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# MODIFICATIONS OF THE APPLICATION OF SOIL EROSION CONTROL TECHNOLOGIES IN SUBSISTENCE AGRICULTURE

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## ABSTRACT

*Diffusion theory and research in the developing countries have not adequately examined the adaptive or coping strategies of small scale farmers to farm-level environmental degradation brought about by population pressure and agricultural intensification. Data gathered through personal interviews and participant observation with farmers in high density, highly erodible soil areas of Anambra State in South Eastern Nigeria are used to study the patterns of modification of the application of soil erosion control practices. It was found that of 23 soil erosion control practices identified in the study area, the ways 7 of them were applied by farmers had been significantly modified to cope with increasing levels of soil erosion, and that the erosion control measures used by the farmers addressed multiple objectives, including those goals that do not necessarily have to do with erosion control. It is suggested that research should concentrate on the 7 practices that have been modified by the farmers themselves in order to refine them further for reinjection into the farmers' production system. Also, extension should always recommend erosion control practices that have multiple objectives in order to increase their chances of being adopted by farmers.*

**Key words**: Soil erosion, control technology

## INTRODUCTION

Recent evidence from detailed studies have shown that soil erosion is by far the most severe hazard affecting the lands of Nigeria-ravaging all of its bio-climatic regions as rill, sheet and gully erosion (Ofomata, 1964, 1980, 1982, 1984a and b; Ologe, 1971; Ojanuga, 1978; Sada and Omuta, 1979; Anon, 1988). Gully and sheet erosion types have been noted to be the most rampant in Anambra State (Anyanwu, 1991), where steep slopes, high rainfall, sandy and ferralitic soils increase susceptibility of the terrain to erosion (Okafor, 1991). The problem has been so serious that by 1964, 47% of the soils of Eastern Nigeria were affected by measurable sheet erosion while 20% suffered from severe sheet erosion (Ofomata, 1976). Another estimate by Grove (1951) indicated that 5.7% of the land in Oko in Orumba North Local Government Area of the State was occupied by gullies. It was in realisation of the enormity of the erosion problem and the futility of unorganised response to it, that the Government of Anambra State was compelled to establish the Anambra State Task Force on Soil Erosion Control (ASTFSEC) which by 1990 had identified 530 severe gully erosion sites in parts of the State (ASTFSEC, 1986).

Research recommendations on how to reduce environmental degradation on small farms often centre on prescriptions of adoption of modern methods of production or environmental management. Yet many of these studies do acknowledge that modern recommended practices for erosion control tend to be unsuitable. For instance, Anderson and Thampapillai (1991) observed, as has been formalised in Todaro's (1977) "False Paradigm" model, that some of the recommended technologies do not suit tropical agricultural regimes. Equally, terrace systems have been found not to be adapted to the economic, social and climatic conditions of the tropics, particularly in West Africa and Madagascar (Roose, 1977). The need to integrate erosion control practices in the cultivation systems have either been implied or clearly suggested by several authors. Young (1989) states that the costs, or labour requirements of physical erosion control works necessary to control run-off by such means as bunds and terraces were commonly found to be excessive." Conservation farming" or "integrated land use", the 'emerging' farming systems approach to environmental conservation, has been practised by Nigerian farmers for a long time. Young (1989) advocated the use of simple methods of erosion control such as mulching, bunding, and cover cropping, which are within the capacity of the farmers to establish and maintain, and endorses external support for sound traditional farming practices. He contends further that diagnosis and design

research approach has the in-built element of farmer acceptance of results therefrom because it builds on existing capacities and practices.

Even where the integration of farmers' generated knowledge in the farming systems research process such as the application of plant-derived substances in pest control is recommended, we find that no specific practices are suggested. Two inferences could be drawn from this. First, there is probably an inadequate knowledge of what innovations farmers are generating or are capable of generating from their own experimentation in soil erosion control. Thus, once available, recommended practices are rejected by farmers, and as is often the case, there tends to be more or less a break down in the extension service's efforts. Second, the agenda of research in soil erosion control often does not seem to be directed at improving what the farmer is already doing by way of soil erosion control technology use. In this paper, we identified the specific impacts and directions of farmers' attempts to adapt to changing environmental effects of farm-level soil erosion. The study also provided information on who generated them, how they were initiated or heard about.

