Research Imperatives in Conservation Farming and Environmental Management of Sloping Lands: An ICRAF Perspective

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Paradigm Shifts in Hillslope Conservation Farming

The theory and practice of conservation farming for hillslopes in the tropics is undergoing dynamic revision. Paradigm shifts are occurring at several levels. The body of conventional wisdom has been seriously modified in recent years. We may identify three paradigm shifts of particular significance:

1) The engineering approach has yielded to the biological approach to conservation on smallholdings,
2) the top-down watershed management approach is yielding to a bottom-up approach with a farmer and community focus, and
3) the pruned leguminous tree hedgerow concept of contour farming is diversifying toward a much more robust array of hedgerow options.

In light of the current flux in knowledge, there is need for clearer models to articulate and rationalize conservation farming options. They would help clarify the contrasts among alternative pathways toward sustainability, and better define the array of recommendation domains.

The ICRAF mission in Conservation Farming

ICRAF's purpose is "to work towards mitigating tropical deforestation, land depletion, and rural poverty through improved agroforestry systems". The role of agroforestry in conservation farming on sloping lands is a key element in its research activities.

Our work in southeast Asia has emphasized strategic research on issues underlying the application of contour hedgerow systems. In the context of this work we identify a number of urgent research needs in consonance with the prospective scope of the proposed consortium.

A Conceptual Framework for Research

Although there is a wide range of smallholder pathways to apply conservation farming, most research and development efforts tend to emphasize specific practices or packages. These may be suited to particular circumstances, but tend to be recommended with little serious concern about defined recommendation domains. In developing its research agenda, the consortium could consider starting from a operational model of farming

Figure 1 is an attempt to illustrate the major systems pathways that may provide a starting point for discussion. The diagram illustrates the options based on whether an external nutrient supply is available to the farmer (Garrity, 1994). This creates a dichotomy of pathways. Farmers without access to nutrient inputs must depend on some form of fallowing. To increase productivity they need better ways of accelerating the accumulation of nutrients in the fallow vegetation. The viable options are improved fallows (A1 in the figure), fallow-rotation hedgerow systems (A2), and agroforests containing cash-generating perennials (A3).

When continuous cropping becomes feasible (B) further evolution is needed to protect investments in soil fertility through some form of conservation farming. Options range from natural vegetative strips (B1), that may be enhanced by value-added perennials (B2), to pruned leguminous tree hedgerows (B3). Further transformation may lead to commercial perennial crops or tree horticulture (B4).

There is a correspondence between the options appearing opposite each other on the left and right pathways in the figure, reflecting the potential for a lateral transfer from left-to-right, or right-to-left, depending on changing nutrient availability.

The limitations of pruned-tree hedgerows have prompted interest in a wide range of other alternative hedgerow systems. The figure may help to place pruned-tree hedgerows in a bit clearer perspective vis-a-vis other options. We now outline some of the areas that we believe deserve urgent attention in the conservation farming research agenda. ICRAF is focussing on several of these issues in its ongoing work and impending activities.

Key Research Issues

Continuous Cropping

1. Low-maintenance contour hedgerows, particularly natural vegetative strips (B1). Research and farmer adoption have shown this option to have some major advantages in establishing vegetative filter strips for soil conservation. It tends to be limited to continuous cropping situations in which external nutrients are applied. At this point we believe natural vegetative strips deserve wider testing and popularization, with research focussed on monitoring their performance under farmer practice in diverse situations.

2. Full-canopy cash perennials in contour hedgerows (B2). Farmers often establish fruit trees or other perennials in contour grass strips. The interactions and production tradeoffs between full-canopy trees and annual crops have not been explored. We are initiating work to model these interactions as a means to guide recommendations on the design and management of such systems.

3. Pruned tree contour hedgerows (B3). It is now clear that they are suited to a much narrower recommendation domain than initially conceived. The most urgent need is realistic economic analysis of these systems: Exceedingly little useful economic analysis has so far been done--even though wide-ranging extension has been promoted. Second, much more in-depth analysis of the tree-soil-crop interactions is needed to predict performance across environments. Third, the specific hedgerow species makes a definitive difference, and serious evaluation of alternative hedgerow species is needed, with more emphasis on local species with promising adaptive features. New methods of root characterization will be tested for applicability to this work.

