AGRICULTURE ISSUES AND POLICIES

HUMAN DIMENSIONS OF SOIL AND WATER CONSERVATION: A GLOBAL PERSPECTIVE

TED L. NAPIER
EDITOR

Nova Science Publishers, Inc.
New York

In: Human Dimensions of Soil and Water Conservation
Editor: Ted L. Napier, pp. 321-339
ISBN: 978-1-61728-957-6

Chapter 19

Human Dimensions for Conservation-Effective Natural Resource Management in the Tropics

Samir A. El-Swaify[1] and Gerald G. Marten[2]
[1]University of Hawaii, Honolulu, HI 96822
[2]East-West Center, Honolulu, Hi 96848

Abstract

Sustainable use of natural resources in tropical regions is subject to more constraints than in temperate areas. Aggressive climates, fragile ecosystems, high population densities, inappropriate land use; and socio/political and economic uncertainties promote significant land and soil degradation and dictate high levels of community awareness of and compliance with conservation principles. In this chapter we discuss human factors that threaten natural resource stability and sustainability in the tropics; present available information on degradation extent and trends; provide some reasons for the insufficient adoption and conservation technologies by land users; suggest means for maximizing the harmony between production-driven and environmentally sensitive objectives of land use; and employ an "EcoTipping Points" perspective to present a case study from Thailand, in which agroforestry and community protection forests leveraged a turnabout from ecosystem degradation to restoration and sustainability.

The Setting

The tropical (or inter-tropical) zone lies between the tropics of Cancer and Capricorn, and has very diverse attributes. It contains regions with wide differences in climatic, biological, geological, and geo-morphological properties. The International Union for Conservation of Nature (IUCN, www.iucn.org) lists 160 countries and island groups in the world that have part of their land mass in the tropics.

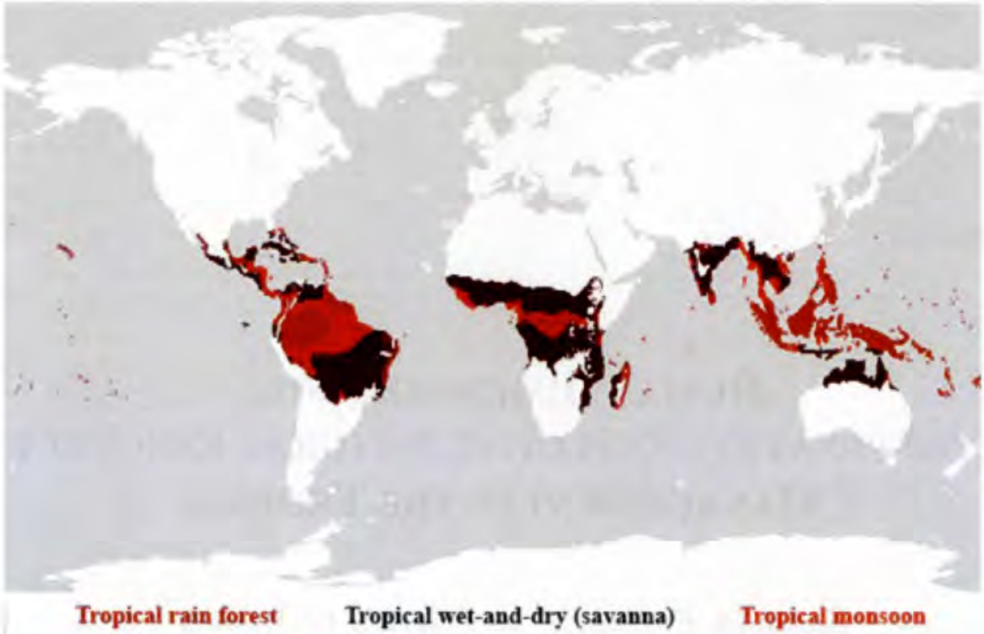

Figure 1. Dominant climates in the tropics.

While tropical climate is commonly presumed to be hot and humid, considerable variations in temperature and rainfall patterns exist depending on geographic location, elevation and exposure to prevailing winds. Subsequently, natural vegetation covers the full range from rainforest to seasonally wet and dry savanna (Figure 1). The latter areas, especially Sahelian semi-arid Africa, have been subject to well-documented, highly devastating cycles of famine as a result of both droughts and inappropriate land management (Mariam, 2010).

On both the humid/wet and arid/semiarid ends of the spectrum, tropical climates are acknowledged to be generally aggressive in promoting land, soil and watershed degradation. Desertification abounds in arid/semiarid areas, while erosion by runoff water is a constant threat in humid/wet areas (Eckholm and Brown,1977, El-Swaify et al, 1982, Abate 1994).

Tropical regions are topographically endowed with a substantial range of elevations and landscapes. As in other regions, large cities and population centers have historically grown on low-lying flat areas, often on the flanks of major rivers. However, considerable populations have encroached on hilly and mountainous lands previously in forests or other natural vegetation as favored areas have reached or exceeded their capacity, or became no longer available (Buringh,1982 and El-Swaify,1991). Human influences on these fragile ecosystems have often led to rampant degradation, especially in the form of water-induced soil erosion (El-Swaify, 1993).

Tropical soils are so highly diverse that most *Orders* in the U.S. Soil Taxonomy are found in this region. However, particularly common are the highly weathered, red, acidic, well-structured but nutrient poor *Oxisols* (and their "relatives" with Oxic horizons, Figure 2). To be optimally productive these soils, which are restricted to the tropics, generally require a substantial quantity of costly inputs, including plant nutrients and organic matter. The latter is often a precious commodity because the use of crop residues by resource-poor farmers is subject to competing uses such as fodder and fuel.

THE PEOPLE

The majority of the global population resides in tropical countries whose population densities are high and show little tendency to decline with time. Figure 3 shows the global population distribution and Table 1 includes a list of populous tropical countries.

Farming is the primary occupation and in some areas women carry most of the burden. Rural populations are often characterized by distinct cultures that must be respected when technological "improvements" are researched, developed or recommended. We are reminded of a case where a doubling of farm income was nearly guaranteed by adopting a watershed-based technology that required land preparation for cropping prior to the rainy season (El-Swaify et al, 1985 and El-Swaify, 1990).