## CONCEPTUAL CONSIDERATIONS

An understanding of the processes of generation and transfer of traditional technical and ecological knowledge and practices is an important requirement for planning intervention programmes in agriculture and rural development. Writing on ethnoscience and the African farmer, Knight (1980) observed that the accumulation and dissemination of knowledge in form of shared environmental beliefs and rules for production activities is critical for the development and maintenance of complex agricultural systems. By implication, such systems were characterised by the existence of culturally defined cognitive patterns which are passed through generations by enculturation, the existence of domains of agricultural production technology that are altered by individual idiosyncrasies, and by local innovation and discovery of new knowledge or diffusion of knowledge into the society.

Although traditional soil erosion control processes are systematic, rational and technically sound (Fujisaka, 1986 and 1987), their development and continued use are characterised by what Knight (1980) terms "bounded rationality" which has two basic connotations. First, environmental knowledge and its articulation as agricultural practices are internally consistent and, second, to a large extent, self-fulfilling in that premises upon which actions are taken are reinforced when such actions are successful; that is, for example, that crops yield well justifies the system by which they were cultivated. In other words the empirical validity of traditional practices is determined at the utilitarian level. Traditional erosion control practices may have their origins "rooted in religious beliefs or in cosmographies alien to Western science; their ultimate roots, belie, however the validity and efficacy of environmental knowledge" (Knight, 1980). Thus, the existence, functioning, and resilience of traditional erosion control practices may be seen as an enduring evolutionary product of human activity and environmental modification.

Modifications in the application of soil erosion control practices by farmers could take several forms. It could be as a result of changes in place or time of application, changes in make up of erosion control structures, or changes from incidental (unplanned) use to deliberate (planned) application. Unless an activity has to qualify as soil erosion control practice only when it is consciously applied for that purpose, the scope still exists for the identification of more traditional erosion control practices at the farm level. There are many stabilised farming adaptations to environmental degradation and population pressure in the study area the applications of which are independent of any specific wish to control erosion or outside the portfolio of technical prescriptions of the extension service but which nevertheless serve that function. Considerations of soil erosion control practices in traditional agriculture must recognise the fact that most of them are multi-objective in scope.

This research was anchored on three apriori assumptions, namely: (a) that there are some traditional soil erosion control technologies and practices among small scale farmers yet undescribed; (b) that farmer-generated changes in the methods of, or places of application of recommended or traditional practices under prevailing resource use constraints are likely to be most adapted socio-economically, agronomically, technically and environmentally to the farmers' needs; (c) that traditional erosion control practices cannot be conceived in isolation from routine land use processes;

## METHODS

The data for this study were gathered in Anambra State in South Eastern Nigeria in 1999. Anambra State is one of the 36 states of Nigeria and comprises 21 Local Government Areas (LGAs). This area was chosen because of a unique combination of factors, namely: (i) with a statewide population density of between 887 and 1384 people per $km^2$ it falls within what Buchanan and Pugh (1955) described as the ultra-high density belt of the Igbo heartland; (ii) the state is dominated by red acid soils that lose their fertility rapidly under cultivation (Grove, 1951). These facts, coupled with a low land/man ratio, low fallow periods and land fragmentation has created serious limitations to efficient land use management practice in

