A FARM LEVEL SUSTAINABILITY INDICATOR FOR HORTICULTURAL CROP PRODUCERS IN *FADAMA* AREAS OF SOUTHERN GUINEA SAVANNAH OF NIGERIA

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Abstract
A farm level sustainability indicator was determined within the framework of small-scale farming households utilizing *Fadama* for the cultivation of horticultural crops in the Southern Guinea Savanna of Nigeria. The study determined Indicators of Sustainable Agricultural Practices (ISAP) and identifies the critical farming practices to monitor in order to sustain productivity of *Fadama* land. A two- stage simple random sampling technique was used to obtain 180 horticultural crops producing households interviewed for the study. The data were collected for 2008 cropping season. The data were analyzed with descriptive statistics such as frequency distribution, mean, standard deviation, scoring and weighting of farm practices and sustainability web. The Indicator of Sustainable Agricultural Practices (ISAP) mean score of 0.622 implied that crop production practices of sampled farming households were fairly sustainable. The study showed that methods of pest control, weed control, and soil fertility maintenance were the critical indices to monitor for the improvement of sustainability. In order to ensure sustainability of *Fadama* for horticultural crops production the study recommends increased, integrated pest management and regulated use of agro-chemical.

Key words: *Fadama*, Sustainability indicator, Farming practices.

Introduction
Fadama or inland valleys are the seasonally flooded plain along major rivers and or depression on the adjacent low terraces. These contracts sharply with the surrounding dry top land in terms of resources. The potential of this agro-system is based on two distinguishing features. One is the presence of sufficient soil moisture that reduces crop risk in the wet season and permits the cultivation of a wide variety of crops during the dry season. The second is the presence of soil that is generally more fertile than that of upland. Thus, they present a unique opportunity towards reversing the declining per capita food production in Nigeria. The *Fadama* size of Nigeria is estimated at about 4.6 million hectares. Although this is spread across the country but major part of it is in the Guinea Savannah ecological zone (Ingawa, 1998). If the potential of the inland valleys for intensive crop production could be realized, they might serve as a kind of safety valve for relieving pressure in other agro ecosystem particularly the humid forest and moist savannah (Lawal, 2008).

The quest for harnessing the benefit of *Fadama* land has ushered in technological innovations such as development of small irrigation pumps, small earthen dams and shallow tube wells. This has led to intensification in the use and management of *Fadama* for agricultural activities. The Ministry of Water Resource and National *Fadama* Development Project (*Fadama* II, World Bank and African Development Bank assisted project) is especially active in *Fadama* development in eighteen (18) states of Nigeria. By and large the inland valleys are cultivated by small holders whose land utilization and management with limited resources are aimed at achieving farm level objectives in term of food security and economic viability. Their land use practices have a short term planning horizon with little attention to the status and management of agricultural land (Krusemen *et al.* 1996; Pannell and Glenn, 2000; Adewumi and Omotesho, 2002). Production objectives of short term food security and income that guarantees economic production by the farmer might be achieved. However, the achievement may have come at the expense of long-term sustainability of land resources and development. Sustainable development is consistent with increasing environmental assets or development without destroying the future of natural capital stock (Kolawole and Scoones 1995). The most critical issue that this study addresses is to identify the farming practices to monitor as indicators of sustainable agricultural practices in the production of horticultural cops in the *Fadama*.

Therefore, this study will answer the following research questions in the assessment of *Fadama* land use;

(1) Is horticultural crop production practices in the *Fadama* sustainable?

(2) What are the farming practices to monitor as indicators of sustainability?

Objectives of the Study:

The main objective of the study is to assess the sustainability of production practices of horticultural crop farming households and identify land use indices to monitor as sustainability indicator in a typical smallholder *Fadama* agro-ecosystem.

