LINKING RAINFALL VARIABILITY AND PRODUCTION DECISIONS IN SEMI-ARID TANZANIA

[1]Hella, J. P[1].; [2]Vah Huylenbroeck; G., [2]Haese, L. D and [1]Mlambiti M. E.
[1]Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture, P. O. Box 3007 Morogroro Tanzania.
[2]Department of Agricultural Economics, University of Gent, Coupure Links 653, B-9000 Gent Belgium.

ABSTRACT

Rain-fed agriculture in Semi-Arid Tropics (SAT) varies from one year to another depending on the number of rainfall attributes. Thus, in most cases successful production depends on farmers' ability to make multiple decisions on key production variables, which sometimes have multiple dependent attributes. This paper uses cross-sectional data collected from selected villages in Dodoma region to established the linkage between rainfall variability and production decisions from both economic and environmental point of view. The need for household food security and cash income was found to be more signification on decision behaviour although they were not continuous over time. Further, the result revealed that, production and consumption decisions vary between farms, farmers and seasons depending on social and economic situation of the decision-makers.

***KEY WORDS**: Semi-arid, rainfall, farming systems, farmer's behaviour and coping strategies*

INTRODUCTION

Semi-arid zones occupy about one third (295,000 km^2) of the total area of Tanzania extending between North East and SouthWest across the central part of the country. This zone covering; Dodoma, Singida, part of Arusha, Kilimanjaro, Shinyanga, Mbeya and Tabora regions; is a home of close to 10 million Tanzanians and more than half of livestock population. The zone is characterised by low and unstable crop and livestock yield due harsh climate (Ngana, 1993; SWMP, 1995), declining soil fertility due to erosion (Shishira and Payton 1996 and Mung'ongo, 1996), and poor farming practices (Wilson *et. al.*, 1998). Ever growing demand for food, fuel and fodder both by human and livestock populations, coupled with poor and highly variable rainfall and deteriorating economic condition, the availability of food and other necessities to resource poor farmers in this zone, is always a problem. As a result, annually farmers are forced to make complex production decisions that integrate a large amount of factual information - economic, strategic, social, and environmental - with the value judgements, public opinions and policy management goals.

Many of the previous studies in this zone reflected that central to many types or combination of decisions made by farmers' hinges on rainfall characteristics. In this zone, rainfall is not only low but also of high variability. The onset of the rain can be a problem as the rain can come either too early or too late. Duration of rain season as well as the possibility of mid-season devastating drought is not known to farmers. The consequence of the above constraints is high frequencies of crop and livestock production failure, and waste of agricultural inputs. Studies in other countries in the developing World indicate that, in such uncertain climate in the realm of unpredictable and traditional socio-economic and cultural environment, farmers have adopted a number of emeriorating measures either through tolerance, escape or both which can at least guarantee their survival (Scoones, 1996 and Cossins 1983).

So far, several scientific research works in areas of breeding and husbandry (agronomy) practices of crop and livestock which are adaptable to semi-arid climate of Tanzania have been conducted (Various research reports from Mpwapwa and Hombolo Research stations). Some of these works are dated in the 1940s. However, recent evidence particularly in Dodoma regions, indicate that production strategies - in this context are referred to as decisions - which were in use three or four decades ago are still practised in the region. From these findings, two scenarios emerges; first, little work has been devoted towards understanding behaviour of farmers from economic and socio-cultural point of view with regard to production decisions in variable climatic environment. Secondly, is lack of empirical evidence to explain why farmers do what they do to cope with climate in particular rainfall variability.

It is within this background that this study which has tried to establish a link between rainfall variability and inherent characteristics of farmers in production decision was conducted.

When farmers embark on any production ventures, they are uncertain on what the actual outcome will be. According to (Ellis, 1988) uncertainty in agriculture has three main causes; (a) environmental variation causing production and yields uncertainty, (b) price variation causing price and market uncertainty, and (c) lack of information. All these have significant effect in African agriculture.

