A LITERATURE REVIEW OF NATURAL RESOURCES MANAGEMENT PRACTICES:

Case Studies on Agroforestry, Soil & Water Conservation, and Soil Fertility Enhancement

Submitted to:
AID/AFR/SD/PSGE/NRM

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INTRODUCTION

Environmental and natural resources degradation arising from wanton deforestation and non-sustainable farming systems are of utmost concern to governments of developed and developing countries alike. The consequences of the misuse and abuse of natural resources are obvious and are felt by everyone. Global warming, desertification, and impaired hydrologic cycles represent just a few of the numerous catastrophes we see today and will continue to experience if destruction of our forests and soils go unchecked.

Donor agencies and other international bodies have invested heavily in research and technology transfer mechanisms that have potential impacts on environmental degradation. Information pertaining to technologies currently in use to address the situation are dispersed and can be found in libraries and the individual donor or project offices and files. This document is an attempt to concentrate information on those interventions that are directly applicable to African conditions. For each case study, we give: 1) the technical name of the practice(s) reviewed, 2) a brief description of activity, 3) reasons for using, 4) potential impact on degradation, 5) potential impact on yields/productivity, 6) enabling conditions associated with adoption, 7) constraints associated with adoption, 8) programmatic actions associated with adoption and 9) a reference.

Technologies are organized by region/agroecological zone to facilitate immediate applicability. In this way, we minimize duplication of efforts and save money and time. We believe it will be useful as a quick reference to planners, researchers, non-governmental organizations and voluntary extension groups whose activities contribute to sustainable use of natural resources so as to make the world a comfortable place to live.
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SECTION ONE
AGROFORESTRY SYSTEMS

Agroforestry is the term used for agricultural systems in which trees and/or shrubs are deliberately grown with crops and/or livestock. Although the term agroforestry has been coined only recently, agroforestry techniques have been practiced for generations. Indeed, trees and shrubs are an integral part of most traditional low-resource agricultural systems, and cleared treeless fields, such as those common in the temperate zones, are the exception rather than the rule in Africa (MacDonald, 1981).

Agroforestry systems can help alleviate three of the most important constraints in African agriculture: (i) low-fertility soils; (ii) insufficient, erratic water availability, and; (iii) lack of animal fodder. Leaves from trees and shrubs, and to a lesser extent branches and roots, increase soil organic matter as they decompose. This organic matter improves soil structure, soil fertility, and soil water-holding capacity. The deep root systems of trees enable them to use nutrients deep in the soil profile. Some of these nutrients have leached down from the topsoil and are no longer available to short-rooted crop plants, a problem that is especially severe in degraded soils. The recycling mechanism of trees and shrubs brings these nutrients back to the soil surface where they can become available to shallow-rooted annual crops (Nair, 1984; Weber and Stoney, 1986).

More...
Technical Name of Practice: Field trees

Description of Case Study: Field trees are grown within and adjacent to crop fields in the Sahel, West Africa.

Reasons for Using: Fodder/fuelwood, reduce soil erosion and water runoff, soil fertility enhancement.

Potential Impacts on Degradation: Trees reduces soil erosion and water loss from runoff and evapotranspiration (water loss from evaporation and crop transpiration) and allows more intensive use of the land.

Potential Impacts on Yields/Productivity: For example, in semi-arid areas a nitrogen-fixing tree, Acacia albida, can double yields of certain crops grown under its canopy and provide valuable browse for livestock.

Enabling Conditions Associated with Adoption: Secure land and tree tenure rights, access to seedlings.

Constraints Associated with Adoption: Damage to regenerated trees by grazing animals, lack of seedlings.

Programmatic Actions Associated with Adoption: A deliberate effort should be made to involve church groups, schools and women associations in nursery establishment and tree planting activities.

Technical Name of Practice: Field trees

Description of Case Study: Mobilization of farmers to plant trees in Zambia.

Reasons for Using: This tree planting program was initiated in response to farmers’ needs assessed through a formal survey. The rationale was to satisfy farmers’ need for fuelwood, construction poles, fodder, green manure and live fences and to provide a source of income to farmers as well. Diminishing wood and wood products arose from long-term land abuse by the local population.

Potential Impacts on Degradation: Trees restore fertility of the degraded lands by supplying organic matter and recycling of leached nutrients. As physical barriers on sloping lands, they help slow down erosion damage caused by water and wind. Trees give year-round fodder to increase livestock productivity per unit land area and avoid extensive over grazing.

Potential Impacts on Yields/Productivity: Farm families who began tree planting and agreed to protect Acacia albida in their fields improved their soil and harvested more food than those who did not.

Enabling Conditions Associated with Adoption: The project began by addressing farmers’ own needs. A close farmer-extension contact was stressed. Farmer participation in decision-making and his/her feedback proved fruitful. The decentralized nursery system helped reach out to many people with seedlings and the organized training and demonstrations convinced them of the merits of tree planting. Using role plays, scheduled farm visits, field days and demonstration plots, the project succeeded in training farmers and reviving their interests in tree planting and other organic farming methods such as composting and green manuring. The colonial administration had used highly subsidized fertilizers and farm loans at independence as incentives to discourage farmers from practicing the organic-based traditional methods for conservation. Nurseries were set up in schools and scattered in other remote areas of the community to assure easy accessibility of seedlings to everyone. The program receives government support.

Constraints Associated with Adoption: Development projects find it difficult in getting seeds from the forestry department. Lack of proper coordination among projects working in the area which may lead to waste of limited resources. Survival rates of Leucaena and Eucalyptus are low in this moisture-stressed area. Men dominate in most project activities.

Programmatic Actions Associated with Adoption: Farmers must be taught how to set up seed orchards. Deliberate effort must be made to include women in important project’s business.

Technical Name of Practice: Agro-pastoral systems

Description of Case Study: Permanent farming systems for crop production, animal husbandry and community forestry in the mountainous areas of Rwanda.

Reasons for Using: To develop land use practices that would permit intensive and multiple use of the Rwandan hillsides on sustained basis.

Potential Impacts on Degradation: Integration of trees, grasses, herbaceous and shrub legumes, and livestock conserved soil fertility, checked soil erosion, assured year-round fodder availability, as well as wood for cooking and other domestic uses.

Potential Impacts on Yields/Productivity: Sequential integration of trees, e.g. *Grevillea robusta* and shrubs such as *Cajanus cajan* and *Sebania sesban*, over a 9-10 year period produced mulch for coffee plantations, green manure, firewood, fodder and other benefits which were valued higher than the cost of implementing the technologies. For example, 9 year old *Grevillea* at a density of 350/ha yielded 14.6 cubic meter of wood products and 3.1 tons of leaves for mulching purposes. Intercropped maize and sweet potato registered yield increases of 17 and 29%, respectively, over 5 years of cropping.

Enabling Conditions Associated with Adoption: The value of *Grevillea* wood for domestic construction and as timber for the local market motivated farmers to embrace agroforestry. Existence of communal work force (umuganda), controlled by the central government, is equally responsible for widespread farmer participation in soil conservation and reforestation exercises. Establishment of 170 tree nurseries to supply seedlings to farmers as compensation for their participation in the work group served as an incentive for tree planting. Finally, raising communal taxes provided the means to secure funds to undertake small-scale social forestry and soil conservation programs.

Constraints Associated with Adoption: Trees and grasses compete with food crops for land ares, therefore, scarcity of arable land may limit the number of trees that can be integrated into the farming systems.

Programmatic Actions Associated with Adoption: Government and donor support for tree planting activities and soil conservation work should be continued and expanded.

Technical Name of Practice: The Chagga Homegarden

Description of Case Study: Indigenous, multi-storied and intensive farming systems are described whereby food crops, trees, shrubs, and animals are raised on the same piece of land near human settlements in Tanzania. A special feature contributing positively to its operation is the continuous addition of household organic materials (including animal litter) to the garden.

Reasons for Using: To maximize food, fodder and wood production per unit land area without serious adverse effects on the natural resource base.

Potential Impacts on Degradation: Soils in the homegardens receive household organic refuse regularly which makes them exceptionally fertile and productive. The multi-strata vegetation are effective in checking soil erosion. Additionally, the improved soil structure due to increased soil organic matter favors water infiltration and results in reduced runoff and erosion. Also, because of increased crop productivity per unit land area, cultivation of marginal lands usually becomes unnecessary.

Potential Impacts on Yields/Productivity: The Chagga homegardens on the slopes of Mt. Kilimanjaro in Tanzania have been extremely productive. Gross return per hectare for the Chagga homegardens is about $850 for banana and bean compared to $110 recorded for a typical maize/bean lowland cropping system. Cultivation of bean, vegetables and root crops are important components of the Chagga homegardens which provide in income as well.

Enabling Conditions Associated with Adoption: High returns to labor input is the major attractant to the system.

Constraints Associated with Adoption: Land shortages arising from demographic pressures.

Programmatic Actions Associated with Adoption: The system is traditional in the area and has been practiced for many generations.

Technical Name of Practice: Windbreaks

Description of Case study: Continuous rows of trees planted perpendicularly to the direction of the prevailing winds in Nigeria.

Reasons for Using: To reduce wind speed, crop lodging, and to supply fuelwood and other tree products.

Potential Impacts on Degradation: Minimize wind erosion and serves as woodlots.

Potential Impacts on Yields/Productivity: In Kano of northern Nigeria, crop yield increases of between 15 to 25% have been attributed to the positive effect of windbreaks with Eucalyptus.

