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Wirtschaftlichkeit der Regenwassersammlung für die landwirtschaftliche Produktion in ausgewählten semiariden Gebieten Tansanias

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Stichworte
Regenwassersammlung (RWS), Wasserkonzentrationsanbau, Tansania, Methodik der ökonomischen Bewertung von RWS, Deckungsbeiträge: Mais, Reis, Zwiebeln, Investitionsanalyse, Sensitivitätsanalyse

Keywords
Rain water harvesting (RWH), Tanzania, methodology of economic evaluation of RWH, gross margin analysis: maize, rice, onion, investment analysis, sensitivity analysis

Zusammenfassung

Unter den Bedingungen der semiariden Gebiete in Tansania erscheint der Wasserkonzentrationsanbau, d. h. die gezielte Sammlung des Niederschlages und dessen Verwendung in der landwirtschaftlichen Produktion, gerechtfertigt. In der vorliegenden Arbeit wird über Ergebnisse einer Untersuchung berichtet, mit der versucht wurde, Erkenntnisse über die Wirtschaftlichkeit der Regenwassersammlung bzw. des Wasserkonzentrationsanbaues zu gewinnen.

Die Studie basiert vor allem auf Befragungen der Landwirte in den Untersuchuangsgebieten. Um umfassendes, detailliertes Datenmaterial zu erlangen, wurde die Anzahl der Befragungen relativ klein gehalten. Deckungsbeiträge und Investmentanalyse (Cost-Benefit) wurden zur Bewertung der Wirtschaftlichkeit der Regenwassersammlung bzw. des Wasserkonzentrationsanbaues benutzt. Die Ergebnisse zeigen, dass die entsprechende Nutzung des Regenwassers unter den Bedingungen der Untersuchungsgebiete die Deckungsbeiträge wie auch die Arbeitseinkommen erhöht. Innerhalb eines Systems des Wasserkonzentrationsanbaues wurden deutliche Unterschiede zwischen wirtschaftlichen Erfolgen von einzelnen Farmern festgestellt. Im Regelfall erfreuten sich die Farmer am Anfang und in der Mitte des Verteilersystems einer höheren Wirtschaftlichkeit als die am Ende des Systems wirtschaftenden Farmer. Dort wo Wasserspeichermöglichkeiten gegeben sind, fallen diese Differenzen deutlich geringer aus. Als besonders wirtschaftlich erwies sich das Verfahren bei Zwiebeln. Voraussetzung ist hierbei allerdings, wie bei allen Kulturen mit hochwertigen Produkten, dass ein Markt für diese Produkte vorhanden ist. Angesichts des vorhandenen Potentials und der gegebenen Wirtschaftlichkeit kommen die Autoren zu einer positiven Bewertung der Regenwassersammlung bzw. des Wasserkonzentrationsbaues in den semiariden Gebieten Tansanias.

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Abstract

In semi-arid areas of Tanzania, over dependence on agriculture, low and unreliable rainfall, poverty and high livestock numbers, justify the considerations of Rainwater Harvesting (RWH) for agricultural production. This study was conducted with the aim of providing an understanding of the profitability of RWH for agricultural production in semi arid areas of Tanzania. The study villages are Makanya and Hedaru located in the Western Pare Lowlands (WPLL) and Bukangilija village located in Maswa district in the Lake Zone (LZ) The study used mainly primary data, collected using structured questionnaires. Relatively small samples were used to allow in depth data collection such as actual yield and farm size measurements. Gross Margin and Investment (Benefit-Cost) analyses were used to assess the profitability of RWH systems. Rainwater harvesting improves Gross Margin (GM) as well as returns to labour. Under the maize system, the position of the farm is an important determinant of performance. The difference between farmers at the head and those at tail end of the water system was not significant in the rice system. The reason may be that the storage of water in majaluba helps to even out distribution of water, since even large flows can be captured. This is not the case with maize systems, where large flows must be allowed to drain to avoid water logging. The relatively high GM and returns to labour obtained by onion farmers, show the tremendous benefit of RWH. Where markets are available, RWH enables farmers to switch to high value crops, with very significant improvement of incomes and thus livelihood. Maize production with RWH (using diversion canals) had positive Net Present Value (NPV), Benefit to Cost ratio (B:C) of greater than one and an Internal Rate of Return (IRR) of 57%. Similarly, paddy production with RWH had a positive NPV, B: C ratio greater than one and an IRR of 31%. Due to existing potential and profitability of RWH, it is recommended that RWH be prioritised in Tanzania, particularly in the semi-arid areas.

