns from such investments may often have delayed effects in the near term as agriculture’s natural capital assets are restored and enhanced through this process. It is expected that there would be comparatively better economic and social performance of the green agriculture sector over the mid-to-long term, with the considerable added benefits of healthier planetary ecosystems and less depleted natural resources available for future generations. Given the enormous tasks ahead, timely and effective actions are needed now to begin this transition.

The management and preservation of ecosystems and biological diversity has the potential to create employment in combating soil erosion, rehabilitating degraded land, restoring forest reserves, and guarding and management of protected areas, eco-tourism and ago-forestry, etc. The sustainable development of natural resources can also help ensure long-term income for rural local populations. Successful examples have been seen in both developed and developing countries and in rich or threatened biodiversity areas. The employment gains that have been realized through wildlife conservation in Britain, the increased incomes of cattle farmers who have adopted silvopastoral practices in Latin America, and the conservation of upstream watershed areas in Ecuador are indicative of the potential job impacts of an expanded payments for environmental services labor demand.

Organic farming and local value added food systems can lead to positive net employment gains, as these farms are more labor-intensive than industrialized farms and are often accompanied by on-farm or local food storage and processing and non-farm enterprises that produce organic agricultural inputs. The benefits of organic agriculture have been demonstrated in the successful cases in Uganda and UK. In addition, these expanded on-farm and off-farm activities and associated higher skilled job opportunities generally have an additional economic benefit of local multiplier effects that are seen with the extended circulation of local income earnings within the rural local communities.

To support this transition and promote the creation of decent jobs, changes in policy interventions are required in terms of both fiscal measures (such as subsidies, taxes, public R&D) and regulatory actions (such as standards, mandates and certification procedures) and public information and awareness campaigns. Funding needs to be leveraged internationally, especially with regards to interventions that need to be made in developing countries, as their poverty levels and limited access to financial capital and foreign exchange severely constrains their ability to undertake broad based agriculture sector transitions.

More specifically on the matter of public funding, governments might consider allocating the funds for subsidizing green farming transition activities from parallel policies that reduce existing subsidies that encourage inefficient and unsustainable farming practices (e.g. excessive use of fossil fuel based inputs; monoculture crop production; etc.). However, not all subsidies are clearly positive or negative. Despite the often negative impacts of price support subsidies for selected commodity crops in developed countries; which place developing countries' agriculture sectors at a competitive disadvantage, the effectiveness of linking the rise of one set of subsidies with the reduction of another remains controversial.

An alternate policy initiative could be the development and implementation of PES programs that could motivate farmers to reduce their adverse impacts on the environment by offering compensatory incentives for efforts to enhance the ecosystem services that are created by green agriculture practices. However, PES financial incentives must be based on credible evidence of the environmental benefits that would be realized by such actions. This will require substantial international collaboration to develop the scientific means of monitoring and verifying both the baseline conditions and the subsequent beneficial ecosystem gains that are delivered by farmers' efforts on this front.

Tax reforms could also be a viable option in some national contexts, particularly in those cases where the imposition of eco-taxes have the effect of reducing the tax burden falling on labor inputs while discouraging the further depletion of non-renewable resources and associated carbon-intensive economic activities. R&D on agroecological sciences and technologies will be vital to the introduction and implementation of cost-effective green practices. Finally, in low income regions where the agricultural sector is struggling against lack of financial resources and inadequate investment; expanded and more targeted international aid from developed countries for green transition programs would be a vital source of funding that could help attract matching private sector investments.

In terms of regulatory measures, targets and mandates could be used to develop green production and employment in protection of natural resources (e.g. forest preserves) while taking into account existing markets. Eco-labeling could be further developed to motivate manufacturers to design and sell more eco-friendly products by providing consumers with access to information that describes and confirms the practices behind the products. Better certification schemes would guarantee the compliance of products with environmental and quality standards; and would help justify the premium prices that could help farmers to earn profitable returns for their added efforts. Harmonized standards and regulations are necessary to enhance the accreditation of both labeling and certification systems in the context of rapid growth across both domestic and international markets.

Many challenges confront the future of agriculture, and the system for analyzing optimal transition paths is complex. The removal of subsidies on domestic crop prices in developed countries is often seen as possible solution. However, recent experience in which some OECD countries have decoupled their farm subsidies from commodity production has so far failed to indicate favorable impacts for accelerating a green transition in such countries. Also, although there have been a limited number of PES programs that have brought higher rural employment and income to a few regions of the world, there is a considerable lack of encouragement for most farmers in developing countries where stable and reliable funding is not available. Eco-taxes adopted by many OECD countries have resulted in limited accomplishments to date due to frequent exemptions being granted to incumbent industries. Furthermore, most eco-taxes in developing countries still require better defined regulations and standards in order to be effective. Finally, although low-income countries have opportunities to participate in organic certification programs that have been successful in Europe and the United States; the former countries' domestic markets and their access to international markets remain very limited.

Therefore, given the significant impact of specific conditions (and national contexts) in the agriculture sectors, policies should be carefully designed to complement existing social, economic and environmental national goals. It is also important that national policy makers support efforts to harmonize national and regional standards, certification processes and other program instruments to promote internationally recognized frameworks for advancing green agriculture initiatives. Working towards policy alignment on organic food certification, food health and safety, methodologies for determining GHG emission impacts and verification of environmental benefits and other issues will be critical for success.

Achieving the transition to a more sustainable agriculture that delivers more employment opportunities will require that many general enabling conditions are adequately addressed. These include infrastructure and institutions (roads, power, telecommunications, schools, hospitals, access to credit, health and crop insurance, etc.) and better and more transparent governance (long term national planning, commitments to food and nutrition security, land rights reforms and the elimination of subsidies for unsustainable farming methods and inputs). There are also major international conditions that need to be addressed in order to facilitate improved market access and trade parity between rich and poor nations (e.g. country of origin value added food processing, import subsidies and fair trade agreements).

