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Programming Risks in Wetlands Farming: Evidence from Nigerian Floodplains

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ABSTRACT This paper examines the important risk factors and risk management measures as well as optimal farm plans in floodplains farming in Akwa Ibom State, Nigeria. Findings show that the most important risk factors in floodplains farming are flood and drought. Farmers manage these risks through relay/sequential cropping, planting short gestation and flood tolerant crops. Target-MOTAD model shows that farmers are not operating at optimal level of production, a crop combination consisting of cassava, cocoyam, maize and fluted pumpkin was found to be the least risky and the most profitable while all vegetables crop combination was the most risky.

INTRODUCTION

Of all agricultural ecosystems, wetlands agriculture seems the most risky. The farmers operate under extreme risk situations of flood and drought. The farmers therefore, have to play game with nature in order to reduce losses that could arise from risk occurrence.

Due to the importance of risk in traditional agriculture, a number of studies employing various approaches have been conducted to investigate farmers' behaviour towards it. One of such approaches is the safety – first concept. The safety-first approach is used to indirectly measure the farmers' attitude and behaviour under risk. This model is designed to help farmers ensure that they attain a minimum income necessary to meet the fixed cost of their families' cost of living each year. There have been a number of formulations of safety rule. Despite several formulations of this model, the choice is usually made by maximizing (or minimizing) one of these measures subject to constraints on the others.

One of the earliest safety- first models was proposed by Roy (1952) cited in Hazell and Norton (1986). Roy's criterion stipulates that given a minimum income required for the survival of a farm family, a farm plan that minimizes the probability that income could fall below that minimum income (Y_o) should be selected. A variance of the safety rule concept is the Minimization of Total Absolute Deviation (MOTAD) introduced by Hazell (1971). MOTAD involves the dual criteria of maximizing net return and minimizing the variance of net return. The MOTAD model was modified by Tauer (1983) through his target – MOTAD (also called T - MOTAD) model approach. His study showed that the result generated with the T – MOTAD belong to the second degree dominance techniques about the decision maker's utility function. The T – MOTAD has been used in a number of studies. It has some appeal as its application needs very few restrictive assumptions (McCamley and Kieberstani, 1986; Marr and Carlsson, 1987; Berbel, 1988, 1990; Chavas and Holt, 1990; Pannel, 1990, Foster and Rauser, 1991).

The use of T - MOTAD in the study of Nigerian agricultural system is recent. The first of such application was by Adubi (1992) followed by Ochai (1995). Both researchers used the T – MOTAD to analyze the production risk and attitudes of farmers in upland agriculture in Oyo and Kogi States respectively. However, studies of wetland agriculture in Nigeria have scarcely benefited from the application of this model even though risk elements are greater in wetlands than upland agriculture. The objectives of this study were to investigate the risk factors and their management measures in wetlands farming; and to determine the optimum farm plan incorporating risk, using the T – MOTAD model.

METHODS

(i) The Study Area: The study was conducted in Akwa Ibom State, Nigeria from May to August, 2002. The State which is located in the southeastern corner of the country lies between latitudes 4^0 32' North and longitudes 7^0 25' sand

8^0 25' East. It occupies a contiguous area of 8412 square kilometers with a population of 2.53 million (National Population Commission, 1991). The State situates within the tropical zone. Due to the effects of Maritime Tropical air masses, two seasons characterize the climate of the State: the wet or rainy season lasting from the month of May to October, and the dry season which starts from November and ends about April. The rainfall is heavy along the coasts and may be over 2400 mm. The typical rainfall pattern is bi-modal with an "August break" – two week dry spell in the month of August during the rainy season.

Three agricultural ecological zones are identifiable in the State. These are the marshy land of river washed areas found in Eket, Ibeno, Ikot Abasi, Oron and Itu Local Government Areas; the flat areas peculiar to Etinan, Abak, Uyo and Ikot Ekpene Local Government Areas; and the elevated areas of Ikono and parts of Itu Local Government Areas. The State is endowed with abundant wetlands. Its entire periphery would have been swamps but not for part of the western boundary between Imo river and Enyong creek which is dryland in most parts. The swamp forms a continuum, which have been grouped into discrete units and named after important settlements. The wetlands are cultivated by farmers in coastal communities. Common crops produced in the wetlands include rice, cassava, vegetable, okra, cucumber, pepper, water yam and such tree crops as raphia and oil palm trees.

