

# Options for Up-Scaling Technology Adoption by Smallholder Farmers for Food Security through Irish Potato Production in Rungwe District, Tanzania

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**Abstract**—This study was conducted to determine the existing and feasible options for adoption of technologies that are involved or to be involved in Irish potato (*Solanum tuberosum* L.) production with the focus on Nzunda, Ntokela and Ndaga villages in Rungwe District. This was prompted by the unreliable production systems and the low life standards of the smallholders in the district. One-point-in-time purposive survey was conducted using structured questionnaires and physical observations where 45 households were studied. The results also indicated that the effect of socio-economic and institutional factors were significant ( $LSD_{0.05} = 1.8$ ) in determining Irish potato production in Ntokela village. In addition, the effect of institutional and socio-psychological and land tenure factors were significant ( $LSD_{0.05} = 6.6$ ) for Irish potato production in Nzunda village. However, none of these factors were significant ( $LSD_{0.05} = 32.9$ ) in Ndaga village. Results indicated that Irish potato produced was positively correlated with the farmer's capital and/or access to credits ( $r = 0.700$ ), farming experience ( $r = 0.225$ ), extension services to impart awareness ( $r = 0.698$ ), contribution of innovations ( $r = 0.771$ ), sex-female ( $r = 0.96$ ), and innovative agricultural inputs such as seeds, fertilizers, herbicides, pesticides, and fungicides ( $r = 0.525$ ). Female household head were mostly favoured by adoption of technologies in Irish potato production. These were the factors identified to be pertinent in adoption of Irish potato production technologies for Irish potato production in Rungwe district.

**Keywords**—Adoptions, Food Security, Innovations.

## I. INTRODUCTION

### 1.1 Background of the Study

Agricultural production and food security depends largely on the innovations, technological development and their [www.ijaems.com](http://www.ijaems.com)

adoptions to stabilize short fallows along food chains thereby improving society's standards of life. Agricultural activities, livestock keeping, reforestation, and fishery constitute the socio-economic settings of major smallholders of the developing countries, in which Tanzania is also included [1]. These activities co-jointly aim at food production, income generation and maintaining a biodiversity base in a certain ecological niche.

Agricultural activities have been the major sources of food for most smallholder farmers in Tanzania producing for subsistence, which however, do not meet their food security needs [2]. Efforts invested in production of food crops such as grains (cereals and legumes), tubers (potatoes, cassava and yams), and horticultural crops have been inevitable in most parts of the country [3].

Agriculture is the mainstay of Tanzania's economy, which witnesses its role in food production and security, employment, and export earnings. Agriculture accounts for 50% of Gross Net Product (GNP) and 66% of the total export earnings [4]. According to Nyunza and Mwakaje [3], more than 70% of Tanzania's population depends on subsistence agriculture, which signals that agriculture is inevitably the backbone of the country. The government's report of 2009 indicated however that, employment of personnel in agriculture sector declined from 60% in 2000/01 to 50% in 2007 [5]. This was attributed to the low production levels of food and cash crops because of erratic climatic conditions and the slow pace of technological innovations and adoptions [1].

Irish potato is a sub-staple food crop, which its production and consumption is rapidly increasing in Tanzania [1]. Irish potato is one of the world's most traded food crop produced by smallholder farmers who have remained poor despite of their high engagements in agricultural activities [2]. In rural Tanzania, staple food crops are maize and rice but the

consumption of Irish potato is very high in urban areas. In the farming community Irish potato fetches only domestic markets, which operate mainly at the on-farm and farm-gate basis receiving marginally unrealistic market prices. There is no competitive feasible advantages to harvesting, processing, preparing, handling, and storing of the produce and hence penetrate the frozen chips and fresh Irish potato markets [2].

Among the most reported important factors that affect agricultural sector development in Tanzania include erratic climatic conditions, low rains, poor farming practices and cropping systems, low use of improved agricultural inputs and poor soil fertility [2]. Further to that, other factors include inadequate access to markets and market information, limited access to credit support, shortage of agricultural extension services, lack of confidence towards entrepreneurial skills, poor coordination or the marketing channel and integration of marketing channels and policy uncertainties [6]. Nyunza and Mwakaje [3] reported that Rungwe District is the potential area for agriculture in Tanzania because of its good climatic conditions and it produces about 25% of the Irish potatoes of the country's production.