Economic Concept of Sustainability:

The "unpriced" outputs of agricultural system both positive and negative have become of increased importance as compared with conventional marketed outputs. There is concern that, while technical changes have brought major benefits to consumers in terms of reduced food prices, some developments have taken us into unchartered waters. Society sensitized by problem of pollution, health and other issues arising from earlier technical developments, appears less ready to accept change, which may involve consequences that might be damaging and irreversible, hence, the need for caution and reappraisal. Such concern underlies the move to a spectrum of production systems ranging from "organic" alternative" to "integrated" farming system. The question is how we can induce progress towards farming systems, which are sustainable and how might we measure that progress.

Nix (1990) pointed out that the idea of sustainability is central to attempts to define farm income. He quoted Hick (1946) who defined income as that which could be consumed in a given period leaving the consumer as well off at the end of the period as at start. Recent theories of economic growth have built upon neoclassical foundation (Solow, 1992) and recognize that aggregate capital (K) consists of man-made capital Km, plus natural capital Kn, plus human capital Kh, and social capital, Ks, such that:

$$K = Km + Kn + Kh + Ks \qquad (1)$$

The quantity and quality of this capital determines the level of provision of utility for mankind on a year by year basis (Pearce, 1999). The notion of sustainability arises when it is required that the capacity of K to produce utility from one period to the next does not decline. Important modifiers to K include technological change, which may be regarded as endogenous or exogenous and population growth, which may have positive or negative impacts on the component of capital.

Sustainable Agricultural Production:

FAO (1989) adopted sustainable agricultural production as the management and conservation of the natural resource base and the orientation of technological and instructional changes in such a manner as to ensure the attainment and continue satisfaction of human needs for present and future generation. Such sustainable development in agriculture, forestry and fisheries sectors conserves land, water, plants and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable. Mac Rae *et al.* (1989) regard sustainability as management procedure that work with natural processes to conserve all resources, minimize waste and environmental impact, prevent problems and promote agro ecosystem resilience, self-regulation, evolutional production for the nourishment and fulfilment of all. The implementation of these principles fundamentally leads to environment and equity constraint on economic optimization (Pearce, 1999). Pearce (1998) in his report prepared for the World Commission on Environment and Development (WCED) workshop on Agric-Environmental indicators stated that the concept of sustainability was probably first advanced in 1980 by the international union for the conservation of Natural and National Resources. And that sustainability means different things to different people. Fashad and Zinck (1993) further noted that the concept of sustainability is a multifaceted one involving economic, agronomic, environmental, social and ethical consideration. NRC (1993) consequently accepted that land use is sustainable when its productivity is economically adequate, socially just and culturally viable. Pannel and Schilizzi (1999) argued that sustainable indicators are a practical and reasonable vehicle for attempting to deal with the multifaceted nature of the ambiguous term sustainability. There is a large and growing literature on different types of indicators for sustainable development (SD).

Izac and Swift (1994) however, proposed that the principal way in which shorter-term assessment of sustainability can be made is the use of cross-sectional studies. They argued that the relative values of the key indicators applied to a cross section of different agricultural land use system at a given point in time may in itself give an indicator of relative stability.

Fadama Project in Nigeria:

Nigeria has successfully implemented the National *Fadama* Development Project (NFDP) I and II and she is currently implementing phase III of NFDP. The National *Fadama* Development Project I (NFDP I) focused mainly on the promotion of simple low-cost irrigation technologies in the bid to increase food production, emphasis was placed of food crops farmers. The National *Fadama* Development Project II (NFDP II) is a follow-up to the successfully implemented Phase I Project to achieve the objective of sustainable increase in the income of farmers in *Fadama* areas through the expansion of farm and non-farm activities that could result in high value-added outputs. (*Fadama*, 2007).

