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## Research Program Planning for Natural Resource Management: A Background Analysis

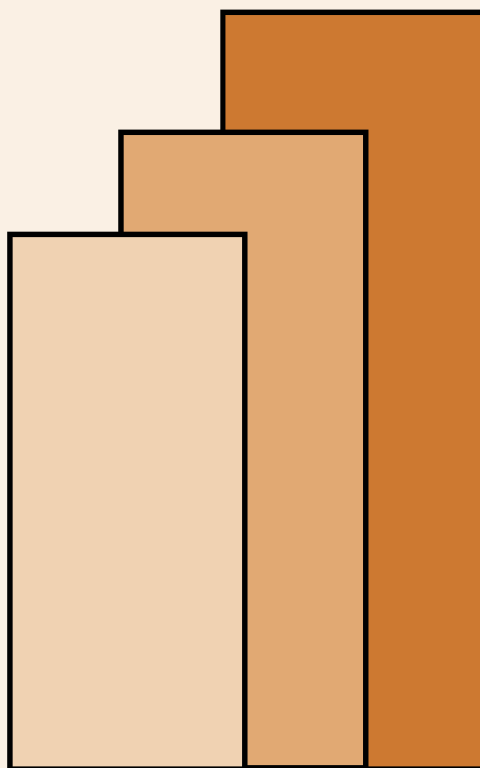
*Agnes C. Rola*

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## RESEARCH PROGRAM PLANNING FOR NATURAL RESOURCE MANAGEMENT: A BACKGROUND ANALYSIS

By: A. C. ROLA

Conventionally, agricultural resource management per se is not a popular area of research. Agricultural production research was crop and input specific. Earlier studies recommended fertilizer levels that maximize yields; or cropping patterns that maximize output and profits. Water was considered a fixed input; water productivity was not an issue, so was soil productivity.

A review of the results of studies on soil and water conducted in the 1980s and the 1990s showed deficiencies in taking into account the optimal management of these agricultural resources that could have assured sustainable productivity impacts. For soil management for instance, there is a need to unravel that black box of the processes on how farmers decide in agricultural resource management. It is a well known fact that information is the most important input in sustainable agriculture. How do farmers handle this information? What are their knowledge bases? For water management, the issue is about water productivity. This is however, a function of water quantity, quality, and water delivery efficiency. Agricultural decision makers should take active part in the management of the watershed as a significant source of surface water for irrigation. But we also have to guard our shallow groundwater from the environmental pollutants that could affect its utility in agriculture. The current debate by experts on the optimal combination of two sources of irrigation water, i.e. surface water and groundwater, should also be taken into consideration. Finally, the most efficient mode of delivery should be studied.

Research on soil and water is numerous. However, the fact that we still observe a lot of resource degradation implies that the desired impact in terms of sustainability outcomes of all these, is not attained. Maybe, a reexamination of the context in which we design soil and water management research agenda, and the process of filtering the results to people who actually use and /or decide on use of the resource is the first item of study. In this regard, an alternative research paradigm for natural resource management (NRM) is proposed.

NRM research will go beyond commodities and beyond disciplines. NRM research should be treated from the *watershed scale*; and take into account the broad range of stakeholders that will be affected and the role of the institutions in the process. Some of the recorded products of research on NRM are actually based on *indigenous farmer knowledge*. It is only with the building up of the farmer knowledge bases that research can make an impact on farmers' practices. Moreover, diagnostics and other farmer/extension friendly kits have to be developed and used as early warning devices. How do farmers learn about these *knowledge intensive technologies (KIT)*? And also, the role of the various *institutions* in the promotion or in the constraint to adoption of sustainable technologies should be noted. NRM research is not to be confined to the study of agriculture technologies or the environmental management alone; but rather to the broader, *intersectoral linkages that potentially affect farmer behaviour and farmer land use and technology decisions*.

# **RESEARCH PROGRAM PLANNING FOR NATURAL RESOURCE MANAGEMENT: A BACKGROUND ANALYSIS<sup>1</sup>**

**By: A. C. ROLA<sup>2</sup>**

## **INTRODUCTION**

Conventionally, agricultural resource management per se is not a popular area of research. Agricultural production research was crop and input specific. For instance, earlier studies aimed at optimizing fertilizer recommendations to maximize yields; or cropping patterns that will maximize output and profits. Water was considered a fixed input; water productivity was not an issue, so was soil productivity.

It was during the 1980's that researchers began experiments that focused at sustainable resource management. The existence of farming systems research institutes in several SUCs in coordination with BAR and PCARRD, made possible the conduct of on-farm trials with farmer participation. These on-farm trials studied not just the productivity effects, but also the environmental effects of the alternative cropping systems. However, there is no systematic evaluation made to determine the adoption of these technologies nor the impact of these studies on soil and water quality.

Agricultural resources are also influenced by the wider environmental quality. Though there were efforts to manage and preserve Philippine watersheds as early as 1968 (PCARRD, 1991), still it is observed to this day that much degradation has taken place. Watershed destruction mostly due to deforestation and upland agriculture, led to land degradation, siltation of waterways, sedimentation, and other environmental externalities, including unseasonal occurrences of droughts and typhoons. Lowland agriculture is greatly affected by these environmental stresses.

This report synthesizes and analyzes the results of studies on soil and water management conducted in the 1980s and the 1990s with the aim of providing a background information for research program planning for Natural Resource Management (NRM) in agriculture. The analyses focus on three points. First, production losses occur because of non-sustainable resource use. Monocropping and intensive cultivation of steep slopes are examples of these non-sustainable practices. Second, there are available research products that could have minimized these losses; i.e. new technologies/knowledge on crop/resource management. Third, the evidence of continuous degradation of the agricultural resource base points to the serious constraints to adoption of these sustainable technologies/management options. Future NRM research programs then will need to highlight activities to relax these constraints.

Data were sourced from different agricultural research institutions, graduate students' theses, and technical reports (Tables 1 and 2). The appendix tables list in detail

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the completed studies, theses, published articles, technical reports, etc., as well as on-going studies. The main report is divided into six parts. Part I establishes the current state

**Table 1. Sources of literature on soil and water management studies, 1990-1998.**

Source	No. of Studies	
	Soil Management	Water Management
UPLB Graduate School	108	30
UPLB Research Office	88	23
SEARCA Library	35	244
PCARRD	94	32
BAR	61	-
IRRI	7	2
BSWM	49	-
PIDS	4	3
<b>TOTAL</b>	<b>446</b>	<b>334</b>

**Table 2. Frequency counts of studies on soil and water management by output category.**

<b>Output Category</b>	<b>T O P I C S</b>			
	<b>Soil Fertility/ Nutrient Management</b>	<b>Soil Conservation</b>	<b>Water Technologies</b>	<b>Water Delivery/ Watershed Management</b>
Graduate (MS/PhD) Theses	86	22	5	25
Publications in Refereed Journals	39	27	43	44
Publications on Books	2	1	-	3
Technical Reports	160	44	4	30
Others (Seminar Paper, Newsletter, etc.)	2	20	25	84
<b>TOTAL</b>	<b>289</b>	<b>114</b>	<b>77</b>	<b>186</b>

of agricultural resources in the Philippines. Part II summarizes the research efforts on soil nutrient management, (on-site effects), including farmers' indigenous practices and research input into these practices. Soil conservation technologies and their adoption constraints are discussed in Part III. Mostly looking at off-site effects, research has produced a number of new location-specific and cropping system-specific techniques for soil conservation. Still, the big question is, why is adoption not satisfactory?

The important topic of watershed management as it affects agriculture is discussed in Part IV. The body of literature available has likewise revealed a number of location specific studies. The changing paradigm in watershed management that focus on the dominant roles of institutions and community in resource management, leading towards sustainable agriculture is also investigated. Part V deals with water management/technologies/alternative delivery systems to increase water productivity and water use efficiency in agriculture. And finally, Part VI lays out the discussion points that could be used for research program planning for natural resource management (NRM) in agriculture.

## **Part I. Managing the Agricultural Resource Base in the Philippines**

### **A. Role of Management in Agricultural Sustainability**

In agricultural resource management, the key factor is the term "management"; and this basically refers to the decisions or choices of resource managers. In general, managers' choices are influenced by the following (Shively, 1999): 1) biophysical resources and constraints, 2) human resources and constraints, and 3) markets, policies and other exogenous factors. These constraints and exogenous factors will result to crop and input choices, technology choices, land and time allocation, and other decisions that would impinge on natural resource exploitation/conservation.

In turn, these decisions will have outcomes in terms of levels of productivity and income, and environmental quality. Outcomes have also on-site and off-site characteristics. One example is that rapid degradation of Philippine upland watersheds directly threatens the livelihood of farmers within the upland areas (on-site); and also of irrigated agriculture downstream (off-site).

Following this framework, sustainable agricultural resource management issues should address the following concerns:

1. Are markets, economic policies, and other institutional factors conducive to optimal management of agricultural resources, i.e. soil, water, and the pest ecology?
2. Are technologies available to promote sustainable agricultural resource management?
3. To what extent are sustainable technologies being adopted; and what are the constraints to adoption?

4. What are alternative strategies for delivering these sustainable (and knowledge-intensive) technologies to farmers and extension workers?
5. Are there indeed (significant?) long-run productivity gains (or losses) if sustainable technologies (or alternative technologies, i.e. intensive cultivation) are adopted by farmers?

## **B. Soil Resources**

The total land area of the Philippines is only 30 million hectares, of which 8.2 million are arable and permanent croplands. About 25.1% of the total area is constraint-free while the remaining 74.9% consists of areas with various kinds of problem soils. The BSWM recognizes and classifies several categories of problem soils in the Philippines as follows with their corresponding extent:

**Table 3. Problem soils of the Philippines, 1991 (Source: BSWM)**

<b>Problem Soils</b>	<b>% of Total Area</b>	<b>Extent (ha)</b>
Steep slopes	29.7	8,900,000
Poor drainage	0.3	91,000
Coarse textured soils	1.6	360,000
Heavy cracking clays	2.5	766,000
Severe fertility limitations	39.2	12,000,000
Saline soils	1.3	400,000
Acid sulfate soils	0.1	27,000
Peat lands	0.1	16,000
Mine tailings & polluted lands	0.1	22,000

About 16 million hectares (71.2%) of the land with various forms of problem soils are further marginalized by various degrees of soil acidity.

More disturbing statistics are indicated by current estimates of soil loss in the Philippine uplands.

Land use statistics in the fragile Philippine uplands shows dominance of rice and corn over other crops (Table 4). Estimated total soil loss for various land uses and slopes reveal that corn production in the uplands seem to have contributed about 90% of the total soil loss (Table 5). Coxhead and Shively (1998) likewise surmised that more than 50% of these erosion is coming from Mindanao.



**Table 4. Land Use in the Philippine Uplands (hectares)**

Land Use	Slope Category (%)		
	18-30	30+	Total
Rice	315,000	52,500	367,500
Corn	375,000	61,250	436,250
Fallow	3,970,000	1,540,000	5,510,000
Other Agriculture	592,000	96,250	688,250
Non Agricultural (Forest)	-	-	7,900,000
<b>All Uses</b>	<b>-</b>	<b>-</b>	<b>14,902,000</b>

Source: Coxhead and Shively, 1998

**Table 5. Estimated Total Soil Loss for Land Uses and Slopes (Tons/Year)**

Land Use	Slope Category (%)		
	18-30	30+	Total
Rice	15,750,000	5,250,000	21,000,000
Corn with Fallow	217,250,000	240,190,000	457,340,000
Other Agriculture	14,800,000	4,812,500	19,612,500
Non Agricultural (Forest)	-	-	7,900,000
<b>All Uses</b>	<b>-</b>	<b>-</b>	<b>505,852,500</b>

Source: Coxhead and Shively, 1998

On the other hand, an estimate of the gross wetland rice soil resource base of the Philippines is 4.2 million hectares (Fernandez, 1999). The gross area of highly suitable and moderately suitable lands amount to 2.3 million ha; and thus, some 1.9 million hectares of the rice lands are marginal and unsuitable for wetlands rice production.

According to the land suitability estimates by Fernandez (1999), there are 32 provinces rated highly to moderately suitable, and 22 provinces falling under marginal to unsuitable ranges. Earlier land suitability evaluation for wetland rice (Fernandez 1997, 1998) indicated that the dominant constraints to moderately and marginally unsuitable to unsuitable lands were long dry months and drainage and texture.

### **C. Watershed Resources**

The productivity of soil resource is “intimately tied up” to the status of the host watershed areas (Fernandez, 1999). Among others watershed health also influence supply of irrigation water, occurrence of floods and encroachment of salinity in marine coastal and estuarine areas.

Watershed (or river basin) is a drainage area of a stream or river system. There are 421 principal river basins in the Philippines; 18 are major, with a minimum drainage area of 1,400 sq. km. (PCARRD 1991), or the equivalent of 10.8 million hectares. Two-thirds of the land resources are distributed in 403 minor river basins, where these make the Philippines vulnerable to aridity during the dry season.

**Table 6. Distribution of Philippine river basins according to drainage area.**

DRAINAGE AREA (sq. km.)	RIVER BASINS
Major River Basin	
>10,000	3
10,000 – 5,001	5
5,000 – 2,001	9
2,000 – 1,400	1
<b>Sub-Total</b>	<b>18</b>
Minor River Basin	21
1,400 – 1,001	63
1,000 - 501	155
500 - 201	113
200 - 101	51
100 - 50	
<b>Sub-Total</b>	<b>403</b>
<b>TOTAL</b>	<b>421</b>

*Source: Fernandez, 1999*

The major river basins in Luzon are situated in mainland Luzon; in the Visayas, in Panay and Negros; and in Mindanao, in mainland Mindanao (Table 7). Luzon accounts for the largest river basin, the Cagayan River Basin; relatively larger river basins with drainage areas exceeding 3,300 square km; and the largest aggregate area of all the major river basins amounting to over 58 thousand square km. Mindanao claims the second and third largest river basins in the country, namely the Mindanao River Basin and Agusan River Basin. The rest of the river basin in Mindanao have drainage areas smaller than two thousand square km comparable in drainage area to those in Negros and Panay. In the Visayas, Panay has two major river basins with a combined drainage area larger than that of the lone large river basin in Negros (PCARRD, et al., 1999).

Current assessment of the state of the watersheds concluded that many of these are in varying state of degradation (PCARRD, et al. 1999). Soil erosion is considered to be the worst problem, with estimates of between 74 and 81 million tons of soil being lost annually, (very much lower than estimate of Coxhead and Shively, 1998) and between 63% and 77% of the country's total land area affected. According to the PCARRD et al. Report (1999), 13 of the country's 73 provinces have over half of their land area affected by moderate to severe erosion. Sedimentation has also reduced the storage capacity of the country's major reservoir that affects, among others, irrigation water supply. It was further estimated that, over a 25 year period up to 1998, an estimated 20-30% reduction

occurred in the area irrigated to the dry season in a significant number of irrigation systems.

**Table 7. Major River Basins of the Philippines. Drainage Area in sq. km (after PCARRD, 1991)**

Rank	River Basin	Region	Drainage Area
1	Cagayan	Cagayan Valley	25,649
4	Pampanga	Central Luzon	9,759
5	Agno	Central Luzon	5,952
6	Abra	Ilocos	5,125
7	Pasig-Laguna Bay	S. Luzon	4,678
8	Bicol	Bicol	3,771
9	Abulug	Cagayan Valley	3,372
Subtotal for Luzon			58,306
11	Ilog-Hilabangan	W. Visayas	1,945
12	Panay	W. Visayas	1,843
17	Jalaud	W. Visayas	1,503
Subtotal for the Visayas			5,291
2	Mindanao	S. Mindanao	23,169
3	Agusan	N. Mindanao	10,921
10	Tagum Libuganon	S.E. Mindanao	3,064
13	Tagoloan	N. Mindanao	1,704
14	Agus	S. Mindanao	1,645
15	Davao	S.E. Mindanao	1,623
16	Cagayan	N. Mindanao	1,521
18	Buayan Malungan	S.E. Mindanao	1,434
Subtotal for Mindanao			45,081
<b>Total (sq. km)</b>			<b>≅108,678 or</b> <b>≅10.8 M ha.</b>

*Source: Fernandez, 1999*

#### **D. Irrigation Water Resources**

The shrinking of irrigated areas in the Philippines is caused by among other things, the non-maintenance of the national (NIS) and communal (CIS) irrigation systems. The report by David (1999) cites alarming indication of decreasing efficiency in the planning and implementation of NIS and CIS,” because attractive schemes get fewer and fewer and vital watersheds are increasingly subject to exploitation by an ever increasing population”. He also reports that the area actually irrigated by these systems during the dry season is only about 75% of their designed serviced area. There is also the observation of a 20% decline in ratio of actual area served over design area. So for instance, post 1992 irrigation projects serve only 54% of their designed service areas in contrast to 94% before 1965.

The estimate of potentially irrigable agricultural lands in the Philippines is 4.7 M hectares. Of these, an estimated 0.65, 0.44 and 0.5 M ha. are irrigated by national, communal and minor irrigation systems, respectively (David, 1999). The level of irrigation development average about 33% nationwide.

NIS and CIS utilize surface water. But because of watershed degradation, this resource is becoming limiting. However, we have abundant shallow groundwater resources, with an estimate of 5.1 M ha. shallow well area. David (1999) further states that there is a recognition to shift focus from NIS/CIS to low-cost, farmers' controlled, privatized and sustainable irrigation facilities. But however, it is imperative that rehabilitation efforts be done to avert the decline in the communal area and the performance of NIS and CIS. An estimate of about 70,000 ha. of NIS and CIS irrigation service area are to be rehabilitated in order to maintain the present level of development by these modes of irrigation.

## **E. The Nature of Agricultural Externalities**

The above analysis of the current state of agricultural resource base in the Philippines point to the need for better resource management and more targetted sustainable technologies. Modern production theory has increasingly highlighted the contributions to productivity of the state of agricultural resources, and the management capability of producers. Future analysis of sources of productivity growth should include external (and inter temporal) effects of farmers' production activities.

In economic analysis, externalities are treated in the same way as taxes or exchange rate distortions (Alston, Norton and Pardey, 1995). However, the unavailability of damage information does not warrant, to some extent, the empirical estimation of the marginal damage curve that shifts the supply curve to reveal the total social cost. At best, research would depend on the information that a certain technology, say, a chemical, has adverse environmental effects, and hence, future activities will be directed to reducing the demand of these chemicals.

Minimizing externalities and hence, assuring agricultural sustainability can be promoted through 1) proper management of the agricultural resource base, and 2) through introduction of environment-friendly technologies. The following discussions summarize the existing knowledge about soil and water management as produced by research.

## **II. Soil Degradation in Agriculture: The Role of Nutrient Management**

### **A. The Degradation Story in the Lowland Rice Systems and Other Crops**

In the early 1990s, evidence shows that the rice yields in irrigated areas have leveled off and that there is a danger of future declines in the yield growth (Pingali, Moya and Velasco 1990). The slowdown in rice productivity growth was perceived to be caused by economic and environmental factors. So, for instance, the long-term decline in the world rice price has led to reduced investments for irrigation infrastructure, and rice research and extension. Increased intensity of irrigated land use has led to increasing input requirements for sustaining current yield gains (Pingali and Rosegrant, 1993).

There also is growing evidence that unintended environmental effects of the land intensification are responsible for the decline in productivity growth. This was illustrated by Cassman and Pingali (1993) among others, via an analysis of yield trends from long-term trials conducted on experiment stations of IRRI. Trends from the Philippines, India, Thailand, and Bangladesh indicate that even with the best cultivars and scientific management, yields, holding input level constant decline over the long term. At the farm level, declining yields may not be observed in the long term because input levels are not held constant over time. But, Philippine aggregate data also show that average rice yields in irrigated environments have about zero marginal increase in the 1990s (Rola, et al. 1998).

Intensive rice monoculture in the lowlands results in changes that impose significant environmental costs due to negative biophysical impacts. The most common intensification induced environmental problems include the following (Pingali and Rosegrant, 1993): 1. Build-up of salinity and waterlogging, 2. Micronutrient deficiency and increased incidence of soil toxicities, 3. Formation of hard pan (subsoil compaction), 4. Decline in soil nitrogen supplying capacity, and 5. Increased pest build-up and pest related yield losses.

But the most studied effect of the agricultural intensification is the decline in soil nitrogen supplying capacity, thus a change in the soil nutrient status. The decline in the nitrogen productivity is commonly observed. The reason for this could be due to the fact that nitrogen is an important yield increasing input. Research at IRRI showed that this decline is due to the reduction in the nitrogen-supplying capacity of intensively cultivated wetland soils (Cassman et al., 1994). There was likewise an increased incidence of phosphorus and potassium deficiency that is due to the lack of nutrient balance in fertilizers that were applied (De Datta, Gomez, and Descalsota, 1988). A lot of studies across Asia show the occurrence of nitrogen, phosphorus and potassium deficiencies. The result of the unbalanced fertilization has been a decline in the efficiency of fertilizer use over time (Desai and Gandhi, 1989; Stone 1986; Ahmed 1985).

Further review of the current literature in other crops (but one in banana) does not highlight these problems. This is maybe because there are no data to prove these; or rice is the only crop that is intensively cultivated and intensively researched. However, we can use rice as an example; and note that this phenomenon can also happen in other crops, where intensive cultivation occurs.

Such is the case with bananas. In 1990 a survey was conducted in several plantations in Davao del Norte to identify some soil properties that influence land productivity and to establish a soil fertility management technology to achieve sustained crop productivity (Sadasa, et al. 1991). Results of the study revealed that despite the maximum use of inorganic fertilizers, yields of banana declined steadily with time after reaching a peak during the first few years. The yield decline was associated with the alteration of the nutrient ratios due to the application of some nutrients and none for others. It was recommended in this study that nutrient ratios be carefully managed to sustain soil productivity even after long years of continuous cropping.

One study in Mindanao looked at the yield performance of rice and corn on a long term basis (1981-1990) using different management packages. However, as reported, the experiments involved varietal trials, and different fertilizer rates; and hence it is difficult to ascertain whether indeed in the long term, yields decrease as a result of continuous use of fertilizer and successive cultivation in a particular environment as the upland.

These limited data show that intensive and continuous cultivation at longer periods with the use of pure inorganic fertilizers is not sustainable in the long run.

On the other hand, salinity and waterlogging have not been a popular topic of concern by research. Zinc is commonly observed as a deficient micro nutrient in Asia; while iron toxicity is also prevalent. The first thing that is needed is a diagnostic kit for farmers to know whether they have these problems.

Another environmental problem that is cited in the literature is the formation of hard pans. "Hard pan" refers to compacted subsoil that is 5 cm to 10 cm thick at depths of 10 cm to 40 cm from the soil surface. For rice crops, hard pans contribute to impeded root growth, inability to extract nutrients from the subsoil, and build up of soil toxicity due to the perennial waterlogged condition of the soil layer that is above it. Hard pans can be broken through deep tillage and the soil structure can be improved through the incorporation of organic matter; but these practices affect the productivity of the subsequent rice crop by reducing water-holding capacity of the soil (Pingali and Rosegrant 1993).

### ***B. Technological options for improving soil quality***

Because inorganic fertilizer use practiced in intensive agriculture is not sustainable, technological options are set forth. In the literature, there are at least

three groups of techniques for improving soil quality, and hence, improving/sustaining soil productivity. These are :1) the use of organic fertilizer, 2) the integrated nutrient management or the combined use of organic and inorganic fertilizers, and 3) diversified farming. These are described in Table 2.1

### 1. *Use of organic fertilizer*

There are at least two general classifications of organic fertilizers: organic manure from living organisms and organic fertilizers from dead decaying materials.

**Table 2.1. Technology options for soil management.**

<b>C. Description</b>	
1. Organic Fertilizer	This consist of organic manures from living organisms such as azolla and green manures; and decayed organisms including animal manures and compost.
2.Integrated use of Organic and inorganic fertilizers	
Inorganic/Organic Fertilizer	Recommendations for a 50% inorganic and 50% organic fertilizers. This was disseminated through a national program on rapid composting.
Balanced Fertilization	This involved coming up with location specific recommendations, where both the micronutrients and macronutrients were taken into account. This made use of the diagnostics previously packaged such as the soil test kit, and the chlorometer at IRRI.
3. Diversified Cropping	Recommendations to have diverse crops rather than monocrop that uses intensive inorganic fertilizer use.

Organic manure from living organisms helps convert inert nitrogen in the air into nitrate and ammonium ions that could be used by plants to convert proteins. These organisms are called nitrogen fixers. Examples are green manures such as *azolla* or aquatic fern, *sesbania*, *indigo*, and *leguminous trees* and other substances such as *rhizobium* and *mycorrhiza*.

### *Legumes and other green manure (GM)*

Green manure was thought to have an advantage over the other organic manures because they can be grown right in the field and be incorporated during regular land preparation or weeding operation. However, this has not been popular, due to several constraints (Table 2.2). The most serious constraint is the labor intensity of the process. With increasing commercialization of agriculture and higher wages, this constraint poses great limitation. There is sufficient evidence in the literature concerning the benefits in terms of grain yield increases from GM. However, little is known about its long term effects. The paper by Ventura and Ladha (1996) reported that the long term biofertilizer experiment at IRRI showed that there is an increase in the total N in soil after 10 years of green manuring. There is no such benefit from the urea fertilization. It is suggested that long term field experiments be conducted to provide a better understanding of the nutrient constraints and management problems of soil.

Table 2.2 Potential of N<sub>2</sub> fixing green manures as multi-purpose crop in an integrated farming system.

Green manure	N <sub>2</sub> fixing potential	Actual adoption by farmers	Potential to overcome constraints
Azolla	High 45-120 kg/ ha in 45 d	Low Technological and socio-economic constraints (inoculum, labor, water, P, pests) restrict adoption	Medium Fast growth, can be used also as animal feed (poultry, hog, fish)
Semi-aquatic legumes ( <i>Sesbania Aeschynomene</i> )	High 45-120 kg N/ha in 60 d	Low Socio-economic constraints (seed, labor, opportunity costs) restrict adoption	Medium to High With wide range of suitable species, can be grown under wide range of soil and moisture conditions, and can be used as feeds for ruminants, or stem can be used as firewood.
Indigo	High 60 to 250 kg N/ha in 60 d	Low Usage in the Phil. Is limited in the Ilocos region. Socio-economic constraints (seed, labor)	Medium to High Resistant to drought, adopted in the Ilocos provinces as a GM, commonly intercropped with annual upland crops
Leguminous trees ( <i>Gliricidia, Leucaena</i> )	High 40 to 120 kg N/ha per pruning	Low Technological and socioeconomic constraints (pests, competes with main crop for light, water and nutrients, labor, opportunity costs).	Medium to High Low cultural mgt. requirement; leaves used also as feeds for ruminants, stem as firewood, serves as windbreak and catch crop for excess NO <sub>3</sub> .

Source: Ventura and Ladha, 1996

In general, azolla application as a green manure to paddy was remunerative as it reduces the use of fertilizer N and paddy yield. San Valentin (1990) reported that in the



Philippines, inorganic N fertilizer for lowland rice production can be reduced by at least half when azolla is used as green manure. Plots applied with azolla gave better yields than those applied with inorganic fertilizer alone. Use of azolla can significantly reduce input cost by as much as 30%.

A nationwide program for the utilization of azolla as green manure for irrigated lowland rice fields was launched in 1982. Sixty-eight provincial nurseries and 3,000 community propagation ponds were established to service a target area of 300,000 hectares (ha). By 1988, only about 30% of the target area used azolla as a green manure and as feed supplement to livestock. Azolla does not sporulate all year round, they are resistant to pests and diseases and they cannot stand extremely acid or alkaline conditions. These constraints however have been relaxed by further hybridization work (Payawal, 1989). No current evaluation of this technology is available.

Of the annual cultivated legumes, *crotalaria pincea* and *sesbania cannabina* have been most widely grown by farmers in Asia because of their better adaptability under flooded conditions. Use of green manure *Sesbania* increased rice yields and could be an alternative source of organic fertilizer. Its use at the rate of 50 kg/ha and plowed under 45 days after emergence was recommended. Nitrogen accumulation from sesbania regrowth and cowpea residue ranged from 44 to 231 kg N/ha, with rice yields from 2.91 to 3.58 t/ha, following biomass incorporation. (Furoc et al., 1990).

*Sesbania rostrata* was found to substitute 60 kg N/ha in lowland rice (Valdez, 1994). The study also showed that growth of *S. rostrata* is stunted when planted during the dry season due to its photoperiod sensitivity. Farmers need to understand this. Furthermore, *Sesbania* as fertilizer was proven to be effective in field studies of various crops in Bicol (Castroverde et al. 1993). This included cucumber, sweet potato, pechay, cauliflower and coconut. The results showed that use of *sesbania* reduces inorganic fertilizer use without decreasing yields, however, corresponding additional labor costs are not indicated.

Three plants as green manure (*Crotalaria juncea*, *Sesbania rostrata*, and *Macroptellium*) were evaluated according to their agronomic characters, nature of decomposition, available nutrients after decomposition and germination on five types of soils. This study was done in Bicol in 1991 to 1996 (Cambaya and Capucan, 1996). Results of the study proved that the performance of the different biofertilizers differ with soils in terms of its biological yield response, decomposition rate and nutrient release pattern.

*Crotalaria juncea* L. as green manure in corn was studied by Marcelino and Fortuno (1990). Labor costs of the incorporation of this green manure was not also discussed. Several studies confirmed the fact that ipil-ipil can be substituted for commercial fertilizer (Celestino, et al. 1983, among others).

#### *Other Biofertilizers*

Mycorrhiza are fungi which associate with the roots of the plants and help in the absorption of nutrients, especially phosphorus, and water. It provides many benefits such as: 1) increased absorption of macro-and micro-nutrients; 2) increased resistance of plants to drought; 3) control of pathogenic root infections; 4) production of growth-promoting substances; 5) promotion of activities of other beneficial organisms, e.g. rhizobium; 6) improvement of soil structure and aggregation; and 7) promotion of cycling (dela Cruz, 1987).

Rhizobia is a bacteria which can fix atmospheric nitrogen and convert this into forms utilizable by the plants. The effectiveness of both mycorrhiza (as Vesicular Arbuscular Mycorrhiza or VAM) and the rhizobia for the improvement of the growth of and yield of peanuts and mungbean was studied in Isabela and Negros Occidental in 1991-1992. Peanuts and mungbean inoculated with Rhizobia and the VAM produced higher yields than the unfertilized and uninoculated plants, regardless of the season (dela Cruz, et al. 1994).

In an independent study, Perdido et al (1993) evaluated the economics and effectiveness of the mycorrhiza and rhizobia as inoculants. Results of the study showed positive benefits; inoculants are not as expensive as the inorganic fertilizer. Adoption studies are not available, although some limited commercialization as discussed below, is taking place with these biofertilizers.

Nitroplus is the commercially prepared rhizobia developed by Paterno et al (BIOTECH, 1994). This technology utilizes the ability of the root nodule bacteria (rhizobia) and the legume to work as a team to convert free nitrogen gas in the air into ammonia which is the nitrogen form utilized by plants for growth and development. The bacteria rhizobia are made available in abundant quantity by applying the inoculant to the seed prior to planting. Studies have shown that large increases in yields were obtained with inoculation and inorganic fertilizer use substantially decreased.

Trichoderma resii as a fungal inocula and Azoto bacter as the bacterial inocula were developed at Biotech in 1989 (Espiritu, 1992). Initial field test showed increase in grain yield in rice. There are pilot sites for the production of the BOF, one at BIOTECH and another by a cooperative in Silang, Cavite. Two commercial BOF plants are operational.

The second group of organic fertilizers are those derived from dead or decaying materials, including animal manures and compost. Some living organisms such as the trichoderma harzianum is used as an agent to hasten decomposition of the decaying matters.

In the Philippines, *trichoderma harzianum* is commonly known as compost fungus activator (CFA) and was developed by Cuevas (1989). Organic fertilizer produced with use of the CFA was evaluated for rice, vegetables and sugarcane (Rola et al 1995, Rola et al. 1997). Results on rice showed the long term effects on yield (increase not considerable, but stable yields), as compared to the current inorganic fertilizer

practice only, and reduced N application, for farmers who realize the advantage of this technology. Technology was pushed for commercialization but recent sales data show a decreasing trend.

Market garbage-swine manure (with use of the *Trichoderma harzianum*) as alternative source of N fertilizer was generated by Ebuna, et al. (1992). This provides an option for better utilization of domestic wastes, as well as minimizing on inorganic fertilizers. Level of utilization of this technology is not known at the moment.

Biosludge, a byproduct of biogas digester was also studied (Santos 1985) at Bureau of Soils, and was found to be a potential source of N.

Use of press mud (a by-product of sugar cane, which is a waste product of the milling process) to supply 30% of usual nitrogen dose increased yield by 34% and 10% in the plant and ratoon crops, respectively (Burgos, 1989).

Rice hull was also found to be a substitute for complete fertilizer (Aganon and Silva, 1985, 1992). Asio (1985) of VISCA also found that industrial wastes like coal ash and mudpress could substitute for the effect of corn, and improved the chemical and physical condition of the soil.

Microorganisms were found to be producers of indigenous fertilizers (Ocampo, 1985). Earthworms were also producers of indigenous fertilizers. In the Mountain province, a material called 'lamud' was used as fertilizers by farmers (Recel and Grifal, 1985). Though it was found to be not an organic material, it increased pH and cation exchange capacity and enhanced the release of K. The researchers also noted that this lamud could serve as an ameliorant.

The impact reports on the increases in yields, improvement in soil characteristics, more activities of the nitrogen-fixers and better root horizon environment.

### **Commercializing organic fertilizers**

At least six types of biofertilizers have been commercialized in the Philippines. The process of commercialization varies in each type. While private investors have picked up some of the technologies, the public sector had also significant investments in the commercialization process. The other form of commercialization is through farmer cooperatives and with close support of the academic/research institute that produced the technology. Here are the status of these commercialized technologies, as summarized in Table 2.3.

