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Cost Benefit Analysis Of Rice Production Systems In The Varying Ecologies Of Sierra Leone

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Abstract:
Global demand for rice has increased significantly and its production requires careful consideration to ensure farmers benefit from their production activities.
In Sierra Leone, rice is cultivated in five growing ecologies. The understanding on the cost-Benefit for cultivating rice in these different ecologies is still relatively poor. As a result there is the need to investigate and provide information on the cost and returns of rice production in the different rice ecologies. The study was done in four districts each representing a rice ecological zone. Data on farmers' practices were collected using structured questionnaires. Farmers' cost and returns were then compared to cost and returns using Rokupr Agricultural Research Center (RARC) recommended technologies. Gross revenue, net operating profit returns to management and return to person day were calculated for the study ecologies. The marginal rate of returns MRR) was determined to ascertain the financial reliability of adopting RARC technologies. Result of the study showed that adopting RARC technologies have huge financial benefit.
Keywords: *Rice Ecology; Cost-benefit analysis, Rice Production in Sierra Leone*

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I. Background

The agricultural sector employs about 70 percent of the Sierra Leonean labour force, and contributes at least 45 percent to the country's gross domestic product (GDP). This suggests the importance of agriculture in Sierra Leone's economy. Given the important role played by the agricultural sector in the economic development of the country, the government of Sierra Leone has poetized the sector as its engine of growth. Eradication of hunger and increased food security and value-added agriculture has been at the fore of national policy discourses since the end of the country's civil war in 2002. Central to this objective has been a special focus on the need for substantial in production and productivity particularly in rice the staple food. The country is endowed with enormous agricultural potential. Seventy four percent of the country's land area, covering 5.4 million hectares, is suitable for cultivation, about 78% of this land is upland and 22% is lowland (MAFFS, 2001).

Rice is the staple in Sierra Leone with annual per capita consumption reaching the level of 104 kg. This level of per capita rice consumption is among the highest in sub Saharan Africa. Total rice consumption in Sierra Leone represents 85% of total cereal consumption in the country (FAO, 2000). Rice is grown by about 80% of the farming population (MAFFS, 2010) and it involves in mostly small scale farmers who cultivate rice mainly for subsistence and use rudimentary tools with traditional management. Rice is grown on both the upland and lowland ecologies. Most of the rice grown in the country is in the upland ecology. This ecology is low yielding but has the advantage of mix-copping been practice. Rice is grown on the upland, throughout the country, relying on the traditional slash and burn shifting cultivation system. The lowland ecology is more suitable for rice cultivation compared to the upland. Four low land ecologies exist in Sierra Leone; these include the inland valley swamp (IVS) covering 12.9% of total arable land, the boli land, mangrove swamps and the riverain grassland. The IVS are found in every rejoin of the country, inland valley swamps are fertile and some allows for double cultivation in a year, however iron toxicity remain an important limiting factor to rice cultivation in this ecology. Mangrove swamps are low-lying areas along the coast of the Atlantic Ocean. In Sierra Leone, this ecology extends from the south of the country and the Western Area to the Northwest region. Mangrove swamps are inundated by tidal waves twice daily. The saucer shape boliland, found predominantly in the north, are less fertile and are prone to high weed infestation. The riverain grasslands are located in the south of this country. This ecology is characterized by deep flooding. At the peak of the rainy season areas along the sewa and Wanji Rivers are flooded to about one meter deep.

According to the Sierra Leone Agricultural Sector Review (2003), the country experienced self-sufficiency in rice in 1975. The lowest production (198,000 ton of paddy) was recorded at the peak of the civil

war in 1999. Since then, rice production is estimated to have increased from 310,000 tons of paddy in 2000 to 637,983 tons in 2007. Estimates have shown that the share of households with adequate food increased from 56% in 2005 to 71% in the 2007, yet hunger and poverty is still prevalent. Despite the country's potential, in agriculture investment in the sector remain low and the country still import about 40% of its staple food rice.