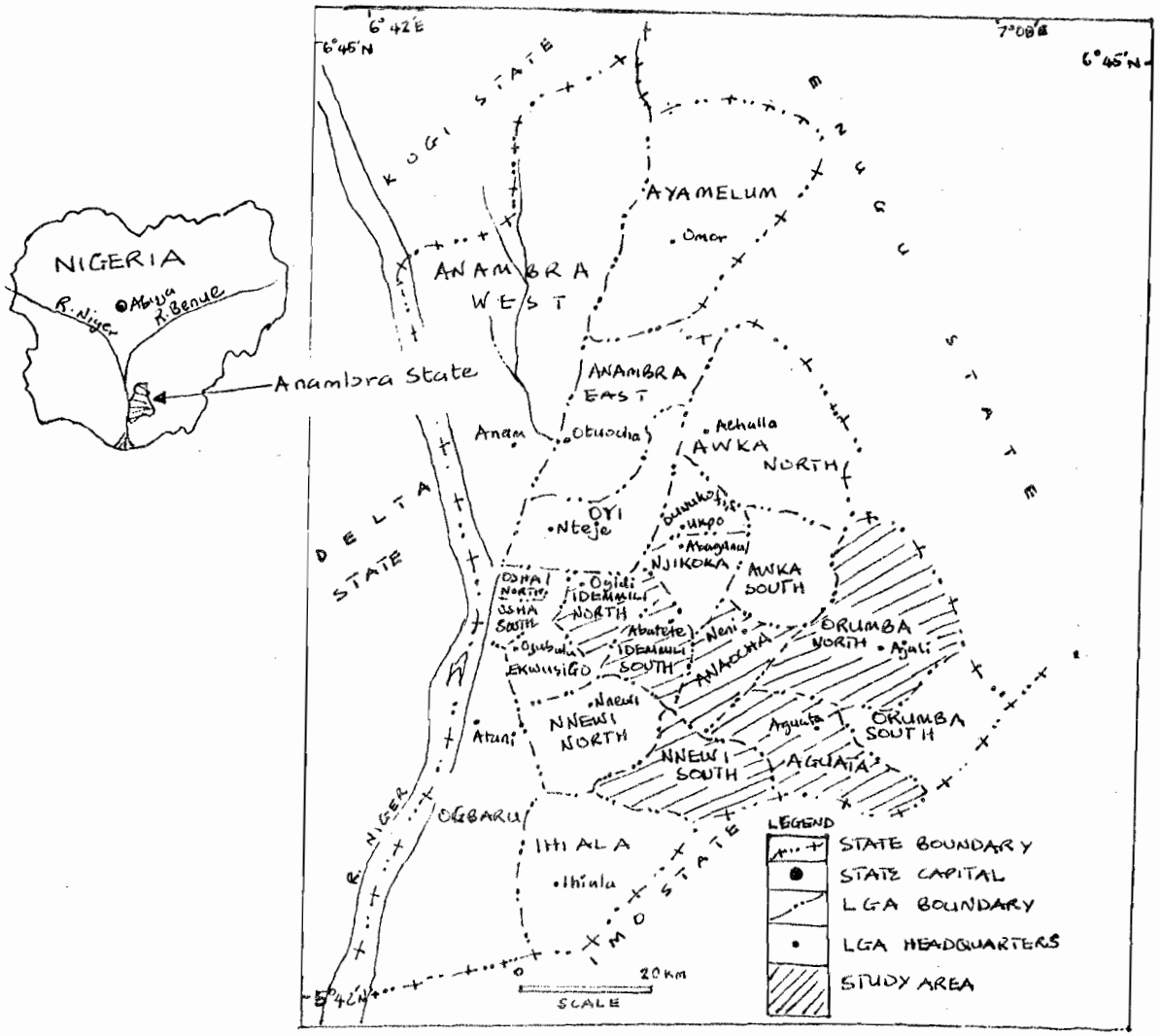


FIGURE 1: Map of Anambra State Showing the Study Area

the area. In the Awka uplands, the average farm size is 0.45 hectares compared to a national average of 1.2 hectares; (iii) As a result of human activity, the vegetal cover in the area has largely transformed into secondary plant cover and much of the forests have turned into "derived" savannah and farm land mosaic (Okafor, 1991); (iv) The study area covers the most erosion-prone areas of Nigeria, including the famous Agulu-Nanka erosion complex where severe and active soil erosion has led to farmlands being completely destroyed and abandoned.