Several options are available, and evidence of successes and failures is becoming more and more available. It is now a matter of evaluating options, in concert, to find synergies and avoid dead ends to make the best of the funding available to support social development and environmental preservation simultaneously.

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Appendix I: Analysis of trends in the agriculture sector

Employment

The proportion of the world's agricultural labor force defined as that part of the economically active population engaged in or seeking work in agriculture, hunting, fishing or forestry has been in decline for several decades (ILO, 2009; World Bank, WDI, 2009). It covers employers; self-employed workers; salaried employees; wage earners; unpaid workers assisting in a family farm or business operation and members of producer cooperatives involved in all phases of agriculture input and output systems, with the possible exception of retail services (UNEP, 2008). In 2006, 36.1 percent of the globe's total number of employed people, or around to 1.3 billion people, made their living from growing food and raising livestock; as compared with 44.4 percent in 1995 (UNEP, 2008). The shrinking proportion of employment in agriculture and related industries has been primarily due to labor capacity losses through the out-migration of rural population into cities; lower labor demand per unit of output levels that are driven by productivity improvements throughout the global food system (particularly in mechanized commodity farming); and the rapid growth of non-farm jobs in the industrial and service sectors of a consolidating global food market. (IAASTD, 2009; UNEP, 2008).

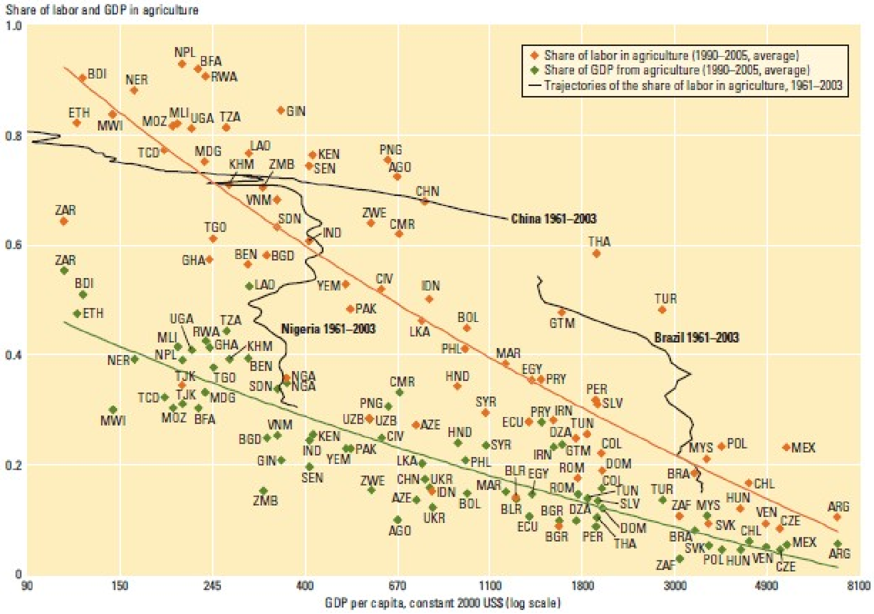
Rural out-migration of adult males, poor rural health conditions and unfair market systems have reduced the capacity of many small-farmer communities to effectively apply their traditional labor-intensive farming practices due to labor shortages and illness. Key reasons for rural migration to cities are the limited economic returns from agriculture and poor access to health, education and modern civil services and cultural activities (IOM, 2007). Whereas in the industrial countries the rural-to-urban shift took nearly a century, in the developing world the process of urbanization is moving at a pace two or three times faster (von Braun, 2007). In China, 81 percent of workers were employed in agriculture in 1950; by 2000 the figure was 50 percent. Significantly, at the global level there has been a tendency for people to move directly from agriculture into service employment. While the quality of service-economy jobs varies, a large number of them are informal and low paying. Many migrants from rural areas live in urban slums and confront the lack of safe water and sanitation; and find themselves in unhealthy proximity to pollutants from manufacturing, food processing and building construction (UNEP, 2008).

Mechanized, high-input, specialized monoculture commodity farming employs far fewer people (Lyson, 2005; Dimitri et al., 2005; Knudsen et al., 2005) in food production; even as its farm outputs have dramatically increased. These improvements in farm labor productivity have substantially depended on the substitution of capital equipment (i.e. farm mechanization) and agrochemical inputs for labor inputs. While there are significant benefits to applying advanced mechanization of farm work in terms of much higher output per worker; there have also been costs in terms of reduced rural farm jobs that have not been balanced by a commensurate increase in non-farm jobs. Such changes can lead to less stable rural communities due to the lack of new investments in the full agricultural value chain. Most farmers' ability to access and benefit from agricultural knowledge, science and technology (AKST) has been uneven at best; with industrialized countries gaining more than developing countries and with particular limitations being experienced by small holder farmers in Africa (IAASTD, 2009).

There is a considerable difference between developed and developing regions concerning employment trends in the agriculture sector - the share of the agricultural employment over total is generally lower in developed than in developing regions. However, there is a wide variation of agriculture's relative proportion of total employment across many developing countries as is demonstrated in *Figure 1*.

Despite the decrease in its proportion of the whole, agriculture continues to be the world's second largest source of employment. The number of people making their living from agriculture is enormous - currently over one billion - and it is expected to remain so in the near future (1.33 billion people by 2020 (FAOSTAT, 2010; Bassi et al., 2010). Among the labor force, about 450 million are wage-earning employees. There are notable trends of more women led farming households and more "casual" part time farm labor conditions in recent years. These trends often provide greater flexibility and lower labor costs for larger growers; although they may also have the effect of reducing livelihood stability for poor farm workers (ILO, 2010).