Several cropping systems are practiced all over the country in the different ecologies, but the traditional manual system is the most famous among small scale farmers in Sierra Leone. In the past, the purpose for producing rice is mainly for household subsistence. Rice is the foremost staple food for more than 50% of the world's population (Thakur *et al.,* 2011). There is an upward shift in demand for rice worldwide due to population increase and urbanization, as people change their eating habits (Mishra, 2009), leading to high rice market prices. Between 2006 and 2008, average world prices for rice grew by 217%, compared to wheat which increased by 136%, corn by 125%, and soybeans by 107% and in late April 2008, rice prices hit 24cents (U.S.) per U.S. pound, more than doubling the price in just seven months (FAO, 2010; Mittal, 2009; Sing *et al*., 2007). This is an incentive for farmers to intensify rice production in an attempt to meet the increase in demand. In doing so, farmers should try alternative farming systems in each of the existing rice growing ecologies.

In order to substantially increase yields, farmers should adopt Rokupr Agricultural Research Centre recommended practices. However, using high levels of improved inputs leads to increase in production cost. The family labour available for farming is dwindling due to urbanization and the increase in the number of children sent to school. This implies a need for more labour efficient methods in rice production in order to meet the increase in demand for rice. Mechanization of some farming activities is a good labour saving tool, but the comparative advantage of RARC practices needs to be compared with farmers' systems in rice production to justify adoption of RARC practices by farmers and appropriately design scaling up mechanisms that can convince policy makers of the necessity to establish a national strategy for out-scaling. The sustainability and the environmental impact of each system must also be considered. Hence RARC recommended practices must be not only economically viable but also environmentally friendly and gender sensitive. It is therefore the objective of this study to compare the input-output relationships of the existing farming systems with RARC recommended practices and to determine the most profitable systems that make best use of available resources.

II. Project's General Objectives

The general objective is to evaluate the economic returns of the various rice production systems in Sierra Leone.

Project's Specific Objectives

1. Analyze the financial cost and returns of the Farmers' rice production system,
2. Compare the financial cost and returns of farmers' rice production system with RARC production system.

III. Research Methodology

Study sites and sample size

The Study was conducted in four districts located in three provinces.

a. Kambia District (Mangrove Ecology),
b. Kenema District (Inland Valley Swamp).
c. Bombali District (Boliland)
d. Kilanhun District (Upland)

These districts were purposively selected because they constitute major rice producing districts for the respective ecologies in Sierra Leone (PEMSD/MAFFS, 2011). From a list of chiefdoms in the study districts, two chiefdoms were randomly selected from each selected district. Subsequently, from a list of all the villages in the selected chiefdom, five (5) villages were randomly selected. In each of the selected village 10 farmers were sampled per village.

Also using secondary data, one popular RARC improve variety with accompany technology was selected for each study ecology. This was done to compare what obtains in farmers condition and RARC promoted technologies. Below are the varieties and recommended RARC technologies for each study ecology.

Ecology	Variety	Accompanying Technology
Upland	ROK34	1. Minimum tillage land preparation 2. Line sowing seed at 80kg/ha 3. Apply 40kg 0-20-20/ha (4 bags of NPK 0-20-20) at seeding 4. Hand weeding once at 6 weeks after seeding/ use herbicide- Buta chlor with 50% Active ingredient for weeding then apply 60kg N/ha (3 bags of urea)
Inland Valley Swamp	ROK 24	1. Use diesel power tiller for ploughing 2. puddle and level the land well 3.Direct seed in moist soil at 60Kg/ha or transplant 3-4 weeks old seedling using 2-3 seedlings

		per hill 4. Apply 40kg P_2O_4/ha at transplanting (4.5bags SSP) 5. Hand weeding once at 6 weeks after seeding/ use herbicide- Buta chlor with 50% Active ingredient for weeding then apply 60kg N/ha (3 bags of urea)
Mangrove	ROK10	1.Use Honda power tiller for ploughing 2. Transplant 4 to 6 weeks old seedlings 3. Apply 40kg P_2O_4/ha at transplanting (4.5bags SSP) 4.Weed once at 6 weeks after transplanting 5.Apply 60kg N as urea after weeding
Boliland	ROK 3	1.Use diesel power tiller for ploughing 2.Direct seed in moist soil using a seed rate of 80kg/ha 3. Apply 40kg P_2O_4/ha at seeding (4.5bags SSP) 4. Hand weeding once at 6 weeks after seeding/ use herbicide- Buta chlor with 50% Active ingredient for weeding then apply 60kg N/ha

Source: RARC rice production leaflet.