(ii) Sampling Procedure: Multistage sampling technique was employed in selecting the sample used in the study. First, wetlands locations were selected. Second, five (5) villages were randomly selected from each of the locations. Since farming takes place in all the villages in all the wetlands locations selected, it was considered that information from any of them will give true representation of the wetlands farming in the study area. This necessitated the use of random sampling approach. Information on the population in the villages and their farming operations were obtained from the Akwa Ibom State Ministry of Agriculture and Akwa Ibom Agricul-ztural Development Programme (AKADEP). Lastly, 100 wetlands farming households were randomly selected for investigation.

A set of structured questionnaire was used in collecting data from the farmers through interview schedule. This method was chosen since many of the farmers were illiterate and could not complete the questionnaire by themselves. Data on farm inputs and outputs were obtained from the farmers. These primary data were supplemented with historical data (1991 – 1996) from Akwa Ibom State Ministry of Agriculture, AKADEP, Federal Office of Statistics (FOS, now Bureau of Statistics) and the Central Bank of Nigeria (CBN). Where possible, direct participation in farming activities was undertaken in order to ascertain the information provided by the respondents, most of who relied on memory recall. The data were standardized by converting the quantities provided in local measures to conventional units of measurement. For instance, land was converted from plots to hectares while seeds, fertilizer and farm outputs were converted from local measures to kilogramme.

Focus Group Discussion (FGD): To obtain qualitative data which could not be captured through the use of the questionnaire, Focus Group Discussions were conducted, one at each wetland location. Thus, a total of five FGDs were conducted. An initial contact was made to the communities to intimate them of the purpose of the study and also to request for their cooperation during the study proper. The FGD was conducted by bringing together 10 – 15 wetlands farmers consisting of both males and females for discussion. Interview guide was used to facilitate the discussion in a lively manner and the responses recorded and latter transcribed.

Analytical Framework

Agricultural decisions are made subject to the interaction of many factors. These factors lead to returns displaying high variability or farm income, which are unstable. Such is also the situation in wetlands farming. Thus, t he optimum farm plans given risk and uncertainty inherent in wetlands farming was determined using the target – Minimization of Total Absolute Deviation (T – MOTAD) model.

The T – MOTAD is a variant or modification of the Linear Programming Model. In the model, the farmer is assumed to evaluate risk on the basis of safety – first criterion. That is, he minimizes the probability of his farm output falling below his subsistence requirements. The safety – first criterion is one of the hypotheses used to explain small farmers' behaviour under risk (Roy, 1952; Roummaset, 1978; Fleisher and Robinson, 1985). This hypothesis suggests that farmers' attitude to risk is to first cultivate the crop (and raise livestock) that he/she, from experience, expects to quarantee minimum income needed for his/her family's survival. The safety – first principles calls for maximizing an objective function to a constraint involving a disaster threshold expressed in terms of a crucial probability (P). In other words, a constraint defined as a minimum assured income is introduced into the analytical model. At a specified level of probability, it implies that the total net cash flow in the current year will be equal to or more than the specified minimum level (Y_{min}). This safety – first criterion is introduced as a risk constraint into a Linear Programming Model of a representative farm. Thus, the individual farmer is assumed to be averse to risk so that his/her objective function is defined by the dual criteria of maximizing expected returns and minimizing the variance of returns. The model is therefore, a two – attribute risk and return model. Return is measured as the sum of the expected returns of activity level. The total absolute deviation is then varied parametrically so that a – risk – return frontier is traced (Tauer, 1983).