1. Background

The research was conducted in two target sites, representing semi-arid areas of Tanzania. The locations were the Western Pare Lowlands (WPLL) within Mwanga and Same districts in North East Tanzania, and Maswa District in Shinyanga Region, South of Lake Victoria (Map 1).

The Mwanga and Same districts are characterised by two major agro-ecological zones, namely the highlands and lowlands. The Pare Mountains are located to the South East of the Mt. Kilimanjaro, between 600 and 2,424 m above sea level. The Western side of the mountains is the leeward side and thus receives low amounts of rainfall. The mountain slopes are steep, abruptly joining with plains that extend to the Pangani River. In particular the Western Pare Lowlands (WPLL) have the following characteristics:

– The lowlands fall within the Maasai steppe agro-ecological zone, which is characterised by rolling plains with reddish sandy clay soils of relatively low fertility formed on basement complex rocks.
– Annual rainfall is in the range of 500 to 800 mm with bimodal pattern, with about 200 mm in *Vuli* and 400 mm in *Masika*.
– Potential evapotranspiration is over 2,000 mm per year.

Attempts to promote adoption of drought resistant sorghum as a food security measure have been met with resistance in favour of maize production. However, due to low rainfall and high potential evapo-transpiration, seasonal soil-water deficit is a major constraint to maize production and other high water demanding cropping options. Improvement of rainwater management is therefore a priority requirement in WPLL.

Maswa District falls within the extensive central semi-arid agro ecological zone, which is characterised by gently undulating plains with long slopes and wide valley bottoms. Annual rainfall ranges between 600 and 900 mm with a transitional regime. Availability of adequate soil-moisture for plant growth is a major constraint, mainly due to the occurrence of long dry-spells during the growing season.

The land use pattern is linked to the recurrent topo-sequence of soils (Figure 1), known as Sukumaland catena as described by MILNE (1936). Up to the 1980s, common crops grown were cotton and other drought resistant crops. However, in recent years farmers' preferences have shifted in favour of maize and paddy rice as dual-purpose crops. Rice cropping system based on RWH techniques involving excavated bunded fields known as *majaluba*, is now a common component of the farming system.

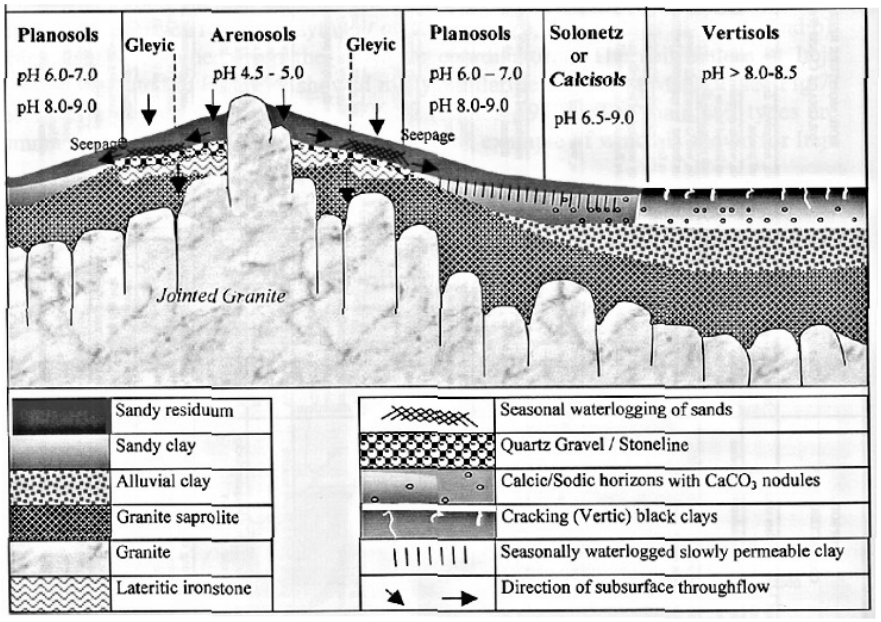
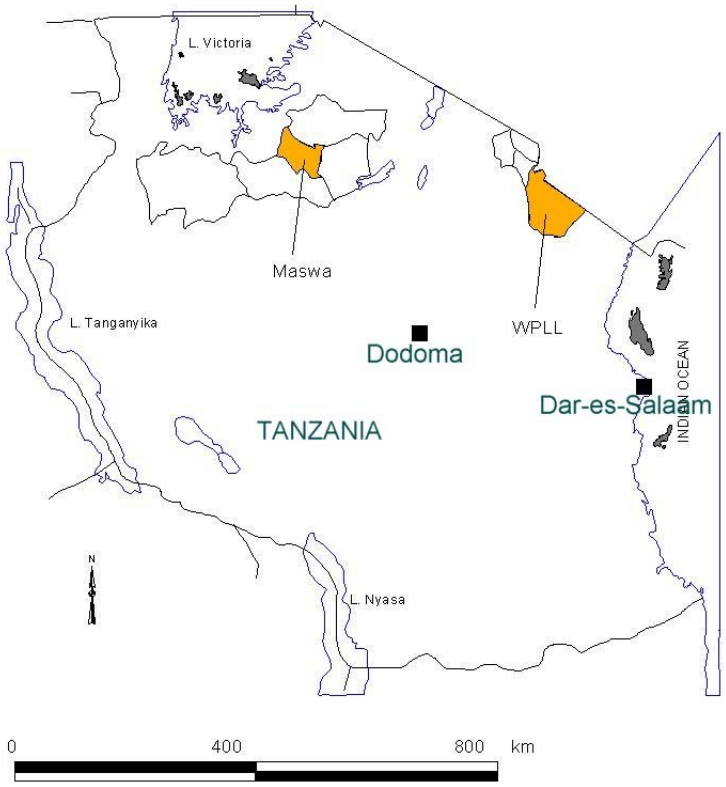