Improved fallows

1. Tree fallows (A1). Limited studies of indigenous managed tree fallows on more neutral pH soils (Cebu, E Indonesia) have highlighted the potential for these systems. Tree species with the key characteristics required for acid soils environments need to be identified to enable these systems to be extrapolated.

2. Rotational fallow systems (A2). The concept of following hedgerows to regenerate fertility seems well suited to the smallholder on marginal sloping soils with no access to fertilizers. Work by ICRAF and IITA in Africa has shown promising results. We are planning to thoroughly investigate the system's applicability in Southeast Asia.

3. Agroforests (A3). Mixed perennial systems are an exceptionally suitable conservation farming system for steeply sloping lands. ICRAF will be intensively analyzing indigenous systems, and how to increase their yielding capacity without degrading their environmental and soil conservation benefits.

Cross-systems research

1. Sustainability implications of soil redistribution as terraces develop behind vegetative barriers. Soil conservation research has emphasized the reduction of off-field soil losses due to the establishment of contour vegetative barriers. A range of studies have demonstrated that soil losses are typically reduced 50-95% by the presence of vegetative barriers. Soil movement and redistribution within the alleyways is not arrested, however, but rather may be accelerated. This results in major spatial changes in soil fertility (degradation in upper alleys, deposition in lower alleys) that affect the sustainability of crop yields in contour hedgerow landscapes. We urgently need to know whether upper-alley scouring effects are a short- or long-term phenomenon, and how they can be effectively avoided or alleviated.

1.1 Understanding the soil processes. Research during the past few years has documented the nature of the spatial changes in soil fertility. The process occurs too rapidly to be explained on the basis of water-induced soil erosion. Currently, we seek to understand the relative contributions of tillage versus water-induced soil displacement. This is critical to modeling these processes to predict the rate and extent to which the problem may develop in different environments, and with varying management practices, particularly tillage frequency and intensity.

1.2 Fertility management in alleyway zones with differential soil properties. Three strategies need to be fully investigated:

(1) Reduce the intensity and frequency of tillage. ICRAF is currently experimenting with ridge tillage as a practical alternative to minimum or zero tillage. Ridge tillage has become a popular conservation tillage system in North America. We are adapting the concept to animal-powered systems using the conventional implements used by smallholder farmers.

(2) Adjust biomass and nutrient inputs according to zonal requirements within the alleyways. Ongoing experiments in Claveria, Mindanao are evaluating the effectiveness of the approach, and the processes involved. This work needs to be expanded to other sites and management systems.

(3) Change the cropping (or hedgerow) systems. Research is needed on how best to use the upper alley zone when degradation is extreme, as occurs on shallow soils, or soils with a very acid subsoil. Annuals or perennials that better tolerate the depleted upper alley need to be identified for a range of environments.

