Organizational diversity in small scale farming and soil conservation strategy in Jamaica

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ABSTRACT

The menace of soil erosion at all spatial and temporal scales has highlighted the critical need for the implementation of soil conservation strategies. The successful implementation of soil conservation mechanisms, however, has been plagued with a complex array of problems related to farmers' organizational diversity. The objective is to investigate the nature of the relationships between organizational diversity and soil conservation strategies in small scale farming. This study also includes an investigation of agrodiversity of farm plots and its relationship with different soil conservation strategies. The sampling methodology included the collection of both primary and secondary data. A quota sample of thirty small scale farmers was chosen non-randomly from five communities. A total of 196 species of plants were recorded in the study area. With respect to organizational diversity and soil conservation methods, a number of socio-economic factors had statistically significant relationships with soil conservation methods adopted.

Keywords: Paul, diversity, Jamaica.

RESUMEN

La amenaza de la erosión del suelo en todas escalas, espaciales y temporales ha destacado la necesidad crítica por la aplicación de estrategias para la conservación de la tierra. La exitosa aplicación de los mecanismos de la conservación de la tierra, sin embargo, se ha plagado con un orden complejo de problemas relacionados con la organización y diversidad de los granjeros. El objetivo principal es investigar la naturaleza de las relaciones entre la diversidad organizacional y estrategias de la conservación del suelo en la agricultura de pequeña escala. Este estudio también incluye una investigación de la agrodiversidad de parcelas de la granja y su relación con diferentes estrategias de la conservación de la tierra. La metodología que fue utilizada incluyó la colección de datos primarios y secundarios. Una muestra de 30 granjeros de escala pequeña fue escogida y no al azar, de 5 áreas. Se encontraron un total de 196 especies de plantas en el área estudiada. Con respecto a la diversidad organizacional y métodos de la conservación del suelo, algunos factores socioeconómicos tenían, estadísticamente relaciones significativas con los métodos de conservación del suelo adoptados por los granjeros.

Palabras clave: Suelo, diversidad, Jamaica.

RESUMÉ

La menace de l'érosion du sol à tous les niveaux de l'espace et du temps a fait surgir l'impérieuse nécessité de l'application de stratégies pour la conservation de la terre. L'application des mécanismes de conservation de la terre, cependant, s'est vu confrontée à un ordre complexe de problèmes liés à l'organisation et à la diversité des fermiers. L'objectif principal c'est de mener des recherches sur la nature des relations entre la diversité organisationnelle et les stratégies de conservation du sol au niveau de l'agriculture à petite échelle. Cette étude comporte aussi une recherche de l'agrodiversité des parcelles de la ferme pour la zone étudiée et sa relation avec différentes stratégies de conservation de la terre. La méthodologie utilisée comporte la collecte de données primaires et secondaires. Un échantillon de 30 petits fermiers fut choisi et sans aucun hasard, dans 5 communautés. On a trouvé un total de 196 espèces de plantes au niveau de la zone étudié. Pour ce qui de la diversité organisationnelle et les méthodes de conservation du sol, quelques facteurs socio-économiques avaient des relations significatives avec les méthodes de conservation du sol adoptées par les fermiers.

1. AN OVERVIEW

Land degradation poses a severe threat to the sustainability of agricultural production in Central America and the Caribbean. Since most countries in the region remain heavily dependent on agriculture, efforts to sustain and improve the productivity of agricultural land are very important for the process of economic development as well as for the welfare of a significant proportion of the population. Unfortunately, many soil conservation programmes designed to address the problem of land degradation have fallen far short of expectations. Farmers have often resisted adopting the recommended conservation practices and have frequently abandoned them once projects are ended (Lutz, Pagiola and Reiche 1994).

Since its emergence, small farming in Jamaica has been an important source of food, employment and income. Most of this farming is practised on steep and fragile hillside terrain which is often exposed to erosion due to a plethora of factors such as high rainfall and the lack of/or inadequate soil conservation strategies employed by farmers. This has resulted in a reduction in the resilience of the land as a resource as well as a reduction in the agrodiversity of the area. In order to preserve the agrodiversity of the area and to reduce soil degradation, it is crucial to have a comprehensive understanding of how this system operates. Consequently, it is not only important to examine broader issues of soil conservation strategies but also to probe into organizational diversity of these soil conservation mechanisms employed by small scale farmers.

The need to maintain agrodiversity is vital as genetic diversity on small farms appears to be on the decline. This decline can be largely attributed to the increased practice of monoculture by small-scale farmers, who are producing for the export market, where the demand is for a limited number of specialised varieties. The large number of species traditionally encountered on small farms has been relegated to subordinate status and the decrease in their genetic diversity has been the result of a transition in the local economic regimes.

As part of the effort to conserve agrodiversity, researchers from the University of the West Indies in Jamaica are collaborating with the United Nations University Project on People, Land Management and Environmental Change (PLEC) to work with small farmers on the island to conserve the wide range of agrodiversity that characterise their farming systems. Demonstration plots will be selected from among plots in the study area to highlight innovative ways in which local individuals are preserving crop diversity, engaging in soil conservation and other sustainable practises, while at the same time obtaining a good income, food and other materials from their operations (Thomas-Hope, Semple and Spence 1999b).

2. THE CONCEPTUAL FRAMEWORK OF THE STUDY

Figure 1 gives a diagrammatic representation of the conceptual framework of the study. As indicated the farmer is faced with the perennial problem of soil erosion, which is as a result of three major factors, namely; poor agronomic techniques, climatic factors and geological / soil factors. The farmer is faced with a number of interrelated factors which strongly influences his farming decisions. He would either react to the situation by implementing mitigating mechanisms or take an inert position on the matter by the non-adoption of mitigating techniques. The factors which influence the farmer's decision include socio-economic and technological factors, financial factors relating to external assistance, and the farm factor relating to its dynamics, that is, the manifold dimensions of farm morphology and its operation. All these interrelated factors constitute the farmer's organizational diversity. Soil conservation measures include engineering / mechanical and agronomic / biological strategies. The farmer may use only engineering or only agronomic measures or a combination of both.

These methods, used singly or combined, will affect the nature of agrodiversity of farm plots. Likewise, the non-adoption of soil conservation techniques will affect the agrodiversity of farmplots as well as the productivity of the land. As indicated, the adoption of soil conservation strategies serve as a positive feedback mechanism to check the state of soil erosion and consequently any further decision making by the farmer to mitigate the effects of soil erosion.