Figure 1:
A typical cross-section of the Sukumaland catena (After PAYTON, 2000)



Map 1:
Location of the research target areas in Tanzania

1.1 Economic and financial performance of RWH at field level

In the semi-arid areas of Tanzania RWH has become increasingly important for agricultural production. Farmers are investing resources (land, labour and capital) in order to realise output. Construction and maintenance of RWH structures is normally labour intensive. Structures such as storage ponds and excavated bunded basins (majaluba) may require collective actions or the use of hired labour. As a result economic evaluation becomes an important aspect in the implementation of RWH.

Economic evaluation of the performance of different techniques of RWH varies between simple yield comparison and more sophisticated risk analysis methods

such as stochastic dominance analysis (KUNZE, 2000). However the highly sophisticated techniques are normally limited by data availability.

The most commonly used methods in Tanzania are yield comparisons (RWEHUMBIZA *et al.* 1999, HATIBU *et al.*, 1999); Gross margin analysis (HATIBU *et al.*, 2000) and Investment analysis (LAZARO *et al.*, 2000). All the methods are capable of examining the 'with' and the 'without' RWH situations.

Yield comparisons are normally done when comparing different treatments of RWH. Using yield comparisons in semi arid areas of Morogoro and Mwanga, HATIBU *et al.* (1999) showed that micro-catchment in RWH farming is feasible during short rains of V*uli.* RWEHUMBIZA *et al.* (1999) compared maize grain yields from stone bunding, contour ridges, and live barriers with yields from flat cultivation and zero tillage. The results showed that the farmer had grain yields of between 2.5 to 2.7 tons per hectare compared to 2.2 and 1.7 tons per hectare for flat cultivation and zero tillage respectively. Yield comparisons can also be done using survey data. However, in this case accuracy of data is an important factor to be considered. Whenever possible actual yield measurements need to be taken to ensure data accuracy.

Gross margin is the difference between gross value of output and the total variable costs used in the production process. This usually involves representative farm models for generating gross margins for enterprises (crops and livestock), which are used to compare the situation "with" the project" to that of "without" the project". Gross margin analysis is static, and does not take into consideration the time value of money. This is a deficiency when analysing RWH structures, which produce benefits over a number of years. However, it is a useful tool, which can assist in improving the overall management of the farms as it addresses resource productivity in a given period of time. Hatibu *et al.* (2000) calculated returns to water (RWH) on maize and onions in Hedaru and Mgwasi villages in Western Pare Lowlands. The results showed that, annual return to water for maize production (1.6[2]) was lower than that of onion (19.3).