Figure 1: Share of GDP and Labor in Agriculture (WDR 2008, Ag Development)



Contribution of agriculture to income and GDP

Agriculture is a major source of income for rural households. *Figure 4* shows the participation in agriculture and income obtained from it in 14 countries. Between 60% and 90% of rural households derive practically all of their income from agriculture. In these agriculture-based countries, farm crop and livestock income and agricultural wages generated between 42 and 75% of rural income. In the transitioning and developed countries, the share of rural income from on farm work and agriculture sector wages is between 27% and 48%. Participating in agricultural activities does not necessarily translate into high agricultural income shares, especially in developed countries.[2] Particularly in developing countries, rural non-farm activities have dramatically increased their number of employees and have become a significant source of income for rural populations. Roughly one in four rural workers is employed full time in the non-farm rural sector. According to one study, Kenyan smallholders derive approximately 40 percent of their income from off-farm activities (Jayne et al., 2003).

Figure 4: Population in agriculture and their income share from agriculture.
Source: WDR Agriculture for Development. The World Bank, 2008.

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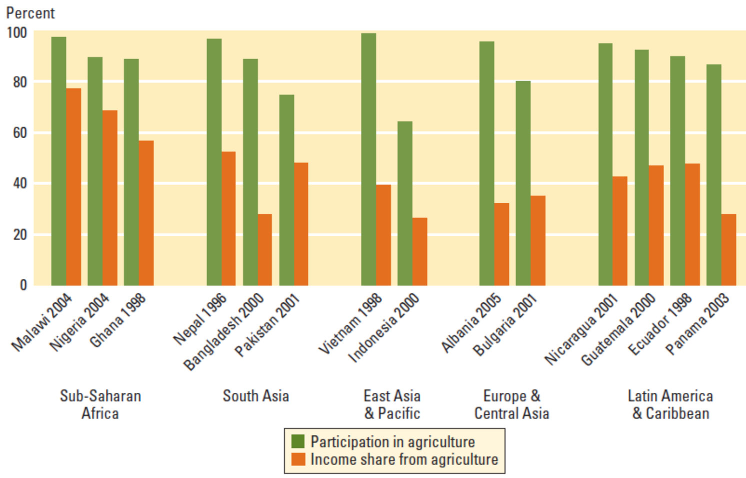
2 WDR Agriculture for development. The World Bank. 2008 (pp 77-78)

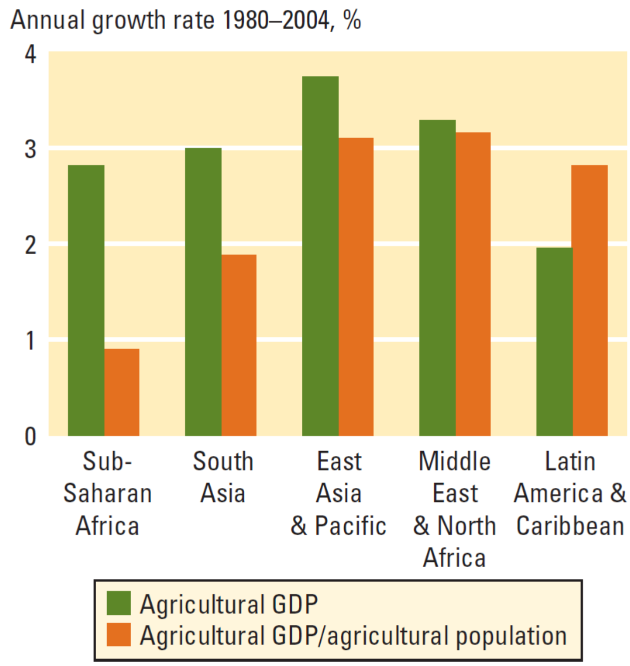


Despite the steady growth of the world's agricultural production over the past few decades (2.3% per annum on average in 1980-2004), its contribution to total global GDP output declined from around 4% during the 1980's to 3.5% today. This reduction of agriculture's share of total GDP should be viewed within the context of a worldwide transition from predominantly agrarian economies to industrial, high technology and service sector led economies (IAASTD, 2009). Although this declining trend was observed in all regions, developing countries achieved much higher average agricultural growth rates (2.6% a year) compared to industrial countries (0.9% a year) over the 1980–2004 period. Developing countries accounted for 79% of overall agricultural growth during this period. Their share of world agricultural GDP increased from 56% in 1980 to 65% in 2004 (WB, 2007).

On the other hand, per capita GDP (for population employed by and relying on agriculture) in the same regions grew by only 0.9% on average, despite a 2.8% growth in agricultural GDP, according to World Bank (2008). Concerning labor productivity, substantial disparities exist between developed and developing countries. The value added per agricultural worker in 2003 and average annual growth between 1992-2003 were respectively US$ 23,081 and 4.4% in OECD countries and US$ 327 and 1.4% in Africa. This wide gap is in part the result of historic social, economic, and political conditions; and also due to current national and international policies that tend to favor urban over rural areas. A radical change in policies as well as investments is needed to change this prevailing trend in the developing countries (IAASTD, 2009). Related to agricultural production, off-farm employment in the value-added food processing and related retail sectors has expanded, but the majority of these jobs are located in urban centers in the developing and developed countries.

Fundamentally, the key factor in creating green jobs in agriculture is transitioning the production of agricultural outputs from current unsustainable practices to more efficient and sustainable methods. As green agriculture productivity increases with higher yields and decreased consumption of often imported inputs; the enhanced profitability of this sector would be a stimulus for growth of both on-farm and non-farm jobs and other local livelihoods that are indirectly improved by the economic multiplier effect of agriculture expenditures within farming regions.

