Reversing Land and Water Degradation: Trends and 'Bright Spot' Opportunities

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ABSTRACT

Land and water degradation threaten food security for many of the poorest and most food insecure living in Asia, Africa and Latin America. It also contributes to persistent poverty, and results in decreasing ecosystem resilience and provision of environmental services. Negative trends in resource degradation are a challenge that must be tackled to meet poverty alleviation goals. The Comprehensive Assessment (CA) on Water Management in Agriculture is a global research and consultative project that evaluates current water management challenges and solutions, and identifies the best options for the future. The 'Bright spots' project of the CA addresses linkages between land and water degradation and agricultural productivity, livelihoods and environment.

This paper briefly reviews the current state of knowledge related to the condition of global land and water resources, and highlights the importance of linking land and water management at local and landscape scales in order to address pressing issues. Evidence, primarily from the 'Bright spots' project, but also from the wider on-going CA consultation process, is presented to support the key messages: 1) significant opportunities exist for integrated land and water management in smallholder systems to improve water productivity and provision of ecosystem services including food supply; 2) larger scale biophysical, social, and policy approaches for preserving landscapes can enhance positive impacts of intensification on local 'Bright' spots and go beyond 'up-scaling'; 3) productive use of low quality waters is possible and provides opportunities to close large gaps in nutrient cycles to slow or reverse trends in land degradation and water pollution. These strategies could help reverse land and water degradation, and intensify agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services, including food production, clean water, biodiversity, carbon sequestration, and resilience to climate change.

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1. INTRODUCTION

The Comprehensive Assessment (CA) on Water Management in Agriculture is a research and consultation project that evaluates current water management challenges and solutions, and identifies the best options for the future. Governments, donors and rural communities have invested billions of dollars in water development and management to boost food production, improve livelihoods and foster economic growth. Yet we still don't have a comprehensive view of the impacts of that investment or a clear consensus on questions such as: "How much water will be needed to produce enough food for our growing population?" "How can we grow more food with less water?" "How can we best manage land and water in rainfed agriculture to increase food production, improve rural livelihoods and maintain biodiversity?" (Molden and de Fraiture, 2004). One important research question under the CA is, "What are the consequences of land and water degradation on water productivity and the multiple uses of water in catchments?" The 'Bright spots' project of the CA addresses this question, exploring linkages between land and water degradation and agricultural productivity, livelihoods and environment, to identify key challenges and opportunities for the future.

Land and water degradation threaten food security for many of the poorest and most food insecure living in Asia, Africa and Latin America (Kaiser, 2004). It also contributes to persistent poverty, and results in decreasing ecosystem resilience and provision of environmental services (Costanza et al., 1997). Poor farmers tend to be associated with marginal lands (Table 1), and low yields (Rockstrom et al., 2003). Increased expansion of agriculture into new areas is contrary to conservation goals in many countries, and if expansion is onto even more marginal lands, has little hope of improving livelihoods for poor rural farmers. Meeting poverty alleviation goals therefore requires that downward spiraling trends in resource degradation be arrested and reversed.

This paper briefly reviews the current state of knowledge related to the condition of global land and water resources, and highlights the importance of linking land and water management at local and landscape scales in order to address pressing issues. Evidence, primarily from the 'Bright spots' project, but also from the wider on-going CA consultation process, is presented to support the key messages: 1) significant opportunities exist for integrated land and water management in smallholder systems to improve water productivity and provision of ecosystem services including food supply; 2) larger scale biophysical, social, and policy approaches for preserving landscapes can enhance positive impacts of intensification on local 'Bright' spots and go beyond 'upscaling'; 3) productive use of low quality waters is possible and provides opportunities to close large gaps in nutrient cycles to slow or reverse trends in land degradation and water pollution. These strategies could help reverse land and water degradation, and intensify agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services, including food production, clean water, biodiversity, carbon sequestration, and resilience to climate change.

Table 1: Relationship between rural poor and marginal land

Region	Rural Poor on Favored Lands (millions)	Rural Poor on Marginal Lands (millions)	Rural Poor on Marginal Lands (%)
Sub-Saharan Africa	65	175	73%
Asia	219	374	63%
Central & South America	24	47	66%
West Asia & North Africa	11	35	76%
Total	**319**	**613**	**66%**

Scherr 1999, based on Nelson et al. 1997

2. LAND AND WATER DEGRADATION

Current Trends

Land degradation has been estimated to affect 50% of agricultural lands over the last 50 years, with up to 70% of cultivated land in sub-Saharan Africa now affected by some degree of degradation. Effects including salinization, erosion, nutrient depletion, carbon loss, and loss of water holding and buffering capacity have resulted in reduced productive potential and abandonment of lands (Wood, et al., 2000). Degrading and abandoning land is strip mining our agricultural land resources (Penning de Vries, 2001). While we may not run out of soil before oil, as was predicted by Lester Brown of the Worldwatch Institute in the mid-1980's, the process is similar. It can be estimated for example (Figure 1) that lands abandoned in Latin and Central America account for approximately 15% of historically available arable lands in that region, that an additional 20% are currently cultivated, leaving 'reserves' of approximately 65%. In South Asia, however, land is 'over-cultivated', i.e. in aggregate for the region there are no reserves, marginal lands are already exploited, and 40% of historically available arable land has already been lost. This proportion will increase to 50% by the year 2020 (Penning de Vries, 2001).