Investment analysis allows costs and benefits to spread across the lifetime of the project, which for RWH is always more than one year. The 'majaluba' fields for example may take up to 10 years or more. LAZARO *et al.*, (2000) reported results of economic analysis of rice production using bunded basins (*majaluba)* in Dodoma Tanzania. The results showed that rice production using *majaluba* basins is profitable with a Net Present Value (NPV) of TShs 84,350 at 10% discount rate and TShs 30,408 at 24% discount rate in ten years of the project. In that study the cost of capital in Tanzania in year 2000 was estimated at 10%.

In doing the investment analysis, the following considerations need to be made explicitly. These are:

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2 The study calculated annual returns as a ratio of the benefits to annual costs of water and soil conservation measures. This can be regarded as variants of gross margin analysis.

(a) Choice of the evaluation criteria

Criteria normally used are Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR). NPV is the discounted net benefits over the lifetime of the project. BCR is the ratio of discounted benefits to costs. IRR is the discounting rate that equates the NPV to zero. For small projects such as water harvesting, the IRR has often been used since it allows comparison to average market interest rate (KUNZE, 2000). In West Africa IRR of as high as 45% was observed in sorghum grown using stone dams (KUNZE, 2000). In this study, NPV, BCR and IRR were computed as measures of project worth, for maize, paddy rice and onion.

(b) Time horizon

The choice of the time horizon will greatly depend on the expected useful life of the of the major investment items of the project. It is generally argued that small farmers' time horizon is shorter and has been a factor in determining the acceptance of long-term projects. Proposals for time horizon of many RWH techniques are presented in KUNZE (2000). Based on those proposals, this study set the time horizon of 10 years, after which the RWH structures need to be re-constructed or have major rehabilitation.

(c) Discount rate

The issue of discounting rate is highly debated (ENTERS, 1998). For the purpose of analysing farm level projects, normally market/private interest rates are used. Generally many investment calculations consider interest rates between 5 and 15 % (ENTERS, 1998). This study used discount rate of 10%, which is considered as the opportunity cost of capital in Tanzania as proposed by the World Bank. However, since many farmers may have relationship with local commercial banks, a lending/discount rate of 20% was also used in this study as part of financial analysis. However, this needs to be adjusted for inflation when undertaking economic analysis. In Tanzania if this rate (20%) was to be adjusted for inflation it approaches 10%.

(d) Prices and valuation of labour

Prices play an important role in investment analysis. Normally market prices are used, although there may be differences in prices right after harvest and the prices received after farmers have stored their produce. A decision between the use of current prices versus constant price needs to be made before hand as it has implications in incorporating inflation in the calculation. Normally constant prices are used because of the assumption that general inflation will exert the same relative effect on both costs and benefits (GITTINGER, 1982). It is also difficult to forecast inflation beyond say three years.

Many investment analyses have focused on the use of minimum wages (official urban and rural wages) and disregard the use of opportunity cost of unskilled labour. Minimum wage usually over-estimate labour opportunity costs in the rural areas. Some authors have suggested that family labour has an opportunity cost of zero. However, as noted by KUNZE (2000) this cannot happen even at high unemployment rates, because even social activities, which often express social security involvement, require a rate above zero.

To reflect economic analysis in this study, prices used to value inputs and outputs were taken in such a way that transfer payments (such as taxes, subsidies and credit transactions) are eliminated. Although no adjustments were made in correcting price distortions of traded goods, this study opted for market prices which were believed to reflect the opportunity cost.

The cost of hired labour in the study areas varies with seasons. During slack season the cost is low. An average value (TShs 1000 per day) for the two agricultural seasons (*Vuli* and *Masika*) was considered as the opportunity cost of labour in the study areas.

(e) Sensitivity analysis

This is an analytical technique to test systematically what happens to the earning capacity of a project, if events differ from the estimates during the planning process. It is a means of dealing with uncertainty about the future events and values. As pointed above, prices of agricultural products are highly variable mainly due to season supplies, perishable nature and bulkiness. As a result, there may be drastic changes in prices over time. To test the viability of the calculated measures of project worth, sensitivity analysis is required.

1.1.1 The with and without RWH situations

Project analysis attempts to identify and value the costs and benefits that will arise with the proposed project and to compare them with the situation, as it would be without the project. The difference is the incremental net benefits arising from the project investment. This approach is not the same as comparing the situation "before" and "after" the project. The "before" and "after" situations do not take into account the changes in production that would occur without the project. As a result it leads to erroneous statement of the benefits attributable to project investment.