Two models explain the attitude towards risk and hence decision making; safety first (Lexicographic utility) (LU) model and expected utility model (EUM). According to Lindon et al. (1984), the EUM provides a single valued index that orders action choices according to preferences or attitudes of the farmer. Examples of this model includes MINIMAX choice (i.e. maximize the minimum or worst possible outcome) and MAXIMIN mixed strategy (i.e. best of the worst outcomes). This model entail that decisions can be ranked according to their level of expected utility with highest value being more preferred;

$$\text{Max } EU(x) = \Sigma(x_{ij})\, P(s_i) \quad j = 1, 2, ---- , n$$

Where EU = Expected utility
X_{ij} = set of outcomes
i = i^{th} set of nature
j = j^{th} action choice

The objective of the EU approach is either minimizing the variations of returns, maximize the minimum return or both.

On the other hand LU model entail sequential ordering of multiple goals. The highest priority goal must be achieved at a threshhold level before considering the second goal and so on. This means that, attaining a highest priority goal serves as a constraint with successive lower priority.

LU is expressed as;
$U = f(y_1, y_2, y_3, - - - , y_n)$
Where y = sequencial goals

In relation to the characteristics of smallholder farms in semi-arid area EU model is probably more applicable than the latter. In semi-arid climates where household food security precludes all household goals and objectives, safety first (EUM) seem to govern adoption and production decisions in farming. Lindon et. al., (1994) identified three types of safety rules;

- ***First Safety Rule*** (SR1) which assume that a desicion maker maximizes expected return subject to contraints that the probability of a return (E°) less than or equal to a specified amount (E-min) which does not exceed a stipulated probability (P)

Max. E°
Sto. $P(E \geq E\text{-min}) < P$

- ***Second Safety Rule*** (SR2) chooses a plan that maximizes income at the lower confidence limit (L) subject to constraints that the probability of income being less than or equal to the lower limit does not exceed a specified value P.

Max. L
Sto. $P(E < L) < P$

- ***Third safety rule*** (SR3) chooses the plan with the smallest probability of yielding a return below some specified level;

Min. $P(E < E - \text{min})$

In line to these rules, other conceptual reviews on smallholder decision making and risk management have been presented in Skerratt and Dent (1994); Dixon et. al., (1989) and Barry and Baker (1984). Most of these have presented risk perception with some Neo-classical approaches that view farmers as having profit maximization objectives. There works were follow-up of earlier works by Schultz (1964) and Hopper (1966). However it should be noted that, production decisions in semi-arid climate does not comply with Shultzian hypothesis with argument that, even if farmers are income maximisers, the high degree of uncertainty attending agricultural production make it impossible for them to identify optimal resource allocation - except by chance.

That is because of high rainfall variance there is not a unique Marginal Physical Product (MPPs) and because of high product and factor variance there is not a unique marginal value products (MVP). With only a probability distribution of MPPs and MVPs, farmers resource allocation becomes indeterminate; so does the locus of optimality. With this respect Lipton (1968) and later Ellis (1988) argued that, small farmers, instead of maximising profits or minimising costs, are maximising utility.

Other reasons which explain why concept of profit maximisation cannot be realised in semi-arid production decisions is based on survival algorithm presented in Hella, *et al.* (1999) and Hull *et al.* (1979). Generally both argued that, things other than search for profit motivate farm families. The authors concluded that farmers have to accept environmental constraints on their decision making behaviour which reduce profits and that, over long period, farmers do not necessarily learn to carry out the best practices. Also Clayton (1993) asserted that in semi-arid climate, high variance of rainfall and yields are major influences on farmers decision behaviour and, as a consequence, risk aversion or 'the quest for security' is their dominant objective. Variance and consequently risk, is so high that a profit maximising strategy lead, in short run, to disaster and death for those who practice it. For survival, therefore, they must pursue a lower than mean, lower variance strategy which increases security. Hence in pursuing their survival strategy, the farmers operates a group of practices and decisions for allocating farm resources, which allows them operate just at tolerable levels of profit, security and status so that it can allow them to muddle through in good years and bad years alike.

METHODOLOGY

Location and Description of the Study Area

The study was conducted in Dodoma region. The region lying between latitude 4°49' and 7°00' South and 35°55' and 36°56' longitude East, has a total area of 41,311 km^2. Much of the region is plateau raising gradually from some 830 m. above sea level in Bahi swamps to 2,000 m. above sea level in the highlands North of Kondoa.