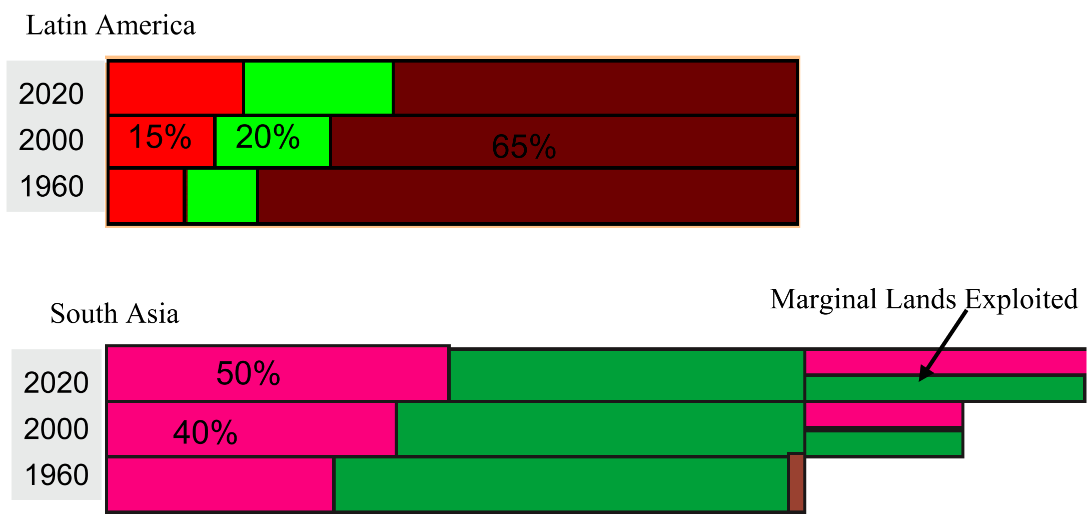

Figure 1. "Strip mining" of soil resources. For each region the full length of the bar represents historically available arable lands, which is split into fully degraded (red); currently in use for agriculture (green) and still available (brown). Where the bar is split green/red indicates when more land is "used" than is "available" for sustainable agiculture. Penning de Vries, 2001

Water resources are also over-exploited in many basins. Surface water in important river basins such as the Colorado, Huang-He (Yellow), Indus, Nile, SyrDarya, and Amu Darya is 100% exploited, to the detriment of aquatic ecosystems and human wellbeing (WRI, 2000). Equally important are trends in unsustainable ground water exploitation particularly in South Asia (Morris et al, 2003). Water scarcity is generally agreed to be a key factor limiting food production and wealth generation for poor people, and increasing scarcity is projected (Rijsberman, 2000). Water pollution is also an increasing concern (WRI, 2000), and there is now about 12,000 km^3 of polluted water on the planet, equal to more than the contents of the world's ten biggest river basin, and equivalent to six years worth of worldwide irrigation needs. Water quality degradation limits the range of productive uses of that water, and in particular degrades the value of that water for environmental services. The conflict between irrigation and wildlife conservation is already considered to be at a critical point (Lemly et al., 2000), due to the impacts of irrigated agriculture on wetlands and wildlife.

Processes linking land and water degradation

Parallel trajectories of land and water degradation on-site

Land and water degradation occur in parallel and are interlinked. The relationships are obvious, but often these resources are still considered independently. In particular land management options can be understood and acted upon in relation to the 'water crisis.' Mismanagement of land degrades water quality and reduces water productivity (Molden et al., 2003; Zwart and Bastiaanssen, 2004). At the extreme, complete crop failure in rainfed systems reduces water use efficiency to zero. While this is often due to temporary or seasonal drought, is also caused by soil nutrient and carbon depletion that reduce productivity and increase drought sensitivity. More commonly chemical and biological degradation of land results in incremental reductions in water productivity. Examples from Northeast Thailand demonstrate that on tropical sandy soils, chemical and physical degradation strongly limit water productivity in both rainfed and irrigated systems (Noble et al., 2004a). Water productivity can be increased 250% and over 500% in irrigated and rainfed systems respectively, when soil amendments that alleviate chemical degradation are applied. Even in the relatively dry Sahel region it is often the supply of nutrients, not water as commonly assumed, that limits farm productivity (Penning de Vries and Djiteye, 1982; Breman, 1998).

Mismanagement of water similarly contributes to degradation of land, such as increasing erosion, salinization and water logging. Salinization of soil and water affects productive potentials, reduces water use efficiency, results in loss of high quality water to saline sinks, and abandonment of previously arable lands. Although data is poor, estimates indicate that worldwide 20% of irrigated land suffers from salinization and waterlogging (Wood et al., 2000). Central Asia provides a compelling example. Due to overuse and mismanagement of irrigation waters over the last 50 years, high levels of salinity and rising water tables affect significant areas of irrigated land with productivity losses exceeding 30% (US$1,750 million annually) (WEMP, 2003). Currently, 47.5% of the irrigated land in Central Asia is affected by salinization, ranging from 95.9% in Turkmenistan to 11.5% in Kyrgyzstan. 289,000 hectares are affected by medium to high salinity levels and approximately 405,000 hectares are classified as sodic. It has been estimated that with improved on-farm and system water management, between 20 – 25% of the annual available surface water in the region used for leaching could be delivered to the Aral Sea as increased environmental flow, and loss of productive land could be slowed (WEMP. 2003).

Landscape cycles and off-site impacts

The costs of degradation in terms of lost ecosystem services are not all realized or appreciated by the local landowners and resource users. Similarly the benefits of local investments in resource conservation are not all appreciated or realized locally. This limits the ability of the users to invest in resource conservation, and at the same time limits the will for investments to be made from higher levels, either regionally or nationally. Consideration of landscape scale cycles and flows of water, sediment and nutrients is necessary to understand and address land and water degradation. The causes and consequences of degradation are better understood at landscape scales, and it is at these larger scales that policy instruments can effectively either drive degradation or enable resource conservation. Two important larger scale cycles are upstream and downstream transfers in watersheds, and rural – urban nutrient flows.