A random sample of 125 farmers was selected for the study. The selected farmers had at least 0.45 hectares of farm land (the average in the area, Okafor, 1991); planted either cassava, yam or cocoyam, or a combination of two or more of them on the most severely eroded soils in the state. Our guide in this process was a published record of erosion gully counts by the Anambra State Task Force on Soil Erosion Control (ASTFSEC). Our sample frame for community-level farmer selection was the list arising from the Anambra State Agricultural Development Project's (ADP's) baseline survey of farm families in the various communities. A positive correlation was assumed between gully incidence, the incidence of sheet erosion and the probability of changes in the methods and places of application of erosion control practices. The selected LGAs and communities studied are as shown in Figure 1 and Table 1.

To ensure that only farmers with tenure security were sampled, we took only those who were sure to be using their present farmlands uninterrupted for the next three years.

Table 1: Selected Study Areas

| LGA | Communities |
|---|---|
| Aguata | Igbo Ukwu. Ekwulobia. Umuchu. Akpo. Amesi |
| Anaocha | Nneni. Adazi Enu. Agulu. Nri. Akwaeze |
| Idemili | Nnobi. Nkpor Agu. Eziowele. Oba. Oraukwu |
| Nnewi South | Unubi. akwaihedi. Utuh. Amichi. Ukpor |
| Orumba North | Oko. Omogho. Ajalli. Ndiokpaleke. Awgbu |

Field work was done during the cropping season in

Table 2: Distribution of Farmers by Observed Symptoms of Soil Erosion on Their Farms

| Reported Sign of Soil Erosion | No of Farmers Reporting | % of Total |
|---|---|---|
| Gullies | 31 | 25 |
| Rills | 42 | 34 |
| Soil Washed Away | 65 | 52 |
| Crop/Tree Roots Exposed | 56 | 45 |
| Stones Exposed | 23 | 18 |
| Drainage Ditches Covered With Soil | 33 | 24 |
| Sand Deposited At Lower Portions | 35 | 28 |
| Crops/Trees Felled | 29 | 23 |
| Land Slides | 27 | 22 |
| Decreasing Crop Yields | 42 | 34 |

Source: Field Survey, 1999.

Table 3: Distribution of Farmers by Use of Erosion Control Measures

| Erosion Control Practice | No. of Farmers | % |
|---|---|---|
| 1. Zero tillage | 68 | 54.0 |
| 2. Ridging | 97 | 77.6 |
| 3. Mounding | 104 | 83.2 |
| 4. Minimum Tillage | 48 | 38.4 |
| 5. Trenching For Yams | 57 | 45.6 |
| 6. Terracing | 33 | 26.4 |
| 7. Contour Strip Cropping | 63 | 50.4 |
| 8. Contour Ridging | 46 | 36.8 |
| 9. Using Dead Tree Trunks | 69 | 55.2 |
| 10 Cover Cropping | 75 | 60.0 |
| 11. Fallowing [weed Tolerance] | 58 | 46.4 |
| 12. Incorporating Stubble | 54 | 43.2 |
| 13. Incorporating Manure[2] | 40 | 32.0 |
| 14. Allowing Trees/shrubs | 46 | 36.8 |
| 15. Not Burning Field | 49 | 39.2 |
| 16. Planting In Rotation | 49 | 39.2 |
| 17. Diversion Pits/Channels | 80 | 64.0 |
| 18. Planting Trees[3] | 37 | 29.6 |
| 19. Hedgerows Between Crops | 57 | 45.6 |
| 20. Mulching | 81 | 64.8 |
| 21. Planting Early | 52 | 41.6 |
| 22. Making Very Big Mounds | 62 | 49.6 |
| 23. Planting Densely | 32 | 25.6 |

[1]On uncultivated plots. [2]Green manure. [3]Deliberate planting.
Source: Field Survey, 1999.

1999 and consisted of personal interviews and direct inventory of the application of soil erosion control practices in the area. Information was obtained on farmers' socio-economic characteristics, farm structure and sizes, cropping patterns, land tenure, soil erosion control practices, types and sources of material inputs, sources of farm information on soil management practices, nature and contents of inter-farmer and farmer-extension information exchanges and innovation, ethnohistorical information regarding techniques employed by farmers in the past for handling specific environmental problems. Our analytical approach was to describe the characteristics of the identified practices in terms of structural make up, size, lay-out, time of use and place of use among others. We also gathered information on who effected what modifications and the farmer's perceived reasons why the identified practices were modified.