Enabling Conditions Associated with Adoption: Use of fruit trees as windbreaks stands greater chances of being readily adopted than trees with little or no commercial value.

Constraints Associated with Adoption: Lack of adequate skills on the part of farmers to manage tree nurseries, subsequent outplanting, and location of nurseries are too distant from the fields where the seedlings would be planted.

Programmatic Actions Associated with Adoption: Active community involvement should be encouraged right from the outset. Local government should provide financial and material support to meet part of operational costs of the tree planting activities.

Technical Name of Practice: Windbreaks

Description of Case Study: Continuous and uniform rows of trees planted perpendicular to the direction of the prevailing winds in Niger.

Reasons for Using: To reduce the destructive effects of sand storms on emerging food crops in the Sahelian area and to increase crop yields.

Potential Impacts on Degradation: Stabilization of long-term crop production in the Sahelian environment through soil and moisture conservation.

Potential Impacts on Yields/Productivity: In southern Niger, windbreaks spaced 6-20 m resulted in a 48 to 90% increase in early millet total dry matter and a 74 to 89% improvement in cowpea ground cover. Even though these improved growth parameters were not reflected in immediate crop yields, the large amount of biomass returned to the soil stabilized soil fertility and crop yields over the long-term.

Enabling Conditions Associated with Adoption: Most farmers are used to planting trees. Farmers obtain immediate benefits, e.g. fuelwood from planting trees and other tree products.

Constraints Associated with Adoption: Planting materials may either not be readily available or may be present in limited quantities.

Programmatic Actions Associated with Adoption: Structures must be put in place to provide farmers with the appropriate seedlings at the right time. Campaigns to alert farmers of dangers of deforestation and the positive influence of forests on the environment should be intensified.

Technical Name of Practice: Windbreaks

Description of Case Study: Double rows of closely planted neem trees spaced at 100 m intervals and placed perpendicularly to the direction of the prevailing wind in Niger.

Reasons for Using: To protect top soils of the Majjia Valley in Western Niger from being eroded by the Harmattan winds.

Potential Impacts on Degradation: The 300 km neem tree windbreaks has saved 3000 ha of cropland from losing 20 tons of topsoil annually through wind erosion.

Potential Impacts on Yields/Productivity: Grain yield increase of between 15-20% and biomass yield of about 70% relative to unprotected sites are expected after three years of tree establishment. This benefit due to windbreaks is equivalent to $60 per hectare protected. Additionally, sale of harvested wood during the eighth year and beyond can provide an income of between $54 and $160 per hectare.

Enabling Conditions Associated with Adoption: Participation of herders and women in project design and implementation of the projects. Farmers benefit from proceeds of sale of the wood products.

Constraints Associated with Adoption: Competition for water and light result in crop yield loses amounting to $15/ha as well and a further loss of $20/ha due to cropland sacrificed for windbreaks.

Programmatic Actions Associated with Adoption: A concerted effort from government and non-governmental organizations to demonstrate long-term benefits of windbreaks to the farming communities. Examples are improved crop yields, income from wood, provision of raw materials for village industries and soil and water stabilization.

Technical Name of Practice: Community tree plantation

Description of Case Study: Tree planting by a local self-development cooperative (MOBISQUAD) initiated by the Government of Ghana.

Reasons for Using: To rehabilitate overused and infertile farmlands.

Potential Impacts on Degradation: Reforestation of abandoned fields with fast-growing trees and shrubs restored the productivity of the land.

Potential Impacts on Yields/Productivity: The group rehabilitated about 37.6 ha of farmland in four years and engaged itself in similar food and cash cropping activities which brought in a total revenue of approximately $9850/year.

Enabling Conditions Associated with Adoption: Villagers participated in conception, design and implementation of the group programs. Group effort was backed and facilitated by local chiefs and government. Monetary gains from MOBISQUAD’s operations was an incentive to join in tree planting exercises.

Constraints Associated with Adoption: Lack of resources to expand group activities to many villages.

Programmatic Actions Associated with Adoption: Community leaders need training in organizational and management skills to better promote programs that conserve the environment and natural resources.

Technical Name of Practice: Trees to counter desertification

Description of Case Study: The organization of a rural community in Kenya by church groups to raise ecological awareness and undertake afforestation programs to prevent desertification.

Reasons for Using: To develop a farming system that would preserve natural resources and counter desertification.

Potential Impacts on Degradation: Trees on the landscape slow down environmental impairment through production of organic matter and erosion control.

Potential Impacts on Yields/Productivity: Adopters of the technology increased their farm productivity and income.

Enabling Conditions Associated with Adoption: Tree seedlings were supplied free of charge to farmers. Selection criteria for core project staff were traditional knowledge of and interest in trees, and dedication to home area; academic degrees was unimportant in this regard. A bottom-up approach was emphasized in all aspects of project implementation meaning the people collectively saw desertification as a threat to their survival which must be overcome at all cost. Mass education on dangers of forest resources depletion was topical in the agenda of the program. Establishment of models of 40 sustainable agricultural systems in two severely degraded agroecological zones served as community demonstration plots.

Constraints Associated with Adoption: Poor infrastructure, especially roads, and lack of adequate funding to support adaptive research and extension of workable findings.

Programmatic Actions Associated with Adoption: Government and donor assistance to upgrade road network, provide materials and fund limited adaptive trials would go a long way in complementing the actions initiated by the poor church groups.

Technical Name of Practice: Alley farming

Description of Case Study: Integration of shrub legumes and food crops on farm fields in Nigeria.

Reasons for Using: To study the conditions which determine adoption of alley farming at farm level.

Potential Impacts on Degradation: Over the long-term, alley farming offer farmers wood products and a source of mulch to fertilize their land in order to continuously crop their fields.

Potential Impacts on Yields/Productivity: Immediate benefits reported by most participating farmers included production of fodder during dry season, stakes for yam, mulch during rainy season and weed control. Others mentioned easier workability of soils, control of Imperata (a weed) and improved crop yields.

Enabling Conditions Associated with Adoption: Good and rapid establishment of shrubs are crucial to adoption of alley farming. Obviously, shrub establishment could be delayed by impoverished soils, low rainfall and weed infestation. Also, shrubs establish better when intercrops do not shade or strangle the shrubs.

Constraints Associated with Adoption: Shrubs take much time to establish on poor soils. The soil fertility improvement aspect of alley farming takes several seasons to show effects. Some farmers were unsure of the alleged benefits and question the wisdom of losing food crop space to non-edible trees.

Programmatic Actions Associated with Adoption: Involvement of extension to explain the mode of operation of alley farming will remove doubts as to its ability to bring about sustained yields. Alley farming should be promoted among women groups because of their key role in traditional farming systems.

Technical Name of Practice: Alley farming for livestock/crop production

Description of Case Study: Inclusion of small ruminants in alley cropping systems to improve both soil and animal productivity in Nigeria.

Reasons for Using: To enable small farmers to continuously crop their fields using shrub prunings and animal litter as sources of manure. Additional benefits include supply of fodder for livestock, yam stakes and wood for cooking and construction.

Potential Impacts on Degradation: The tree and animal litter conserve soil fertility, permits intensive cultivation and sustainable land use.

Potential Impacts on Yields/Productivity: At Ibadan, Nigeria, Leucaena yielded 8 t dry matter/year, 156-282 kg N/ha and doubled maize yield in the fourth year relative to the control plots without Leucaena and animal litter. Maize yields for the respective plots were 2.6 and 1.3 t/ha.

Enabling Conditions Associated with Adoption: Secure land and tree tenure rights, access to more land, and wealth increased farmers’ ability to take risk.

Constraints Associated with Adoption: Labor shortage, difficulty in technology management.

Programmatic Actions Associated with Adoption: Government support for well trained extension personnel to educate farmers on management aspects of alley farming and better pricing policy for farm produce.

Technical Name of Practice: Alley cropping for soil improvement

Description of Case Study: A technique where crops are planted in narrow "alleys" between rows of nitrogen-fixing, perennial leguminous trees and/or shrubs in Nigeria.

Reasons for Using: Alley cropping will find its greatest acceptance in areas where land scarcity is most acute, that is, where shifting agriculture is no longer possible. Shrubs are pruned frequently, with the trimmings used as mulch, fodder, and/or fuelwood.

Potential Impacts on Degradation: Alley cropping, which is an organized agroforestry model, combines production with conservation of the natural resource base. By its design, alley cropping systems guarantee continuous addition of organic materials to upgrade or at least maintain the productivity of the soil.

Potential Impacts on Yields/Productivity: Yields of maize stabilized at about 2 t/ha after 6 years of continuous alley cropping; without alley cropping, the yield was no more than .5 t/ha.

Enabling Conditions Associated with Adoption: The system satisfies farmers wood and fodder needs in the short-term and conserves soil fertility over the long-term.

Constraints Associated with Adoption: It is difficult for farmers to fathom and appreciate the long-term merits of alley cropping, e.g. soil fertility improvement. Farmers may also encounter problems with procurement of the right seeds and/or seedlings and in the management of the system itself.

Programmatic Actions Associated with Adoption: Long term field demonstrations under farmers' own conditions are required to win farmers confidence and for them to accept the alleged desirable effects of alley cropping on crop yields.

Technical Name of Practice: Alley cropping to stabilize yield

Description of Case Study: The growing of food crops in spaces created by hedgerows of leguminous shrubs in Nigeria. The hedgerows are pruned periodically to remove shading effects and prunings are used as green manure to the soil.