Downstream effects of upstream catchment land degradation cascade throughout watersheds. It is well recognized that intensified land use in upper catchments, largely by poor farmers increasingly forced onto marginal lands, results in increased sediment discharge and elevated nutrient loads reducing water quality and availability downstream. It is estimated that more than 25% of the world's water storage capacity will be lost in the next 25 to 50 years in the absence of measures to control sedimentation in both large and small reservoirs (Palmieri et al., 2001). Striking examples are found in Southeast Asia where upper catchments are extensively exploited. Rapid deforestation of the steep hillsides above Hoa Binh reservoir, Vietnam, increased soil erosion and accelerated siltation of the reservoir reducing the projected life of the Hoa Binh dam from 100 to about 50 years (UNDP, 2002). This dam generates 80% of the electricity for Hanoi and Northern Vietnam. Sedimentation not only reduces the useful life of reservoirs (Maglinao and Valentin, 2004) but also results in increased labor demand to de-silt irrigation canals. Sedimentation and eutrophication of aquatic ecosystems leads to declining fish catches that in turn threatens the nutrition and health of downstream communities. Marginalized communities can be hardest hit, because local fisheries form a high proportion of the protein in their diets. Reduced quality and quantity of surface waters directly affects community health, and requires people to find alternative sources of drinking water (Fengtong et al., 2003). Women are burdened with having to devote a greater proportion of their time transporting water or caring for ill children as a result of drinking poor quality water. In Vietnam, shifting from surface to groundwater resources for drinking water has resulted in the potential exposure of 14 million people to elevated levels of arsenic (Tanh, 2003).

One-way nutrient flows occur ubiquitously, from forest to farm, from terrestrial ecosystems to the ocean, and increasingly from rural to urban areas, including across continents. The result is nutrient depletion at the source and pollution at the sinks. Nutrient depletion in agricultural soils during 1996-1999 is so high in many countries in Asia, Africa and Latin America that current land use is not sustainable (Craswell et al., 2004). Worldwide natural regeneration of soil fertility plus fertilizer applied compensates for only half of what is taken from the soil on cultivated fields (Sheldrick et al., 2002). Nutrient balance analysis demonstrates nutrient depletion in many Asian countries on the order of 50 kg NPK per hectare per year (Sheldrick et al., 2002). Trends are more negative in Africa, where nutrient depletion in some East and Southern African countries is estimated to average 47 kg N, 6 kg P, and 37 kg K per hectare per year (Smaling, 1993; Stoorvogel et al., 1993). Country averages hide important site-specific variation. Where farmers are poor, and cannot afford inputs, nutrient mining is much higher. Nutrient depletion is now considered the chief biophysical factor limiting small-scale farm production in Africa (Sanchez et al., 1997; Drechsel et al., 2004). While nutrient depletion is the rule in rural and poorer countries, nutrient accumulation occurs in urbanized countries where much food and feed is imported (Penning de Vries, 2004), and in densely populated urban areas of Asia and Africa. Increasingly large volumes of domestic and industrial wastewater are produced in rapidly growing cities around the world. Each day over 2 million tons of waste is dumped into rivers and lakes (WWAP, 2003). Globally, a very small percentage of these wastewaters receive even primary treatment. In India less than 35% of wastewater receives primary treatment, and there is little, if any treatment in smaller cities and rural areas. Untreated wastewater, clearly a pollution problem, is also a resource valued by farmers in peri-urban areas because of its year round supply and high nutrient content.

3. REVERSING DEGRADATION: "BRIGHT SPOT" OPPORTUNITIES

Opportunities to begin to slow or reverse negative trends in land and water degradation while meeting poverty alleviation goals do exist. Promising opportunities include: 1) integrated land and water management for smallholder farmers to provide on- and off-site ecosystem services including sustainable livelihoods; 2) larger scale biophysical, social, and policy approaches for preserving landscapes; and 3) sustainable utilization of low quality waters to reduce pressure on high quality waters and preserve land.

"Bright Spots"

Intensification of agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services, including food production, clean water, biodiversity, carbon sequestration, and resilience to climate change, is possible and is demonstrated in numerous examples. Successful cases involving smallholder farmers and communities have received considerable attention in recent years [1]. One key feature of indigenous success stories is that land and water management are always integrated (Critchley, 2004). To explore the potential and driving forces behind these successes, the CA 'Bright spots' study compiled a dataset from a collation of new survey information and published case studies, including the previously compiled SAFE World database of the University of Essex (Pretty et al., 2000; Pretty and Hine, 2004) and other public domain and grey literature sources. The 'Bright spots' database currently contains 286 recent cases from 57 countries covering 36.9 M ha that show increased productivity across 12.6 M farms (Table 2). While degradation trends globally are still strongly negative, these cases provide compelling evidence that improvement is possible. These gains in productivity were accompanied by improvement in the supply of other environmental services (Pretty et al., 2004). These 'Bright spots' sequester 11.38 Mt C yr^{-1}, with an average gain of 0.35 t C ha^{-1} yr^{-1}. When Integrated Pest Management (IPM) was implemented yield increases were accompanied by reduction in pesticide use of between 50% to 90%. Water productivity was improved approximately 16% and 30% in irrigated rice and cotton systems respectively and 70% to 100% in rainfed systems growing cereals and legumes.

1. Groups with projects cataloguing and detailing success stories: Centre for Development and Environment (CDE), Berne; Centre for Environment and Society, University of Essex; Ecoagriculture Partners; FAO Land and Water Development Division; FAO/AGL Gateway Project; Ingenious farmers; Centre for International Cooperation, University of Amsterdam; IRCD; Sustainability Institute, Stockholm Environment Institute (SEI); UNEP success stories; WOCAT, World Overview of Conservation Approaches and Technologies, Berne (not a comprehensive list).