The Third National *Fadama* Development Project (*Fadama*-III) is a follow-up on the Second phase. The development objective of *Fadama* III Project is to increase the incomes of users of rural land and water resources on a sustainable basis. It relies on the facilitation for demand – driven investments and empowerment of local community groups and to improve productivity and land quality. The Project is assisted by the World Bank and covers the thirty-Six States and the Federal Capital Territory (FCT). Also, the *Fadama* Development Project (FDP) is co-financed with loans from the African Development Fund (ADF) to cover the programme in six (6) States of Kogi, Katsina, Jigawa, Plateau, Kwara and Borno (World Bank, 2008).

Issues in Literature on Sustainability Indicators:

An indicator is a quantitative measure against which some aspects of policy performance or management strategy can be assessed (Glenn and Pannell, 1998). Pannell and Schilizzi (1999) argued that sustainable indicators are a practical and reasonable vehicle for attempting to deal with the multifaceted nature of the ambiguous term sustainability. These indicators attempt to capture important aspects of the broad concept of sustainable development. Indicators are useful at a number of different levels; for research purposes, for policy makers and as a source of information for the general public. They force those involved in discussion of sustainability to identify the key aspects of sustainability of agriculture and to assign weight to them. Webster (1999) noted that while farmers may attach value to sustainability goods, they are unlikely to adopt socially optimal levels without regulation or incentives. Since sustainability issues at the farm level are usually long run, dynamic and have social dimension, a central task for farm management researchers lies in investigation which allows trade off between different sustainability criteria to be determined and then optimized according to society's norm. Izac and Swift (1994) proposed that the principal way in which shorter-term assessment of sustainability can be made is the use of cross-sectional studies. They argued that the relative values of the key indicators applied to a cross section of different agricultural land use system at a given point in time may in itself give an indicator of relative stability. These work attempts to contribute to the growing literature on different types of indicators for sustainable development (SD) by identifying critical indicator to monitor in a small holder *Fadama* agro-ecosystem as indicator of sustainable farm practices.

Methodology

Area of Study:

The study was carried out in the *Fadama* areas of Niger State, in the Southern Guinea Savannah of Nigeria. The *Fadama* along river Niger and river Kaduna and other minor rivers and floodable plains in Niger State were used for the study. Niger State lies between longitude 8^{o} 11' and 11^{o} 20' north of the equator and between 4^{o} 30' east of the equator. It covers an estimated land area of 4240 km sq. The mean annual rainfall ranges between 1110mm in the north and 1600mm in the south. The average annual number of raining days ranges between 187 and 220 days. The rain starts in late April and ends in October with the peak being in July. The average minimum temperature is about 26^{o}C while the average maximum temperature is about 36^{o}C. The mean humidity ranges between 60% (January to February) and 80% (June to September) (NCRI, 1997)

Method of Data Collection:

Data used for this study were from both primary and secondary sources. The relevant primary data were obtained through a farm management survey of *Fadama* food crops farming households conducted between August and September 2008. The main instrument for data collection was structured questionnaire. These were administered on head of *Fadama* horticultural crop farming households by trained enumerators under the supervision of the researcher. Data collected covers information on *Fadama* food crop farming, households head socio-economic characteristics (age, level of education, family size etc), land use and management practices, crop combination and diversification etc. The secondary data collected include *Fadama* farming villages and households from official records of Niger State Agricultural Development Project (NSADP).

Sampling Procedure:

The target population for this study is the *Fadama* food crops farming households in Niger State, Southern Guinea Savannah, Nigeria. A two stage simple random sampling technique was used to select sample for the study. The first stage involved the random selection of *Fadama* farming villages in the three ADP zones of the State. About five percent of the total *Fadama* farming villages in each of the zones of NSADP that make up the study area were randomly selected for the study. The second stage of sampling involved the random selection of horticultural *Fadama* farming households. About ten percent of the horticultural *Fadama* farming households in each of the selected villages were sampled for the study. A cross sectional data from 180 households was used for study.