3. LITERATURE REVIEW

Soil Erosion Status: Soil erosion is a major environmental and agricultural problem worldwide and has been widely documented (Worthen Edmund 1968; Hudson 1981; McGregor 1986: Perez Dominquez 1989; Mcgregor and Barker 1991; Eyre 1992). Although erosion has occurred throughout the history of agriculture, it has intensified in recent years. Globally, 75 billion metric tonnes of soil are removed from the land by wind and erosion annually, with most coming from agricultural land. The loss of soil degrades arable land and eventually renders it unproductive. Worldwide about 12 x 10^6 ha of land are destroyed and abandoned annually because of non-sustainable farming practices (Pimentel *et al.* 1997).

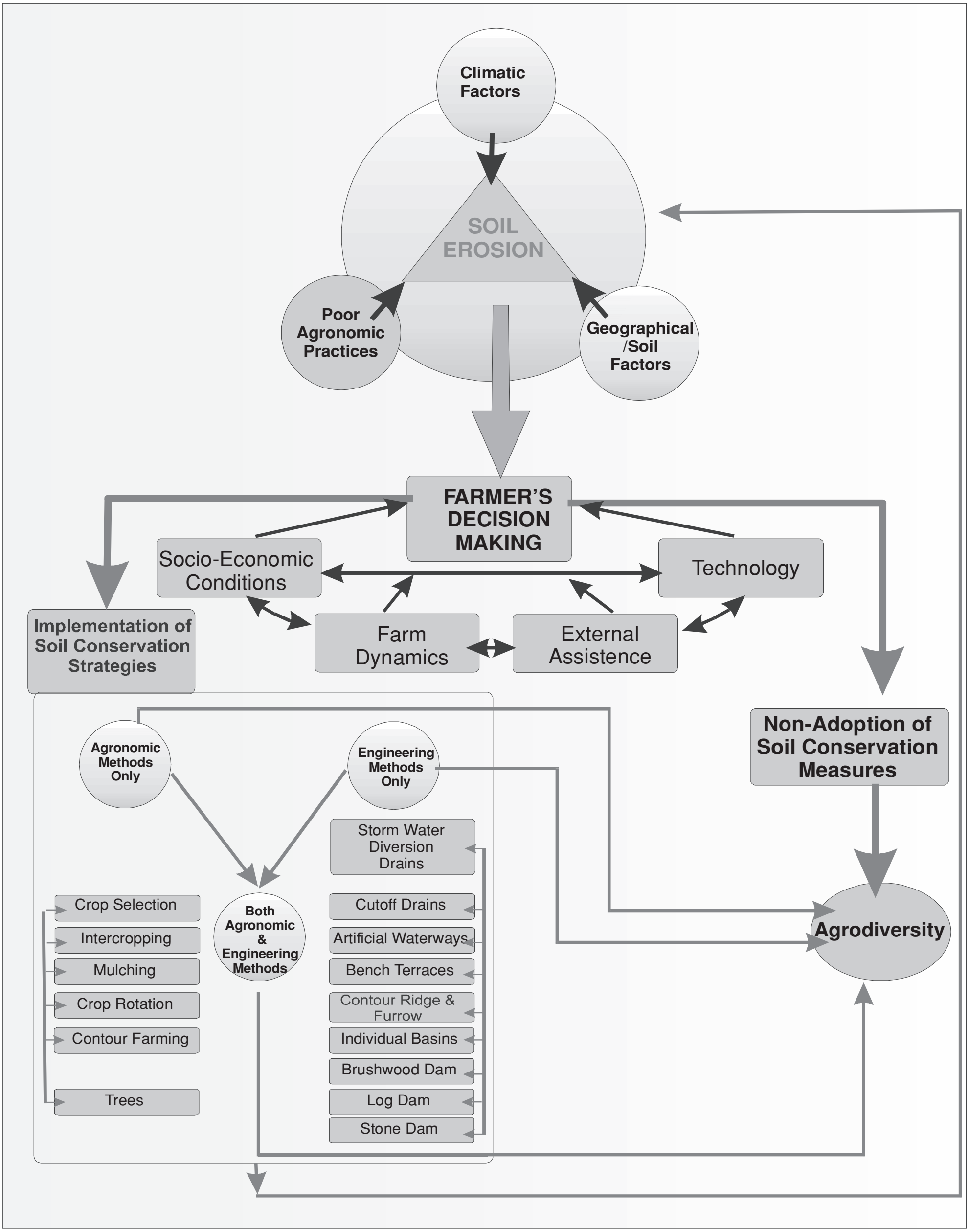

Figure 1. The conceptual framework of the Study.

According to Campbell (1991) soil erosion is a normal phenomenon in the process of aggradation and degradation of any given landscape. Rockie (1956) asserts that the major problem lies in non-caused erosion and that this is potentially universal over the whole island and its presence is almost always a direct indication of either clearing or subsequent cultivation. The major factors that cause erosion are poor agronomic practices, climatic factors and soil factors.

Ahmad (1997) indicated that in the West Indies soil erosion by water is the main form of soil loss. The extent to which this takes place depends on vegetation, topography, erodibilty of the soils and land-use pattern. Agricultural systems in the Caribbean can be divided into two categories. One is plantation crops grown on the best lands, the main crops being sugar cane, banana and citrus and the second system being small scale farming such as gardening and subsistence cropping. Grossman (1997) adds that erosion is less of a problem in banana production than under other cropping systems. Although the soil is exposed when bananas are first planted, the crop eventually provides a dense protective canopy that lasts for several years as farmers usually produce several ratoon crops. The land is also protected from erosion by the large amounts of trash – banana leaves and skin that are routinely cut off and discarded in the fields – covering the grounds.

Combating soil erosion is indeed a gargantuan task and concerted efforts have to be made to militate and mitigate its power. The view that «a nation that destroys its soils, destroys itself» echoed by President Roosevelt in 1937, points to the need to curb the effects of soil erosion by adequate and effective mitigating measures. By extension farmers should be aware that «a farmer that fails to practise proper soil conservation strategies, fails to sustain his livelihood».