The T- MOTAD Specification

The formulation of T – MOTAD model used in this study is as follows:

$$\text{Max } E(Z) = \sum_{j-i}^{24} cj\ xj \qquad (1)$$

Subject to:

$$\sum_{j-i}^{24} aij\ xj\ bi \quad (i == 1, \dots m) \qquad (2)$$

$$T - \sum(crj\ xj - Yr < 0 \qquad (3)$$

i.e. $\sum Pr\ Yr = \infty \quad (\infty = M, \dots > 0)$

where, $E(Z), x, Y > 0$.

The element of risk was formulated as a matrix of gross margin deviations from expected returns. Points on the risk efficiency frontier were obtained by decreasing the value M, parametrically in arbitrary decrements. Along the efficiency frontier, the T – MOTAD model minimizes the mean absolute deviation for any given expected gross margin. This minimizes the standard deviation of returns to the farm. The standard deviation was measured by the estimator:

$$\text{Std. Dev.} = [\Pi s/D2(S\text{-}1)]^{1/2} \qquad (4)$$

Where s = number of states of nature, here represented by farming year, D = estimated mean absolute deviation of return of the farm. The mean absolute deviation (MAD) or D for an activity (j) and for the whole farm over all states of nature (years) was estimated as follows:

$$D = S\ \text{-}1 \sum_{r-1\ j-1} (crj - cj)xj \qquad (5)$$

This transformation into standard deviation allows the model to determine a set of efficient farm plans along the variance – efficiency frontier (or E - δ). An estimate of each activity's level of risk or risk associated with a particular farm plan (enterprise combination) was derived by calculating the standard deviation and (or coefficient of variation) for the activity of farm plan. This was done for the existing farm plan of the farmer in order to obtain an estimate of the level of risk at which the farmers are operating as well as profit maximizing and risk minimizing plans.

RESULTS AND DISCUSSION

(I) Risk Factors in the Floodplain

There may be several risk confronting wetlands farmers. However only the dominant risk factors and their ranking by the farmers are presented and discussed. The dominant risk factors and their ranking by the farmers are presented in Table 1. Two most serious risk factors were identified. More than half (60%) of the farmers identified flooding as the most dominant risk factor while 32.7% identified drought. Other less serious risks are pest and what was collectively grouped as "others". They include pilfering and general crop failure. The common pests mentioned were birds and stem borers which attack rice, leaf miners which are said to be particularly destructive to fluted pumpkin. The result further confirms the precarious environmental condition which the wetlands farmers operate. These conditions are in large part beyond the control of the farmer.

Table 1: Farmers ranking of dominant risks factors in the floodplain

Risk Factor	*% of Farmers identifying*	*Ranking*
Flooding	60.0	1
Drought	32.7	2
Pest	5.5	3
Others	1.8	4
	100.0	

Farmers who identified drought as an important risk factor further explained that drought occurs whenever the dry season lasts longer than usual. This often leads to "caking" of the soil and eventual wilting of crops. They however, observed that sudden rain intervention or irrigation would resuscitate the crops which exhibit luxuriant growth afterwards.

(II) Risk Management /Mitigation in the Floodplains

Left without external intervention to assist in managing the risks which confront them in the course of crop cultivation, the farmers have by themselves devised measures to manage these risks. Caught between the two extreme of drought and flood, farmers have to strike a delicate balance between water stress on the one hand and flooding on the other. The strategy adopted seems to be dictated, to a large extent, by how an individual farmer perceives the environment regarding the behaviour of the flood, the soil condition and the reaction of crops to water stress or flooding. Some of the measures adopted by the farmers are discussed below.

Mixed Cropping: Mixed cropping is a kind of insurance against crop failure. Science has established that different crop varieties respond variously to flood, drought and even pest attack. In order to reduce the chance of total loss, farmers consider that in the event of one of the risk elements occurring and one or two crops being adversely affected, they can fall back on the ones that are not so affected. This consideration has given rise to the practice of mixed cropping. Mixed cropping involves the cultivation of more than one crop on the same plot of land at the same time. Such crop mixture may include cassava, cocoyam, fluted pumpkin; fluted pumpkin, okra and pepper; or cassava, cocoyam, fluted pumpkin or a mixture of any of these. Farmers claimed that this strategy is adopted so that if crop fails, they can rely on others for household food needs and income.