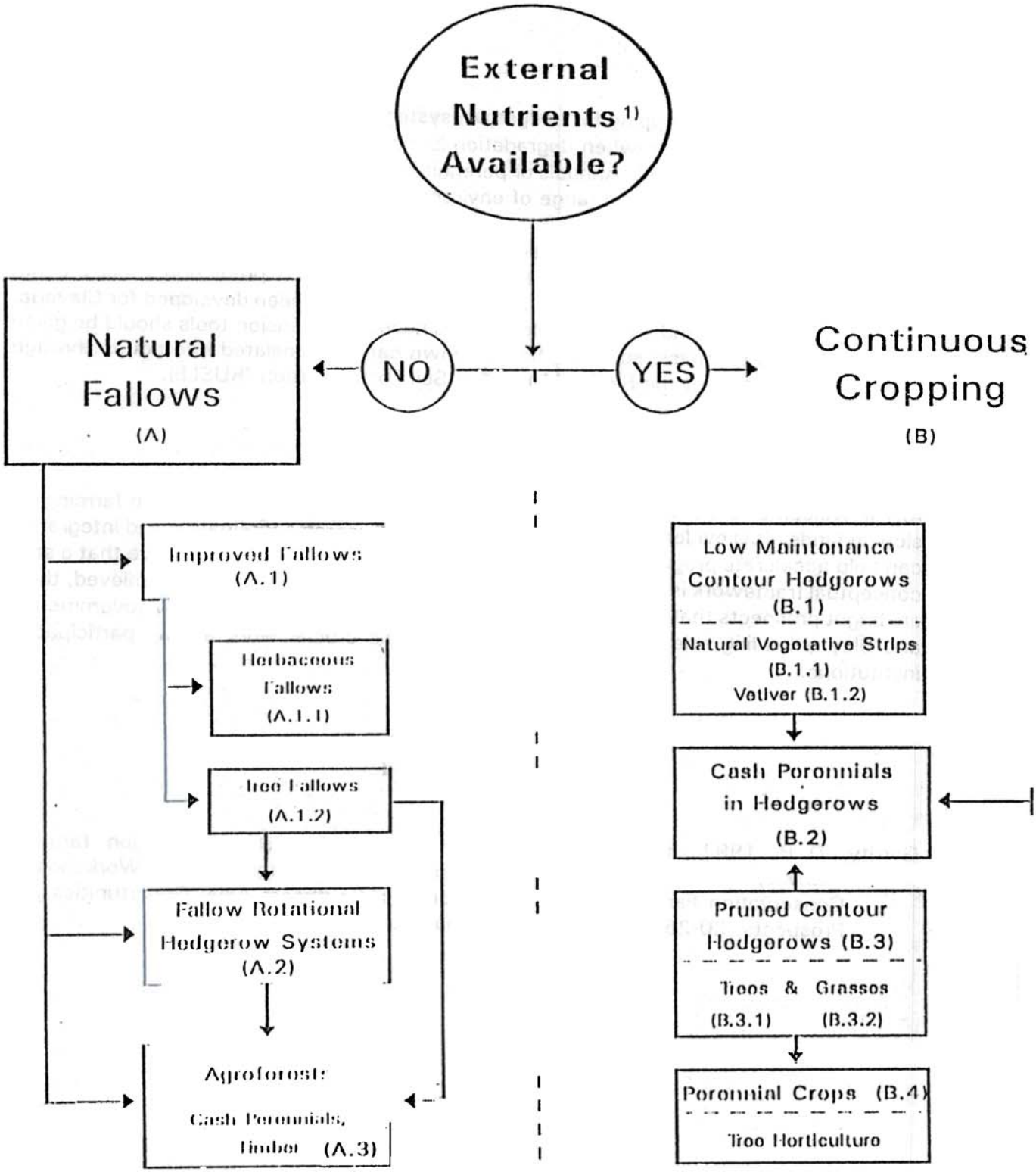
2. Practical tools that enable conservation farming extensionists to estimate soil losses and make recommendations at the field level. Empirical erosion prediction tools are not available for use by field practitioners. A preliminary tool has been developed for Claveria. Much more validation and model development is needed. Extension tools should be given more immediate emphasis so that what is known can be translated into action through empirical application of the Revised Universal Soil Loss Equation (RUSLE).

Conclusion

ICRAF welcomes the prospect of an international consortium on conservation farming for sloping lands. It is evident that greater international research coordination and integration can help accelerate progress in this broad and complex endeavor. We believe that a solid conceptual framework is needed in starting such a consortium. If it can be achieved, there are bright prospects that the agenda will capture the attention of donors and governments, and play a leading role in setting the pace for this crucial work among participating institutions.

Reference Cited

Garrity, D P. 1994. Improved agroforestry technologies for conservation farming: Pathways toward sustainability. Paper presented at the International Workshop on Conservation Farming for Sloping Uplands in Southeast Asia: Opportunities and Prospects, 20-26 November, 1994, Manila.



1 Manure, fertilizer or off-field plant residues

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Figure 1 Pathways in smallholder farming systems evolution on sloping lands as mediated by the availability of external nutrients.