Based on 1988 population census, the region's population is estimated to be 1,640,000 of which at least 90% depend mainly on agriculture.

Climate of Dodoma region may be described as semi-arid highland climate in which there is a distinct rainy season of 5 months (December - April) and 7 dry months (May - November) and evaporation exceeds rainfall every month. Average seasonal rainfall for the region is 580-690 mm. Sorghum, pearl-millet, groundnut, bambaranuts, cowpeas and pigeonpeas are major crops grown in the region, but where rainfall is high and reliable, maize, sunflower, beans, and castor are grown. Tomato and paddy production is increasingly becoming important crops in valley bottoms and flood plains. Livestock keeping (mainly cattle) is also an important practice in the region. Other types of livestock kept include; goats, sheep, donkey, chickens, ducks, guinea fowl, and pigs particularly in urban areas. According to the most recent National sample census of livestock conducted in 1994/95 the region's cattle population stand at 1,600,000 (Ashimogo *et. al*.,1998). Data for this study was collected in Mvumi makulu and Chalinze villages in Dodoma rural district. Agro-pastoral Gogo is the main tribe in the village.

Sampling and Sample Size

Respondents were randomly selected from the list of villagers stratified in two groups based on wealth. Finally 60 farmers[1] were interviewed for obtaining primary data. Due to low variability between farmers, the sample size of 60 was thought to represent the population of smallholder farmers in semi-arid area.

Data Collection and Analysis

[1] Two farmers did not appear for the interview.

Single visit structured questionnaire was the principal instrument in collecting most primary data which used in this study. Use of checklists, especially for clarification in case of doubtful information, was directed to key informants' e.g. Village Extension Officer, Village elders, etc.

Qualitative assessments and descriptive statistics were widely employed in the exploratory or preliminary analysis of survey data. This includes the estimation of means, and standard deviations of some critical variables of the study. Variable categorisation and mean difference significance tests were conducted on a number of respondent socio-economic variables with respect to various production decisions undertaken by farmers. The fact that production decisions are subject to a number of independent socio-cultural-economic and environmental variables, multivariate analytical method of the form specified below, was used.

RESULTS AND DISCUSSION

Demographic Characteristics of the Respondents

Of the 58 people interviewed in the village, 25.0% were females and 75,0% were males. The youngest respondent was aged 22 years and the oldest was 70 years old, giving an average of 40.2 years. About (75.0%)[2] of the respondents can read and write. Only 37.2% did not attend formal education. 14.3% have attended adult education. Highest literacy rate was recorded at Mvumi than Chalinze village. Such level of education is considered to be lower than the National average.

Total members in the household varied extensively from one household to another. Average family size was 7.03 with range between 2 and 18 indicating slightly higher than the national average of 5.8 (Population census, 1988). Analysis of household members is presented in Table 1.

Table 1: Selected household characteristics in study area

Variable description	Minimum	Mean	Maximum
Number of wives	1.00	1.24	3.00
No. working in household farm	1.00	2.50	7.00
Number of fields	1.00	2.91	5.00
Total family size	2.00	7.03	18.00
Total land owned	1.50	7.31	30.00
Total fallow land	0.50	2.75	6.00

Source: Survey results, 2000

Economic Activities of the Respondents

Almost all adults who are not hindered by physical disabilities work full time on the farm. In Dodoma region, on average, about 20.7% of the household members are fully engaged in farming and 48.3% occasionally work in the household's farms. About 12.1% work off-farm (migration) and 6.9 are not economically active i.e. are either too old or too young to work. This distribution suggests that labour constraints at the household level, which is further, reflected in production behaviour to be explained later.

[2] Include those who attended Adult education classes

The climate, soil conditions and village proximity to town centres or major roads affect economic activities in the study region, to some extent. Farming, livestock keeping, carpentry, petty trading, craft works and regular employment are the main economic activities identified. Of these activities, agriculture is the main occupation for majority of the respondents. The main agricultural activity is the production of food crops. Important crops grown in the region include sorghum, maize, pearl-millets, sweet potatoes, sunflowers, simsim, bambara-nuts, and various types of vegetables. Closer look at the crops in study village reveals a substantial concentration on food crops mainly maize, pearl-millets and sorghum.