3.1. SOIL CONSERVATION: REGIONAL AND LOCAL CONTEXTS

Soil conservation means wise land management and good stewardship of soil resources (Chapman & Fitch 1950). Soil conservation implies not only the retention and preservation of the soil but also the rehabilition and restitution of degraded soils to its former capacity. Soil conservation aims at achieving the maximum potential productivity of each soil type (Baxter 1973). According to Stocking (1995), soil conservation is defined as any set of measures that control or prevents soil erosion or maintains soil fertility. Gumbs (1992: 57) alluded to the fact that several national projects in soil conservation and watershed management have been implemented over the years and several million dollars have been spent but they have not had the desired impact. The methods proposed have not generally been adopted by farmers. In this sense many of the projects have been distinct failures. The seriousness of the problem of soil erosion has not changed and soil erosion still remains a major threat to sustained agricultural production in most Caribbean countries.

Jamaica has been concerned about soil erosion and its control for a very long time. There have been reports of soil conservation since the 1930s in which increasing problems and threats posed to the ecosystem were emphasized repeatedly. (Lindsay and Douglas 1993). Steele (1954) and Rockie (1956) have presented reports on the need for land use planning and soil conservation. The review of the literature revealed that many soil conservation projects implemented in Jamaica have had few successes (Sheng 1984; Gumbs 1997). A common feature running through these projects is the top-down approach which lacks adequate farmer participation in selection / modifications of the various soil and water management techniques. Soil conservation by means of enforced policies are also non-starters. Lindsay (1999) indicated that the failure of soil conservation projects can be attributed to the 'projectised' nature of these projects. Also, there is no follow up to ensure that methods taught were still being used effectively.

3.2. AGRODIVERSITY AND ORGANIZATIONAL DIVERSITY

The term agrodiversity is modern and was coined by researchers from the United Nations Project on People, Land Management and Environmental Change (PLEC). Brookfield and Padoch (1994: 9), cited in Brookfield (1999) defined agrodiversity as «the many ways in which farmers use the natural diversity of the environment for production, including not only their choice of crops but also their management of land, water and biota as a whole».

Brookfield and Stocking (1999: 10) classified agrodiversity into four main elements, all of which overlap and are interrelated. These elements are as follows:

1. Agro-biodiversity, plant diversity within cultivated and managed areas. This involves all crops and other plants used by people or which are useful to them. Particularly important is the diversity of crop combinations and the manner in which they are used to sustain or increase production, reduce risk and enhance conservation.
2. Management diversity, or the diverse methods of managing the soil, water and biota for crop production and the maintenance of soil fertility and structure. Biological, chemical and physical methods of management are included, but they overlap. Local knowledge, constantly modified by new information, is the foundation of this diversity.

   Around agro-biodiversity and management diversity are two groups of elements which condition what is done on the land. These are:
3. Bio-diversity, including soil characteristics and their productivity, the biodiversity of natural plant life and the soil biota.
4. Organizational diversity. This is more often called the «socio-economic aspects», but the term is inadequate. Organizational diversity includes diversity in the manner in which farms are owned and operated and in the use of resource endowments. It underpins and helps explain «management diversity» and its variation between particular farms. Explanatory elements include labour, household size, the differing resource endowments of households, and reliance on off-farm employment. Also, of great importance are differentials between farmers and farming households in access to land and the resources of production. Around all this, lie the market economy and the political system which

impinge to a greater or lesser degree on what farmers are able to do (Brookfield 1999: 11).

4. GENERAL OBJECTIVES

1. To determine the types and prevalence of soil conservation methods used by small scale farmers in the study area.
2. To determine any interrelationships between agrodiversity and the use, or lack of soil conservation strategies employed by small scale farmers.
3. To investigate the nature of agrodiversity on farm plots.
4. To investigate and determine the relationships between the farmers' organizational diversity and the methods of soil conservation employed.
5. To investigate the farm dynamics associated with farming practices.

5. RESEARCH STATEMENTS / HYPOTHESES

1. What specific types of agronomic and engineering soil conservation strategies are employed and to what extent?
2. What is the number of species (both cultivated and naturally grown) on farm plots?
3. Is there any relationship between the adoption of soil conservation methods and agrodiversity. That is, what soil conservation methods increase or decrease agrodiversity?
4. Are there any statistically significant relationships between the soil conservation methods (both agronomic and engineering) employed by farmers and the following variables: Farmers' educational status; Farmers' gender, age and household size; Farmers' land tenure; Farmers' dominant crop type; Farming systems; Farm plot size.

6. DESCRIPTION OF STUDY AREA

Topography: The Lower Rio Grande Valley is located in the Rio Grande Watershed of the Blue Mountains, north hydrological basin, in the parish of Portland, northeast Jamaica (Figure 2). It is situated some 104 kilometres from the capital city, Kingston and approximately 114 kilometres from the tourist mecca of Ocho Rios.

The Rio Grande Valley covers an area of approximately 286,000 ha, which is about one-third the size of the parish (Thomas-Hope, Spence and Semple 1999a). More than three-quarters of the parish is 1500 m, or more, above sea level and over one-half of the land has slopes that are over 20 per cent. The altitude of terrain studied, ranged from a low of 30m in Berridale to approximately 230m in Coopers Hill. Approximately 60% of the farm plots had slopes less than 15 degrees, 35% of the slopes ranged from 15-30 degrees and 15% had slopes greater than 30 degrees.

Figure 2. Map of Jamaica showing parish divisions and relative location of study area.

Climate and Drainage: Portland, like the rest of Jamaica, has a tropical maritime climate and the prevailing north-east trade winds bring heavy orographic rainfall to the axial mountain ranges and northerly slopes of the area. The Rio Grande Valley is the rainiest part of Portland, a parish that is recorded as being the wettest in Jamaica having an average rainfall of approximately 2250 mm annually. Rainfall data from 1931 – 1980, from four stations within the valley indicated that there are two seasons of heavier rainfall, that is, a short rainy period between May and June and a long rainy period between October and January (Edwards 1998). Temperature data over a 50 year period indicated that the mean daily temperature for the summer and winter varied by less than 4 degrees Celsius. The hottest months are July and August, while the coolest months are January and February. Variations in surface drainage are determined by the type of rocks and general geology of the area. Port Antonio and surrounding areas are drained by a total of eight small rivers. The Rio Grande River is the largest in the study area and has a drainage basin that impacts on a large number of communities dependent on the river valley for economic survival. The Spanish and Swift drainage basins cover the western section of the basin while the eastern side indicates an absence of surface drainage because of the presence of carbonate rocks which only allows sub-surface drainage (Harris 1998).