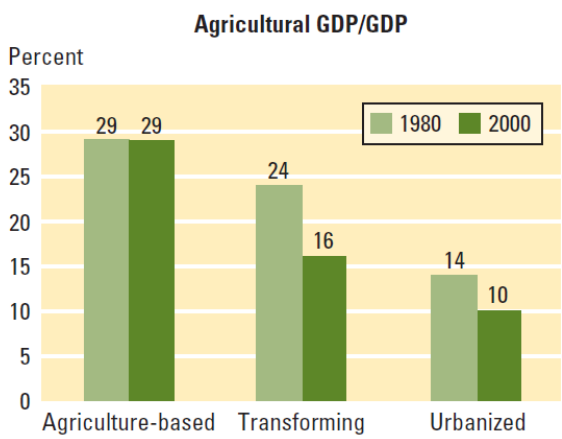
Figure 5: Growth in agricultural GDP per agricultural population in developing regions.
Source: WDR Agriculture for development. The World Bank, 2008; FAOSTAT, 2006.

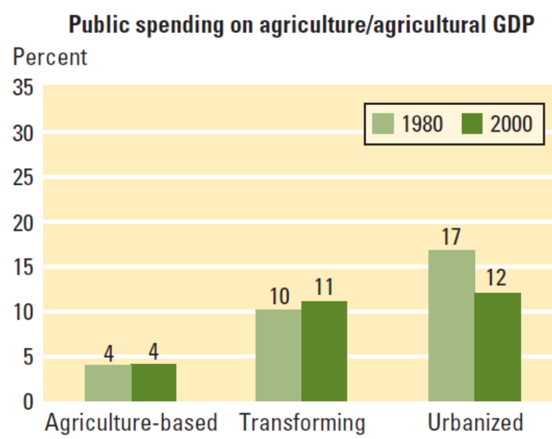


Agriculture investments

Public investments in agriculture were and still are very low in agriculture-based countries as a share of their agricultural GDP (4% in 1980 and 2000) when compared with successful transitioning countries when they still had a high share of agriculture in GDP (10% in 1980). *Figure 6* shows that in comparison to public investments as a share of agricultural GDP in manufacturing and service based economies; investments in agriculture-based countries are three times lower, although their share of agricultural GDP as a percentage of total GDP is three times as high (WB, 2007).

Figure 6: Share of agriculture in GDP (left) and ratio of public spending on agriculture to agricultural GDP (right). Source: WDR Agriculture for development. The World Bank, 2008.





Global consolidation of the agriculture market

Today's global food system is dominated by the rising market power of a consolidating agribusiness industry. According to several studies, a small number of large transnational corporations have been concentrating their market shares and influence over most major sub-sectors of agricultural commodities (e.g. grains, livestock feed, meat and dairy products) through both vertical and horizontal integration strategies. This growing market domination of the global food supply chain is also being matched by the continued pace of consolidation in the retail grocery sector. In 2004 the top ten food retailers were responsible for a quarter of global food sales; and the thirty largest firms had more than one-third of total food sales (ILO, 2007). The large market shares of leading grocery retailers, global food brands, and international commodity suppliers are effectively reducing the market negotiation power of small farmers and producers. These changing market conditions generally result in stagnant or declining returns to the farmers who produce these agricultural products (Murphy. IATP, 2002).

Small farmers are losing competitiveness to large capital-intensive farming operations that are able to supply high volume produce under contract to market leading distributors, processors and grocery retailers (UNEP, 2008). To become more economically competitive, some smallholders and entrepreneurs are moving into higher value, “new agriculture” products, such as cut flowers or biofuel crops at times. However, the cultivation of these crops often entails more environmentally damaging practices and create lower quality, casual employment. Many farmers who lack adequate economic and political support for their efforts to adopt appropriate agricultural practices may be forced onto marginal lands with fragile ecosystems by expanding large commercial farms (UNEP, 2002). These conditions have contributed to rural unemployment and are accelerating urbanization; and pose challenges to the development of green jobs in agriculture.

Employment benefits generated by global value added food supply chains have generally been confined to a relatively small number of developed countries. The great majority of food exports from developing countries are raw or minimally processed produce; and in these cases, the employment levels in the food system sector picture is far less positive. According to the ILO “trade integration can also lead to job dislocation, increased informality and growing income inequality (ILO, 2007a).”

In parallel with large multi-national enterprises’ (MNE’s) consolidation of power over global wholesale and retail food markets, there has been a similar rising level of market concentration across global supply chains for industrial agriculture inputs. These market conditions are particularly relevant in the manufactured and mineral fertilizer industry; and in the increasingly horizontal integration of hybrid crop seed, herbicide and pesticide manufacturing industries. A recent IFPRI analysis of the fertilizer industry found that the top five firms in each of the major fertilizer categories in the aggregate controlled between one half to more than three-quarters of the global market for each fertilizer segment (Hernandez, M et al. 2010). Further analysis of these industries are needed to better determine the degree to which such concentration of market power is impacting farmer productivity, profitability and employment levels on a global basis.

Food Security

Looking ahead, in terms of food security, the upcoming larger, more urban and affluent population will require food production to increase (especially in most developing countries where it is critically needed). In light of the ongoing challenge to provide food security for the nearly one billion people who are currently malnourished or hungry (FAO, 2009), the global consolidation of the food and agriculture industry has not made strides in providing available and affordable food to all.

Whether addressing temporary or chronic food insecurity, the challenge goes well beyond ensuring sufficient food in any given period of time. The challenge facing public policy decision makers requires that they take a broader perspective of the needs and options facing rural households. Consideration of available resources and external conditions that influence those choices should result in a range of sustainable livelihood strategies that could enable families to meet their food and other needs through multi-sector rural development efforts (FAO, 2009).