Livestock, mainly cattle, goats, sheep and chickens are important in the farmers' household especially in Chalinze village. Mvumi village was forced to adopt zero grazing since early 1980s, following severe land degradation manifested by deep gully erosion caused by over-stocking of grazing livestock.

Rainfall Characteristics

In the rainfed agricultural production systems, climatic constraints in general and rainfall in particular, present a most limiting factor in crop production and hence land productivity (Sutherland *et. al.*, 1991; Pathak *et. al.*, 1987). The situation is more serious in semi-arid tropics. Rainfall attributes like; limited total precipitation, short unimodal rain season, high inter-seasonal variability (Table 2. Figure 1 relates rainfall distribution with selected husbandry practices in Dodoma region.

Table 2: Coefficient of Variability %(CV) for selected stations in semi-arid Tanzania

	Rainy months								
Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Apr.	May	Season
Dodoma	309	186	57	60	60	57	93	192	26
Farkwa	261	123	59	54	55	55	71	104	23
Manyoni	219	130	62	50	41	60	83	87	26
Singida	267	121	61	50	50	58	96	142	30
Nzega	116	75	47	48	46	43	57	125	24
Lubaga	124	82	46	48	55	50	48	112	24
Maswa	102	78	46	55	53	47	47	83	24
Kondoa	200	93	66	60	77	61	148	99	27

Source: Ngana, 1996

As far as agricultural production is concerned, limited total precipitation poses little decision problems to farmers, but, when manifested with high rainfall variability leads to one of the most pervasived challenges in development efforts in the semi-arid areas. Rainfall variability determine what, how and when to plant, type of animal and crop combination to plant. Number of plots and plot allocation to adopts. All these decisions have far reaching social and economic consequences.

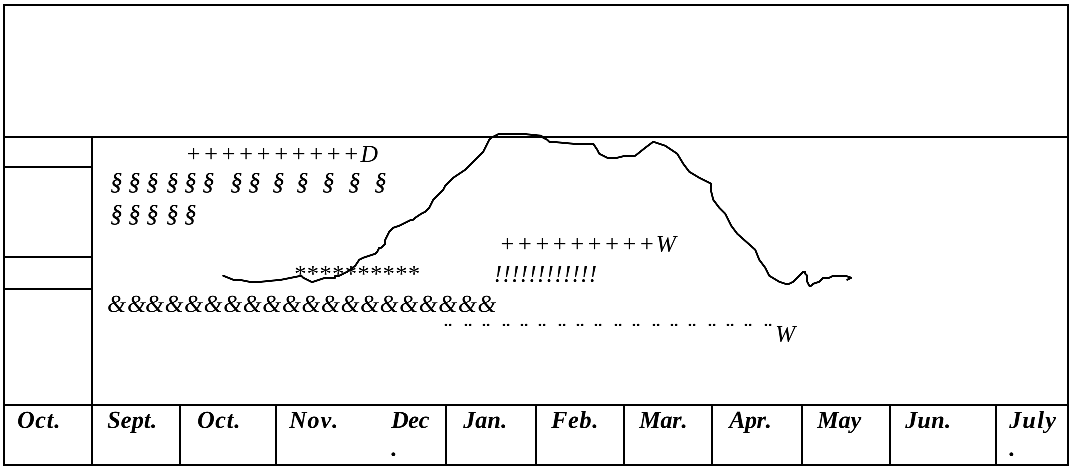

Figure 1: Production decision in relation to rainfall distribution in Dodoma region

Legends

+ + + + + + + + + + +	*Land preparation wet (w) and dry (d)*
************	*Planting sorghum/millets dry (D)*
!!!!!!!!!!!!!!!!!	*Gap filling*
¨ ¨ ¨ ¨ ¨ ¨ ¨ ¨	*Weeding for all crops*
&&&&&&&&	*Harvesting*
§ § § § § § §	*Dry season, severe shortage of pasture*

Types of Production Decision in Sem-Arid Climate

Relationship between smallholder farming activities and the environment in semi-arid area is well documented (Christiansson, 1996; Lindberg, 1996; and Hella, 1997). Also a large body of literature exist in the field of risk perception in decision making process both at theoretical and empiriacal levels in the developing countries (McHenry, 1994; Schoorlemmer et. al., 1994; Hassan, 1996; 1994 and Webber, 1994).