Soils: There are about 13 sub-classes of soil textures present in the Rio Grande watershed. The two most dominant classes are gravely sandy loam and silt / clay loam. Other soil textures include clay loam, stony loam and channery clay loam. The gravely sandy loam consists of a mixture of small pebbles interlinked with sand that is immersed in a 5-10% clay matrix. It is a light soil located over weathered granitic rocks. This type of soil texture allows excessive draining and covers a portion of the town of Portland to Breastwork, then continues on the south side of the river through Coopers Hill to Mango Gap. The stony silt / clay loam covers the southwesterly and southern sides of the Rio Grande watershed. This type of texture ranges from thin to moderately thin but well drained in most areas, produced from weathered conglomerates, tufts, hornfels and shale or schist (Edwards 1998).

7. SAMPLING METHODOLOGY

Five study sites or communities were selected in the Lower Rio Grande Valley, namely; Fellowship, Toms Hope, Berrridale, Golden Vale and Coopers Hill. A quota sample of 30 farmers from all five communities was chosen, non-randomly, with unequal distribution across communities. A small farmer was defined as an individual who cultivates a plot not exceeding the size of 25 acres (Edwards 1995). The unit of selection was the household which was defined as «a unit comprising either one person (farmer) living alone or a group of people, whether related or not, living at the same address» (Thomas-Hope, Spence and Semple 1999b: 3). Household members share housekeeping duties and have at least one meal a day, or share common living accommodation (for example, a living room or a kitchen). Anyone who was away from a home continuously for a long period of time (e.g. 6 months) was excluded from the household.

The study site was selected for the following reasons:

- The prevalent ecological conditions make soil erosion an inherent, local problem and the marked misuse of the natural resources exacerbate the already high degree of erosion;
- The need to emphatically test hypotheses relating to farmers' socio-economic conditions and their soil conservation practices;
- The relative ease of obtaining pertinent resource materials to aid with research project, for example, maps and literature;
- To add to the electronic data base as part of an on-going project with the University of the West Indies in Jamaica in collaboration with the United Nations University Project on People, Land Management and Environmental Change (PLEC) in looking at and examining critical issues relating to small scale farming and agrodiversity.

A reconnaissance visit was conducted on the 2nd of June 1999 and this proved invaluable to the final design of questionnaires and the refinement of the field methodology in the collection of biodiversity data via quadrat sampling. The approach used is what anthropologists describe as the «emic» approach, whereby the researcher interprets the environment of his respondents according to their perception, and interacts closely with the community by living in the general study area. Consequently, field data were collected on a continuous basis lasting for an uninterrupted period of one month (mid-June to mid-July). Field researchers resided in the Port Antonio area and travelled daily to the selected communities (multiple visits to the farmers' households were necessary to gather all the required data). Contact was made with RADA officials in Port Antonio and they were instrumental in making contact with some of the farmers.

8. PRIMARY DATA COLLECTION

Survey Questionnaires: A total of thirty questionnaires were administered to farmers in five different communities. The questionnaires sought to elicit information on the socio-economic background of the farmers, agro-biodiversity information and soil conservation data.

Interviews: Both formal and informal interviews were conducted with RADA officials, such as, the Land Husbandry Officer and the Extension Officer. Other soil specialists were consulted to ascertain their views on soil conservation issues, especially as they relate to the Jamaican scenario.

Field Survey: The use of an abney level (to record slope angles) and a tape measure proved useful in plotting profiles of slopes and bench terraces. A clinometer was used to collect data on slope inclination. A large scale topographic map of the area and a GPS were used to aid in locating and plotting farmers' households.

Quadrant Sampling: Fifteen farm households were chosen using a systematic sampling procedure, that is, every other farm or every second farm was chosen. This approach was selected because it provided the flexibility required for collecting plant species data where there is a high degree of spatial variation in the occurrence of plants. Agro-biodiversity data were collected at the level of individual farms using five transects. Four of the transects followed the cardinal compass directions from the edge of the plot while the fifth was taken in up-slope direction following the border of the plot. Quadrant frames, of 1 x 1 m, were used in a systematic manner at intervals of 15 m. The absolute number of species, as well as the species percentage cover, were recorded, for each quadrant. Farmers were instrumental in the identification of species (both cultivated and naturally growing plants) and their uses.

9. SECONDARY DATA COLLECTION

Internet searches were conducted but little information was found. Most of the literature was obtained from the libraries and documentation centres of the following governmental and non-governmental institutions: Caribbean Agricultural Research and Development Institute (CARDI); Food and Agricultural Organization (FAO); Forestry Department of the Ministry of Agriculture; Institute of Social and Economic Research (ISER); Instituto de Geografía (Institute of Geography), Havana, Cuba; Inter American Institute for Co-operation in Agriculture (IICA); Ministry of Agriculture; Natural Resources Conservation Authority (NRCA); Rural Agricultural Development Authority (RADA); United Nations Development Programme (UNDP); UWI Centre for Environmental Development ; UWI Main Library and Science Library.

The analysis and presentation of data involved extensive use of computer application systems such as SPSS, and Corel Draw. Quantitative analysis was done using SPSS, for example for testing significant relationships among variables using Chi-square tests. Whenever applicable, correlations between variables were ascertained using Spearman Rank Correlation Tests. A series of charts, maps, graphs and tables were generated to aid in the explanatory process.

10. FARM DYNAMICS, ORGANIZATIONAL DIVERSITY AND AGRODIVERSITY: RELATIONSHIPS WITH SOIL CONSERVATION STRATEGIES

Farm dynamics and organizational diversity are essential components or concepts in understanding the farmer's decision making as it relates to soil conservation. These concepts constitute a number of factors that are not rigid in nature nor do they act independently but rather they are interrelated in a unique matrix. The fact that soil conservation is not only a technical problem, but also a behavioural or social problem, gives credence to the importance and relevance of understanding the nature of farm dynamics and organizational diversity apropos of the adoption of soil conservation strategies by farmers.

11. ASPECTS OF FARM DYNAMICS

Farm dynamics in its most amplified concept deals with the morphology of farms, that is, their physical characteristics plus the interactions and activities involved with the farmer and his farms. Farm plot issues as they relate to the farmers' labour on different plots and time spent farming on multiple plots along with the farmers' investment according to plots will be briefly addressed. The technological component of farm dynamics will also be succinctly discussed.