Sequential/Relay Cropping: Sequential and relay cropping is another important feature of floodplains farming. This arrangement is to make use of the residual moisture that is left in the dry part of the wetland as the water recedes. Cassava and maize are planted early in November while fluted pumpkin follows, at the bottom valley, in December/January. Where rice (which is a common crop in the floodplains) is planted as a sole crop, a combination of cocoyam, cassava or banana are planted on the bonds formed from heaps of rice straw used to demarcate one plot from another. This approach is mainly used to check flood in the farm. It demonstrates the wisdom of the farmers in dealing with risk and uncertainty in their farming activities.

Table 2: Risks management or mitigation measures

Mitigation measure	*Type of risk*
Mixed Cropping	Flood; Drought; Pest
Sequential/Relay Cropping	Flood; Drought.
Cultivation of flood tolerant crops	Flood
Early Planning	Flood
Hand Irrigation	Drought

Cultivating Flood Tolerant Crops: One of the common flood tolerant crops cultivated by farmers is rice. Farmers view the cultivation of swamp rice as a risk aversion strategy. Swamp rice can thrive under waterlogged condition. For this reason, most farmers prefer such varieties as MAS 2401 and IR 5 which are tall varieties and may not be submerged in the flood. For other crops, farmers could not identify those that can tolerate flood. The most vulnerable crop to flood was identified to be cassava. The tubers were reported to rot rapidly in waterlogged conditions during flood.

Early Planting: Another risk management measures adopted by farmers in the floodplains is early planting. Most farmers sow their crops immediately the flood starts to recede. The calculation is that the crops will mature to be harvested before the field is flooded again. If the rains come late, the farmers win by recording a huge harvest. If farmers are not favoured in their forecast and flooding starts earlier that expected great, losses may be incurred. Often, crops are hurriedly harvested prematurely ("panic harvesting").

Hand Irrigation: Hand irrigation is drought mitigation measure used by farmers. Farmers, especially those who settle in the islands, with wetlands farming as the main occupation, resort to manual watering of their crops whenever there is indication (or occurrence) of drought. This is a tedious operation, and often less effective. It is also labour intensive, particularly if a farmer has large scattered plots.

(III) Optimal Farm Plans for Floodplains

Table 3 presents the existing and normative plans for the floodplains. The existing plan (Plan I) is the farmers' plan as practiced by the average

Table 3: Existing and optimal farm plans with minimized Risks in floodplains.

Enterprise	*Existing plan*		*Risk minimized plans*				*Profit max plan*
	I	*II*	*III*	*IV*	*V*	*VI*	*VII*
Total Absolute Deviation		4505.60	5632.00	7040.00	8800.00	11000.00	
Gross Return (#)	28623.83	5949.60	13762.42	15668.03	19911.94	28063.39	33743.90
Rice	0.42(46.15)	-	0.09(18.75)	0.10(17.54)	0.22(30.98)	0.42(46.15)	0.64(70.33)
Fluted Pumpkin	0.08(8.79)	0.08(33.33)	0.08(16.66)	0.08(14.03)	0.08(11.27)	0.08(8.79)	-
Fluted pumpkin Pepper/ Okra	0.05(5.49)	0.03(12.50)	0.03(6.25)	0.03(5.26)	0.05(7.04)	0.05(5.49)	-
Cassava/Okra/ Fluted pumpkin	0.06(6.59)	-	0.06(12.50)	0.06(10.53)	0.06(8.45)	0.06(6.59)	-
Cassava/Cocoyam/ fluted pumpkin	0.1(10.99)	-	0.02(4.17)	0.10(17.54)	0.10(14.08)	0.10(10.99)	-
Cassava/Cocoyam/ Maize/Fluted pumpkin	0.20(21.98)	0.13(54.17)	0.20(41.66)	0.20(35.08)	0.20(28.17)	0.20(21.98)	0.27(29.67)
Total cropped Area (Ha)	0.91	0.24	0.48	0.57	0.71	0.91	0.91

N/B: Figures in parentheses are the percentages of cropped area of the total cultivated area.

farmer of the floodplain in the study area. The normative plan (Plan VII) is based on profit maximizing model. This plan is likely to be selected by a risk neutral farmer.