Types of decisions have been classified by different scholars (Matlon, 1991) and Rowland, 1993 and Hull et. al., 1979). So far levels categories are evident; first based on time of application. According to Scoones (1996) these include; Ex-ante methods (intended to place the household at a less vulnerable position before the occurrence of the shock), Interactive methods (involve the re-allocation of resources at a time when a shock occurs with the objective of minimising its ultimate impacts); and Ex-post methods (which involve actions taken after the shock has already reduced production (minimisation of the current impact in consumption). Secondly is based on the levels of operation. The level of operation involves application of management decisions at several levels of operation (Multistage decision-making). For instance at plant, plot, farm, household, village and at regional levels. A Summary of types of, reasons for and subsequent outcome is presented in Appendix 1

Ex-ante Decision Making at Plant, Plot and Farm Level

Different crops and varieties of the same crops differ with regard to crop tolerance to varying moisture stress. As a result farmers adopt different cropping enterprises across dispersed plot areas as well as mixture of different crops on the same plot.

Table 3 present crop and plot variation per household. Results show more that 75% of the respondent own more that three plots. Likewise, atleast 4 different crops are planted per plot. Evidences in semi-arid areas indicate that, agricuture has important spatial dimension with respect to slope and space. Different possibilities are realised with respect to contrasting micro-agroecologies, upland/lowland fields, dry plot/riverbank, main/gardens plots, and at field levels with variation in soil type, topography, water flow dynamics, home and outfield, and wet and dry fields. As such, in the region farming is carried out in a variety of niches at different spatial scale. Analysis of plot positions has indicated that farmers have three main plots namely; backyard plots, upland and valley bottom (mbuga) plots. Early maturing crops/varieties are planed at backyard plots and mbuga plots are meant for security reasons particularly in extremely dry years.

Further, survey results have revealed that farmers apply different management strategies across different plots. There is high correlation between rate of manure application and the distance from farmers' house. In the surveyed villages more that 70% of the respondents planted high value crop like maize on plots with exceptionally good soils than otherwise.

Table 3: Crop allocation priority in Dodoma region

Type of crop	Primary crop in plot 1 (n=58)	Primary crop in plot 2 (n=52)	Primary crop in plot 3 (n=41)	Primary crop in plot 4 (n=12)	Primary crop in plot 5 (n=2)
Maize	51.8	40.4	7.3	25.0	-
Sorghum	41.1	25.0	19.5	8.3	50.0
Pearl-millets	5.4	11.5	17.1	16.7	50.0
Beans	-	-	4.9	-	-
Cassava	-	1.9	2.4	-	-
Groundnuts	1.8	15.4	39.0	33.3	-
Sunflower	-	-	4.9	16.7	-
Bambara nuts	-	-	4.9	-	-
Paddy	-	5.2	-	-	-
Others	-	-	-	-	-
Total	100.0	100.0	100.0	100.0	100.0

Source: Survey results, 2000

Livestock play an important role in supporting the farm household. Livestock contribute a large proportion of income through sale of live animals, by-products, and they provide valuable dietary contributions to household. It is argued that risk inflates the incentives to invest and since animal are the only assets, herders are forced to maintain more than the profit maximization number in oder to ensure that they remain viable after the disaster (Stewart, 1991). Risk aversion, therefore, encourage overstocking not prestige as always contended. Other management decisions reported by farmers include; keeping different types of livestock enterprises across dispersed areas, keeping different livestock on same area, mobility i.e. longer and novel migration looking for pastures, communal grazing ground, and skew sales i.e. withhold stock in good years and sale -off stock in bad years.

Survey results in Dodoma region indicate that farmers keep different type of livestock. Type of livestock kept in decreasing order include; chickens, ducks, cattle, sheep and goats, and pigs. Currently attempt to domesticate wild guinea fowl has resulted into considerable success. In general, decision on mult-species ownership act as a response to probability of drought and disease for exploiting the often-mixed grassland shrub-land and wood. Grassland management decision include use of fire to control bush, stimulate the regrowth of grass or to control ticks. Average number livestock household is presented in Table 4.