Table 1. Populations and densities of selected tropical zone countries

COUNTRY	Population	Land Area (Sq Km s)	Pop. Density/ Sq Kms
India	1,080,264,400	3,287,590.00	328.59
Sri Lanka	20,064,800	65,610.00	305.82
Philippines	87,857,500	300,000.00	292.86
Vietnam	83,535,600	329,560.00	253.48
Nigeria	128,772,000	923,768.00	139.40
China	1,306,313,800	9,596,960.00	136.12
Thailand	65,444,400	514,000.00	127.32
Indonesia	241,973,900	1,919,440.00	126.06
Uganda	27,269,500	236,040.00	115.53
Ghana	21,029,900	239,460.00	87.82
Cambodia	13,607,100	181,040.00	75.16
Ethiopia	73,053,300	1,127,127.00	64.81
Myanmar	42,909,500	678,500.00	63.24
Kenya	33,829,600	582,650.00	58.06
Mexico	106,202,900	1,972,550.00	53.84
Tanzania	36,766,400	945,087.00	38.90
Cameroon	16,380,000	475,440.00	34.45
Zimbabwe	12,747,000	390,580.00	32.64
Madagascar	18,040,300	587,040.00	30.73
Congo (Dem. Rep. of)	60,085,800	2,345,410.00	25.62
Mozambique	19,406,700	801,590.00	24.21
Sudan	40,187,500	2,505,810.00	16.04
Mali	12,291,500	1,240,000.00	9.91

This effort, however, was often in conflict with cultural traditions, including the customary wedding season, so the acceptance and diffusion of this "technically sound" technology was significantly impeded.

Most tropical farmers are small holders, many practicing a combination of subsistence agriculture and cash cropping. Many have uncertain land tenure or access privileges. Though dependent on the land, many tropical farmers cannot afford the inputs necessary to sustain high crop yields. Their staple crops are the common grain cereals, grain legumes and root crops, all of which are sometimes combined with woody species in polyculture and agroforestry systems. Farm animals, especially livestock, play multiple roles: providing milk, meat and fiber; supplying manure for use as a soil amendment or fuel; serving as a power source for transportation and farm operations; and replacing bank accounts as a depository for family "wealth".

The 2000 United Nations General Assembly proclaimed that "by improving the productivity of smallholder farmers across the developing world, it should be possible to come closer to meeting two of the United Nations' Millennium Goals: by 2015 both the number of people living on less than $1a day and those who are hungry should be reduced by 50%" (Pell et al, 2004).

Illiteracy, poverty, unemployment and disease are more prevalent in tropical countries than in other regions, with disproportionately high rates in tropical Africa. Nevertheless, farmers have coped with such constraints and hardships, and developed alternative technologies that fit the ecological, economic and social conditions in their locations. These technologies are part of the "local or indigenous knowledge" that has been acquired from centuries of trial-and-error experience. While considered by many to be valuable, such knowledge has often been ignored or overlooked in "modern" research and technology development by foreign "experts," who may lack the necessary knowledge of tropical settings, commodities or people.

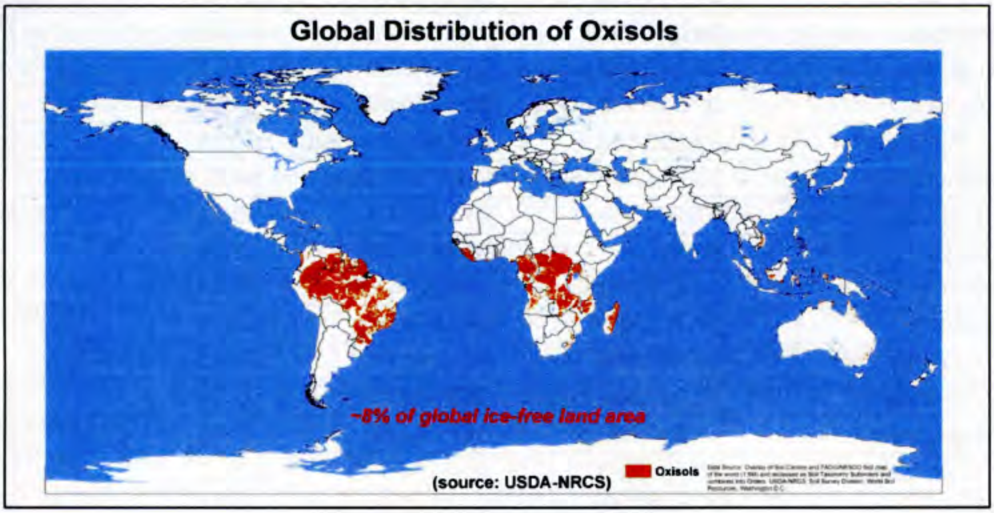

Figure 2. Abundance of highly weathered red soils (Oxisols) in the tropics.

Awareness of the contribution that local-knowledge and insights might make in development has grown in part out of farming systems research, which emerged in the 1960s when the complexity of natural resource management in diverse and risk-prone environments was realized, and research at the experiment station scale proved limiting (Shaner et al, 1982).

The farming systems approach encountered serious limitations and was subsequently followed by a number of alternative research methods, sometimes called "paradigms," all incorporating a commitment to "participatory, grass-roots or bottom-up approaches." The emergence of this area of research, however, has not been without controversy. Some "modernization" scientists have questioned whether local knowledge research has anything to offer in the context of tropical agriculture development, while anthropologists have advocated that the scientist-user combination alone is not enough (Sillitoe, 1998).

A possible compromise is to acknowledge that there are some points at which anthropology and other social sciences can be helpful in developing technologies that are economically affordable, socially acceptable and aim to empower rural groups to actively assert their true needs (Sillitoe, 1998). Such mixing is necessary when it associates technological advances and improvements by natural scientists and hard systems on one hand, with empowerment of the poor and disadvantaged by social scientists and soft systems approaches on the other.

This facilitative role in technology generation depends on being both "technologically literate" and aware of stakeholder needs (Sillitoe, 1998). In the USA, stakeholder involvement is now a standard requirement in agricultural developmental research that uses public funds and makes claims toward promoting sustainability.