In this study, the 'with' and 'without' project situations analysis was calculated in maize production. The other crops i.e. paddy and onion cannot be produced in a situation without RWH. As a result the 'without' RWH situation do not yield any output. In investment analysis, incremental net benefit approach was used, assuming that the 'without' RWH project situation yields zero net benefits.

2. Methodology

This study concentrated on three crops that are grown in semi-arid areas of Tanzania. These are maize (with and without RWH), rice production with RWH and onion production with RWH. In addition the study looked into livestock production with and without RWH.

In the WPLL the study was conducted in Makanya and Hedaru villages. Makanya village was purposely selected for the study of maize production because of the existence of a very elaborated system that has been developed in the village for harvesting ephemeral flows. Makanya village was also earmarked for the livestock study because of the existence of several charco dams. More than 25 % of the households keeping livestock have private charco dams.

Hedaru Village was selected for the study on the economics of onion mainly because it has a long history of practising RWH using water storage ponds (*ndiva*) for horticultural crop production (see also HATIBU *et al.* 2000).

Bukangilija village in Maswa District was purposely selected for the study of rice system. In this village, RWH using *majaluba* is widely practised.

2.1 Sampling Procedure

Household survey techniques and case study approaches were used to collect the data required for this study. A minimum of thirty households was selected for each category (Table 1). Despite the analytical/statistical disadvantages of the small sample, the method was preferred because close monitoring of farmers for example measurements of their actual farm sizes and yields were necessary. Sampling procedures for each enterprise are presented in the following subsections.

Table 1:
Sample sizes for studied enterprises

Enterprise	Number selected Households
Maize production *with* RWH	30
Maize production *without* RWH	30
Rice Production *with* RWH	30
Onion producing farmers *with* RWH	34

2.1.1 Maize

Sampling was planned such that different locations of the canals (head, middle and tail) were represented. Sampling was done in each location as shown in Table 2. It was hypothesised that farmers located at head, middle and tail will have location

advantages/disadvantages as far as the availability of water is concerned, and hence this reflected in their respective yields.

Table 2:
Position of selected maize farms in relation to the canal

Location of the farm	Frequency	Percent
Head	10	33
Middle	13	43
Tail	7	23
Total	30	100

2.1.2 Rice
Rice is grown mainly on bunded basins (*majaluba*). Rainwater is harvested mainly using external catchment and directed to the bunded basins. As noted earlier Rice can only be grown under RWH. A random sample of 30 farmers was selected in Bukangilija village in Maswa District. No field categorisation was made (as noted in maize).

2.1.3 Onions
As mentioned earlier, onion production in Hedaru depends on RWH storage structures called *ndiva*. Again the onions in this area can only be grown with RWH. A sample of thirty-four farmers was randomly picked to provide the needed data for this study. Categorisation of filed locations was not done. This is because onion farms are small and are located within the surroundings of a *ndiva*.

2.2 Data Collection
2.2.1 Questionnaire Design
The basic tool for data collection was structured questionnaires. A set of five questionnaires was prepared to collect data from maize and rice based systems in WPLL, and Maswa District. In WPLL, the study was extended to cover economics of onions and livestock production. The questionnaires were slightly different to reflect the differences in nature and operations for each enterprise. Generally, the questionnaires were designed to capture data on input costs and revenues.

2.2.2 Pre-testing
The questionnaires were pre-tested to ascertain the validity of questions before final administration was made. In each case, six respondents were randomly selected for pre-testing of the questionnaire. Necessary adjustments were made accordingly to improve the questionnaires after the pre-testing exercise.

2.2.3 Questionnaire administration procedure

Data collection was conducted by researchers and enumerators based in the field. The data for economic analysis were supplemented with data collected using the household survey questionnaire described.

2.3 Field measurements

To determine yield of maize and rice, small plots (3 m x 12 m) were demarcated and harvested under the project supervision, for each farmer. After harvesting, maize was shelled and the total grain weight determined. A small sample was oven dried at 70 ^{0}c to determine the moisture content at harvest. This moisture content was used to convert the weight at harvest to dry weight. Yield per hectare was then determined by extrapolation. Similar procedure was repeated for rice. Yield determination prior to harvest was necessary because it is common for households to store their maize/rice without shelling/dehusking.