Appendix II: Methodology

This section presents the preliminary modeling work and analytical/scenario methodology adopted to evaluate the potential job creation resulting from the transition from conventional to more sustainable agricultural practices. Part of the research carried out on integrated simulation models was supported by UNEP in the context of the upcoming Green Economy Report (GER).[3]

A more detailed structural documentation of the model utilized is available in Bassi et al. (2010), and a more in depth analysis of its behavior is currently being peer reviewed and will be available in a scientific journal soon.

Technical specifications

While the model developed and employed to generate results presented in this report is global and accounts for over 80 modules, the analysis concentrates on agriculture, fishery and forestry production and employment.

Finding that currently available national and global planning models are either too detailed or narrowly focused, and perhaps too decision-oriented and prescriptive, this report proposes an approach that:

- Extends and advances the policy analysis carried out with existing tools by accounting for the dynamic complexity embedded in the systems studied; and
- Facilitates the investigation and understanding of the relations existing between society, economy and the environment.

This is crucial, since understanding the characteristics of real systems, feedback (Roberts et al., 1983), delays (Forrester et al. 2002; Forrester, 2008)[4] and non-linearity[5] is fundamental for the correct representation of structures, whose behavior is outside their normal operating range (Sterman, 2000). The inclusion of cross-sectoral relations -social, economic and environmental- allows for a wider analysis of the implication of policies by identifying potential side effects or longer-term bottlenecks for development. In other words, a policy can have very positive impacts for certain sectors and create issues for others. Also, successful policies in the longer term may have negative short-term impact, for which mitigating actions may be designed and implemented.

There exist a variety of methods to apply a systemic approach to development policy analysis, of both qualitative and quantitative nature. Qualitative methods (e.g. system thinking) are found to be especially useful to chart the fundamental feedback relationships that characterize the system, and to broaden the perspective on the issues at stake. However, when confronted with systems characterized – as in the case of agriculture – by a high degree of complexity, policy analysis requires the use of quantitative methods, and more specifically, of computer-modeling, in order to derive a correct understanding of the system's workings.

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3 The analysis presented here differs from the one included in the upcoming Green Economy Report (GER). Different investment assumptions are simulated and a comparative analysis, or an update, will be possible as soon as the GER is published.

4 Delays in this context are characterized as "a phenomenon where the effect of one variable on another does not occur immediately" (Forrester et al., 2002). These can in fact lead to instability, such as overshoot and oscillations, when coupled with balancing processes. Since delays influence the efficacy of policies in both the short and the longer term, their explicit representation generates many advantages. Among others, the direct understanding that integrated complex systems are dominated by inertia in the short term, therefore the implementation of policies does not produce immediate significant impacts. As Jay Forrester states "A system variable has a past path leading up to the current decision time. In the short term, the system has continuity and momentum that will keep it from deviating far from an extrapolation of the past" (Forrester, 2008).

5 Non-linear relationships cause feedback loops to vary in strength, depending on the state of the system (Meadows, 1980), and determine how structure defines behavior.

Threshold 21 (T21) World model

The Threshold21 (T21) World model is a System Dynamics structured to analyze medium-long term development issues. The model integrates in a single framework the economic, the social, and the environmental aspects of development planning. The level of aggregation used makes it ideally suited to look at resources allocation issues among different sectors. T21 is conceived to complement budgetary models and other short-medium term planning tools by providing a comprehensive and long-term perspective on development.

T21-World includes both monetary and physical indicators, to fully analyze the impacts of investments on natural resources, low carbon development, economic growth and job creation. Key characteristics of the model are highlighted below.

Boundaries: Variables that are considered an essential part of the development mechanisms, object of the research, are endogenously calculated. For example, the GDP and its main determinants, population and its main determinants, and the demand and supply of natural resources are endogenously determined. Variables that have an important influence on the issues analyzed, but that are only weakly influenced by the issues analyzed or that cannot be endogenously estimated with confidence, are exogenously represented.

Granularity: The T21-World model is global, with no regional or national disaggregation. However, there are model applications on several national cases. Thus, the framework is very applicable to different scales, ranging from communities to the world[6]. Despite being a global model, the main social, economic and environmental variables of T21-World are broken down in sub-components as required in order to analyze the focus issues. For example, population is divided into 82 age-cohorts and 2 genders, and the age-gender distinction is used in most social indicators; production is divided into industry, services and agriculture, this last further divided into crops, fishery, animal husbandry and forestry; land is divided into forest, agriculture (croplands –also harvested land- and pastures), fallow, urban and desert. Finally, given its level of aggregations, the model is generally based on global average values for variables such as unit costs and prices.

Time horizon: T21-World is built to analyze medium to long-term development issues. The time horizon for simulation starts back in 1970 and extends up to 2050. Beginning the simulation in 1970 ensures that, in most cases, the patterns of behavior characterizing the issues being investigated can be fully observed and replicated.

Modules, sectors and spheres: As a result of the variety of issues considered, T21-World is a relatively large size model accounting for over 200 stock variables and several thousand feedback loops. Given the size and the level of complexity of the model, its structure has been reorganized into smaller logical units, labeled as modules. A module is a structure, whose internal mechanisms can be understood in isolation from the rest of the model[7]. The 80 modules comprising T21-World are grouped into 18 sectors: 6 social, 6 economic and 6 environmental sectors. Sectors are groups of one or more modules of similar functional scope. For example, the water sector groups both the water demand and water supply modules. Finally, society, economy and environment are known as the three spheres of T21-World. All sectors in T21 belong to one of the three spheres[8], depending on the type of issue they are designed to address. Modules

6 For more information see Bassi and Baer (2009), Bassi and Yudken (2009), Bassi and Shilling (2010), Bassi et al. (2009a, 2009b, 2010), Magnoni and Bassi (2009), Pedercini and Barney (In Press), Yudken and Bassi (2009).