Table 2. Summary of adoption and impact of agricultural sustainability technologies and practices on 286 projects in 57 countries. Pretty et al. 2004. (Standard errors in brackets)

FAO farm system category	Number of farmers adopting	Number of hectares under sustainable agriculture	Average % increase in crop yields
1. Smallholder irrigated	179,287	365,740	184.6 (±45.7)
2. Wetland rice	8,711,236	7,007,564	22.3 (±2.8)
3. Smallholder rainfed humid	1,704,958	1,081,071	102.2 (±9.0)
4. Smallholder rainfed highland	401,699	725,535	107.3 (±14.7)
5. Smallholder rainfed dry/cold	604,804	737,896	99.2 (±12.5)
6. Dualistic mixed*	537,311	26,846,750	76.5 (±12.6)
7. Coastal artisanal	220,000	160,000	62.0 (±20.0)
8. Urban-based and kitchen garden	207,479	36,147	146.0 (±32.9)
All projects	12,566,774	36,960,703	83.4 (±5.4)

Notes: Yield data from 405 crop project combinations; reported as % increase (thus a 100% increase is a doubling of yields)
* Dualistic refers to mixed large commercial and smallholder farming systems, mainly from southern Latin America.

A key area for impact, as demonstrated in the 'Bright spots' study, is where productivity is much below potential due to lack of inputs, land degradation or climatic uncertainty in rainfed agriculture (Figure 2). In the latter case, development of independently managed supplemental irrigation systems can reduce risk and greatly increase productivity of both land and water (Rockstrom, et al., 2003).

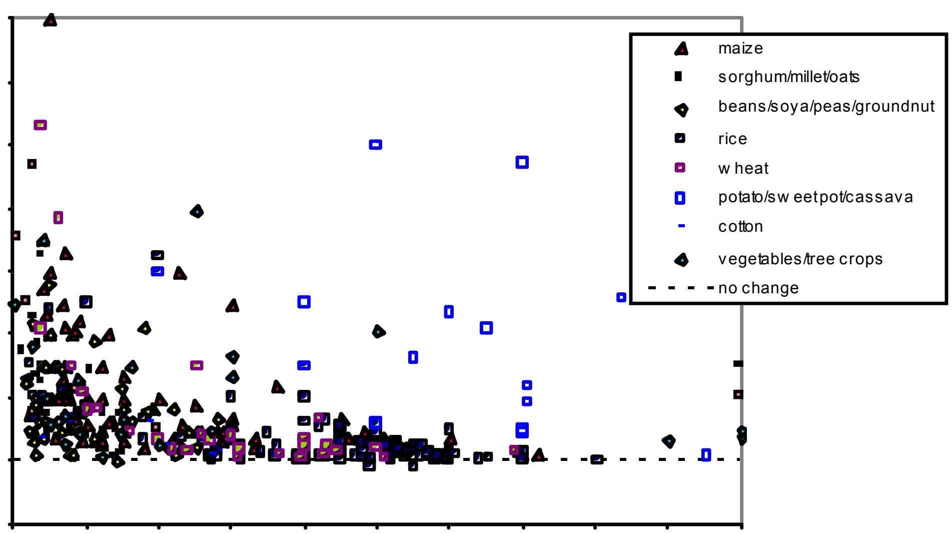

Figure 2. Changes in crop yields with agricultural sustainability technologies and practices (360 crop yield changes in 198 projects). Pretty et al. 2004.

"Bright Spots" Drivers

Key priming factors in these successful cases include investment, secure land tenure, appropriate integrated land and water technologies, and aspirations for change amongst the local population. And while participatory approaches alone could not reverse degradation processes, they were one key driver of change. This set of 'Bright Spots' was compiled from well-documented cases, where evidence suggested they were able to sustain themselves beyond implementation, although continued sustainability cannot be guaranteed. It should be noted that the dataset primarily describes development projects where impacts were achieved through external investment therefore they under represent individual, or spontaneous 'Bright Spots,' and do not represent examples of development project failure. Nevertheless, their numbers and impact provide grounds for cautious optimism.

Although data is scant, the issue of investment deserves some discussion in this context. Almost all 'Bright spots' in the database were based on development projects, and therefore represented a certain amount of investment from international, bilateral, national government, community, NGO or other sources. Few published cases or survey respondents included a breakdown of investment, but data from 10 cases in Latin America and 15 from Africa was compiled and can be summarized as follows: Funds to individual projects ranged from US$ 3,000 to US$ 10.5 million and from US$ 45,000 to US$ 8.9 million in Latin America and Africa respectively. The mean investment per hectare directly impacted by the projects could be estimated at US$ 714 per hectare in Latin America, and approximately half of that, US$ 366 per hectare, in Africa (Noble et al., 2004). Although these cases are few, it is informative to compare to the rates of expenditure for conventional irrigation projects, which are often 10 times as high. For 233 Worldbank and ADB irrigation projects in Asia and Africa, unit costs ranged from US$3,000 per hectare in South Asia to US$28,000 per hectare in Africa for new construction, and from US$1,000 per hectare in South Asia to US$5,000 per hectare in Africa for irrigation infrastructure rehabilitation projects (Inocencio, et al., 2004).

Local 'Bright' spots can play an important role in regional development by resonating laterally to increase adoption of promising farming systems, and vertically to improve policy making to support sustainable development. To facilitate understanding of the success of these 'Bright Spots', a preliminary 'drivers' analysis was undertaken in which the relative importance of a range of individual, social, technical and external drivers (Box 1) was determined. Case studies were classified into three primary groups (Box 2): Community Bright Spots such as integrated watershed development, in which investment in social capital such as community organizations was as important as technical inputs for success and sustainability; Technology Bright Spots which were successful in large part through strong individual initiative and because the new technology or knowledge was particularly appropriate and effective; and Spontaneous Bright Spots where significant improvement was made in resource condition and profitability without external investment, driven by strong leadership and the availability of appropriate technology (Figure 3). It is hoped that this type of analysis of drivers will help inform efforts aimed at replicating success.