Recognizing the fundamental need to enhance agriculturally-based economic development and achieve sustainable food security in developing countries, the Consultative Group on International Agricultural Research (CGIAR) commissioned the establishment of 15 Research Centers, the majority of which serve tropical regions. These include the Africa Rice Center, CIAT (Centro Internacional de Agricultura Tropical) , CIFOR (Center for International Forestry Research), CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), CIP (Centro Internacional de la Papa), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), IITA (International Institute of Tropical Agriculture), ILRI (International Livestock Research Institute), IRRI (International Rice Research Institute), IWMI (International Water Management Institute), ICRAF (World Agroforestry Centre), and (WFC) the World Fish Center. The missions and activities of these research centers provide current insights into the food security and natural resource issues faced by tropical communities (CGIAR, 2009).

Trends in Human-Induced Soil and Land Degradation in Tropical Regions

The following (paraphrased) are among the major findings of the UNEP Millennium Ecosystem Assessment (www.MAweb.org October 2005):

- Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history.
- The changes that have been made to ecosystems have contributed to substantial net gains in human wellbeing and economic development, but these gains have been achieved at growing costs due to the degradation of many ecosystem services.
- The degradation of ecosystem services could grow significantly worse during the first half of this century.
- The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios, but involve significant changes in policies, institutions and practices that are not now under way.

Continuing growth of the world's population is undoubtedly at the core of many dramatic changes on a global scale during recent years, including land use and climate changes, and associated impacts on desertification and biological diversity (El-Swaify, 2002). High population density and lack of favorable land to earn a livelihood have led to steadily-increasing human encroachment onto natural ecosystems of mountainous areas in the tropics. Associated land clearing has led to ecosystem disturbances which have resulted in substantial soil and land degradation. Information abounds on *shifting cultivation*, *slash and burn*, and certain intensive farming management practices that have proved neither stable nor sustainable for dense human populations (El-Swaify et al, 1983, van Noordwijk et al, 2001).

A snapshot of Global Assessment of Soil Degradation, GLASOD (Oldeman, et al,1991) is shown in Figure 4. This map, and subsequent higher-resolution ones with political delineations show the substantially higher degradation incidences and rates encountered in tropical areas.

Aggressive tropical climates combine with inappropriate land use to induce severe degradation and fuel the spiral of poverty. This ongoing degradation is despite the plethora of available, proven technologies and practices designed to counter it.

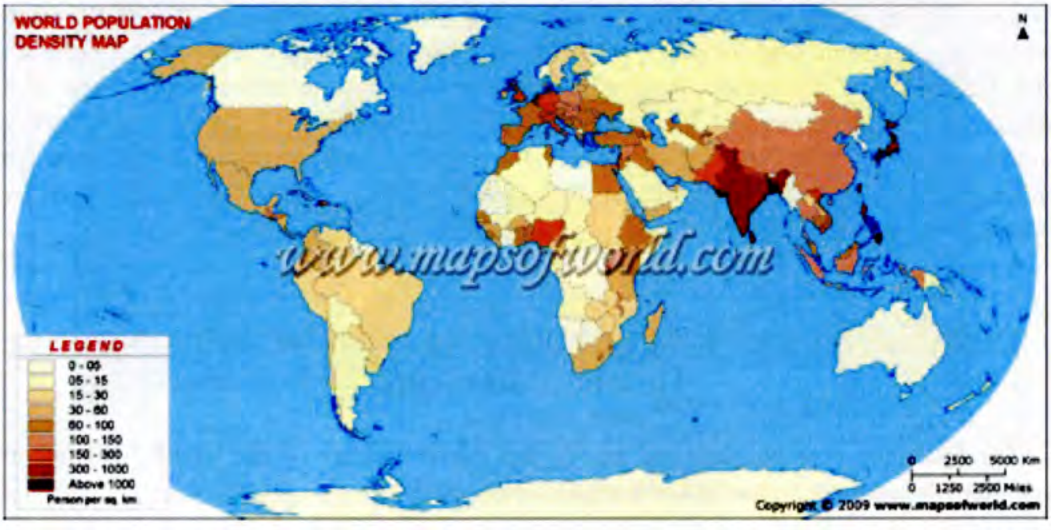

Figure 3. Map of global population densities.

El-Swaify (1990 and 1993) suggested the following as bottlenecks or barriers that inhibit the implementation of proven science-based conservation technologies, especially in developing countries:

- Lack of suitable land for intensive cultivation
- Lack of systematic land resource inventories to guide policies for optimal land-use planning and necessary designation of protected/conservation areas
- Lack of recognition, awareness, or education of land users concerning the detrimental consequences of degradation and benefits of conservation
- Reluctance to assume the risk of adopting "improved" farming technologies at the expense of proven, low-risk traditional ones
- Uncertainties in land tenure or guaranteed accessibility
- Increased land fragmentation due to inheritance provided to successive generations
- Lack of technology-transfer personnel trained to address real farmer concerns
- Unavailability of financing for mitigation or remedial measures to counter degradation
- Uncommitted decision makers and policy makers
- Ignoring farmer inputs, indigenous knowledge and culture while developing technologies
- Lack of proper monitoring of total degradation impacts and effectiveness of applied technologies