In order to see the implications of risk of variation on farm plans, parameterized risk minimized plans were also obtained (Plans II – VI). Analysis reveals that the maximum attainable income with profit maximizing plan is ₦33, 743.90. The plan is based on 0.64 hectare of rice, 0.27 hectare of cassava, cocoyam, maize, fluted pumpkin mixture. It is associated with the maximum variability [over 6 years measured by total absolute deviation (TAD)] of ₦11, 000.00. The total absolute deviation was reduced and parameterized from ₦11000 to ₦0 (Zero) and a set of minimized efficient plans was generated. These are feasible plans II – VI. The plans cover a wide range of available choice options for the farmer or decision-maker on the basis of enterprise combination and resource allocation. The trade-off between expected income and the variance of income determines the suitability of any of the plans.

Result shows that returns or expected income decreased as total absolute deviation (TAD) was decrease from plan VI to II. At TAD of ₦11,000.00, the expected income was ₦28,063 and fluted pumpkin, pepper, Okra (FL, PP,OK), cassava, fluted Pumpkin, Okra (CS, FL,OK) as well as cassava, cocoyam, fluted pumpkin (CS, CY, FL) mixture entered the solution. Accordingly, the areas of land cultivated in the normative profit-maximizing plan decreased. Generally, as the TAD was decreased, cropping activities decreased in the floodplains farms and rice (RC), Cassava, fluted Pumpkin, okra (CS, FL, OK) and cassava/ cocoyam/fluted pumpkin (CS, CY,FL) did not enter the risk minimized plans at TAD N2,200.

It can be observed that cassava, cocoyam, maize, fluted pumpkin (CS, CY, MZ, FL) mixture is present in all the plans. The crops in this combination are the common arable crops in the study area. It consists of root crop (cassava), tuber crop (cocoyam), grain (maize) and vegetable (fluted pumpkin). Other researchers (Norman 1970; Erhabor, 1982; Gomez and Gomez, 1983; Ikeorgu, et al, 1989) have reported that this practice while displaying the characteristic of subsistence agriculture is the farmers' insurance against crop failure. In an extremely risk prone environment as wetland, the consistent presence of these varieties of crop in the plans reveal the desirability of crop diversification in floodplains. The enterprise consists of four different crops which make the farmer sure of obtaining some proceed from one of the crops should any be struck by one risk situation or another.

(IV) Risk and Return to Different Farm Plans in the Floodplain

Table 4 contains estimates of optimal value of plan or return to farm resources in the floodplains. It also shows the estimates of minimized standard deviations and coefficient of variation corresponding to these plans. The latter indicates the estimated risk level of operation under the plans. It measures variation in return and reflects the change in risk accompanying increased hectarage of the higher

Table 4: Risk and return level of different farm plans in the floodplains

Enterprise	*Existing plan*		*Risk minimized plans*				*Profit max. plan*
	I	*II*	*III*	*IV*	*V*	*VI*	*VII*
(a) Return to farm	28623.83	5949.60	13764.42	5668.08	19911.94	28063.39	33743.90
(b) Minimized Standard Dev.(₦)	2115.18	2124.0	1007.88	735.68	735.63	729.38	1846.62
a) Coefficient of Variation of Return (%)	7.39	35.70	7.32	4.70	3.66	3.69	5.47