Irish potato in the Southern Highlands, Rungwe District inclusive, is characterized by smallholder farmers who own less than 0.8 ha of fields [3]. On these small producing fields there is usually mixed cultivation, with the most popular combination being maize, beans, pyrethrum, sunflower and groundnuts [7]. Personal observations (2013 and 2014) revealed that Irish potato is intercropped with maize during short rainy season, and pure stand cultivation is seen only during long rainy season.

### **1.2 Statement of the Problem and Justification**

Andersson [8] depicted that Mbeya Rural and Rungwe districts produce more than 58% of Irish potato in Tanzania. However, despite the potential of these areas to Irish potato of more than 25 t ha<sup>-1</sup>, [9], only 5–8 t ha<sup>-1</sup> has been attained by the smallholder farmers [8][10]. The Agricultural Research Institute of Uyolet (ARI-Uyolet) has been the central inference to technological innovations in agriculture and dissemination of knowledge to the farming community in the Southern Highlands (Iringa, Mbeya, Njombe and Rukwa). However, the rate of adoption of such technologies has been lagging behind with time, which does not really realize the needs for change or socio-economic transformations.

The technologies convened by ARI-Uyolet so far include use improved varieties, use of inorganic fertilizers at a rate of 150 kg ha<sup>-1</sup>, foliar application of NPK fertilizer- (as

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booster), use of pesticides and insecticides. Others are the planting spacing of 60 cm × 30 cm and seed rate of 8 to 10 bags of 100 kg each and timely sowing. However, based on the recent survey conducted by Namwata et al. [1], fertilizers were only given as a blanket recommendations by ARI-Uyolet because 150 kg ha<sup>-1</sup> does not indicate specific nutrient element(s) referred to. From the existing facts, [1], only seeding rate, time of sowing and application of fungicide were the highly adopted technologies.

Access to credit services, agricultural extension services, sex of household head, and farming experience to smallholder farmers have been the identified needs for improvement of Irish potato farming in Tanzania [3]. However, despite the existing efforts embarked, there is no documentation that narrates availability, accessibility, stability and sustainability of Irish potato as a food-base in smallholder farming communities. Therefore, this study was meant to bridge the existing gap between food production and its sustainability by addressing the feasible options for up-scaling technologies for adoption by smallholder farmers in food security through Irish potato.

### **1.3 Objectives of the Study**

The objectives of the present study were to assess the socio-economic settings of farmers in Rungwe District based on the farming of Irish potato. In addition, existence and feasible options for up-scaling of technologies for Irish potato production were assessed. Furthermore, constraints hindering the adoption of improved practices for Irish potato production were addressed and sorted through multiple linear regressions analysis.

### **1.4 Conceptual Framework of the Study**

Several important factors have been reported to influence the technological innovations and their adoptions behaviour of farmers from qualitative and quantitative models for the exploration of the subject. Rogers [11] and Degnet and Belay [12] showed that demographic variables, technology characteristics, information types and sources, knowledge, awareness, attitude, and mob influence affect technological transformations and adoption behaviour among farmers. Furthermore, Liberio [13] reported that the technology adoption or non-adoption at farm level varies with location and time, and yet, the factors influencing adoption are neither exclusively economic nor purely non-economic. Degnet and Belay [12] depicted that economic and non-economic factors are the essential motives for shaping the farmers' attitude towards the new technology and its adoption. Fig. 1 presents the conceptual model which served the framework of this study.