Farm Plot Issues: Central to the farming system is the management and allocation of time and financial resources to plots. In this study it is imperative to note that Plot 1 refers to the house plot or the plot nearest to the house plot. Similarly, Plots 2 and 3 are those that are situated at greater distances respectively from the farmers' household. Regarding the time spent on plots it was evident that houseplots were given greater priority, as the average number of days per week spent on Plot 1 and Plot 2 was 5.13 and 4.80 respectively. Most farmers dedicated more time on Plot 1 than other plots. Even though more than 50% of the farmers spent more than five days on Plots 1 and 2, there was a disproportionate number of hours spent per day on farm plots.

The mean time spent on Plot 1 was 7.1 hours with a standard deviation of 2.19 while that of Plot 2 was 4.8 hours with a standard deviation of 1.93 hours. This clearly indicates the greater importance of Plot 1 in terms of time dedicated to farming activities.

The financial resources spent on Plot 1 were evidently more than that spent on Plot 2 as indicated by the average amount of money invested on these plots. The mean amount of money spent on Plot 1 per month was US$267.40 while that spent on Plot 2 was US$172.50. These financial estimates included the average monthly expenses spent on all farming operations such as the use of agrochemicals and labour. Farmers' monthly expenditure was subjected to temporal and seasonal variations depending on the magnitude and intensity of farming operations.

Farm Technology: The level of technology utilized by farmers, with respect to the equipment / machinery used on a diurnal basis reflected a traditional, relatively inexpensive, low technology orientation. As illustrated in Table 1, about eleven «tools» were used by farmers in the study area.

Table 1. List of Farming Tools

Tools	Unit price		Duration of use
	$ JA	**$ *US***	
Machete	180-220	*4.5-5.5*	1-6 months
Fork	2000-2200	*50-55*	6+ years
File	75-100	*1.9-2.5*	1-3 months
Spray Pan	3000-6000	*75-150*	5+ years
Spade	450-650	*11.3-16.3*	3+ years
Pick Axe	800	*20*	5+ years
Hoe	800	*20*	5+years
Hose	500-1000	*12.5-25*	2+years
Mist blower	16,000-25,000	*400-625*	5+years
Hook Knife	350-450	*8.8-11.3*	1 year
Dehanding Knife	500	*12.5*	1 year

Source: Author's fieldwork

All farmers had in their possession at least a machete, file, fork and a knife. Other equipment when, needed, were rented or borrowed. For example, when the services of a mist blower were needed, farmers' would pay rentals between the range of US$12.50 - 7.50 per day. The minimum cost associated with any of the tools was US$1.88 (for a file) while the maximum cost attached was US$1,000 for a mist blower which is used for the application of pesticides. The effective «use time» of tools ranged from less than one year to as much as over eight years. Tools that were frequently used, especially on a daily basis had a short «use time», for example machetes, knives and files. Tools that were used less frequently and were made of stronger and durable materials lasted longer, for example, forks and spray pans. Machines (such as bulldozers) were needed for sophisticated farm works, such as the construction of bench terraces, and were provided by governmental agencies, for example RADA, or were rented.

12. SOIL CONSERVATION STRATEGIES ON SMALL FARMS

There are basically two major categories of conservation strategies that are practised on small farms. These are agronomic / biological strategies and engineering / mechanical strategies. In its generic sense, agronomic methods include all farming practices in which vegetation helps to minimise erosion while engineering methods aim to allow the infiltration of excess water into the soil or to prevent the rapid down-slope flow of water by conducting it safely across and down the slope through semi-permanent or permanent engineering structures. Farmers adopted six different agronomic strategies and nine engineering methods (refer to Figure 1).

A total of twenty-four farmers adopted at least one soil conservation method. Ten farmers adopted only one conservation method while only one farmer adopted a maximum of twelve methods. Six farmers adopted two conservation methods, three farmers adopted three, two farmers adopted four while only two farmers adopted five conservation methods. The average number of conservation methods adopted was 2.03 with a standard deviation of 2.37 methods. The mean number of biological methods used was 1.10 with a standard deviation of 1.35 methods while that of mechanical methods was 0.93 with a standard deviation of 1.31 methods. A total of 19 farmers implemented agronomic techniques while eleven did not. A total of twelve farmers adopted only one method while only one farmer attempted a maximum of six methods. Four farmers adopted two methods, while one adopted three methods and only one farmer adopted four conservation methods. The agronomic methods which gained favourable adoption were mulching (14 farmers) and the planting of trees (8 farmers).

Four farmers practised intercropping while three practised crop rotation and contour farming, each. Just over 50% of the farmers (16) practised engineering conservation techniques. A maximum of 6 methods was practised by one farmer while ten farmers adopted two conservation methods while two adopted three conservation strategies. The use of artificial waterways was the most popular engineering method practised (13) while contour ridge and furrows, individual basins, stone dam and log dam were the least popular and were adopted by farmer each. Cutoff drains were adopted by five farmers while three farmers had bench terraces. Storm water diversion drains and brushwood dams were adopted by two farmers each.

Mulching and artificial waterways were the two most popular methods employed by farmers. The use of these methods was dictated, *inter alia,* by the topography, the dominant crop grown, the availability of assistance and the general ease of implementation. For example, mulching was practised on relatively flat land, on banana farms where the mulching agent was acquired from old banana trunks, trash and leaves which had no cost attached to them. Also, the relative ease of applying the mulch was time and cost effective and was done on-site without the need for transportation. The adoption of agronomic methods was also marginally favoured over engineering methods. This could be attributed to the farmers' technological competence, the expensive nature of implementing engineering methods, the farmers' traditional attitudes, the need and adequacy for such methods and the amount of external assistance given to farmers in implementing relatively new and expensive mechanical checks.

Table 2 indicates the farmers' use of soil conservation methods by locality. More than a third of the farmers (36.67%) adopted both agronomic and engineering methods, whereas 26.67% and 16.67% of the farmers, respectively, adopted agronomic methods only and engineering methods only. One-fifth (20%) of the sample did not adopt any soil conservation methods.