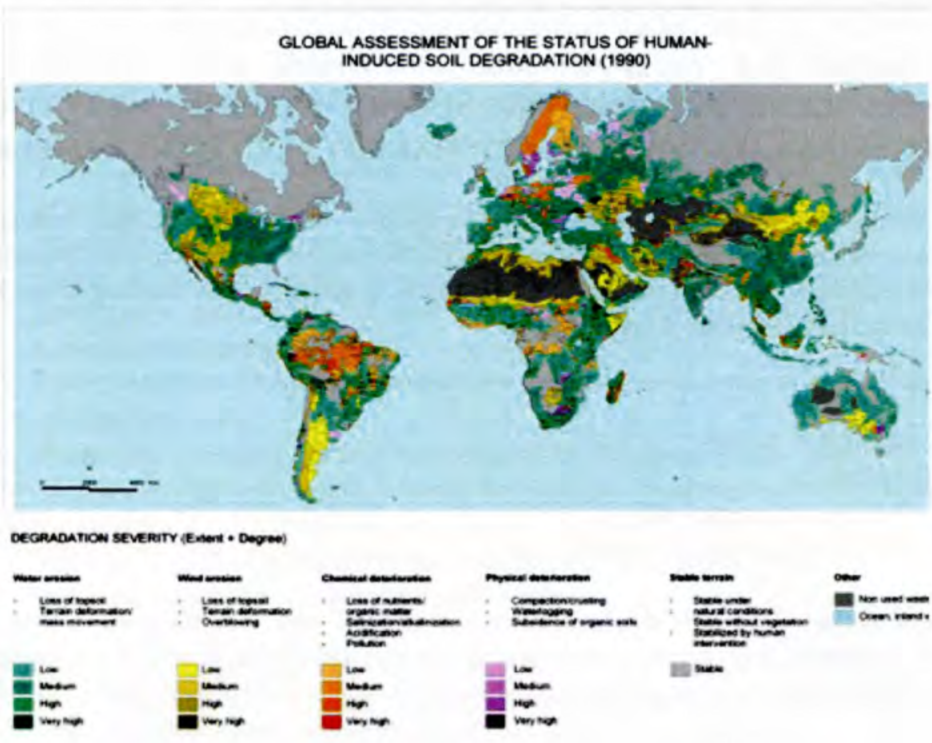

Figure 4. A snapshot of global soil degradation (Oldeman, 1991).

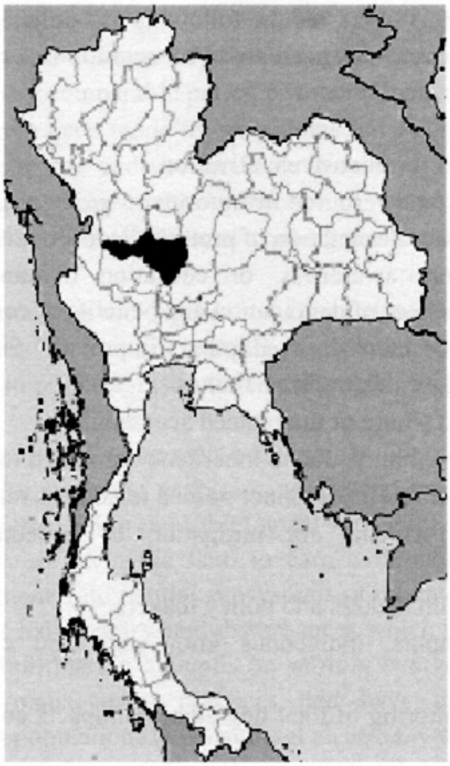

Figure 5.Map of Thailand showing the location of Nakhon Sawan province.

CHALLENGES IN IMPLEMENTING SCIENCE-BASED CONSERVATION TECHNOLOGIES WHAT POLICY MAKERS NEED TO REMEMBER

El-Swaify et al (1999) suggested that a comprehensive approach to plan, manage, or evaluate agroecosystems should incorporate several factors that act collectively, dynamically, and simultaneously to determine whether the system is sustainable in the long term. These factors (or pillars) determine if the system is:

- productive,
- has little or no risk,
- profitable,
- socially compatible, and
- ecologically/environmentally sound

These factors bear special significance for tropical and resource-poor farmers and societies. However, they present potentially conflicting objectives in decision making. El-Swaify (1998) suggested that planners, policy makers, and scientists may be able to achieve maximum harmony between production-driven and environmentally sensitive objectives of land use by:

1 Keeping a holistic perspective of sustainability during the planning process and conducting comprehensive, ex-ante accounting of land use and management impacts on the ecosystem as a consequence of proposed interventions.
2 Identifying physical, biological, economic, and socio-cultural-political determinants of "success' and quantifying specific measurable criteria for exercising "holistic" judgment.
3 Conducting the planning, implementation, and evaluation of land-use systems at meaningful temporal and spatial scales. The first should provide a sufficient time horizon for planning, implementation, and evaluation to detect unsustainable consequences of development. The latter should be landscape-based (e.g., at a watershed scale), even if the required continuity crosses political boundaries (El-Swaify and Hurni, 1996.)
4 Maximizing the match between site attributes, planned land use, and selected management technologies. Substantial mismatches often necessitate massive landscape modifications and the use of high levels of external inputs to achieve unrealistic production targets with negative environmental consequences.
5 Emphasizing incorporation of concepts and lessons learned from natural systems, including maximization of biological diversity and recycling, and minimization of soil disturbance.
6 Employing preventive rather than corrective strategies against natural resource degradation. Even if the degradation is reversible, the economics and length of time required for reclaiming or rehabilitating degraded lands are such that "Prevention is Better than Cure".
7 Planning of food production ventures for efficient use of added inputs rather than for maximum yields. Over-prescribed agrichemicals pose both productivity and pollution hazards. Tools include integrated pest management, intercropping (including agroforestry), crop residue management, and conservation tillage.
8 Defining objective indicators and realistic thresholds for the agroecosystem's productive capacity and ecological integrity, and monitoring of these indicators for regular ex-post evaluations of project performance.
9 Using sound site-specific information (data bases, models, decision aids) for quantitative optimization of land use plans and management from a balanced (sustainability) perspective.
10 Easing barriers to long-term research for achieving confidence in predictive models and decision tools.
11 Promoting scientists' active involvement in heightening the awareness of the "powers that be" with regard to merits and pitfalls of evolving land-use policies.
12 Benefiting from, rather than emotionally dismissing, emerging innovations (e.g. biotechnology and irradiation) which often reduce the need for agrichemical inputs and increase tolerance to environmental stresses..

Multi-criteria analyses will assist in defining the most critical bottlenecks for achieving land-use sustainability and ranking alternative management options according to their expected benefits. A simplified semi-quantitative integrative approach to a decision support system is shown in Table 2.