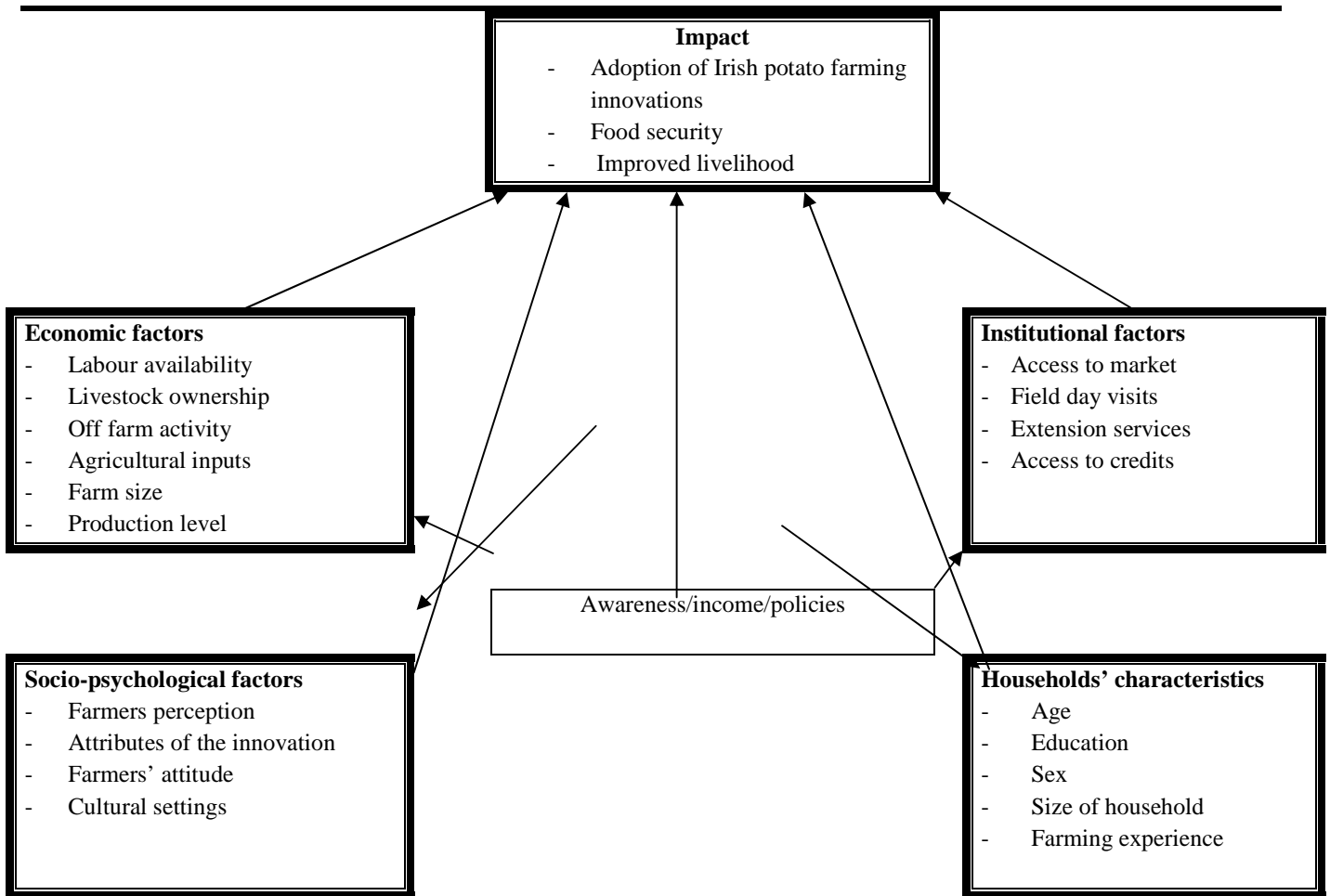


Fig.1: Factors affecting adoption of Irish potato farming technologies and its impact on food security

## II. MATERIALS AND METHODS

### 2.1 Description of the Study Area

Rungwe District is located between latitudes 08° 30' and 09° 30' South of Equator and longitudes 33° 00' and 34° 00' East of Greenwich Meridian. The district covers a land mass of 2,211sq. km of which 1,668.2 sq. km (75%) is the potentially arable land used for agricultural activities and it is one of the densely populated districts in Tanzania. The average annual rainfall ranges from 900 mm in the Lower Zone to 3300 mm in the Higher Zone [7].

The district is found at an altitude of 770 to 2865 m above mean sea level and it is divided into three agro-ecological zones (AEZs), namely the Upper, Middle and Lower zones. The Upper Zone is a continuation of the Uporoto Mountains covering about 10% of the district, which is cold throughout the year with the average annual rainfall ranging from 1500 mm to 2700 mm [3] [7].

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### 2.2 Research Design

A cross-sectional research design was used in this study because it allows collection of data at a single point in time without repetition from the representative sample. This approach is easier, reliable and worthwhile economically where resource constraints such as time, labour and funds dictate the operation and outcomes [14].