Analytical Techniques:

Sustainability of agricultural practices measured with Indicators of Sustainable Agricultural Practices (ISAP) as used by Taylor *et al.* (1993); Rigby *et al.* (2001) and Lawal, (2008) was adopted for the study. The indexes were further presented with sustainability web or radar diagram.

Construction of Farm Level Indicators of Sustainable Agricultural Practices (ISAP):

The information that was used to generate the indicator of sustainable agricultural practices relates to seven aspects of *Fadama* crop production. These are: seed source, weed control, crop management, pest/disease control, maintenance of soil fertility, tillage, and water control methods. The different farming practices within each of these categories are identified in Table 1.

Scoring and Weighting Sustainability of Farming Practices:

The impact of the farming practices in Table 1 on farm sustainability was assessed by identifying from literature criteria commonly adopted for agricultural sustainability, and then allocating simple scores to each farming practice according to whether a particular practice is considered to improve or diminish a farm’s performance.

Rigby *et al.* (2001) identified four (4) criteria of sustainability based on literature on impact of farming practices on sustainability. The criteria are with regards to the effects of the practices on increased yields and reduced losses while

* Minimizing off-farm inputs (Hodge, 1993; Petty, 1995).
* Minimizing input from non-renewable sources (Hodge, 1995).
* Maximizing use of natural biological processes (Ikerd, 1993; US Farm Bill, 1993).
* Promoting local biodiversity/environmental quality (Petty, 1995)

The scoring system shown in Table 2 combines information from Table 1 on farming practices with sustainability criteria identified by Rigby *et al.* (2001).

Following Rigby *et al.* (20001) each farming practice scored in absolute term ranges between 0, and 3 points for each criterion. The scoring system could be interpreted as 0 for no significant impact, 0.5 indicates marginal impact, 1.0 indicates significant impact, 2.0 indicates strong significant impact, 3.0 indicates very strong significant impact. As could be observed from Table 2, the seven categories of farm practice represent different proportion of the total number of points obtainable. The proportional contributions of each farm practice to sustainability of *Fadama* land are as follows; seed source (3%), tillage(7%), pest and disease control (8%), water control (10%), maintenance of soil fertility (20%), weed control (22%), and crop management (30%) methods.

As shown in Table 2, the score for each farming practice used by each *Fadama* farming household during the survey was scored for example as follows:- The use of synthetic fertilizers to maintain soil fertility on all farms will register -1 with respect to each of "minimizing off-farm inputs", "minimizing use of non-renewable input" and "maximizing natural biological processes". It is classified as having no significant effect (negative or positive) with respect to local biodiversity and hence no point is score under this category. Hence, the minimum number of point that can be generated with respect to synthetic fertilizer is –3 for use on all farms and the maximum is zero (0) for use on none of the farm. The score for each farming household was calculated by adding the total score attributed to each farming practice in table 1 as used by each farming household. Index value calculated this way can range between -17.5 and +30.5 depending on each households pattern of inputs use in *Fadama* horticultural crop production. Linear transformation was used to convert the index score to between 0 and 1 for each of the *Fadama* farming households. The closer the linear transformation score to one (1) the more sustainable the farm practices being used by the household on the *Fadama* land.

Assumptions for Constructing Indicator for Sustainable Agricultural Practices (ISAP):

- Farming practices are scored on prediction about their impacts on ecological processes and local biodiversity.
- It is assumed that insecticides would in general be more damaging (via impact on animal food chain) than herbicides.
- It is assumed that synthetic insecticides and herbicides not found in nature are more likely to be damaging than synthetic fertilizer, which supplies the same nutrients as organic manure but in soluble form.
- Organic form of fertilizer is assumed to be better than synthetic fertilizer because they are likely to confer physical improvement to the soil in addition to nutrition supply.

Index Validation:

In developing ISAP for Malaysia, Taylor *et al.* (1993) circulated the proposed scoring schedule to natural scientist and Rigby *et al.* (2001) followed these in their work on U.K. horticultural producers. In this work, the scoring of agricultural practices in Table 2 and the assumptions for developing the I.S.A.P. was circulated among natural scientist and agronomist at University of Ilorin. Adjustment was made on the scores as suggested before Table 2 which shows scoring of farm practice was drawn.