Reasons for Using: The systems conserves soil fertility through nitrogen fixation and nutrient recycling.

Potential Impacts on Degradation: Continuous hedgerows may help reduce erosion. Dependent upon shrub management style, fodder, firewood and poles may be obtained. On the whole, alley cropping increases land use intensity and by so doing, reduces pressure on natural forest lands.

Potential Impacts on Yields/Productivity: At Ibadan, Nigeria, alley cropping with Lacuna and Gliricidia species spaced 2-6 m between rows maintained maize yield around 1.5 t/ha during a period of 6 years. There was a substantial drop in the yield of cowpea which may be ascribed to its poor germination after incorporation of shrub prunings.

Enabling Conditions Associated with Adoption: Early adoption is usually based on short-term provision of wood and fodder since the soil improvement aspect takes some years before it becomes visible. Being a new technology, most of the inputs associated with its implementation are provided to farmers free of charge.

Constraints Associated with Adoption: Cropland forgone in favor of trees. Additional labor in managing fast growing species like Lacuna and Gliricidia in the lowland humid tropics. Inability of farmers to perceive the long-term benefit of the system.

Programmatic Actions Associated with Adoption: Need to demonstrate the value of alley cropping under farmers’ conditions in different agroecological settings. Effort on the part of extension and research personnel to educate farmers on the long-term merits of alley cropping. Practical examples may speak louder than volumes of scientific publications in this respect.

Technical Name of Practice: Rehabilitation of degraded forests

Description of Case Study: Installation of microcatchments, check dams, earth/stone buds and mulching techniques to conserve soil moisture and stimulate regrowth of a degraded natural forest in Niger.

Reasons for Using: To rehabilitate and protect the Guesselbodi national forest from wanton destruction by farmers and grazers.

Potential Impacts on Degradation: Reconstitution of the original vegetation induced infiltration through creation of favorable soil structure and consequently minimized runoff and erosion.

Potential Impacts on Yields/Productivity: The project rehabilitated 3,000 ha, i.e 60% of the Guesselbodi forest, with an additional 10% each year. Members of the woodcutters association received additional income from the revenues from the park.

Enabling Conditions Associated with Adoption: The project employed local human and material resources by the formation of a woodcutters association to enforce judicious forest utilization. The natives living around the forest shared in the benefits from the forest. The project had external funding. Farmers and young scholars alike were trained in forest management. Monitoring and evaluation systems were instituted to oversee sustained growth of the forest.

Constraints Associated with Adoption: Lack of financial support at the end of project life.

Programmatic Actions Associated with Adoption: Government extension agents should assist farmers to replicate the techniques on their private lands.

Technical Name of Practice: Communal afforestation

Description of Case Study: An institution-building project to strengthen the capacity of four communes in Rwanda to undertake agro-silvicultural practices.

Reasons for Using: To redress constraints relating to deforestation, soil erosion and declining crop yields.

Potential Impacts on Degradation: The practice of agroforestry and community tree plantations supply the people’s wood needs, offer a means to reduce soil erosion and stabilize soil productivity on hillsides where most farming is done.

Potential Impacts on Yields/Productivity: Project activities resulted in establishment of 400 ha communal woodlot, 37 tree seedling nurseries and tree planting on about 2500 ha of private farmlands.

Enabling Conditions Associated with Adoption: The project enjoyed the unflinching support of the country’s president. Farmers came to learn about the project’s activities through UMUGANDA (a national self-help work force) coordinated by the office of the president. An important addition to the project’s outputs was the training of forestry extension staff who taught farmers nursery management principles, contour planting and alley cropping techniques, and set up agroforestry demonstration plots as well.

Constraints Associated with Adoption: Premature cancellation of project-funded extension support positions and resignation of Peace Corps volunteers assigned to help out with project’s outreach component.

Programmatic Actions Associated with Adoption: Participation of community work force in the project’s tree planting exercise were enforced.

Technical Name of Practice: Restoration of degraded forests

Description of Case Study: A reforestation program in refugee settlements in the Gedaref district of Eastern Sudan.

Reasons for Using: To address land deterioration problems arising from erosion and restore the area's potential to produce sufficient wood products to match the needs of the local residents.

Potential Impacts on Degradation: Environmental degradation is reversed by having vegetation on the terrain to minimize the impact of erosive agents (rainfall and wind) on the already fragile soils.

Potential Impacts on Yields/Productivity: 1) Establishment of fuelwood plantations on 3,091 shelterbelts on 90 feddans, 2) planting of 250,000 trees in household compounds for shade and ornamental purposes, 3) setting up nurseries, each with a capacity of 600,000 seedlings in two villages. The nurseries produced about 1,800,000 seedlings of species which were planted as shelterbelts. Other achievements include introduction and sale of over 500 improved charcoal stoves and reinforcement of the national Forestry Department.

Enabling Conditions Associated with Adoption: People valued trees for providing early services such as shade, live fences, and/or food. Frustration associated with tree establishment in dryer environments were overcome by applying existing subsoiling, microcatchments, mulching, weed control techniques. The Forestry Department has widened its scope to embrace new efforts in extension, agroforestry, and shelterbelts. Seedlings were given at no cost to users. Timely provision of material and technical assistance.

Constraints Associated with Adoption: Low survival rates of transplanted seedlings.

Programmatic Actions Associated with Adoption: Funds from government and donors to sustain the current level of effort.

Technical Name of Practice: Trees on farmlands

Description of Case Study: *Acacia albida* (gao tree) either planted or regenerated on food crop fields in Southeast Niger.

Reasons for Using: The trees provide shade, fodder, improve soil fertility, conserves soil moisture, and enhances overall farm and off-farm productivity.

Potential Impacts on Degradation: The uniqueness of foliation and defoliation of *Acacia albida* makes it an excellent species to intercrop with most food crops in the Sahelian region. It sheds its nitrogen-rich biomass during the cropping season to recycle nutrients for soil fertility improvements, and allows sunlight to reach intercrops. The tree develops leaves during off-season to protect the soil against wind erosion and the Sahelian scorching sun from ‘baking’ the fragile agricultural soil.

Potential Impacts on Yields/Productivity: Millet under *Acacia albida* outyielded its counterpart in the open field by 100 to 150%. The observed yield advantage could partly be ascribed to the supply of nitrogen, phosphorus and magnesium by 100 to 150 *Acacia* trees per hectare. The respective amount of each nutrient is 300, 30, and 25 kg/ha.

Enabling Conditions Associated with Adoption: Good cooperation between government agents promoting tree planting and village heads. Interest and participation of local leaders in project’s decision making process. Markets outlets for processed and raw *Acacia* products should be developed to generate extra monetary income to farmers.

Constraints Associated with Adoption: Poor survival of *Acacia* resulting in high cost of tree establishment.

Programmatic Actions Associated with Adoption: Government should recognize and support effort of village leaders who are genuinely interested in tree planting activities. Government and non-governmental organizations should give financial, material (seedlings) and training support to farmers.

Technical Name of Practice: Trees on farmlands

Description of Case Study: Fast-growing multipurpose trees on farm fields in Western Kenya.

Reasons for Using: Principally to resolve firewood crises among women and also to provide food, fodder, poles, green manure and mulch for soil fertility conservation.

Potential Impacts on Degradation: The trees replaced the original vegetation which had almost disappeared and offered protection against erosion, fertility decline and minimized further encroachment to marginal lands.

Potential Impacts on Yields/Productivity: No yield data is available. However, the CARE-administered project has succeeded in creating farmer awareness with regard to deforestation and environmental degradation. Consequently, farmers were encouraged and supported technically and logistically to embark on a district-wide tree planting program. Apart from satisfying their domestic wood needs, farmers gained supplementary income from the sale of poles and other tree products.

Enabling Conditions Associated with Adoption: Free supply of inputs by CARE for establishment of nurseries which is criticized in terms of long-term sustainability of the practice. The economic benefits from tree marketing attracted farmers to adopt agroforestry. Furthermore, the involvement of local chiefs and moral support from the government lured several farmers into accepting tree planting to halt environmental degradation.

Constraints Associated with Adoption: Trees compete with food crops for land. No reliable markets for excess wood produced.

Programmatic Actions Associated with Adoption: Support from local authorities should be strengthened. Emphasis should be placed on role of women in planting and marketing of tree products.

SECTION TWO

SOIL AND WATER MANAGEMENT SYSTEMS

Africa’s lands are under pressure to provide increased production to feed the continent’s growing population. To meet this demand, farmers have shortened fallow periods on lands already in use and they have expanded cultivation onto lands of marginal productivity. The result is that many agricultural lands are now showing signs of widespread environmental degradation (Lal, 1987; Swindale, 1988).

Soil and water conservation systems may be defined as all measures designed to improve or preserve the productivity of the land (Reij, 1988). Techniques of erosion control usually also contribute to water retention. Some measures for improving soil fertility can, through their effect on organic matter production improve soil structure. This ultimately increases both the resistance of the soil to erosion and the water-holding capacity of the soil bearing in mind that fertilizer use efficiency is a function of soil moisture conditions.

More...
Technical Name of Practice: Grass strips

Description of Case Study: Planting of 0.5 m wide Vetiver (Vetiveria zizanioides) bands at predetermined intervals along contours to decrease water runoff velocity, increase water infiltration and sedimentation of eroded soils in India.