Table 2. An illustrative multiple objective matrix for evaluating the sustainability of land use

Management Alternatives (Open-ended to suit a specific situation AND Identify information gaps)	Desired ecosystem benefits (products and services) with Sustainability Perspective (Open-ended to accommodate emerging management goals) Weighting values (fraction of %) reflect perceived importance of desired benefits Scores (1-5) in matrix reflect likely success in achieving the benefits							
	Maximize Crop Production	Maximize Profits and cash flow	Improve Soil Quality (Fertility, Structure, etc)	Minimize Surface and Ground Water Pollution	Stabilize Watersheds by Control of Runoff and Erosion	Minimize Pest Infestation	Provide Multiple uses (food, energy, etc	System Score
	15%	20%	10%	15%	10%	15%	15%	
Indigenous or Current land use system New land use system or crop *Random agroforestry* *Alley cropping* *Other hedge-row farming* Scores to be inserted here in matrix pattern Modified Management *Minimum tillage* *Zonal tillage* *Residue cycling* *Legume-ley farming* *Bench terracing* *Ground cover use* *Integrated pest management (IPM)*								

It allows the decision maker to compare the impacts of alternative land use or management systems of his/her own choosing (examples shown in the first column), using weighted criteria that are selected to address his/her ultimate goal in terms of both the products and services expected from the target agroecosystem.

DEMONSTRATED CASE STUDY FOR CENTRAL THAILAND

The "EcoTipping Point" approach was designed to identify levers for turning environmental and social decline to a course of restoration and sustainability. It examines success stories to extract the lessons they offer (www.ecotippingpoints.org, Marten 2005, Marten et al. 2005, Marten and Williams 2006, Suutari and Marten 2007). For a specific location, it identifies:

- the interconnected and mutually-reinforcing vicious cycles driving decline;
- the intervention which leveraged a turnabout from decline to restoration.

The intervention is a typically a catalytic action that combines (1) a critical technology for setting restoration in motion with (2) the social organization to put that technology effectively into use.

The EcoTipping Point approach can be illustrated by the story of watershed deterioration and restoration at Khao Din village in Thailand (Marten and Suutari 2008). In 1954, migrant families from the impoverished Khorat Plateau of Northeast Thailand settled on newly opened forest land in Nakhon Sawan province (Figure 5). They found dense jungle well-endowed with seemingly infinite natural and wildlife resources. The newcomers cleared a small portion of the land for crop production and used the cut trees for house construction and firewood. "It was easy to find and grow food here. Fish in the streams were easy to catch." recalls one of the settlers (Marten and Suutari 2008). This abundance and a cooperative spirit in the village community provided a significant assurance of sustainability.

A dramatic change was triggered in the 1960s when the Thai government, with encouragement from the World Bank, launched an economic growth program with export-led development as its centerpiece. Natural resource use and agricultural focus were re-oriented toward industrial-scale exports to overseas markets. Farmers were encouraged to "modernize" by getting loans from the Agricultural Bank to acquire hybrid seed, chemical fertilizers, pesticides, and farm equipment. Countless small-scale farmers switched from traditional low-input diversified agriculture to intensive-input mono-cropping of cash crops that are heavily dependent on the use of agrichemicals. As a consequence:

- Thailand's economy grew at around 10% per year, one of the fastest-growing in the world. But this took a heavy toll on the health of the watersheds.
- Thailand's forest cover declined from 53% in 1961 to 29% in 1985.
- After an initial flush of quick cash, crop prices began to decline because of over-supply.
- Dry spells caused unusually severe crop failures

- Farmers were unable to keep up with loan payments fell prey to opportunistic money lenders who charged excessive interest rates, and began to go deeper into debt.
- Farm lands were increasingly foreclosed due to continued failure in paying off loans.

This was the beginning of a severe downward spiral (summarized in Figure 6). In desperation, villagers cut the last forest remnants to expand their fields. Extensive monoculture of cash crops from exposed fields induced soil erosion and rapid decline in soil quality, thus necessitating increased use of costly chemical fertilizers. Water sources were drying up due to watershed degradation. Back-up food supplies from forests were exhausted, fish populations declined due to runoff pollution, and wildlife virtually disappeared. As these hardships continued, people began looking for work in the cities, families were split up, and migration in search of urban jobs led to the disintegration of village communities.

The leverage to reverse this downward spiral began to take form in 1986, when an assistance team from the non-profit organization Save the Children was sent to Khao Din village by the Thai government. Rather than simply distributing aid from donors, the team awakened villagers' awareness about the causes of their predicament.

After long and arduous discussions, villagers recognized that they were primarily responsible for bringing about their own problems, because of decisions they had made on how to use and manage their land resources.

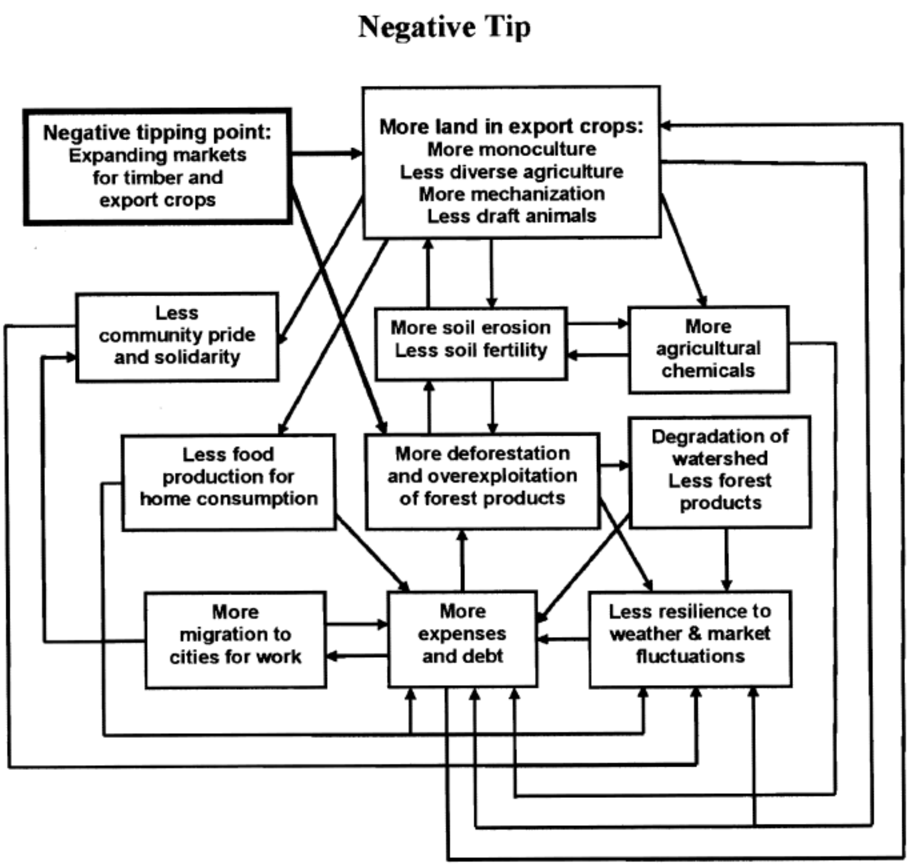

Figure 6. Vicious cycles driving decline in Nakhon Sawan province, Thailand.