7 As it is emphasized later on in the text, although it is possible to understand the internal mechanism of a specific module in isolation from the rest of the model, the fully understanding of its functioning and relevance requires studying its role in the whole model's structure.

8 In certain country customizations, with energy being a key area of analysis and using a variety of modules, we represent it as the 4 th sphere of T21.

are built to be in continuous interaction with other modules in the same sector, across sectors, and across spheres.

More specifically, agriculture employment (See Text Box 7), as well as industry and service employment, is included in the Social sphere of T21-World. The sphere also contains detailed population dynamics organized by gender and age cohort. Fertility is a function of the level of income and education and mortality rates is determined based on the level of income and the level access to basic health care. Access to education and health care services, nutrition and basic infrastructure are also represented in this sphere. Access to basic social services is used – in addition to income – to determine poverty levels in a broad sense.

The Economy sphere of the model contains major production sectors (agriculture, industry and services). The calculation of production is generally characterized by modified Cobb-Douglas production functions with inputs of labor, capital, and technology, but the specification varies from sector to sector (See Text Box 8). Agriculture (crop and livestock), fishery and forestry production are highly influenced by the availability and quality of natural resources. While capital and labor contribute to production, the stock of fish, forest and the quality of soil -together with water availability for agriculture- are key determinants of the performance of the sectors.

For this reason T21-World tracks the physical flow of key natural resources, endogenously calculating depletion and its impacts on production. Further production in the three major economic sectors is influenced by social factors, such as life expectancy and education level, included in the calculation of total factor productivity (TFP) together with the impact of natural resources availability and energy prices.

The Environment sphere tracks land allocation, water, waste and energy demand and supply. T21-World calculates also air emissions (CO_2, CH_4, N_2O, SO_X and greenhouse gas) and the ecological footprint. Economic activities and demographic growth concur on creating increasing pressure on natural resources, while at the same time allowing for development of better and more efficient technologies. In the case of energy, stocks of fossil fuel resources and reserves are explicitly and endogenously modeled. These stocks are among the primary drivers of fossil fuel prices, which are calculated by taking into account short and longer-term trends.

Scenario definition

We are simulating and analyzing a variety of investment scenarios, both for green agriculture (GA) -promoting resource efficiency, environmental preservation and low carbon development- and conventional -industrial- agriculture (CA) -favoring a more conventional use of resources-, as well as a business as usual (BAU) or baseline scenario.

The BAU case replicates history over the period 1970-2009, simulates approved legislation and assumes no fundamental changes in policy or external conditions going forward to 2050. This scenario is set-up and calibrated to consistently reproduce baseline projections of various existing reports, including among others, World Bank's World Development Indicators (WDI) (WB, 2009) for economy, ILO's Global Employment Trends Report (ILO, 2009) for employment, FAO's FAOSTAT (FAO, 2010) for agricultural yield and resources, McKinsey's Charting Our Water Future report (McKinsey, 2009) for water, and IEA's World Energy Outlook 2009 (IEA, 2009) and Energy Technology Perspectives to 2050 (IEA, 2008) for energy, Global Footprint Network (GFN) reports (GFN, 2010).

Both GA and CA scenarios assume increased investments, but they differ considerably from each other as explained below.

GA scenarios simulate additional investments that are aimed at increasing resource efficiency and reducing carbon intensity while creating jobs and stimulating economic growth. Examples include investments in organic and ecological farming, but this category would include as well renewable energy (e.g. power supply) and energy and water efficiency improvements. Further, investments are allocated to conserve and rebuild natural resource stocks, in action that –among others- would reduce deforestation and increase afforestation, or reduce production capacity in the fishery sector to support the restoration of fish stocks while investing in aquaculture.

BAU and CA scenarios assume additional investments, but consider the continuation of the current trends for unsustainable resource use. More specifically, these scenarios would assume that no additional investments -relative to BAU- will be allocated to the expansion of renewable energy, that agriculture will continue to rely on chemical fertilizers and industrialization of processes, and that deforestation will not be curbed. Instead, primary sector growth will be attained through increased levels of resource exploitation, including the continued depletion of fossil fuels, fish and forest stocks.

To contrast the BAU and explore possible avenues to green the agriculture sector to 2050, the following assumptions were made for the green investment scenarios, as highlighted below. A further disaggregation is proposed for investments in crop production in the table below. This is based on a preliminary analysis of an allocation of investments that would allow reaching positive synergies in crop production.

- Pre harvest losses: 33% of the agriculture investment ($12-19 billion in 2011 to $ 31-56 billion in 2050) with an average investment of $21-35 billion per year over the 40-year period is invested in measures aimed at reducing pre harvest losses, currently estimate to reach about 30% of total crop production. Investments in our scenarios include training activities and effective pesticide use.
- Agriculture management practices: 33% of the agriculture investment ($12-19 billion in 2011 to $ 31-56 billion in 2050) with an average investment of $21-35 billion per year over the 40-year period is invested in transitioning to more ecological practices. We assume an average cost of $85-$100 per ha, taking as references costs to transition from till to no till agriculture.
- Research and development: 33% of the agriculture investment ($12-19 billion in 2011 to $ 31-56 billion in 2050) with an average investment of $21-35 billion per year over the 40-year period is invested in R&D, including research on crop improvement, soil science and agronomy, appropriate mechanization, plant and animal health, water use efficiency, animal production and in all classical biological and ecological disciplines relating to agriculture, in addition to biotechnology and climate change adaption which are already well funded.
- Forestry: US$30-45 billion per year are invested on average in the forestry sector, with 54% or US$16 billion going to reforestation and 46% or US$14 billion per year to avoided deforestation.
- Fisheries: US$10-30 billion per year invested in reducing catch capacity and restoring stocks.