Table 2. Farmers' Use of Soil Conservation Methods by Locality

Locality	No Soil Conservation Method	Agronomic Methods Only	Engineering Methods Only	Both Agronomic and Engineering Methods
Berridale	0	2	0	1
Coopers Hill	0	1	0	1
Fellowship	5	4	5	4
Golden Vale	1	0	0	3
Toms Hope	0	1	0	2
Total	**6**(20%)	**8**(26.67%)	**5**(16.67%)	**11**(36.67%)

Source: Author's fieldwork

13. AGRONOMIC VS ENGINEERING METHODS

In summary, the effective choice is dictated significantly by the nature of the topography and the farming system. In most cases, the effective use of conservation methods involves a combination of both strategies. According to FAO (1975), simple agronomic conservation measures such as contour planting and mulching are best applied where the slope is gentle, rainfall is not heavy and where semi-permanent or permanent crops are to be established. Since Jamaica, and in particular Portland, has frequent torrential rains with very high intensity and the majority of cultivated slopes are over 20‡ (36%), the effectiveness of the measures is rather doubtful.

Regarding the present use of mechanical and biological methods in the valley, it appeared as though the farmers were not prejudiced to using one particular method but rather a combination of both. The latter observation was confirmed by a chi-square test, which returned a probability value of 0.008 (with 20 df). That is, a statistically significant relationship existed between the use of mechanical methods and the use of biological methods. This relationship exhibited a low positive correlation as indicated by a spearman correlation value of 0.26. This means that farmers are not restricted to using or favouring a particular method, in fact, they are more likely to use both methods. This sheds some hope, *ceteris paribus,* for the future status of the use of soil conservation methods in the valley, as a combination of both agronomic and engineering methods seems to be more advantageous than their individual practice.

14. ORGANIZATIONAL DIVERSITY AND SOIL CONSERVATION

Educational Status of Household and Soil Conservation: Education is important as it relates to a number of factors, such as the ability to read instructions, farmers' trainability and the ability to make use of credit facilities. According to Gumbs (1997) the farmers on hillsides often lack formal education and therefore any training programmes must take this into consideration. The ratio of educational level attained was 1: 2: 3 in order, vocational: secondary: primary, respectively. That is 50% of the farmers have had at minimum a secondary level education. This, however, is not a significant measure of literacy as some farmers did not actually complete school. Overall, no statistically significant relationship existed between educational status and soil conservation methods practised. A chi-square test returned a probability value of 0.12, a value too high for the null hypothesis to be rejected. This means that higher educational level does not necessarily encourage the adoption of more soil conservation strategies. It was interesting to note that one particular farmer who had only primary level tutelage practised 12 soil conservation methods. His situation was due to the fact that his farm plot was a demonstration site. Not withstanding, 2 farmers who possessed secondary level education practised five methods each. These findings do not concur with a study done by Wiitala (1980) on Nebraskan farmers, as cited in Anderson and Thampaillai (1990), in which conservation measures were more common among young, well-educated males.

Gender of Household Head and Soil Conservation: The sample consisted of total of 28 male-headed households and 2 female-headed households, a ratio of 14: 1 respectively. This distribution is indicative of the persistent male dominance in small farming in Jamaica and many other West Indian islands. It would have been expected for males to employ more mechanical methods than females due to the «manly» nature of the implementation process. This was not the case. A chi-square test yielded a probability value of 0.90, indicating that no statistically significant relationship exists between gender and soil conservation methods.

Age of Head of Household and Soil Conservation: Age of farmers is important as elderly farmers generally have different attitudes towards farming from the younger farmers. The mean age of the farmers was 42.2 years with a standard deviation of 12.7 years. The age of farmers ranged from 18 to 70 years. A bimodal age of 34 and 53 years was observed. The data indicate that a significant proportion of the farmers was mature in age as more than 50% of the farmers were over 40 years. A study done by Meikle (1994), in the same study locality indicated that the farmers' age ranged from 22 to 80 years. The present data have indicated that younger persons are getting more involved in farming while older persons are retiring from the profession at an earlier age.

There was no statistically significant relationship between age and biological conservation methods used by farmers. This means that older farmers do not necessarily practise more biological methods on their farms than younger farmers do. On the other hand, a statistically significant relationship existed between age and the use of mechanical methods. A chi-square test returned a probability of 0.04 (with 84 df), a value low enough for the null hypothesis to be rejected at the 0.05 level of significance. A spearman correlation test returned a value of – 0.39, indicating a moderate negative correlation between age and mechanical conservation methods. This means that as the farmer's age increases his / her use of mechanical methods decreases. That is, older farmers are less inclined to adopt mechanical conservation methods. Also, younger farmers are more likely to use mechanical methods than older farmers. The following are possible reasons for the above observed relationship:

- Younger farmers are more willing to invest money in this relatively expensive venture.
- Given the intensive labour requirements for the implementation and maintenance of these mechanical methods, older farmers are often despondent in adopting these strategies.
- Given the relative newness of these methods in the valley, older farmers may be adamant in not adopting them as these farmers are already indoctrinated in their own traditional methods.
- Younger farmers may be more open-minded and, therefore, may adopt new methods.

Household Size and Soil Conservation: Household sizes in the study area ranged from 1 to 16 persons with the most frequent size being 4. The mean household size in the study area was 4.83 with a standard deviation of 2.84. The sample accounted for 53.3% of households consisting of 4 or less persons (small households) while 47.67% accounted for household consisting of 5 or more persons (large households). Overall, no statistically significant relationship was found to exist between soil conservation and household size. A chi-square test returned a probability value of 0.84, a value too high for the null hypothesis to be rejected. This means that large households do not necessarily adopt more soil conservation strategies than small households.

Land Tenure and Soil Conservation: According to Ahmad (1997) land tenure includes the formal and informal right of access to different kinds of land, the rights to control products of that land, obligations to maintain the land, the rights of transfer and rights to determine changes in use of land. It has often been argued that conservation practises are not adopted because insecurity of tenure implies that farmers are not sure if they will be able to draw the long-term benefits of their investments. Unless tenure lasts at least as long as the minimum time for the investment to be repaid, farmers are unlikely to undertake it (Lutz, Pagiola and Reiche 1994; Pagiola 1994; Grossman 1997; Gumbs 1997).

Table 3 shows that 46.7% of the farmers had security of tenure (family/farmer owned land) while the other 53.3% had insecurity of tenure. The latter included tenure arrangements such as lease agreement and captured land. One farmer indicated that lease agreements were not stringent, as in some instances the land was eventually captured by the farmers.