### 2.3 Sample Size and Sampling Procedure

The target groups for this study were all smallholder farmers, extension officers, and traders of Irish potato in Rungwe District. The sampling unit was definitely the household and a household in this study is defined as a single person or group of persons who live and eat together and share common living arrangements i.e. share expenses [13]. In collection of primary data total of 45 households were randomly selected from the villages of Ndaga, Ntokela and Nzunda as well as 10 key informants. The choice of

these three villages was purposive because of their high production potentials of Irish potatoes and the village rosters will be used as sampling framework [3]. However, because of high district's terrain variability hence unreliable transport facilities it was too difficulty in this study to adhere exact to the level of precision of 95% for the 5% allowable error [15].

#### 2.4 Data Collection

Primary and secondary data were collected, which included qualitative and quantitative data in order to address the objectives of this study.

Primary data were collected through household questionnaires survey with open-ended and closed-ended questions. Farmers were interviewed at their homesteads as well as physical observation. The primary data collected included socio-economic characteristics of respondents as well as food production practices and attitude towards Irish potato improvement and food security. On the other hand, secondary data were collected through reviewing of the existing official documents in the village offices and internet surfing.

The qualitative data collected included the types of crops produced, cropping systems and practices, seasonality, types of Irish potato varieties produced, access to market, terms of selling crops and livestock, use of traditional and improved seeds. Other data included land acquisition, fertility of soils and their suitability for crop production, livestock ownership, types of livestock kept, tools/implements used in agricultural activities, field and crop management practices, types and access to agricultural inputs. Furthermore, the information on the farmers' access

to village agricultural extension services, other sources of funds, constraints to crop production, and perception on benefits of Irish potato production was collected. On the other hand, the quantitative data collected included the ages, sex and education level of respondents, size of the household, farm size, total land area under crop production, and crop production levels.

#### 2.5 Data Analysis

Statistical data analysis was done using MS-Excel and correlations among response variables were performed using the *MS-Excel 2007 Adding-in the Data Analysis Toolpack*. Comparison of the significant means was done using two-sided t-test of mean variable against zero and separation of the significant means was done using Least Significance Difference (LSD) at 5% error to establish 95% Confidence Interval (CI).

### III. RESULTS AND FINDINGS OF THE STUDY

#### 3.1 Introduction

This chapter represents the results of the findings obtained from the study. The results are basically on socio-characteristics of the respondents as well as the factors affecting Irish potato production in the study area. It also represents statistical comparison of the pooled means of the studied factors affecting adoption of technologies involved in Irish potato production.

##### 3.1.1 Socio-characteristics of the respondents

Table 1 indicates the socio characteristics of the respondents which are likely to have either direct or indirect significant impact on Irish potato production in the study area.

Table 1: Socio-Characteristics of the respondents in the study area

Characteristic Parameter	Category of parameter	Villages		
		Ndaga (N=15)	Ntokela (N=15)	Nzunda (N=15)
Sex	Male	11(73)	10(67)	11(73)
	Female	4(27)	5(33)	4(27)
	<b>Total</b>	<b>15(100)</b>	<b>15(100)</b>	<b>15(100)</b>
Education	Tertiary	0(0)	1(7)	0(0)
	Secondary	1(7)	1(7)	0(0)
	Primary	11(73)	8(53)	11(73)
	None	3(20)	5(33)	4(27)
	<b>Total</b>	<b>15(100)</b>	<b>15(100)</b>	<b>15(100)</b>

Age	<16	6(40)	5(33)	4(27)
	16-60	9(60)	9(60)	11(73)
	>60	0(0)	1(7)	0(0)
	<b>Total</b>	<b>15(100)</b>	<b>15(100)</b>	<b>15(100)</b>
Marital status	Married	14(93)	13(87)	14(93)
	Single	0(0)	0(0)	0(0)
	Widow	1(7)	2(13)	1(7)
	<b>Total</b>	<b>15(100)</b>	<b>15(100)</b>	<b>15(100)</b>
Occupation	Employed	0(0)	0(0)	0(0)
	Farmer	8 (53)	12(80)	11(73)
	Business person	0(0)	0(0)	3(20)
	Mixed activities	7(47)	2(13)	1(7)
	Retired	0(0)	1(7)	0(0)
	<b>Total</b>	<b>15(100)</b>	<b>15(100)</b>	<b>15(100)</b>
Periods (years) of farming		23 (100)	13(100)	24(100)
	<b>Total</b>	<b>15(100)</b>	<b>15(100)</b>	<b>15(100)</b>