Tools of Analysis

The data collected was analyzed using the following techniques:

Cost-benefit Analysis

Gross margin (GM) is the difference between gross return (GR) and total variable cost (TVC) and is expressed as: GM = GR – TVC

Where

GR = Price of output (paddy) X Quantity of output

TVC = The cost of all inputs that varies in rice production

All costs and returns variables are expressed in local currency the Leone (Le).

Other financial performance measures are also computed and these relate to the net operating profit, the return to management, and return to person-day.

Marginal Rate Of Returns (MRR)

Marginal analysis as used within this context is a procedure for calculating marginal rates of return between Farmers practices and RARC technologies. MRR proceeds in a stepwise manner from a lower-cost methodology (Farmers Practices) to the next higher-cost (RARC practices), and comparing marginal rates of return to acceptable minimum rates of return (Perrin, et al., 1988). The procedure is useful for making adoption recommendations to producers and for selecting alternative technologies. The economic principle underlying the analysis is that it is worthwhile for a producer to continue investing up to the point where the return from each extra unit invested equals the cost of the extra unit. As applied to a situation in which the producer is confronted with a set of discrete alternative methodologies/technologies, the producer should invest as long as the marginal rate of return (in switching from a lower-cost methodology/technology to a higher-cost methodology/technology) is greater than the minimum acceptable rate of return. Hence, recommending to producers is not based solely on the premise that it must be profitable (i.e., added returns are greater than added costs), but that it must also satisfy the added criterion that the marginal rate of return must be above a given minimum acceptable rate of return. Technologies satisfying these criteria stand the greatest chance of being adopted.

Marginal rate of return is computed by expressing the difference between the net benefit of the pair as a percentage of the difference of the total cost. The computed marginal rate of return gives an indication of what a producer can expect to receive, on average, by switching technologies.

$$\text{MRR} = \frac{Difference\ in\ Net\ Benefit\ of\ RARC\ Practices\ and\ Farmers'\ Practice}{Difference\ in\ total\ variablet\ Cost\ Of RARC\ Practices\ and Farmers'\ Practice} \text{ x } 100$$

Hence, a 150% marginal rate of return in switching from Conventional practice to SRI Methodology implies that for each Le 1 invested in SRI, the producer can expect to recover the Le1 invested plus an additional return of Le1.50.

To incorporate risk factor, a minimum acceptable rate of returns (MARR) needed to be determined. Perrin, et al. (1988) provides some general guidelines for determining minimum acceptable rate of return. Without asking producers what they considered to be a reasonable rate of return, researchers noted that experience and empirical evidence suggest that a rate between 50% and 100% seems adequate. If the methodology/technology is new and requires learning new skills, then the upper-bound should be used. In cases where switching technologies simply represents an adjustment, such as a different fertilizer rate, then the lower-bound may be acceptable.

IV. Results And Discursion

Cost of Production

Land Cost

Most often land is communally owned in Sierra Leone. However ownership by renting is increasing particularly in the IVS and mangrove ecology. Although family communal system of land tenure has precluded the development of an effective market for agricultural land, rental fees are been paid by some farmers. The average rental fee paid by the proportion of farmers who rent land is used as a proxy for the cost of land rental. As that fee is the opportunity cost of land for farmers who cultivate on own land. The table below shows the rental fee for land in the different ecologies.

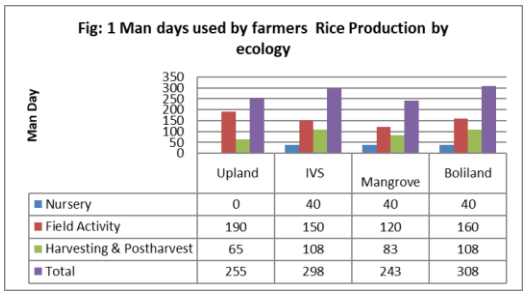
Table: 2. Land Rental Fee

Ecology	Rental fee (Le/ha)
Upland	28,000
Inland Valley Swamp	200,000
Mangrove	250,000
Boliland	100,000

Source: survey data 2015

Table 2 show the rental fee paid for land use in rice production for the different ecologies. Result indicates that fee (Le. 250,000/ha) for mangrove ecology was the highest than all other ecologies. This may be because of the scarce nature of the mangrove ecology accounting for only 3% of total arable land in the country.