Reasons for Using: To minimize runoff and loss of fertile top soil in erosion-prone fields.

Potential Impacts on Degradation: The deep, strong and fibrous root system of Vetiver improves soil aggregation and consequently water infiltration. The planted grass along contours form physical barriers to decrease runoff velocity and therefore allows time for soil particles loaded in the runoff water to re-settle on the field. Over time, soil that accumulates behind the strips form terraces which reinforces erosion control on the field.

Potential Impacts on Yields/Productivity: Vetiver strips contribute to soil productivity by preserving the fertile top soil. It has been proven, under certain circumstances, to be more effective in limiting erosion than other known measures such as alley cropping and/or bunds. For example studies in India showed 10.9 t/ha eroded soil in Vetiver stripped plots as opposed to 22.7 t/ha in Lacuna alley cropped fields and 19.9 t/ha in fields with contour bunds.

Enabling Conditions Associated with Adoption: In comparison with other erosion control measures, planting of grass is inexpensive and simple to do. Vetiver grass in particular adapts to a wide range of agroecological conditions. Specifically, it thrives in altitude ranges of 0-2500 m and rainfall zones between 200 to 6000 mm per year. Economically, oil from Vetiver roots are extracted for use in the cosmetic industry.

Constraints Associated with Adoption: Bush fires in the semi-arid and arid areas may hinder adoption.

Programmatic Actions Associated with Adoption: Intensive campaign by government extension staff to popularize the technology among farmers. Enforcement of local regulations prohibiting uncontrolled bush burning.

Technical Name of Practice: Grass strips

Description of Case Study: Planting of a one meter wide continuous band of Napier grass spaced 8 m along contours to control soil erosion on a 25% sloping hillside in South-western Uganda.

Reasons for Using: Properly established and managed, grass strips along contour lines effectively control soil erosion, serve as fodder banks and produce stakes for climbing bean in the high elevation areas of East and Central Africa.

Potential Impacts on Degradation: Soil that settles behind the grass bands develop into terraces over time and modifies the landscape. With reduced gradient and shortened slope, velocity of runoff and hence soil erosion, are minimized.

Potential Impacts on Yields/Productivity: The above system has made it possible for farmers to reap 5 to 6 bags of Irish potato and sorghum per year which are valued between $435 and $522 in the local market. Yields of sweet potato have been maintained at a reasonable level of 2.5-3.1 t/ha for 50 years using grass strips.

Enabling Conditions Associated with Adoption: The grass strip is welcomed by farmers because unlike other conservation measures, this technique allows them to farm their fields twice every year. Also, the popularity of the system among farmers is partly attributed to the presence of well trained and committed extension staff and secure land tenure rights.

Constraints Associated with Adoption: Relocation of fields every 8 to 9 years is tedious and adds to production costs.

Programmatic Actions Associated with Adoption: The system can be improved by judiciously integrating grass with leguminous shrubs so as to combine erosion control and fertility improvement with shrub prunings. At that time more dedicated extension personnel will be required to spread the technology.

Technical Name of Practice: Bench terracing

Description of Case Study: Terracing is used in Kenya as an engineering support structure for controlling water runoff and soil erosion. It involves excavation of earth at right angles to the slope to stop runoff. Terracing requires earth movement to create a 'bench' (generally 4-8 m wide) and a wall of about 3 m dependent upon slope.

Reasons for Using: Terraces are effective in overcoming land degradation caused by accelerated erosion on very steep slopes.

Potential Impacts on Degradation: In the semi-arid agroecological zones where rainfall is low, terraces become useful by intercepting overland flow of water and distributing it over the entire field. In this respect, terraces help conserve rainfall and soil better than vegetative methods on croplands.

Potential Impacts on Yields/Productivity: The Katheka self-help group in Machakos, Kenya have employed bench terracing to cut down soil loss and regenerate their deteriorating farmlands. Currently, 15 self-help teams construct an average of 20 km terraces every year.

Enabling Conditions Associated with Adoption: Primary motivating factor in the case of Katheka, was total community awareness of the fact that agricultural and natural resources productivity were declining at an alarming rate. The people had long recognized the potential of terraces in combating soil erosion. Terracing was introduced by the British colonial rulers but the idea was shunned at that time probably due to their 'top down' approach of presenting it. Terracing, however, resurfaced after independence with the assistance of local chiefs who involved the people in all decision-making matters affecting them as individuals and the community.

Constraints Associated with Adoption: Expensive to construct and maintain on an individual basis. Poorly constructed terraces especially on shallow soils could cause landslides or result in gullies if badly maintained.

Programmatic Actions Associated with Adoption: Local government should train and offer material assistance to volunteer groups working on terracing and allied conservation structures.

Technical Name of Practice: Water harvesting

Description of Case Study: In Sudan, fields using a technique called trus cultivation are bounded on three sides by embankments 30-40 cm in height, while the top side is left open to trap overland water flow. It is suited for clay soils on sloping lands.

Reasons for Using: To revive Acacia senegal plantations, maintain soil fertility, and improve soil water retention.

Potential Impacts on Degradation: Trus cultivation is suitable for moisture storage on sloping lands in semi-arid areas where water is major limiting factor to crop production. As a physical barrier, it functions as a soil conservation structure.

Potential Impacts on Yields/Productivity: In Sudan, trus farming on clay soils has shifted land use pressure from impoverished sandy soils and allowed some farmers to re-establish Acacia plantations. The practice of trus cultivation also has led to intensive market-oriented vegetable farming to boost farmers’ income.

Enabling Conditions Associated with Adoption: Through tribal heads, dangers associated with resources depletion is made known to villagers. They accept the fact that their livelihood depends largely on judicious manipulation of these resources. To this effect, they cooperate with the local authorities and government agencies to develop and execute programs such as trus cultivation, that have potential to sustain the natural resources base.

Constraints Associated with Adoption: The tenurial rights regarding trus farming favors mostly the rich people. A lot of human and material resources are wasted as the system is still based on trial and error.

Programmatic Actions Associated with Adoption: There is a need for a national policy that will facilitate access of poor farmers to trus lands. Government researchers and extension personnel should work with farmers and traditional leaders to fine tune the existing design of the trus to improve upon its efficiency.

Technical Name of Practice: Water management

Description of Case Study: Introduction of the concept of water management to rural communities in Guinea. Techniques taught were reforestation of land areas above springs and construction of infiltration structures like dams, ditches and contour barriers.

Reasons for Using: To provide year-round potable water to rural communities in the Fouta Djallon region of Guinea.

Potential Impacts on Degradation: Reduced runoff and erosion hazards through improvements in surface and ground water collection and storage techniques.

Potential Impacts on Yields/Productivity: Water was available to people during most part of the year. Most important was the first-time realization of and acceptance of water as a manageable natural resource by the people.

Enabling Conditions Associated with Adoption: The technical and material support given by the USAID-funded Natural Resources Management project. The tedium of having to trek long distances for water during dry spells was alleviated. The proposed interventions were simple to implement.

Constraints Associated with Adoption: Difficulty in erasing the misconception among certain sections of the population that the developed water sources were to the advantage of the project more than their own.

Programmatic Actions Associated with Adoption: Intensive extension education is needed to dispel the above misconception and to organize farmers collectively to participate in these simple conservation techniques for their own good.

Technical Name of Practice: Earth/stone bunds

Description of Case Study: This study describes the use of earth and stone bunds in Ethiopia. Following demarcation of contours with "A" frame or bubble level, trenches are dug along them and the excavated soil is thrown uphill to form bunds. The bunds are kept in place with grass strips, trees or food crops. Stones lines were constructed in conjunction with the contour bunds. Additional practices were afforestation and livestock management.

Reasons for Using: To protect watersheds and reclaim farmlands extremely degraded through agricultural practices and uncontrolled grazing in the Ethiopian highlands.

Potential Impacts on Degradation: Erosion is checked by the above structures through reduction of slope length and gradient. Vegetation used to stabilize the bunds, give fodder, food and wood.

Potential Impacts on Yields/Productivity: Since 1974, about 60,000 km of earth and stone bunds were built to salvage cultivated lands. Subsequent developments included natural formation of 300,000 km terraces on the hillside and closure of 100,000 ha of sloped lands for natural regeneration of vegetation to take place. The program exposed peasant farmers to various soil conservation measures and taught them techniques for their implementation as well.

Enabling Conditions Associated with Adoption: Organization of farmers into about 20,000 associations, externally funded food-for-work and technical support programs.

Constraints Associated with Adoption: High labor input for construction and maintenance of earth and stone bunds. Terrace formation was limited on the shallow soils found on the very steep slopes. Landslides and mudslides become rampant under such conditions. The food-for-work approach later made farmers more interested in grain provided by the program than conserving their own land to produce grain.

Programmatic Actions Associated with Adoption: Level of funding allocated to soil conservation should be maintained or expanded so as to enable the Ministry of Agriculture to reach more farmers and also to try out new methods.

Technical Name of Practice: Contour farming

Description of Case Study: This study describes contour farming in Burkina Faso. Contours were marked with a water tube and barriers, 10-50 cm high and 10-100 m long were built along them. Materials used were rocks, bundles of cereal stalks or branches of trees, and/or grass. Barriers were spaced 10-50 m apart or further distances if labor is a constraint.

Reasons for Using: To harvest runoff water, reclaim land and conserve applied manure and crop residues on farms.

Potential Impacts on Degradation: Terraces develop over time to control erosion.