This "awakening" created inspiration and confidence that they could similarly come up with their own solutions, guided by remembering what the forestland and local natural resources were like when they first arrived.

Realizing that the absence of perennial vegetation (e.g., trees) from landscapes promotes ecosystem degradation, the farmers and the team explored the potential of integrated farming built around agroforestry. Agroforestry is the simultaneous growing of trees on the same site as agricultural crops and/or livestock in order to increase the total yield of products, generate short-term income, maintain ecosystem services and improve environmental benefits. This land-use system is common in the tropics, where traditional subsistence systems have incorporated the same elements for centuries, although often with a less structured design than advocated by contemporary agroforestry experts. Because it mimics a natural forest, agroforestry can promote similar natural processes for restoring and maintaining the ecological health of the landscape. The benefits of agroforestry have been well documented from both farmer experience and scientific research (see www.worldagroforestry.org).

It serves as a source of food, fodder, fuel, fiber and organic matter for soil enrichment, thus cutting household and farming costs. Perennial woody species lend more stability and resilience to the ecosystem and promote watershed restoration.

Positive Tip

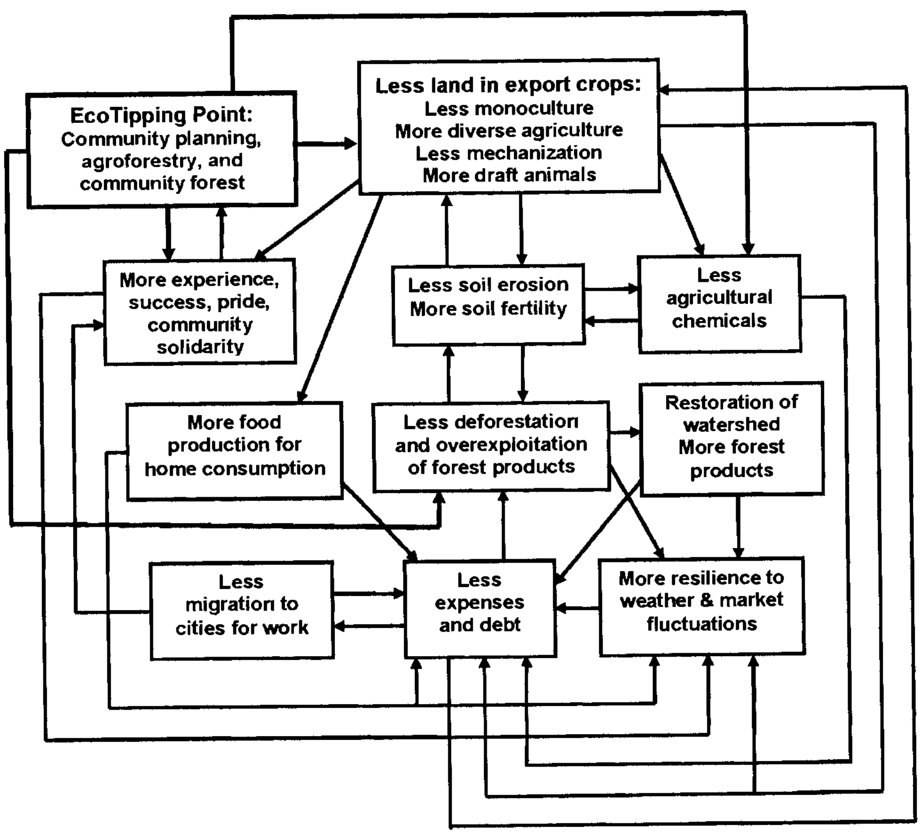

Figure 7. Reversal of vicious cycles to create virtuous cycles driving restoration and sustainability.

Farm biodiversity enhances crop protection against severe infestations, and reduces the overall risk of crop failure.

After deciding to try agroforestry, some of Khao Din's farmers who had more tolerance for risk set up pilot demonstration plots designed through discussion with the entire community. Within a few years, the other villagers adopted agroforestry on their own farms, sharing in the benefits and contributing to the overall health of the watershed. The Khao Din villagers also decided to restore mature forest to appropriate parts of their landscape by establishing "community protection" forests. The restored forests now provide fruits, nuts, fuel-wood, medicines, and building materials; and are vital for enhancing the watershed health, reducing soil erosion and degradation, and stimulating the reemergence of native fauna and flora. To protect the forest, the villagers devised and enforced rules governing the harvest of forest resources by village members. Outsiders were completely excluded. They were not allowed to cut trees or otherwise damage Khao Din's forest.

The success of agroforestry and community forest initiatives is summarized in Figure 7. Khao Din is now a thriving community and the socially disruptive migration to Bangkok has declined. Farmers in the area founded a group called "Association of Agriculture, the Environment and Development, which coordinates mutual assistance among forty villages pursuing a variety of locally designed forms of agroforestry and sustainable agriculture on land covering thousands of acres. In the late 1990s, their efforts were reinforced by the Thai government as it began supporting agroforestry and community managed forests throughout the nation under the auspices of the King's "Sufficiency Economy" program.