Table 4: Proportion of respondents by type of livestock kept.

Type	Mean	Minimum	Maximum
Pigs (n=11)	1.64	1	3
Sheep and goats (n=12)	4.25	1	11
Cattle (n=10)	4.66	1	45
Guinea fowl (n=7)	5.50	2	9
Ducks (n=6)	6.00	1	20
Chickens (n=43)	9.40	1	25

Survey results, 2000

Holding larger than profitable livestock number has been recorded as one of the most important production decision in semi-arid areas. In Mvumi division for example, prior to 1984, livestock population was greater that the natural carrying capacity of the land. The result was severe land degradation that made the Government to enact the by-law that discouraged grazing livestock in the division. When asked about the suitability of zero to extensive grazing, farmers indicated that zero grazing system is both difficult and uneconomical especially during dry season when there is acute shortage of both water and fodder. Communal grazing land seem to be the best management decision in semi-arid area because of high variability and unreliability of rainfall, thus planned rotational grazing is not feasible. It pays for livestock keepers to have access to as large area as possible. Figure 2 present smallholder livestock sale behaviour in Dodoma region. Evidence (also see Ashimogo, et al., 1998) indicate sale of livestock usually concide with a period where there is no food in the household. Skewed sale behaviour is one of the most important decision in semi-arid climate where livestock are kept for insurance against unknown future drought.

Sequential decision making at the beginning of the cropping season

At the beginning of each growing season farmers have subjective expectations developed from the past experience concerning; the probable onset, amount, and distribution of rains; the possibilities of pest and disease attack; and the possibilities of inadequate labour at the key points in the cropping cycle. As the season progresses, the expectations indicated above are revised and farmer sequentially adjust their cropping patterns and cultivation practices to correspond to the occurrence of exogenous shocks (Scones *et. al.*, 1996). Considering these two aspects together there are number of decisions which are made as risk management strategies. Depending on the production cycle the decisions includes; time and methods of land preparation, planting time, decision on plant population, and variety.

Initial land clearing which may include removal of crop residues, cutting regenerated tree stumps (in case of fallow fields and opening virgin land) and breaking up of the soil ready for planting. In semi-arid tropics, seedbeds that will minimise runoff and conserve moisture are mostly recommended. Flat, sunken, mould, and ridges are widely used in semi-arid tropics based on type of crop to be planted, availability of labour, slope percent and soil type

(Wiggins, 1995). Evidence from survey results indicates that shortage of labour, poor equipment and hardness of soil (since land preparation has to be done before the onset of rain season) force farmers to prepare flat seedbed. In most cases land preparation is limited to removal of grasses (*kuberega*) and burns any remaining crop residue or grasses. Other methods of land preparation like ridges, moulds and sunken beds are used but to specific crops and time of land preparation (Table 5).

Table 5: Methods of land preparation for arable cropping in the surveyed villages.

Method	Type of crops	Time of preparation	Percent of the farm
Remove grasses and burn (kuberega)	Maize, sorghum, pearl-millets, beans, sunflower	Before the onset of rains	80
Flat bed	Groundnuts, bambara-nuts,	After the onset of first rains	10
Ridges	Sweet potatoes,	mid-rain season	6
Sunken beds	Paddy, vegetables e.g. tomato,	Wet season in mbuga soils, dry season under irrigation	2
Deep trenches	Vineyards, Banana	After the onset of rains	1
Moulds	Cassava	After the onset of rains	1

Source: Survey results, 2000

Minimum (zero) tillage (*kuberega*) is commonly practised in surveyed villages primarily because farmers have no means to break hard soils when it is dry. For them waiting until after the first rain means delayed planting which can lead to a very significant yield decline.

Decision on planting

Crop establishment is a particularly high-risk operation for subsistence farmer who annually lack the resources for speedy cultivation and planting. Delay in planting carry risk of adverse effects on later stages of growth and development of the crop. Some of the decision management recorded in the study are presented in Table 6.