Table 3. Land Tenure Arrangement

Household Type	Frequency	Percentages
Family/Farmer owned	14	46.7
Captured land	5	16.7
Lease Agreement	7	23.3
Rented	2	6.7
Owned and leased	2	6.7

Source: Author's fieldwork

Given the nature of land tenure in the area, one would surmise, *prima facie,* that farmers would be more inclined to adopting soil conservation measures. However, there was no statistically significant relationship between land tenure and soil conservation. A chi-square test returned a probability value of 0.68, a value too high for the null hypothesis to be rejected. The data indicated, however, that farmers with security of land tenure tended to favour adoption of biological methods rather than mechanical methods.

Dominant Crop Type and Soil Conservation: The dominant crop types are bananas accounting for 66.7% and plantains accounting for 10%, the second highest. The dominant crop type was markedly influenced by market availability. There existed no statistically significant relationship between dominant crop type and mechanical methods. However, a chi-square test indicated a probability value of 0.001 (with 30 df) for the relationship between dominant crop type and biological methods. This means that farmers' who cultivate banana prefer to use biological methods of soil conservation on their farms. This explains the high occurrence of mulching of banana farms.

Farming System and Soil Conservation: Farming systems were categorized into four groups namely; domestic root crop dominant, vegetable dominant, traditional export dominant and mixed types. Traditional export dominant accounted for 53.3% of the total farming system indicating the importance of export agriculture. The second most important system was mixed type (30%). It was observed that traditional export dominant systems utilized at least one type of soil conservation method (e.g. drains). Mixed-type systems had a tendency to utilize more agronomic conservation measures on farm plots such as intercropping, mulching and trees. Vegetable dominant systems appeared to have the least number of conservation methods. Overall, there was no statistically significant relationship between farming system and soil conservation methods.

Farm Plot Size and Soil Conservation: Farm plot size is critical to the nature of soil conservation strategy employed. According to Gumbs (1997) many conservation practices are considered unacceptable because they reduce the already small land area for cropping, for example drains, terraces, some types of contour barriers and trees. There were 56 plots in total and fourteen farmers had a minimum of 1 plot, ten farmers had 2 plots, four farmers three and only two farmers had a maximum of 5 plots.

The mean size of plots was greatest for Plot 2 (3.86 acres) while Plot 1 recorded the lowest mean (2.53 acres). Farm size of Plot 1 (based on farmers' estimates) ranged from 0.2 to 12.0 acres and the size distribution was positively skewed. The size of Plot 1 for twenty-six farmers was less than four acres while the size of Plot 1 for only four farmers was greater than five acres. Thirteen farmers had second plots less than four acres whereas only 3 farmers had second plots greater than ten acres. In terms of the size of Plot 2 and 3 and soil conservation methods no statistically significant relationship existed. However, a statistically significant relationship was found to exist between the size of Plot 1 and biological conservation methods (chi-square probability value of 0.038; 40df). Also, this relationship had a low positive correlation, as indicated by a spearman correlation value of 0.28. This means that the larger the size of Plot 1, the greater the number of biological conservation methods used.

15. AGRODIVERSITY ON SMALL FARMS

The Nature of Biodiversity: A total of 196 different species of plants were recognised as being part of the systems in the study area. The total number of species indicates an increase in more than 100% of the total number of species (80) encountered in the same study area by a previous study conducted by Thomas-Hope, Spence and Semple, in January 1999. The difference in the total number of species may be attributed to either an improvement in the sampling methodology of collecting biodiversity data or the temporal and spatial distribution of plant species or a combination of both factors. These plants included roots and tubers, legumes, cereals, fruits, vegetables, condiments, ornamental and medicinal plants, and timber trees. The different plant species were grown on plots in arrangements described by Hills (1988) as «food forests» which fall into the category of intensive mixed-garden cultivation.

Food forests have one or more dominant crops, but there are varying proportion of a wide variety of crops. The banana dominant food forest was most frequently encountered as indicated by approximately 30% of the farms, followed by banana/ plantain dominant and banana / coconut dominant. The popularity of banana in the valley is evidenced by the fact that 66.7% of the farmers had banana as their dominant crop grown. The prevalence of banana is due to its status as the most important export crop in the area as well as being an important staple for residents in the area. Maize (Corn) was the only cereal grown.

Apart from banana, other popular crops, in terms of proportion of farms, were coconuts, dasheen, plantain, breadfruit, oranges and yams. Dasheen, plantain, breadfruit and yams are staple subsistence crops and reflect the African culture heritage of most of the residents in the study area. Legumes are both widely cultivated and consumed, but most farmers grow a limited variety, that is, string beans, kidney beans, gungo pea or pigeon pea, cow pea and broad beans. Given the importance of rice and peas in the Jamaican diet, it was surprising that only a few varieties of peas were encountered on the sample farms, and that only a limited proportion of farmers grew peas (Thomas-Hope, Spence and Semple 1999a, b).

A maximum of thirteen different vegetables was grown on any one plot. Lettuce, Pak Choi, and Callaloo were grown throughout the year. After medicinal plants, fruits were the largest variety of cultivated plants found on the sample farms. The dominant fruit was banana, followed by coconuts, breadfruit, orange, mango, ackee and apple. An interesting feature was that not all farms had the same combination of fruits, an indication of variation in soil type as well as farmers' preference for certain types of fruits. Other species that added to the biodiversity of the area included timber trees (e.g., Mahogany and Teak) as well as wild plants, such as Penny Royal and Guaco Bush, that possess medicinal and other uses and are therefore kept specifically for these purposes. Ornamental plants were predominant on house plots (Plot 1) and included popular varieties of ferns, crotons, orchids and hibiscus.

In terms of household structure and biodiversity, no statistically significant relationships were observed. The latter was confirmed in recent studies done by Thomas-Hope, Spence and Semple (1999b). They concluded that market forces, particularly, the strength of export demand, is evidently the major factor influencing the reduction in biodiversity in the area.

With respect to farm dynamics (in particular size of plots 1 and 2; distance of Plots 1 and 2 from the household; the number of days per week spent farming on Plots 1 and 2) and biodiversity, there were not many statistically significant relationships observed. However, high probabilities were observed that could have resulted in the rejection of the null hypothesis and the acceptance of the research hypothesis (at the 90% level of significance), that there were not significant relationships among variables. Statistically significant relationships were accepted at the minimum level significance of 0.05.

Biodiversity was sub-divided into two categories, that is, total number of herbs / plants and the total number of food crops for each household. A chi-square test returned a probability value of 0.04 with 120 degrees of freedom (df) for a relationship between the number of days worked per week on Plot 1 and the total number of herbs / plants. A probability value of 0.09 was recorded for the relationship between the size of Plot 1 and the total number of food crops grown, which is statistically significant at the 95% confidence level.