risk enterprises. Under the existing farm plan (plan I), the farmers are operating at a risk level of 7.39% and return to farm resource is ₦28,623.83 per hectare. Return to resources in the profit maximizing plan (Plan VII) is ₦33743.90. This indicates that farmers can earn higher return by moving away from their current level of activities. Plan VI (a risk minimized plan), is the least risky plan. It has almost the same level of return (₦28063.39) as the farmer's plan. Wetlands farmers are here shown not to be operating at the optimum level of production. They can reduce risk while at the same time making as much return from their effort by choosing farm plan VI. A profit-maximizing farmer would choose plan VII. However, it will require some effort on the part of the change agent (Extension Agent) to cause the conservative and risk averse to adopt the most desirable plan (plan VI). It is obvious that other farm plans are not so desirable. For instance, plan II with the highest return also has the highest risk (standard deviation = ₦2,124.18; coefficient of variation = 35.70%) level and thus, is not so desirable. The findings seem to be in consonance with the result of the study of upland farming by Adubi (1992) which reported that though farmers try to avoid risks, especially in the adoption of new technology, their chosen farm plan was more risky than profit – maximizing.

The deviation of the farmer's plan from the optimal can be attributed to several factors. First, sudden flooding which often occurs on the flood plain usually compels farmers to harvest premature crops (panic harvesting). Such premature produce does not command the price commensurate with the cost of production. Heaps of skinny and tinny cassava tubers were seen along roadsides and farm gate in wetland communities, during the field study. This rarely attract reasonable patronage and price. Second, during the FGDs, farmers also identified the lack of important inputs including fertilizer and labour as constraint to optimum farm production. The discussants reported that while wetland farming is labour intensive, the size of family and hired labour is depleting due to withdrawal of youths for school and other non-farm activities. These, they observed was constraining to efficient and optimal utilization of available resources like land, etc.

(V) Risk Levels of Enterprises (Crop Mix) in Floodplain

Using estimated standard deviation as a measure of risk (variance of returns) under Expected Returns-Absolute Deviation (E-A) criterion for each crop enterprise, the risk level of crop enterprises in the floodplain were calculated (Table 5). The results indicate that a combination of fluted pumpkin, pepper and okra is the most risky of all crop enterprises. It has a risk measure of 0.32. Following in the risk level, is fluted pumpkin cultivated sole as well as a combination of cassava, cocoyam and fluted pumpkin. They have a risk measure of 0.31. Rice (cultivated as sole crop) and a mixture of cassava, cocoyam, maize and fluted pumpkin are the least risky of all the enterprise. It is to be observed that enterprises with vegetables in the mixture tend to be highly risky. Other farm plans with such crops as cassava, cocoyam and maize are less risky. The risk involve in enterprises with vegetable may be, because vegetables are more

Table 5: Estimated risk level of enterprises in the floodplain

Enterprise	*Standard expected risk*		
	Deviation (₦)	*Gross margin (₦)*	*Measure*
Rice only	2553.46	40951	0.06
Fluted Pumpkin	8775.22	28204	0.31
Fluted pumpkin/ paper/okra	7916.82	24698	0.32
Cassava/fluted pumpkin/okra	1968.77	21864	0.09
Cassava/cocoyam/ fluted pumpkin	6915.02	22067	0.31
Cassava/cocoyam/ maize/fluted pumpkin/	2058.46	33959	0.06

Source: Estimated from L.P Results

vulnerable to common risk inducing situation – (flood and drought) in wetlands farming. It appears, however, that enterprises with high expected gross margin show loss variability. This could be that the income generating potentials of these crops are high enough to sufficiently offset the mean absolute income deviation. Thus, the cropping pattern seems to have a major impact on the risk and returns in floodplain farming.