Potential Impacts on Yields/Productivity: Average cereal yield was 290 kg on contour-farmed fields compared to 155 kg/ha on non-treated farms. The increase of 135 kg grain more than offset the amount of food (90 kg) given to workers in exchange for their labor constructing barriers on a hectare of land. Water harvesting permits farmers to plant about a month earlier. In this case, farm labor is spread out evenly during the season. Additional advantage is that growing crops suffer less from drought stress commonplace in the Sahel zone.

Enabling Conditions Associated with Adoption: Farmers’ participation in all aspects of the development of the technology was encouraged, i.e., from identification of problem to extension of tested solutions. Farmers perceived soil degradation as vital to their survival and therefore worked with government and aid agencies to search for control measures and to extend them. In response to farmers’ real need, project’s focus shifted from tree planting to exploitation of runoff water and soil improvement for cereal production. Through informal training and field demonstrations, many farmers learned of several soil fertility conservation techniques. This enabled them to raise their farm productivity without endangering the environment.

Constraints Associated with Adoption: Labor for collection of rocks and construction of barriers.

Programmatic Actions Associated with Adoption: Government extension staff should help disseminate the proven soil conservation practices through demonstration and training.

Technical Name of Practice: Contour farming

Description of Case Study: This study describes contour farming in Cochabamba in Bolivia. It entails plowing and building rock walls along contours on sloping lands. Size of bunds vary with slope. For 8-15% slope rock walls are 25-50 cm wide and 40-60 cm high; and for 20-25% slope, walls are 50-60 cm wide and 1-3 m high. Contours are 20 m apart. In addition, 20 kg of nitrogen and phosphorus fertilizers were applied.

Reasons for Using: To harvest and conserve water and improve soil fertility for production of food crops for home consumption and commercial purposes and to create rural employment.

Potential Impacts on Degradation: The practices allow sustained crop production without degrading the natural resource base.

Potential Impacts on Yields/Productivity: In a semi-arid region in Bolivia, these practices made water available to permit intensive cropping of high-valued crops, e.g. spring potatoes, onions and vegetables. Crop yields increased and cash benefits ranging between $b 250 to $b 270 per hectare were reaped with benefit/cost ratios greater than unity. Many people profited from the technologies by working primarily as farm laborers to maintain the conservation structures.

Enabling Conditions Associated with Adoption: The technologies are profitable and under the prevailing circumstances (steep slopes, erratic rainfall, and poor soils), offer farmers the most appropriate means to exploit their land and water resources to better their living conditions. Also, the practices were simple to learn and emulate.

Constraints Associated with Adoption: Lack of initial funds to invest in conservation structures and to purchase production inputs (fertilizer, improved seeds, plows etc.).

Programmatic Actions Associated with Adoption: Government should facilitate acquisition of farm loans and production inputs. Extension networks should be expanded and equipped with facilities to help with dissemination of the practices.

Technical Name of Practice: Contour walls

Description of Case Study: This study describes field demonstrations and extension of rock walls along contours on farms located on slopes of Mt. Fouta Djallon in Guinea.

Reasons for Using: To slow down soil and water movement on farms and save them for crop production.

Potential Impacts on Degradation: The technology preserved the environment by controlling runoff and erosion.

Potential Impacts on Yields/Productivity: The project succeeded in motivating farmers to construct stone walls on their farms to increase the crop yields.

Enabling Conditions Associated with Adoption: As an inducement allowance, participating farmers received 3 cents per meter of stone wall built by themselves on their own farms. Even though cash and food aid as incentives in technology transfer have been criticized as non-sustainable, their application can be justified in situations where projects have a limited time frame to demonstrate an impact. This is especially the case with long-term interventions such as agroforestry and soil conservation. In this particular case, farmers expressed a willingness to continue the operation on their own after they have had the chance to witness the potential of the proposed soil and water saving technologies.

Constraints Associated with Adoption: Problem of land ownership and distraction by other village commitments.

Programmatic Actions Associated with Adoption: A "bottom up" approach that involves farmers in problem identification, elaboration of solutions and testing of proposed interventions may be tried alongside giving of incentives.

Technical Name of Practice: Contour stone bunds

Description of Case Study: Rocks bunds, 10-15 cm high and buried 10-20 cm deep to form physical barriers along contours in Burkina Faso.

Reasons for Using: To protect croplands in the Sahel against erosion.

Potential Impacts on Degradation: Like other physical barriers, the stone lines literally blocks water from running across the field. In this way, runoff and sediment transportation leading to land degradation are prevented or minimized. Terraces gradually form behind the stone bunds in the course of time and act as long term erosion control devices.

Potential Impacts on Yields/Productivity: Increased crop yields of up to 53% in fields with contour stone bunds relative to non-treated plots have been reported as are improvement in soil organic matter levels and water retention. About 3,500 ha of cropland has been protected by stone bunds.

Enabling Conditions Associated with Adoption: Active farmer participation at all levels of project implementation and excellent farmer-extension contact helped technology adoption. The technology, which is low risk and uses local materials, addressed farmers’ real needs of harvesting water for cereal crop production. Additionally, existence of organized women groups and immediate gains from the technology all contributed to its wider spread among farmers.

Constraints Associated with Adoption: Collection and transportation of stones to farmlands could be tedious and labor-demanding. A certain portion of cropland is lost to the bunds.

Programmatic Actions Associated with Adoption: Stone and earth bunds are being applied by most farmers because they seem to work for them. Governments can facilitate their dissemination through national media, workshops and field days.

Technical Name of Practice: Integrated land management

Description of Case Study: A rural development project in Lesotho, with the following components: soil conservation, rangeland improvement, afforestation, growing of fruit trees, fodder production, and spring development.

Reasons for Using: To optimize benefits from land resources without adverse effects to the environment.

Potential Impacts on Degradation: Application of the above practices at individual and community levels has halted degradation and regenerated landscapes to sustain productivity of current crop and pasture lands.

Potential Impacts on Yields/Productivity: Project staff, in concert with the rural community and Ministry of Agricultural personnel, have achieved the following: development of micro-catchments, gully and rangeland rehabilitation, spring development, and management of crop lands. The ultimate result is increased farm productivity through improved water, soil and crop husbandry practices.

Enabling Conditions Associated with Adoption: The program has full government backing in terms of material and technical support. Payment of incentives to participating farmers in form of cash and kind (seeds and fertilizers). Emphasis on use of farmers as trainers has accelerated widespread adoption. Farmer boards and training schemes were put in place to further ensure sustainability and promotion of these practices.

Constraints Associated with Adoption: Farmers partially adopted interventions that require the use of purchased inputs such as fertilizers. Results of research conducted under more favorable environments elsewhere in the country were not applicable to the drought-prone project’s operational zone.

Programmatic Actions Associated with Adoption: More local land resource managers are needed to oversee implementation of conservation measures at the village level. Multi-disciplinary testing of research results in the project area should precede wide scale extension of technologies.

Technical Name of Practice: Tied furrows

Description of Case Study: This study describes a system in Zimbabwe consisting of ridges and furrows on cropland with the furrows tied at regular intervals. Crops are grown in the furrows to take advantage of rain water collected in them at the onset of the season. Furrows could be 1, 1.5 or 2 m wide but the 1.5 m furrows were preferred because they produced permanent ridges on the vertisols where they were tested.

Reasons for Using: To prevent loss of rain water by runoff and increase surface water storage for crop use.


Potential Impacts on Yields/Productivity: Crops grown in furrows over eight seasons outyielded their counterparts on flat lands in all seasons. For example furrowing increased sorghum yield by 25%, maize by 46%, and cotton by 32% relative to sowing on flat lands. Advantages of growing crops in furrows over flat lands is more appreciated in bad seasons when mid-season droughts are more frequent. At this time, furrow-grown crops exhibit less wilting than on the flat lands. In an exceptionally good season with more than average rainfall, furrow crops suffered temporary effects from inundation, but recovery and survival were better than on flat lands following the next mid-season drought. The final yield increases due to furrowing were 12%, 136%, and 40% for sorghum, maize, and cotton, respectively.

Enabling Conditions Associated with Adoption: A series of field days and training workshops were organized to expose farmers, school children, teachers, and managers to the technology. About 200-500 farmers and over 800 school children and teachers have received training to date. The interest expressed by farmers in the practice led to the setting up of a government tractor-for-hire service to respond to their needs. A private sugar company impressed with the technology assisted its extension by furrowing 100 ha and dividing the field among 100 farmers at a subsidized rate.

Constraints Associated with Adoption: Lack of equipment and money to hire labor to build the tied furrows.

Programmatic Actions Associated with Adoption: An oxen-drawn ridger should be designed and manufactured on a commercial scale and made available to farmers at affordable rate. Extension should intensify their demonstration activities for the technology.

Technical Name of Practice: No-tillage

Description of Case Study: This describes a study in Nigeria whereby crops are seeded through crop residue without plowing.

Reasons for Using: To conserve moisture, minimize soil erosion and save labor.

Potential Impacts on Degradation: When crop residue are left on the surface as mulch, impact of raindrops on soil particles is lessened as are detachment and transport of the particles. Little or no disturbance of the soil surface due to the absence of tillage gives further protection of the soil against erosion.

Potential Impacts on Yields/Productivity: At Ibadan, Nigeria, maize grown on a 15% slope under no-till and plowed systems yielded 3.6 and 3.0 t/ha, respectively. Soil loss in the respective plots were 0.1 and 24 t/ha.