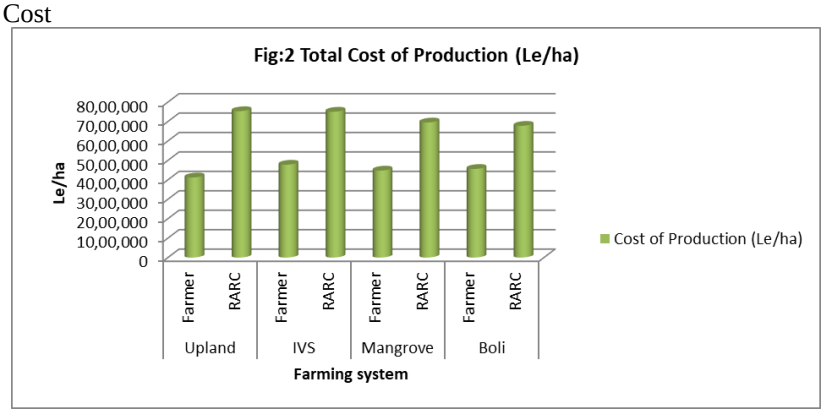
Man day use in Rice Production



Source: Survey Data

In the traditional system of farming, traditional practices are mainly employed. Manual labour is the most important source of farm power. The figure 1 above show the number of person day spent in the production of rice by ecology. In all the ecologies farmers spent more time in the field activities than in the other activity. Upland farmers used 190 person days for field activities, which is the highest compared to the other ecologies studied. The figure also shows that more person days (308) are required for rice cultivation in the Boliland, and this is closely followed by IVS rice cultivation, as 298 man days are needed to cultivate one hectare, while 255 person days are required in the cultivation of the upland. Fewer person days are used in upland compared to the Boli and IVS because upland farmers employ slash and burn for land clearing as opposed to the brush, gather and through away of brushed remains practiced in the boli and IVS ecologies. The result also indicates that mangrove rice farmers used less person days (243) compared to other ecologies. A possible explanation for this could be due to the absence of bird scaring and weeding activities in that ecology.

Total Production Cost



Note:
Leone (Le) is the Sierra Leone currency with a rate of exchange at the time of the study of Le 5000 = 1 USD
Farmer= This refers to rice farming using traditional farming system
RARC= Refers to growing rice using Rokupr Agricultural Research Centre recommended practices
Source: Field Survey, 2015

Figure 2 gives the total cost of production of rice in a hectare of land and shows that the cost of production for farmers in the different ecology varies only slightly. It cost Le 4,122,787, Le 4,780,215, Le4, 477,511 and Le4, 562,381 to produce rice on one hectare of upland, IVS, mangrove and boliland ecologies respectively if tradition system farming methods are employed.

In the farmer practice (use of tradition farming method), as used in this study rice production cost is mainly on labour. The chart also indicates that it cost more to use RARC recommended practices, as it involves the use of fertilizers, machinery and herbicide.

Cost and Returns of Rice production Systems
Cost and Returns for upland Rice System