Table 6: Common management decisions on crop establishment

Planting decision	Influencing factors
Dry planting (ploughing before rains)	Prepare land before rain season
Dry planting (without ploughing)	• Existence of hard pan for deeper cultivation. • Shortage of modern equipment
Making planting hole with a hoe before the rain and planting after	– Utilising idle labour, – Maximise rain season – Allowance for replanting
Planting immediately after the first adequate rains	– Availability of plenty labour
Decrease hill density (plant population)	Minimising competition for water
Increase hill depth	Rain water harvesting
Increase seed density per hill. Allowance for thinning and transplant (in case of good rain) or reduce plant population in case of bad year.	Increase chance of germination on every hill
Staggered planting (Hassan, 1996)	Avoid possible mid season drought
Choice of varieties and crops type	– Resistant drought of known origin (local) – Sorghum and millets for food security – Maize for income sale
Planting larger that the area which would be weeded	Maximise return in good years

Source: Survey results, 2000

CONCLUSION AND RECOMMENDATION

The goal of the study was to improve the understanding of the rationale underlying production decisions by smallholder farmers in semi-arid Tanzania. The study showed that production decision in this zone is aimed at minimising variance of return from both agricultural and non-farm activities point of view. Most decision described above entails the reasons why farmers do what they do, sometimes contrary to the recommendations put forward by the Ministry of Agriculture. Decisions related to intercropping, mixed cropping, shifting cultivation, variety/crop combination and so on, are determined to; 1) suit a particular situation or a rage of conditions, 2) alleviate a particular limitation of resources, 3) suit the size of their enterprises, 4) suit their level of technologies (e.g. hand hoes), and 4) market opportunities.

This understanding, therefore, has increased our understanding on the rationale of various production decisions and farming systems before embarking on any sets of recommendations based on prior criteria. With this understanding, Socio-economic policies of the country as well as the environmental and trade policies must be modified to make sure that options are acceptable for local recipients.

REFERENCES

Ashimogo, C. G.; S.M. Nnko, L. Mtenga, G. Maeda (1998) Feasibility study for Construction and management of a Modern Abattoir in Dodoma Municipality, A final Report, MoAC. Dar es salaam-Tanzania.

Barry, P. J; and C. B. Baker (1984). Financial Responses to Risk in Agriculture. *In* Risk Management in Agriculture - Descriptive approach; Proceedings of 38th AEEA conference Denmark, 183-9.

Christiansson, C.; and I.S. Kikula (1996) (eds) *Changing Environments: Research on Man-Land Interraction in Semi-arid Tanzania* RSCU Serial No. 13; Nairobi

Clayton, E.(1993). *Agriculture, Poverty and Freedom in developing* Countries Macmillan London

Cossins, N. (1993) Production strategies and Pastrol man: Pastrol systems in Sub-Saharan Africa, Proceedings of the Workshop held at ILCA 21-24 March, 1993. Addis Ababa

Dixon, J. A.; D. E. James; P.B. Sherman (1989) *The Economics of Dryland Management*. Earthscan publications, London

Ellis, F. (1988). *Peasant Economics: Farm households and agrarian development*; Cambridge University, London.

Hassan R. M. (1996) Planting Strategies of Maize Farmers in Kenya: a simultaneous equation analysis in the presence of discrete dependent variables. Journal of Agricultural Economics 15 (1996) p137-149

Hall, A.E.; K.W. Foster and J. G. Wainer. (1979). Crop Adoption to Semi-Arid Environments In *Agriculture in Semi-Arid Environments*, Hall, A.E.; Cannell, G.H.; Lawton, H.W (Eds.) p148-173

Hella, J.P. (1997). The problems of Three Ps (population, poverty and government policies) in promoting environmental conservation programs. RE working paper, SUA Morogoro.

Hella, J. P.; G. Van Huylenbroeck, L. D'haese and G. C. Ashimogo (1999): Multicriteria Nature of Decision Making In Smallholder Farming Systems in Semi-arid Tanzania. A paper presented to the 2nd International Conference MODSS'99, Brisbane Australia. 1-6 August, 1999.

Hopper, D. W. (1966). Allocation Efficiency in Traditional Indian Agriculture, *Journal of Farm Economics*, Vol. 47 No 3.