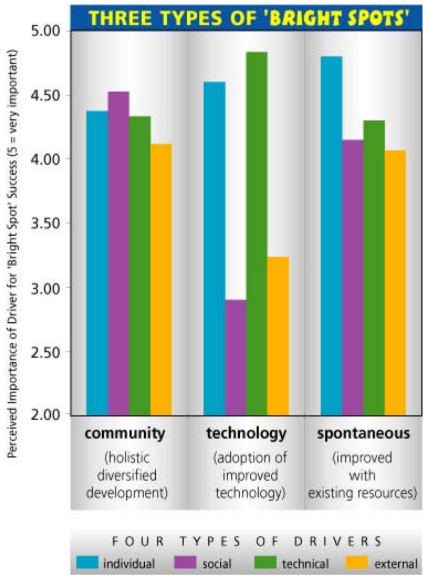

Figure 3. Preliminary drivers analysis for three types of ‘Bright’ spots: community (n=15), technology (n = 95), and spontaneous (n=3).

Box 1. Key drivers for success of ‘Bright’ spots

Individual
1. *Aspiration for change*. This reflects an internal demand by an individual or community for change that may be driven by faith or a wish to try something different.
2. *Leadership*. In order for a ‘Bright’ spot to develop and continue there is a need for strong leadership. This may include a single individual or group that champion change.

Social
3. *Social Capital*. ‘Bright’ spots develop where there are community organizations, networks, and partnerships (private as well as public). This social capital also includes intangible aspects of social organizations such as norms and rules of behavior that can play an important role in promoting sustaining change.
4. *Participatory approach*. ‘Bright’ spots require deliberative processes that actively involve the community in the decision making process. This includes a strong element of learning and teaching.

Technical
5. *Quick and tangible benefits*. Immediate tangible benefits to the community or individual are an important requirement for the development of a ‘Bright’ spot. For example this may include increased yields within the first year of implementing changes; a reduction in the costs of labor etc.
6. *Low risk of failure*. Resource poor farmers by their very nature are risk-averse hence any changes that are made to create a ‘Bright’ spot need to have an element of low risk.
7. *Innovation and appropriate technologies*. Innovations, new technologies and information are important components in ‘Bright’ spot development and continuance. This includes new skills and knowledge.

External
8. *Market opportunities*. In order for a ‘Bright’ spot to develop, markets need to be present and assured.
9. *Property rights*. Secure (individual or communal) property rights are important to facilitate change.
10. *Supportive policies*. Favorable changes in supportive policies at the local, regional and national levels.

Box 2. Case studies representing three ‘Bright spot’ typologies.

Community Bright Spot

Smallholder farmer managed irrigation in Zimbabwe

Dryland farmers in Murara, in Mutoko district, Zimbabwe, faced significant resource problems including poor soil fertility and irregular and insufficient rainfall, resulting in food insecurity. A group of about 36 farmers now manage a small irrigation scheme covering 18 ha of land. They have increased cropping intensity 200%, and increased maize yields from 1.5 t/ha under dryland farming to 6 t/ha in the irrigation scheme. There has been a significant increase in food security, drought tolerance, and farm incomes. They have been able to invest in, and diversify their farming enterprises, including growing vegetables for market, purchasing livestock and planting trees and woodlots. Farmers have been able to acquire new entrepreneurial skills, and have become more self-reliant. Significant ecosystem benefits have resulted because farmers have given up destructive gold panning activities that used to be undertaken to supplement their incomes. Smallholder, primarily farmer managed, irrigation systems now cover 13,000 ha of land in Zimbabwe, serving farms with plot size ranging from 0.5 to 2ha.

Technology Bright Spot

Quesungual Agroforesty in Honduras

The Quesungual Slash and Mulch Agroforestry System (QSMAS) has contributed to a successful development strategy in improving rural livelihoods in the Lempira Department, Honduras. This alternative to slash and burn agriculture strongly builds on local knowledge and has been a major production system to achieve food security by resource poor farmers. The widespread adoption of the QSMAS by more than 6,000 farmer households has been driven by a 100% increase in crop yields and cattle stocking rates and significant reduction in costs associated with agrochemicals and labor. Farmers recognize that a remarkable feature of the QSMAS is the increased soil water holding capacity and extended time of soil water availability thus preventing crop failures. Besides making a substantial contribution to food security, QSMAS has shown a remarkable degree of resilience to extreme water deficits and also to excess water during natural catastrophes. Farmers practicing this system reported less soil, water and crop losses as a consequence of the El Niño drought event in 1997 and the Hurricane Mitch in 1998.

Individual Bright Spot

Uzbekistan, Central Asia

Newly privatized farms of the Former Soviet Union have experienced declining yields, declining incomes, and increased soil degradation from rising salinity levels and wind erosion. A few farms have achieved higher yields (40% and 64% higher cotton and wheat yields respectively), reduced salinity, increased profits between 3 and 7 fold, and increased farm workers income by 125%. The stimulus for change in all cases appears to be internally driven by resourceful individuals who have a vision. These individuals exhibit strong leadership skills, have innovative approaches to addressing biophysical and economic problems and have a strong social commitment to their labor force and the community as a whole.