To overcome problem of single score aggregation as identified by Bockstreal *et al.* (1997) that compensation can occur between the values of components that are aggregated, this study used mean score of aggregated components for sustainability webs as used by Swete-Kelly, 1996; Gomez *et al.* 1996; Bockstreal *et al.* 1997; Webster, 1999 and Lawal, 2008. These simultaneously display scores for different components in addition to the linear transformation scores of each households. This shows the contribution of the components to the overall mean ISAP score of the sampled households. It also allows the identification of critical farm practices to monitor in order to improve the sustainability of the *Fadama* land.

Results and Discussion

Indicator of sustainable agricultural practices (ISAP) scores were calculated for each of the 180 horticultural crops farming household in the *Fadama* of Southern Guinea Savannah, Niger State, Nigeria using the method outlined earlier. The ISAP scores were used to assess the effects of the agricultural farm practices adopted by individual farming household on the sustainability of the *Fadama* land in horticultural crop production. Seven categories of farming practices were used to generate a single score used to describe each of the households based on the sustainability of the adopted farming practices. Table 3 presents the mean score of the ISAP components for the horticultural crop producers in the *Fadama* of Southern Guinea Savannah, Niger State, Nigeria.

The mean scores in Table 3 were used to draw "sustainability web". Each spine of the web is calibrated from zero at the origin to highest percentage of the index weight farthest from its origin. So the farther the web is to the origin the "better" the categories within the ISAP index.

Table 3 and Figure 1 shows that the mean score of the adopted farming practices in the methods of water management (61.67 %), tillage (71%), crop management (78.33%), weed control (51.14%), fertility maintenance(65.5%) and seed source.(60%) were generally above average on the sustainable practices score. The mean score in method of pest control (22.4%) is lower than average of the expected scoring. This result implies that the critical indexes to monitor with respect to sustainability of horticultural crops production in the *Fadama* area of Guinea Savannah; Niger State, Nigeria is the method of pest control.

The aggregation of the scores of individual farming household across the seven categories of farm practices identified earlier was used to obtain the ISAP score for each of the farming households. The distribution of the ISAP scores among horticultural crops *Fadama* farming households is presented in Table 4.

Table 4 shows that the ISAP scores generated is between 0.31 and 0.90. About 7.23 percent of the sampled farming household had ISAP score of 0.50 and below while majority of the sampled farming household (92.77 percent) had ISAP score more than 0.50. The mean ISAP score for all the respondents was 0.622. This implies that the combined effects of all the farming practices used in generating the ISAP score would result in a fairly sustainable production of horticultural crops in the *Fadama* of Southern Guinea Savannah; Niger State, Nigeria. However, it is important to monitor and improve upon the method of pest control and management. The results of this study shows that the production practices in horticultural crop production is more sustainable than those used in food crop production generally. Lawal *et al.* (2009) reported a mean ISAP score of 0.512 for food crop producers in the *Fadama* of Southern Guinea Savannah; Niger State, Nigeria. This result is similar to the work of Taylor *et al.* (1993) and Rigby *et al. (*2001) that reports a mean ISAP score of 0.657, and 0.652 among rice producers in Malaysia, and horticultural producers in England respectively. Taylor *et al.* (1993) identified pest control, fertility maintenance and tillage methods while Rigby *et al.* (2001) reported pest management method as the farm practice to monitor in order to improve sustainability.