Table: 3. Upland Rice Production System

1. Gross value of output, Le/Ha	Lowest Yield under farmer practice	Average Yield under farmer practice	Highest Yield under farmer practice	Yields under RARC practice
1.1. Average Yield, kg/ha	835	935	1200	3000
1.2. Price, Le/Kg	3,674	3,674	3,674	3674
1.3. Gross Revenues, Le/Ha	3,067,790	3,435,190	4408800	11022000
2. Costs				
2.1. Land Rental Le/ha	28,000	28,000	28,000	50000
2.2. Intermediate inputs costs, Le/ha	2744840	2744840	2744840	4835063
2.3. Interest on Capital, Le/Ha	274,484	274,484	274,484	483506
2.3. Operating Capital Le/ha	3,019,324	3,019,324	3,019,324	5318569
2.4. Total Operating Costs, Le/ha	3,047,324	3,047,324	3,047,324	5368569
3. Family Labor/Supervision*				
3.1. Family labor, person-day/ha	120	120	120	130
3.2. Cost of Family labor, Le/Person-day	8,962	8,962	8,962	16667
3.3. Cost of Family labor, Le/ha	1,075,463	1,075,463	1,075,463	2166710
4. Performance Measures				
4.1. Gross Margins Le/ha	48,466	415,866	1,389,476	5,703,431
4.2. Net Operating Profit Le/ha	20,466	387,866	1,361,476	5,653,431
4.3. Return to Management Le/ha	-1,054,997	-687,597	286,013	3,486,721
4.4. Net Revenue/Person-Day, Le/person-day	171	3,232	11,346	43,488

Note: Family labour in farmers' practice is cost as supervision cost in RARC practices
Source: Survey Data 2015

Table 3 present data for costs and returns of rice farming in the upland ecology. The table shows cost and returns for farmer who obtained the lowest yield, average and highest yields under farmers' condition, and under RARC recommended practices. Lowest yield obtained in the study was 835Kg/ha and the heist yield was 1200kg/ha, average yield in the upland under farmers' was 935kg/ha. Under RARC cultivation practice, ROK 34 yielded 3000kg/ha in the upland. A yield increase of 2065kg/ha (68.83%) is obtained between the average obtainable yield under farmer condition and RARC Practices. This difference in yield is reflected in gross revenue obtained for using farmers' practices and RARC recommended practices.

Cost of production is higher in RARC practices compared to traditional farmers' practice, because improved farming techniques were employed. These techniques that have high cost implication include use of fertilizer, power tiller for ploughing and herbicide use for weed control.

Negative returns to management (return to family labour) of Le 1,054,997 and Le 687,597 respectively were obtained for upland farmers with the lowest and average yields under farmer practices. However, farmers who can obtain the maximum yield of 1.2t/ha can pay for their investment and still have Le286, 013 as return to management. Upland rice farming under traditional farmer practices yields a return per person day which is less than the going wage rate for farmers who obtain the lowest yield and average yields, however farmers with yields of 1.2t/ha (maximum obtained yield) obtain returns per day of Le11, 346 which is higher than the going wage rate of Le 8,962 per person day. In a study of the economics of rice production in Sierra Leone by D.S.C Spencer in 1975 showed that traditional upland rice cultivation was profitable. This study however, indicates otherwise. This is because the fertility status of the uplands has been depleted and yields under traditional farming practices have dwindled also cost of production have more than double. Hence, under the current

farming environment, upland rice cultivation can only be encouraging if RARC recommended technologies are adopted by farmers.

Under RARC recommended practices, upland rice farming is highly profitable contrary to what is obtained under traditional farmers' practices. A positive return to management (return to supervision) of Le 3,486,721 was obtained with RARC recommended technologies. An excess of Le 3,200,708 is received as return to management even with the highest obtained yields with farmers' practiced by switching to RARC recommended technology. With RARC technologies, upland rice farming yielded Le 43,488 as return per person day which is higher than the going wage rate.