Table 3: Proposed optimal investment allocation across high impact areas selected for major support in this report (some of these investments could not be modeled due to lack of information on specific costs and impacts, but the categories they belong to are consistent with the allocation of investments simulated).

Investment area	%
Soil	15
Water (agric)	10
Diversity	20
Plant & animal Health	25
Mechanization	5

Food Systems	10
Cross cutting issues	15
Total	100

While investments have “intended” or “expected” outcomes, the use of a model built upon causal relations that accounts for a high level of horizontal integration (across sectors), allows to identify and estimate side effects and elements of policy resistance. It is very common to encounter “worse before better” situation, in which, as in the case of green agriculture, crop yields would decline in the short term to grow above BAU in the medium to longer term. Similar impacts are visible for employment as well, where investing in the conservation of natural resources (e.g. forestland and fish stocks) results in lower employment in the fishery and forestry sectors in the short and medium term. On the other hand, synergies can also be identified, such as the advantage of investing in green agriculture, which makes investments in forest management more effective (primarily by reducing the pressure to convert forestland into arable land).

It is important to acknowledge that the highly localized nature of best practices for a sustainable and productive agriculture requires more detailed national and sub-national studies to thoroughly assess the job creation impacts –which are also feasible, but are not a requirement of this report. The integrated review provided in this paper indicates that there are clear employment benefits possible at the global scale, with positive, inclusive returns on investment in economic, social and environmental terms.

Appendix 2: Selected Green Agriculture interventions and their potential outcomes and benefits

Soil

Intervention Action	**Outcomes**	**Agroecology Benefits**	**Economic Benefits**	**Employment Benefits**	**Environmental Benefits**
Investing in local/regional organic compost production & distribution capacity	Sustainable supplies of locally sourced organic fertilizers for field use & commercial sales	Increased Soil Organic Matter (SOM) improved fertility; retains moisture; sequesters carbon. Crop yields increased with needed nutrient inputs	Substitution for external/imported inorganic fertilizers. Local Input expenditures stay within community. Input cost savings vs. imported	Farm jobs to harvest crop residues, manures & other biomass Non-farm mfrg. jobs in organic fertilizer production distribution	Improvement of : soil fertility water holding capacity soil erosion resistance Carbon sequestration services Reduction of fertilizer leaching & water pollution
Crop/Livestock Diversification with N-fixing crops; green manures; livestock mgmt.; Push/Pull practices; grazing Perennial grasses; aquaculture; etc.	Biological soil nutrient restoration; Increased resistance to pest threats Organic waste recycling	Increased total food/fodder yields Supports livestock productivity	Increased total income from crops/meat/dairy Improved stability of annual incomes Livestock assets as collateral for loans Draught animal power farm mechanization	1/3 more labor needed for organic & diversified farming operations More consistent rural labor demand throughout the year	Improved Biodiversity Pollination ecoservices Reduced runoff of inorganic fertilizers and agrochemicals
Support mfrg and distribution of minimum tillage equipment	Increased farm area under NT cultivation (millions of ha's added per year)	Increased SOM Increased water retention Reduced soil erosion Crop yields equal or better than conventional Ag	Reduced fossil fuel use by 50-70% vs. conv. Ag Reduced labor costs and reduced labor Increased crop yields over multi-year period	New jobs in NT equipment mfrg and customer sales and support New jobs with 'For hire' NT crews Conservation tillage monocultures displace labour	Reduced soil erosion Improved water use efficiencies Soil biodiversity Reduced soil temperatures Increased soil carbon sequestration
Increased funding of agroecological soil fertility research	Improved beneficial soil microbes, fungi and nematodes Enhanced impact of cropping synergies	Increased performance of biological processes for soil nutrient building	Developing new germplasm and IP for AE best practices	New jobs in higher education and public research institutions Establishing core AE scientific community in each country	Overall reduction in inorganic fertilizer & agrochemical pollution; AE improved ability to mitigate Climate Change GHG threats
Organic soil management – a package of actions including minimum tillage, rotations, green manure cycles, agrobiodiversity, ecosystem services (for pollination and pest predation) and landscaping (hedges, planting associations, etc.)	Increased farm area under organic soil management	Improved soil fertility	Reduced use of fossil fuel and chemical fertilizer Increased productivity	Increased farm labor for soil mgmt and field contouring work	Reduced soil erosion Improved water holding capacity Increased carbon sequestration Soil biodiversity

Sustainable Water Use and Improved Water Productivity

Intervention Actions	Outcomes	Agroecology Benefits	Economic Benefits	Employment Benefits	Environment Benefits
Train farmers in soil mgmt and cropping practices to improve water use efficiencies	Increased SOM levels with improved moisture retention	Increased Water Productivity levels (more crop per drop)	Reduced cost of water inputs	Increased farm labor for residue mgmt and field contouring work	More water available for other uses Reduced water and soil runoff losses
Financial support and investment in drip irrigation systems	More farmers adopt drip irrigation to save water Suppliers of drip systems increase market share of irrigation equipment mkt.	Increased yields & output of vegetables & fruit Crop Water Productivity levels increase	Farmer incomes improve with higher value produce Recurring costs of water inputs reduced 30-50%	Saved water is available to irrigate additional land that can be cultivated. New drip system; installation & service jobs	Reduced demand pressure on sustainable fresh water resources
Establish or expand rural public works development and maintenance of watershed mgmt. infrastructures	Increased construction of rural water reservoirs, catchments & distribution canal networks	Enables irrigation of rainfed lands Irrigation increases crop yields by 40% More resilient to drought risks Enables rural aquaculture	Increased incomes of rural manual laborers Increased crop yields & farmer incomes Improved water access for rural communities	Poor rural households gain jobs from building and maintaining community water infrastructures	Improved ground water tables More poor farmers can irrigate Vegetative borders for ponds support more biodiversity
Training farmers to improve Water Productivity by cultivating SRI rice & water efficient crops (sorghum)	Conversion of flooded rice to SRI brings water savings of 30%	Increases rice yields with less water use	Increased yields and reduced input costs bring higher incomes and profits Oppty for GHG emission credits	Minor increase in labor inputs to practice SRI	Reduced water consumption Reduced methane GHG emissions vs. conventional rice
Financial support for poor farmer use of treadle pumps and small scale power pumps combined with AE field practices	More small holder farmers adopt manual irrigation practices that increase yields	Enables higher planting densities and rotations Portable pumping can be shared by many farmers	Farmer incomes improved with more crops and for hire services High ROI enables farmer cost recovery in 2 yrs	Improves labor productivity for watering crops Enables for hire pumping service jobs	Improved yields reduce pressure for deforestation and marginal land
Invest in AE research of aerobic rice; saline tolerant crops; etc.	New plant varieties that use less water and that productively use saline water	Aerobic rice yields similar to flooded rice but with uses less water Saline farm lands can be productive	Marginal lands yield commercial crops & incomes Reduced costs for water inputs	Agronomic R&D scientific/technician job creation	Reduces Ag demands for water Reduces land use conversions as marginal lands can now be productive