(VI) Policy Implications of Findings

The results from this study suggest that despite the contribution of wetlands to the household and indeed national food needs, it is still subject to the extreme fluctuations in environmental conditions- flood and drought. Equally, farmers were found not to obtain the optimum profit from their current level of production. The results also reveal that cultivating vegetables as sole crop or a crop mix dominated by vegetable is more risky than others. The findings have important implications for agricultural policies in Nigeria and indeed other countries where wetlands farming is an important part of their agricultural system. Flood and drought are the two extreme weather conditions that can cause and has indeed caused drastic reduction in agriculture outputs. For example, the 1983 and 1993 drought in Nigeria led to serious food crisis in the country. To check distortion in the food supply situation and the national economy which may be brought about by flooding or drought, weather information from the meteorological units should be made available at all times to the farmers. Early warning systems need to be made available so as to give farmers prior information before disaster strikes. Efficient drainage system is also necessary in the wetlands farms to reduce the incidence of flooding and ultimately, the effect of flood in the farm. Also, appropriate irrigation system for the wetlands farm, particularly in dry season farming is necessary. That farmers are operating at sub-optimal level may mean either inefficient management of farm level resources or non-availability of resources at the right time and quantity for judicious use. This, in some sense, calls to question the impact of agricultural education by way of agricultural extension which gained impetus with the establishment of a World Bank supported nationwide Agricultural Development Project (ADP) in the mid 1970s. If the problem is that of non availability of farm inputs, then the efforts of the various levels of government over the years become suspect. For example, in the 1970s there was Operation Feed the Nation Programme, which had as its major objective the distribution of inputs to farmers. The Green Revolution Programme succeeded this. Presently, farm input delivery is handled by the States and the Local Government Councils. All these should, expectedly, make inputs available to farmers. In order to check the problems identified in wetlands faming, effective agricultural education through extension services to the wetlands farmers is highly recommended. At the same time, the issue of provision of farm inputs needs serious attention, more so, given the remote location of most wetlands farms.

NOTES

(a) $\sum_{J=I} aj\ xj < b_1$ land (hectares)

(b) $\sum_{J=1} a_2 j\ x\ j < b2$ Jan (February/March family labour (mandays)

(c) $\sum_{J=1} a_3 j\ x\ j < b_3$ April/May/June family labour (mandays)

(d) $\sum_{J=1} a_4 j\ x\ j < b_4$ July/August/September family labour (mandays)

(e) $\sum_{J=1} a_5 j\ x\ j < b_5$ October/November/December family labour (mandays)

(f) $\sum_{J=1} a_6 j\ x\ j < b_6$ Jan/February/March hired Labour (mandays)

(g) $\sum_{J=1} a_7 j\ x\ j < b_7$ April/June hired labour (mandays)

(h) $\sum_{J=1} a_8 j\ x\ j < b_8$ July/August/September hired labour (mandays)

(i) $\sum_{J=1} a_9 j\ x\ j < b_9$ October/November/December labour (mandays)

(j) $\sum_{J=1} a_{10} j\ x\ j < b_{10}$ Own-Capital (Naira)

(k) $\sum_{J=1} a_{11} j\ x\ j < b_{11}$ Borrowed capital (Naira)

(l) $\sum_{J=1} a_{12} j\ x\ j < b_{12}$ Risk in 1991 (Deviation in Naira)

(m) $\sum_{J=1} a_{13} j\ x\ j < b_{13}$ Risk in 1992 (Deviation in Naira)

(n) $\sum_{J=1} a_{14} j\ x\ j < b_{14}$ Risk in 1993 (Deviation in Naira)

(o) $\sum_{J=1} a_{15} j\ x\ j < b_{15}$ Risk in 1994 (Deviation in Naira)

(p) $\sum_{J=1} a_{16} j\ x\ j < b_{16}$ Risk in 1995 (Deviation in Naira)

(q) $\sum_{J=1} a_{17} j\ x\ j < b_{17}$ Minimum Absolute (Deviation in Naira)

(r) $\sum a_{18}j \ x \ j < b_{18}$ Minimum Absolute (Deviation in Naira)
J = 1

(s) $\sum a_{19}j \ x \ j < b_{19}$ Minimum Maize (tonne)
J = 1

(t) $\sum a_{20}j \ x \ j < b_{20}$ Minimum cocoyam (tonne)
J = 1

(u) $\sum a_{21}j \ x \ j < b_{21}$ Minimum cocoyam (tonne)
J = 1

(v) $\sum a_{22}j \ x \ j < b_{22}$ Minimum fluted pumpkin (tonne)
J = 1

(w) $\sum a_{23}j \ x \ j < b_{23}$ Minimum pepper (tonne)
J = 1

(x) $\sum a_{24}j \ x \ j < b_{24}$ Minimum okra (tonne) and
J = 1

(y) 25xj$\geq$- 0

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