Cost and returns of Inland Valley Swamp Rice production Farming System

Table: 4. Cost and returns of Inland Valley Swamp Rice Farming System

IVS cropping system	Lowest Yield under farmer practice	Average Yield under farmer practice	Highest Yield under farmer practice	Yields under RARC practice
1. Gross value of output, Le/Ha				
1.1. Average Yield, kg/ha	1320	1900	2300	4000
1.2. Price, Le/Kg	3,674	3,674	3,674	3,673
1.3. Gross Revenues, Le/Ha	4,849,680	6,980,600	8,450,200	14,692,000
2. Costs				
2.1. Land Rental Le/ha	200,000	200,000	200,000	250,000
2.2. Intermediate inputs costs, Le/ha	3,061,632	3,061,632	3,061,632	4,960,482
2.3. Interest on Capital, Le/Ha	306,163	306,163	306,163	496,048
2.3. Operating Capital Le/ha	3,367,795	3,367,795	3,367,795	5,456,530
2.4. Total Operating Costs, Le/ha	3,567,795	3,567,795	3,567,795	5,706,530
3. Family Labor/supervision*				
3.1. Quantity Family labor, person-day/ha	110	110	110	108
3.2. Cost of Family labor, Le/Person-day	11,022	11,022	11,022	16,667
3.3. Cost of Family labor, Le/ha	1,212,420	1,212,420	1,212,420	1,800,036
4. Performance Measures				
4.1. Gross Margins Le/ha	1,481,885	3,612,805	5,082,405	9,235,470
4.2. Net Operating Profit Le/ha	1,281,885	3,412,805	4,882,405	8,985,470
4.3. Return to Management Le/ha	69,465	2,200,385	3,669,985	7,185,434
4.4. Net Revenue/Person-Day, Le/person-day	11,653	31,025	44,385	83,199

*Family labour in farmers' practice is cost as supervision cost in RARC practices

Source: Survey Data 2015

Tables 4 present result for costs and returns of rice farming in the Inland valley swamp ecology. Results obtained showed the cost and returns for farmer who obtained the lowest yield, average and highest yields under farmers' condition, and under RARC recommended practices. Lowest farmers' yield obtained in the study was 1320Kg/ha and the heist yield was 2300kg/ha, average yield in the IVS was 1900kg/ha. Those yields are higher than those obtained in the IVS ecology. This is not surprising as IVS yields are generally higher than yields in the upland.

With RARC cultivation practice, ROK 24 yielded 4000kg/ha. A yield increase of 67%, 52.2% and 42.5%is obtained between the lowest, average and highest obtainable yield under farmer condition and RARC Practices. This yield differences are large enough to stimulate adoption of RARC recommended practices. However, adoption of these RARC technologies is still low reasons for this include but not limited to the economic status of farmers, the socio-cultural norms of farmers and access to some of these technologies.

As in the upland ecology cost of production is higher in RARC practices compared to traditional farmers' practice in the IVS, because improved farming techniques were employed.

Returns to management (return to family labour) of Le 69,465, Le 2,200,385 and Le3, 669,985 respectively were obtained for IVS farmers with the lowest, average and highest yields under farmer practices. IVS rice farming under traditional farmer practices yields a return per person day which is higher than the going wage rate even for farmers with the lowest yield in the IVS.

Under RARC recommended practices, IVS rice farming is more profitable than using traditional methods. A positive return to management (return to supervision) of Le 7,185,434was obtained with RARC recommended technologies compared to Le 69,465, Le 2,200,385 and Le3, 669,985 obtained respectively for lowest, average and highest yields under farmer practices. With RARC technologies, upland rice farming yielded Le 83,199 return per person day which is higher than the going wage rate.

Cost and returns of Mangrove Rice production Farming System

Table: 5 Cost and returns of Mangrove Rice Farming system

Mangrove Rice Farming system	Lowest Yield under farmer practice	Average Yield under farmer practice	Highest Yield under farmer practice	Yields under RARC practice
1. Gross value of output, Le/Ha				
1.1. Average Yield, kg/ha	1335	1835	2035	3500
1.2. Price, Le/Kg	3,674	3,674	3,674	3,674
1.3. Gross Revenues, Le/Ha	4,904,790	6,741,790	7,476,590	12,859,000
2. Costs				
2.1. Land Rental Le/ha	250,000	250,000	250,000	250,000
2.2. Intermediate inputs costs, Le/ha	2,841,192	2,841,193	2,841,194	4,855,063
2.3. Interest on Capital, Le/Ha	284,119	284,119	284,119	180,500
2.3. Operating Capital Le/ha	3,125,311	3,125,312	3,125,313	5,035,563
2.4. Total Operating Costs, Le/ha	3,375,311	3,375,312	3,375,313	5,285,563
3. Family Labor/Supervision*				
3.1. Quantity Family labor, person-day/ha	100	100	100	100
3.2. Cost of Family labor, Le/Person-day	11,022	11,022	11,022	16,667
3.3. Cost of Family labor, Le/ha	1,102,200	1,102,200	1,102,200	1,666,700
4. Performance Measures				
4.1. Gross Margins Le/ha	1,779,479	3,616,478	4,351,277	7,823,437
4.2. Net Operating Profit Le/ha	1,529,479	3,366,478	4,101,277	7,573,437
4.3. Return to Management Le/ha	427,279	2,264,278	2,999,077	5,906,737
4.4. Net Revenue/Person-Day, SLL/person-day	15,295	33,665	41,013	75,734