Beyond “up-scaling”

The importance of linking local ‘Bright spots’ to larger scale biophysical, social and policy opportunities to reverse land and water degradation and preserve landscapes, particularly relevant to watershed development, cannot be overestimated. Landscape management can provide opportunities beyond ‘upscaling’ of local solutions. Landscape approaches take into account the ecology and function of landscape components and makes strategic use of their potential (Ryszkowski and Jankowiak, 2002). Forests, woodlots and riparian buffer zones are important in this respect as trees provide larger scale opportunities to influence the water cycle and maintain water quality. In the Eastern Himalaya, Sikkim, Assam and Nepal, steep slopes, low fertility, intense precipitation resulting in erosion and slumping, and increasing population pressures complicate land management. Strategic planting of the Alder-cardamom agroforestry system in riparian zones (Figure 4) satisfies a diversity of farmers’ needs while also providing watershed protection (Zomer and Menke, 1993). Riparian buffers trap sediments and reduce bank erosion, providing significant water quality benefits. Purposeful use of this type of production system provides opportunities to increase the provision of ecosystem goods and services at the landscape scale, which cannot always be achieved when management targets only those lands under annual cropping systems, without regard to landscape features. Another landscape approach aims to restore natural bio-drainage processes that have been disrupted through deforestation, to alleviate high water tables. Studies are underway to assess the potential of this approach in Eastern India, Central Asia, and Northeast Thailand. Policy and institutional mechanisms (Rosegrant, 2004) and basin level water management (Karar, 2004) are required to support these opportunities for reversing trends in land and water degradation. Likewise, investment in social capital, recognizing and building upon gendered and social organization of smallholder farming communities, creates new opportunities that enhance both productivity and equity (Pretty 2003).

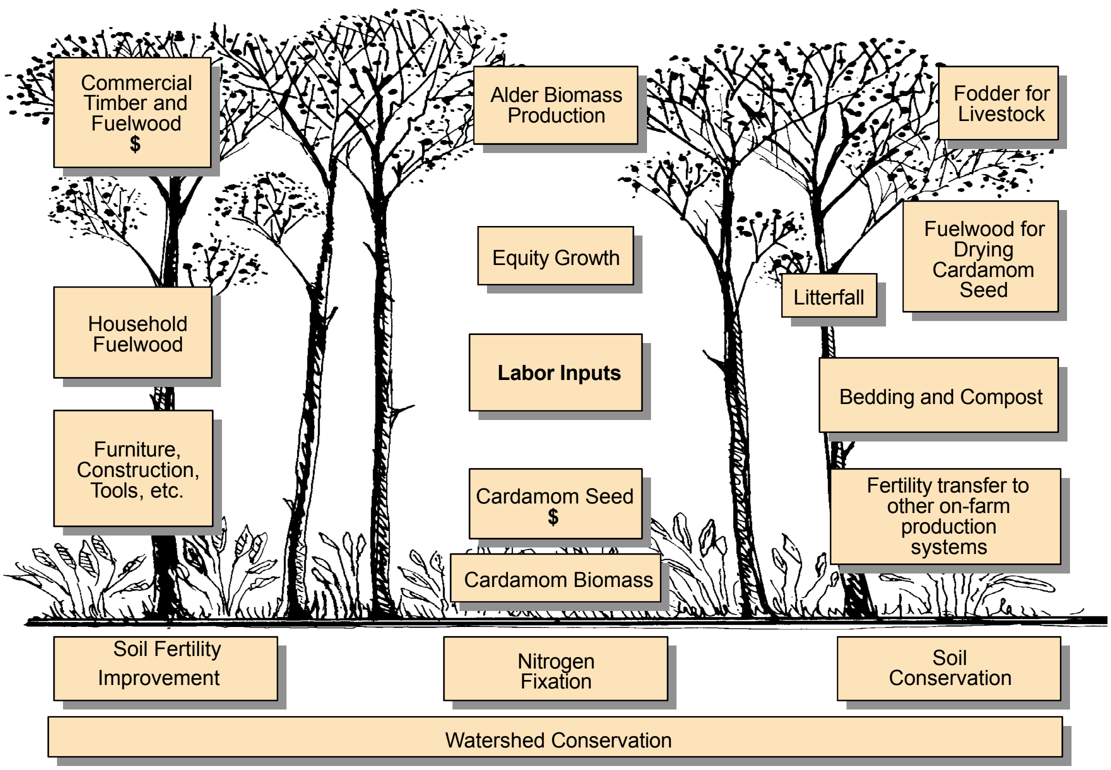

Figure 4. Alder-cardamom agroforestry system provides for a diversity of farmer's needs simultaneously without the need for external inputs or heavy labor, and while also stabilizing riparian zones and providing watershed protection. Source: Zomer and Menke, 1993.

Productive use of waste waters

Using low quality waters productively to address one-way nutrient flows and salinization of land and water is an area with increasing opportunity, due to increasing volumes of these waters. Appropriate utilization has the potential to help close rural-urban nutrient cycles, limit continued water logging and salinization of soils, and reduce the impact of agriculture on the environment (Sanio et al., 1998). State-of-the art, environmentally friendly systems for productive use of low-quality waters are being tested and employed primarily in developed countries. Sequential biological concentration to eliminate off-site drainage of saline waters (Cervinka et al., 1999), and agroforestry systems for productive land-based sustainable wastewater disposal (Myers et al., 1999) are two examples. One challenge is to adapt these technologies for application in developing countries by ensuring economic opportunities for local communities that depend on these low quality waters. For example, peri-urban agriculture has the advantage of proximity of markets and low transportation costs for urban wastes. However, currently economic incentives favor using wastewaters to produce high value vegetable crops with potentially large negative health consequences. Local policies tend to ignore this agricultural sector completely despite its importance (wastewater produce supplies 95% of the fresh vegetable market for cities like Kumasi in Ghana, Drechsel, 2004). Productive use of wastewater that is environmentally sound and without health risks is a biophysical, social, economic, institutional and policy challenge.

CONCLUSION

Through a consultative process including workshops and joint research on the 'Bright' spots project preliminary consensus was reached on three key messages: 1) significant opportunities exist for integrated land and water management in smallholder systems to improve water productivity and provision of ecosystem services including food supply; 2) larger scale biophysical, social, and policy approaches for preserving landscapes can enhance positive impacts of intensification on local 'Bright' spots and go beyond 'upscaling'; 3) productive use of low quality waters is possible and provides opportunities to close large gaps in nutrient cycles to slow or reverse trends in land degradation and water pollution. These strategies could help reverse land and water degradation, and intensify agricultural systems in a way that is sustainable and compatible with the needs of nature and society for ecosystem services.