## RESULTS AND DISCUSSION

**Demographic Characteristics, Farm Structure and Ownership:** The age and sex distribution of the respondents shows that 73% were males while 27% were females. Most of the respondents were in the age range of 50-59 years. The mean, modal and median ages are 46.2, 55 and 48 years respectively. Nearly half of the interviewed farmers possessed farmland of less than 1 hectare. However, the mean farm size of 0.98ha is much higher than the 0.45ha earlier reported in the area by Okafor (1991). Most of the farms (73%) were more or less homestead farms located very close to residential areas. Investigations revealed that multiplicity of farmlands was associated with the culture of communal farm ownership. Also, communal ownership of farm plots appears to be associated with longer distance between the farm plots and residential (homestead) areas. Also the transaction cost of decision to apply an erosion control practice or to choose among alternatives is likely to be high, and appreciation of the need to control erosion on farm lands may vary among the communal farm owners. These characteristics would probably have some

Table 4: Nature and Frequency Counts of Modifications of the Application of Soil Erosion Control Practi

| Soil Erosion Control Practice | Nature of Modification and Percentage of Farmers Reporting | | | |
|---|---|---|---|---|
| | Material Composition | Size of Structures | Place of Use | Deliberate Application |
| Cover crops | 20 | - | - | 18 |
| Pits/trenches | - | 22 | - | - |
| Soak-away pits | - | 19 | 15 | - |
| Tree planting | 8 | - | - | 8 |
| Mounds/ Ridges | - | 77 | - | - |
| Fallowing | 17 | - | - | 14 |
| Spot tillage | - | - | - | 38 |

Source: Field Survey, 1999.

Table 5: Reasons for Modification of Erosion Control Practices

| Place of Observed Modification | Reasons for Modification | | | |
|---|---|---|---|---|
| | % of Farmers | | | |
| | A | B | C | D |
| Cover Crops | 63 | 48 | - | 17 |
| Pits/Trenches | 54 | 81 | 44 | - |
| Soak-away Pits | 98 | - | - | - |
| Tree Planting | 49 | 13 | - | - |
| Mounds/Ridges | 85 | 04 | 22 | - |
| Fallowing | 36 | 66 | - | - |
| Spot Tillage | 75 | 20 | 33 | 21 |

**Key:** A = erosion control. B = soil enrichment. C = labour saving. D = weed control.
Total % for each modification > 100 because of multiple responses.
Source: Field Survey, 1999.

influence on the way erosion control practices are used.

**Soil Erosion and Its Control:** Table 2 shows that soil wash, reported by 52% of the farmers is the most widespread erosion symptom followed by exposure of crop roots (45%). But with the exception of gullies, felling of trees and landslides, all the signs in Table 2 could be associated with sheet erosion. The farmers that reported decreasing crop yields were convinced that erosion was responsible for it although that may not necessarily be so. What it suggests, however, is a high level of awareness about erosion hazards in the study area.

Table 3 shows the distribution of the farmers by the type of erosion control practice used. The twenty three practices displayed on the table are those which the farmers personally identified as having specific erosion control value in their farming activities.

**Observed Modifications**: Table 4 presents the nature of modifications of the application of soil erosion control practices, which were observed in the field. Out of 23 practices recorded in the study area, 7 were observed to have been significantly modified on the basis either of material composition, size of structures, place of use or whether decision to use it was deliberate or incidental. This last distinction is important because, for instance, a farmer who notices that some wild cover plants do control erosion in his farm cannot be said to have specifically planted and maintained them for erosion control. If, however, there is a change from non-tolerance to tolerance of the plant (most likely a weed), then that represents a modification of erosion control behaviour.