For onions, the determination of yield per hectare was straight forward as farmers sell their crop immediately after harvesting. Because of small onion farm sizes it was easy for the enumerator to verify them during data collection exercise.

2.4 Data Processing and Analysis

Data analysis was done using MS EXCEL 5.1 and SPSS/PC+ version 9.0. As pointed out in section 1.3 the following measures of project worth were calculated. These are gross margins (land and labour productivity), NPV, IRR and BCR. For NPV, IRR and BCR the discounting rates and time horizon are as specified in section 1.3, i.e., 10% and 20%, for discounting rates and 10 years for the time horizon.

For livestock production, total revenue was obtained by aggregating income from sales of fresh milk and culled animals. Live animals sold were mainly bulls and steers. Female animals were disposed mainly to meet social obligations like paying dowry. All these were valued at average market prices, which were assumed to reflect the opportunity cost.

Instead of investment analysis a slightly different approach in analysing livestock production was used. This was mainly attributed by data limitations. Projection of herd sizes and calculation of productivity indicators was used in livestock. Herd sizes were projected over the entire project period of 10 years. Farmers were asked to recall sizes and composition of their herds at the end of the year for the last three years (1998,1999, 2000). Coefficients used in herd projection were:

– Fertility rate of 90%
– Calf mortality of 20%,
– Adult mortality of 10%
– Calving rates of 45-55%

3. Results

3.1 Gross Margin Analysis

3.1.1 Maize

Table 3 shows results of gross margin analysis for maize in 'with' and 'without' RWH situations. The results show that the 'with' RWH situation covers all the variable costs of production and remains with a positive balance i.e. the gross margins per hectare and returns to labour are positive.

For maize, gross margins varied with location of the farm in irrigation canal. Farms located at the middle of the canals received the highest return to land (154,581 TShs/ha) followed by farms at the head (126,496 TShs/ha) and then by those at the tail end (51,854 TShs/ha) (Table 3).

Just like gross margin per hectare, return to labour followed similar pattern. Farms at the middle had the highest return to labour, followed by those located at the head and the tail. The average returns (3,713 TShs/day) to labour for the 'with' RWH is significantly higher than the opportunity cost of labour in the area ($p=0.00$, $n=30$). The 'without' RWH situation in maize yielded a negative returns to labour.

The results show that farmers at the middle had higher gross margins as compared to those at the head. These are unexpected results. The possible explanation for this is that farmers at the head may be experiencing fast moving runoff which cause erosion. At the middle the speed of water slows down and the water infiltrates easily into the soil.

In the study area of Makanya (WPLL) the situation without RWH in many case results into no grain yield. More than 70% of the respondents (without RWH) did not harvest anything. In the 'with' RWH situation the recorded average yield is 1.97 tonnes per hectare. Table 3 shows that the without RWH situation farmers were not able to cover their production costs, and their gross margins are negative. This implies that maize production without RWH in Makanya is not economically viable.

In summary a maize farmer without RWH makes a loss of over Tshs 50,000 per ha per season, and incurs a negative return to labour of 26 Tshs per day. On the other hand, on average the GM is increased by nearly 175,000 Tshs/ha as a result of RWH. The return to labour achieved with RWH is nearly four times the prevailing farm wages. Farms located at the head and middle of the system realised higher GMs than those at the tail end. This is an indication that either available water resources are not adequate, or there is inequity in the distribution of the harvested water. Water in these systems is a common pool resource (CPR) and is distributed from one farm to the next using crudely designed system of canals.

Table 3:
Gross margin analysis results[3]

ENTERPRISES		WITH RWH		WITHOUT RWH	
		Gross Margin TShs / ha	Return to labour TShs /person days	Gross margin Tshs /ha	Return to labour TShs /person days
MAIZE	Head	126,496	3,997	N/A	N/A
	Middle	154,581	4,139	N/A	N/A
	Tail	51,854	2,556	N/A	N/A
	Overall	121,069	3,713	-53,197	-26
PADDY		136,814	868	N/A	N/A
ONION		2,204,017	11,057	N/A	N/A

3.1.2 Rice

Gross margin analysis for paddy rice production in Maswa District (Bukangilija Village) shows positive average gross margin of TShs 138,814 per hectare. Returns to labour for rice came out to be TShs 868 per person-day. Returns to labour in rice production was lower than the opportunity cost of labour in the area. The results were however not significantly lower ($p = 0.05$, $n = 30$). About 13% of the farmers in Bukangilija obtained zero grain yields from their bunded basins (Majaluba). The main reason for this was failure to harvest enough rainwater to cover the whole growing period. For the 2000/2001 season, rainfall was low and many farmers did not harvest enough water for rice production. This consequently lowered the overall gross margins. However, the observed average yield of 2.1 tonnes per hectare is higher than the reported national average of 1.2 tonnes per hectare (URT, 2000).