*Family labour in farmers' practice is cost as supervision cost in RARC practices

Source: Survey Data 2015

Tables 4 present results for costs and returns of rice farming in the mangrove rice ecology. Results obtained showed that gross returns for mangrove rice cultivation can pay for the total operating cost of production even for the lowest obtained yield of 1335kg/ha. However, under farmer practice, the net operating profit (Le4, 101,277) obtained for the highest yielding mangrove farmer makes only $ 1.88 available to the household per day in a year. On the other hand, RARC farming technologies in the mangrove yields an operating profit of Le 7,573,437 providing $3.45 to the household per day in a year.

With RARC cultivation practice, using ROK 10 yields of 3500kg/ha was obtained. A yield increase of 61.9%, 47.6.2% and 41.9%is obtained between the lowest, average and highest obtainable yield under farmer condition and RARC Practices. Returns to management (return to family labour) of Le 427,279, Le 2, 2,264,278and Le2, 999,077 respectively were obtained for mangrove farmers with the lowest, average and highest yields under farmer practices.

Under RARC recommended practices, mangrove rice farming is more profitable than using traditional methods. A positive return to management (return to supervision the equivalent of return to family labour) of Le 5,906,737 was obtained with RARC recommended technologies and return of Le75.00 per person day was also observed for mangrove rice cultivation. The return to person day is higher than going wage rate.

Cost and returns of Mangrove Rice production Farming System

Table: 6. Boliland Rice cultivation System

Boliland cropping system	Lowest Yield under farmer practice	Average Yield under farmer practice	Highest Yield under farmer practice	Yields under RARC practice
1. Gross value of output, Le/Ha				
1.1. Average Yield, kg/ha	975	1350	1680	3000
1.2. Price, Le/Kg	3,674	3,674	3,674	3,674
1.3. Gross Revenues, Le/Ha	3,582,150	4,959,900	6,172,320	11,022,000
2. Costs				
2.1. Land Rental Le/ha	100,000	100,000	100,000	250,000
2.2. Intermediate inputs costs, Le/ha	2,918,346	2,918,346	2,918,346	4,935,063
2.3. Interest on Capital, Le/Ha	291,835	291,835	291,835	493,506
2.3. Operating Capital (total variable costs), Le/ha	3,210,181	3,210,181	3,210,181	5,428,569
2.4. Total Operating Costs, Le/ha	3,310,181	3,310,181	3,310,181	5,678,569
3. Family Labor				
3.1. Quantity Family labor, person-day/ha	100	100	100	100
3.2. Cost of Family labor, Le/Person-day	11,022	11,022	11,022	11,022
3.3. Cost of Family labor, Le/ha	1,102,200	1,102,200	1,102,200	1,102,200
4. Performance Measures				
4.1. Gross Margins Le/ha	371,969	1,749,719	2,962,139	5,593,431
4.2. Net Operating Profit Le/ha	271,969	1,649,719	2,862,139	5,343,431
4.3. Return to Management Le/ha	-830,231	547,519	1,759,939	4,241,231
4.4. Net Revenue/Person-Day, SLL/person-day	2,720	16,497	28,621	53,434

*Family labour in farmers' practice is cost as supervision cost in RARC practices

Source: Survey Data 2015

Results obtained showed that operational profit derived by farmer under farmers' condition and under RARC recommended practices are all positive indicating a markup for their investment in rice cultivation in the boliland ecology. However, the return obtained for RARC practices is substantially higher than that for farmers' practices.

On the other hand return to management for farmers who obtained the lowest yield cannot pay for all their investment. With RARC cultivation practice, using ROK 3 and recommended technology the boliland ecology yielded 3000kg/ha. As in the upland ecology cost of production is higher with RARC practices compared to traditional farmers' practice.