**Table 2.3. Commercializing organic fertilizers.**

Name	Description	Year of Development	Year of Commercialization	Sales in 1998 In Pesos	P/unit
1. Bio-green	Bio/organic fertilizer from agricultural and agro-industrial wastes composted with fungal inoculant and enriched with free or living N-fixing bacteria.	1991	1993	No estimate	P160/40 kg-bag
2. Mycovam	Mycorrhiza inoculants which promote symbiotic association between plant roots and fungi	1988	1991	74,950	P25/kg
3. Bio-N	Biological nitrogen fixers for rice and corn which is a microbial-based fertilizer providing 30-50% nitrogen requirements of plants.	1989	1990	55,385	P20/200 g-packet
4. Nitroplus	Biological nitrogen fixer for legumes	1976	1982	15,000	P20/150 g-packet
5. Mycogroe	Tablet inoculant which acts as a supplement/replacement of chemical fertilizer; promotes growth and survival of tree species.	-	1990	30,000 <sup>1/</sup> stopped production in 1996)	P1.00/tablet
5. Rapid Compost	Makes use of <i>Trichoderma harzianum</i> as compost fungus activator (CFA)	1989	1991	No estimate in 1998	P15/.5 kg pack of CFA P135-150/50 kg of compost

Source of Data: Biotech, UPLB, 1999

<sup>1/</sup>Stopped production in 1996. Has current stocks of around 2M tablets.

1. Bioorganic fertilizer, also known as BIOGREEN is derived from agricultural and agroindustrial wastes composted with fungal inocula and enriched with free living N-fixing bacteria. Tables 2.4 and 2.5 show the groups/individuals/cooperators assisted by BIOTECH in the establishment of bioorganic fertilizer business. The technology was developed in 1991 and commercialized since 1993.

**Table 2.4 Other individuals/groups assisted by Biotech in establishment of bio/organic(Bio-green) fertilizer business.**

<b>D.</b>	<b>Name of Enterprise</b>	<b>Office/Plant Site</b>	<b>Estimated Capacity (bags/mo.)</b>
1.	Bulacan Gardens	Quezon City	2,000
2.	SUSI Foundation	Tiaong, Quezon	1,000
3.	EDNAC Enterprises	San Fernando, Pampanga	1,000
4.	PAYOGA	Gamu, Isabela	100
6.	Kaunlaran Bio/organic Fertilizer Enterprises	Labuin, Sta. Cruz, Laguna	100
6.	MANCHEM	Cubao, Quezon City	(awaiting ECC approval)
7.	Mr. Federico Pascual	Balayan, Batangas	200
8.	Mr. Lito Javier	Sto. Tomas, Batangas	100
9.	Mr. Vic Machado	Palestina, Pili Camarines Sur	100
10.	KABAN Group, Inc.	Old Sumapa Malolos, Bulacan	1,000
11.	VMC Farmers' Cooperative	Bacolod City	2,000
12.	PHELA Resources	General Santos	2,000
13.	JMSS Microbials	General Santos	1,000
14.	Envirophyll, Inc.	Balayan, Batangas	1,000
15.	NOVATECH	Malacampa Farms Camiling, Tarlac	100

Source: Biotech, 1999

**Table 2.5. Most active cooperators presently engaged in bio/organic (Bio-green) fertilizer business.**

<b>Name of Enterprise</b>	<b>Office/Plant Site</b>	<b>Estimated Capacity (bags/mo.)</b>
1. National Dairy Authority (NDA)	Sto. Tomas Dairy Center, Davao	1,000
2. Minola Corp./Coconut Industry Investment Fund	San Jose, Batangas	1,000
3. Gratia Plena Social Action Center	Muñoz, Nueva Ecija	1,000
4. Bio-manna Agribusiness, Inc.	Tuy, Batangas	1,000
5. INFARMCO	San Isidro, Cabuyao, Laguna	500
6. ECOBI	Quezon City	250
7. Bio-blends Corp.	Dagupan City	200
8. Hilltop Farms	Bulacan	1,000
9. KAAGAPAY, Inc.	NCP Bldg., Makati City	1,000

Source of Data: Biotech, 1999

There are several brand names: Full of Grace in Nueva Ecija, Bionomics in Tuy, Batangas, Cocorich in Bauan, Batangas, Buhay Lupa in General Santos City and Lakas Ani in Cabuyao, Laguna. Biofertilizer bought at BIOTECH is produced in Bauan, Batangas, with brand name Cocorich. The price of the product is P160 per 40kg. bag.

2. *Mycorrhiza inoculants* (Mycovam)- promotes symbiotic association between plant roots and fungi; and used in agricultural crops (such as upland rice, corn, sugarcane, peanuts, mungbean, soybean, sweet potato, potato) fruit trees and reforestation species. This was developed in 1988 and commercialized since 1991. This is produced and distributed by BIOTECH only. The transfer of technology (in terms of production and marketing) to Los Banos Biotechnology Corporation is under negotiation. There are other private enterprises that are also interested but no negotiation has taken place as of the moment.

For this inoculant, the total production is 3820 kg in 1997 and 3500 in 1998. The price is P25/kg. Total sales is P83,000 in 1997 and P74,900 in 1998.

3. Biological nitrogen fixers for rice and corn (BIO-N). This is a microbial based fertilizer which provides 30-50% nitrogen requirements of plants. This was developed in 1989 and commercialized since 1990. Like the Mycovam, this is also produced and distributed by BIOTECH only. It is claimed that this is used all over the country. A memorandum of agreement (MOA) with the TLRC is under negotiation. In this set-up, the TLRC extends loans to the farmer cooperators who will produce the BIO-N. The farmer cooperators will represent various areas in the country.

This technology is sold at P20/250gm pack. Sales in 1998 is P55,385; while for Jan.-May, 1999, this is P 35,275.

4. Biological nitrogen fixers for legumes (Nitroplus). This was developed in 1976 and commercialized since 1982. It is produced only at BIOTECH but is used all over the country. The price is P20/150 gm packet. Total production in 1998 is 750 packets, while total sales in the same year is P 15,000.
5. Mycogroe is a tablet inoculant which acts as a supplement/replacement of chemical fertilizer; promotes growth and survival of the tree species. The production of this is handled by the Los Banos Biotechnology Corporation since 1990. MYCOGROE is protected by a Philippine patent and is registered with the Philippines' Fertilizer and Pesticide Authority (FPA) as a biological fertilizer. One table costs about P1.00 and one tablet per plant is needed to inoculate seedlings at planting time. Consumers of this technology are mostly institutional users such as the Paper Industries Corporation of the Philippines (PICOP). Large reforestation programs in the countries like Thailand, Indonesia, and Kenya also subscribe to the technology.

Other users /buyers are nursery men, foresters, and golf course developers coming from different parts of the Philippines. The production of Mycogroe stopped since 1996; with a current stock of about 2million tablets. The 1998 sales is only P30,000.

6. The *trichoderma harzianum* or compost fungus activator (CFA) which has a potential as low-cost and environment friendly technology was not attractive to a private marketing firm because it was difficult to extend. While MYCOGROE was to

be used by institutional users, the CFA was to be used by the small scale rice farmers. The Philippine national government launched a program in May 1990 to promote the CFA on a wider scale, with the end of full commercialization in view. CFA shortened the decomposition of base materials from five months to three weeks, thus the term rapid compost was used to describe its product which can be used as organic fertilizer.

CFA was introduced as a component of the package in the Rice Production Enhancement Program (RPEP) of the DA with a corresponding recommendation of 50% use of compost and 50% inorganic fertilizers. CFA was mass produced initially by the local offices of the Department of Science and Technology (DOST) and the Department of Agriculture (DA) with government subsidy. This strategy did not work because the government officials involved could not sustain the business operation, which was over and above their other official functions. There also was the problem of the unavailability of raw materials for production (Rola et al., 1995; Rola et al. 1997).

CFA is just one ingredient to the manufacture of compost. The other raw materials needed are the rice straw, ipil-ipil leaves, kakawate leaves and manure from pigs, chickens, carabaos and cows, and sawdust. The nutrient content of the compost depends on the proportion of the mix or raw materials used. Water is constantly needed to maintain the moisture of the compost heap. Because of this, technology was introduced initially in irrigated areas.

Several problems arose with respect to the farmers' production of the compost with the CFA. Foremost of these is the fact that the operation is very labor-intensive. It needs about 30 man-hours to produce a compost during the turn-around time. Sometimes, the raw materials are not available, including water. When the CFA dissemination by the government was not working, the DOST encouraged farmer cooperatives and the private sector to mass produce CFA and the compost as well.

The national program that backstopped the commercialization was terminated in 1996. At present (1999), there are 34 private enterprises that are still engaged in the production of the compost. Some DA/DOST offices and private enterprises produce the activator. DA/DOST also monitor the performance and give technical assistance upon request.

The 1998 sales figures are not available but the price of the activator is P15/ .5 kg; and price of compost is P135-150/ 50kg bag. In 1997, estimated total sales of compost was P7.569 M, down from P77.919 M in 1994, the height of the commercialization program of the government. In the case of the CFA, estimated total sales in 1997 was P .266M, down from P3.144 M in 1994.

## **2. Integrated use of organic and inorganic fertilizers for Nutrient Management**

Integrated use of organic manures and mineral fertilizers has been found to be promising in maintaining stability in crop production on certain soils.

A 10-year study on the effects of organic and inorganic fertilizers applied separately on “MAWA” hybrid coconut was conducted in Davao from 1984-1994. Results revealed that palms applied with inorganic fertilizers and goat manure produced significantly the biggest girth, tallest palms, most number of leaves, leaflets and the earlier flowering of palms (Secretaria and Maravilla, 1996). It was also noted that while organic fertilizers improved soil fertility, it alone cannot sustain the high yield during the later years of production. An integrated fertilizer management is found to be more sustainable.

A study that examined the effects of organic and inorganic fertilizers on the population dynamics of pests in rice showed that combinations of organic and inorganic fertilizer had lower pest counts; while the treatment that used pure inorganic fertilizer had the highest rate of disease occurrence (Lorenzana, 1994). These experiments were done in Isabela, in the wet seasons of 1990 and 1991-1994.

For lowland rice, the experiments in the 1990s showed that a combination of compost (organic materials) and inorganic fertilizer gave the highest yields.

### **Role of Rapid composting technology in Integrated Nutrient Management (INM)**

The rice farm sector was first introduced to the Integrated Nutrient Management (INM) through the program using the rapid compost with the use of the CFA. This was recommended to be used as ½ organic and ½ recommended dose of inorganic fertilizer (Cuevas, 1989). This technology improved crop yields by as much as 20%. Labor input cost in compost preparation and field application were expected to be offset by the gains in yield increase. Later studies show that this is true only if wages in the community are low and non farm incomes are not available (Rola et al., 1995).

The deficiency of this program was that the recommendation was a blanket one for the whole country. Aside from the other administrative setbacks of the rice program, (i.e. delay in supply of the compost, inadequate knowledge of both the technicians and the farmers on the use of compost), this technology did not prosper due to technical constraints. Only users who have the a priori knowledge of the soil characteristics were able to capture the benefits (in terms of lower inorganic fertilizer use and stable yields) of this program. Soil analysis at the farm and community levels, however, was not promoted nor encouraged when this program was conducted.

### ***Balanced fertilization Program for rice and corn***



A natural sequel to the blanket recommendation of the rapid compost is the balanced fertilization program launched in 1998. Balanced fertilization is defined as the optimum use of organic and inorganic fertilizers with the proper grades and amounts that supply the correct ratio of plant nutrients and which ensure that soils will sustain high crop yields over long cropping season. The Gintong Ani Balanced fertilization program was the central strategy for sustainable agricultural development. For this purpose, the BSWM has classified the various soils devoted to rice and corn into five soil fertilizer groups.

In the balanced fertilization, the recommendations were location and season specific and also dynamic. That is, a recommendation of a mix of fertilizer this year is different from next year and the year thereafter. Again, this technology is very knowledge intensive. Farmers need to know the base nutrient content of their soil and based on what amounts of organic and inorganic fertilizers applied and the crop grown in the current year, then a corresponding adjustment in the proportion of the organic and inorganic fertilizer will be applied the following year.

The balanced fertilization program strategy is currently demonstrated in techno demo sites all over the country for both 10 and 20 hectare farms. The activity is jointly funded by BSWM and the Philrice following the protocol that was developed by the BSWM (1998). The protocol states that rapid testing using the soil test kit (STK) be done to determine the uniformity of fertility status of the area. Farm lot within a given fertility range (pH, N,P,K) shall comprise one monitoring site. Composite soil samples from each monitoring site shall also be collected to be submitted to the Soil laboratory. This first step of soil sampling and soil analysis is done to determine the right amount of nitrogen fertilizer to be added. This complements the Leaf Color Chart reading which determines the proper timing of nitrogen application.

This strategy contributes two things to advance our knowledge and practice in INM: 1. By targetting the amount of additional nitrogen, and 2. By targetting the timing of nitrogen application. Note that in case of deficiency in other nutrients, farmers still have inadequate decision support systems.

Several research outputs backed up the balanced fertilization program. One is of course the characterization of the soil at the local level to get local recommendations. The others would be the use of the diagnostics such as the soil test kit and the leaf color chart.

Studies to come up with regional fertilizer recommendations have been done. One is a study conducted in Region 6, (Loot, 1994) where different agricultural schools in the region conducted studies for field corn and upland rice during 1987-1993. The first phase of the study was to establish the critical levels of organic matter, phosphorus and potassium while the second phase was the calibration of soil tests and formulation of fertilizer recommendations. Results showed that the colorimetric method for organic matter determination showed a positive correlation of crop response to added nutrient. It was found that potassium is high in the region. Other regions may have these types of

studies and could be a good bases for regional recommendations on soil nutrient management.

There have been several attempts to characterize soils in the Philippines. The BSWM has a lot of these studies. One study was done in Mt. Pangasugan in Leyte (Taburada, 1994). Most of these studies also analyze suitability of the crops currently grown. In the Key Production Area of the DA, the objective was to plant the right crop at the right soil at the right time. This means that land is suited to the crop and that that crop should address the demands of the market.

One other study that could have supported the Balanced Fertilization program was a project funded by BAR and whose main concern was to combine the data on agro-environment characteristics and agrotechnology requirements (Alcantara et al. 1999). A simple database on soil, rainfall, air temperature, typhoon occurrence, crop, water, and pest management and crop yield was established for various rice and corn farms representing low, medium and high levels of farm management in the major soil series of the key production areas in 18 provinces in Luzon. Land suitability evaluation and fertility capability classification identified the soil related constraints and opportunities for high production of lowland rice and corn. The study recommends that soil series and its phases should be the basis for planning and management and soil based agrotechnology transfer for rice and corn in the key production areas.

BAR could initiate a study that will analyze the data generated from the monitoring activity of the balanced fertilization program. Furthermore, BAR could also study the extension strategies that would be compatible for this technology.

### **3. Diversified Cropping: The Role of Farming Systems Research**

The rationale for the farming systems research of the 1980s was indeed to develop technologies that would increase small farmer incomes while promoting environmental sustainability. In the early period of this paradigm, the research activities focused on developing through on farm research, cropping patterns that will increase farm incomes. It was only of late that data to support the sustainability of the resource base corresponding to the introduced cropping systems were generated.

Also, initially, farming systems had several stages: technology development, verification, adaptation, and dissemination. With the current trend of participatory research, these stages may be modified, where one starts with the farmer technology and build components from there. This is in contrast with the method before that farmer's indigenous practice was one of the technologies being verified and pitted against the researchers' technology.

Farming systems research was primarily done in resource poor environments. Hence, the upland systems were a popular subject of research. Likewise, water scarce areas in the lowland were given some attention. For instance, because of water scarcity in

the lowland irrigated areas, and to minimize the intensive and continuous rice cultivation, traditionally upland crops were tried in the lowland areas at UPLB and in Bulacan. The crops include mungbean, cowpea, sweet potato, green corn and baby corn. Irrigation water was from a small farm reservoir. Bioorganic and inorganic fertilizers were superimposed in cropping pattern plots. Results showed that all the upland crops evaluated in this study can be grown after lowland rice under UPLB condition, while mungbean did not perform well in Bulacan (Labios, et al. 1995). Yield performance differed for each crop and the combined use of bioorganic and inorganic fertilizers gave comparable yields to that of the sole inorganic fertilizer use.

Another system for crop diversification is planting corn after wet season rice. This was introduced in several areas in Central Luzon. There was a positive response on the options provided to the farmers regarding corn variety and management technologies (Labios et al. 1994).

The response of hybrid maize to tillage, nitrogen and moisture regimes after irrigated wetland rice was studied by Alam (1995), in Nueva Ecija. Results indicate that the soil moisture fluctuations from allowable depletion to permanent wilting point resulted from decreasing moisture regimes based on irrigation water to cumulative pan evaporation ratios and increasing tillage intensity. This resulted in the good performance of the maize crop. Grain production increased to a maximum of 7788 kg/ha with N levels equal to 180 kg/ha.

As previously mentioned, cropping systems research was first planned as a recommended diversified farming that will increase farm incomes. Later, the merit of soil amelioration due to its advantage vis a vis the monocrop was the highlight of these trials. Hence, for instance, in an experiment in Iloilo (Oren, 1992) the kakawati was a part of the cropping system and was a potential source of compost.

In a hillyland development projects in Isabela, traditional farmer practice of corn-corn systems in the hillyland ranging from 6 to 18% slope, was compared to two improved systems, namely: banana (with corn and peanut) and Banana/calamansi (with upland rice/mung+corn+watermelon). This research was done in 1989-1992 by Asuncion, et al. (1992). The improved cropping pattern gave higher net economic benefits and a healthier soil base. There was also an observed levelling off of the soil in the test areas indicating the contribution of the improved patterns in the control of soil erosion. But, impact of cropping systems/farming systems studies have to be evaluated, to determine the levels of adoption of the new practices.

***Nutrient management in the highly acid upland soil was also studied via farming systems research. The following were evaluated: fallow, liming, and use of acid tolerant crops. Results of the experiments in Cavinti, Laguna showed that upland rice cumulative yield was substantially increased following grazed fallows in contrast to continuous rice cropping for three years (Magbanua et al. 1994). There are also substantial benefits from liming of acid sensitive crops in highly acid unproductive***

*upland soils. There was no statement as to the cost of liming, but it is known that it needs 8 tons per hectare for the result cited above.*

Other experiments in some other soil types also indicate that lime is a good neutralizer (Taburada, 1994). Between relay cropping and mono crop systems, it was found that relay cropping is in a way environmentally and in most cases, economically better than the monoculture scheme.

Several studies also looked at the suitability of the field crops in the lahar areas. Ashfall or lahar did not render the lands unproductive as indicated by the farmers' ability to grow crops. There was of course a different set of crops, mostly high valued as rice is expensive to grow. Farmers' crop and soil management are also compatible with the base soil.

### ***Crop Specific Soil Management Technologies***

#### **1. Legumes/Rootcrops**

Results of the field trials conducted by Paterno, et al (1983) showed that legume inoculation with Rhizobia has a fertilizing value either equal to or better than the application of 30kg N/ha. No added benefits were obtained when P205 AND K20 rates were increased from 30kg/ha to 100kg/ha. Yields of mungo, soybeans, and peanuts increased with inoculation and with experiments done in different soil types. For garden pea, the combined application of organic and inorganic fertilizers was found to be more economical (Dar and Merstela 1985). This is a combination of chicken dung and inorganic NKP. Decomposed chicken dung and carabao dung were also found to be as good as urea in increasing herbage of lagundi and sambong (Campos, et al. 1983). This was deemed to be an indigenous technology of farmers.

A comparative economic analysis of different animal manures and inorganic fertilizer for cassava and gabi (Sarong 1987) showed that cow manure application gave the highest net return followed by pig manure, chicken dung, inorganic fertilizer and guano. The indigenous technology in Leyte where the experiment was done is not known. Price structures of organic materials and the labor required are not mentioned in the study.

Inorganic fertilizer treatments for sweet potato did not significantly affect yield in the early experiments at VISCA (Javier, et al. 1985), but continuous application of ipil-ipil herbage increased the yields. There were studies on screening of mungbean, peanut, sweet potato, corn, ipil-ipil for tolerance in acid soil conditions (Samonte, 1985). There were identified problems during these trials like a finding that there are toxic levels of aluminum (Al) and Manganese (Mn).

#### **2. Coffee**

Experiments with soil management were done during the early years of the plant growth (Cabangbang et al. 1986). As such, the yield response is not available (only height and girth increments) – coffee as a perennial should have long-term experiments.

### 3. Sugarcane

The efficacy of ipil-ipil leaves as a source of fertilizer for sugarcane was also studied (Gerardino 1983) in the early 80s in Negros. Results showed that plant yield and quality of juices were responsive only depending on the soil quality. Still, with yield as the only indicator, it was concluded that the combination of ipil-ipil and inorganic fertilizers only (175-100-0 NPK) was effective. With more knowledge on the impact of continuous inorganic fertilizer use to the health of the soil, these need to be investigated some more. There are no studies to define the current farmer technologies.

Early experiments also showed that there are still a high supply of nutrients in the soil of sugar cane farms, so there were even observed decreases in yield with the P205 experiments in sugarcane (Tapay and Homrebuena, 1983, Bacol, 1983). At this time, it is also worthwhile to characterize the soils in the sugar areas.

Effectiveness of vesicular arbuscular mycorrhiza (VAM) as biological fertilizer in promoting growth and yield of sugarcane was also studied by Quilloy and Lansang (1992). They found significant increases in yields with VAM, but no effect in cane juice quality; however, higher levels of fertilizer application reduces sucrose content of the juice. Bacol and Talahm (1996) studied the appropriate fertilizer recommendation for specific soil type to attain the optimum growth and yield. The current recommendation is 200-200-600 kg/ha NPK. It was shown that these rates can be lowered in specific soil types. This highlights the need that fertilizer recommendations should be soil type specific.

### 4. Vegetables

Early 80s experiments on the efficacy of organic (chicken manure) and inorganic fertilizer applied in tomatoes (Maape, 1984) showed that chicken manure alone was sufficient to attain optimal yield. The combination of chicken manure and inorganic fertilizer was not superior. But we need to study the economic and environmental implications of continuous chicken manure application. Current farmer practice is a combination of organic and inorganic fertilizers, especially in the upland areas (Rola et al. 1998).

Chicken manure as fertilizer for sitao proved to be a good substitute to inorganic fertilizers aside from improving the soil condition (Jamorallin, et al. 1990). This was found to be true in Sorsogon.

The 75:25 organic and inorganic fertilizer combination boosted blackpepper production in Cotabato (Lumbao, et al. 1994). Organic fertilizer were farm manure and farm wastes.

## 5. Corn

Use of *Azospirillum* for corn production was studied by Cosico, et al. (1990). This is a bacteria that is isolated from the roots of talahib grass and can supplement nitrogen fertilizer requirement of corn. Response of corn to the inoculant were affected by the type and the fertility level of the soil, the inoculant concentration and the season. Inoculation was less effective when the soil was subjected to very low or very high fertilization rates.

*Sesbania rostrata* as a source of fertilizer for corn was the subject of Satorre's study in Region XI (1990). The advantages of this green manure were cited as follows: 1. It increases the organic matter content and the nitrogen mobilization, 2. It improves the microbiological and physical properties of the soil, 3. It has a potential to accumulate N and substitute for N fertilizer, and 4. It increases corn yield and farmers' income. The limitation as cited by the researcher is that when grown from February to August in the study location, it grows very tall, thus additional labor is required to cut it into pieces before plowing. Computed marginal rates of returns are quite low; although the technology is adaptable to upland conditions when labor is expected to be abundant. Economic evaluation is also needed.

Organic fertilizer for green corn production was studied in the highly alkaline soils and in Sorsogon (Jamoralin and Lasala, 1992). Application of chicken manure resulted to high yields. It also improved the condition of the soil.

### C. Constraints to adoption

Constraints to adoption of sustainable soil management technologies can be grouped into the following: technical, socioeconomic, and institutional constraints.

#### 1. Technical constraints

Meeting the nutrient needs of modern short duration high yielding crops through organic manures alone poses several problems (Schoning and Wickman, 1990):

- Nutrient contents of organic materials are rather low, even when expressed on a dry matter basis.
- Together with the varying nutrient contents of individual batches or organic manures, the slow, irregular release from these manures makes target fertilization impossible.
- When materials with high C/N ratio are used, i.e. straw, even soil-borne N will be immobilized by microorganisms during its decomposition which could result in a depressed yield from the subsequent crop.

- Where organic manure is applied to paddy, the decomposition of large amounts of organic materials under anaerobic conditions may lead to the formation of phytotoxic substances, such as hydrogen sulfide, methane, etc.
- A hazard from the use of organic waste such as sewage sludge and town refuse may be their contamination with heavy metals or toxic organic compounds.
- There is no data available to determine nutrients yielded by a 50% rapid compost and 50% inorganic fertilizer.

## E. 2. Socioeconomic constraints

Growing green manure means competing for land and water. Farmers are not willing to pay money for seeds and inoculum and to invest for something which does not provide immediate results. Also, green manuring has not gained general acceptance for several reasons: 1) it gives no immediate income; 2) has not fit into the farmer's traditional mixed cropping systems, and 3) requires labor that farmers consider unnecessary (Less and Warni, 1989).

On the whole, the low nutrient necessitates the transport, distribution and incorporation of several tons of manure per hectare to achieve adequate fertilization. This operation is very tedious and expensive for the farmers.

The low demand for commercialized organic fertilizers may stem from the fact that farmers do not understand how to use this; and long-term effects are of course not visible to the farmer, who always has short-term production plans. Diversified cropping system is dependent on output prices, and prices are dependent on policies and other government incentives.

## 3. Institutional constraints

Sustainable agriculture as a way of farming was demonstrated through a tripartite partnership (private sector, NGO and academe) in a farm that was previously monocrop-chemical based. Pacamalam, (1996) recorded this case study of a farm that was converted into a lowland based integrated diversified farm. There was an increase in incomes, and perceived decrease in household expenditure, although the study did not indicate why this is so. The system is so labor intensive that it would be difficult to practice this in labor scarce farms.

But the point is it took several sectors in partnership to promote these sustainable agriculture practices. It has to be recognized that sustainable technologies are knowledge-intensive; long-term in benefits; and very location specific. In this sense, a major institutional restructuring is needed to meet the aim of promoting such technologies. First, we have to investigate the role of extension and the kind of extension strategies needed consistent with the nature of those technologies. Participatory approaches are warranted because one needs to know farmers' level of awareness with respect to sustainability and resource management.

Commercialization of products like biofertilizer has not also taken off successfully, again due to severe institutional constraints. First, there is a need to get a patent; second, a permit from the Fertilizer and Pesticide Authority, and third, a mechanism for quality assurance of the product, in the hands of the private marketing agent is needed.

#### **D. Towards Sustainable Soil Management**

##### **1. *Need for a Soil data Base***

There have been several studies to explain the soil base information that could be used for soil resource management and technology development. Alcantara, et al. 1984, has collated 909 abstracts (and more current computer packages of info) on soil resources. Slope maps for the watershed of the Laguna province is available. A later study of Alcantara et al (1999) has soil, water and climate data for 18 Luzon provinces. These data have to be integrated and processed in a form that can be used by planners and policymakers.

##### **2. *Diagnostics at the extension and farm level***

Knowledge based technologies or practices are more difficult to extend to farmers than new varieties. From research to farmer adoption, a number of steps are involved: synthesizing and distilling the complex research findings into simple forms that farmers can understand and use effectively; training the extension staff on the delivery of new techniques to farmers; educating the farmers to select, adapt, and fine tune the new techniques; organizing continuous farmer participatory evaluation of new practices; modifying and improving the techniques based on farmers' feedback; and using innovative mass communication methods for wider dissemination of the new technologies (IRRI).

Use of simple decision tools may help improve farmer adoption of knowledge intensive technologies. One tool that has been developed is the leaf color chart for promoting need-based N application for rice. The leaf color chart is an ideal tool to optimize N use efficiency in rice cropping, irrespective of the source of N applied-inorganic, organic, and/or biofertilizers. It determines the correct time of N application to their rice crops based on crop demand and soil N supply. It was designed as an ecology friendly tool in the hands of the small farmers. This is also described to be inexpensive, but no price quotation is available. As cited earlier, this is currently used as a diagnostic tool in the balanced fertilization program. But this technology to detect N optimal use is only a start. Soon, we need technologies for a real balanced macro micro nutrient diagnosis.

The other tool that is now available at IRRI is the chlorophyll meter. This is a simple, reliable, and nondestructive diagnostic tool used to monitor leaf N status in rice plants. It will assist users in deciding the right time of N topdressing to their rice crops. However, this is expensive for an ordinary farmer; a farmer cooperative may own it.



## **Soil Test Kit**

A Soil test kit was developed by Bonoan et al. (1995) to determine the fertilizer requirements of the tobacco crop. The test involves the assessment of the levels of organic matter, N, P, and K in the soils. Test results can be related to the fertilizer requirements of the crop.

Another SOIL TEST KIT that is a complete package of soil testing was developed at UPLB by Dr. Eduardo Paningbatan. It uses simple colorimetric chemical analyses in which chemical reagents are made to react with a soil sample in a test tube to give a characteristic color depending on the amount of available nutrients in the soil. The colors produced are matched with a standard color chart that rates whether the soil is low, medium, or high in available nitrogen, phosphorus or potassium. Also determined by the soil test kit is the soil Ph and the acidity.

Analysis of the soil test kit is a quick method of evaluating the fertility status of a soil. It involves chemical analyses that measure the amount of nutrients in the soil that are available to the plant. Results are interpreted and used as basis in making a recommendation on the right kind and amount of fertilizer for a particular crop when grown in the soil being tested.

But, the soil kit can only detect the macronutrient deficiency. And so, with the need for balance fertilization, this is not a sufficient diagnostic. The soil kit could be effective for intelligent farmers only. Farmers need to know about the technique in soil sampling, has to have almost sterilized test tubes; has to be aware that the chemicals used are corrosive and poisonous, etc. As such, this could be a service to be rendered by extension, rather than for farmers to individually own the device. The test kit is cheap and has been widely accepted, as reported by the UPLB Department of Soils. The kit is used by institutions like IRRI, Philrice, the San Miguel Corporation, etc. and some colleges and universities.

In the 1990s, the soil test kit was validated across different production environments in the country. The STK fertilizer recommendations almost always gave higher yields than did soils laboratory recommendations. These were validated for several crops, i.e. rice, corn, garlic, tomato, peanuts and mongo. However, economic analysis showed that recommendations from the soils laboratory analysis showed higher returns. This may be due to the high price of the STK, as the full cost is not difficult to quantify. The soil laboratory as a government facility may have been valued at a minimal figure in this analysis. We need to examine more closely the services that are being rendered by the soils laboratory nationwide. These are expected to give a recommendation that will benefit the farmers optimally. In Region 6, upland rice yield data showed that STK recommendations and the regional soils laboratory recommendations did not differ.

### **3. *Indicators of Sustainability***

If soil test kits are not available, are there other indicators that can help farmers and other decision makers in relation to soil management? Soil properties can be defined to determine soil productivity. But what are the indicators of sustainability in these productivity levels? Although in theory, it is a bit difficult to define such indicators, it is suffice to say that we (meaning both scientists and farmers) need this as an early warning device. An argument has been put forth that for an agricultural system to be sustainable, two conditions are required: farmer's needs are satisfied, and that the natural resource base is conserved (Gomez, 1997).

As proposed by Gomez (1997), the indicators for sustainability could be the following: 1) for farmer satisfaction- gross return, material cost, diversity index, farm size, membership in organization and number of large animals; 2) for resource conservation-organic matter content, CEC, moisture content, water dispersable solid, permanent ground cover and soil depth. These and other types of indicators have to be studied and matched with what farmers are doing, in order to develop sustainable technologies.

### **4. Towards assessment of soil productivity**

A current study being done by the BSWM is the soil productivity for soil degradation assessment with Isabela as the initial case study site. This study used the Geographic Information System (GIS) in determining the sites where soils are productive. The soil map, slope map and the erosion map were used as the bases for determining the soil degradation in the different areas of the province. From these maps, the soil degradation map was derived. Through the color coded GIS map, one is able to examine the areas of no degradation, slight degradation, moderate degradation, and severe degradation. In slightly degraded areas, the degradation will not significantly reduce productivity or benefits, such that additional costs to reduce degradation will not affect profitability. In the moderate degradation, the degradation will reduce productivity because of the increasing inputs required to correct the degradation so that sustainable agricultural production will be maintained. The added costs to correct the degradation will bring almost equal added benefits. On the other hand, in severely degraded areas, the degradation will significantly reduce productivity and the private investments to correct the degradation is not justifiable because the added benefits is less than the added costs (Evangelista, et al. 1999).

The resulting soil degradation mapping units were subjected to Soil Productivity Capability Classification (SPCC) that was developed through the STDC-JICA Technical Cooperation Phase II. In this process, soil qualities are evaluated using a set of criteria for soil characteristics and these are defined as soil properties which can be described or measured by field or laboratory observations. The soil qualities that were considered were: sufficient soil depth, ease of seed germination and root penetration, low risks from water stresses, capacity for nutrient renewal, availability in the top soil of the nutrients

needed by the crops, high inherent fertility, absence of soil fertility constraints, ease of plowing (for upland soils), or puddling (for lowland soils, absence of impediments to cultivation, absence of erosion hazards, and absence of flooding hazards.

Each of the classified units according to degradation had a score. The authors also interpreted the SPCC rating as percent of maximum potential yield assuming zero limitation. Corresponding to these degradation units, an agro-socio-economic survey generated the yields of corn by farmers (Samar and Evangelista, 1997). In the no degradation and the slightly degraded areas, the annual corn yield (for two croppings) is about 7.6 tons per hectare; in moderately degraded soils, 5.02 tons/ha. For the severely degraded soils, there was no records of harvest in Isabela, but the available data for the whole country is about 2.6 tons/ha (Lapis, et al. 1997).

How will the ratings be interpreted given the the yield data in particular sites? The computed soil rating is 94 for no degradation and 89 for slight degradation. Expressing this as a percent of maximum potential yield, and that 94% for the no degradation areas, the farmers are already getting about 7.7 tons/ha/year, then this means that the yield can still be increased at the sustainable yiueled level of about 8.3 tons/ha. And still within the carrying capacity of the soil. From these estimates, one will be able to calibrate the fertilizer recommendations in particular areas. However, these are data in one period of time. Soil productivity is also a function of climatic, biotic, and management factors. So, there must be a dynamic way of examining these. Maybe a database that can track the soil productivity changes over time, with the different management practices can be put up.