*In brackets/parentheses are the percentages (%) of each category of the parameter.*

### 3.1.2 Sex, education and age of respondents

Results indicated that most of the respondents were males (71%) and a few (29%) were females (Table 1). In addition, results further indicated that most of the respondents had attained primary education in the order of Ndaga and Ntokela villages (73%) and Nzunda village (53%). Also results revealed that 20% of the respondents from Ndaga, 33% from Ntokela and 27% from Nzunda villages did not attend school at all. On the other hand, it was found that only 7% of the respondents from Ntokela and Ndaga villages had attained secondary education while only 7% from Ntokela village had tertiary education.

Furthermore, results indicated that most of the respondents were of the age between 16–60 years in the order of 60% for Ndaga nad Ntokela villages and 73% for Nzunda village. Also results revealed that some of the respondents, 40%, 33% and 27% from Ndaga, Ntokela and Nzunda, respectively, were at the age less than 16 years. However, only 7% of the respondents from Ntokela village were at the age above 60 years.

### 3.1.3 Marital status of respondents

Results indicated that most of the respondents were married in the order of 93% from Ndaga and Nzunda villages and 87% from Ntokela village as opposed to the unmarried.

### 3.1.4 Occupation and farming experience of respondents

Results indicated that none of the respondents from all villages in the study area were employed while 20% of the respondents from Nzunda village were involved in business activities (Table 1). However, 47%, 14% and 7% of the respondents from Ndaga, Ntokela and Nzunda villages, respectively, were involved in mixed activities such as farming, livestock keeping, tailoring and motorists (*bodaboda*). Furthermore, results indicated that most of the respondents from the study area in the magnitude of 53%, 80% and 73% from Ndaga, Ntokela and Nzunda, respectively, were the sole farming communities.

Furthermore, results revealed that the study areas had been under cultivation in magnitudes of 23 years for Ndaga village, 13 years for Ntokela village and 24 years for Nzunda village.

### 3.2 Studying factors affecting Irish potato production in the study area

This study focused on as many factors as possible which are likely to contribute to whether increase or decrease of Irish potato production in the studied villages of Rungwe District. These factors are grouped into socio-economic factors, institutional factors, socio-psychological factors as well as cultural or traditional settings of the studied areas.

### 3.2.1 Land tenure and allied factors

Land ownership was 49% in Ndaga village and this outperformed other land owning communities in Nzunda and Ntokela villages (Table 2). In addition, the size of the land rent decreased from Ndaga (12%) through Ntokela (3%) to Nzunda (1%) and the size of land allocated to Irish potato decreased from Ndaga (90%), Ntokela (16%) to Nzunda (9%).

Results also revealed that Irish potato production in the studied area was purposefully for business with 41% from Ndaga, 4% from Ntokela and 5% from Nzunda villages. In addition, besides business, Irish potato is also produced for food and this had the magnitude of 21% for Ndaga and 2% for Ntokela and none (0%) is produced in Nzunda village for both business and food. Labour was fairly available in

magnitudes of 41% Ndaga, 3% Ntokela and 4% Nzunda villages and the main sources of labour were both hired and family.

In addition, results revealed that the use of improved agricultural inputs such as fertilizers, pesticides, fungicides and herbicides, and improved seeds was high in all the three villages which decreased from 49% Ndaga to 4% in Ntokela and Nzunda villages. Results also revealed that road infrastructure accessibility was easily in magnitudes of 45% Ndaga, 3% Ntokela and 2% Nzunda. Storability of Irish potato was reported to be the major problem of which results indicated that Irish potatoes were not easily stored in magnitudes of 12% Ndaga, 3% Ntokela and 5% Nzunda villages.