In the words of Khao Din's village leader: "Most of all, in terms of change, the change was in people's thinking. We are learning together as a community, sharing knowledge with each other. People no longer think: 'we are in trouble, and we can do nothing about it.' We know now that with some careful thinking and a lot of shared effort, we can solve our problems, and fix what is broken. Even though we don't have much money, I'm happy. We have friends who come to visit and we have enough food for them. We don't have to buy much of anything."* This case study suggests that success in addressing resource management issues in developing tropical countries can be promoted by:

- Outside stimulation and facilitation. A turnabout from decline to restoration seldom bubbles up from within. A success story typically begins when people or information from outside a community stimulate a shared awareness about a problem – how the situation is changing and what seems to be responsible – while providing fresh ideas for possible actions to deal with it.
- Strong local democratic institutions and enduring commitment of local leadership. Genuine community participation, in which the community moves forward primarily with its own decisions, manpower, and financial resources, generating a sense of individual and group ownership for the achievements, instead of top-down regulation or elaborate development plans with unrealistic goals.

* The authors wish to state that although Khao Din has restored environmental sustainability, the social sustainability of its break from monoculture export crops remains to be seen. Agroforestry in Khao Din provides well for basic family needs and fosters a healthy social environment in many ways. However, it has not generated large cash incomes and therefore is not completely in tune with trends in the larger society for the acquisition of more consumer goods.

- Complementary social system and ecosystem. Environmental sustainability happens when the social system and ecosystem fit together, functioning as a sustainable whole (Marten 2001). For community resource management, key features for success are clear definition of ownership and boundaries, agreement about rules, and effective enforcement of the rules (Ostrom 1990).
- "Letting nature do the work." Micro-managing environmental restoration is beyond human capacity. An effective management system gives nature the opportunity to marshal its self-organizing powers for restoration.
- Rapid results. Quick "payback" helps to mobilize community commitment.
- A powerful symbol. A sacred site such as a community forest, or a respected leader or champion for a resource conservation cause, represents the entire effort and consolidates community commitment and action to carry it forward.
- Overcoming social obstacles. Greater social complexity generally increases the magnitude of obstacles to effective problem solving (Tainter 1990), while local autonomy can be helpful for overcoming such obstacles (Ostrom 1990).
- Social and ecological diversity. Greater diversity provides more choices and opportunities – and better prospects that some of the choices will be successful in reaching desired outcomes.
- Social and ecological memory. As mentioned earlier in the context of indigenous knowledge, social institutions and technology from the past have "stood the test of time." They often have something to offer for the present.
- Building resilience. Resilience is the ability to continue functioning in the same general way despite sometimes severe external disturbance. A community's ability to withstand threats to sustainability is enhanced by its adaptive capacity – its openness to change based on shared community awareness, prudent experimentation, learning from successes and mistakes, and replicating success (Berkes et al. 2002).

CONCLUSIONS

It is important to recognize the high degree of site-specificity of human dimensions in land use planning, especially when it comes to strategies, policies and practices for sustainable soil and water management and conservation. Even so, there are certain common characteristics of developing countries within tropical regions, most of which can be determinants of or constraints to the success and failure of sustainability. Overpopulation, input-hungry soils, diminishing productivity of the natural resource base, large-scale watershed degradation, inadequate extension services, insufficient monitoring of the natural resource base, limited appreciation of the benefits to be gained from effective conservation, uncertainty in land tenure, and the reluctance of leaders to install essential long-term land protection policies stand out among these constraints. Technologies and models abound for overcoming most of them.

The seminal role of Save the Children in the Khao Din story suggests that turning the existing decline in tropical watersheds to restoration could be advanced substantially by introducing large-scale extension services with that mission, functioning in a manner similar to US land-grant institutions and the USDA Natural Resources Conservation Service (NRCS, 2010). Conservation and restoration efforts will require concerted efforts by all stakeholders, including government policies that are committed to sustainable and productive tropical ecosystems. Documenting tropical landscape degradation in a way that captures "negative tip" dynamics as in Figure 6 can help communities to take stock of their situation and figure out what to do about it. Effective programs to facilitate the process include face-to-face contact between extension agents and farmers, operational-scale demonstration plots, and early adopters whose initiatives serve as pilots for spreading conservation practices to others (Rogers 2003).

It is worth noting that there are some significant operational differences between the NRCS model and the Khao Din example:

- NRCS focuses on individual farmers while operating in partnership with citizen-managed Soil and Water Conservation Districts. The Conservation Districts, and the way that NRCS connects with them, have the same structure throughout the nation. The Khao Din model does not depend on an existing structure of this sort. It focuses opportunistically on communities where dissatisfaction with decline offers potential for action and allows shared community awareness and shared decisions to work across a community's entire landscape, spreading a model for success to other communities in the area.
- NRCS emphasizes specific, prescriptive, formally sanctioned "Best Management Practices" and well-defined assessment tools such as the Revised Universal Soil Loss Equation (RUSLE). The Khao Din model is more open-ended. It starts with a broad menu of possible choices for a community to consider.
- Government subsidies have played a major role in shaping the land-use decisions of American farmers. Subsidies were not involved in the restoration phase of the Khao Din story. Ideas came from outside, but the community proceeded with its own financial resources and manpower. This is essential in the tropics, where governments cannot afford large sums of money for large-scale ecosystem restoration.

With the above in mind, the following elements are particularly significant for effective protection and restoration of tropical ecosystems, including watersheds:

- A functioning "social commons" that assumes responsibility for stewardship of its environmental commons through: group strategic planning (Spencer 1989); drawing upon community knowledge for rapid assessment of problems and alternative solutions; analytical tools such as the vicious cycle identification in Figure 6 to help communities devise effective solutions and forge "levers" to set the solutions in motion (Coyle 2004); and fostering the "social capital" to drive restoration and sustainability.
- Dedicated leadership and a broad commitment by all stakeholders
- Land husbandry based on "ecological technologies" that fit the local ecosystem and social setting and require small cash outlays because they allow "nature to do the work."

- Making full use of indigenous knowledge and traditional, locally-based technologies while also recognizing the value of drawing upon new technologies.
- Outside advisers to suggest possible interventions to stakeholders with the understanding that they can put together their own land-use plans and action packages – as individuals and as a community.

The above elements suggest broad areas of applied research to develop "toolkits" that agricultural advisors or extension agents can use to be effective in tropical settings. High-quality toolkits do not presently exist but most of the ingredients that they require are already available. The assembly and integration of those ingredients into coherent and practical toolkits can provide a concrete framework for strategically targeted research.