## **E. Second generation problems**

### **D. Methane Emission**

Corton et al. (1997) studied the management options to reduce methane emissions from irrigated ricefields. They suggested the following: intensify rice cropping and apply more nitrogen during the dry season; or diversify during the wet season, use of ammonium sulfate or sulfate containing fertilizers instead of urea alone, use of compost instead of rice straw incorporation for nutrient cycling and application of phosphogypsum in sulfur deficient soils and as soil conditioner. The problem of N soil leaching has to be considered.

### **E. Heavy metals in the soil**

Concentration of heavy metals such as lead, cadmium, chromium, nickel, cobalt, zinc, and copper in the soils and plants, mostly vegetables and herbal, in Metro Manila and the neighboring provinces were determined in a study by Grifal et al. 1997). Results reveal that there are heavy metal pollutants in the soils which may have come from air pollution, agricultural chemicals such as fertilizers, and effluents from industries. Plants that were observed to be heavy metal accumulators are spinach, pechay, mustard, guava,

tomato, sambong, stringbeans, and kangkong. The absorption of heavy metals by plants may either be through the roots or through the leaves. In the former pathway, some soil properties such as pH, organic matter, and the amount and type of clay minerals may influence the solubility and concentration of these heavy metals in the soil.

Proper waste treatment and prevention of pollution factors on the part of industries such as the use of unleaded gasoline and the judicious use of fertilizers and pesticides would stabilize the normal ecological functions of the soils as media for good plant growth. The authors recommend the following: 1. Environmental monitoring of the agricultural soils for heavy metals especially when there is suspicion of pollution (peri-urban agriculture), 2. Educate farmers on good agricultural practices with emphasis on the importance of soil testing to promote balanced fertilization.

## Imperatives for Soil Conservation in the Uplands

### **A. Does Upland Agriculture Create an Environmental Problem?**

Because of population pressure, agriculture now encroaches on unfavorable uplands, suited only for forestry or perennial crops. But, the question to ask is whether and to what extent upland agriculture creates an environmental problem. If this were so, what would be the solutions for a more sustainable agriculture in the uplands?

A recent investigation in the highlands of Lantapan, Bukidnon showed that expansion of sugar and corn cultivation at low altitudes, and of vegetables and corn at high altitudes, has occurred substantially at the expense of perennial crops, whether pasture/grassland, forest/bush fallow, or coffee (Coxhead and Rola, 1998). Field measurements and experiments with the cultivation of corn and vegetable crops under a range of management regimes in Lantapan confirm rapid soil erosion rates and depletion rates of soil nutrient and organic matter content in soils that are generally of poor initial quality (Midmore et al. 1997). In spite of these negative effects of the spread of the annual crops, few farmers display deep knowledge of soil degradation relationships. Land fallowing and rotation is rare and usually undertaken only when yields of commercial crops decline to the point of economic losses in the current season. Although soil erosion and land degradation problems appear to be widespread, very few farmers report significant investments in soil conserving structures or technologies.

Agricultural intensification without adequate management of soils has deleterious effects both on-site, as documented in Lantapan, Bukidnon field study; and offsite (Francisco, 1998). Intensive cultivation of annual crops in general, and the increased use of fertilizers, pesticides and other chemicals on vegetable crops in particular, are likely to degrade water quality and could create health problems for farm families and those living downstream. Lantapan based water quality monitoring reported in Deutsch et al. (1998) reveals both qualitative and quantitative evidence of water quality degradation. Perceptions of pesticide residues have made some residents reluctant to water animals in streams during or after the rainfall events. (Lantapan is newly opened for intensive agriculture. This community can learn from the experiences of the communities in Benguet, which is about 30 years ahead in terms of agricultural development.)

Finally, the unchecked expansion of agricultural production at the margins of the remaining forest systems poses a potential threat to the integrity of those systems. Some of the consequences are reduction in the water retention capacity of the upper watershed and thus changes in the quantity and seasonal distribution of water flow in the springs and rivers, and possibly irreversible changes in biodiversity (Coxhead and Rola, 1998). Is there an environmental problem in the uplands like Lantapan, Bukidnon? The mass of scientific evidence that were

generated by a group of researchers who stayed in the site for almost five years tells one that there is so (SANREM-CRSP, 1998). Other areas studied also showed severe land degradation as a result of upland farming (Navasero, 1993), such as that shown in Lucban, Quezon.

There are a number of other studies that investigated the onsite and offsite effects of upland agriculture. The results of these studies also show the same evidence. We need to understand the policies and technologies to counter the environmental degradation that is taking place in these fragile environments. The solutions will have to address both the onsite and the offsite problems. Most of the solutions center on the usefulness of soil conservation measures such as agroforestry and diversified cropping systems. Policy options, however, are not popular solutions to upland degradation.

## B. Technology Options for Soil Conservation

For soil conservation, erosion control was the subject of a number of studies. Soil conservation practices can be vegetative, structural, or agronomic in nature. Vegetative and agronomic technologies influence soil detachment and transport by reducing raindrop impact, increasing infiltration, and reducing runoff volume and velocity (Celestino, 1985). On the other hand, structural measures only influence the transport of eroded soil.

A review of the effectiveness of soil conservation measures in preventing soil erosion was done for several countries in Southeast Asia. Findings showed a considerable amount of benefits from these measures (Francisco, 1998). However, as noted in most studies, adoption is low.

### 1. Contours and Hedgerows

In the Philippines and Southeast Asia, in general, hedgerow or alley cropping is the most popular form of soil conservation technology. These technologies are however indigenous in some parts of Asia. So for instance, farmers in Cebu, Philippines have used indigenously a contour hedgerow system of *Leucaena leucocephala* in cultivating steep slopes since before 1923, according to the research of Francisco (1998). Planting hedgerows of leguminous tree species along the contour of sloping fields, to provide a vegetative barrier to soil erosion while contributing green leaf manure to the cereal crops (rice or corn) grown in the alleys was deemed to be a promising technology. By early 1980s, hedgerow inter cropping was advocated widely as a technology to better sustain permanent cereal cropping with minimal or no fertilizer input (Garrity, 1993). More evidence in Northern Philippines suggest that agroforestry systems (alley cropping) reduces the dangers from erosion in the watersheds and the hilly areas (Ayson, 1997); and reduces runoffs and sediment yield (Agustin 1993). *Alnus* hedgerows could also be used (Colting 1993). Planting buffers and contour tillage on 10% slope was found to decrease surface runoff (Monte, 1985). At

20% or more degree of slope, the planting of buffers and contour tillage were found to be ineffective. Nabao (1985) also found that even in 3% slope, erosion occurred.

Results of the study by Manubag (1990) in Bukidnon showed that contour hedgerow is the most desirable/appropriate soil conservation measure in the area. At the same time, Manubag (1990) also reported that contour giant ipil-ipil hedgerows minimized surface runoff and sedimentation better than the contour canals. Hedgerow planting lowered the production costs, minimized surface runoff and sedimentation in cultivated hillsides.

Contour strip planting of peanut and flemingia for soil conservation in hilly lands was investigated in North Cotabato by Cambel and Descuatan (1990). Peanut is a high priced cash crop while flemingia is a nitrogen-fixing plant which provides herbage and serves as organic fertilizer. This was found to prevent soil erosion. While the economics is extremely high (222% ROI), adoption rates has to be known. In some instances, adoption is difficult to determine as the technology is indigenous in the area.

Most studies conducted by BAR during the 1990s focused on the management of soils and upland rice crop. The projects included an examination of indigenous materials to be used as fertilizer, the timing of fertilizer applications that will maximize yields, the timing of planting to minimize the harsh effects of the different mulch media and tillage practices on the growth and yield of upland rice. Different rates of rice straw compost and guano as supplementary fertilizer to upland rice was also studied. In this later study, the exact or appropriate amount of supplemental fertilizer to be used has not been established. All these studies are location specific.

In almost all of the studies, the economic returns of the introduced practices are very high. However, this may be because the family labor is not imputed as cost. Most of these operations are labor intensive and the farmer would usually reason out that they don't have enough time for this.

Several fertilizer trials were also conducted in several sites across the country, to determine the yield response of upland corn. The usual farmer practice is no fertilizer use. The economics of using fertilizer was shown to be favorable in these various studies.

A five year study to determine the effect of alley cropping for rehabilitating the degraded hillylands was conducted in Batangas (Huelgas, et al. 1994). In this experiment, three alley cropping treatments were tested against the farmer practice which is plowing parallel to the slope without fertilizer. The study found out that the alley cropping can stabilize, sustain and improve agricultural production in the sloping lands.

## **2. Agroforestry and Diversified Cropping in the Uplands**

Studies show that agroforestry is an indigenous technology in the uplands. Results of the study of the indigenous systems of the Hanunuo Mangyans revealed that they maintain three agroforestry systems; swidden/kaingin, multistory farming and home gardens (Gascon 1998). Swidden farms were cropped with rice or corn; multistory with cash crops such as bananas and mangoes. The basic need is produced in the kaingin farms. These were found to be non sustainable and expectedly so, because they cut more forest land for swidden farming. Current recommendations to discourage more areas to be opened for swidden farming is to give more security of tenure to forest occupants.

As studied by scientists, agroforestry was found to be effective as a soil conservation technology (Colting, 1985). Intercropping of vegetables with trees reduced erosion considerably than when the sloping areas were only planted to trees. In the Benguet area, the treatments that were observed promising in forming vegetative erosion control strips were alnus, native sunflower and pine trees. Another interesting finding was that sweet potato developed intensive vegetative parts that offered good cover for coffee-pine agroforestry area, but was found to compete greatly for nutrients with coffee (Colting, et al., 1985). Hence, there are also trade-offs in the diversified cropping systems.

The study that assessed the biophysical and economic consequences of land use change from Imperata to tree based systems showed that the latter system has increased soil fertility and organic carbon stock resulting from enhanced nutrient cycling.

The sloping agricultural land technology is another agroforestry scheme. In Laguna, this was studied in a modified form (from the one developed by the Mindanao Baptist Rural Life Center) (Calanog, 1990). However, the recorded rate of adoption is also low (Garrity, 1993).

Lasco et al. (1993) designed an Agroforestry farm assessment (AFA) to assess the positive and negative impacts of any introduced agroforestry technology. This provides a continuous feedback mechanism for immediate technology refinement and improvement for farmer adoptors. The farmer and upland extension worker can use this. There are four defined criteria in this assessment: productivity, security, sustainability and adaptability. However, this has to be tested for practical use. There was no mention of how would sustainability criteria be observed in the short-term.

Furthermore, researchers from UPLB (Lawas, et al. 1993), recommend the use of ALCAMS or agroforestry land capability mapping schemes to plan



agroforestry programs. This answers two key questions: adaptability of the given site to or better use for agroforestry; and appropriate systems, practices and components of the area. No application of this nor the AFA is reported in the literature.

F. C. *Policy Options for Soil Conservation*

Policy options for soil conservation in the uplands has not been a popular area of study. This is because of the common perception that technologies are the better option because upland farmers are just self-sufficient. In general, this is a wrong perception as there is an increasing upland area of commercial use. In a study of factors affecting land use decisions by upland farmers, it was noted that pests and prices were some of the issues of concern (Rola, 1995; Coxhead, 1995).

There is an intricate story behind why we need to look at policy options for soil conservation. Coxhead and Rola (1998) argue that prices outside the watershed influence both land use and soil conservation decisions of upland farmers. This assumes that planting of perennial crops is also a soil conservation measure. It is also argued that non-farm incomes also affect upland farmers labor use and hence, technology choices (Rola and Coxhead, 1998). Commodity and input prices, and other economic instruments are affected by economy wide shocks, both at the global and local levels. It is important to understand that intersectoral linkages can significantly influence environmental degradation caused by agriculture.

There are instances, where it is difficult to sell the soil conservation technology to individual farmers (Francisco, 1998). This is so because the benefits derived from this will affect the community at large, and including upland farmers. Hence, some incentives or subsidies may make economic sense. But the appropriate subsidies and incentives are still a researchable issue.

*Factors Influencing Adoption of Soil Conservation Practices*

Early on, reasons for the low adoption of perennial crops was due to the security of tenure. This could occur in areas where a lot of migrants come to use the lands. But native groups have to also be taught of more sustainable technologies to prevent them from kaingin system of farming. So government has put in place some programs such as the stewardship contract certificate where tillers in government lands of more than 18% slope have a long term contract to till. There were other programs such as reforestation and agro forestry to encourage farmers to go back to perennial crops. Evidence show that once the market is accessible, farmers would have increased incomes and have sustainable means of livelihood with agroforestry systems.

Soil conservation practices were also described through a socio economic survey done by SEARCA led researchers in the following Philippine sites: Nueva Viscaya, Bukidnon, Davao del Sur and Cebu. In these studies, an evaluation of the contour hedgerows adoption was one of the objectives. The SALT technology adoption was also evaluated. The pattern of adoption that was observed suggested that differences in the farmers' goal and circumstances resulted in a modified SALT. Adoption of soil conserving technologies, such as the hedgerows is influenced by access to land and security of tenure. It was also found by Garcia et al. (1996) that while hedgerow intercropping has potential to sustain maize yields by reducing soil erosion and contributing nitrogen, the benefits cannot be realized rapidly enough to compensate farmers for establishment and maintenance costs. Natural vegetation and grass strips incur lower establishment costs. High discount rates and insecure land tenure have reduced the value to farmers of sustained economic returns from hedgerow intercropping.

Hence, lowering of the cost of capital may reduce farmers' discount rates, improving the long term viability of low cost forms of hedgerow intercropping as natural vegetation and grass strips. But this should be supported with security of tenure.

Based on the study of VISCA researchers, the factors affecting adoption of soil conservation practices are (Villanueva, et al. 1993): 1. Farmers' perception of the extent of the soil erosion problem, 2. Family income, liquidity position, and debt-asset ratio; farm size, land tenure, age of farmer, land productivity and slope of the land.

Other important factors influencing adoption of soil conservation technologies and practices are:

### **1. Policies**

In areas where agroforestry is not practiced, farmers will be cultivating erodible crops. Also, in the semi commercial highlands, where farmers are responsive to market prices, pricing policies should also be taken into account in farmers' use of soil conserving measures. Credit policies could also be linked to farmers' behavior on choice of crops to produce.

### **2. Indigenous Knowledge**

Farmers' indigenous knowledge about soil fertility management was studied for sweet potato based farming systems (Evangelio et al. 1996). These were done in three sites, Leyte, Lanao del Norte and Quezon. The farmers indigenous practices are no different from those reported by the research studies, previously cited. These are proper crop rotation, use of green manure and organic fertilizer, and fallowing. The finding of this study reveals that it

is difficult to determine adoption as farmers are already practicing these technologies that are being promoted by research. Maybe, a future strategy is to first characterize farmers' knowledge of their agricultural systems, and then suggest technologies to improve on these base practices.

### **3. Institutions**

The influence of land titling on the behavior of farmer participants toward the adoption of conservation technologies in the uplands was studied by Luna, et al. (1996). Findings showed that farmers with land titles affirmed that land titling guarantees adoption of technologies, provided that training, technical assistance, and planting materials were available.

#### **IV. Watershed Management and Implications in Agriculture**

##### **A. Importance of Watershed**

Watershed is a basin-like geographic structure bounded by surrounding ridges. It has a network of stream tributaries that leads to a common mouth or drainage channel. It is a combination of components, such as soil, water, terrain, vegetative cover and associated animal life.

If a watershed is adequately covered by vegetation, the river/streams in the area are continuously fed by springs throughout the year from subsurface flow and from the water table. The rivers in turn flow down to the ocean, thus completing the cycle. In watershed areas devoid of vegetative cover, soil erosion or even landslides commonly occur. Due to the reduced holding capacity of the watershed, tremendous run-off occurs during intense or extensive rainfall. Eroded soil accumulates in rivers, lakes and nearby oceans and results to sedimentation/siltation.

Among the agriculture related problems of the watershed is soil erosion that is brought about by the denuded state of our watersheds. Many of our major watersheds are now declared critical due to severe soil erosion (PCARRD et al. 1999). Destructive land uses, such as mining, logging, and shifting cultivation cause soil erosion and consequently make life for the upland and lowland settlers more difficult due to the resulting adverse ecological effects.

In 1992, PCARRD produced a Philippine Recommendations for Watershed Management. In 1999, another publication is devoted to watershed management. Despite these, we still observe accelerated degradation of the watershed.

##### **B. Causes of Watershed Degradation**

About a quarter of the whole watershed of the country is in critical condition in the early 1990s, (Foronda and Serrano, 1992). Currently, PCARRD et al (1999) reports that many of the watersheds are in varying state of degradation characterized by soil erosion, erratic streamflow, diminishing groundwater resource, loss of biodiversity, microclimate deterioration, and declining land productivity. Watershed degradation is attributed to a wide range of issues, including physical and socio-econ factors, but it is deemed to be a localized, issue. For this reason, it is argued that each watershed needs to be assessed separately in order to determine the causes of degradation and the solutions required to reverse the trend (PCARRD et al. 1999).

Among the direct causes of watershed degradation is the inappropriate agricultural activities. These activities include a wide variety of practices, such as the absence or poor maintenance of erosion control measures, improper crop rotations, shortening of the fallow period in kaingin cultivation,

insufficient or excessive use of fertilizers, and overuse of irrigation water. Degradation types commonly linked to this causative factor are soil erosion, soil compaction, soil nutrient loss, and water pollution.

Indirect causes of watershed degradation are underlying reasons why inappropriate types of land use and management are practiced and usually relate to the socio-economic circumstances of the land users and/or the social, cultural, economic and policy environment in which they operate. Among these are the population growth and the movement into the uplands, land tenure, lack of credit, among others.

Lack of political will to manage the watershed could also be the cause of degradation. This is promoted by the assignment of watershed management to several groups of entities. Traditionally, Department of Environment and Natural Resources (DENR) has been the primary government agency vested with jurisdiction and administrative control over the country's watersheds. Through the years, other government agencies have been given the authority and administrative control over watersheds which support major power plants and irrigation structures. These include agencies such as the NPC, PNOC and the NIA.

In recent years, the management and administration of more watersheds have been translocated from DENR to other sectors. A number of watersheds are now under the LGUs in line with the devolution law which mandates the LGUs as comprehensive land managers. Some local water districts are also now vested with the jurisdiction and control over a number of watersheds. In the passage of the IPRA, the indigenous communities also became administrators of the country's watersheds within their domains.

While Executive Order No. 192 (1987) mandates the DENR as the primary government agency responsible in the management, conservation and development of the country's forest lands including but not limited to watershed areas; The AFMA (RA 8435-1997) prescribes that the DA will coordinate with DENR concerning the preservation and rehabilitation of watersheds to support irrigation systems, and promote development that is compatible with the preservation of the ecosystem in areas where agriculture and fisheries activities are carried out.

### **C. Impact of Watershed Management and Related Programs**

Watershed management refers to the application of business methods and technical principles on the handling of all renewable resources of a watershed. It aims at developing and maintaining the multiple uses of the watershed. Such uses include irrigation, hydroelectric power generation, grazing, fishing, timber harvesting, and agroforestry or upland farming (PCARRD et al, 1999).

According to the PCARRD (1991) report, government has pursued various programs to manage the watersheds. In relation to agriculture, government established new dams, such as the Dagat and Chico dams. Under the Integrated Social Forestry Program (ISFP), a farmer can lease and occupy a portion of the public forest for 25 years and renew for another 25 years with all the produce from the land accruing to him. The government has also initiated and maintained soil erosion control projects in the critically eroded watershed areas in the country with interagency collaboration. In addition, a number of government agencies, research groups, both public and private and the local government have conducted research projects on upland rehabilitation and cropping systems. The private institutions such as the World Neighbors and the Mindanao Baptist Rural Life Center have developed agroforestry technologies, namely bench terracing and sloping agricultural land technologies. Other foreign funded projects have also promoted these sustainable technologies, in Agrarian Reform Communities (ARCs) (PCARRD, et al. 1999).

Several studies were devoted to the understanding of the impact of agricultural activities on the watershed sustainability. For instance, study was done to measure soil loss from the watershed scale, where one could estimate the maximum soil loss rate, establish relations between the soil and the rainfall intensity and duration, and develop a refined sediment rating curve (Agua 1995). Though the study did not relate the analysis to land use patterns it is known that land in the study area is devoted for annual agriculture (Rola, et al. 1995). A watershed-scale soil loss equation was developed by Agua and Bhuiyan (1996) in the same site in Bukidnon. The sediment load of run-off water resulting from rainfall events during the 1995 WS was analyzed to determine the dominant factors affecting soil erosion from the subwatershed.

A case study was conducted in the semiclosed watershed of about 265-ha in Ilocos Norte to assess the groundwater quality in relation to current land use and fertilizer N inputs using the GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) model. The cropping practices in the area showed an accumulation of about 200 kg N/ha in the soil which could increase the nitrate level in the shallow groundwater by about 1 ppm per year. The salinity levels (700-3000 umho/cm) in all wells exceeded the FAO's threshold quality for irrigation. This level could no longer sustain the crop to give maximum yield. It also is not safe for drinking. Gumtang et al. (1997) have recommended to diversify crops in the area. Nitrate concentration in the groundwater maybe reduced by planting deep rooted cash crops such as indigo, corn, and mungbean during the dry to wet transition period: applying fertilizer in three to four splits following the recommended application rates; and moderate restrictions of the use of tubewells for irrigation by applying small amount of irrigation water at more frequent interval.

By using the GLEAMS, Castañeda et al (1996) showed that 167 kg/ha of NO<sub>3</sub>-N would annually be added to the subsoil below root zone from the present

practices in the rice pepper system. This would eventually raise the NO<sub>3</sub>-N concentration of groundwater by about 1 ppm annually. Already, the NO<sub>3</sub>-N concentrations in the area (water table fluctuates between <1 and 6 m) are in excess of the limits set for human consumption.

Monitoring pollution levels of two rivers in Calamba, Laguna also showed that runoff from agricultural watersheds contribute to the rise in P fractions, N fractions and total suspended solids of the river waters (Madamba, et al. 1992).

### **Role of Institutions**

Factors affecting watershed rehabilitation in Capiz showed that access to information, organizational affiliation, opportunity for participation and awareness were significant in the dweller's extent of participation in the watershed rehabilitation (Gregorio, 1991). In the watershed near the Tumauni Irrigation Systems, it was found that the annual erosion loss for the entire watershed is 335,163 tons (Romero, 1991). The study indicates that a watershed management scheme will improve the condition of the community. Using a discount rate of 10%, the analysis showed an NPV of P1,935,280 and a BCR of 1.01 for the without watershed management while watershed protection such as reforestation and ISF in the area had an NPV of P 176,867,460 and a BCR of 3.27.

Seven tenure types/instruments were evaluated to determine the land tenure alternative that will promote good management of the watershed in Bais City (Cadelina, 1996). Of the seven types, the Certificate of Stewardship Contract (CSC) provided the greatest motivation to tenure holders to manage the watershed. This result was due to the soil and water conservation provisions integrated in the tenure instrument. This strategy was necessary to motivate people to rehabilitate and manage the watershed.

### **D. Guidelines for Watershed Management**

There have been several research programs and institutional programs to ensure sustainable watershed management. This started in 1968 when UNDP established a training center on multiple use forest management in Baguio City. With the creation of the PCAR in 1972, watershed management research was further intensified. But the fact that we still observe all the degradation of the watershed to this day, there must be some serious constraints that impede the application of these research and institutional programs. Manpower training programs were in place, so with watershed management courses which were part of the recommendations.

As was previously mentioned, two guidebooks have been published to promote watershed management. The 1999 guidebook intends to supplement and complement the Philippines Recommends for Watershed Management (PCARRD, 1991). The 1999 guidelines put into details the data (both

biophysical and socioeconomic) that are needed for a sustainable watershed management plan. It also designs how to select and allocate the best land use for particular areas. It mentions that it is impossible to allocate land uses that is acceptable to everyone. A project proposal guideline and the actual implementation of the management plan is also described. The guide is mainly written by researchers and could be understood by researchers. It would be interesting to note the actual users of this guide. Current guideline is very participatory in nature; as watershed management planning “requires an analysis of rural households' circumstances, identify the main productions problems', and constraints to overcome them”.

These guidelines will be useful to watershed users. There are very few watershed areas without some cultivation of annual food crops taking place in the upland areas. Often, in what may legally be forest lands, indigenous cultural communities with a tradition of hill farming exist. Such communities typically exhibit a high degree of adaptability and managerial capability in response to the specific constraints and opportunities found in their areas. Also, long term settlers have their own knowledge base gained from their experience with farming in an upland environment. Thus, when formulating agricultural development proposals within the watershed management plan, the starting point should be the agricultural knowledge of the existing farm communities, the bio-diversity of their farming systems, and the variety of agro-ecological niches exploited (PCARRD, et al., 1999).

PCARRD et al. (1999) further recommends that good watershed management requires the identification, development, and dissemination of improved technologies and land management practices that are both productive and conservation effective. This requires that watershed management programs should not be narrowly focused on soil conservation and forest protection alone. Instead, when the biophysical and socio-economic circumstances permit, improved watershed management should promote production-oriented land use enterprises such as Upland farming, grazing, orchards, plantations etc. managed in such a way as to provide sustainable economic benefits to the land user, not only for the present but also for the future generation.

To ensure a successful implementation of watershed development projects data such as sedimentation rate, soil fertility decline or build-up, progress or rehabilitative measures, meteorological observations and socio economic variables have to be monitored and evaluated.

There is also a need to regularly document weather variables which affect watershed parameters. These include water yield, quality of soil erosion, and nutrient loss. It may be necessary to establish a weather station in a strategic location in the watershed.

Information generated from the watershed characterization could then be used as a basis for land use planning and policy making under an integrated area



development context. The information is also helpful in predicting water yield and quality as well as the degree of erodibility of the area.

**E. Example of a successful ISFP - Makiling Reserve Management**

A report on the “Community Forestry in the Mt. Makiling Forest Reserve: The Conflict between foresters and farmers in being resolved by a cooperative approach” by T. R. Villanueva ( UPLB, nd) relates of the success of the Integrated Social Forestry program in this area.

One of the major causes of deforestation in the Mt. Makiling reserve is the in-migration and forest occupancy, either for settlement, farming or both. So far, the Master Plan for Mt. Makiling Forest Development has identified various projects under its People Oriented Forestry Program to address the social problem that is afflicting the reserve . The program's goal is the establishment of partnerships with relevant communities for their development as well as for the conservation of the resource. It takes care of the designing and implementing occupancy management, conservation education, provision of social services, livelihood development, and community organizing. It promotes agroforestry as a farming technology in the area. The program also promotes public awareness and appreciation of the value of the reserve as well as to solicit public support for conserving it.

There is evidence of success in the community approach to the management of the Mt. Makiling. The university is able to forge cooperative projects for such activities as the construction of waiting sheds and manning stations, tree planting, boundary delineation, and survey, tree inventory inside and outside farmlots, forest use monitoring, clean-up drives, and information campaigns. This cooperative approach was not easily achieved. The university emphasizes that it is not longer the sole manager of the resource; and that communities have a big role to play in keeping the resource intact and sustainably managed.

## **Water Management**

Watershed destruction affects the performance of the national irrigation system (NIS). De Vera and Pingali (1992) found that more than half of the 147 national irrigation systems in the Philippines are showing signs of degradation as influenced by upper watershed destruction and by the unavailability of maintenance investments. Increased logging, upland agriculture, and mining were among the upper watershed activities found to have caused irrigation system degradation. The adverse effect of this is loss in the total lowland agricultural production

Moreover, the increasing awareness of the potential impacts of climate variability/change on water sources led to investigation and assessment of such impact on selected major water reservoirs (Jose and Sosa 1996). Several studies have already been undertaken to investigate long-term rainfall and temperature trends. The analysis shows decreasing inflows in major multipurpose reservoirs in Luzon. Currently, hydrometeorological and climatological indices for estimating potential impact of climate variation and run-off and the subsequent impacts of run-off changes to water uses/demands are being developed.

The impact of the degradation of the watershed is an important knowledge to be gained. Is there scope for increased water usage within the watershed area through the development, or expansion of irrigated crop production (i.e. paddy rice, vegetables, fruit trees)? Is there scope for improving water use efficiency (i.e. adoption of water conservation measures in the crop lands, use of improved irrigation practices, reduction in water storage and distribution losses due to evaporation and losses from broken pipes) (PCARRD, et al. 1999)?

If water supply for agriculture is at all declining, what are the alternatives? What needs to be done in the water stressed areas of the lowland agriculture? What are more efficient types of water delivery systems? The review in this section will focus on the productivity of water, the available alternative water technologies, and the constraints in the efficient delivery of water to the farmlands.

## **Water Productivity**

Traditionally, the Philippines has been putting a lot of public sector investments on national and communal irrigation projects which are medium to large scale projects. But it seems that most of these systems have proven to be unsustainable and costly to develop, operate and maintain (David, 1999).

A recent investigation about irrigated rice farming in Iloilo showed that water was a major constraint to higher productivity. Water was the most significant source of yield loss and measured to be about 50% in one particular season (Rola, et al. 1998). The study site was a water stressed area, just like thousands of other irrigated lowlands in the Philippines. Hence, even if farmers are trained on the merits of IPM and INM as well as good crop management, they are not able to attain high yields, than their counterparts, say in Nueva Ecija where water is well managed. The reason for the unavailability of water and incorrect water timing is the degraded watersheds and the poor maintenance of the CIS, in the area. As such, maximizing the benefits due to correct timing and application of agro chemicals was constrained by the optimal timing and amounts of irrigation water. It was shown in this case study that any efforts to maintain and sustain lowland agriculture must take into account the source of water. Along this argument, we must be able to come up with alternative water sources and alternative water delivery technologies that will lead to an efficient and more productive water input.

The topic on water productivity was addressed in the paper of Guerra et al. (1998) where the authors reviewed the literature on irrigation efficiency and the potential for increasing the productivity of water in rice-based systems. They argued that there is a need to measure the productivity of water at the farm, system and the basin levels, and to understand how the productivity at one level relates to the productivity at another. Information from these water balance studies can be used to identify the potential economic benefits of alternative interventions and the most appropriate strategies for increasing water productivity in rice-based systems. Water balance modeling has been initiated by some research groups at the UPLB College of Forestry (c/o Rex Cruz).

### **Water Technologies**

Aside from the national and communal irrigation system, several water technologies have been developed to provide alternatives to the conventional national irrigation system (NIS) delivery, and different water sources. Table 5 summarizes these several technologies.

Experimental studies at Philrice showed that intermittent irrigation can save about 40% reduction in water for irrigation, without sacrificing on yield in the dry season (De Dios, et al. 1998). Intermittent irrigation consists of applying 5 cm water every 14 days from 10 to 80 days after transplanting (DAT). This was compared to the conventional continuous system wherein 1-5 cm of water was maintained above soil surface throughout the season. Intermittent irrigation significantly reduced the cumulative water applied without any reduction in yield. Yield ranged from 3.3 to 8.4 t/ha for intermittent flooding; while yields were 4.1 to 8.2 t/ha for the conventional method.

Drip irrigation is a method used to provide water most efficiently by applying it at the right rate and practically only to the plant root area. It keeps soil moisture at a constant optimal level by renewing the water supply to the rootzone at the same rate it is used up. The results of the drip irrigation trials for cotton production as reported by Ganotisi et al. (1998), showed that this was more economical than the conventional furrow irrigation methods. However, drip irrigation is quite expensive for small farmers,

**Table 5.1. Available water technologies in the Philippines, 1999.**

Technology	Description
Intermittent irrigation	Used in rice, this consist of applying 5 cm. water every 14 days from 10 to 80 days after transplanting.
Drip irrigation	This is a method used to provide water most efficiently by applying it at the right rate and practically only to the plant root area.
Designed trickle irrigation system	This uses a twin-wall emitter tubing.
Rainwater management	A weather-based decision-making for water management and crop production, this involves developing localized cropping patterns based on climatological probabilities of the occurrence of significant weather.
On-Farm Reservoir	Stores water for intermine production. Socio-economic and technical constraints impeded farmer adoption.
Shallow tubewells for irrigation	These are equipped with centrifugal pumps which are driven by single cylinder diesel engines. Optimal placement of rice in the fields can sustain continuous water supply. This is popular in most areas of the country.
Drainage technology	Practical surface drainage method that is used to reduce interlogging through a simple ridging technology.
Small electric pumps	Just like shallow tubewell principle, but needs electricity. This is only feasible if electric lines are near the fields.
Hydroponics	Production is in a soilless and waterless medium.

Note: For more information of constraints and advantages of some of these technologies, refer to David (1999).

but affordable to medium and large scale farmers as noted in a study in Cavite (Lamanilao, 1990).

Four drip irrigation systems, namely: buho-polytube, polyethylene-polytube (PE-polytube), buho-dextrose, and commercial drip systems were constructed and their field performance evaluated by Baqui and Angeles (1991). Results showed that the cost was lowest (P18,813/ha/year) in PE-polytube drip and highest in buho-dextrose drip system (P45,127/ha/year). The cost of the commercial drip was P36,248/ha/year. The PE-polytube drip system showed the highest productivity ratios of 24, 27, and 608 for irrigation, capital, and energy, respectively.

Drip irrigation of sugarcane (of which variety is Phil 7544) gave an average yield of 156.74 TC/ha over 100 TC/ha of the unirrigated plot. Based on the actual farm data, economic analysis showed a P6520 added benefit per ha in drip system (Marcelo, 1990). Moreover, Pascual and Dumaoal (1992) compared the drip and the conventional method for lowland potato production in Ilocos Norte in 1992. Economics of scale suggest that drip irrigation is suitable for potato production in large scale (more than 1 ha) farms, while conventional method is feasible on small farms.

Farmer friendly indicators for drip and furrow irrigation scheduling in tomato was studied by Tanguilig et al (1996). The leaf of the upland rice was used as an indicator and compared with other indicators like tensiometer, *Mimosa pudica* L. Leaf folding tomato crop's leaf elongation rate (LER), and the standard practice of watering the crops every 2days for 1 hour at 1.5 li/emitter/hr (control for drip); and irrigation at field capacity every two days (control for furrow). Using upland rice, irrigation was done whenever the leaves rolled slightly. Water application was stopped when the leaves of the indicator became fully unrolled. With this rice indicator, irrigation frequency was reduced by 67% (in drip) and 60% (in furrow) when compared to the control. Results further show that upland rice can be used as an indicator for drip irrigation scheduling while LER is a good indicator for furrow-irrigation scheduling. It would be interesting to know whether this is indigenous knowledge. What is the feasibility of developing a plant indicator-based water application scheduling for farmer adoption? The literature does not reveal evidence of farmer adoption.