3.1.3 Onion

Results of gross margin analysis for onion are TShs 2,204,017 per hectare and labour productivity of TShs 11,057 per person day. Again returns to labour from onion production is significantly higher than the opportunity cost of labour in the area ($p = 0.01$ $n = 35$). These returns are also higher than those of maize. Discussions with farmers showed that a decision to grow onions is mainly based on previous year's prices. These prices are determined by the supply/production in other areas, which are more, advantaged by availability of water, for example the northern highlands agro-ecological zone. The demand for the product also influences the prices.

3.2 Results of Investment Analysis

The investment analyses were performed for maize, rice and onion production and results are presented at Table 4. The Net Present Value (NPV)[4] for maize, paddy and

3 By the timer of this study average exchange rate was Tshs 850 to a US dollar.

4 Ideally, if a project has an IRR that is greater than the discount rate, then it must have NPV>0 and BCR>1 if the same discount rate is used. Therefore discussing using all the measures could have been necessary when we are ranking projects.

onion were positive. This indicates that present value of benefits exceeded the discounted present values of costs. Benefit costs ratios are all greater than one and IRR are greater than opportunity cost of capital (which are 10% and 20%). The IRR particularly on onion production are high. However similar results have also been recorded in West Africa (KUNZE, 2000).

These results imply that, investment in RWH for crop production is profitable in the long run as farmers can pay for investment and operational costs and yet attain profits.

Table 4:
Results of investment analysis

Enterprise	NPV (10%) (TShs)	NPV(20%)(TShs)	B:C ratio	IRR (%)
MAIZE	379 669	202 460.6	1.6	57
PADDY	20,623	7,549.	1.0	31
ONION	2,583,259	1 155 384	1.5	38

3.3 Sensitivity Analysis

The cost benefit analysis does not capture potential changes in factors that alter the profitability of enterprises (does not consider risks and uncertainties). NPV, IRR and BCR are subject to change with changes in market prices for inputs and outputs. To test whether our results are stable or unstable as a result of the above changes, sensitivity analysis is recommended. The main assumption is that one factor is changed at a time. The results of sensitivity analysis are presented in Tables 5, 6 and 7.

For maize production an increase in production costs by 20% all the measures of project worth still remains viable (Table 5). Likewise a twenty percent decrease in product price did not alter the viability of the measures of project worth. The results also suggest that maize production is more sensitive to changes in product prices than input prices. This may be expected, as use of variable inputs was low in the study areas. However, maize production remains viable when the suggested changes are made.

Table 5:
Results of Sensitivity analysis for maize

Scenarios	Performance indicators			
	NPV (10%)	NPV (20%)	B:C ratio	IRR (%)
Basic scenario	379, 669	202, 460	1.6	57
20% increase in costs	241, 419	103, 906	1.3	37
20% decrease in product price	165, 485	63, 413	1.3	33

For onion production similar results are obtained as in maize production (Table 6). The results suggest further that onion production is more sensitive to changes in

input prices than output prices contrary to maize production. Onions being high value crop complementary inputs such as fertilisers and pesticides are used, justifying the high sensitivity to changes in input prices. However, onion production under RWH remains profitable regardless of such changes.

Table 6:
Results of Sensitivity analysis for onion production

Scenarios	Performance indicators			
	NPV (10%)	NPV (20%)	B:C ratio	IRR (%)
Basic scenario	2, 583, 260	1, 155, 384	1.5	38
20% increase in costs	1, 454, 919	335, 703	1.1	25
20% decrease in product price	2, 272, 883	916, 084	1.3	34

Paddy rice production in Maswa District showed very high sensitivity to changes in prices of inputs and outputs. If input is increased and output decreased by more than 1 and 2 percent, respectively the project becomes not viable (Table 7). A number of reasons may be attributed to these results. Perhaps the most important reason is that yields used for making revenue projection were based on yields of year 2000/ 2001. In this season rainfall was inadequate and many farmers failed to harvest enough water for the season. Consequently this led to low yields.