Lindberg, C. (1996). A Case Study on the Relationship Between Poverty and Land Degradation in Babati District Tanzania. *In* Changing Environment: Research on man-land interrelations in semi-arid Tanzania. RSCU Serial No. 13; Nairobi 121-131

Lindon, J.R; P.J.Barry. J.B. Kliebenstein and G.F. Patrick (1984). Risk Altitudes: Concepts and measurement approach. *In* Risk management in agriculture, Iowa State University, USA. 11-30

Lipton, M. (1968) The Theory of Optimizing Peasants. *Journal of development Studie.* Vol. 56. No. 2.

.

Malton, P.J. (1991) Farmers Risk Management Strategies: The case on West African Semi-aridtropics In *Risk in Agriculture*; Proceedings of the 10th Agricultural sector symposium, Holden, D.; P. Hazell; & A. Pritchard (eds), World Bank, Washington DC.

McHenry, H. (1994). Understanding the Scottish Hill Farmers Decision-Making With Regard to Environmental Schemes. *In* Risk Management in Agriculture - Descriptive approach; Proceedings of 38th AEEA conference Denmark,

Mortimore, M (1989) *Adapting to Drought: farmers, farmine and desertification in West Africa,* Cambridge University press, NY.

Ngana, J. O. (1993). Rainfall Charactristics and Their Relevance to Agricultural Planning in semi-arid Tanzania. Proceedings of Planning workshop, SWMP, 13-15th January 1993. SUA Morogoro.

Rowland, J.R.J (1993) (eds.) *Dryland Farming in Africa*, J.R.J. Rowland, Macmillan p336

Sconnes, I. C.; C. chibudu; S. Chikura; P. Jeranyama; D. Machaka; W. Machanja; B. Mavedzenge; B. Monboshora; M. Mudhara; C. Muziwa; F. Murimbarimba and B. Zirereza (1996). *Hazards and Opportunities: Farming livelihoods in drylands Africa, Lessons from Zimbabwe*; Zed Book LTD, London

Sunderland, Bryan and Wijendes, (1991) ; Analysis of the monthly and annual rainfall climate in a semi-arid environment, kenya. Journal of Arid Environment (20) p257-75

Sanders, J.H.; B.I. Shapiro and R. Ramaswamy (1996). The Economics of Agricultural Technology in Semi-arid Sub Saharan Africa. John Hopkins University, London;

Schoorlemmer, H.B.; de Buck, A.J. and G.A.A. Wossink (1994). Risk and Risk Perception in the Convention to Sustainable Production Methods in Arable Farming; *In* Risk Management in Agriculture - Descriptive approach; Proceedings of 38th AEEA conference Denmark, 191-202

Schultz (1964). *Transforming Traditional Agriculture*, Yale University Press, NY.

Shishira, E. K. and T. W. Payton (1996) The Causes and Effect of Accelerated Soil erosion and Sedimentation in Kondoa Eroded Area: evidence from the Lake Haubi Basin Kondoa district. *In* Christiansson, C.; and I.S. Kikula (1996) (Eds) *Changing Environments: Research on Man-Land Interraction in Semi-arid Tanzania* RSCU Serial No. 13; Nairobi

Soil and Water Management Project (SWMP) (1995) Final Report. Sokoine University of Agriculture, Morogoro – Tanzania

Stewart, J. I. (1991) Managing Climatic Risks in Agriculture. In *Risk in Agriculture*; Proceedings of the 10th Agricultural sector symposium, Holden, D.; P. Hazell; & A. Pritchard (eds), World Bank, Washington DC. p17-37

United Republic of Tanzania (URT) (1988). Population Census: The preliminary findings, Bureau of Statistics Dar es Salaam.

Webber, E.U. (1994). Production and Pricing Decisions in Cash-crop Farming: Effects of decision traits and climate change expectation in farmers' decision making. *In* Risk Management in Agriculture - Descriptive approach; Proceedings of 38th AEEA conference Denmark, 203-218

Wiggins, T.A. (1995) The effect of seedbed design on sorghum production in Arid environment, Journal of Arid Environments, 29 (1995) p317-324

Wilson, K.S.L.; A.M. Julian; A. Mbwaga and J.P. Hella (1997). Significance and Management of Sorghum Diseases in Smallholder Farming Systems in Dodoma Region Tanzania. Natural Resource Institute, UK