**Cover Crops**: The use of cover crops in the study area has undergone some modification in the sense that the type of crops used have been changed, the places where they were used have also changed, and some farmers (18%) now plant these crops deliberately to control soil erosion. The evidence shows that the stabilised cropping mix in the study area which had mainly plants of the *Cucurbitaceae* family [eg. fluted pumpkin] is now being altered towards the inclusion of other crops such as *Ipomoea batatas* (sweet potato) and *Citrulus vulgaris* (melon) (20%), both of which are thought to help tremendously in erosion reduction, while contributing some income to the farm.

**Pits/Trenches**: Some farmers (22%) have reportedly adopted the planting of yams in enriched pits with very low mounds, rather than just mounds as has been the practice in the areas since time immemorial. The objective is to disturb the soil as little as possible.

**Soak-Away Pits**: As the name suggests, the purpose of soak away pits is to collect run-off after a heavy storm so that it gradually gets absorbed thereby limiting erosion.

Table 6: Sources of Modification Ideas

| Place of Observed Modification | Source of Modification Idea % of Farmers Reporting | | | | |
|---|---|---|---|---|---|
| | Self | Friend | Fellow Farmer | Govt. | Don't Know |
| Cover Crops | 12 | 36 | 47 | 15 | 5 |
| Pits/Trenches | 32 | 28 | 15 | - | 75 |
| Soak-away Pits | - | 19 | 12 | 23 | 58 |
| Tree Planting | 41 | 11 | 54 | 44 | 9 |
| Mounds/Ridges | 49 | 34 | 37 | - | - |
| Fallowing | 27 | 12 | 60 | 18 | 26 |
| Spot Tillage | 19 | 35 | 38 | 2 | 5 |

Key: Govt. = ADP/ Ministry extension staff.
Total % for each modification > 100 because of multiple responses.
Source: (1994): Field Survey.

These pits, which are of varying sizes, are located mainly at strategic points by roads bordering the farm. From our survey, 19% of the farmers who used soak-away pits within the farms indicated that they were using bigger pits. This was particularly evident in Nneni, Nnobi, Adazi-Enu, Oraukwu, Umuchu, and Ekwulobia. Also, because of increasing awareness of the erosion problem some farmers (15%) were now employing these pits within the farms rather than just by roadsides.

**Tree Planting:** The use of trees and shrubs for erosion control is a widespread practice in the study area, particularly in Nnobi, Oraukwu, Agulu, Nri, and Eziowele. Prominent among these plants are *Bambusa sp.* (bamboo), *Acioa barteri* (ahaba) and *Anacardium occidentale* (cashew). In the past, although *A. Barteri* was introduced by the colonial masters to fight erosion, its role among the small-scale farmers was different. They were generally for wood and stakes and, in Aguata particularly, for colonising open lands in time past. These days, the plant is maintained in small wood lots to check erosion on farmlands. There was no evidence of farmers deliberately planting *A barteri*, a situation brought about by the fact, according to the farmers, that it takes time to grow and that it has stubborn roots that interfere with hoeing, the very reason why it is suitable for erosion control.

*Bambusa spp.* was found to be popularly used in soil erosion control although its use is limited to the protection of incidence points of severe gullying and not for siltation or sheet erosion control. One identified draw back of bamboo is the claim by some farmers that it impoverished the soil. It was found that some of the farmers that were interviewed had started using vetiver grass for erosion control in Agulu, Nneni, Nnobi, Oraukwu, and Nri.

**Mounds/Ridges:** The farmers (77%) reported that while making mounds/ridges one of the foremost considerations they have is how to make them withstand soil wash. Making them bigger is one common response by the farmers. Lower-sized mounds/ridges tend to be washed down faster before the crops get established thereby exposing the seeds and roots. But making the mounds/ridges bigger means higher costs of cultivation. As such the result is an overall reduction in the size of mounds/ridges used by the farmers. While the use of mounds/ridges on exposed acid sand soils may facilitate and enhance splash and sheet erosion, their continued use in the study area has cultural origins, which appear not to have been questioned by the farmers.