Designed trickle irrigation system uses a twin-wall emitter tubing when compared with the conventional method of irrigation in cotton, (Cruz, et al.). Results showed that this system produce seed cotton yield that is 25% higher than that of the conventional irrigation method. At the same time, 30% water can also be saved.

Baradas (1998) argued that natural rainwater management is a very efficient and cheap precursor, complement or even an alternative in some cases, to the irrigation of currently rainfed areas. Floods and droughts are nature's solutions to low food production. To use this phenomenon needs a lot of knowledge about the weather trends and management of the water resource. Baradas' (1998) concept of a water-based ways to food security are threefold: 1. Optimize photosynthetic efficiency, 2. Increase water use efficiency, and 3. Minimize the negative impact of flood and drought through integrated flood and drought control. In practice, these concepts boil down to sunshine harvesting, rainfall harvesting, and integrated flood, soil sediment, and drought control.

The components of his weather-based decision making for water management and crop production is to develop cropping patterns based on climatology probabilities of the occurrence of significant weather. This cropping pattern should not coincide with the unfavorable weather such as a typhoon. The sensitive stage should preferably coincide with favorable weather such as the reproductive stage of the rice coinciding with high sunshine. Baradas (1998) argues that farmers will have to learn more about this in regional rainfall management promotion and demonstration centers. Moreover, it was also learned that PAGASA has evolved cropping pattern recommendations based on long-term weather data.

On-Farm reservoirs (OFRs) store rainwater for intensive rice production. An OFR provides supplemental irrigation to the entire rice farm (average of 3.3 ha in the study areas of Moya et al. 1998) in the wet season and meets the water requirements of about 40% of the farm for growing rice in the dry season. The technology is found more favorable for areas that have mild slopes to support gravity distribution of the stored

water and where water loss by seepage and percolation is low. The economic analysis, assuming a 15-year life span of the reservoirs with a three year maintenance schedule, shows a high benefit-cost ratio of 5.1, or an IRR of 177%. This was found to be viable in parts of Central Luzon (Moya et al. 1998).

OFR was also found to be an indigenous technology. An OFR optimization model (FROM) was developed (Galang and Bhuiyan, 1994, 1995), with the objective of maximizing returns from the use of the OFRs. But it was found out that this method is difficult at the level of the extension agents. FROM is composed of four submodels: 1) Water supply estimation submodel, which forecasts total available water for a season; 2) crop-area allocation submodel, which uses the linear programming technique to allocate land, water, and capital to crops for each season; 3) reservoir operation simulation submodel, which simulates water balance both in the OFR and in the fields; and 4) water supply reliability submodel, which uses decision tree analysis to determine the risk associated with the estimated seasonal water supply. A nomograph (Galang and Bhuiyan, 1995) was developed which can allow practical use of the model. This nomograph is expected to help farmers as well as extension staff to decide what crops to plant and the area to cultivate for particular crops to maximize profits. It is not however known whether this tool was actually used by farmers or by extension.

Geographic Information Systems (GIS) method was also recommended to be used in identifying the ideal location for OFR (Galang et al. 1994). The spatial analysis systems (SPANS) was used - but this is macro level.

Micro level surveys are still needed to determine whether OFRs should be developed in a given area and where they should be located.

A 1994 evaluation of the OFR showed that additional benefits included being able to grow dry season rice crop and fish in the reservoirs. Farmers' main complaints were insufficient capacity, high water loss, and locations that required pumping (Fujisaka, et al. 1994).

In small farmer reservoir (SFR), surplus rain and surface runoff are impounded through dams and reservoirs. This has embankment height of less than 4 meters. The SFR is an upstream defense against soil erosion and flooding of the low lying areas (Teruel, 1994).

Undan et al's paper (1994) presented results obtained on the pilot SFRs set up in 10 towns of the 6 provinces in Central Luzon. It also discusses the linkages and collaborative work done to promote the adoption of the system. Since the SFR technology promotion efforts started in 1990, some 572 SFRs have already been established in 42 barangays within the 12 towns of the 6 provinces. It is not known at this time whether this system became sustainable.

The Shallow groundwater potential for irrigation was studied by Sibayan and Undan (1994). In this technology, farmers either dig wells or drive 4 inch GI pipes into the ground to draw water from shallow wells. Results revealed that the individual pump systems have service areas ranging from 1.3 to 2 ha for the non-rice crop; and can increase to 1.9 to 3.2 ha for maximum pump efficiency in NE. Initial results revealed that pump systems could be spaced at least 30 meters apart with depths ranging from 7 to 10.5 meters. In this situation, planting onions gave an ROI of 1.67 and rice is 0.18.

The study of Pernito and Garrity (1992) demonstrates that there is a substantial potential to expand the area planted to pre-rice upland crops on rainfed lowland ricelands if practical drainage methods can be used to reduce waterlogging during the early rains. This could be done through a simple ridging technology. Farm studies show that

comparative net returns with ridging were higher (P2150/ha vs P149/ha) than the no ridging. Simple surface drainage techniques tend to stabilize yields, and enable expanded pre-rice mungbean production on waterlog prone ricelands.

Small electric pumps were also introduced to Philippine farmers (Rotor, et al. 1993). It was deemed to be a promising technology only if there are electric lines near the rice fields. Based on the Iloilo data, the total costs of the supplemental irrigation from the electric pump is P1406 or 564 kg/ha (Resurreccion and Salazar, 1991). Spiral pumps were likewise designed as nonconventional means to harness the available water (Naegell, et al. 1990).

One of the latest technologies for water as well as soil management is the hydroponics, (Dorado and Balimbing 1999). This is production in a soilless medium. Under this system, the variable weather condition in the field which are sometimes damaging to the crop can be controlled to suit the best environmental requirement of the crops. Hydroponics production will produce higher quality products free of pesticides and other chemicals. This is a very promising technology although it needs an ex ante economic analysis. This is also appropriate for vegetable crops and other high value crops. The future challenge according to the proponents of this technology, lies in the improvement of present soilless culture methods with the view towards the new field of water culture, nutrient film technique, aeroponics and vertical growth.

### **Constraints to Effective Water Delivery and Efficient Water Use**

Why is there a decline in the system performance of the irrigation structure? The possible reasons are two-fold: 1) the deterioration of the quality/quantity of the irrigation water and 2) the management of the system. Some of the constraints to effective water delivery and efficient water use as cited in the literature are discussed below.

The poor performance of many governments on public irrigation systems is well documented (Easter, 1993). This is due to the government failure or the free rider problem. Easter (1993) uses a model including internal and external assurance, commitment and fairness to explain the performance of irrigation in the various Asian countries.

Public investments in irrigation have tapered off due to lack of funds for systems operations and maintenance (Marciano, et al. 1997). The deterioration condition of some systems have encouraged investments in privately owned irrigation facilities. The economics of the private system as analyzed by Gascon et al (1995), showed that yield and rice farm incomes of pump irrigated farms improved land productivity and profitability. This is due to the reliable and efficient water source.

The irrigators' association has an important role in increasing efficiency in water use. Llandelar (1995) showed that irrigators' association could bring about more services (and of better quality). Oliva (1995) also noted that NIA's support to

the agrarian reform beneficiaries significantly affected the extent of the irrigation project in Legaspi, Albay.

What has been the impact of the changes in the NIA policy to turnover the irrigation management to the farmer coops? What are the changes made in the NIA? What extent have farmers taken over the management for irrigation - what is the management performance? What are the productivity effects? (Wijayarathne and Vermillion, 1994). What are the indicators for evaluating whether farmer managed system works? This was attempted by developing a social learning framework of the performance indicators at the Pulangui River Irrigation System in Bukidnon (Magallanes, 1992). Results of this study is vague in terms of defining the impact of the indicators. This needs to be followed up if we want to encourage privatization of management of national systems.

An earlier study in Iloilo by Alicante (1991) showed that irrigation systems which were economically and socially sustainable were those with larger farms and with mostly farm owners and lessees. Other factors affecting performance of communal irrigation system members in terms of involvement in irrigation conflict are kinship and political relationship (Poudel, 1990). But the political relationship and kinship had a significant negative impact on members' amount of time devoted to repair and maintenance, while farmer to farmer reciprocal relationship, and agricultural incomes, had positive effects. The location of the members' farm within the service area had no significant effect on any of their performance except their participation in repair and maintenance.

Serious policy, management, and technology problems cannot seem to lift the gains in the Green Revolution. Adequate maintenance of the irrigation has fallen by wayside. In the future, development of surface reservoirs will be increasingly difficult. To ensure reliable supplies, groundwater can be used more effectively; possibilities for utilizing more modern water delivery technologies are also increasing (Peterson, 1989).

A recent analysis of options for new irrigation system development shows that the thrust in the development of new irrigation facilities should be on small scale, private sector-led, farmers'-controlled, cost effective and efficient minor irrigation technologies (David, 1999). Furthermore, in other Asian countries, water markets are getting to be popular in the farming communities. The arrangement is especially convenient if farmers have several plots that are far apart. The farmer can sell his water from the pump to his adjoining (neighboring) farmer; and he buys water from whoever is near his plot (Bhandari, 1999). Other farmers who cannot afford to have a pump installed are net water buyers. On the other hand, farmers who may have other income sources, but have the fortune to have a land with low water table could be a net water seller.

Part of the efficient use of water for irrigation is disciplined scheme for water distribution and rotation in the service areas. During the dry months, where water level is very low, a scheme of water rationing may have to be devised (PCARRD, et al. 1999).



## **Other Issue on Water Management: Methane emissions and other second generation problems**

### **1. Methane emission**

It was found that water management is a sound means of abating methane emissions from ricefields (Javellana et al. 1996). But the management practices that reduce methane emissions and increase rice yields must be developed.

### **2. Water loss due to percolation**

Water loss in irrigated rice is also due to percolation. Techniques to minimize this was studied by Toung et al (1994). Maintaining shallow ponding water depth did not significantly affect percolation loss, but sealing the bund walls with puddled soil material will decrease the horizontal conductivity of the bunds and may further reduce under-bund percolation.

### **3. Cracked rice soils**

Knowledge of water flows into cracks of dry soil is needed to understand high water loss in rice fields. Tuong et al. (1996) presented a methodology to quantify flow processes during the land soaking of dry, cracked rice fields. Crack geometry is determined from measurements of crack depths and width. This seems to be a very complicated methodology. The farmer might not be able to use this. But to know this means that we can maintain yields at lower water depths (Masta and Vijaykumar, 1993).

Bypass flow is the water flow into vertical continuous soil macropore (cracks) that bypass a surrounding unsaturated soil matrix. This also results in the inefficiency in water use. Maligaya et al. (1992) noted that bypass flow can be reduced by applying low rates of irrigation water or by shallow surface tillage.

4. One could also control paddy water loss with a subsurface barrier (Herrera et al. 1995). This was done with the use of a plastic barrier, installed at 25 to 40 cm depths. The grain yield increases due to the barrier ranged from 94 to 166 percent over those without the barrier (No economic analysis on this). The authors recommend that more practical and economical types of percolation barriers should be evaluated, e.g. thru subsurface compaction of spraying of Bitumin and similar materials.

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## VI. Research Program Planning for Natural Resource Management

### A. Features of an NRM Research Program

As gathered from this review, the salient features of a research program on NRM could be the following:

1. It is quite clear that NRM research will go beyond commodities and beyond disciplines. What is getting to be important is to treat NRM research from the *watershed scale*; and taking into account the broad range of stakeholders that will be affected- on-site; off-site; and the role of the institutions in the process. The *location specificity* of the problem is also an important consideration.
2. A significant lesson learned from this review is the fact that some of the recorded products of research on NRM are actually indigenous farmer practices; or based on *indigenous farmer knowledge*. More and more, the art and science of *participatory research* come to the fore. It is only with the building up of the farmer knowledge bases that research can make an impact on farmers' practices. This means characterizing farmer indigenous knowledge (IK) and promoting technologies that will result to a higher level of farming performance. This is very on farm oriented; and the role of extension and communication should be well defined.
3. Diagnostics- The challenge with natural resource management problems is that they manifest only in the long term. Ex post analysis are not very useful; on the other hand, ex ante analysis needs reliable estimates. This is where scientists have to be creative. *Diagnostics and other farmer/extension friendly kits have to be developed and used as early warning devices.*
4. There are a number of existing technologies for NRM; but they are not the mere varieties nor fertilizer packages. They appeal to the knowledge systems of the farmers and extension. How do farmers learn about these *knowledge intensive technologies (KIT)*? What are other appropriate extension strategies, if farmer field schools are deemed to be very expensive? What are the role of science/ technology policies in the promotion of and commercialization of KIT?
5. The role of the various *institutions* in the promotion or in the constraint to adoption of sustainable technologies was mentioned. These include land tenure, irrigation delivery, and the credit system. In this light, it is noted that NRM research is not to be confined to the study of agriculture technologies or the environmental management alone; but rather to the broader, *intersectoral linkages that potentially affect farmer behaviour and farmer land use and technology decisions.*

It was mentioned in the introduction to this paper that despite the products of research towards sustainable resource management, evidence of serious degradation of the agricultural resource base has been observed. NRM research program then has to address the causes, consequences and the preventive measures of the degradation of the agricultural resource base.

## **B. Proposed Research Program Plans for NRM: Focus on Agricultural Resource Management**

### **1. Soil Management**

As was previously discussed, several research areas can be defined for sustainable soil resource management, in particular, and to NRM in general. These are:

- i. The need for a local data base on the characterization of the soil and the dynamics of its features as a result of the farmer cropping patterns. In the case of problem soils, both in the upland and lowlands, we may want to study whether subsidizing the treatment to bring it back to its fertile state may make economic sense, as soils can also be treated as common property resources. What is the economics of giving the information on sustainable soil management technologies to the community as a whole rather than expecting individual farmers to be optimal managers of the resource?

What is the cost of agricultural sustainability? Who is going to shoulder this cost? Is it fair for farmers to bear this burden alone? What policies can be formulated to share this cost to consumers and other beneficiaries?

- ii. It is a well known fact that information is the most important input in sustainable agriculture. How do farmers handle this information? How do we upgrade their management skills so they could perform better in this aim of sustainable agriculture?

We also need to unravel that black box of the processes on how farmers decide in agricultural resource management. What are farmers' knowledge bases? What other information can increase that knowledge base for sustainable resource management? How do we extend this knowledge intensive technologies? How do researchers scan farmer knowledge, and hence determine the base by which intervention would be useful?

One can also study farmers' responsiveness with respect to the current application of diagnostic kits to help him in his soil management decisions. What are the roles of government laboratories as decision support to farmers? How do we measure impact in terms of improvement in soil quality?

- iii. Long term farming systems research could generate data to determine the impact of alternative cropping patterns and soil management technologies on the resource base, and on farmer incomes. The RIARCS could do this, but planned to be on a long term basis. The choice of crops and technologies should be attuned to the market demand in the area, and the feasibility and social acceptability of the technologies. Along this line, ex ante technology assessment could use the data that are generated from these experiment stations.
- iv. Why is it difficult to commercialize biofertilizers? What are the merits of its use? What would be the economics of purely subsidizing the use of biofertilizers? What would be the economics of having a package of fertilizers that contain both the organic and inorganic elements? Why don't the private sector respond to the knowledge that a combination of organic and inorganic fertilizer is more sustainable across all crops studied, and thus package the combination of such? What is the role of the Fertilizer and Pesticide Authority (FPA) in the use and commercialization of biofertilizers?
- v. How do we place sustainable soil management technologies in the context of the broader economic development objectives? How do we reconcile labor intensive sustainable agricultural technologies and the growing scarcity of labor in agriculture as a result of increases in non-farm income opportunities? This condition is to be expected as we transform into a higher level of economic development.
- vi. Future productivity growth analysis should take into account the contribution of the resource base, i.e. soil productivity. This means an interdisciplinary work with soil and social scientists in assessing soil productivity in the different production environments.

## **Water Management**

The issue in water management is also about water productivity. This is however, a function of water quantity, quality, and water delivery efficiency. Agricultural decision makers should take active part in the management of the watershed as a significant source of surface water for irrigation. But we also have to guard our shallow groundwater from the environmental pollutants that could affect its utility in agriculture. The current debate by experts on the optimal combination of two sources of irrigation water, i.e. surface water and groundwater, should also be taken into consideration. Finally, the most efficient mode of delivery should be studied. Research areas for water management in agriculture could fall under any of the following:

- i. Good watershed management is a prerequisite for a sustainable source of groundwater. How can the Department of Agriculture help in preventing

future degradation of this water resource? What is the economics of water use in agriculture when compared to other competing uses? How do we highlight the roles of institutions and policies in the sustainable management of watersheds? What are local initiatives for watershed development and management?

- ii. Quality of water also influences its use in agriculture. What are the causes of the water pollution? How can this be minimized? What are the causes of salinity in water?
- iii. Alternative delivery of water is also an interesting study. In other countries, use of small water pumps and other private initiatives are getting popular. Water markets are in the process of development in other countries. This is to make the most efficient use of water in particular locations. What are incentives for efficient water market to work? Public sector research on the optimal distancing, coverage and timing of water extraction is needed; but design development of irrigation machines maybe left with the private sector. However, institutional support in terms of credit for small farmers and subsidies in gasoline/diesel fuel have to be studied.
- iv. The merits of the use and promotion of more knowledge intensive water management (i.e. rainwater harvesting) technologies could also be an area of research. Optimal timing of irrigation in crops, use of diagnostics for the right timing of irrigation, farmers' indicator of timing of water use, etc. have been studied but not popularized. What could have been the constraints?

### **C. Role of regional research programs in NRM research**

NRM research emphasis is well placed in the context of a regional research program. Regional research programs contribute to agricultural development in number of fields (Janssen and Kissi, 1997), among which is the rational exploitation of the natural resources such as water, soil, vegetation and genetic resources. Among others, regional research programs take into account the different ways in which natural resources are used, by farmers and others, and the links between resource use and resource quality.

This literature review also emphasized that the varying degradation of agricultural resources (i.e. watershed degradation) have location specific causes. Consistent with the provision of the 1991 Local Government Code for decentralization of decisions with respect to the natural resource management, regional research could be strengthened. One of the potentially useful exercises is to generate a critical review of the literature of the NRM research in the regions

and the provinces. These could be topics on watershed management, farming systems, and other locally designed sustainable resource management technologies. Biophysical characterization, knowledge gained from the local research, and the gaps defined in ground truthing , together can be used to prioritize a more user oriented, regional research agenda.

In view of all of the above, it seems that research on soil and water management, has in the past, been substantial. However, the fact that we have outputs in terms of research reports and other kinds of publication, but still observe a lot of resource degradation implies that the desired impact in terms of sustainability outcomes of all these, is not attained. Maybe, a reexamination of the context in which we design soil and water management research agenda, and the process of filtering the results to people who actually use and /or decide on use of the resource is the first item of study.

Appendix Table 1a. Frequency count of technical reports on soil management, by study area, crop, by agency, 1990-1998.

Crop	Soil Management					
	Soil Fertility (from PCARRD highlights) 1990-1997	Soil Conservation	Soil Fertility 1991-1997	Soil Conservation BAR	Soil Fertility	Soil Conservation BSWM 1998
<b>LUZON</b>						
Rice	3		16			
Corn	8		1			
Coconut	5		1			
Yambean	1		1			
Stringbeans	1					
Sorghum			1			
Tobacco	2					
Cotton	2					
Potato			1	1		
Sweet potato		1				
Cassava			1			
Arrowroot	1		1			
Ginger						
Tomato						
Tomato and cabbage	1					
Chinese cabbage	1					
Sugar cane			1			
Roses	1					
Peanut		1				
Banana						
Rice and corn			1			
Corn,peanut and rice			1			
Rice, corn and cowpea						
Mungbean and peanut			1			
Mungbean, sweet potato, corn						
Tomato and cabbage	1					
Cotton and legume	1					
Agroforestry		5				
Miscellaneous	15	11	4	4		

Appendix Table 1a. Frequency count of technical reports on soil management, by study area, crop, by agency, 1990-1998.

<b>VISAYAS</b>						
Rice			1			
Corn						
Coconut	1					
Sorghum			1			
Tomato			1			
Sugar cane	3		1			
Tobacco	1					
Ginger			1			
Rootcrops	1	1	2			
Mango	1					
Pandan	1					
Kakwate	1					
Rice and corn			1			
Rice, corn, comwpea,mungbean				1		
Agroforestry		1				
Miscellaneous	4	2	3			
<b>MINDANAO</b>						
Rice			4			
Corn	3		4			
Coconut	1		1			
Fiber	1					
Blackpepper	1					
Banana			1			
Guyabano	1					
Rice and corn			1			
Cassava				1		
Cassava with peanut or corn	1					
Miscellaneous	4	3	1			
<b>PHILIPPINES</b>						
Rice and corn					1	
Corn					2	
Mango					1	
Corn and ginger					1	
Bell pepper					1	



Appendix Table 1a. Frequency count of technical reports on soil management, by study area, crop, by agency, 1990-1998.

White potato					1	
Soybean					1	
Legume					1	
Legume/grass					1	
Pili					1	
Ipil-ipil		1				
Cogon/talahib						1
Agroforestry						1
Miscellaneous					27	9
Total	68	26	54	7	38	11



Appendix Table 1b. Frequency count of technical reports on water management, by study area, by crop, 1990-1998.

Crop	Water management		Water mgt.& Soil Fertility	Water mgt. & Soil Conservation
	Water delivery/ Watershed mgt.	Water technology		
LUZON				
Forage grasses			1	
Mixed crops		1		
Unclassified	5			2
VISAYAS				
Mixed crops	1			
Unclassified	1	3		3
MINDANAO				
Unclassified	1			
PHILIPPINES				
Rice	6			
Mungbean	1			
Mixed crops	1			
Unclassified	8			
TOTAL	24	4	1	5

Appendix Table 1c. Frequency counts of graduate thesis, by study area, by crop, UP Los Baños, 1990-1998.

Crop	Soil Management Soil Fertility	Soil Conservation	Water Management Water delivery/ watershed mgt.	Water Technology
<b>LUZON</b>				
Rice	5		1	
Corn	2		1	
Potato	1			
Acacia	1			
Agroforestry	1	4		
Mixed crops		1		2
Miscellaneous	1	3	13	
<b>VISAYAS</b>				
Rice				1
Miscellaneous	2	3		
<b>MINDANAO</b>				
Rice	1			
Agroforestry		1		
<b>PHILIPPINES</b>				
Rice	30		5	
Corn	6			
Coffee	1			
Cashew	1			
Coconut	1			
Soybean	2			2
Cauliflower	1			
Sugarcane	1			
Papaya	1			
Sweet corn and mungbean	1			
Rice-mungbean		1		
Trees (e.g., acacia, narra)	5	1		
Vegetable crops		1		
Rootcrops		1		
Agroforestry	7			
Mixed crops	1			
Miscellaneous	14	6	5	
<b>TOTAL</b>				
	86	22	25	5

Appendix Table 1d. Frequency count of publications on soil and water management, by study area, by crop, 1990-1998.

Crop	Soil Management		Water Management	
	Soil Fertility	Soil Conservation	Water delivery/ Watershed mgt.	Water technology
<b>Refereed journals</b>				
<b>LUZON</b>				
Rice	15	1	4	7
Corn	1			
Cotton	1		1	2
Onions			1	
Garlic		1		1
Cowpeas				1
Mungbean			1	1
Sugarcane	1			1
Sorghum				1
Ramie	2			
Peanut	1			
Rice/mungbean				1
Forage grasses	1			
Mixed crops	10	5	3	4
Unclassified		2	9	6
<b>VISAYAS</b>				
Rice		1		6
Sweet potato	1			
Cassava	1			
Mixed crops	1	2		
<b>MINDANAO</b>				
Rice		1	1	
Corn	1		1	
Rubber			2	
Mixed crops		3		
Unclassified		1	1	
<b>PHILIPPINES</b>				
Rice	1	1	7	7
Corn		2		
Mungbean			1	
Cotton			1	1
Vegetables	1			
Mixed crops	1	7	1	
Unclassified			10	4
<b>TOTAL</b>	<b>39</b>	<b>27</b>	<b>44</b>	<b>43</b>
<b>Book</b>				
<b>LUZON</b>				
Mixed crops	1			
<b>MINDANAO</b>				
Unclassified	1			
<b>PHILIPPINES</b>				
Rice			3	
Unclassified		1		
<b>TOTAL</b>	<b>2</b>	<b>1</b>	<b>3</b>	<b>0</b>

Crop	Soil Management		Water Management	
	Soil Fertility	Soil Conservation	Water delivery/ Watershed mgt.	Water technology
<b>Monograph/papers</b>				
<b>LUZON</b>				
Mixed crops		1		
Unclassified		1	2	
<b>VISAYAS</b>				
Mixed crops		1		
Unclassified		1	2	
<b>MINDANAO</b>				
Corn		2		
Mixed crops		2		
<b>PHILIPPINES</b>				
Rice			2	
Corn		2		
Mango	2			
Mixed crops		1	2	
Unclassified		6	10	3
<b>TOTAL</b>	2	17	18	3
<b>Proceedings</b>				
<b>LUZON</b>				
Rice			4	
Cotton			1	
Unclassified			1	
<b>VISAYAS</b>				
Unclassified			1	
<b>MINDANAO</b>				
Unclassified			1	
<b>PHILIPPINES</b>				
Rice			1	
Unclassified		3	11	4
<b>TOTAL</b>	0	3	21	4
<b>Others (newsletter, articles)</b>				
<b>LUZON</b>				
Rice			2	1
Potato				1
Mixed			3	
Unclassified			5	4
<b>VISAYAS</b>				
Unclassified		2	3	1
<b>PHILIPPINES</b>				
Rice			5	4
Mixed			2	
Unclassified			25	7
<b>TOTAL</b>	0	2	45	18

Appendix Table 1e. Frequency count of on-going research for soil and water management, by crop, UPLB, Philippines, 1990-1998.

Crop	Soil Management		Water Management	
	Soil Fertility	Soil Conservation	Water delivery/ watershed mgt.	Water technology
Rice	12		16	
Corn	3			
Papaya	3			
Fruit crops	1			
Mango	1			
Legume			1	
Legume, peanut, corn	2			
Upland-based crops		1		
Unclassified	2			
<b>Total</b>	24	1	17	0

Appendix Table 2. UPLB Graduate theses on soil management by crop, by area, 1990-1998.

CROP	YEAR	T I T L E	AUTHOR
<b><i>Luzon - Soil Fertility</i></b>			
Rice	1990	Economics of Azolla use by rice farmers in South Cotabato and Laguna, Philippines	Revilla, I.M.
Rice	1990	Effect of zinc-organic complexes on zinc ion activity in soil solution of a flooded soil [in Bugallon, Pangasinan, Philippines]	T.M. Metra
Rice	1995	Crop establishment, nitrogen and weed management of drought tolerant rice cultivars in rainfed lowland fields in Bacnotan, La Union	Neri, F.
Rice	1995	Dynamics of soil and applied nitrogen in selected rice-based cropping systems in Northern Luzon, Philippines	B.P. Triphati
Rice	1996	Potential Nutrient Contributions of a Lakeshore rice-based agroecosystem in Barangay San Antonio, Bay, Laguna to Laguna de Bay	Manaligod, R.L.
Corn	1990	Effect of NPK fertilizer application on the performance of corn (zea mays L.) I three major soil series of Isabel, Philippines	R.L. Raymundo
Potato	1990	Response of potato (Solanum tuberosum, L.) to boron and fertilizers in some soils of Benguet (Philippines)	R.B. Castillo
Acacia	1990	Nodulation and seedling growth of acacia mangium and gliricidia sepium grown in two soils from Oriental Mindoro	Erana, L.N.
Agroforestry	1994	Responses of mahogany (Swietenia macrophylla King.) and yemane (Gmelina arborea Roxb.) seedlings to bio-organic and inorganic fertilizer and mycorrhizal inoculation in two Camarines Norte soils	A.L. Erasga
Miscellaneous	1991	Labor productivity and income performance of the major cropping patterns in the Laoag-Vintar River Irrigation System	Esteban, Z.H.
<b><i>Luzon - Soil Conservation</i></b>			
Miscellaneous	1990	Vegetation-soil pattern along altitudinal gradient in the western slopes of Mt. Banahaw, Luzon, Philippines	E.G. Aragon, Jr.
Miscellaneous	1994	Effects of land use change on soil and hydrologic characteristics of experimental watershed in Angat, Bulacan	A.M. Daño
Agroforestry	1990	Production of agroforestry farms in two integrated social forestry projects in Oriental Mindoro, Philippines	J.T. Dizon



<b>CROP</b>	<b>YEAR</b>	<b>T I T L E</b>	<b>AUTHOR</b>
Agroforestry	1990	Policy issues in the development of a social forestry program: the case of Mt. Resort, province of Rizal, Philippines	C.G. Abrenilla
Agroforestry	1990	Factors associated with farmers' adoption of agroforestry: a study of four selected ISF [Integrated Social Forestry] projects in Ifugao province [Philippines]	R.T. Ngidjo
Agroforestry	1990	Environmental and socio-economic impact analysis of an indigenous and an introduced agroforestry systems in Luzon, Philippines	R.C. Serrano
<b><i>Visayas - Soil Fertility</i></b>			
Miscellaneous	1991	Social and Economic Sustainability of Communal Irrigation Systems in Iloilo Province	Alicante, E.L.
Miscellaneous	1999	Salinization of Aquifers and Estimation of Its Damage and the Cost of Groundwater Protection in Cebu City, Philippines	Baquinao
<b><i>Visayas - Soil Conservation</i></b>			
Miscellaneous	1990	Determinants of soil conservation measure adoption among upland farmers of selected integrated social forestry projects in Regions VII and VIII	B.D. Dolom
Miscellaneous	1991	An assessment of the family and school hillyland development project (FSHDP) in Cebu Province	A.A. Pasaje
Miscellaneous	1991	Technology transfer and the economic profitability of the hillyland farming system in Central Visayas	G.M. Pasaje
<b><i>Mindanao - Soil Fertility</i></b>			
Rice	1990	Economic evaluation of azolla use by rice farmers in South Cotabato and Laguna, Philippines	I.M. Revilla
<b><i>Mindanao - Soil Conservation</i></b>			
Agroforestry	1994	Comparative evaluation of two farming systems in response to hedgerow treatment at Dinaig, Maguindanao, Philippines	M.K. Musa
<b><i>Philippines - Soil Fertility</i></b>			
Rice	1994	Effect of hydrogen uptake (Hup) characteristics on survival of Bradyrhizobium japonicum (Buchanan 1980) comb. Nov. in flooded soil	S.L. Maskey

CROP	YEAR	T I T L E	AUTHOR
Rice	1990	Nature of indigenous rhizobia from <i>Arachis hypogaea</i> L. in some Philippines soils	E.G.C. Gaminde
Rice	1990	Agronomic feasibility and efficiency of <i>Indigofera tinctoria</i> as a green manure in rice-based cropping systems	Pye-Tin
Rice	1990	Sustainability of wheat-rice cropping-systems; use of <i>Indigofera tinctoria</i> intercropped with wheat as a green manure for the rice crop	R.A. Mann
Rice	1990	Integrated soil, crop and nutrient management practices in broadcast seeded flooded tropical rice	N. Nabheerong
Rice	1990	Productivity rating and yield potentials of major lowland rice soils in the Philippines	R.G. Garcia
Rice	1990	Suitability evaluation of paddy riceland resources in Luzon Island, Philippines	R.O. Ilao
Rice	1990	Genotype x environment interactions, stability and adaptability of irrigated lowland rice	S.O. Samonte
Rice	1991	Comparison of foliar and soil nitrogen fertilizer management on growth, nitrogen use efficiency and yield of direct seeded rice	M.N. Mnzava
Rice	1991	Growth and nitrogen accumulation of four azolla genotypes at different stages of rice canopy development and their efficiency as organic fertilizer	V.P. Parot
Rice	1991	Productivity evaluation of Philippine soil resources for lowland rice	J.D. Rondal
Rice	1991	Biodiversity, productivity, and socio-economic impacts of azolla utilization in rice production	A.S. Tisico
Rice	1991	Time of planting rainfed lowland rice after green manure incorporation	G.A. Tutanés
Rice	1992	Effect of method and duration of incorporation of <i>Sesbania rostrata</i> (Brem. And Oberm.) on lowland rice	J.K. Khatib
Rice	1992	Response of rice to urea fertilizer, cowpea ( <i>Vigna unguiculata</i> L.) Walp. Subs. <i>Unguiculata</i> and mungbean ( <i>Vigna radiata</i> L.) Wilczek cv.	C.B. Zandamela
Rice	1992	Population of rhizobia in the lowlands of North-western Philippines as affected by soil, climate and crop management practices	S.R. Pascua, Jr.
Rice	1992	Phosphorus sorption isotherms of selected acid sulfate soils of the Philippines and Vietnam and improving the productivity of acid sulfate	Phan-Thi-Cong
Rice	1993	Identification of five root-knot nematode ( <i>Meloidogyne</i> sp.) lines and comparison of their effects on the growth and yield of selected rice cultivars grown under different water regimes and soil types	I.S. Soriano