Crop and Livestock Diversification Interventions

Intervention Actions	Outcomes	Agroecology Benefits	Economic Benefits	Employment Benefits	Environment Benefits
Invest in Ag R&D of legumes and other N-fixing crops that improve soil nutrient balances & produce valuable food/fodder	Increased biological production of N and SOM for soil fertility without the use of agrochemical inputs	Increased and sustainable crop yields that does not deplete soil fertility Supports both food and feed markets	Significant reduction in use & input costs of fossil fuel based N Crop and Livestock diversification earns more farmer income and manages risks	Modest increase in labor for polyculture farming practices	Increased on farm biodiversity /habitats Substantial reduction of GHG emissions of fossil fuel N fertilizers
Investment in livestock breeding programs to combine local stock varieties with higher yielding breeds that are adapted to local areas	Introduces more productive breeds that feed on local grasses and fodder; and are more resilient to local biotic stresses	Increased production of meat, dairy and other high value food	Increased farmer income from meat and dairy products Basis for building value added protein processing operations	Helps maintain rural jobs in livestock husbandry & related food production firms	Recovery of manures provides organic fertilizers for arable lands
Strengthen Ag Extension & farmer field school training in diversification skills	Widespread adoption of crop rotation techniques HH and community integration of livestock & crops	More complete use of all biomass yields for food production Opportunity to recover wastes as organic input for field/animal	Farmers' livestock are liquid assets that can be collateral for loans	Jobs created for FFS trainers and farm demonstration field workers	Widespread implementation of crop rotation practices improves soil health and biodiversity (e.g. IPM)
Integrated plant/animal systems, such as polycultures, agroforestry, and crops/livestock and rice/fish systems	Optimize nutrient and energy flows	Lower use of pesticides, external fertilizers and feeds		Increases labor in practices of integrated systems Requires jobs for training of agroecological knowledge	Increased biodiversity Reduced vulnerability to risk

Plant and Animal Health Management Interventions

Intervention Actions	Outcomes	Agroecology Benefits	Economic Benefits	Employment Benefits	Environment Benefits
Increased education and training of farmers in PAHM	Increased adoption of PAHM practices and inputs to reduce or replace pesticide use	Produce crop yields comparable to yields with pesticide use	Reduce pesticide input costs and shift expenditures to local labor and biocontrol inputs	Increased labor intensity of PAHM creates new jobs on the farm & producing biocontrol inputs	Reduced pollution from pesticides Increased biodiversity of beneficial insects Reduced health hazards to humans
Increased R&D of biocontrol methods & beneficial organisms	Discovery of new beneficial species and crop dynamics to resist pests	Increased crop yields with limited or no inputs of inorganic pesticides/herbicides	Opportunity for domestic & local biocontrol input production Reduced import costs for chemical inputs	New jobs in PAHM scientific R&D, education; and new rural businesses that mfr & mkt bio-inputs	Justifies the value of biodiversity & efforts to protect/extend
Support public policy advocacy of CBD treaty revisions that improve international cooperation & access to beneficial PAHM insects & organisms	Better multi-lateral collaboration on R&D and sharing of beneficial species to combat pest epidemics	Reduced delay in responding to pest infestations with effective biocontrols	Reduced costs of implementing PAHM Esp. in LDC's Oppty to generate revenues for the use of beneficial species	Facilitates the establishment of national & regional PAHM services and technicians	Enhanced global biodiversity and populations of beneficial organisms
Financial incentives and support for investing in PAHM assets/local capacity	Leverages private investment in PAHM biocontrol technology & production facilities	Stimulates rapid emergence of PAHM supply chain that enables adoption of PAHM practices	Counters & reduces historic subsidies for chemical pesticides Helps farmer coops & private enterprise to produce PAHM inputs and application services	Creates new jobs in PAHM supply chain Increases on-farm labor engaged in PAHM practices	Reduces overall health/environmental hazards of pesticides
Expand and improve local/regional access to animal health clinics and preventive health methods	Farmers would have improved support from veterinarians & technicians Increased health and survival of livestock	Reduced risks of crop and livestock diversification Increased yields of meat/dairy/fish protein for local use and for sale	Livestock are key poor farmer assets & collateral for loans Livestock are high value-added produce Draft animals help labor productivity	Rural jobs as PAHM clinicians & support Livestock husbandry jobs are increased New jobs in meat & dairy processing	Reduced risk of pandemics caused by poor animal health & proximity to humans Improved nutrient cycles between crops/manure/soil