Enabling Conditions Associated with Adoption: Labor requirements for land preparation is greatly reduced. Impacts from no-till on reducing soil erosion and improving soil fertility are evident over the short- to medium-term.

Constraints Associated with Adoption: Weed control is usually problematic in no-till systems. Difficult to practice in clay soils which are readily compacted.

Programmatic Actions Associated with Adoption: Cultural practices which generate surface mulch and cover to smother weeds and conserve moisture should be pursued.

Technical Name of Practice: The "zay" technique

Description of Case Study: This study describes digging pockets of 5-15 cm depth and 10-30 cm diameter and spaced about 50 to 100 cm on croplands in Burkina Faso. Some manure and grass are mixed with seeds sown in the holes.

Reasons for Using: The zay pockets trap water, aid infiltration and reduces runoff and erosion.

Potential Impacts on Degradation: Crop growth on extremely degraded land is better in the zay pockets where water and nutrients are concentrated. Soil degradation is minimal under good crop growth because of return of large quantities of biomass and excellent soil coverage. Also, increased soil faunal and termite activities due to the organic biomass improves soil structure.

Potential Impacts on Yields/Productivity: Sorghum and millet grown in the zay system produce about 1000 kg grain/ha compared to 400-500 kg/ha typical on non-zay farms.

Enabling Conditions Associated with Adoption: This is simple technology which most farmers can afford to use. Farmer-to-farmer visits have proven extremely effective in spreading technology adoption rates.

Constraints Associated with Adoption: Acquisition of sufficient manure for zay in the Sahelian region can be difficult due to competition between use of manure for farming and other activities.

Programmatic Actions Associated with Adoption: The zay practice should be improved and disseminated by extension personnel.

Technical Name of Practice: Improved traditional planting pit

Description of Case Study: This study describes a modified form of the zay system in Niger with the following dimensions: pit diameter, 2-40 cm; depth, 15-30 cm and spacing 80-100 cm. The excavated soil is deposited down slope to hold water from running over the field. Manure is applied to the pits.

Reasons for Using: Tassa is an improved version of the zay designed to harvest more water for crops in the dry environments.

Potential Impacts on Degradation: Tassa checks environmental degradation through reduced runoff, increased infiltration, limited soil particle movement and termite activity which improves soil structure enhances crop growth.

Potential Impacts on Yields/Productivity: Average crop yield on nine farmers fields in Niger was 522 kg/ha with tassa as opposed to no crop yields being found on non-tassa plots. Certainly, the yield obtained gave favorable economic returns to the labor invested in adopting tassa. This data came from extremely degraded lands where crops could hardly grow. Close to 1500 ha of barren land has been treated with tassa following the visible gains from earlier on-farm testing of the technology.

Enabling Conditions Associated with Adoption: From farmers’ perspective, tassa is workable technology given current human and animal population pressures on arable land. On their own, tassa-cropped fields give reasonable yields, but productivity per area could be doubled if tassa is mixed with small amount of fertilizer. In this case, more people may be accommodated on a small parcel of land.

Constraints Associated with Adoption: It is difficult to secure enough manure for the pits.

Programmatic Actions Associated with Adoption: The government should provide technical and material inputs (mainly fertilizer, seeds) to enable many farmers to try tassa farming.

Technical Name of Practice: Tied ridges

Description of Case Study: This study describes tied ridges in Burkina Faso comprised of embankments made at regular intervals between ridges to create basins for water microcatchment (about 0.5 m² for sorghum).

Reasons for Using: Tied ridges capture rain water and make it available for crop use.

Potential Impacts on Degradation: The tied ridges reduce overland flow to the barest minimum and preserve soil and water for crop production.

Potential Impacts on Yields/Productivity: In the Sahel, plowing followed by tied ridging a month later increased sorghum grain yield to 1410 kg/ha whereas control plots with neither plowing nor tied ridging yielded 523 kg/ha.

Enabling Conditions Associated with Adoption: Tied ridging is simple to learn and practice if labor is not a constraint.

Constraints Associated with Adoption: Tied ridges are not efficient in sandy soils as a lot of water may be lost through seepage. Also, under high rainfall conditions, collapse and repairs of the sand-made embankments become more frequent and this adds to production costs. Tied ridging is extremely labor intensive.

Programmatic Actions Associated with Adoption: Extension personnel should assist in dissemination of the technology.

Technical Name of Practice: Mulching

Description of Case Study: This study describes spreading of crop residues on the surface of the soil on crop fields in Nigeria.

Reasons for Using: Mulching offers protection against wind and water erosion, enhances infiltration of rain water, adds organic matter, increases soil biological activities and improves soil physical properties.

Potential Impacts on Degradation: The above attributes of mulch farming makes it possible to cultivate sloping and flat terrains alike on a sustained basis.

Potential Impacts on Yields/Productivity: Evidence of effectiveness of mulch in bringing about reduced runoff and soil erosion is found in Nigeria. For example, runoff on a 15% slope mulched with crop residues was 20 mm and 375 mm for unmulched plots. Soil loss for the same treatments were 0.7 and 96 t/ha respectively. The amount of crop residue required to achieve adequate ground cover ranges from 1 to 6 t/ha bearing in mind that mulching in turn leads to production of more mulch material through better crop growth.

Enabling Conditions Associated with Adoption: Mulching is an appropriate practice given sufficient sources of crop residues and/or other vegetation.

Constraints Associated with Adoption: Mulch materials are generally scarce in the Sahelian region where crop residues are often used as livestock feed, fuelwood and/or construction materials.

Programmatic Actions Associated with Adoption: Research and extension should develop and popularize alternative sources of mulching materials, e.g., agroforestry and green manure systems.

Technical Name of Practice: Reclamation of degraded land

Description of Case Study: This study describes the use of infiltration trenches, tree planting, grazing management and protective methods for land reclamation in Zaire.

Reasons for Using: The above approach was employed for restoration of mountain soils degraded by erosion and grazing.

Potential Impacts on Degradation: A combination of the above practices led to reappearance of dense vegetation and reversed degradation rates.

Potential Impacts on Yields/Productivity: Improved grass species were brought in to upgrade pasture quality and livestock productivity per unit area. Livestock manure fertilized soil and sustained crop yields.

Enabling Conditions Associated with Adoption: The project staff made a special effort to accommodate the interests of native herdsmen and food crop farmers with mutual benefit to both parties. Installation of anti-erosive trenches facilitated rain water infiltration and made it possible to achieve a good tree stand. A temporary ban placed on bush fires and controlled grazing in conjunction with the water exploiting strategies contributed to a quick reconstitution of the original vegetation and establishment of introduced species, particularly grass for cattle.

Constraints Associated with Adoption: Initial difficulty in getting vegetation to grow on denuded hillside, especially to provide pasture for livestock. Herdsmen may be unwilling to wait for this to happen. The use of fires to revitalize overgrown grass destroy useful plants as well.

Programmatic Actions Associated with Adoption: Conservationists should take the interests of livestock herders and food crop farmers in account in program planning.

Technical Name of Practice: Land preparation and fertilization

Description of Case Study: This study describes the effects of plowing to a depth of 15 cm, ridging (75 cm between ridges and 15 cm high), surface roughness/mulching and fertilization on millet production in Niger.

Reasons for Using: To create soil conditions that would increase infiltration, decrease erosion, raise fertility and maintain millet yield.

Potential Impacts on Degradation: The above soil management practice slows down erosion and ensures a conducive environment for sustained crop production.

Potential Impacts on Yields/Productivity: Plowing and ridging were more effective in raising crop density and yield when combined with fertilizer use. Plant stand and yield were 87% and 681 kg/ha for plowing and fertilization as opposed to 68% and 254 kg/ha for plowing without fertilization. Similarly, yield due to plowing and residue addition in the absence of fertilizer was 416 kg/ha. The yield increased to 568 kg/ha with application of fertilizer.

Enabling Conditions Associated with Adoption: Study was conducted on-station.

Constraints Associated with Adoption: High cost and unavailability of chemical fertilizers to peasant farmers. Limited quantities of crop residues in the Sahelian region poses a constraint to quick adoption.

Programmatic Actions Associated with Adoption: Alternative sources of plant nutrients must be sought. Long-term field demonstration of the package should be set up to convince farmers about its potential.

Low soil fertility is a major constraint to improving African agricultural productivity. Fertility levels vary throughout the continent, but they are generally low because of extensive weathering of the soils (Davies, 1973). Traditional farming systems relied heavily on fallow periods to restore soil fertility (Lal, 1987; Nye and Greenland, 1960). But this practice is less viable now in much of Africa because of human population increases. Consequently, more intensive management is necessary to replenish soil fertility. Soil fertility can be maintained or improved through a variety of practices that optimize the benefit of internal farm resources. For example, soil and water management practices can conserve nutrients by reducing soil erosion and by reducing leaching of nutrients below crops' root zones. Organic fertilizers also can improve or help maintain soil fertility. For example, legumes and other biological nitrogen fixers can typically add some 100 kg of nitrogen per hectare per year (ha/yr) in the tropics (Halliday, 1985).

More...
Technical Name of Practice: Animal manure

Description of Case Study: This case study describes the effects of 25 and 50 t/ha of poultry manure which were applied to a degraded tropical soil in Nigeria.

Reasons for Using: To ameliorate the physical properties of the soil which has been degraded through continuous farming activities.