CROP	YEAR	T I T L E	AUTHOR
Rice	1990	Nature of indigenous rhizobia from <i>Arachis hypogaeae</i> L. in some Philippines soils	E.G.C. Gaminde
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Rice	1992	Phosphorus sorption isotherms of selected acid sulfate soils of the Philippines and Vietnam and improving the productivity of acid sulfate	Phan-Thi-Cong
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CROP	YEAR	T I T L E	AUTHOR
Rice	1993	Yield loss due to sheath blight in direct-seeded rice as affected by plant density, nitrogen level and amount of inoculum	E.M. Dildla
Rice	1993	Sulfur and nitrogen nutrition for sustainable rainfed lowland rice	A. Mazid
Rice	1993	Screening criteria for evaluating efficiency of N use in rice and genetic background of rice-bacteria associated nitrogen fixation	W. Ping
Rice	1993	Performance of rice under different soil boron levels and azolla application	M.A. Deseo
Rice	1994	Zinc solubilization in the rhizosphere; *rhizosphere; *acidification; *nutrient-uptake	J.B. Bajita
Rice	1994	Genotypic variation in associative nitrogen fixation in lowland rice	R. Shrestha
Rice	1994	Solubilization of phosphorus in the rhizosphere of lowland rice	Md-Abu-Saleque
Rice	1995	Response of upland rice varieties to nitrogen fertilization and intercropping	O.R. Jaballa
Rice	1995	Crop establishment, nitrogen and weed management of drought tolerant rice cultivars in rainfed lowland fields in Bacnotan, La Union	F.R. Neri
Rice	1995	Organic and bio-fertilizers on rice sheath blight severity and the economics of their use	A.M. Sinohin
Rice	1995	Kinetics of nitrogen mineralization in anaerobic rice soils: use of cation exchange resin to improve in vitro anaerobic incubation methods	Zahid-Saeed
Rice	1995	Population dynamics of Bradyrhizobium japonicum (Kircher) Jordan in rice-soybean rotation	M.L.Q. Sison
Corn	1990	Nitrogen use efficiency and yield of corn (Zea mays L.) as affected by weed management and time of nitrogen fertilizer application	I.V. Caraniwan
Corn	1990	Simultaneous young cob and green corn production through high density planting and nitrogen fertilization using urea and sesbania	C.J. Andam
Corn	1990	Influence of silicate and sulfate sources on phosphorus sorption and corn yield	C.M. Duque, Sr.
Corn	1993	Growth and decomposition of three green manure species under varying conditions and their effects on growth and yield response of corn	P.P. Nebrida
Corn	1995	Available phosphorus and zinc and calcium-potassium ration for optimum growth of corn (Zea mays L.) on a tropudult and a pellustert	O. Trisilawati
Corn	1995	Response of corn to nitrogen fertilizer and green manure management	A.A. Balisi
Sweet Corn and Mungbean	1991	Effects of lime and organic matter on soil acidity, aluminum, phosphorus and growth of sweet corn and mungbean on two acidic soils	W.M. Bandara

<b>CROP</b>	<b>YEAR</b>	<b>T I T L E</b>	<b>AUTHOR</b>
Mungbean	1992	Root acid phosphatase activity and phosphorus response of mungbean genotypes ( <i>Vigna radiata</i> ) in Luisiana clay	M.C. Rustico
Coffee	1995	Litterfall and soil nutrient dynamics in three coffee-based agroforestry cropping systems	L.C. Lapitan, Jr.
Cashew	1990	Growth response of cashew ( <i>Anacardium occidentale</i> L.) seedlings to varying light intensities and nitrogen levels	B.A. dela Rosa
Coconut	1993	Productivity and nutritional status of coconut ( <i>Cocos nucifera</i> L.) under different production scheme	F.P. Tagarino
Soybean	1990	Performance of three soybean ( <i>Glycine max</i> (L.) cultivars at varying water table depths	Ma. J.C. Alacos
Soybean	1994	Organic and inorganic nitrogen fertilizers sources on soybean growth, seed yield, germinability and storability.	K. Pisithkul
Cauliflower	1992	Adaptational responses of cauliflower ( <i>Brassica oleracea</i> L. var. botrytis L.) cultivars subjected to excess water.	Adhikari, R.R.
Sugarcane	1991	<i>Crotalaria juncea</i> L.: some aspects of its biology, its use as nitrogen fertilizer supplement and for weed suppression in sugarcane	R.E. Tapay
Papaya	1994	Application of rapid nitrate test in papaya ( <i>Carica paapaya</i> L.)	R.L. Tantung
Aquaculture	1990	Effect of chicken manure on the availability of phosphorus in acid sulfate fish pond soils	E.T. Taberna
Miscellaneous	1990	Logit models for land capability classes in the Philippines	M.C. Gregorio
Miscellaneous	1990	Developing an ecophysiological rice yield prediction model	Suryamin
Miscellaneous	1990	Nature of indigenous rhizobia from <i>arachis shypogaea</i> L. in some Philippine soils	E.G. Gaminde
Miscellaneous	1990	Effect of chicken manure on the availability of P in acid sulfate fishpond soils	E.T. Taberna
Miscellaeous	1992	Soil moisture distribution, erosion and nitrogen Availability in some alley cropping systems	C.G. Umali
Miscellaneous	1992	Population of rhizobia in the lowlands of Northwestern Philippines as affected by soil, climate and crop management practices	S.R. Pascua, Jr.
Miscellaneous	1992	Influence of shallow water table in Quingua silty clay loam on soil moisture availability	C.P. Aganon
Miscellaneous	1992	Effect of nitrogen and various shade levels on coriander ( <i>Coriandrum Satiym</i> L.) production	K. Kongsar
Miscellaneous	1993	Regrowth and nutritive value of <i>Setaria splendid</i> Stapf at different cutting intervals and levels of nitrogen fertilization	A. Rahman-Sy
Miscellaneous	1994	The effect of monocrotophos on soil microfloraa in a ricefield ecosystem	A.G. Moldez

CROP	YEAR	T I T L E	AUTHOR
Miscellaneous	1994	Influence of clay mineralogy on phosphate fixation in red-yellow soils in the Philippines	M.F. Pampolino
Miscellaneous	1995	Effect of VA-Mycorrhiza inoculation on growth performance, coppicing ability and drought resistance of two agroforestry tree species	J.B. Kung'U
Miscellaneous	1995	Technology transfer and commercialization of bio-organic fertilizer technology through enterprise development	N.O. Espiritu
Miscellaneous	1996	Fertilizer and irrigation management for selected forage grasses on Alaminos sandy clay	
Agroforestry	1991	Herbage decomposition of some agroforestry species and their effects as mulch on soil properties and crop yield	R.D. Lasco
Agroforestry	1992	Effects of nurse trees, fertilizer and mulch treatments on the growth performance of inter-planted white lauan ( <i>Shorea contorta</i> (Vidal) Merr. And Rolfe) seedlings	M.P. Flores
Agroforestry	1992	Effects of mycorrhizal inoculation and fertilization on the establishment and growth of <i>Eucalyptus camaldulensis</i> Denh seedlings	M.A. Transfiguracion
Agroforestry	1992	Response of <i>Leucaena diversiflora</i> (Schlecht.) Benth seedlings to <i>Rhizobium</i> inoculation in Macolod and Luisiana soils	M.T.A. delos Reyes
Agroforestry	1992	Response of <i>Acacia auriculiformis</i> to <i>Rhizobium</i> inoculation and ash application at varying N-levels	S.P. Garma
Agroforestry	1993	Nutrient addition from rainfall, stemflow, throughfall and litterfall in three types of ecosystems in Mt. Makiling	J.M. Castillo
Agroforestry	1993	Survival and Early Growth of <i>Rhizophora</i> species seedlings of selected provenances as affected by salinity	D.M. Melana
Acacia	1993	Effects of inoculation and nitrogen fertilization on the early growth and nodulation of <i>acacia auriculiformis</i> Cunn. Ex Benth. and <i>acacia mangium</i> Wild. In Zamboanga del Norte	B.P. Ranes
Narra	1993	Physiological responses of narra ( <i>Pterocarpus indicus</i> Willd.) inoculated with VA mycorrhiza and rhizobium in Macolod soils	E.T. Castillo
Ipil-ipil, Malabatatong and Kakawati	1991	Germination and early seedling performance of <i>leucaena leucocephala</i> (Ipil-ipil), <i>flemingia congesta</i> (Malabatatong) and <i>gliricidia sepium</i> (Kakawati) at different levels of soil acidity and water deficit	V.D. Amante
Mahogany	1991	Growth responses of tagititik ( <i>Calamus filispadix</i> Becc.) germinants outplanted in a mahogany ( <i>Swietenia macrophylla</i> King) plantation to fertilization, watering and mulching treatments	F.C. Baradas

CROP	YEAR	T I T L E	AUTHOR
Acacia	1991	Assessment of growth and nodulation of acacia mangium Willd. and sesbania grandiflora (L) (L.) Pers. in two Philippine soil types	C.A. Cali
<b>Philippines - Soil Conservation</b>			
Rice	1993	Performance of rice under different soil boron levels and azolla application	Deseo, M.A.
Rice	1995	Rainwater conservation and management as influenced by tillage, land levelling and field bunds in rainfed lowland dry seeded rice	Yadav, M.K.
Corn	1994	Influence of crop cover and shear strength of soil on surface runoff and soil loss	K.C. Singh
Corn	1994	Effects of Gliricidia sepium hedgerows number and pruning frequency on soil properties and maize (Zea mays L.) performance in an alley cropping system	R.G. Visco
Rice-Mungbean	1992	Productivity and sustainability of upland rice-mungbean cropping system using Desmanthus virgatus as hedgerows	A.B. Rabarimandimby
Vegetable crops	1993	Upland farming systems in Lucban, Quezon [Philippines] and its ecological implications in the conservation and management of Mt. Banahaw de Lucban watershed	C.S. Navasero
Agroforestry	1992	Effects of kakawate (Gliricidia sepium Jacq. Steud) contour hedgerows on the rate of soil erosion and crop yield of upland rice on hillside	J.T. Agustin
Agroforestry	1992	Biomass production and some soil properties under a Leucaena leucocephala fallow	J.B. Kung'u
Agro-forestry	1992	Land evaluation for agroforestry in the Philippines	P.P. Evangelista
Agroforestry	1993	Effects of site preparation and soil amendment on the early growth performance of Acacia auriculiformis A. Cunn. Ex Benth planted in Alimodian clayloam soil	B.H. Garnace
Agroforestry	1993	Assessment of the performance and impact of an agroforestry project in Ilocos Norte	Ma. E.T. Palafox
Agroforestry	1993	Tenurial rights and conservation behaviour in highland Cordillera [Philippines].	L.A. Calanog
Agroforestry	1993	Biological control of damping-off fungi of agoho (Casuarina equisetifolia L.) using forestry program	E.C. Gumpal
Agroforestry	1993	People-centered approach to forest resource management: the case of integrated social forestry program implementation in selected project sites in Isabela	A.B. Masipiguen

<b>CROP</b>	<b>YEAR</b>	<b>T I T L E</b>	<b>AUTHOR</b>
Agroforestry	1993	Evaluation of hillylands for appropriate conservation-oriented farming systems.	C.M. Limbaga
Agroforestry	1994	Nutrient returns and some hydrologic characteristics of <i>Coffea robusta</i> L. (Rub.) + <i>Gmelina arborea</i> Roxb. And <i>Theobroma cacao</i> L. + <i>Gmelina arborea</i> Roxb. Agroforestry systems in Mt. Makiling	A.F. Gascon
Agroforestry	1994	Effects of land use change on soil characteristics and hydrology of experimental watersheds in Angat, Bulacan	A.M. Dano
Kakawate	1992	Effects of kakawate <i>gliricidia sepium</i> jacq. Steud.) contour hedgerows on the rate of soil erosion and crop yield of upland rice on hillyside farm	Agustin, J.T.
Rootcrops	1993	Potentials of selected tree species as hedgerows for gabi [ <i>Colocasia esculenta</i> (L.)] and camote [ <i>Ipomoea batatas</i> (L.) Lam.] as alley crops in Samar	W.A. Baya
Miscellaneous	1990	Effect of vegetative cover on soil loss and surface runoff	Kebede, A.G.
Miscellaneous	1993	Crop-hedgerow interactions with natural vegetativefilter strips on sloping acidic land	DMVH Ramiaramanana
Miscellaneous	1995	Predicting soil erosion losses	Kismosatmoro
Miscellaneous	1999	Development and evaluation of a composite indicator for lake water quality monitoring and assessment	Gauran, N.L.
Miscellaneous	1999	The economic impact of soil erosion on hydro-electric power and irrigation facilities operating in the Philippines	Indab, A.L.



Appendix Table 3a. Technical Reports on Soil Management, by crop, 1990-1998.

CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
<b>Luzon - Soil Fertility</b>				
Coconut	1990	Response of Mawa hybrid to increasing levels of sodium chloride (on-going)	Padrones, G.D., J.A. Habana and R.Z. Margate	PCA-DRC (PCA-funded)
Coconut	1992	On-farm verification trial under coco-based cropping pattern	Sala	(Mindoro)
Coconut	1992	Farm level production of Trichoderma-activated compost fertilizer and its influence on soil properties and yield of coconuts (on-going)	Ebuna, R.M., M.N. Eroy, E.C. Concibido and R.Z. Margate	PCA-DRC
Coconut	1992	Variety x fertilizer trial on abaca under established coconut plantation (completed)	Sodsod, F.R.	FIDA: Guinobatan, Albay (FIDA-funded)
Coconut	1995	Response of hybrid coconut to organic and inorganic fertilizer application in four agro-climatic conditions of the Philippines (completed) I. Inland soil of Cotabato II. Coastal upland soil of Zamboanga City III. Inland soil of Tabaco, Albay IV. Inland soil of Solana, Cagayan	Margate, R.Z., M.I. Secretariat, G.D. Padrones, J.N. Maravilla, S.S. Magat, J.A. Mantiquilla, E.C. Silva, R. Corsame J. Borrromeo and V. Rivera	PCA-DRC (PCA-funded)
Corn	1990	Regional verification trials on the use of Azospirillum in corn production (completed)	Cosico, W.C., M.U. Garcia and R. Alag	BIOTECH-UPLB
Corn	1992	Utilization of Croton tiglium L. as a green manure in corn (completed)	Marcelino, L.R. and M.E. Fortunato	DA-Region V
Corn	1992	Effect of zinc fertilization on different varieties of corn and on the physical and chemical properties of soils (completed)	Perlas, F.B.	CSSAC
Corn	1992	Fertilizer management on green corn under open land condition at San Rafael, Castilla, Sorsogon (completed)	Jamoralin, A.M and J.N. Lasala	DA (DA-funded)

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Corn	1992	Response of corn varieties/hybrids to different nitrogen rates in the Alcala riverflood plains (completed)	Guimmayen, S.A., M. Gaspar, V. Gacutan and E. Yabes	DA-APC, DA-Region II (DA-APC-funded)
Corn	1992	On-farm verification trial on corn-based cropping systems (completed)	Dela Torre, E.	DA-PRS: Albay
Corn	1993	Soil fertility and corn-yield under alley cropping scheme involving selected legumes as hedgerows	Soriano, Jr.	TCA
Corn	1996	Response of soybean to various fertilizer sources and levels in upland corn-based area	Mamuri et al.	Da-Region II
Rice	1992	Rice-based farming system development in rainfed areas for agrarian reform beneficiaries in Pangasinan	Mana and Aquino	DA-Region I
Rice	1992	Utilization of rice hull as partial replacement for inorganic fertilizer in transplanted rice (completed)	Juico, C.R., E.M. Orden, L. Pagaduan and D. Pagaduan	CLSU, DA
Rice	1994	Green manuring trials in farmers' field under lowland irrigated rice-based farming system (completed)	Valdez, .M.	OPA, Nueva Ecija (OPA-funded)
Mungbean, Sweet Potato and Corn	1993	Soil amelioration and fertilizer management for mungbean, sweet potato, and corn (completed)	Molina, E.C., L.B. Laranang and J.M. Baquiran	TCA (Camiling, Tarlac)
Yambean	1990	The effects of different systems of planting on the growth and yield of yambean (completed)	Aala, O.G.	BPI-LGNCRDC (DA-funded)
Sitao	1991	Response of bush sitao to different levels of organic and inorganic fertilizers under open upland condition in San Rafael, Castilla, Sorsogon	Jamoralin, A.M., J.N. Lasala and L.C. Barbonio	DA-Region V - Sorsogon (DA-RIARS-funded)
Sugarcane	1992	Effectiveness of VA mycorrhiza in increasing growth and yield of sugarcane and its ability to serve as nutrient uptake enhancer (completed)	Quillooy, O.T. and P.F. Lansang	SRA-LAREC Floridablanca, Pampanga (SRA-funded)
Tobacco	1992	Development of alternative crops to tobacco	Castro et al.	NTA

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Tobacco	1995	Development, evaluation, and verification of rapid soil and plant tests (RSPT) as guide in fertilizer recommendation for tobacco (completed)	Bonoan, R.R., J.V. Raquel, R.J. Raganit, A.S. Cristobal, B.L. dela Cruz, N.Q. Abrogena, I.N. Riñen, P.C. Alquiza, C.R. Sambo, and L.C. Javier	NTA (Bata, Ilocos Norte, NTA-funded)
Cotton	1992	Cultural management practices: plant spacing nitrogen levels on CRDI-1 cotton variety (completed)	Cedeño, V.D.	CRDI (CRDI-funded)
Cotton and Legume	1995	Cotton and legume intercropping	Biag, L.D., E.L. Mangasep, B.A. Repoyo, J. Cimafranca, Jr., J.C. Unciano, and C.B. Damo	CRDI (Ilocos Norte) CRDI-funded
Cotton	1996	Soil characterization of cotton production area	Castillo, F.S., P.C. Orpia and Z.D. Orpia, Jr.	CRDI Batac, Ilocos Norte (CRDI-funded)
Arrowroot	1992	Nitrogen fertilizer rate for arrowroot	Peñaflorida	DA-QAES (Tiang, Quezon)
Legume	1993	VA-mycorrhiza and Rhizobia: A fertilizer booster for legume production	Dela Cruz, R.E. and V.C. Perdido	DA-CVIARC
Legume	1994	Regional technology dissemination on the use of microbial inoculant in legume production (on-going)	Paterno, E.S., E.S. Garcia, F.G. Torres and M.L.Q. Sison	BIOTECH-UPLB (DA-Region IV-funded)
Legumes	1994	Field evaluation of rhizobial inoculants for pasture and forage legumes (on-going)	Tilo, S.N., Mendoza and E.H. Lales	UPLB (DOST-funded)
Chinese Cabbage	1997	Response of chinese cabbage to chicken manure with fixed level of inorganic- N fertilizer	Pablo, A.D.	NSVIT (Bayombong, Nueva Viscaya)
Tomato and Cabbage	1997	Low-cost organic fertilizer management for off-season production of tomato and cabbage	Perello, F.A., M.E. Fortuno and L.R. Marcelino	DA-BIARC (Pili, Camarines Sur)
Roses	1992	Nutrition studies on roses, chrysanthemums, gladiolus, shasta, daisy, statice, anthrium, carnation and poinsettias (completed)	Ladidlad, B.D.	PICRI (Kabacan, Cotabato) PICRI-funded
Miscellaneous	1990	Preliminary study on the growth and yield performance of five Sesbania species planted monthly under Cagayan conditions	Ladia, E.S. and I. Guimayen	DA-APC

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Miscellaneous	1990	Pilot project on rapid composting and use of compost as fertilizer (completed)	Santos, R.B., D.S. de Leon, F.O. Deca, J. Corbe, R. de los Trinos, R. Manalo and D. Salviejo	PCARRD-DOST II
Miscellaneous	1991	Biological nitrogen fixation in food and tree legume production systems in the Philippines (completed)	Paterno, E.S., F.G. Torres and E.S. Garcia	UPLB-Dept. of Soil Science (ACIAR-PCARRD)
Miscellaneous	1991	Integrating fodder production with cropping systems plus goad (completed)	Nieva, J.S. and R.V. Perez	DA-RIARC
Miscellaneous	1992	Bio-organic fertilizers enhancing the value of farm wastes through microbial inoculation (on-going)	Espiritu, B.M.	BIOTECH-UPLB
Miscellaneous	1992	Seed production of promising grass species: Fertilizer rate (N) and timing in harvesting on seed yield Brachiara decumbens and Panicum maximum (completed)	Marbella, A.F., A.D. Espinola and F.A. Moog	BAI-DA Milagros, Masbate (BAI-DA-funded)
Miscellaneous	1993	Production and utilization of sesbania as fertilizer for crops grown in the Bicol region (completed)	Castroverde, Y.L., G.S. de Asis and A.A. Obias	CSSAC
Miscellaneous	1993	Training and technology transfer on bio-organic fertilizer for small farmers and entrepreneurs (on-going)	Espiritu, B.M. and M.J. Tanico	BIOTECH-UPLB
Miscellaneous	1994	National program on rapid composting and use of compost as fertilizer - Phase I expansion	Ilao, R.O.	PCARRD-Los Baños (NAFC/PCARRD-funded)
Miscellaneous	1994	Technical and economic feasibility of mass producing sawdust compost causing brown rot fungus	Quimio, M.J.	ERDB-Los Baños
Miscellaneous	1994	Program on rapid composting and use of compost as fertilizer		IBS-UPLB (NAFC-funded)
Miscellaneous	1995	Performance of Stylosanthes guianensis cv. Cook stylo as influenced by the application of soil amendments (completed)	Garcia, N.P. and F.E. Venturina	PCC at CLSU (PCC-funded)

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Miscellaneous	1996	Socio-economic evaluation and policy analysis of the commercialization of the rapid composting technology (RCT)-Phase II	Rola, A.	CPDS-UPLB (PCARRD-funded)
Miscellaneous	1996	Trichoderma-fungus compost activator (CFA powder)	Madrigal, A.R., L.B. Salisi and L. Averion	DOST-IV Los Baños, Laguna/QAES Tiaong, Quezon
Miscellaneous	1997	Lab to land: Application and commercialization of Rhizobium inoculant for small scale farmers in the Philippines		UPLB/LGU-Tarlac/LGU-Pangasinan/DA-CVIARC
<b><i>Luzon - Soil Conservation</i></b>				
Sweet Potato	1990	Evaluation of traditional subsistence sweet potato production practices in the highlands	Dalang, P.A., L.M. Pacuz, E.T. Balaki, J.S. Luis, H.B. Torres, A. Padioan, I.C. Gonzalez, C.G. Kiswas and A.A. Cadiogan	BSU-NPRCRTC and DA-CAR-HADP (HADP-funded)
Peanut	1993	Evaluation of different soil and water conservation structures in Isabela with peanut under cultivation	Reyes, T.C. and H. Lasuden	Isabela State University
SALT	1995	Economics of goat production in SALT 2 Farm (completed)	Cumpio J.	DENR-ERDS-Region I
Agroforestry	1993	Agroforestry farming system for hillyland development	Malab	MMSU
Agroforestry	1994	Agroforestry practices to control runoff and erosion on steepplands in Ilocos Norte	Agustin, E.O.	MMSU
Agroforestry	1996	Lowland agroforestry system research cum development project (on-going)	Saplaco, S. and R. Dalmacio	UPLB-DENR CARP-funded
Agroforestry	1996	Performance of several tree and shrub legumes as hedgerows in agroforestry cropping system (completed)	Malab, S., J.I. Rosario and E.O. Agustin	MMSU-Ilocos Norte (MMSU-funded)
Miscellaneous	1990	Characterization of Farming Systems Agroenvironment for Agrotechnology Transfer (on-going)	Paningbatan, Alcantara, Basilio, Culiati and Pasion	UPLB-FSSRI

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Miscellaneous	1991	Sloping Agricultural Land Technology in Liliw	Calanog, L.	ERDB (ERDB-funded)
Miscellaneous	1991	Successional sequences of pioneer species; effects on soil and microclimate properties and on growth performance of planted dipterocarps (on-going)	Dalmacio, R.	UPLB (PCARRD-funded)
Miscellaneous	1993	Hedgerow intercropping for soil and water conservation	Agustin	MMSU
Miscellaneous	1993	Agroforestry farm assessment (AFA)	Lasco et al.	UPLB
Miscellaneous	1993	Agroforestry land capability mapping scheme (ALCAMS)	Lawas et al.	UPLB
Miscellaneous	1994	Alley cropping system for rehabilitating degraded hillylands in Batangas (on-going)	Huelgas, G.M., M.B. Silva and V. Recafort	DA-STIARC (Lipa City) PCARRD-IBSRAM-funded
Miscellaneous	1994	Environmental awareness and conservation of the Cordillera rainforest	Dincog and Basilio	ISCAF
Miscellaneous	1994	Environmental and sociocultural influences on the access, utilization and conservation of forests in selected sites of Ifugao	Cansanay and Daniels	ISCAF
Miscellaneous	1995	Agricultural rehabilitation of ash- and lahar-affected areas in Central Luzon (on-going)	Aganon, C.P., N.E. dela Cruz, M.G. Patricio, A.L. Ferrer, T.D. Gajete and J.L. Galindez	CLSU (CLSU-TPEC Foundation, Inc.-Rotary Club of Manila-Canadian Embassy-Mt. Pinatubo Commission-funded project)
Miscellaneous	1997	Cropping systems for hilly areas	Adriatico, V.E. and R.D. Pedro	DA-CVIARC-SWMS (Ilagan, Isabela)

CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
<b>Visayas - Soil Fertility</b>				
Rootcrops	1990	Effect of <i>Desmondium ovalifolium</i> on the growth and yield of root crops in hillyland (completed)	Gonzal, D.G. and M.A. Valenzona	ViSCA-PRCRTC (ViSCA-funded)
Coconut	1992	Farm level production of Trichoderma-activated compost fertilizer and its influence on soil properties and yield of coconuts (on-going)	Ebuna, R.M., M.N. Eroy, E.C. Concibido and R.Z. Margate	PCA-DRC
Sugarcane	1992	Yield response of PHIL 8361 and PHIL 8477 to NPK fertilization in two soil types (completed)	Bombio, R.M. and L.C. Cosico	SRA-LGAREC (La Granja, Negros Occ.)
Sugarcane	1994	Yield response of Phi 8583 to NPK fertilization in Guimbalaon clay loam and Isabela clay soil (completed)	Bombio, R.M. and G.L. Talan	SRA-La Granja (SRA-funded)
Sugarcane	1996	Fertilizer recommendation on specific soil type for sugarcane	Bacol and Talahm	SRA-LGAREC
Rice, corn, cowpea, mungbean	1992	Rice-corn + cowpea + mungbean/kakawate cropping systems in hillyland	Oren, C.D.	Iloilo City
Carabao mango	1995	Response of carabao mango to different foliar fertilizers (completed)	Covacha, S.A.	DA-funded (Jordan, Guimaras)
Tobacco	1996	Recommended fertilizer rate for Batek tobacco production	Moswa et al.	NTA (Iloilo)
Pandan	1996	Increased pandan production through fertilization (completed)	Cartagenas, D.	DA-RFU-7 (DA-funded)
Kakawate	1996	Kakawate hedgerows for improved soil fertility and crop yield (completed)	Tura, C.	DENR-ERDS-Region VII
Miscellaneous	1992	Collection, identification and evaluation of Trichoderma species in Region VIII for rapid composting (on-going)	Martinez, M.A.	DA-EVIARC

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Miscellaneous	1992	Regional performance trial for pasture and forage crops under Region VIII conditions (on-going)	Posas, O.B. and R.R. Javier	ViSCA (PCARRD-funded)
Miscellaneous	1996	Soil fertility management in Dolores, Quezon; Baloi, Lanao del Norte; and Dudlag, Leyte	Evangelico, F.A.B., C.D. Amihan-Vega and V. Godoy	ViSCA
Miscellaneous	1997	GIS on three villages in Matalom, Leyte	Dela Rosa, Z.M.	ViSCA-FARMI
<b><i>Visayas - Soil Conservation</i></b>				
Agroforestry	1994	Documentation and assessment of agro-forestry farms and farm practices in Central Visayas	Baggayan, R.L., J.L. Baggayan and R.L. Lanuza	ERDS-DENR Region VII
Camote	1996	Performance of camote (Ipomoea batatas (L.) Lam) as alley crop in agroforestry farming systems (completed)	Baya, W.	UEP (Catarman, Samar)
Miscellaneous	1993	Socio-economic constraints to the adoption of cropping methods for soil conservation by upland farmers in Leyte, Philippines (completed)	Villanueva, C.D., L.S. Parilla and S.B. Gisulga	ViSCA (ACIAR-PCARRD funded)
Miscellaneous	1996	Tree establishment technologies in the Philippines (completed)	Nasayao, E. and E. Germano	DENR-ERDS-Region VIII (ACIAR-funded)
<b><i>Mindanao - Soil Fertility</i></b>				
Cassava with peanut or corn	1992	Mixed cropping of cassava with peanut or corn	Malacad	CA-USM
Corn	1990	Utilization of Sesbania rostrata as supplemental source of nitrogen for corn	Satorre, C.E.	Da-Davao
Corn	1992	Liming and fertilizer management trials for corn production in Bukidnon (completed)	Josue, A.R., E.A. Auxtero and P.Y. Dumalag	CMU (DA-BAR-CARP-funded)



CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
Corn	1996	Corn varieties tolerant to acid soils	Franje and Franje	CMU
Fiber	1994	Utilization of fiber plantation wastes as organic fertilizer for green onion (completed)	Peralta, A.G., R.S. Palcon, M. Catiempo, Jr., O. Macarayan and A.A. Ramos	FIDA-Manambulan, Davao (FIDA-funded)
Blackpepper	1994	Response of blackpepper as influenced by different levels of organic and inorganic fertilizer (completed)	Lumbao, J.A., L. Gumapac and A.F. Abrazado	RIARC-Kidapawan, Cotabato (RIARC-funded)
Coconut	1996	Cultural management: Response of coconut to recycling of coconut crown residues and circle weeding	Padrones, G.D., R.Z. Maragate and J.N. Maravilla	(Bago-Ohiro, Davao City) PCA-funded
Guyabano	1995	Fertilizer study on guayabano	Loquias, V.L.	DA-BPI-funded (Bago-Oshiro, Davao City)
Miscellaneous	1992	Growth and yield of RRIM 600 as affected by cover crops and fertilizer (completed) (completed)	Garcia, A.V. and A.P. Pasig	PICRI (Kabacan, Cotabato) PICRI-funded
Miscellaneous	1995	Growth performance and dry matter yield of mamalis (Pittosporum pentandrum) seedlings as influenced by nitrogen and phosphorus fertilization (completed)	Tiongco, L. and L. Agne	DENR-ERDS-Region X
Miscellaneous	1996	Field evaluation of rhizobial inoculants for pasture and forage legumes	Cagmat, R.B.	CMU
Miscellaneous	1996	Effect of trace element fertilizer on the growth performance of mamalis (Pittosporum pentadrum) applied singly or in combination with guano (completed)	Agne, L. and D. Cacanindin	DENR-ERDS Region X (USAID-LBII-funded project)
<b>Mindanao - Soil Conservation</b>				
Rubber trees	1990	Growth of RRIM 600 rubber trees as affected by cover crops (on-going)	Garcia, A.	USM-PICRI (PICRI-funded)

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Ipil-ipil	1991	Contour canals and giant ipil-ipil hedgerows minimized surface runoff and sedimentation and increased production of corn and peanut (completed)	Manubag, J.	CMU (CMU-funded)
Miscellaneous	1991	Evaluation of different soil and water conservation structures appropriate in Bukidnon	Manubag, J.	CMU
Miscellaneous	1996	Sustainable agriculture promotion in Sinaawan, Parish, Valencia, Bukidnon (completed)	Pacamalan, A.V.	Xavier University College of Agriculture (Misereor-funded)
Miscellaneous	1997	USER-FIRST Research for sustainable development and natural resource management (completed)	Salvani, J. and C. Lapoot	DA-NOMIARC (Lantapan, Bukidnon) (SANREM-CRSP funded)

Appendix Table 3b. Technical Reports on Soil Management, by crop (BAR-funded).

CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
<b><i>Luzon - Soil Fertility</i></b>				
Miscellaneous	1991	Validation of the soil test kit	I.E. Santos and A.P. Carandang	BSWM-IV Soil and Water Division )
Miscellaneous	1994	Collection, evaluation, decomposition and nutrient release studies of different biofertilizers on various soils	R. Cambaya, and L.H. Capucan	DA-V, Bicol Integrated Agricultural Research Center (BIARC)
Miscellaneous	1995	Effect of continuous application of organic matters on soils of CLIARC, Magalang, Pampanga	E.T. Pelayo	DA-RFU-III CLIARC
Miscellaneous	1996	Biological nitrogen fixation under stress environment	M.J. Palis, C.C. Grospe, and J.S. Rojas	BSWM
Rice	1991	Use of indigenous fertilizer materials for upland rice production	G. Barbero	DA-XIII Abra
Rice	1991	Technology adaptation trial on promising weed control management practices for upland rice	R.S. Yanson, V.A. Llorente , and V. Adalla	DA-V Masbate
Rice	1991	Component technology development and adaptation trials on upland rice in the riverflood plains of Cagayan	S.A. Guimayen, R. Ventura, and M. Wandagan	DA-II Agricultural Pilot Center
Rice	1991	Component technology development and adaptation trials on upland rice in the acidic marginal soils of southwestern Cagayan	V.I. Miguel, N. Conag, E. Dupitas, G.C. Galindon, and N.M. Yabis	DA-II Agricultural Pilot Center
Rice	1991	Effect of fertilizer application on lowland rice varieties planted to volcanic (Mt. Pinatubo) ash-laden soils	J.L. de Dios, T.M. Metra, A.A. Corpuz, C.A. Asis, Jr., P.C. Sta. Cruz, S.R. Obien, and E.A. dela Rosa	PhilRice
Rice	1991	Yield of rice in volcanic ash-laden soil at Central Luzon under green manuring	J.L. de Dios, T.M. Metra, A.A. Corpuz, C.A. Asis, Jr., P.C. Sta. Cruz, S.R. Obien, and E.A. dela Rosa	PhilRice/WLAC

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Rice	1991	Comparative study on the use of chicken dung and inorganic fertilizer on rice	M.F. Buanzi	DA-XIII Mountain Province
Rice	1991	On-farm adaptation trial on the use of organic and inorganic fertilizer on rice under lowland irrigated areas	R. Gallardo and A. Rodeo	DA-III Bataan
Rice	1991	Integrated soil fertility and fertilizer management studies under irrigated rice areas	E.S. Ladia, E.D. Guzman, I.I. Guimmayen, and R.T. Pizarro, Jr.	DA-II Agricultural Pilot Center
Rice	1991	Phosphorous, potassium and lime correlation trials in acidic lowland rice areas in Kalinga-Apayao	M. Pagurigan and D. Gonzalo	DA-XIII Kalinga-Apayao
Rice	1991	Slow-release starch and flour coated urea for lowland rice	I.B. Lapis and E.M. Bautista	BSWM-IV Soil and Water Resources Research Division
Rice	1991	Pilot project on rapid composting technology (RCT) and use of compost as fertilizer	D. de Leon, F. Doca, R. Santos, J. Corbe, R. delos Trinos,	Da-II Isabela
Rice	1992	Comparative study on the use of inorganic fertilizer and chicken manure on the yield of rice	M.F. W. Buanzi	DA Region XIII Mt. Province
Rice	1992	Screening for varietal tolerance to acid soils in upland areas	C.A. Orbien and M.P. Pajarillo	DA-Region V
Rice	1994	Effect of organic and inorganic fertilizers on the the population dynamics of pests in rice	O. Lorenzana	DA-RFU2, CVIARC Crop Protection Laboratory Isabela
Rice	1994	Potential of combined organic and inorganic fertilizer as source of nitrogen for rice production in lowland rainfed coastal areas	J. Bisgo, R. Garcia, J. Miniano, and G. Narciso	DA-ICIARC, La Union
Corn	1991	Effects of seeding rates, dates of thinning and rates of fertilizer application on the grain yield and fodder yield of corn	A.T. Asuncion and M.T. Mamuri	DA-II Ilagan Experiment Station

CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
Corn	1991	Response of corn to fertilization under zero tillage condition	V.C. Perdido, S.C. Tumamang, and C.C. Ramos	DA-II Ilagan Experiment Station
Corn	1991	Fertilizer trial on green corn	F.D. Palsario and M.R. Agarano	DA-XI Davao Province
Corn	1991	Effect of different seeding rates of <i>Casia tora</i> Linn. As green manure in combination with organic fertilizer on growth and yield of corn	F.M. Salomes and R.T. Esturas	DA-IX Ipil Expt. Station and Seed Farm
Corn	1991	Improvement of soil productivity and management of selected volcanic ash soils in the Philippines	P. Pajaro and F. Torres	BSWM-IV Soil Resources Development Center
Rice and Corn	1991	Effect of NPK fertilization on the yield of rice and corn after successive cultivation	E.T. Molina, F. Penaranda, and F. Bongolan	DA-IX Betinan Research Station
Corn, Peanut, and Rice	1992	Technology verification trial on green corn plus peanut minus transplanted rice (TPR) cropping pattern	M.F. W. Buanzi and C.P. Wangdali	DA-Mt. Province
Sugarcane	1991	Drip irrigation of an intercropped sugarcane farm at double row planting - 1st ratoon cane	M.P. Marcelo, S.M. Samiano, and N.P. Pecho	SRA-III -Luzon Agricultural Research and Extension
Coconut	1995	Response to integrated soil fertility management of hybrid coconut on an inland soil of Tabaco, Albay, Bicol, Region	G.D. Padrones, R.Z. Margate, S.S. Magat and J. Borromeo	PCA-Albay
Mungbean and Peanut	1992	Study on the effectiveness of vesicular arbuscular mycorrhiza (VAM) and rhizobia for the improvement of growth and yield of mungbean and peanut	R. dela Cruz, E. Paterno, V. Perdido, L. de Guzman, and R. Aquino	DA-CVIARC Ilagan, Isabela
Potato	1995	The use of sweet potato as partial substitute to commercial feeds in gestating sows	I. Adion, J. Yadao, and C. Pineda	DA-RFU-III CLIARC
Cassava	1996	Fertilizer rates of N, P and K for cassava grown in an ultisol	I.B. Lapis and P.P. Evangelista	BSWM

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
Rootcrops (Ubi)	1991	Yield response of ubi to different levels of NPK	A. Bayot	BPI-Central Experiment Station
Arrowroot	1992	Response of arrowroot to varying levels of nitrogen fertilizer	G. Penaflorida	DA Region IV
Sorghum	1991	Comparative effects of organic and inorganic fertilizers on the yield of sorghum	D.B. Usero, M.B. Abaquita and J.O. Penuela	BPI-VI (LGNCRDC)
<b>Luzon - Soil Conservation</b>				
Potato	1995	The use of sweet potato as partial substitute to commercial feeds in gestating sows	I. Adion, J. Yadao, and C. Pineda	DA-RFU-III CLIARC
Miscellaneous	1991	Influence of some vegetable barriers/contour buffers in the production of field crops	R.A. Monte and V.G. Estoconing	BSWM-IV
Miscellaneous	1993	Alley cropping system for rehabilitating degraded hillylands in Batangas	G.M. Huelgas, M. Silva, E.P. Vila, and V. Pecafort	DA-IV (STIARC) Lipa City
Miscellaneous	1994	Management and rehabilitation of degraded hillyland at BPI-LBNCRDC Compound	D.G. Cortiguerra	BPI-LBNCRDC
Miscellaneous	1997	Status of heavy metal concentrations in soils and plants of Metro Manila and neighbouring provinces	R.B. Grifal, E.D. Ayo and R.P. Ulibas	BSWM
<b>Visayas - Soil Fertility</b>				
Rice	1991	POT trial on upland rice	T.A. Londina, S. Toledo, M.A. Martinez, M.T. Sacay, D.M. Partiles, and D.B. Palang	DA-VIII Abuyog Experiment Station (AES)
Rice and Corn	1991	Multi-agency pilot project on rapid composting and use of compost as fertilizers-Region VIII	E.Z. Alama, B. Lucero, R. Padayhag, E. Estrada et al.	DA-VII/DOST
Tomato	1994	The effect of inorganic and organic fertilizers on the growth and yield of corn and their residual effects on tomato	L. Rafols	BPI-La Granja National Crop Research and Dev't Center, Negros Occidental
Sugarcane	1992	Yield response of Phil 8361 and Phil 8477 to NPK fertilization on two soil types	L.C. Cosico	SRA, La Carlota, Negros Occidental

CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
Rootcrops (Ubi)	1991	Time of fertilizer application on the growth and yield of ubi using inorganic fertilizer	C.M. Golosino	CENVIARC, Bicol
Cassava	1991	Varietal selection and nitrogen fertilization for cassava foliage production	J.C. Ladera	CENVIARC, Bicol
Ginger	1992	Increase giner yield through minimum fertilization and mulching	M.B. Abaquita	BPI-LGNCRDC Negros Occidental
Sorghum	1991	Comparative effects of organic and inorganic fertilizers on the yield of sorghum	D.B. Usero, M.B. Abaquita and J.O. Penuela	BPI-VI (LGNCRDC)
Miscellaneous	1991	Validation of the soil test kit	I.E. Santos and A.P. Carandang	BSWM-IV Soil and Water Resources Research Division
Miscellaneous	1991	Analytic studies on acid soil problems in Bohol and its countermeasures	C.B. Payapaya, A.T. dela Cruz, and Kiyoko Hitsuda	DA-VIII Bohol Agricultural Promotion Center
Miscellaneous	1991	Collection and identification of trichoderma species for rapid composting in Eastern Visayas	M.A. Martinez	DA-VIII Abuyog Experiment Station
<b>Visayas - Soil Conservation</b>				
Rice, Corn and Cowpea	1991	Technology verification trial on upland rice-corn + cowpea/farming kakawate cropping system in hillyland, Iloilo	C.D. Oren	DA-VI, Iloilo City C-Vis
<b>Mindanao - Soil Fertility</b>				
Rice	1991	The effect of different fertilization schemes on the agronomic and economic performances of IR-5	F.M. Magana	DA-IX (RIARS)
Rice	1991	Study on the effect of different mulch media and tillage practices on the growth and yield of upland rice	H.R. Povadora and C.G. Alama	DA-IX Ipil Expt. Station and Seed Farm

CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
Rice	1991	Different rates of rice straw compost and guano as supplementary fertilizer for upland rice (Tumindog)	E.R. Apao, B.I. Omboy, and R.H. Mercado	DA-IX Ipil Expt. Station and Seed Farm
Rice	1991	Effect of tillage conservation and varying amounts of nitrogen fertilization on weed population and yield of upland rice (Tumindog)	E.S. Ragay	DA-IX (RIARS)
Corn	1991	Fertilizer trial on green corn	F.D. Palsario and M.R. Agarano	DA-XI Davao Province
Corn	1991	Effect of different seeding rates of <i>Casia tora</i> Linn. As green manure in combination with organic fertilizer on growth and yield of corn	F.M. Salomes and R.T. Esturas	DA-IX Ipil Expt. Station and Seed Farm
Corn	1991	Validation of the soil test kit	Z. Jomoc, M.V. Bacala, H. Galang and M. Valmoria	DA-X
Corn	1994	Verification trial on organic and inorganic fertilizers and their combination in relation to insect pest and disease incidence in corn	R. Mallorca, and P. Laysa	ROS for lowland, S. Kudarat
Rice and Corn	1991	Effect of NPK fertilization on the yield of rice and corn after successive cultivation	E.T. Molina, F. Penaranda, and F. Bongolan	DA-IX Betinan Research Station
Banana	1991	Nutrient management for sustaining crop production	D. Sadasa, M. Baratang, L. Siase, H. Aplinares, and M.R. Recel	BSWM-IV Soil Resources Development Center
Coconut	1991	Nutrient depletion in coconut soils thru harvest of matured nuts	M.N. Erooy, R.Z. Margate, and R.M. Ebuna	PCA-XI Davao Research Center
Miscellaneous	1991	Validation of the soil test kit	I.E. Santos and A.P. Carandang	BSWM-IV Soil and Water Resources Research Division
<b>Mindanao - Soil Conservation</b>				
Cassava	1991	Soil conservation practice in hillyland area for cassava production	T.L. Cambal, W.A. Descuatan and R.A. Lumbao	DA-XII RIARC





Appendix Table 3c. Technical Reports on Soil Management, BSWM, Philippines.

CROP	DATE OF PUBLICATION	T I T L E	PROJECT STAFF
<b>Soil Fertility</b>			
Rice and Corn	1998	Balanced fertilization strategy on rice and corn	BSWM staff
Mango	1998	Synergistic effect of parent materials and soil mineralogy in the quality of mango	SWRRD
Maize	1998	Effect of mycorrhizal fungi on the utilization of maize on Ultisols	C.C. Grospe
Maize	1998	Phosphate and lime requirements of maize and groundnut on Utisols	T. Manuel and A. Cruz
Maize and Ginger	1998	Sources of organic matter from various hedgerows and its effect on ginger and maize grown in Ultisols	M.J. Palis, P. Mmontalla and C. Grospe
Bell pepper	1998	Inorganic soil amendment for Ultisols (using bell pepper as test crop)	I.E. Santos, E. Loberiza, P. Pajaro S. Villaraey, A. Carandang, L. de Leon and C. Serrano
White Potato	1998	Response of white potato to N.P. K. Ca. M.G. and micronutrients in Ultisols	P.P. Evangelista and L.C. Agustin
Soybean	1998	Estimation of thebiological N <sub>2</sub> fixation of soybeans using <sup>15</sup> N isotope dilution method	A. Yambot and L. Rubite
Legumes	1998	Uses of legumes to increase productivity of Ultisols	M. Palis, A. Yambot, J. Rojasles, and L. Rubite
Legume-grass	1998	Soil improvement on soil organic matter accumulation by legume-grass mixture	A.A. Bangalan, E.V. Dacanay, J.P. Mercado, and V. Esticoning
Pili	1998	Soil and fertility mgt. of Pili trees	W.S. staff
Lablab and Fish grown	1998	Influence of organic and inorganic fertilizers on the abundance of lablab and fish grown	R. Ulibas, E.M. Bautista, and B.C. Magno
Miscellaneous	1998	Crop response to fertilizer application on different soils	C.B. Alcalde and V.F. Naboa
Miscellaneous	1998	Effect of organic and inorganic amend-ments on crop grown in lahar and Ultisols	W. Peralta, V. Naboa, and C. Alcalde
Miscellaneous	1998	Status of Mg.S. and miconutrients in Ultisols	V. Naboa and T. Manuel
Miscellaneous	1998	Cropping systems and agricultural residue management and their effect on crop yield and fertility status of Ultisols	J. Rojasles and M. Palis

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>
Miscellaneous	1998	Integrated field experiments for fertilizer improvement in Ultisols	R. Ulibas, E. Bautista, and B. Magno
Miscellaneous	1998	Integrated soil amendments for crops grown in Ultisols	F. Torres and J. dela Cruz
Miscellaneous	1998	Essential element deficiency study on Ultisols (Tanay)	E. Bautista, R. Ulibas, and B. Magno
Miscellaneous	1998	Management of P sustainable food crop production on acidic upland soil in Australia, Vietnam and the Philippines	P.P. Evangelista and I.B. Lapis
Miscellaneous	1998	Micronutrient management in highly weathered soil	E.D. Ayo
Miscellaneous	1998	Survey of trace metals in some Philippine soil	R.B. Grifal
Miscellaneous	1998	Physico-chemical and micro-biological validation of soils affected by natural calamities	V.V. Babiera
Miscellaneous	1998	Management of saline soils	V.V. Babiera
Miscellaneous	1998	Competitive survival of rhizobia in Ultisols	M.J. Palis, J. Rojas, and A. Yambot
Miscellaneous	1998	Lahar as inorganic amendment for heavy cracking soils	L. de Leon, W. Peralta, and C.B. Alcaide
Miscellaneous	1998	Field survey of crops adaptable to Ultisols	F. Torres and J. dela Cruz
Miscellaneous	1998	Lysimeter method of determining fertilizer efficiency	E. Dacanay and V. Naboja
Miscellaneous	1998	Effects of differential soil moisture regime on fertilizer efficiency, growth and yield of upland crops grown in Ultisols	V. Babiera, P. Pajaro, and C.F. Serrano
Miscellaneous	1998	Improvement of efficiency and environment impact of N fertilizer through their effective requirements in Asia	P.P. Evangelista and C. Bersabe
Miscellaneous	1998	Potential n mineralization	J. Rojas
Miscellaneous	1998	Trends in the bio-physico-chemical characteristics of Ultisols with the application of organic matter and inorganic fertilizer	M.J. Palis et al.
Miscellaneous	1998	Cumulative residual soil P response to the application of P fertilizer	I.B. Lapis
Miscellaneous	1998	Evaluation of analytical methods of soil and crop determinations	R.B. Grifal et al.
Miscellaneous	1998	Evaluation of analytical methods for soil solution extracted from Ultisols	R.B. Grifal et al.
Miscellaneous	1998	Remote sensing study on Pinatubo affected areas	J. Manguerra
Miscellaneous	1998	Macro and micronutrient mapping computerization	A. Flores and C. Perlado, et al.

<b>CROP</b>	<b>DATE OF PUBLICATION</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>
Miscellaneous	1998	Field validation of soil productivity capability classification	R. Carating, M. Vinluan, et al.
Miscellaneous	1998	Development of methods for basic land classification	R. Carating, O. Costelo, et al.
<b><i>Soil Conservation</i></b>			
Mango	1998	Soil loss quantification and economics of high density planting of mango	A. Gesite, J. Bura, A. Latoza, F. Agustin, F. Ventigan, and H. Apolinales
Agroforestry	1998	An approach to agroforestry management on rolling to hilly grassland	A. Gesite, J. Rojas, R. Creencia, and H. Apolinales
Cogon and Talahib	1998	Competitive potential of mucuna against cogon and talahib in Ultisols	J.P. Mercado, A.A. Bangalan, V. Estoconing, E. Dacanay, and R.B. Grifal et al.
Miscellaneous	1998	Assessment of soil erodibility and rain-fall erosivity	J. Rojas, A. Gesite, P. Montalla, H. Cacayan, C. Serrano, and D. Magtalas
Miscellaneous	1998	Assessment of soil productivity decline associated with erosion	S. Salguero, A. Latoza, J. Bura, and R. Creencia
Miscellaneous	1998	Evaluation of some high value crops/tree crops as contour hedgerows and/or vegetative barriers in controlling erosion	E. Reyes, F. Ventigan, E. Go, M. Marges, and L. Semana
Miscellaneous	1998	Improvement of erosion control practices under various land uses on sloping land	W. dela Cruz, R. Creencia, S. Balading, and A. San Andres
Miscellaneous	1998	Effect of tillage and plant residue management on soil properties, crop yield and erosion	J. Rojas, P. Montalla, F. Agustin, and R. Creencia
Miscellaneous	1998	Management and rehabilitation of degraded hillylands in the Philippines	-
Miscellaneous	1998	Evaluation of different cover crops and soil conservation techniques on surface runoff, sediments and enrichment ratio on microwatershed	-
Miscellaneous	1998	Preparation of technical manual of soil conservation practices	-
Miscellaneous	1998	Establishment of Demo projects for high value crops for vegetative erosion control	-

Appendix Table 3d. Publications on soil management, by crop, Philippines, 1990-1998.

Crop	Author	Year	Title	Publication Title
<b>SOIL CONSERVATION, PHILIPPINES</b>				
Corn	Shively, G.E.	1998	Impact of contour hedgerows on upland maize yields in the Philippines	Agroforestry-Systems (Netherlands) 39 (1)
	Nelson, RA Cramb, RA Meng, KM	1996	Bioeconomic modelling of alternative forms of hedgerow intercropping in the Philippine uplands using SCUAF [Soil Changes Under Agroforestry].	Monograph (SEARCA)
Corn	Shively, G.E.	1996	Upland corn yields in a contour hedgerow system: a production function approach.	Monograph (SEARCA)
Mixed Crops	Mercado, A, Jr. Montecalvo, A Garrry, DP Basri, IH	1992	Upland rice and maize response in a contour hedgerow system on a sloping acid upland soil.	Philippine-Journal-of-Crop-Science (Philippines) 17(1)
Mixed Crops	Baconguis, SR Ranes, LC	1994	Soil and water conservation, strategies for sustainable upland farming in the Philippines.	Philippine-Lumberman (Philippines) 40(1)
	Saplaco, SR	1992	Bench terracing for soil and water conservation: a monograph	Monograph
Mixed Crops	Elliot, PC Moody, K	1991	Influence of weed-control practices in the first crop on the tillage requirements for the succeeding crops in an upland rice-maize-cowpea cropping sequence.	Crop-Protection (United Kingdom) 10(1)
Mixed Crops	Maclean, RH Litsinger, JA Moody, K Watson, AK	1992	The impact of alley cropping Gliricidia sepium and Cassia spectabilis on upland rice and maize production..	Agroforestry-Systems (Netherlands) 20(3)
	Ly-Tung, Balina, FT	1991	Methodological account on the introduction of vetiver grass (Vetiveria zizaniodes) to improve an indigenous technology for soil and water conservation.	Rice-Fareming-Systems-technical-Exchange Philippines 1(4)
	Mendoza, T. C.	1994	Adoption of Soil Benefitting Agricultural Practices for Lowland Rice Production in the Philippines	Philippine Agriculturist 77 (2)

Crop	Author	Year	Title	Publication Title
<b>SOIL CONSERVATION, LUZON</b>				
None		1994	Asian Farming System Symposium (3rd: 1994: Manila) Asian Farming Systems Association	Abstract of paper presented at the 3rd Asian Farming Systems Symposium
	Garcia, JNM Gerrits, RV Cramb, RA Saguiguit, GC, Jr Conchada, JJ Yao, RT Bernardo, RG Perez, AS	1996	Soil conservation in an upland farming system in Nueva Vizcaya [Philippines]: a socioeconomic survey.	Monograph (SEARCA)
Mixed Crops	Magbanua, RD Garrity, DP George, T	1994	Nutrient management strategies for sustainable crop production in highly acid upland soils	Philippine-Journal-of-Crop-Science (Philippines) 19(1)
	Puma, MC and Valerio RF	1992	Climatological Data Analysis for Rainfed Rice Production Management Decisions.	Philippine Agriculturist 75(1 and 2)
	Paningbatan, E.P.	1994	Management of Soil Erosion for Sustainable Agriculture in Sloping Lands.	Philippine Agriculturist 77(1)
	Kawtasi, S. and R.B. Badayos	1997	Toposequence of Soil on Diorite Mountain in Benguet, Philippines	Philippine Agriculturist 80(3 and 4)
	Lantin, R.S., C.C. Quijano; R.Y. Reyes and H.U. Neue	1990	Rice and Problems Soils in the Philippines and the Humid Tropics: Past Development and Strategies for the 21st Century	The Philippine Journal of Crop Science 15(1)
Mixed Crops	Gascon, C. S. N.	1998	Sustainability indicators of the Hanuno Mangyu Agroforestry Systems	Ph. D. Thesis
None	Limbaga, C.	1993	Evaluation of hillylands for appropriate conservation onset farming system.	Ph. D. Thesis
<b>SOIL CONSERVATION, Visayas</b>				
Mixed Crops	Taburada, LAD	1994	Response of basey peat soil to cropping .	Philippine-Journal-of-Crop-Science (Philippines) 19(1)
Mixed	Gonzal, DG	1994	Influence of Gmelina arborea in contour hedgerows under lateral pruning on yield on some upland crops	Philippine-Journal-of-Crop-Science

Crop	Author	Year	Title	Publication Title
Crops	Garrity, DP Dela Cruz, LU		and soil fertility.	(Philippines) 19(1)
Mixed Crops	Garcia, JNM Gerrits,RV Bernardo, RG Conchada, JJ Cramb, RA Perez, AS Saguiguit, GC, Jr Yao, RT	1995	Soil conservation in an upland farming system in Cebu [Philippines]:a socio-economic survey.	Monograph
Rice	Mendoza, T.C.	1994	Adoption of Soil Benefitting Agricultural Practices for Lowland Rice Production in the Philippines	Philippine Agriculturist 77(2)
<b>SOIL CONSERVATION, Mindanao</b>				
Mixed Crops	Macandog,D.B.M. Predo, C.D. Rocamora, P.M.	1998	Environmental and economic impacts of land –use change in tropical Imperata areas.	Philippine-Journal-of-Crop-Science (Philippines) 23(1)
Corn	Garcia, JNM Gerrits,RV Cramb, RA Saguiguit, GC, Jr Conchada, JJ Yao, RT Perez, AS Bernardo, RG	1995	Soil conservation in an upland farming system in Bukidnon [Philippines]: a socio-economic survey.	Monograph (SEARCA)
	Garcia, JNM Gerrits,RV Cramb, RA Saguiguit, GC, Jr Conchada, JJ Yao, RT Bernardo, RG Perez, AS	1995	Soil conservation in an upland farming system in Davao del Sur [Philippines]:a socio-economic survey.	Monograph (SEARCA)

Crop	Author	Year	Title	Publication Title
	Pava, AM Arrances, JB Mugot, IO Manubag, JM Sealza, IS Magallanes, JM	1994	Farmers' participatory processes on soil and water conservation of Bukidnon uplands (Philippines)	Philippine-Journal-of-Crop-Science (Philippines) 19(1)
Mixed Crops	Elliot, PC Moody, K Franje, HD	1990	Determining suitable weed control approaches in an upland rice-cowpea inter crop	Monograph (IRRI)
	Kaing, SA	1994	Indigenous agroforestry systems of the Tausug in Western Minadanao [Philippines].	MS thesis
<b>SOIL CONSERVATION, Mindanao</b>				
Mixed Crops	Elliot, PC Moody, K Franje, K	1993	Effect of tillage on upland crops and weeds in Claveria, Misamis Oriental [Philippines]	Philippine-Journal-of-Weed-Science (Philippines) 20
	Coxhead, I. and Rola, AC	1998	Econ. Development; Agricultural Growth and Environmental Mgt: An investigation of their Linkages in Lantapan, Bukidnon.	Working Paper #98-04 ISPPS, UPLB
Rice	Mendoza, T.C.	1994	Adoption of Soil Benefitting Agricultural Practices for Lowland Rice Production in the Philippines	Philippine Agriculturist 77(2)
	Tagarino, E.P. and A. C. Rola	1996	Productivity Analysis of Upland Corn Systems: The Case of Lantapan, Bukidnon, Philippines	Philippine Agriculturist 79(3 and 4)
None	—	1991	Philippine Land and Soil Management Atlas for Mindanao: Region IX-XII	Book. BSWM, Agricultural Land Evaluation Division
<b>SOIL FERTILITY, Philippines</b>				
Mixed Crops	Lales, JS Lapitan, MA	1993	Morphological and physiological response of four upland crops to geothermal effluent residues and fertilizer in a contaminated lowland soil.	Philippine-Agriculturist (Philippines) 76(2)
Vegetables	Villareal, RL Paje, MM	1990	Vegetable production in the Philippines	Tropical-Agriculture-Research-Series (Japan)



Crop	Author	Year	Title	Publication Title
Mango	Babiera, Victorcito Ibbay, Sheila	199_	Synergistic Effect of Parent Materials on Soil Mineralogy on the Quality of Phil. Mango.	paper (unpublished)
		1997	Research and Promotion on Bio/organic Fertilizers for Rural Development.	Terminal report. BIOTECH, 1996-1997
None		19_	Wastong Paggamit ng Soil Insulse	
Mixed Crops	Shrestha, R. K.	1997	Nitrogen conservation and recycling and carbon management for the sustainability of intensive rice-based cropping system.	Ph. D. Thesis
<b>SOIL FERTILITY, Luzon</b>				
Mixed Crop	Dela Cruz, AA Manuel, BT Sana, EJ Aromin, FB Rasco, ET, Jr.	1992	Intercropping sweet potato on white potato.	Philippine-Journal-of-Crop-Science (Philippines) 17(1)
Mixed Crops	Suyat, MN Lacson, RT Bayot, AJ	1992	Adaptability of different field crops under lahar laden soils.	Philippine-Journal-of-Plant-Industry (Philippines) 57(3-4)
Mixed Crops	Mendoza, T. C. Cabangbang, R. P.	1992	Effects of Mt. Pinatubo [Philippines] eruption in crop production system.	Philippine-Agriculturist (Philippines) 75(1 and 2)
Mixed Crops	CLSU Research Office	1995	Crop Production technoguide in Ash and Lahar Laden Areas Muñiz, NE. Res Office, CLSU	Book CLSU
Ramie	Buendia, LV Cabangbang, RP Franco, DT		Responses of Ramie (Boehmeria nivea Gand) to Soil Moisture Stress and Flooding	Philippine Agriculturist, 73(3 and 4)
Rice	Basilio, PR GO San Valentin	1990	Potassium Quantity-Intensity Relationship in Some Lowland Rice Soils	Philippine Agriculturist, 73(1)
Mixed Crops	Reglos, RA CC de Guzman	1991	Morpho-Physiological Modifications in Patchouli, Pogostemon cablin (Blanco) Benth, Under Varying Shade and Nitrogen Levels	Philippine Agriculturist 74(3)
Mixed Crops	Monsalud, RG, OS Sabiniano, NU Trillana and JC Lanceras	1991	Comparison of Competitiveness, N <sub>2</sub> Fixation and Persistence of Three Centrosema Rhizobium Spp. In a Grassland Soil	Philippine Agriculturist 74(4)

Crop	Author	Year	Title	Publication Title
Azolla	Payawal, PC, AC Tilde, MAR de Macale	1991	Population growth of Selected Azolla Hybrids Grown on Lahar-Contaminated Soil	Philippine Agriculturist 74(4)
<b>SOIL FERTILITY, Luzon</b>				
Sugar-	Mendoza, TC,	1993	Minimizing Inorganic Nitrogen Fertilizer Application in	Philippine Agriculturist 76( 2)
cane	Aromin, EB, Celestino, ER Andam, CJ		Sugarcane Production Through Intercropping with Inoculated Legume	
Ramie	Hondrade, EG, Cabangbang, RP	1993	Fiber Fineness as Affected by fertilization and Harvest Stage in Ramie	Philippine Agriculturist 76( 2)
Mixed varied crops	Lales, JS Lapitan, MA	1993	Morphological and Physiological Response of Four Upland Crops to geothermal Effluent Residues and fertilizer in a Contaminated Lowland Soil	Philippine Agriculturist 76( 2)
Rice/ azolla	Lales, JS Lapitan, MA Lales, EH	1993	Performance of Lowland Rice and Azolla on a Soil Contaminated with Liquid Geothermal Effluent	Philippine Agriculturist 76( 2)
	Paningbatan, E.P., Jr, J.R. Medina, S.M.F. Calumpang, and M.J. Medina	1993	Movement of Monocrotophos and Endosulfan in Saturated Soil	Philippine Agriculturist 76( 3)
Rice	Garcia, AG, Lansigan, FP and Orno, JL	1993	Simulated response of Upland Rice to Phosphorus Fertilizer in Two Acid Upland Sites in the Philippines	Philippine-Agriculturist 76(2)
Peanut	Serojihos, R.C. and H.P. Samonte	1993	Liming, Phosphorus and Sulfur Fertilization of Maasin Clay and Dolongan Peat Grown to Peanut	Philippine-Agriculturist 76(4)
Forage Grasses	Olermo, N.C. and H.P. Samonte	1996	Fertilizer and Irrigation Management for selected Forage Grasses on Alaminos Sandy Clay	Philippine-Agriculturist 79(3 and 4)
Rice	San Valentin, G.O., K.S. Mosomos, and R.G. Bayot	1996	Phosphorus Sorption of Some Flooded Rice Soils in Laguna	Philippine-Agriculturist 79(3 and 4)
<b>SOIL FERTILITY, Luzon</b>				
Rice	Obcemea, W.N., J.G. Real and SK De Datta	1990	Reducing Nitrogen Losses by Switching from Transplanted to Broadcast Seeded Flooded Rice	The Philippine Journal of Crop Science 15(2)

Crop	Author	Year	Title	Publication Title
Rice	Shah, A.L. and S.K. De Datta	1991	Sulfur and Zinc Interactions in Lowland Rice	The Philippine Journal of Crop Science 16(1)
Rice	Reyes, R.Y. and H.U. Neue	1991	Characterization of the volcano Ejecta from Mt. Pinatubo and Its Impact on Rice Production	The Philippine Journal of Crop Science 16(2)
Rice	Novero, R.P., S.K. de Datta and E.L. Aragon	1992	Grain Yields and Nutritional Uptake of Irrigated Maize, Sorghum, and Rice Fertilized with Different Levels of Nitrogen	The Philippine Journal of Crop Science 17(1)
Rice	Metra-Corton, T.M., J.B. Bajita, C.A. Asis, Jr. and R.R. Pamplona	1995	Methane Emission from an Irrigated Philippine Paddy Field Subjected to Several Fertilizer Treatments	The Philippine Journal of Crop Science 20(1)
Rice	Faustino, F.C., H.S. Lips, and E.P. Pacardo	1996	Physiological and Biochemical Mechanism of Salt Tolerance in Rice: Sensitivity Thresholds to Salinity of Some Physiological Processes in Rice ( <i>Oryza sativa</i> L.)	The Philippine Journal of Crop Science 21(1 and 2)
Rice	Tripathi, B.P., J.K. Ladha and S. Pandey	1997	Economic Feasibility, Production Potential and Nitrogen Behavior in Intensively Cultivated Rice-Based Cropping Systems in Northern Luzon, Philippines	The Philippine Journal of Crop Science 22(1)
<b>SOIL FERTILITY, Visayas</b>				
Sweet potato	Pardales, J. R.	1993	Inhibitory influence of sweet potato-used soil on the root growth of sweet potato plants.	The Philippine Journal of Crop Science 18(3)
Cassava	Agili, S.M. and J.R. Pandalo, Jr.	1997	Influence of moisture and allelopathic regimes in the soil on the development of cassava and mycorrhizal infection of its roots during establishment period	The Philippine Journal of Crop Science 22(2)
Mixed crops	Taburada, L.A.D.	1994	Characterization of soils in the Mt. Pangasugan (Philippines) floodplain	Philippine Journal of Crop Science 19
<b>SOIL FERTILITY, Mindanao</b>				
Rubber	Tolentino, L. M.	1998	Soil management & mineral nutrition in Hevea	Philippine Journal of Crop Science v.23 Supp. #1 p.50
Corn	Duque, Sr. C.M., HP Samonte	1990	Influence of Silicate and Sulfate on Phosphorus Sorption of yields of corn	Philippine-Agriculturist 73(1)

Appendix Table 4. UPLB Graduate theses on water management by crop, 1990-1998.

CROP	DATE OF PUBLICATION	T I T L E	AUTHOR
<b><i>Luzon - Water Delivery</i></b>			
Miscellaneous	1990	Factors affecting performance of communal irrigation system members: the case of Bugaan communal irrigation system [Laurel, Batangas, Philippines]	R. Poudel
<b><i>Philippines - Water Delivery</i></b>			
Rice	1990	Effects of irrigation on productivity, output and income: a decomposition analysis	J.T. Quintana
Rice	1990	Effect of different levels of light and drought stress on individual spikelet filling in rice ( <i>Oryza sativa</i> L.)	F.A. Begum
Rice	1992	Drainage problems in a typical diversion irrigation system	K.R. Sharma
Rice	1993	Influence of water regime on rice-Meloidogyne graminicola relationships and its implications in testing for resistance or tolerance of rice cultivars	I.C. Tandingan
Miscellaneous	1992	Impact of upper watershed destruction on the performance of national irrigation systems in the Philippines	M.V.M. De Vera
Miscellaneous	1993	Assessment of the environmental impacts of the proposed water resource development project on the lake water aquaculture industry of Taal Lake, Batangas Province	M.M. Acedera
<b><i>Philippines - Water Technology</i></b>			
Rice	1994	Design and performance of the rod cultivator principle in irrigated lowland rice for reducing soil cracks	Bui-Duc-Quy
Soybean	1990	Effect of border length and inflow on water application and distribution efficiencies in border strip irrigation	A.K. Shukla
Soybean	1990	Performance of three soybean ( <i>Glycine max</i> (L.) cultivars at varying watertable depths	M.J.C. Alagos

Appendix Table 5a. Technical reports on water management, by crop.