Conclusion and Recommendations

The mean ISAP score estimate was 0.622. This shows that the production practices of the sampled *Fadama* horticultural crop producers in the Southern Guinea Savannah of Nigeria are fairly sustainable. The critical farming practices to monitor in order to improve the sustainability of the *Fadama* for horticultural crop production is the method of pest/ diseases control. Arising from the findings of this study, the following recommendations are made to further aid sustainability of the *Fadama* programme:

1. The use of agrochemicals (herbicides and insecticides) by farming households should be properly monitored to protect the environment. Appropriate government agency such as National Agency for Food Administration and Control (NAFDAC) and produce section of Ministry of Agriculture at all levels of government should monitor and regulate the importation and use of agrochemical.
2. Farmers should embrace the use of integrated pest management in the control of pest and diseases on horticultural crops.

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Table 1: Farm Practices Used in the Construction of ISAP.

Seed source	Weed control	Crop management	Pest/ diseases control	Maintenance of soil fertility	Tillage	Method of water control
- Own farm - Conventional supplier	Chemical herbicides Manual/mechanical - Biological e.g. Crop cover	- Sole Crop crop rotation Intercropping	Natural pest control Synthetic pesticide	Synthetic fertilizer e.g. NPK - Natural fertilizer e.g. bones, wood wash - Organic manure Poultry manure Composted fertilizer Green manure	Zero tillage Conventional tillage	Mould Bond

Source: Adapted with modification from Rigby *et. al.* (2001).

Table 2: Scoring Farm Practices with Respect to Sustainability.

Farm practice	Dimension of sustainability: Minimizes off-farm inputs	Minimizes Non-Renewable inputs	Maximize Natural Biological Processes	Promotes local Biodiversity	Total
1. **Seed sourcing**					
Own farm	+1	0	0	0	+ 1
Conventional supplier	0	0	0	0	0
2. **Weed control**					
- Chemicals	-1	-1	-1	-0.5	-3.5
- Manual	+1	+0.5	+1	+0.5	+3
- Biological (e.g. cover crop)	+1	+1	+1	+1	+4
3. **Crop management**					
- Bush fallow	0	0	+2	+1	+3
- Crop Rotation	+0.5	+0.5	+1	0	+2
- Inter-cropping	+1	+1	+1	1	+4
4. **Pest & Diseases**					
- Natural pest control	0	+0.5	+1	+1	+2.5
- Synthetic pesticide	-1	-1	-3	-3	-8
5. **Maintenance of soil fertility**					
- Synthetic fertilizer e.g. NPK	-1	-1	-1	0	-3
- Natural fertilizer e.g. wood	-1	-1	0	0	-2
- Organic manual e.g. poultry manure	+1	0	0	0	+1
- Compost	+1	+1	0	0	+2
- Green manure	+1	+1	+1	0	+3
6. **Tillage**					
- Zero tillage	+1	0	+1	0	+2
- Conventional tillage	-1	0	0	0	-1
7. **Method of water control**					
- Mould	0	0	+1	0	+ 1
- Bond	0	0	+1	+1	+ 2

Source: Adapted with modification from Rigby *et al.* (2001).

Table 3: Mean Value of ISAP Components.

Score	**Seed source 3%**	**Method of weed control 22%**	**Crop mgt. 30%**	**Pest control 8%**	**Fertility maintenance method 20%**	**Tillage method 7%**	**Water mgt method 10%**
Expected	1	7	9	2.5	6	2	3
Mean	0.6	3.58	7.05	0.56	3.93	1.42	1.85
percentage	60	51.14	78.33	22.4	65.5	71	61.67

* Figure in parenthesis is mean score as a percentage of expected score.

Source: Field Survey, (2008).