Potential Impacts on Degradation: As a nutrient-rich organic material, poultry manure fertilizes and improves soil physical condition so that revegetation of the land could occur at a faster rate.

Potential Impacts on Yields/Productivity: Incorporation of 50 t/ha poultry manure stopped further deterioration and restored the following parameters to levels comparable to those of the original forest prior to clearing. The parameters in question were: stable aggregates, bulk density, humus, total porosity and air-filled porosity. Manuring for three seasons increased water infiltration but not to the level of pre-clearing. To fully restore water infiltration to pre-clearing status, a combination of manuring and crop residue or cover crops is suggested.

Enabling Conditions Associated with Adoption: Application of manure is a common practice in most low-input farming systems.

Constraints Associated with Adoption: The acquisition of 50 t manure per hectare is difficult for peasant farmers.

Programmatic Actions Associated with Adoption: Generation of organic manure and mulch in-situ from herbaceous legumes and grasses should be pursued as alternatives.

Technical Name of Practice: Animal manure

Description of Case Study: This case study describes the continuous use of animal manure in traditional farming systems in North-eastern Nigeria.

Reasons for Using: To maintain fertility status and physical properties of semi-arid soils for sustained crop production.

Potential Impacts on Degradation: Rapid reconstitution of soil properties and vegetation.

Potential Impacts on Yields/Productivity: Manuring maintained soil porosity and bulk density following decades of cultivation. Additionally, exchangeable magnesium, potassium, cation exchange capacity and available phosphorus were unaffected by decades of farming if manure is applied. However, nitrogen, pH, organic matter and calcium declined with continuous land use even in the presence of manuring. Spread on the surface, manure decomposes very fast under the high temperatures prevailing in the Sahel area, and substantial amount of nitrogen is lost via volatilization prior to crop establishment.

Enabling Conditions Associated with Adoption: Manuring is a straightforward cultural practice for farmers in the Sahelian region.

Constraints Associated with Adoption: It is difficult to secure adequate quantities of manure for farming purposes as it has several uses besides farming.

Programmatic Actions Associated with Adoption: Green manuring and cover cropping with legumes may be practiced in conjunction with animal manuring.

Technical Name of Practice: Manure and crop residue integration

Description of Case Study: This case study describes the use of manure and crop residues for soil fertility management in the Sahelian and Sudanian zones of West Africa.

Reasons for Using: To minimize declining soil productivity and permit continuous land use amidst a growing population on fragile lands.

Potential Impacts on Degradation: Manuring and residue application provides nutrient recycling mechanisms to assure sustained soil productivity without doing serious harm to the environment.

Potential Impacts on Yields/Productivity: In Niger, initial application of 4 t/ha pearl millet stover followed by yearly retention of crop residues on fields for three years, resulted in almost the same millet yield as chemically-fertilized fields. With fertilizer, millet yielded 15 times more in the combined plots than the control with neither crop residues nor fertilizer. In a separate study, animal manure applied at 5 t/ha with phosphate rock doubled millet yield after one year. Phosphate fertilization was found to be unnecessary when the manure rate was raised to 20 t/ha. Finally, farmers who fertilized their fields with 13 kg P and 30 kg N/ha, were able to generate enough biomass to satisfy both farm and domestic needs.

Enabling Conditions Associated with Adoption: Manuring is a traditional production practice. The extremely high potential of manure/residue plus modest rates of fertilizer can bring about remarkable improvements in land-use sustainability.

Constraints Associated with Adoption: Manures and crop residues have several uses such as fuelwood, animal feed, construction, etc. Fertilizers could be expensive for most farmers and are usually not delivered on time.

Programmatic Actions Associated with Adoption: Extension messages should stress the need for limited amounts of fertilizers as a supplement to manuring. In this connection, formation of farmer groups to purchase and share fertilizers should be encouraged.

Technical Name of Practice: Cattle manure

Description of Case Study: Management and use of cattle manure for crop production on farm fields in the savanna zone of Central Nigeria.

Reasons for Using: To increase soil fertility and improve soil physical properties for crop production.

Potential Impacts on Degradation: Manuring aided quick establishment of food crops to protect the soil against erosion. Biomass from the above vegetation, either in the form of surface mulch or incorporated as organic matter contributed to the ability of the soils to retain water and nutrients.

Potential Impacts on Yields/Productivity: Cattle manured fields yielded 1.1 t/ha more maize grain than fields without manure. Soil organic matter and water holding capacity were increased through manuring.

Enabling Conditions Associated with Adoption: The overnight manuring strategy (stacking animals) applied throughout the seasons eliminated labor for collection, transportation, storage and spreading of manure. Manures are available, albeit in insufficient quantities to farmers, and crop fields fertilized with manure tend to sustain yields longer than those with chemical fertilizers. Manuring is a simple and low cost practice.

Constraints Associated with Adoption: Weed infestation was 90% more in manured than in the control fields with no manure. In the Sahel, weeds compete with crops for scarce soil moisture and nutrients.

Programmatic Actions Associated with Adoption: Extension should focus on ways of manipulating weeds in manured fields to benefit associated food crops, e.g., targeted weedings to recycle nutrients trapped in weeds back to food crops.

Technical Name of Practice: Fertilizers

Description of Case Study: The study describes the effects of the application of nitrogen, phosphorus, and molybdenum to groundnuts in Niger.

Reasons for Using: To stimulate N fixation, growth and yield of groundnut.

Potential Impacts on Degradation: Fertilization leads to increased vegetative cover and biomass production which improves overall productivity of land.

Potential Impacts on Yields/Productivity: The use of P alone did not affect pod yield but in combination with molybdenum, the increased pod yield by 37-86%. Molybdenum increased nitrogenase activity by a factor of 2-4 compared to P only. Also, nitrogen uptake was 53 for P alone and 108 kg/ha when molybdenum was added. Application of 60 kg/ha mineral nitrogen or farmyard manure (130 kg N/ha) increased shoot but not pod dry matter. Besides, the nitrogen-treated plants exhausted soil moisture and wilted earlier than molybdenum-plants.

Enabling Conditions Associated with Adoption: The quick returns associated with chemical fertilization and the small amounts needed to bring about a yield increase.

Constraints Associated with Adoption: The high cost and unavailability of chemical soil amendments to rural farmers.

Programmatic Actions Associated with Adoption: Extension should educate farmers on the use of organic fertilizers as these may help overcome micronutrient deficiencies. For sustained production, however, modest application of chemical fertilizers is inevitable and infrastructure must be put in place to facilitate farmers’ access to them.

Technical Name of Practice: Fertilizers

Description of Case Study: The study describes the impacts of field demonstrations and multi-locational testing of NPK fertilizers on maize, sorghum, and cotton in Botswana, Lesotho and Swaziland.

Reasons for Using: To demonstrate and promote the potential of NPK fertilizers in some Southern African countries.

Potential Impacts on Degradation: Fertilization usually results in better crop growth and biomass yield which, if incorporated in the soil or retained on the surface as mulch can sustain productivity of the land.

Potential Impacts on Yields/Productivity: On a sandy soil in Botswana, phosphorus at 45 kg P₂O₅/ha was economical (benefit:cost ratio = 2.7) with respect to maize production. Nitrogen stimulated vegetative growth and depleted soil moisture faster than the other treatments. In Lesotho, maize and sorghum responded significantly to N, P and K fertilizers. While P alone would have sufficed for sorghum, maize needed P and the other elements to give economic returns. Maize responded poorly to K in Swaziland but positively to N and P interaction. Cotton responded significantly to P and K. Drought was a major setback to NPK response in all the countries.

Enabling Conditions Associated with Adoption: Fertilizers were distributed free to farmers for demonstrations.

Constraints Associated with Adoption: High fertilizer prices relative to farmers’ income levels. Frequent mid-season droughts may limit crops’ responses to fertilizers.

Programmatic Actions Associated with Adoption: Moisture conservation practices are required to assure that fertilizers maximize their yield potential.

Technical Name of Practice: Soil fertility management

Description of Case Study: The study describes field testing of phosphorus from various sources in the Sahelian region of West Africa.

Reasons for Using: Phosphorus is the most limiting nutrient element for food crop production in the Sahelian zone of West Africa.

Potential Impacts on Degradation: Deficiency of phosphorus causes abnormal root development culminating in poor crop establishment, growth and yield. Phosphorus fertilization reverses this phenomenon and protects the soil through better soil coverage and increased biomass production.

Potential Impacts on Yields/Productivity: Farmers’ tests indicated millet yield increases of more than 250% through the use of phosphorus fertilizers. Phosphorus rate for optimum yield ranged between 15-20 kg/ha.

Enabling Conditions Associated with Adoption: Crop varieties that have low phosphorus requirements.

Constraints Associated with Adoption: High prices of phosphatic fertilizers and unavailability to peasant farmers.

Programmatic Actions Associated with Adoption: Local and cheaper sources of phosphorus must be sought. Farmers should have access to credit facilities to enable them purchase phosphorus and similar production inputs.

Technical Name of Practice: Soil fertility management

Description of Case Study: This study describes soil management practices in semi-arid areas of West Africa. Proposed soil interventions included: 1) Application of imported and locally-mined phosphatic fertilizers, 2) Inorganic nitrogen, leguminous crop rotations and agroforestry systems, 3) Crop residues and animal manures, 4) Tillage using animal traction, and 5) Water-use efficient varieties.

Reasons for Using: The above soil management practices were designed to address major soil-related factors affecting productivity of sorghum and millet in the West African Semi-arid Tropics (WASAT).