CROP	YEAR	T I T L E	PROJECT STAFF	IMPLEMENTING AGENCY
<b>WATER MANAGEMENT, LUZON</b>				
Upland Crop	1990	Evaluation of soil parameters for irrigation planning and design for upland crops for the town of Sta. Ana, Pampanga.	Gatas, R.S.	Malabon, Metro Manila
None	1990	Factors affecting performance of communal irrigation system members: the case of Bugaan communal irrigation system, Laurel, Batangas, Philippines.	Poudel, R.	College, Laguna
None	1990	Water quality assessment and management of Laguna de Bay (Philippines): concepts, problems and strategies.	Barril, C.R.	College, Laguna
None	1991	Watershed management: impacts on the Tumauni Irrigation System, Tumauni, Isabela.	Romero, M.R.	College, Laguna
None	1994	Final report, program on farmer-manage irrigation systems and support services.		
None	1997	Irrigation management for rice-based farming systems in Indonesia, Bangladesh and the Philippines	Gumtang, R.J.; P.S. Bucao, L.B. Taclan	
<b>WATER TECHNOLOGY, LUZON</b>				
Mixed crops	1989	Optimum farm ditch density for irrigated diversified cropping: a preliminary study.	Pascual, C.M.; W.B. Adap	MMSU, Batac, Ilocos Norte
None	1990	Viability of drip irrigation in northeast Cavite (Philippines): a mini-assessment of an emerging technology.	Lamanilao, J.D.	College, Laguna
<b>WATER MANAGEMENT AND SOIL FERTILITY, LUZON</b>				
Forage grasses	1996	Fertilizer and irrigation management for selected forage grasses on Alaminos sandy clay.	Olermo, N.C.	UPLB
<b>WATER MANAGEMENT/SOIL CONSERVATION, LUZON</b>				
None	1992	Soil and water conservation in an upland farming system in Nueva Viscaya		
None	1996	Soil conservation in an upland farming system in Nueva Viscaya (Philippines)	Garcia, J.N.M.; R.V. Gerrits, R.A. Cramb	

Appendix Table 5a. Continued...

CROP	YEAR	TITLE	PROJECT STAFF	IMPLEMENTING AGENCY
<b>SOIL CONSERVATION/WATER MANAGEMENT, VISAYAS</b>				
None	1991	Methodological account on the introduction of vetiver grass ( <i>Vetiveria zizanioides</i> ) to improve an indigenous technology for soil and water conservation.	Balina, F.T.	VISCA, Baybay, Leyte
None	1992	Soil and water conservation (SWC) technologies and agroforestry systems		
None	1996	Influence or impact of land tilting on the behavior of farmer-participants toward the adoption of conservation	Luna, A.; A. Calderon, V. Austria, and Jr.	PCARRD
<b>WATER MANAGEMENT, VISAYAS</b>				
None	1991	Social and economic sustainability of communal irrigation systems in Iloilo Province (Philippines).	Alicante, E.L.	College, Laguna
Mixed crops	1992	Management arrangements for accommodating non-rice crops in rice-based irrigation systems.	Miranda, S.M. and A.R. Maglinao	IIMI, Colombo, Sri Lanka
<b>WATER TECHNOLOGY, VISAYAS</b>				
None	1991	Participation of dwellers in water shed rehabilitation in Capiz, Philippines.	Gregorio, E.L.	College, Laguna
None	1994	Process documentation and analysis of the first phase of the Development Action Program of the Bais Ba	Walters, B.B.; A.M. Cadelina, A. Cardano	
None	1994	Intensive cropping and groundwater quality deterioration	Walters, B.B.	

Appendix Table 5a. Continued...

<b>CROP</b>	<b>YEAR</b>	<b>TITLE</b>	<b>PROJECT STAFF</b>	<b>IMPLEMENTING AGENCY</b>
<b>WATER MANAGEMENT, MINDANAO</b>				
None	1991	Factors affecting pricing of irrigation water: the case of Aris I (First Allah River Irrigation System, South Cotabato and Sultan Kudarat, Mindanao	Rendon, E.A.A.	College, Laguna

Appendix Table 5a. Continued...

CROP	YEAR	TITLE	PROJECT STAFF	IMPLEMENTING AGENCY
<b>WATER MANAGEMENT, PHILIPPINES</b>				
Mungbean	1989	Field-level drainage requirement of pre-rice mungbean crop in a waterlogged-prone environment.	Polthanee, A.	College, Laguna
Mixed crops	1992	Irrigation management for diversified cropping in rice-based systems in the Philippines	Valera, A.	International Irrigation Management Inst. Kathmandu (Nepal) Colombo (Sri Lanka)
Rice	1990	Contamination of water resources by pesticides from irrigated agriculture.	Castañeda, A.R.; S.I. Bhuiyan; P.L. Pingali; E.F. Acedo	IRRI Bacolod City
Rice	1995	Rainwater conservation and management as influenced by tillage, land leveling and field bunds in rainfed lowland dry seeded rice.	Yadav, M.K.	UPLB
Rice	1996	Quantifying flow processes during land soaking of cracked rice soils.	Tuong, T.P. ; R.J. Cabangon; M.C.S. Wopereis	IRRI Soil-Science-Society of America (USA)
Rice	1996	Biology and management of the floodwater ecosystems in ricefields.	Roger, P.A.	IRRI
None	1990	Effect of border length and inflow on water application and distribution efficiencies in border strip irrigation.	Shukla, A.K.	College, Laguna
None	1993	Economic failure plaques developing countries' public irrigation: an assurance problem		
None	1994	Management of groundwater resources in the Philippines.	Dumandan, G.S.	FAO, Bangkok (Thailand)
None	1994	Operation and maintenance of lifting irrigation systems in the Philippines.	Dumandan, G.S.	FAO, Bangkok (Thailand)
None	1995	The other side of the coin: a case study on the impact of financial autonomy on irrigation management performance in the Philippines.	Ooerhuizen, J.; W.H. Kloezen	Landbouuniversiteit Wageningen (Netherlands)



Appendix Table 5a. Continued...

<b>WATER TECHNOLOGY, PHILIPPINES</b>				
None	1990	Effects of irrigation on productivity, output and income: a decomposition analysis.	Quintana, J.T.	College, Laguna
None	1990	Drip irrigation: a promising technology for sustainable dryland agriculture.	Pacardo, E.P.	UPLB
None	1991	Evapotranspiration and yield of wetland rice under non-submerged condition.	Redulla, C.A.	College, Laguna
None	1995	Effect of irrigation on soil crusting and seedling emergence.	Torres-Guy, A.	UPLB Uppsala (Sweden)
Rice	1996	Nitrogen use efficiency of irrigated tropical rice established by broadcast wet-seeding and transplanting	Peng S. ; F.V. Garcia, H.C. Laza, R.C. M.I. Samson, A.L. Sanico; A.L.; R.M. Visperas, K.G. Cassman	IRRI Agronomy, Plant Physiology and Agroecology Div. Fertilizer-Research (Netherlands)
Rice	1996	Intensification of irrigated rice systems: learning from the past to meet future challenges.	Cassman, K.G.; P.L. Pingali	IRRI

Appendix Table 5b. Publications on water management, by crop, and by region, Philippines, 1990-1998.

Crop	Author	Year	Title	Publication Title
<b>WATER DELIVERY/WATERSHED MANAGEMENT, Philippines</b>				
Mixed Crops	Baconguis, SR Ranes, LC	1994	Soil and water conservation, strategies for sustainable upland farming in the Philippines.	Philippine-Lumberman (Philippines) 40(1)
	Saplaco, SR	1992	Bench terracing for soil and water conservation: a monograph	Monograph
none	Fujita, Masako, Yuhiro Hayami, Masao Kikuchi and Esther P. Macriano	1996	Deterioration of a National Irrigation System in the Phil. A Preliminary Appraisal.	SS Disc Paper 4/96 IRRI (unpublished)
<b>WATER DELIVERY, Luzon</b>				
various crops	Agricultural and Rural Dev't of Community Foundation of the Phil.	1996	Dev't. of Community-Based Integrating Farming Systems on Non-Irrigated Farms in Talugtug, Nueva Ecija	Progress Report 3 (unpublished)
none	Martinez, Elmer and Gerald Shively	1999	Can Agriculture Intensification Stop Deforestation? Irrigation, Employment and Poor Cautious Optimism in Southern Palawan, Phil. CIFOR	unpublished, CIFOR
Rice	Saleh, A.F.M. and S.I. Bhuiyan	1993	Improving Soil Water Regime for Crop Intensification in Rainfed Lowlands: The Role of Dry-Seeded Rice	The Philippine Journal of Crop Science 18(2)
Corn	Del Rosario, D.A., P.A. Santos, and A.C. Sumague	1991	Response of Corn (Zea mays L.) to High Temperature and Drought Stress Treatments	Philippine Agriculturist 74(2)
none	Medina, J.R., S.M.F. Calumpang and M.J.B. Medina	1991	Insecticide Residues in Selected Well Water in Calamba, and Calauan, Laguna	Philippine Agriculturist 74(2)
<b>WATER DELIVERY, Luzon</b>				
Various crops	Del Rosario, D.A. and F.F. Fajardo	1991	Waterlogging Resistance in Crops	Philippine Agriculturist 74(1)
Rice	Lales, J.S.	1991	Liquid and Vapor Phase Conductance of Rice Exposed to Soil Drying	Philippine Agriculturist 74(4)

Crop	Author	Year	Title	Publication Title
Rice	Dumaoal, I. D. and F. Pascual	1991	Adaptation trial of PSB recommended lowland rice varieties under Ilocos Norte conditions	PCARRD Highlights ' 91
Rice	Posadas, W. S.	1991	Varietal trial of rice under lowland rainfed conditions	PCARRD Highlights ' 91
Rice	Paz, J. O.; L. D. Bagaoisan; R. J. Raganit Jr.; A. Q. Ganal; A. S. Cristobal; L. C. Javier	1991	Water quality survey in tobacco-growing areas	PCARRD Highlights ' 91
Okra	Garcia, N. C. Jr.	1991	Varietal trials of okra during wet and dry season planting	PCARRD Highlights ' 91
Eggplant	Posadas, R. S. and D. N. Simon	1991	On-farm testing of a potential eggplant variety for dry season planting	PCARRD Highlights ' 91
<b>WATER DELIVERY, Luzon</b>				
none	Pascual, C. M.; M. P. Caluya; C. G. Acosta; E. Barit; E. Galacgac; E. Nalundasan	1991	Field testing of irrigation management innovations for the Laoag-Vinta River Irrigation	PCARRD Highlights ' 92
Rice	Dela Cruz, H. C. Jr. et al	1993	National coop performance test for rainfed lowland rice	PCARRD Highlights ' 93
none	Gumtang, R. J.; E. S. Galacgac; R. Pambid L. Bareng; Z. Agngarayngay; Llaguno; R. A. Natividad	1993	Evaluation of groundwater resources for irrigation in Ilocos Norte	PCARRD Highlights ' 93
Rice	Bingo, J. P.; R. Garcia; J. D. Miniano; G. Narciso	1994	Integrated use of organic and inorganic nitrogen fertilizer on rice in rainfed coastal area, Bacnotan, La Union	PCARRD Highlights ' 94
Rice	Bugaoan, L. C.; R. M. Soriano; R. D. Ballesteros	1994	Adaptability trial on the different varieties of lowland irrigated rice	PCARRD Highlights ' 94
Rice	Galvez, A. M.	1994	National cooperative performance test for rice	PCARRD Highlights ' 94
none	Gumtang, R. J.	1994	Groundwater quality evaluation for irrigation in Ilocos Norte	PCARRD Highlights ' 94
Rice	Sibayan, E. B. and R. C. Undan	1994	Shallow groundwater potential and constraints for irrigating lowland rainfed rice-based farms	PCARRDS Highlights ' 94

Crop	Author	Year	Title	Publication Title
<b>WATER DELIVERY, Luzon</b>				
Rice	Torres, L. D.; S. F. Kalaw; R. L. Gutierrez; E. A. Malamug	1994	Quality of groundwater in farming areas in Central Luzon	PCARRD Highlights ' 94
Rice, peper, mung-bean	Gumtang, R. J.; L. B. Taclan; D. S. Bucao; A. R. Castañeda; E. Q. Agustin; T. P. Tuong; J. K. Ladha; S. I. Bhuiyan; W. Obsemea	1995	Sustainability of intensive cropping with reference to water management and ground water resources	PCARRD Highlights ' 95
<b>WATER TECHNOLOGY, Philippines</b>				
Mung-beans Sweet	Pernito, R Garrity, DP Evangelio, F. A. B.;	1992	Farm level evaluation of drainage technology for mungbeans grown prior to lowland rice.	Philippine-Journal-of-Crop-Science (Philippines) 17(1)
potato	C. D. Vega;; V. Godoy	1996	Soil fertility management in Dolores, Quezon, Bialoi, Lanao del Norte, and Dulag, Leyte.	PCARRD Highlights ' 96
<b>WATER TECHNOLOGY, Luzon</b>				
Grasses	Olermo, NC and HP Samonte	1996	Fertilizer and irrigation Management for selected Forage Grasses on Alaminos Sandy Clay	Philippine Agriculturist 79(3 and 4)
Rice	Labios, RV, VT Villancio JD Labios, AM Salazar and RE de los Santos	1997	development of Alternative Cropping Patterns in Rainfed Lowland Area with Small Farm Reservoir	Philippine Agriculturist 80(3 and 4)
Rice, mung-beans	Pernito, R. and DP Garrity	1992	Farm level Evaluation of Drainage Technology for Mungbeans Grown Prior to Lowland Rice	The Philippine Journal of Crop Science 17 (1)
Rice	Undan, R. C.	1991	Small farm reservoir pilot project in Region III	PCARRD Highlights ' 92
Rice	Unciano, H. C. and L. H. Bondad Temanel, B. E.; S. C. Benigno; R. Lajola; E. Eniego; F. Vicente; A.Uh-hub; C.Hernando; L. E. Draman	1992	Rice hull pyrolyzer for farm irrigation	PCARRD Highlights ' 93
		1992	Small Farm Reservoir development project in Quirino	PCARRD Highlights ' 93

Crop	Author	Year	Title	Publication Title
	Maglinao, A. R.	1994	National program on small farm reservoir, Los Baños, Laguna	PCARRD Highlights ' 94
Rice	Valdez, J. R.	1995	Utilization of on-farm reservoir for growing non-rice crops	PCARRD Highlights ' 95
<b>WATER TECHNOLOGY, Visayas</b>				
none	Belonio, A.T. and A. C. Rico	1995	Design and evaluation fo DA-SFI windpump	PCARRD Highlights '95
<b>WATER TECHNOLOGY, Mindanao</b>				
Upland crops	Ramos, E. P.	1995	Spring water for irrigation purposes	PCARRD Highlights ' 95

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't.)

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>JOURNALS</b>				
<b>WATERSHED MANAGEMENT/WATER DELIVERY, LUZON</b>				
None	Madamba, L.S.F. Galapate, R.P. Decena, A.M. Samaniego, N.A.	1992	Pollution load contribution of San Juan and San Cristobal Rivers to Laguna de Bay [Philippines]	Philippine Journal of Science (Philippines). (Jul-Sep 1992). v. 121(3) p. 317-344.
Rice	Corton, T.M. Bajita, J.B. Pamplona, R.R. Grospe, F.S. Lantin, R.S. Wassman, R.	1997	Management options to mitigate methane emissions from irrigated ricefields	Philippine Journal of Crop Science (Philippines). (May 1997). v. 22 (supplement no. 1) p. 37.
Rice	Confeso Jr., R.B. To Phuc Tuong	1997	Hydraulic properties and crack pattern of dried puddled soils under transplanted and wet-seeded rice	Philippine Journal of Crop Science (Philippines). (May 1997). v. 22 (supplement no. 1) p. 18.
Rice	Cabangon, R. To Phuc Tuong	1997	Reducing bypass flow during land preparation of cracked rice soils	Philippine Journal of Crop Science (Philippines). (May 1997). v. 22 (supplement no. 1). p. 25-29.
Rice	Herrera, W. Blanco, A. Garrity, D.P.	1995	Stabilizing rice yields by controlling paddy water loss with a subsurface barrier	Philippine Journal of Crop Science (Philippines). (Nov 1991). v. 16 (supplement no. 1) p. 58.
<b>WATER TECHNOLOGY, LUZON</b>				
None	Baqui, M.A. Angeles, H.L.	1991	Design and test of a drip irrigation system with alternative materials	CLSU (Central Luzon State University) Scientific Journal (Philippines). Nov 1991- Mar 1992). v. 12(2).
Cotton	Cruz, R.S. Agulto, I.C.	1998	Seedcotton yield increase and water saving with a designed trickle irrigation system	Philippine Journal of Crop Science (Philippines). v. 23 (supplement no. 1) p. 24.
Cotton	Ganotisi, N.D. Cruz, R.S. Cosico, V.B. Catedral, I.G.	1998	Drip irrigation trial for cotton production using three levels of N-fertilizer	Philippine Journal of Crop Science (Philippines). v. 23 (supplement no. 1) p. 24.
Cowpeas	Timsina, J. Robles, R.P. Garrity, D.P. Pandey, R.K.	1989	Weed population in cowpeas (Vigna unguiculata (L) Walp) as influenced by water table, moisture regime and cultivar	Philippine Journal of Crop Science (Philippines). (Dec 1989). v. 14(3) p. 115-121.
Mungbean	Pernito, R.	1992	Farm level evaluation of drainage technology for	Philippine Journal of Crop Science (Philippines).

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
	Garritty, D.P.		mungbeans grown prior to lowland rice	(Apr 1992). v. 17 (1) p. 27-35.
Rice	De Dios, J.L. Corpuz, A.A. Punzalan, E.M.S. Quiland, J.P. Cruz, R.T.	1998	Intermittent irrigation and yield of transplanted lowland rice	Philippine Journal of Crop Science (Philippines). v. 23 (supplement no. 1) p. 76.
Rice	Marciano, E.B. Fujita, M. Mahabub-Hossain Kikuchi, M.	1997	Economic analysis of the deterioration of a national irrigation system in Laguna [Philippines]	Philippine Journal of Crop Science (Philippines). (May 1997). v. 22 (supplement no. 1) p. 48
Sugarcane	Marcelo, M.P.	1990	Drip irrigation of an intercropped sugarcane farm at double row planting under Pampanga conditions [Philippines]	Philippine Sugar Quarterly (Philippines). (Jul-Sep 1990). v. 1(3) p. 1-12.
<b>WATER TECHNOLOGY, VISAYAS</b>				
Rice	Urich, P.B.	1993	Stress on tropical karst cultivated with wet rice: Bohol, Philippines	Environmental Geology (USA). (Jun 1993). v.21(3) p. 129-136. Available at US (DNAL QE1.E5)
<b>WATERSHED MANAGEMENT, LUZON</b>				
CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
None	Tactay, F.C. Quintana, S.B.	1996	Attitudinal levels of forest occupants toward ecological concerns in Antipolo, Marikina Watershed	Araneta Research Journal (Philippines). v. 34 p. 44-49.
<b>WATER CONSERVATION, MINDANAO</b>				
None	Heaney, L.R. Tabaranza, B.R. Jr.	1995	Preliminary report on mammalian diversity and conservation status in Camiguin island, Philippines	Technical Journal of Philippines Ecosystems and Natural Resources. v. 5 (1-2) p. 57-64.
<b>WATER MANAGEMENT, MINDANAO</b>				
None	Magallanes, J.M.	1993	Developing a social framework of performance indicators system: a study for effective irrigation management at Punlangui River Irrigation System (PRIS), Valencia, Bukidnon, Philippines.	Central Mindanao University (CMU) Journal of Science (Philippines). (Jun 1992). v. 5(2) p. 10-21.
<b>WATERSHED MANAGEMENT/DELIVERY, PHILIPPINES</b>				
CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
None	De Vera, Ma.V.M. Pingali, P.L.	1992	Impact of upper watershed destruction on the performance of national irrigation systems in the Philippines	Philippine Journal of Crop Science (Philippines). (May 1992). v.
None	Atega, P.C. Gulinao, M.	1996	Hydrolic behavior of Sloping Agricultural Land Technology (SALT) within Marikina Watershed	Araneta Research Journal (Philippines). v. 34 p. 56-59.

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
None	Munasinghe, M.	1991	Groundwater resource management and environmental protection. A case study of the Philippines	Natural Resources Forum (UN). (Nov 1991). v. 15(4) p. 302-321.
None	Agua, M.M.	1995	Conceptual development of soil loss estimation at the watershed level	Philippine Journal of Crop Science (Philippines). (Apr 1995). v. 20 (supplement no. 1). p. 23-30.
None	Guerrero III, R.D.	1991	Conservation and management of our freshwater ecosystems	Philippine Technology Journal (Philippines). (Oct-Dec 1991). v. 16 (4) p. 59-64.
Cotton	Ganotisi, N.D. Cruz, R.S.	1994	Effects of water stress imposition on the growth and yields of three cotton varieties	Cotton Research Journal (Philippines). (Jan-Dec 1994). v. 7(1-2) p. 41-51.
Forage Grasses	Olermo, N.C. Samonte, H.P.	1997	Fertilizer and irrigation management for selected forage grasses on alaminos sandy clay	Philippine Agriculturist (Philippines). (Jul-Dec 1996). v. 79 (3 and 4) p. 145-157.
Rice	Mastan, S.C. Vijaykumar, B.	1993	Water management in transplanted wetland rice	International Rice Research Notes (Philippines). (Sep 1993). v. 18(3) p. 38-39.
Rice	Maglinao, A.R.	1990	Water management for improved post-rice production of upland crops in irrigated paddies	Philippine Technology Journal (Philippines). (Oct-Dec 1990). v. 15(4) p. 23-26.
Rice	Gacon, F.B. Hossain, M.	1995	Relative efficiency of private and public irrigation system: the case of two Philippine villages	Philippine Journal of Crop Science (Philippines). (Apr 1995). v. 20 (supplement no. 1). p. 44.
Rice	Corton, T.M. Bajita, J.B. Grospe, F.S.	1998	Reduction of methane emission from irrigated lowland rice cropping	Philippine Journal of Crop Science (Philippines). v. 23 (supplement no. 1) p. 49.
<b>WATER TECHNOLOGY, PHILIPPINES</b>				
None	Merrey, D.J. Valera, A. Dassenaike, L.	1994	Does assessing irrigation performance make a difference? Results of a comparative study of three irrigation systems	Quarterly Journal of International Agriculture (Germany). (1994). v. 33(3) p. 276-293.
None	Naegell, L.C.A. Real, J.G. Mazaredo, A.M.	1990	Research and development of the spiral pump for water-disadvantaged areas in the Philippines; par 1; statistically aided design of prototypes at Los Banos [Laguna, Philippines]	Philippine Technology Journal (Philippines). (Oct-Dec 1990). v. 15(4) p. 7-16.
Cotton	Cruz, R.S. Agulto, I.C.	1996	Economics of a designed trickle irrigation system using a twin-wall emitter tubing	Cotton Research Journal (Philippines). v. 9 (1-2) p. 52-58
Rice	Surek, H. Aydin, H. Cakir, R. Karaata, H. Negis, M. Kusku, H.	1996	Rice yield under sprinkler irrigation	International Rice Research Notes (Philippines). (Aug-Dec 1996). v. 21 (2 & 3) p. 81-82.



CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
Rice	Olk, D.C. Cassman, K.G. Mahieu, N. Randall, E.W.	1998	Conserved chemical properties of young humic acid fractions in tropical lowland soil under intensive irrigated rice cropping	European Journal of Soil Science (United Kingdom). v. 49 (2) p. 337-349.
Rice	Timsina, D. Ferrer, A.L. Paris, T. Duff, B.	1993	Rural women in irrigated and rain-fed rice farming in the Philippines: Decision-making involvement and access to productive resources	Journal of Farming Systems Research Extension (USA). (1993). v. 3(2) p. 147-161. Available at US (DNAL S494.5.S95J68).
Rice	Rotor, P.V.B. Jr. Gonzalo, B.C. Silva, T.C. Salazar, G. Tadeo, B.O. Stickney, R.E.	1993	Design, development and testing of a small electric pump for supplementary irrigation in rainfed areas	Philippine Journal of Plant Industry (Philippines). (Oct-Dec 1991). v. 56(4) p. 33-45.
Rice	Angadi, V.V. Imapathy, P.N.	1996	Supplemental irrigation for dry seeded upland rice	International Rice Research Notes (Philippines). (Aug-Dec 1996). v. 21 (2 & 3) p. 81.

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>JOURNALS</b>				
<b>WATERSHED MANAGEMENT, LUZON</b>				
	Sierra, Z.N. Macandog, D.B.M. Sotalbo, D.D. Guzman, M.E.	1990	Land use inventory of Laguna de Bay watershed areas.	UPLB
	Garzon, R.S.	1990	Development and application of the fluctuating watertable model in the management of a controlled-drainage/subirrigation system.	USM
Sorghum	Cruz, R.T.	1994	Growth and hydraulic conductance of sorghum roots.	Philrice, Muñoz, Nueva Ecija
Mixed crops	Maligaya, A.R. Sanidad, W. Wopereis, M.C.S. Kropff, M.J.	1992	Measurement of bypass flow and internal catchment of rainfall in a dry, previously puddled clay soil.	IRRI
Mixed crops	Cabangon, R.J. Marquez, J.A.	1993	Quantifying seepage-induced excess water for upland crops grown in rice irrigation systems.	IRRI
Mixed crops	Saleh, A.F.M. Bhuiyan, S.I. Tuong, T.P.	1993	Improving the soil water regime for crop intensification in rainfed lowlands: the role of dry-seeded rice.	Bangladesh University of Engineering & Technology
Cotton	Ganotisi, N.D.	1997	Response of cotton to inter tillage and irrigation schedule under lowland after rice condition.	Phil. Journal of Crop Science
Rice	Cruz, R.S. Pablico, P.P. Yamauchi, M. Cabangon, R.	1993	Effect of water level on the performance of direct seeded, anaerobic rice cultivars and on weed infestation.	IRRI
Rice	Confessor, R.B. Jr. To-Phuc-Tuong Pablico, P.P. Yamauchi, M. Moody, K.	1994	Performance of wet seeded rice under different tillage and water management systems.	IRRI
Rice	Javellana, A.M. Bueno, C.S. Lantin, R. Wassman, R. Neue, H.U.	1996	Effect of water management on methane emissions.	IRRI

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>WATERSHED MANAGEMENT/WATER DELIVERY, MINDANAO</b>				
Corn	Villancio, V.T. Medina, S.M. Escobin, R.P. Medina, C.M. Josue, A.R. Franje, N. Fava, H. Cagmat, V. Ysulat, A. Lubos, L.	1996	Farming systems interaction in corn-based agroecosystem of the Manupali watershed in Lantapan, Bukidnon, Philippines.	UPLB
Ramie	Buendia, L.V. Cabangbang, R.P. Franco, D.T.	1990	Responses of ramie ( <i>Boehmeria nivea</i> Gaud) to soil moisture stress and flooding.	CEAT, UPLB
Rice	Chaturvedi, G.S. Ingram, K.T.	1989	Growth and yield of lowland rice in response to shade and drainage.	IRRI
Rice	Gascon, F.B. Hossain, M. Depositario, D.T.	1994	Relative efficiency of private and public irrigation system: the case of two Philippine villages.	IRRI
Mungbean	Garrity, D.P. Permito R.	1996	Mungbean response to surface drainage when grown as a pre-rice crop on waterlog-prone ricelands.	IRRI
	David, W.P.	1990	Irrigation development in the Philippines - present status, issues, problems and policy recommendations.	CEAT, UPLB
	Munasinghe, M.	1991	Groundwater resource management and environmental protection: A case study of the Philippines.	World Bank, Washington, D.C.
	Gutierrez, H.M.	1994	Surface water resource assessment of the Arakan Valley complex.	USM-R&D
	Urich, P.B.	1996	Deforestation and declining irrigation in Southeast Asia: a Philippine case.	Department of Geography New Zealand
	Tan-Kim-Yong, U.  Pingali, P.L. Paris, T.R.	1996	Irrigation participation and local self-determination	Chiang Mai University Chiang Mai (Thailand) IRI
	Pradhan, N.C., Pingali, P.L.	1996	Participatory irrigation management: the costs and benefits of working together.	IRRI

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>WATER TECHNOLOGY, LUZON</b>				
Rice	Sibayan, E.B. Undan, R.C.	1994	Shallow groundwater potential and constraints in irrigating lowland rainfed rice-based farms.	Philrice
Rice	Siopongco, J.D.L.C. Ingram, K.T. Boling, A.A. To-Phuc-Tuong	1994	Use of line-source sprinkler irrigation system in examining the effects of intermittent rainfall on establishment and early growth of dry seeded rainfed lowland rice.	IRRI
Rice	Caledacion, A.N. Quilang, J. Cruz, R.T.	1996	Replaceability of nutrients and water in the rainfed lowland rice ecosystem of Central Luzon[Philippines]	IRRI
Mixed crops	Castaneda, A.K. Bhuiyan, S.I. Gumtang, R.J.	1996	Modelling nitrate pollution of groundwater under an intensive rice-based cropping system	IRRI
Mixed crops	Tanquilig, V.C. Obrero, F.P. Zacal, J.M. Undan, R.C. Tabago, J.L. Aganon, C.P. Orden, E.M. de la Cruz, N. E. Lopez, E.	1996         1994	Using upland rice ( <i>Oryza sativa</i> L. cv Dinorado) as an indicator for drip- and furrow-irrigation scheduling in tomato.  Small Farm Reservoir (SFR) technology for improving productivity of rainfed farms.	Dolefil, 9504 Polomolok South Cotabato  CLSU, Muñoz Nueva Ecija
	Galang, A.L.A. Bhuiyan, S.I.	1995	Alleviating drought and intensifying cropping with on-farm reservoirs.	IRRI
Garlic	Abrina, R.A. Pascua, E.M. Castro, E.I. Simon, L.D.	1993	Response of garlic to methods of crop establishment and frequency of irrigation.	MMSU, Batac, Ilocos Norte
Rice	Cabangon, R.J. Bui-Duc-Qut Pasuquin, E.M. To-Phuc-Tuong Quick, G.R.	1995	Effect of tillage on crack formation and water losses during fallow and pre-saturation period in irrigated rice lands.	IRRI

<b>WATERSHED MANAGEMENT/DELIVERY, LUZON</b>				
	Abao, E.B., Jr. Bronson, K.F. Neue, H.U. Dondeyne, S. Opoku-Ameyaw, K. Puginier, O. Sumande, C.	1996  1995	Methane and nitrous oxide emissions in irrigated ricefields.  Agricultural land-use in eroding uplands: a case study in the Philippines	IRRI  Katholieke Univ. Leuven (Belgium), Inst. For Land and Water Management Tropicultura (Belgium)
Mixed crops	Castañeda, A.K. Bhuiyan, S.I. Gumtang, R.J.	1996	Modelling nitrate pollution of groundwater under an intensive rice-based cropping system.	IRRI
Rice	Castañeda, A.R. Bhuiyan, S.I.	1991	Nitrate-nitrogen contamination in shallow groundwater underneath ricefields.	IRRI
<b>WATER TECHNOLOGY, MINDANAO</b>				
mixed crop	Tanguilig, V.C Obrero, F.P. Zacal, J.M.	1996	Using upland rice ( <i>Oryza sativa</i> L. cv Dinorado) as an indicator for drip-and furrow-irrigation scheduling in tomato	Dolefil
<b>WATER TECHNOLOGY, PHILIPPINES</b>				
Rice	Dingkuhn, M. De-Datta, S.K. Javellana, C. Dorffling, K.	1989	Varietal differences in leaf water potential, leaf net CO <sub>2</sub> assimilation, conductivity and water use efficiency in upland rice.	IRRI
Rice	Tabbal, D.F. Lampayan, R.M. Undan, R.C.  Alicante, E.L.	1993  1990  1991	Water efficient irrigation technique for rice.  Challenges and opportunities in developing small-scale water resource systems for agriculture. Social and economic sustainability of communal irrigation systems in Iloilo Province.	IRRI  CLSU, Muñoz, Nueva Ecija College, Laguna
<b>WATER MANAGEMENT/SOIL CONSERVATION, MINDANAO</b>				
	Pava, A.M. Arrances, J.B. Mugot, I.O. Manubag, J.M. Sealza, L.S. Magallanes, J.M.	1994	Farmers' participatory processes on soil and water conservation of Bukidnon uplands.	CMU, Musuan, Bukidnon

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>WATER DELIVERY/SOIL FERTILITY, PHILIPPINES</b>				
Rice	Castillo, E.G. Buresh, R.J. Ingram, K.T.	1992	Lowland rice yield as affected by timing of water deficit and nitrogen fertilization.	IRRI
Rice	Caledacion, A.N. Quilang, J. Cruz, R.T. Wade, L.J.	1996	Replaceability of nutrients and water in the rainfed lowland rice ecosystem of Central Luzon[Philippines]	IRRI
Rice	Cabangon, R.J.	1994	Water loss due to cracks during the pre-saturation period of rice land preparation.	IRRI
Mixed crops	To-Phuc-Tuong Castaneda, A.K. Bhuiyan, S.I. Gumtang, R.J. Medina, M.J.B.	1996	Modelling nitrate pollution of groundwater under an intensive rice-based cropping system	IRRI
Cotton	Cruz, R.S. Orpia, E.D., Jr.	1997	Irrigation of cotton at critical stages of growth and development.	Cotton Research & Dev't. Institute
Corn	Labios, R.V. Villancio, V.t. Tamisin, L.L.. Jr. Labios, J.D. Limosinero, R.L. Cayabyab, B.F. Bayot, R.G. de Chavez, D.M.	1997	Development of alternative corn production technologies in paddy fields.	UPLB
Mixed crops	Labios, R.V. Labios, J.D. Villancio, V.T. Salazar, A.M. delos Santos, R.E.	1996	Development of alternative cropping systems in rainfed area served with small farm reservoirs.	UPLB

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't.)