Table 7:
Results of Sensitivity analysis for rice production

Scenarios	Performance indicators			
	NPV(10%)	NPV(20%)	B:C ratio	IRR (%)
Basic scenario	20, 623	7, 549	1.0	31
1 % increase in costs	4, 651	-7, 091	1.0	13
2% decrease in product price	1, 682	-5, 469	1.0	12

4. Discussion

This section presents discussion of the results of economic analysis of RWH for crop production in semi arid areas of Tanzania. Specifically the results have demonstrated that gross margins and returns to labour for the three selected crops (maize, paddy rice and onions) are positive. Therefore farmers are able to cover their variable costs and remain with a positive balance. Returns to labour for maize and onions are significantly higher as compared to the average opportunity cost of capital in the respective areas. Returns to labour for rice production using 'majaluba' system were lower than the going opportunity cost of labour. This may have been attributed by the labour intensive nature of paddy rice production. The 'with' RWH

situation in maize had higher returns to labour compared to the 'without' RWH situation. All these show that RWH is a viable and potential option in semi-arid areas of Tanzania.

With respect to investment analysis, all the crops have favourable measures of project worth (i.e. NPV are positive, IRR are greater than the opportunity cost of capital and BCR are greater than one). The measures of project worth are also comparable to those obtained elsewhere. Sensitivity analysis shows that when prices of inputs and outputs are changed by 20% the project remains viable with respect to onion and maize production. However, paddy rice was very sensitive to changes in both input and output prices. Slight changes in input and output prices by 2% alter the viability of the project.

Generally in Tanzania poverty is higher in areas with no dependable cash crop, a situation that is more common in semi-arid areas. However, as shown in this study, there are potential benefits that can be derived from application of RWH. Wider adoption of paddy rice and onion production, and other similar high valued crops will assist in poverty reduction. This together with the improved maize yields under RWH can considerably improve food security in semi-arid areas. But as noted earlier, area under crop production applying RWH need to be increased to provide the desired benefits. However, it is important to note that RWH alone may not be a solution to poverty reduction if other complementary inputs, markets and infrastructure are not in place.

Further research is required in the economic analysis of RWH on specific techniques, evaluating their performance and the overall impacts they have on households, community levels and to higher levels such as, catchment, basin and national. The impacts of RWH at the household level need to be evaluated further. For example there is a need for assessing the impact of RWH on the following:

– Labour requirements in various seasons,
– RWH on household food security,
– RWH on incomes of the household and
– Changes in household income distribution as a result of RWH.

There is therefore a need for in-depth further work on economics of RWH techniques and their effects on households, community levels and higher levels.

The approach of categorising farms into head, middle and tail need further in depth study to investigate equity issues in the distribution of resources particularly water. RWH depends on slope differentials in water flow. The longer the distance between steep and gentle slope area, the more the need for consideration of equity issues. Water as a common pool resource in the area, which depends among other things on compliance among members requires an in depth analysis with respect to equity.

The findings from the economic study have shown that high value crops such as onions bring a lot of benefit from RWH. However, the effects of markets and marketing systems on the potential for successful enterprises in different areas are not well understood. It is proposed that further research is needed to investigate in more details marketing potential and linkages and therefore assess economic potential for alternative enterprises for areas identified with a RWH potential. In addition marketing potential for other high valued crops that can benefit from RWH needs to be investigated and recommended. Studies related to the determinants of supply of these high valued crops need to be undertaken. The present study showed that farmers are highly responsive to previous year's price when making production decisions of high valued crops like onion. Thus there is a need for understanding the supply response of these high valued crops. Recommendations such as value adding/ processing may emanate from such studies.

5. Conclusions

Based on the existing potential for RWH and the profitability of the crops, it is concluded that RWH should be prioritised in Tanzania, particularly in the semi-arid areas, because it has a potential for poverty reduction and minimising food security problems. The increase in GM and return to labour and the favourable performance of investment indicators show that there is an improvement in the means of livelihood, as a result of RWH.

Improvement of the existing RWH techniques, which are already practised will be of great advantages to the farmers and can also promote wide adaptability. However, issues related to farm sizes need to be looked into. This may necessitate application of various techniques that can allow expansion of farms. Development projects to extend the most viable techniques of RWH are one way of increasing the areas under RWH.

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