16. AGRODIVERSITY AND SOIL CONSERVATION

An analysis of the agrodiversity (in particular biodiversity) in the area and the soil conservation strategies employed by farmers will now be attempted. The analysis involved categorising biodiversity into the total number of food crops and the total number of herb / plants found on farm plots. The nature of soil conservation methods practised by farmers was obtained from the data gathered and was grouped into the following four categories: those farmers who practised no conservation methods; those who practised agronomic methods only; those who practised engineering methods only; and those who practised a combination of both agronomic and engineering methods.

Table 4 summarises the number of plant species by category. As indicated, the mean number of food crops was 14.00 while that of herbs / plants was 12.10 species. There was an observable disparity in their modes as food crops were significantly higher (17.00) than that of herbs / plants (4.00). The distribution in the number of farmers having food crops and herbs / plants according to the specified range was quite similar. For example, 13 farmers each had food crops and herbs / plants on their farm plots, within the range of 11-20 species.

Table 4. Summary of Species According to Category

Range of Species	Number of Farmers		
	Food Crop	*Herb Plants*	*Total Species*
0 - 10	12	13	5
11 - 20	13	13	5
21 - 30	3	4	9
31 - 40	2	0	6
> 40	0	0	5

Source: Author's fieldwork

Table 5 gives the distribution of the mean values of the categories of all species as they relate to the type of conservation methods. In general, the mean number of herbs / plants recorded the highest value (13.80) with the practise of engineering methods only, whereas the lowest value (11.00) was recorded with the practice of agronomic methods only. The latter feature could be linked to major crop types and production systems.

Table 5. Mean Value of Plant Species on Farm Plots

Type of Conservation	Mean Number Of Plants/Herbs	Mean Number Of Food Crop	Mean Number Of Species
No Soil Conservation Method (NCM)	12.83	17.50	30.33
Agronomic Methods Only (AMO)	11.00	11.75	22.75
Engineering Methods Only(EMO)	13.80	11.00	24.80
Both Agronomic and Engineering Methods (AEM)	11.73	15.09	26.82

Source: Author's fieldwork

The low mean value associated with agronomic methods only, could be attributed to the farmers seriousness of purpose in cultivating mostly food crops, which are more economically viable and thus their «effective» use of space which decreases the biodiversity of herbs / plants. Given the fact that 14 farmers employed mulching as the principal biological strategy, may have resulted in fewer species of herbs / plant, as the mulching agent would have occupied a significant portion of the land surface, thus stifling their growth. The high mean value associated with engineering methods could be linked to the notion that the effectiveness of these semi-permanent structures are not significantly disturbed or hindered by these herbs / plants, and so they are indiscriminately allowed to grow freely, thus accounting for their high biodiversity. Also, some farmers expressed their desire to have a high diversity of herbs / plants given their inherent and traditional utilitarian value. The second and third highest means of herbs / plants were recorded where no soil conservation methods was practised and where both agronomic and engineering methods were practised respectively. Therefore, the best practise in conserving herb / plant diversity is the adoption of engineering methods only.

With regard to the mean number of food crops grown, the non-adoption of soil conservation methods yielded the highest mean value (17.50) while the adoption of a combination of both agronomic and mechanical methods yielded the second highest (15.00). The use of agronomic methods only yielded a mean value of 11.75, which was marginally greater than that yielded by the use of mechanical methods only (11.00). The high mean value yielded of the non-adoption of soil conservation methods may be a function of «nature» taking its course. That is, natural growing trees such as breadfruit and ackee trees are in relative abundance on farm plots and are allowed to remain *in situ,* independent of soil conservation methods. Hence, nature perpetuates its course. The practice of agronomic or mechanical methods only initiated low mean values, however, their combination seemed to be more effective in yielding higher food crop biodiversity.

The mean values associated with all species increased from the use of agronomic methods only (22.75) to the non-adoption of soil conservation methods (30.33). The use of engineering methods only recorded the second lowest value (24.80) whereas the use of both agronomic and mechanical methods recorded the second highest value (26.82). From these results, one is led to believe that the non-adoption of soil conservation methods is the most critical factor in maintaining high genetic diversity. This notion accentuates the self-perpetuating ability of nature to take care of itself and maintain some level of sustainability. However, given the influence of man's activities in a fragile environment and the consequences associated with such behaviours, it is apparent that in order to preserve genetic diversity and reduce the risk of depleting biodiversity, a combination of both agronomic and mechanical conservation methods should be utilized as deemed appropriate.

The only statistically significant relationship found was that between the total number of herbs / plants and the total number of conservation methods used (chi-square probability value of 0.026; 80 df). This relationship also exhibited a low positive correlation as indicated by a spearman correlation value of 0.1. This means that the lower the number of mechanical methods used the more herbs / plants will be encountered or simply the greater the biodiversity in herbs / plants.

17. CONCLUSIONS

This study has shown that organizational diversity does affect, to some degree, the nature and type of soil conservation methods adopted by farmers in the lower Rio Grande Valley. The power of market forces cannot be overlooked as many farmers are increasingly tending to the cultivation of bananas, which has implications for the type of soil conservation methods used and consequently will affect the nature of agrodiversity in the area. Central to the kind of soil conservation methods implemented by farmers, are their age, the size of major plot or household plot (Plot 1), and the dominant species grown. Younger farmers seemed to be more receptive to change with regard to adopting modern soil conservation techniques, especially those that involve engineering structures.

The high average age of Jamaican farmers indicates the implications of policy instruments and the design and implementation of soil conservation programmes. Given that older farmers exhibit a higher degree of reluctance to adopt new technology, one could model age as a function of technology to determine whether this hypothesis is substantiated.

Au fond, each conservation method may be used separately or in combination with other erosion-control techniques. To determine the most advantageous combination of appropriate conservation technologies, the soil type, specific crop type, slope, and climate (rainfall and wind intensity), as well as the socio-economics of the people living in a particular site must be critically considered.

In terms of soil conservation and agrodiversity, the non-adoption of soil conservation methods indicated greater mean species diversity. However, where conservation checks are necessary, a combination of both agronomic and engineering methods is recommended, as this will yield higher mean species diversity than employing singly agronomic or engineering methods. Soil conservation practices in the valley, therefore, have implications over time as they relate to the long term sustainability of farm productivity and agrobiodiversity.

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