REFERENCES

Abate, Zewdie. 1994. *Water Resources Development in Ethiopia*. Ithaca Press, Reading (206 pp).

Berkes, F., J. Colding and C. Folke. 2002. *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press.

Brown, Joel R. and Neil D. MacLeod. 1996. Integrating ecology into natural resource management policy. *Integrating ecology into natural resource management policy Environmental Management* 20 (3):289-296

Buringh, P. (1982) *Potentials of world soils for agricultural production. Transactions of the12th International* Congress of Soil Science. Indian Society of Soil Science, New Delhi.

CGIAR (Consultative Group for International Agricultural Research). 2009. http://www.cgiar.org/

Coyle, G (2004) *Practical strategy: structured tools and techniques*, Prentice Hall, Upper Saddle River, NJ.

Eckholm, E., and Brown, L. R. 1977. *Spreading deserts - the hand of man*. Worldwatch Paper 13, Worldwatch Institute, Wasington, D.C.

El-Swaify, S. A. 1990. Conservation-effective farming systems for the tropics. In *Challenges to Dryland Agriculture, A Global Perspective, Proc*. International Conference on Dryland Farming (Unger, P.W., Sneed, T.V., Jordan, P.W., and Jensen, R., Editors): 134-136. Texas Agric. Exp. Sta., Temple.

El-Swaify, S. A. 1991. Land-based limitations and threats to world food production. *Outlook on Agriculture*, 20 (4): 235-242. C.A.B. International.

El-Swaify, S.A. 1993. Soil Erosion and Conservation in the Humid Tropics. In *World Soil Erosion and Conservation* (D. Pimentel, Ed). Cambridge Studies in Applied Ecology and Resource Management (a contribution of the Commission on Ecology, International Union for the Conservation of Nature and Natural Resources):233-255. Cambridge University Press.

El-Swaify, S.A., Sitanela Arsyad and P. Krishnarajah. 1983. *Soil Erosion by water*. In The Handbook on Natural Systems Information for Development (R.A. Carpenter, Ed): 99-161. The MacMillan Co., Inc. New York.

El-Swaify, S. A., Dangler, E. W. and Armstrong, C. L. (1982). *Soil Erosion by Water in the Tropics*. Research and Extension Series 024, Hawaii Institute of Tropical Agriculture. University of Hawaii Press, Honolulu. (173 pp).

El-Swaify, S.A., P. Pathak, T.J. Rego and S. Singh. 1985. Soil management for optimized productivity under rainfed conditions in the semi-arid tropics. *Advances in Soil Science, Volume 1*:1-64, Springer-Verlag, New York.

El-Swaify, S. A. and Hurni, Hans. 1996. Transboundary effects of soil erosion and conservation in the Nile Basin. *Land Husbandry* 1: 31-47.

El-Swaify, S.A. with an international group of contributors. 1999. *Sustaining the Global Farm - Strategic issues, principles, and approaches*. Special Issue Paper of the International Soil Conservation Organization (ISCO). Department of Agronomy and Soil Science, University of Hawaii at Manoa, Honolulu, HI, USA (60 p).

Marten, G.G. 2001. *Human Ecology: Basic Concepts for Sustainable Development*. Earthscan Publications.

Marten, G.G. 2005. Environmental tipping points: a new paradigm for restoring ecological security, *Journal of Policy Studies* 20:75-88. (Online at www.ecotippingpoints.org/articles/ecological-security.html)

Marten, G.G., S. Brooks and A. Suutari. 2005. Environmental tipping points: a new slant on strategic environmentalism, *WorldWatch Magazine* 18(6):10-14. (Online at www.ecotippingpoints.org/articles/strategic-environmentalism.html)

Marten, G.G. and D.G. Williams. 2006. Getting clean: Recovering from pesticide, *The Ecologist* 36(10):50-53. (Online at www.ecotippingpoints.org/articles/escaping-pesticide-addiction.html)

Marten, G.G. and A. Suutari. 2008. *Watershed restoration with agroforestry and community forest management*. (Online at www.ecotippingpoints.org/articles/reversing-tropical-deforestation)

Natural Resources Conservation Service (NRCS). 2010. *A Legacy of Conservation – 75 Years of Helping People Help The Land*. http://www.nrcs.usda.gov/about/

Oldeman, L.R.; Hakkeling, R.T.A.; Sombroek, W.G 1991. *World Map of the Status of Human-Induced Soil Degradation* (GLASOD). International Soil Reference and Information Centre (ISRIC), United Nations Environment Programme (UNEP), in cooperation with Winand Staring Centre, International Soil Science Society, Food and Agriculture Organization of the United Nations (FAO), International Institute for Aerospace Survey and Earth Science (ITC). ISRIC (Wageningen) and UNEP (Nairobi.)

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.

Pell, A.N, D.M. Mbugua, L.V. Verchot3, C.B. Barrett1, L.E. Blume1, J.G. Gamara1, J.M. Kinyangi, C.J. Lehmann1, A.O. Odenyo, S.O. Ngoze1, B.N. Okumu1,

M.J. Pfeffer1, P.P. Marenya1, S.J. Riha1, and J. Wangila. 2004. The Interplay Between Smallholder Farmers and Fragile Tropical Agroecosystems in the Kenyan Highlands.*AAAS Biocomplexity Paper*:2004-02-10.

Spencer, L.J. 1989. *Winning through Participation*. Kendall/Hunt Publishing Co., Dubuque, IA. (www.ica-usa.org/store/bk-html/bk-06.php).

Rogers, E.M. 2003. *Diffusion of innovations*, 5th editon, Free Press, New York, NY.

Suutari, A. and G.G.Marten. 2007. EcoTipping points: how a vicious cycle can become virtuous," *Earth Island Journal* 2 (2):26-31. (Online at www.ecotippingpoints.

org/articles/vicious-cycle-virtuous.html)

Tainter, J.A. 1990. *Collapse of Complex Societies*. Cambridge University Press.

van Noordwijk, M., T. P. Tomich, and B. Verbist. 2001. Negotiation support models for integrated natural resource management in tropical forest margins. *Conservation Ecology* 5(2): 21.