The value of the 'Bright spots' analysis is that it was based on existing cases where arresting or reversing resource degradation trends were achieved. Thus results provide the basis for asserting that smallholder systems, even on marginal and degraded lands, are not always hopeless cases, where the only option is for off-farm employment and urbanization to rescue the rural poor. Several external factors are necessary. Land rights were a precondition of these successes. Institutions that bolster smallholder farmers within a wider context of preserving landscapes can help balance food production with other ecosystem services. The pivotal role of leadership was also clearly evident in the 'Bright spots' analysis, thus emphasizing the need to increase the capacity of farmers themselves, and not just researchers and extension agents. Policies that address larger scale underlying causes of degradation, and support rather than ignore the growing sector of urban and peri-urban waste water agriculture are needed. And there is need for substantial investment. Past investments aimed at addressing degradation have been too modest. Investments in land and water conservation have generally represented less than 5% of agricultural spending (Penning de Vries et al., 2002). Another clear message, is that contrary to a common assumption that all required knowledge already exists, there is a large potential for innovation in smallholder farming systems linking land, soil and water management.

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References

Breman, H. 1998. Soil fertility improvement in Africa: a tool for or a by-product of sustainable production? African Fertilizer Market 11 (5): 2-10.

Costanza et al., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253 – 260.

Craswell, E.T. Grote, U., Henao, J., Vlek, P.L.G. 2004. Nutrient flows in agricultural production and international trade: ecological and policy issues. ZEF Discussion Paper on Development Policy No. 78, Center for Development Research, Bonn, pp. 62.

Critchley, W. 2004 in review. Local innovation in 'Green Water' management: an interesting distraction or something worth a second look?. In: In: Reversing Land and Water Degradation: Trends and 'Bright Spot' Opportunities. Comprehensive Assessment of Water Management for Agriculture. CABI.

Drechsel, P. 2004. Personal communication. International Water Management Institute (IWMI) Ghana.

Drechsel, P., M. Giordano, and L. Gyiele. 2004 forthcoming. Valuing nutrients in soil and water: Concepts and techniques with examples from the developing world. Forthcoming IWMI Research Report. Colombo, Sri Lanka: International Water Management Institute.

Fengtong, F., S. Dethoudom and O. Keosavanh 2003. Drinking water quality in Lao PDR *In*: Simmons R.W. and Bakker. P (Eds.) Selected Papers of the UN-ESCAP/IWMI seminar on Environmental and public health risks due to contamination of soils, crops, surface and groundwater in South-East Asia, 10-12 December 2002, Hanoi, Viet Nam.

Inocencio, A., Kikuchi, M., Tonosaki, M. , Sally, H. , Rollin, D. , and Merrey, D. 2004. In Progress. Understanding the Determinants of Irrigation Investment Costs: Lessons for sub-Saharan Africa. Pretoria:IWMI Africa.

Kaiser, J. 2004. Wounding Earth's Fragile Skin. Science 304, 1616-1618.

Karar, E. 2004. Institutional change in river basin management and its implications for livelihood and ecosystem security in South Africa. SIWI/CA Seminar. Stockholm, August 21.

Lemly, D. A, Kingsford, R. T., Thompson, J. R. 2000. Irrigated agriculture and wildlife conservation: conflict on a global scale. Environmental Management 25, 485-512.

Maglinao, A.R., Valentin, C., 20032004. Community-based land and water management systems for sustainable upland development in Asia. MSEC 2003 annual report. IWMI, Bangkok, 185 p. +1 CD-ROM.

Molden, D., and Fraiture, C de. 2004. Investing in water for food, ecosystems and livelihoods. Blue Paper. Comprehensive Assessment, Stockholm, 22 pp.

Molden, D., Murray-Rust, H., Sakthivadivel, R., and Makin, I., 2003. A water-productivity framework for understanding and action. In: *Water Productivity in Agriculture: Limits and Opportunities for Improveme*nt, Kijne, J.W., Barker, R., Molden, D. (eds.). CAB International, Wallingford, UK, pp. 1-18.

Morris, B L, Lawrence, A R L, Chilton, P J C, Adams, B, Calow R C and Klinck, B A. (2003) Groundwater and its Susceptibility to Degradation: A Global Assessment of the Problem and Options for Management. Early Warning and Assessment Report Series, RS. 03-3. United Nations Environment Programme, Nairobi, Kenya.

Myers,B.J., Bond, W.J., Benyon, R.G., Falkiner, R.A, Polglase, P.J., Smithh, C.J., Snow, V.O. and Theiveyanathan, S. 1999. Sustainable Effluent-Irrigated Plantations: An Australian Guideline. CSIRO Forestry and Forest Products, Canberra, Australia. 239p.

Noble, A. D., Ruaysoongnern, S., Penning de Vries, F. W. T., Hartmann, C. and Webb, M. J. 2004a. Enhancing the agronomic productivity of degraded soils in North-east Thailand through clay-based interventions. In: Water and Agriculture (Eds. Seng, V., Craswell, E., Fukai, S. and Fischer, K.). ACIAR Proceedings No. 116: 147-160.

Noble, A.D., Bossio, D.A., Penning de Vries, F.W.T., and Pretty, J. 2004b in review. Analysis of drivers of Bright spots: Key factors contributing to their development and sustainability. Comprehensive Assessment Research Report, International Water Management Institute, Colombo, Sri Lanka.

Palmieri, A., F. Shah and A. Dinar. 2001. Economics of reservoir sedimentation and sustainable management of dams. Journal of Environmental Management 61(2):149-163.