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>PROCEEDINGS</b>				
<b>WATERSHED MANAGEMENT/WATER DELIVERY, LUZON</b>				
	Coloma, A.G.	1990	Watershed Management and erosion project: National Irrigation Administration soil and water conservation measures at Pantabangan and Magat watershed Philippines	Pantabangan, Nueva Ecija
Cotton	Ganotisi, N.D. Angeles, H.L.	1990	Irrigation strategies for cotton under limited water supply.	CRDI, Batac, Ilocos Norte
Rice	Soriano, L.R. Matias, D.M. Prot, J.C.	1995	Effects of flooding time, water regimes, and soil types on yield of different rice cultivars infected with rice root-knot nematode, <i>Meloidogyne graminicola</i> .	IRRI
Rice	Pablico, P.P. Yamauchi, M. Tuong, T.P. Confessor, R.B. Moody, K.	1995	Performance of anaerobic direct seeding technique under different water and tillage systems.	Pest Management Council of the Philippines, Inc. College, Laguna
Rice	Pablico, P.P. Yamauchi, M. Tuong, T.P. Cabangon, R.J. Moody, K.	1995	Crop establishment and weed competitiveness of direct seeded anaerobic rice cultivar as influenced by seeding and water management systems.	IRRI
Rice	Bhuiyan, S.I. Sattar, M.A. Tabbal, D.F.	1995	Wet seeded rice: water use efficiency, productivity, and constraints to wider adoption.	IRRI
<b>WATERSHED MANAGEMENT, VISAYAS</b>				
	Walag, F.B.	1997	Towards integrated water resources management. A case in Cebu, Philippines.	San Carlos University, Cebu City
<b>WATERSHED MANAGEMENT, MINDANAO</b>				
	Aqua, M.M. Bhuiyan, S.I.	1996	Watershed-scale soil loss equation.	IRRI

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>WATERSHED MANAGEMENT/WATER DELIVERY, PHILIPPINES</b>				
		1992	Asian Regional Workshop on the Inventory of Farmer-Managed Irrigation Systems and Management Information Systems.	Colombo, Sri Lanka
	Travaglia, C.	1995	Groundwater search by remote sensing: case histories, Yemen and the Phils.	FAO, Rome (Italy)
	Pal, A.R. Bhuiyan, S.I.	1995	Rain water management for drought alleviation: opportunities and options for sustainable growth in agricultural productivity	IRRI
Rice	Pandey, S.	1995	Socioeconomic research issues on wet seeding.	IRRI
<b>WATER MANAGEMENT/SOIL CONSERVATION, PHILIPPINES</b>				
	Jasmin, B.B. Dano, A.M.	1990	Soil and water conservation practices in the Visayas and Mindanao: FORI experience Philippines.	FORI, UPLB
	Costale, E.F.	1990	Application/establishment of appropriate Soil and water conservation structures and instrumentation.	DENR, PCARRD
	Maglinaok A.R.	1991	Research and Development direction in soil and water conservation.	PCARRD



Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't).

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
<b>PROCEEDINGS</b>				
<b>WATER TECHNOLOGY/SOIL MANAGEMENT, MINDANAO</b>				
Tomato	Obrero, F.P. Tan, G.P.	1996	Diseases management strategies in tomato under minimum tillage and continuous cropping	No Publication Title. Available at UPLB, College, Laguna 4031, Philippines. E-mail: lbg@mudspring.uplb.edu.ph agris@library.uplb.edu.ph
<b>WATER MANAGEMENT, PHILIPPINES</b>				
None	None	1993	Performance measurement in farmer-managed irrigation systems: the third international workshop of the Farmer-Managed Irrigation Systems Network	IIMI. 1993. 224 pages.
None	Wijayarathne, C.M. Pintor, E.M.	1996	Irrigation system turnover: the Philippine experience	No Publication Title. Available at IIMI, POB 2075 Colombo, Sri Lanka. E-mail: r.desilva@cgnnet.com
<b>WATER MANAGEMENT/DELIVERY, PHILIPPINES</b>				
None	Villenas, N.R.	1997	Groundwater policies and usage	No Publication Title. Available at UPLB, College, 4031 Laguna, Philippines. E-mail: lbg@mudspring.uplb.edu.ph agris@library.uplb.edu.ph
None	Balangue, M.I.RD.	1997	Geology and selected problems on groundwater	No Publication Title. Available at UPLB, College, 4031 Laguna, Philippines. E-mail: bg@mudspring.uplb.edu.ph agris@library.uplb.edu.ph
<b>WATER TECHNOLOGY, PHILIPPINES</b>				
None	None	1996	Modernization of irrigation schemes: past experiences and future options	No Publication Title. Available at FAO Accession No: XF98:377959.ENI:
None	Salvador, P.D.	1997	Water well drilling	No Publication Title. Available at UPLB, College, 4031 Laguna, Philippines. E-mail: bg@mudspring.uplb.edu.ph agris@library.uplb.edu.ph
None	Firmalino, R.B.	1995	Shallow tube well irrigation technology	No Publication Title. Available at UPLB, College, Laguna 4031, Philippines. E-mail: lbg@mudspring.uplb.edu.ph agris@library.uplb.edu.ph

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't).

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
<b>PROCEEDINGS/PAPER</b>				
<b>WATER TECHNOLOGY, LUZON</b>				
None	Undan, R.C.	1993	Small farm reservoir practices in Region 3 [Central Luzon, Philippines]	PCAMRD. 1993. p. 89-101.
<b>WATER TECHNOLOGY, PHILIPPINES</b>				
None	Alcances, R.P.	1993	Environmental impact assessment of water impounding structure	PCAMRD. 1993. p. 127-144.
<b>WATER MANAGEMENT/DELIVERY, PHILIPPINES</b>				
None	Roguel, M.M.	1993	Socio-economic evaluation and policy analysis of the national Program on Small Farm Reservoir in the Philippines: a preliminary report	PCAMRD. 1993. p. 11-19.
<b>WATER MANAGEMENT, PHILIPPINES</b>				
None	Manos, S. Chambouleyron, J	1993	Performance measurement in farmer-managed irrigation systems: proceedings of an international workshop of the Farmer-Managed Irrigation Systems Network	IIMI. 1993. 254 pages. Available at Colombo, Sri Lanka
<b>WORKSHOP PAPER</b>				
<b>WATERSHED MANAGEMENT, PHILIPPINES</b>				
None	Castro, E.N.	1997	When the well runs dry: a civil initiative in watershed planning and management in the Philippines	Program on Environment, East-West Center. p. 153-181.

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't).

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
<b>TECHNICAL REPORT</b>				
<b>WATER MANAGEMENT, LUZON</b>				
None	None	1994	Final report, program on farmer-manage irrigation systems and support services. Phase II, volume 5: self-assessment of performance of farmer-managed irrigation in Bicol, Philippines	No Publication Title. Available at IIMI, POB 2075 Colombo, Sri Lanka.
None	Gumtang, R.J. Bucac, P.S. Taclar, L.B. Pampolino, M.F. Castaneda, A.R. Truong, T.P. Bhuyan, S.I.	1997	Intensive cropping and groundwater quality deterioration	PCCARD highlights 1996. p. 36-37
<b>WATER MANAGEMENT, VISAYAS</b>				
None	Walters, B.B. Cadelina, A.M. Cardano, A. Visitacio, E.	1994	Watershed restoration and protection in the Bais Bay Basin, Philippines	No Publication Title. Available at UPLB, College, Laguna 4031, Philippines.
None	Walters, B.B.	1994	Process documentation and analysis of the first phase of the Development Action Program of the Bais Bay Basin, Philippines	No Publication Title. Available at UPLB, College,
<b>SOIL CONSERVATION/WATER MANAGEMENT, PHILIPPINES</b>				
None	None	1992	Soil and water conservation (SWC) technologies and agroforestry systems	No Publication Title. Available at UPLB, College, Laguna.
None	Luna, A. Calderon, A. Austria, V. Panting, Jr.	1996	Influence or impact of land tilting on the behavior of farmer-participants toward the adoption of conservation technologies in the uplands.	PCARRD highlights 1996. p. 90-91
None	Julian, B.	1990	UPLB-IRRI Collaborative program on environmental monitoring waste effluents	No Publication Title.
<b>WATER MANAGEMENT, PHILIPPINES</b>				
None	Easter, K.W.	1993	Economic failure plagues developing countries' public irrigation: an assurance problem	Water Resources Research (USA). (Jul 1993). v. 29(7) p. 1913-1922. Available at US (DNAL 292.8 W295).
None	None	1997	Program of support systems for local management of irrigation systems: final report	No Publication Title. 28 pages. Available at IIMI, POB 2075 Colombo, Sri Lanka. E-mail: r.desilva@cgnet.com

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
None	Lauraya F.M. Sala, A.L.R. Wijayaratna, C.M.	1996	Research interventions to strengthen irrigators' associations	No Publication Title. 168 pages. Available at IIMI, POB 2075 Colombo, Sri Lanka. E-mail: r.desilva@cgnnet.com
Mixed crops	Miranda, S.M. Maglinao, A.R.	1992	Management arrangements for accommodating nonrice crops in rice-based irrigation systems	IIMI. 1992. 211 pages. Available at Colombo, Sri Lanka
Rice	Miranda, S.M. Maglinao, A.R.	1993	Irrigation management for rice-based farming systems in Indonesia, Bangladesh and the Philippines: a synthesis of findings under the	No Publication Title.

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't.)

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>PAPER</b>				
<b>WATERSHED MANAGEMENT/WATER DELIVERY, LUZON</b>				
None	Barril, C.	1994	Water quality management of Laguna de Bay, Philippines: ecological and political barriers	Stockholm Vatten. 1994. p.173-180.
None	Sly, P.G.	1993	Watershed development and related concerns in the Laguna lake basin, Philippines: a summary and synthesis	ERMP. 1993. p. 282-303. Available at UPLB, College, Laguna 4031, Philippines
None	Lansigan, F.P.	1993	Analysis of Napindin-Pasig-Marikina-Mangahan rivers system and Laguna lake [Philippines]	ERMP. 1993. p. 106-114. Available at UPLB, College, Laguna 4031, Philippines
None	Francisco, F.R.	1993	Lake basin approach to water quality management: the Laguna de Bay experience	ERMP. 1993. p. 85-99. Available at UPLB, College, Laguna 4031, Philippines
Rice	Castaneda, A.R. Bhuiyan, S.	1993	Impact of pesticide use in lowland rice fields on ground water quality	No Publication Title. p. 33. Available at UPLB-National Crop Protection Center Library, College, Laguna, Philippines.
None	Galang, A.L. Bhuiyan, S.I. Hunt, E.D.	1994	Identification of potential areas for use on the on-farm reservoir system for drought alleviation	No Publication Title. Available at AIBA-SEARCA, College.
Rice	Galang, A.L. Bhuiyan, S.I.	1991	Optimizing economic returns from rainfed ricelands with limited water in farm reservoirs.	IRRI
Mixed crops	Natividad, R.A.	1993	Planning and management procedures in an irrigation system with mixed cropping.	MMSU, Batac, Ilocos Norte
	Chancellor, F.	1993	The impact of sediment control on maintenance costs: an illustration from Agno River Irrigation Scheme in the Philippines.	Overseas Dev't. Unit, HR Wallingford Oxon (United Kingdom)
	Undan, R.C. Tabago, J.L. Collado, F.D., Jr. Manabat, R.M.	1994	Design and management of on-farm reservoirs for drought alleviation in the Philippines.	CLSU, Muñoz, Nueva Ecija
<b>WATERSHED MANAGEMENT, VISAYAS</b>				
	Baconquish, S.R.	1990	Infiltration capacities of the different land-uses at the Buhisan Watershed, Cebu City, Philippines.	ERDB, College, Laguna
<b>WATER TECHNOLOGY, LUZON</b>				
None	Undan, R.C. Tabago, J.L. Ringor, O.F.	1992	Shallow groundwater pump system	Technology (Philippines). (1992). v. 14(2) p. 1-.

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
Rice	Moya, T.B. Dela Vina, W.C. Bhuiyan, S.I.	1998	Potential of on-farm reservoir use for increasing productivity of Philippine rainfed rice areas	No Publication Title. Available at UPLB, College, 4031 Laguna, Philippines. E-mail: lbg@mudspring.uplb.edu.ph agris@library.uplb.edu.ph
Potato	Pascual, M. Dumaoal, A.F. Rasco, E.T.Jr. Aromin, F.B. Amante, V.D.R; Lopez, P.J.S.	1992	Comparative study between drip and conventional irrigation methods on lowland potato.	SAPPRAD, UPLB
	Sayco, T. Angeles, H.	1990	Optimal cropping decisions for rainfed farms with on-farm reservoirs.	State University, Muñoz, Philippines
	Guerra, L.C. Watson, P.G. Bhuiyan, S.I.	1991	Design, construction, and maintenance of small farm reservoirs	IRRI
	Bagadion, B.U.	1995	Joint management of the Libmanan-Cabusao pump irrigation system between farmers and the National Irrigation Administration in the Philippines.	Wuhan, China
<b>WATER TECHNOLOGY, VISAYAS</b>				
	Resurreccion, A.N. Salazar, G.C.	1991	Improving farm productivity with small electric pumps.	PCARRD, UPLB
<b>WATER TECHNOLOGY, PHILIPPINES</b>				
	Peterson, D.F.	1989	Irrigation as a factor in food security.	IRRI
	Svensen, M.	1992	Assessing effects of policy change on Philippine irrigation performance.	Washington, D.C. (USA)
		1995	Small farm reservoir program.	UPLB
	Cablayan, D.M. Valera A. Simbahan, G. Elegado A. Francisco A. Pascual C.	1990	Simulation for optimum crop production in irrigation systems adopted for diversified crops during the dry season.	Sri Lanka
	David, W.P.	1990	Irrigation development in the Philippines: brief history, present status, issues, problems and policy recommendations.	College, Laguna  College, Laguna

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
	Pacardo, E.P.	1990	Drip irrigation: a promising technology for sustainable dryland agriculture.	
	Naegel, L.C.A.	1992	The water-powered spiral -pump - its potential for the development of sustainable agriculture in rainfed areas.	UPLB & Germany
Mixed crops	Zhang, Jiabao.	1990	Rice-soil-structural management for prompt and effective wheat emergence and yield in irrigated rice-wheat cropping sequences in the tropics.	College, Laguna
Rice	Thangaraj, M. O'Toole, J.C. Datta, S.K. de	1990	Root response to water stress in rainfed lowland rice.	IRRI United Kingdom
Rice	Miranda, S.M.	1990	Irrigation system principles and practices for reliable and efficient water supply to rice farms.	IRRI
Rice	Bonman, J.M. Estrada, B.A. Kim, C.K. Lee, E.J.	1991	Assessment of blast disease and yield loss in susceptible and partially resistant rice cultivars in two irrigated lowland environments.	IRRI
Rice	Fujisaka, S. Guino, R. Obusan, L.	1994	Costs and benefits of on-farm reservoirs in Central Luzon, Philippines.	IRRI
<b>WATERSHED MANAGEMENT/WATER DELIVERY, PHILIPPINES</b>				
None	Baconguis, S.R. Ranes, L.C.	1994	Soil and water conservation, strategies for sustainable upland farming in the Philippines	Philippine-Lumberman (Philippines). (Jan-Feb 1994). v. 40(1) p. 37-38.
None	Cruz, M.C.J. Cruz, W.D.	1987	Financing irrigation programs in the Philippines	No Publication Title. Available at the Center for Policy and Development Studies, UPLB. 19 p.
None	None	1994	International conference on irrigation management transfer: draft conference papers Volume 1	No Publication Title. Available at IIMI, 127 Sunil Mawatha, Pelawatte via Colombo, Sri Lanka. 336 p.
None	Horstkotte, J.	1994	Socioeconomic complementarities between integrated pest management and aquatic life management - the key to long-lasting adoption?	ICLARM.1994. p.41. Available at UPLB, College, Laguna 4031.
None	Wijayaratne, C.M. and D.L. Vermillion	1994	Irrigation management turnover in the Philippines: strategy of the National Irrigation Administration	IIMI. 1994. 28 pages. Available at International Irrigation Management Unstitute, 127 Sunil Mawatha, Pelawatte via Colombo, Sri Lanka.
None	Gonzales, L.S.	1993	Management turnover of a pump irrigation system in the Philippines: the farmers' way	IIMI. 1993. 103 pages. IIMI country paper, Philippines no. 2.

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
None	Tuong, T.P.	1993	An overview of water management of acid sulfate soils	Selected papers of the Ho Chi Minh City symposium on acid sulphate soils. 1993. p. 265-279.
None	Dano, A.M.	1990	Effect of burning and reforestation on grassland watersheds in the Philippines	IAHS-Publication (United Kingdom). (1990). (no. 192) p. 53-61.
None	Baradas, M.W. Mina, J. DG.	1998	Water management 2000: not by irrigation alone	No Publication Title. Available at UPLB, College, 4031 Laguna, Philippines. E-mail: lbg@mudspring.uplb.edu.ph agris@library.uplb.edu.ph
None	Foronda, S.U. Serrano, R.C.	1992	Research and development strategies and approaches to critical watershed management.	Philippine Lumberman (Philippines). (May-Jun 1992). v. 38(3) p. 6-9.
None	None	1991	Improved Irrigation Management with Farmers' Participation: The Philippines, The Republic of Korea, Sri Lanka and Thailand. Terminal statement	No Publication Title. Available at FAO Accession No: XF93:321759 (Available on Microfiche).
None	Bhuiyan, S.I. Alagean, M.A.	1990	Diversified cropping in high water table conditions	No Publication Title. 11 pages. Available at US (DNAL 290.9 AM32P).
None	Khan, Md. Abril Kashem	1990	Comparative study on water management and yield performance of direct-seeded and transplanted rice	No Publication Title
None	Tabbal, D.F.	1991	Farm level water control and management requirements for crop diversification in rice irrigation systems	No Publication Title
Mixed crops	Valera, A.	1992	Irrigation management for diversified cropping in rice-based systems in the Philippines	IIMI. 1992. 83 pages. IIMI country paper Philippines, no. 1. Available at Colombo, Sri Lanka
Rice	Miranda, S.M. Maglinao, A.R.	1993	Promoting crop diversification in rice-based irrigation systems	No Publication Title
<b>WATERSHED MANAGEMENT/WATER DELIVERY, PHILIPPINES</b>				
	Cruz, Maria Concepcion, J.	1989	Water as common property: the case of irrigation water rights in the Philippines.	CEM, IESAM, UPLB
	Tapay, N.E.	1989	Irrigation as a key factor in food security: the impact of farmer participation on the performance of communal irrigaton systems in the Philippines.	UPLB
	Galvez, J.A.	1990	Irrigation development policies: support to farm systems	NIA, Quezon City CPDS, FSSRI, UPLB
	Svendsen, M.	1991	The impact of irrigation financial self reliance on irrigation system performance in the Philippines.	International Food Policy Res. Inst.



CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
	Maglinao, A.R. Vergara, E.C. Belen, E.M. Jovellanos, M.S.	1994	Philippine national program on small farm reservoirs: experiences, and challenges.	PCARRD, IRRI
	Galang, A.L. Bhuiyan, S.I.	1994	Decision support model for optimizing economic returns from resource allocation in farms with rainwater storage facilities.	IRRI
	Oothuizen, J. Kloezen, W.H.	1995	The other side of the coin: a case study on the impact of financial autonomy on irrigation management performance in the Philippines.	Landbouwniversiteit Wageningen (Netherlands)
	Feder, G. Keck, A. Pingali, P.L. Paris, T.R.	1996	Increasing competition for land and water resources: a global perspective.	World Bank IRRI Sri Lanka
	Jose, A.M. Sosa, L.M.	1996	Preliminary assessment of potential impacts of climate variability/change on water resources of the Philippines.	IRRI
Rice	Tuong, T.P. Wopereis, M.C.S. Marquez, J.A. Kropff, M.J.	1994	Mechanisms and control of percolation losses in irrigated puddled rice fields.	IRRI
Rice	Bhuiyan, S.I. Zeigler, R.S.	1994	On-farm rainwater storage and conservation system for drought alleviation: issues and challenges.	IRRI
Rice	Sharma, P.K. Ingram, K.T. Harnpichitvitaya, D. De-Datta, S.K.	1995	Management of coarse-textured soils for water conservation in rainfed lowland rice.	Ubon Rice Research Center IRRI
<b>WATER TECHNOLOGY, PHILIPPINES</b>				
None	Rosegrant, M.W.	1992	The impact of irrigation on production and income variability: simulation of diversion irrigation in the Philippines	Agricultural Systems (United Kingdom). (1992). v. 40(1/3) p. 283-
Mixed crops	Labios, R.V. De los Santos, R.E. Salazar, A.M. Villancio, V.T. Labios, J.D.	1994	Upland crop production in rainfed lowland rice areas	No Publication Title. Available at the Center for Policy and Development Studies, UPLB. 19 p.

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
Rice	Castaneda, A.R. Bhuiyan, S.	1993	Sediment pollution in a gravity irrigation system and its effects on rice production	Ecosystems and Environment (Netherlands). (Jul 1993). v. 45(3-4) p. 195-202.
<b>WATER MANAGEMENT/SOIL CONSERVATION, VISAYAS</b>				
	Moneva Borinaga, A.R.	1995	Impacts of soil and water conservation in woodfuel production: The Mag-uugmad experience.	Mag-uugmad Foundation, Inc.
<b>WATER MANAGEMENT/SOIL CONSERVATION, PHILIPPINES</b>	Veracion, V.P. Costales, E.F., Jr.	1990	Soil and water conservation for agroforestry.	Likasyaman

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't.)

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
<b>THESIS</b>				
<b>WATERSHED MANAGEMENT/DELIVERY, LUZON</b>				
None	Pasa, A.E.	1997	Effects of rainfall and watershed characteristics on the water yield of the Molawin watershed [Los Baños, Laguna, Philippines]	Thesis (M.S. in Forestry: Forest Resources Management). 86 leaves. Available at UPLB-College of Forestry Library, College, Laguna, Philippines
None	Acedera, M.M.	1993	Assessment of the environmental impacts of the proposed water source development project on the lake water and aquaculture industry of Taal Lake, Batangas Province [Philippines]	Thesis (M.S. in Environmental Studies). Apr 1993. 123 leaves. UPLB call no. LG995 1993 E8A23. Available at UPLB, College, Laguna 4031, Philippines.
None	Navasero, C.S.	1993	Upland farming systems in Lucban, Quezon [Philippines]	Thesis (M.S. in Environmental Studies). Mar 1993. 210 leaves. UPLB Call no. LG995 1993 E8N38. Available at UPLB, College, Laguna 4031, Philippines.
None	Bergonia, A.D.	1995	Analysis of eutrophication problem of Laguna Lake ecosystem [Philippines]	Thesis (M.S. in Environmental Studies). Available at UPLB, College, Laguna 4031, Philippines. E-mail: lbg@mudspring.uplb.edu.ph
None	Sedigo, N.A.	1994	Agroecosystem analysis of Ikloy River Watershed in Indang, Cavite [Philippines]	Thesis (M.S. in Environmental Studies). 163 pages. Available at UPLB, College, Laguna 4031, Philippines.
Mixed crops	Ayson, R.R.	1997	Hydrometeorology of selected land uses at the Quiaoit river watershed, Batac, Ilocos Norte [Philippines]	Thesis (M.S. in Forestry: Forest Resources Management). Available at UPLB-College of Forestry Library, College, Laguna, Philippines
	Sharma, K.R.	1992	Drainage problems in a typical diversion irrigation system.	Muñoz, Nueva Ecija
	Llandelar, L.S.L.	1995	Dimensions of organizational climate and performance of Irrigator's Association in communal systems in the Bicol main-land.	Bicol
	Oliva, J.D.	1995	Impact of CARP (Comprehensive Agrarian Reform Program)-assisted communal irrigation project on agrarian reform beneficiaries of Pulangui, Albay.	Legazpi City
None	Dano, A.M.	1994	Effects of land use change on soil characteristics and hydrology of experimental watersheds in Angat, Bulacan [Philippines]	Thesis (Ph.D. in Soil Science). 195 leaves. Call no. LG996 1994 S72D35. Available at UPLB, College, 4031 Laguna, Philippines.

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
None	Elkaduwa, W.K.B.	1994	Study on sustainability as related to performance of upper Pampanga and Magat River integrated irrigation system in the Philippines	Thesis (Ph.D. in Agricultural Engineering). 242 leaves. Feb 1994. Available at UPLB, College, 4031 Laguna, Philippines.
None	Sharma, K.R.	1992	Drainage problems in a typical diversion irrigation system	Thesis (Ph.D. in Engineering). Jun 1992. 170 leaves. (TNL Call n. S621 K44 1992). Available at The National Library, T. M. Kalaw Street, Manila, Philippines.
Rice	Md Abdus Sattar	1992	Water management and technology adoption for direct seeded rice in an irrigation system	Thesis (Ph.D. in Agricultural Engineering - Soil and Water Management). Mar 1992. 174 leaves. (TNL Call no. SB191 R5S27 1992). Available at The National Library, T. M. Kalaw Street, Manila, Philippines.
<b>WATERSHED MANAGEMENT, PHILIPPINES</b>				
CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
None	Agua, M.M.	1997	Predicting peak rates of runoff and soil loss from a watershed	Thesis (Ph.D. in Agricultural Engineering). Call no. LG996 1997 A2A78. Available at UPLB, College, 4031 Laguna, Philippines.
Rice	Confessor Jr., R.B.	1996	Soil hydraulic properties and cracking pattern of dried puddled soil under transplanted and wet-seeded rice	Thesis (M.S. in Agricultural Engineering). Available at UPLB, College, Laguna 4031, Philippines. E-mail: lbg@mudspring.uplb.edu.ph
	De Vera, M.V.M.	1992	Impact of upper watershed destruction on the performance of national irrigation systems in the Philippines	UPLB
	Manalili, E.V.	1992	Effects of recycling water on freshwater fishpond production.	UPLB
<b>WATER TECHNOLOGY, LUZON</b>				
Mixed crops	Igbokwe, K.N.	1992	Shallow groundwater utilization in crop diversified rice-based areas	Thesis (Ph.D. in Agricultural Engineering). Nov 1992. 158 leaves. (TNL Call no. S618 N8I32 1992). Available at the National Library, T. M. Kalaw Street, Manila, Philippines.
Mixed crops	Begonia, B. Bonifacio	1991	Food crops production planning in Ilocos Sur province, Philippines.	Bangkok, Thailand
<b>WATER TECHNOLOGY, VISAYAS</b>				
Rice	Peñalba,-Madonna-Hicaro	1985	Contribution of water impounding project to rice production in Iloilo Province, Phils.	Bangkok (Thailand)

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE
WATER DELIVERY/SOIL FERTILITY, LUZON Corn	Alam, M.N.	1995	Response of hybrid maize to tillage, nitrogen and moisture regimes after irrigated wetland rice.	Muñoz, Nueva Ecija
WATERSHED MANAGEMENT/SOIL CONSERVATION, VISAYAS	Cadelina, A.M.	1996	Evaluation of land tenure alternatives in community-based rehabilitation and management of Bais City watershed.	UPLB

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't).

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>BOOKS</b>				
<b>WATER MANAGEMENT, PHILIPPINES</b>				
None	Saplaco, S.R.	1993	Watershed management practices and water yield in the ASEAN Region: research abstracts	Watershed management practices and water yield in the ASEAN Region: research abstracts. 86 pages. Available at UPLB, College, Laguna 4031, Philippines.
None	Heim, F. Abernethy, C.L.	1994	Irrigated agriculture in Southeast Asia beyond 2000: proceedings of a workshop held in Langkawi, Malaysia, 5 to 9 October 1992	No Publication Title. Available at IIMI, 127 Sunil Mawatha, Pelawatte via Colombo, Sri Lanka.
Rice	Bhuiyan, S.I. Palanisami, K.	1989	Increasing water-use efficiency on irrigated rice farms.	IRRI

Appendix Table 5b. Publications on water management, by crop, by region, 1990-1998 (con't.)

CROP	AUTHOR	YEAR	TITLE	PUBLICATION TITLE/IMPLEMENTING AGENCY
<b>MANUAL</b>				
<b>WATER MANAGEMENT/SOIL CONSERVATION, PHILIPPINES</b>				
None	None	1994	Soil and water conservation and management (SWCM): a training manual	KAPWA. 1994. 237 p.
None	Del Castillo, R.A.	1994	Soil and water conservation and management: a training manual	UPLB Agroforestry Program, 1994.
<b>WATER TECHNOLOGY, PHILIPPINES</b>				
None	None	1993	Manual on small farm reservoir	No Publication Title. 93 pages. Available at UPLB, College, Laguna 4031, Philippines.
		1993	Manual on small farm reservoir.	UPLB
		1990	Agroforestry technology information kit [soil and water conservation, cropping systems, seeds and plant propagation; home-lot technologies, etc.	DENR
<b>WATERSHED MANAGEMENT, PHILIPPINES</b>				
	Folliott, P.F.	1990	Manual on watershed instrumentation and measurements.	ASEAN-US Watershed Project
	Brooks, K.N.	1990	Manual on watershed management	ASEAN-US
	Gregersen, H.M. Lundgren, A.L. Quinn, R.M.		project planning monitoring and evaluation.	Watershed Project
		1991	Philippines recommends for watershed management.	PCARRD
<b>MONOGRAPH</b>				
<b>WATER MANAGEMENT/SOIL CONSERVATION, PHILIPPINES</b>				
None	Saplaco, S.R.	1992	Bench terracing for soil and water conservation: a monograph	No Publication Title. 28 pages. Available at UPLB, College, Laguna 4031, Philippines.
<b>WATER DELIVERY, PHILIPPINES</b>				
Rice	Guerra, L.C. Bhuiyan, S.I. Tuong, T.P. Barker, R.	1998	Producing more rice with less water from irrigated systems	No Publication Title. Available at IIMI, POB 2075 Colombo, Sri Lanka. E-mail: r.desilva@cgnnet.com

Appendix Table 6. Ongoing researches on soil and water management by crop, UPLB, Philippines.

CROP	T I T L E	PROJECT STAFF
<b><i>Soil Fertility</i></b>		
Rice	Project: National Azolla Action Program: Utilization of azolla as fertilizer for rice, compost and as human food	J.B. Sangalang
Rice	Study 1: Development of a system of azolla propagation commercial feed and compost production	M.A. Lapitan
Rice	Study 2: Utilization of azolla nilotica as replacement for protein in selected meat products	E. Dizon
Rice	Study 3: The effect of selected botanicals and beneficial microorganisms on azolla webworm and golden snails	A.U. Garcia
Rice	Study 4: Utilization of azolla as activator/enhancer in composting of rice straw	R.G. Bayot
Rice	Study 5: Development of a system of azolla spore production	R.B. Begonia
Rice	Study 6: Azolla dual culture with rice (a modified fantillanan system of planting rice)	M.A. Lapitan
Rice	Soil fertility management for sustainable lowland rice production (Phase 2)	D.A. Carandang
Rice	Influence of Marcopper mine tailings on the soil fertility status and growth of rice	H.P. Samonte
Rice	Project: Lowland-based farming systems development program	
Rice	Proj. 1: Sustainable integrated nutrient cycling systems for a homestead in lowland rice-based area	R.P. Escobin
Rice	Proj. 2: Integrating various technology alternatives in lowland rice-based farming system	R.P. Escobin
Rice	Gintong Ani (performance of 10 varieties of rice under four levels of nitrogen fertilization)	G.O. San Valentin
Rice	Responses of irrigated-lowland rice to organic and inorganic fertilizers	A.M. Villamor
Corn	Effect of organic fertilizer on the abundance of major insect pests and its natural enemies in sweet corn	P.P. Javier
Corn	Influence of chicken and hog manure applications on the dynamics of foliage and soil arthropod communities in sweet corn	P.A. Jaiver
Corn	On-farm research and outreach (OFRO) program in major corn growing areas of the Philippines	R.V. Labios
Legume, peanut and corn	Screening of mungbean, peanut and corn for tolerance to acid soil infertility conditions	H.P. Samonte
Legume, peanut and corn	Growth and aluminum concentration of selected peanut cultivars in response to added aluminum on Antipolo clay	A.M. Ocampo



<b>CROP</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>
Fruit crops	Nitrogen diagnosis of selected fruit crops is less than two minutes using the rapid nitrate test	D.E. Angeles
Mango	IRDP-Mango (Enhancing productivity of the Philippine mango) fertilizer application on mango through the diagnostic and recommendation integrated system (DRIS)	M.L.O. Cedo
Papaya	Effects of organic and inorganic fertilizers on papaya ringspot virus (PRSV) incidence: ESBUCAF, Guinobatan, Albay	A.D. Talens
Papaya	Effects of organic and inorganic fertilizers on PRSV incidence: Maurars Farm, Guinobatan, Albay	A.D. Talens
Papaya	Effects of organic and inorganic fertilizers on PRSV incidence: CES-UPLB	A.D. Talens
Cotton	Impact of continued use of monocrotophos on soil as a consequence of cotton crop protection	A.W. Tejada
Unc	Sustainable integrated nutrient cycling systems (SINCs) for a homestead in lowland	R.P. Escobin
Unc	Movement and bound residue formation of profenofos in soil	A.W. Tejada
<b>Soil Conservation</b>		
Unc	Alternative technologies in upland-based farming systems	R.V. Labios
<b>Water Management</b>		
Legume	Varietal improvement for drought resistance in mungbean	E.T.M. Ocampo
<b>Water Delivery</b>		
Rice	Project: Development of irrigated-lowland rice cultivar	J.E. Hernandez
Rice	Study 1: Observational nursery	S.H. Escamos
Rice	Study 2: Hybridization and F1 evaluation (with TH Borromeo)	V.L. Lopena
Rice	Study 3: Selection in segregating generations (early maturing)	E.B. Cayaban
Rice	Study 4: Selection in segregating generations (medium maturing)	A.M. Dela Rosa
Rice	Study 5: Preliminary yield trials of transplanted (early maturing selection)	A.M. Dela Rosa
Rice	Study 6: Preliminary yield trials of transplanted (medium maturing selection)	E.B. Cayaban
Rice	Study 7: Preliminary yield trials of direct seeded (early maturing selection)	S.H. Escamos
Rice	Study 8: Preliminary yield trials of direct seeded (medium maturing selection)	S.H. Escamos

<b>CROP</b>	<b>T I T L E</b>	<b>PROJECT STAFF</b>
Rice	Study 9: Grain quality evaluation of promising irrigated-lowland rice selections	E.T. Lapis
Rice	Project: Development of rice cultivars for rainfed-lowland drought prone environment	D.J. Lalicán
Rice	Study 1: Observational nursery of rice selections adapted to rainfed-lowland drought-prone environment	D.J. Lalicán
Rice	Study 2: Hybridization and selection in segregating generations	D.J. Lalicán
Rice	Study 3: Preliminary performance test	D.J. Lalicán
Rice	Study 4: Grain quality evaluation of promising rainfed-lowland rice selections	E.T. Lapis
Mungbean	Varietal improvement for drought resistance in mungbean	E.T.M. Ocampo