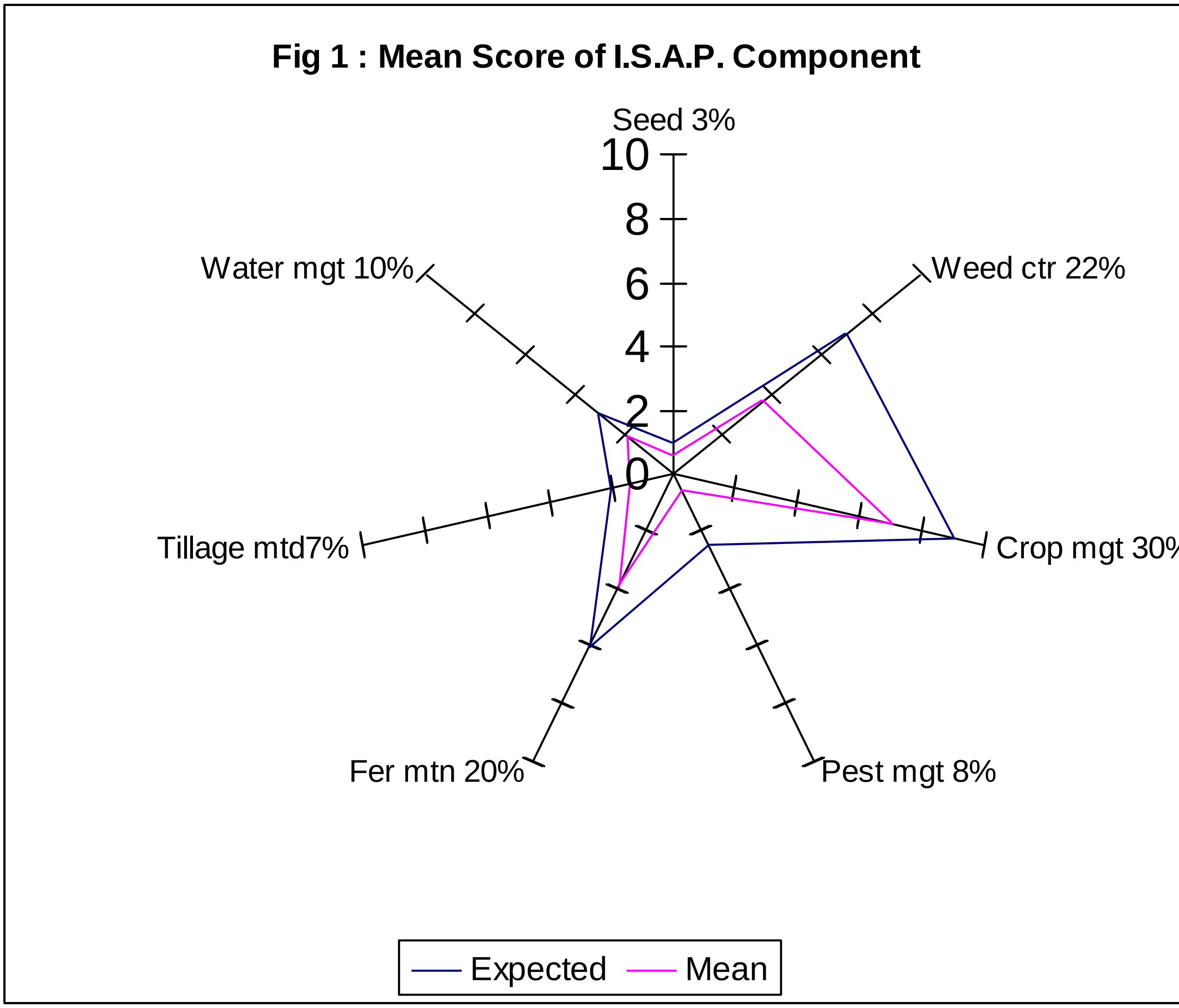

Table 4: Distribution of Indicator of Sustainable Agricultural Practices (ISAP) Scores.

ISAP scores	**Frequency**	**Percentage**
0.31 - 0.40	3	1.67
0.41 - 0.50	10	5.56
0.51 - 0.60	85	47.22
0.61 - 0.70	68	37.78
0.71 - 0.80	8	4.44
0.81 - 0.90	6	3.33
	180	100

Source: Field Survey, (2007)