Comparison of Performance Measures of the Study Ecologies

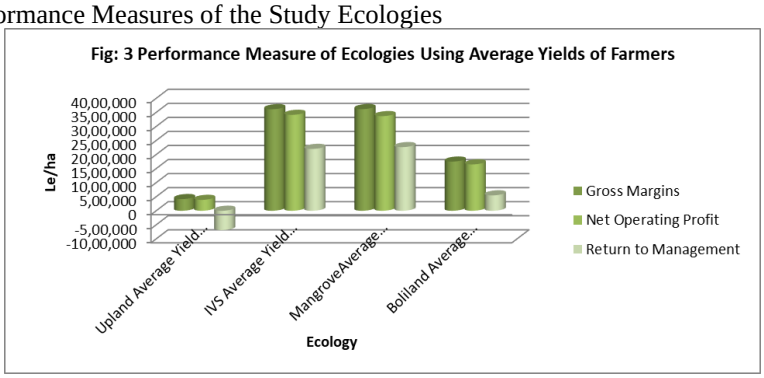


Figure 3 present result of the financial performance measure of rice production in the ecologies studied when average yields are obtained.

This results shows that the inland valley swamp and the mangrove are the most financially rewarding ecologies for rice production.

Rice production in these ecologies yields a return to management of Le 2,200,385 and Le 2,264,278 for the IVS and mangrove swamps respectively. A return to management of Le 547,519 was obtained by boliland farmers. With average yields of 935kg/ha on the upland, farmers can not break even if family labour cost is considered as returns to management returns were negative. Farmers in the upland with average yields are losing Le. 687,597.

Marginal Rate of Returns

Table: 6. Marginal Rate of Returns (MRR)

	Upland		IVS		Mangrove		Boli	
	Farmer	RARC	Farmer	RARC	Farmer	RARC	Farmer	RARC
Total Production Cost	3,019,324	5,318,569	3,367,795	5,456,530	3,125,313	5,035,563	3,210,181	5,428,569
Production cost Difference	2,299,245		2,088,735		1,910,250		2,218,388	
Net Benefit	1389476	5703431	5,082,405	9,235,470	4,351,277	7,823,437	2,962,139	5,593,431
Net Benefit Difference	4313955		4153065		3472160		2631292	
MRR (%)	**188**		**199**		**182**		**119**	

Source: survey data 2015

The marginal rate of returns presented in table 6 was calculated to ascertain the financial reliability of switching from farmers practice to RARC. Result of the MMR indicates a marginal increase of more than 100% in all the studied ecologies. MRR of 188%, 199%, 182% and 119% were obtained for upland, IVS, mangrove and boliland farmers obtaining average yields if they adopt RARC recommended practices. According to CYMMYTE, 1993 technologies that require learning, most give MRR of at least 100% to make them financially attractive for adoption by farmers. Given the MRR results obtained, RARC recommended technologies are financially rewarding in all four ecologies.

V. Conclusions And Recommendations

It is clear that RARC recommended technologies even with their high cost implication can be financially rewarding. In all the ecologies RARC technologies provide more than 50% gain in financial returns compared to what is obtained under farmer practices. Results also showed that the IVS and mangrove rice cultivation are more profitable than rice cultivation in the upland and bolilands. This result justifies Government policy of encouraging IVS rice cultivation. However, the IVS and mangrove account for only 12% and 3% respectively of available arable land in the country. Hence, it show that rice cultivation in the upland cannot be totally abandoned as about 80% of rice farmers cultivate in the upland, it also accounts for about 70% of the total rice produced in the country. As far as rice production is concern in Sierra Leone the effort of upland farmers cannot be ignored. If the welfare of upland rice farmers is to be improved, up scaling the adoption of RARC technology should be strongly considered. Results from table 2 showed that there is a high potential for getting increased yields on upland farms in Sierra Leone with RARC recommended technologies. But in order to get farmers adopt these improve technologies, the Ministry of Agriculture Forestry and Food Security (MAFFS) and other extension agencies needs to direct more effort to upland farmers.

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