Potential Impacts on Degradation: The practices alleviate soil deterioration through the production of large amounts of organic matter to improve the chemical and physical properties of the fragile soils of the WASAT.

Potential Impacts on Yields/Productivity: Crop yields have responded favorably to phosphatic fertilizers. Yield increases ranging between 44 to 130% have been obtained under real farming conditions. Best financial gain was obtained with 24 kg/ha of acidulated rock phosphate/ha when millet was sown with the first rains. Crop yields responded significantly to split-applied nitrogen in the presence of phosphorus and adequate soil moisture. Applied together, tillage, fertilization and selection of appropriate (e.g. early maturing) genotypes stabilized yields under adverse climatic conditions. Trees, notably, *Acacia albida* planted either on farms or on borders as windbreaks increased millet yield by 28%. Total crop yield doubled in a 60-day cowpea/millet intercropping system.

Enabling Conditions Associated with Adoption: Most of the suggested interventions are not complicated and the required inputs are available locally.

Constraints Associated with Adoption: Knowledge-gap between farmers and researchers/extension regarding existing technologies, their procurement and application techniques.

Programmatic Actions Associated with Adoption: Government intervention is important to ensure that users are well informed of most recent developments in agriculture. Governments in the WASAT region should make a joint effort to set up facilities to tap and process the numerous sources of rock phosphates in the region.

Technical Name of Practice: Crop residue management

Description of Case Study: The study describes the effect of harvested crop residues and supplementary fertilizer on yield of pearl millet in Niger.

Reasons for Using: In general, organic matter well known for its importance for soil productivity maintenance in low activity clay soils. Organic matter decomposes rapidly in the warm Sahelian environment, thus, limiting the capability of the soils to retain water and nutrients. The obvious outcome is widespread erosion and loss in soil fertility.

Potential Impacts on Degradation: Return of crop residues to croplands ameliorates soil fertility and structure. These facilitate water infiltration and retention and prevents the land from being degraded by erosion. The synergistic effect of adequate soil moisture and fertilization is better crop establishment, good ground coverage, less erosion as well as reasonable and sustained yield.

Potential Impacts on Yields/Productivity: In Niger, continuous application of crop residues over a 4-year period yielded almost the same as that of chemical fertilizer (800-1000 kg/ha). Millet yields in control plots which received neither crop residues nor fertilizer dropped from 280 to 75 kg grain/ha. A combination of crop residues and fertilizer exhibited additive effect with respect to yield. The combined effect of fertilization and residue application enhanced water use by millet and soil fertility status as well.

Enabling Conditions Associated with Adoption: Field demonstration of the value of residue management.

Constraints Associated with Adoption: Inadequacy of crop residues for farming since they serve other purposes such as fuelwood, animal feed and/or construction material.

Programmatic Actions Associated with Adoption: Other sources of organic materials should be explored for use as soil amendments. A form of agroforestation is needed to supply wood and organic materials for home and farm uses.

Technical Name of Practice: Phosphorus fertilization

Description of Case Study: The study describes the effects of an application of P fertilizer to upland rice in Cote d'Ivoire (Ivory Coast).

Reasons for Using: To correct P deficiency in low-P soils and determine the responses of selected upland rice varieties to P fertilization.

Potential Impacts on Degradation: Improvement in crop growth provides vegetative cover to the soil.

Potential Impacts on Yields/Productivity: P fertilization enhanced rice grain yields. The increases were most significant with P rates between 30 and 60 kg/ha. P-use efficiency varied among the rice entries, with WAB 56-50 being the most efficient (54 kg grain/kg of applied P) and IDSA 6 the least efficient (18 kg grain/kg of P). Application of 30 kg P/ha gave the highest P efficiency and the efficiency diminished with increasing P rates. The above efficiencies obtained under good moisture conditions dropped the following year when rainfall was below average. Furthermore, P application promoted rooting depth and density which enabled the crops to exploit a greater volume of soil for water and nutrients during mid-season droughts. As well, P-fertilized crops flowered and matured earlier than the non-fertilized ones and were able to escape drought and pest incidence in the course of the season.

Enabling Conditions Associated with Adoption: The early rewards that go with P fertilization. Compared to the requirement of large quantity of organic manures such as cow dung, small quantities of fertilizers are needed.

Constraints Associated with Adoption: Phosphorus fertilizers are usually expensive in relation to farmers’ income. Fertilizers are usually not available to farmers in rural areas at the time they are most needed.

Programmatic Actions Associated with Adoption: Crops with low-P requirements must be promoted. Cheaper sources of P, e.g. rock phosphate and chicken manure, needs to be explored.

Technical Name of Practice: Intercropping

Description of Case Study: These studies describe systems of growing two or more crop species or varieties simultaneously in the same field in Sub-Saharan Africa.

Other Common Names:

Row intercropping - Field crops planted in rows, either adjacent rows of different crops, or mixed within the row.

Strip intercropping - Several rows of a crop species grown together forming a strip. Strips, each having a different crop or variety, are wide enough to permit independent cultivation, but close enough to interact agronomically.

Relay intercropping - Growing two or more crops simultaneously during part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage of growth but before it is ready for harvest.

Reasons for Using: Intercropping is a widespread practice among limited-resource farmers because of its numerous benefits, which include: (i) reduces risk or crop failure and improves production stability; (ii) increases yields per unit of land by more efficiently using natural resources; (iii) increases returns to labor and spreads labor requirements, thereby reducing labor bottlenecks.

Potential Impacts on Degradation: Reduces soil erosion and water runoff. In one study, intercropping maize in cassava on a 15 percent slope reduced runoff and soil erosion relative to cassava alone by 38 percent.

Potential Impacts on Yields/Productivity: Increases yields per unit of land by more efficiently using natural resources. Improves control of diseases, pests, and weeds. Intercropping also provides yield benefits over monocropping, usually measured as nutritional or economic gains, that can average 15 to 20 percent or in some cases more.

Enabling Conditions Associated with Adoption: Adaptive research associated with indigenous intercropping systems facilitates adoption.

Constraints Associated with Adoption: Relatively little research attention paid to indigenous production systems which are based on intercropping.

Programmatic Actions Associated with Adoption: Shade-tolerant crop varieties are needed for intercropping in traditional farming systems.

Technical Name of Practice: Improved varieties

Description of Case Study: The study describes the performance of forage/grain varieties of sorghum and cowpea in two villages on the Mossi Plateau of Burkina Faso. Fifty farmers from the two villages, Donsin (650 mm rain/yr) and Thiougou (910 mm rain/yr), participated in the evaluation of sorghum (ICSV-1049) and cowpea (7/180-4-5) varieties in their fields.

Reasons for Using: The purpose was to identify crop varieties that would enable farmers to combine production of forage for livestock and food grains for human consumption in an environment where rainfall is unreliable and population density extremely high.

Potential Impacts on Degradation: Successful cultivation of improved forage/grain varieties of sorghum and cowpea would replace the traditional agro-pastoral practices that have almost wiped out existing vegetation and destroyed land quality.

Potential Impacts on Yields/Productivity: Farmers in both villages welcomed the cowpea variety when grown in pure stand because it offered a reasonably stable grain/forage yields and economic returns under their harsh and uncertain living conditions. In general, the sorghum variety did poorly and was rejected outright by farmers at Donsin where its performance was woefully low. At Thiougou, however, the performance was slightly better due to higher rainfall, and some farmers decided to grow it to serve as supplementary feed for their draft animals.

Enabling Conditions Associated with Adoption: The varieties addressed the two major concerns of the farmers. These were grains for humans and fodder for animals.

Constraints Associated with Adoption: Low and erratic rainfall, weeds, and poor soils are impediments to large-scale adoption.

Programmatic Actions Associated with Adoption: Efforts should be made to integrate cultivation of the improved varieties with sound soil fertility and moisture conservation measures.

Technical Name of Practice: Striga control

Description of Case Study: This study describes screening of sorghum lines for striga resistance in Burkina Faso.

Reasons for Using: To overcome production constraint imposed by striga - a serious parasitic weed threatening cereal cultivation in the Sahelian zone.

Potential Impacts on Degradation: Control of striga would free large spans of fallow land for cultivation and consequently reduce pressure on scarce arable land or the cultivation of marginal lands.

Potential Impacts on Yield/Productivity: Several sorghum varieties were found to resist striga. New sorghum lines bred by Purdue University suppressed striga population to 2-6 plants/m² as opposed to a local variety which accommodated 31 striga plants/m². The introduced lines outyielded the local variety by 242%. Economic returns ranged between 54,084 and 83,500 CFA for the new lines and was 40,667 CFA for the local variety.

Enabling Conditions Associated with Adoption: Striga infestation is felt by majority of farmers in the Sahel area. Available control methods (e.g. hand weeding, herbicide application, fertilization etc.) are tedious and expensive for the predominantly poor farmers in the region. Farmers may therefore adopt new varieties that control the striga weed and are high yielding as well.

Constraints Associated with Adoption: The introduced sorghum lines are yet to receive farmers’ approval in terms of their palatability, storage and other socio-cultural characteristics.

Programmatic Actions Associated with Adoption: Farmer evaluation of the new lines should be an important adjunct to this program. This should be followed by seed multiplication and distribution of preferred varieties. Breeders should also incorporate striga resistance into local materials.

LIST OF REFERENCES

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Soil Fertility Enhancement Systems


DOCUMENTS REVIEWED