**Fallowing:** A decline in the land/man ratio in the study area has given rise to reduced fallow periods (average of 1.9 years) (Okafor, 1991), which compromises farmers' erosion control objectives. To overcome this, some of them (14%) have resorted to selective fallowing and the deliberate keeping of permanent fallows on fragile portions of the farmland. In addition, there is evidence of deliberate planting of fallow and hedge plants (by 17% of the farmers) such as the newly introduced vetiver.

**Minimum Tillage:** In parts of the study area the use of minimum tillage is new. In Agulu, Igbo-Ukwu, Amichi, Ajali, Nkpor-Agu, and Oba, some farmers (38%) would till only the spots on which cassava sticks are to be planted. No mounds were raised at the spot and weeds are kept in check around them by hoeing and slashing.

It was observed that the application of most erosion control practices is based on multiple objectives. However, there is a preponderance of a specific wish to use alterations in the seven recorded modifications therein to control soil erosion (Table 5). Other observed joint objectives include soil enrichment, labour saving and weed control. On the source of the idea to change the method/place of application of an erosion control practice, farmers' friends and their fellows between them accounted for the greatest influence (Table 6).

It was revealed during the interviews that sometimes extension agents do give farmers advice that encourage them to alter the methods of application of

soil erosion control practices away from the officially prescribed measures which the agents are supposed to advocate. Such empathic stances have arisen from the agents' concern that the farmers generally lack the capacity to apply the officially approved measures. Government extension services have been most active in the promotion of tree planting and is completely absent in pits/trenches, mounds/ridges and other more traditional measures. It is noticed that high percentages were recorded under the 'don't know' column for such traditional measures. This supports Knight's (1980) hypotheses on traditional technical and ecological knowledge. The more the generation and transfer processes of a practice in question are characterised by imperceptible diffusion through enculturation, the less farmers are aware of its origins.

## CONCLUSION

Knowledge of reasons for modifying the application of erosion control practices tells us the kind of relevant farmer concerns and objectives that should be incorporated into formal research processes. It also suggests that recommended soil erosion control practices that do not address farmers' joint objectives stand a reduced chance of being adopted by them.

The failure of many recommended soil erosion control practices in the past in much of Anambra State could in fact probably be traceable, to some extent, to the fact that they tended to address a single rather than multiple objectives at a time. Furthermore, in Table 5, the percentage distribution of the farmers by reasons/objectives for modification of the application of soil erosion control practices can be equated to the level of approval, in percentage terms, of various objectives for the given soil erosion control practice. Thus, for instance, we can see that pits/trenches enjoy a high level of approval (81%) among the farmers as measures for soil enrichment while soak away pits are almost exclusively for erosion control. The study shows that the source and reasons for modifications of the application of soil erosion control practices have implications for choice of farmer collaborators in programmes of erosion control. Sources that are most frequently mentioned should be most suitable to link up with in the planning and execution of on-farm client-oriented research. That 'fellow farmer' is the highest source of modification idea with regard to cover crops highlights the need to encourage inter-farmer interactions in order to possibly increase chances of such farmer-to-farmer exchanges that give rise to transfer of useful ideas for erosion control. However, one limitation in our data is that farmers' responses in Table 6 are overly subjective. It is difficult to conclusively associate any given idea on modification of an erosion control practice with any particular farmer given the fluidity of inter-farmer exchanges.

Extension can play a crucial role in bringing effective farmer-generated changes in the application of soil erosion control practices into general use. To achieve this, there is the need to identify relevant modalities of research and extension linkages with mechanisms to test, validate and legitimise erosion control practices arising from farmers' experiences. One of the objectives of this study was to identify those soil erosion control practices that can be improved and subsequently fed back into the small farmer production system. The study suggests that all the seven modifications of the application of soil erosion control practices described in this study (Table 4) are very worthwhile points of departure for the continued refinement of practices that will eventually qualify for re-injection to farmers. Various agricultural regions in Nigeria require the isolation of a unique set of practices on which to focus research attention for continuous refinement and reintroduction to farmers. This will go a long way to ensuring sustainable utilisation of agricultural land thereby promoting sustainable development.

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