Penning de Vries, F. W. T. 2001. Food security? We are losing ground fast. In *Crop science: Progress and prospects,*ed. J. Noesberger; H. H. Geiger; P. C. Struik. Wallingford (UK): CAB International.

Penning de Vries, F.W. and M.A. Djiteye. 1982. La productivité des paturages sahéliens: une étude des sols, des végétations et de l'exploitation de cette resource naturelle. Agricultural Research Report 918, 525 pp.

Penning de Vries. 2004 in review. Large scale fluxes of plant nutrient in food cause environmental problems at the sources and at the sinks. In: Reversing Land and Water Degradation: Trends and 'Bright Spot' Opportunities. Comprehensive Assessment of Water Management for Agriculture. CABI.

Penning de Vries, F.W.T., Acquay, H., Molden, D., Scherr, S.J., Valentin, C., Cofie, O. 2002. Integrated land and water management for food and environmental security. Comprehensive Assessment of Water Management in Agriculture, Research Report 1. Colombo, Sril Lanka: Comprehensive Assessment Secretariat.

Pretty J. 2003. Social capital and the collective management of resources. *Science* 302, 1912-1915.

Pretty, J. and Hine, R. 2004. Measuring progress towards agricultural sustainability in developing regions. Report to DFID for project CNTR 02 4047: An Analysis of Findings from the University of Essex SAFE 2 Project.

Pretty, J., Brett, C., Gee, D., Hine, R., Mason, C. F., Morison, J. I. L., Raven, H., Rayment, M. & van der Bijl G. (2000) *Agricultural Systems* 65 (2), 113-136

Pretty, J., Noble, A., Bossio, D., Dixon, J., Hine, R., Morison, J., Penning de Vries, F. 2004. In review. Resource-conserving agriculture increases yields in developing countries.
Rijsberman, F. R. (Ed.) 2000. *World water scenarios: Analyses.* Draft. 396p.
Rockström, J., Barron, J., and Fox, P. 2003. Water productivity in rain-fed agriculture: Challenges and opportunities for smallholder farmers in drought-prone tropical agroecosystems. In: Water Productivity in Agriculture: Limits and Opportunities for Improvement, eds. Kijne, J.W., Barker, R., and Molden, D. Wallingford (UK): CABI Publishing, pp. 145-162.
Rosegrant, M. 2004. Institutional aspects and water policy problematique – future perspectives. SIWI/CA Seminar. Stockholm, August 21.
Ryszkowski, L., Jankowiak, J. 2002. Development of agriculture and its impacts on landscape functions. In: Landscape ecology in Agroecosystems Management. Ed. L. Ryszkowski. CRC Press. Boca Raton: 9-27.
Sanchez, P.A., K.D. Shepherd, M.J. Soule, F.M. Place, R.J. Buresh, A-M. N. Izac, A.U. Mokwunye, F.R. Kwesiga, C.G. Ndiritu, and P.L. Woomer. 1997. Soil fertility replenishment in Africa: An investment in natural resource capital. In: R.J. Buresh, P.A. Sanchez, and F. Calhoun (eds.). Replenishing soil fertility in Africa. SSSA special publication No. 51, SSSA, ICRAF. Madison, Wisconsin. pp 1-46.
Sanio, M., Burack, D., Siddiqui, S. 1998. Reuse of urban waste for agriculture: an investment program for progressive action. Phase 1 Report. World Engineering Partnership for Sustainable Development. Virginia, USA. Pp. 55.
Sheldrick, W.F., J. K. Syers, and J. Lingard, 2002. A conceptual model for conducting nutrient audits and the national, regional and global scales. In: Nutrient cycling in agro-ecosystems, 62, 61-72.
Smaling, E.M.A., 1993. An agro-ecological framework for integrated nutrient management. PhD thesis Wageningen Agricultural University, Wageningen, Netherlands. (250 pp)
Stoorvogel, J.J., E.M.A. Smaling and B.H. Jansen, 1993. Calculating soil nutrient balances in Africa at different scales. I. Supranational scales. Fertilizer Research, 35, 227-235.
Tanh T.N. 2003. Arsenic pollution in groundwater in the red river delta. *In*: Simmons R.W. and Bakker. P (Eds.) Selected Papers of the UN-ESCAP/IWMI seminar on Environmental and public health risks due to contamination of soils, crops, surface and groundwater in South-East Asia, 10-12 December 2002, Hanoi, Viet Nam.
UNDP, 2002. Development cooperation in Vietnam. Report 2002, UNDP, Hanoi, 125 p.
V. Cervinka, V., Diener, J., Erickson, J., Finch, C., Martin, M., Menezes, F., Peters, D., Shelton, J. 1999. Integrated system for agricultural drainage management on irrigated farmland. Final Report, U.S. Department of the Interior, Bureau of Reclamation.
Water and Environment Management Project (WEMP), Regional Report No. 3. 2003 National and Regional Water and Salt Management Plans. GEF Agency of the IFAS Aral Sea Basin Program. Royal Haskoning.
Wood, S., Sebastian, K., Scherr, S.J. 2000. Soil Resource Condition. In: Pilot analysis of global ecosystems (PAGE). IFPRI and World Resources Institute. Washington, pp 45-54.
WRI (World Resources Institute) 2000. *A Guide to World Resources 2000–2001:People and Ecosystems: The Fraying Web of Life.* Washington D.C. (USA): World Resources Institute.
WWAP (World Water Assessment Program). 2003. UN World Water Development Report.
Zomer, R. and J. Menke. 1993. Site index and biomass productivity estimates for Himalayan alder-large cardamom plantations: a model agroforestry system of the middle hills of eastern Nepal. Mountain Research and Development, Vol. 13:235-255.
Zwart, S.J., and Bastiaanssen, G.M. 2004. Review of measured crop water productivity values for irrigated wheat, rice, cotton, and maize. Agricultural Water Management. Accepted for Publication.