Table 2: Land tenure and other factors affecting Irish potato production in Rungwe district (N=45)

Description of Factors	Villages		
	Ndaga (N=15)	Ntokela (N=15)	Nzunda (N=15)
<b>Land aspects:</b>			
Land owners	12(49)	8(3)	12(4)
Land renters	3(12)	7(3)	3(1)
Size of land (acres) used for all food crops	23.5(97)	44.75(16)	17(6)
Size of land (acres) used for Irish potato	25.5(90)	44.75(16)	23.5(9)
Amount (bags/kg) of Irish potato produced	136(37)	253.2(92)	116(42)
<b>Purpose of producing Irish potato:</b>			
(1) Food	0(0)	0(0)	0(0)
(2) Business	10(41)	10(4)	14(5)
(3) Both (1) and (2)	5(21)	5(2)	1(0)
<b>Labour availability:</b>			
(1) Easily	4(16)	6(2)	3(1)
(2) Fairly	10(41)	9(3)	11(4)
(3) Not easily	1(4)	0(0)	1(0)
<b>Sources of labour:</b>			
(1) Family	4(16)	7(3)	8(3)
(2) Hired	2(8)	1(0)	3(1)
(3) Both (1) and (2)	9(37)	7(3)	4(1)
Estimated production costs (Tshs/ha) of Irish potato	18(74)	64.9(24)	23.1(8)
<b>Agricultural inputs:</b>			
(1) Seeds	12(49)	10(4)	11(4)
(2) Fertilizers	15(62)	15(5)	15(5)
(3) Herbicides	15(62)	14(5)	15(5)
(4) Pesticides	15(62)	15(5)	15(5)
(5) Fungicides	15(62)	15(5)	15(5)

**Road infrastructure accessibility:**

(1) Easily	11(45)	7(3)	6(2)
(2) Fairly	3(12)	5(2)	9(3)
(3) Not easily	1(4)	3(1)	0(0)

**Storability of Irish potato:**

(1) Easily	3(12)	2(1)	1(0)
(2) Fairly	9(37)	4(1)	0(0)
(3) Not easily	3(12)	9(3)	14(5)
<b>Mean (%)</b>	<b>39</b>	<b>9</b>	<b>4</b>

*In brackets/parentheses are the percentages (%) of each category of the parameter*

**3.2.2 Institutional and production returns**

Results indicated that farmers from the study areas were rarely visited by Village Agricultural Extension Officers (VAEOs) in the decreasing order of 12% Ndaga, 10% Ntokela and 6% Nzunda. The main sources of funds for Irish potato production were savings. In addition, results indicated that there were reliable markets for Irish potato in a magnitude of 16% in Ndaga and Ntokela and 17% Nzunda villages while Irish potato production was

profitable in the order of 10% Ndaga, 6% Ntokela and 9% Nzunda villages. This profitability was reported to return production costs in magnitudes of 4%, 9% and 8% for Ndaga, Ntokela and Nzunda villages, respectively. Furthermore, it was also found that some of the Irish potato produced is sold on-farm in the order of Ndaga and Nzunda (17%) and Ntokela (13%) while 3% of the sales in Ntokela village were done at home.

*Table 3: Institutional factors affecting Irish potato production in Rungwe district*

Description of Factors	Villages		
	Ndaga (N=15)	Ntokela (N=15)	Nzunda (N=15)
<b>Visits by extension officers:</b>			
(1) Regularly/Always	0(0)	0(0)	0(0)
(2) Often	0(0)	0(0)	0(0)
(3) Rarely	11(12)	9(10)	5(6)
(4) Not at all	4(4)	6(7)	10(11)
<b>Aspect of field day:</b>			
(1) Yes-Conducted	10(11)	8(9)	5(6)
(2) No-Not conducted	5(6)	7(8)	10(11)
<b>Sources of funds for Irish potato production:</b>			
(1) Savings	13(14)	14(16)	15(17)
(2) Loans from Banks	0(0)	0(0)	0(0)
(3) Savings, credits and loans from banks	2(2)	1(1)	0(0)
<b>Reliable markets for Irish potato:</b>			
(1) Yes	14(16)	14(16)	15(17)
(2) Not easily	1(1)	1(1)	0(0)
<b>Irish potato production advantage:</b>			
(1) Profitable	9(10)	5(6)	8(9)
(2) Returns only production costs	4(4)	8(9)	7(8)
(3) Losses	2(2)	2(2)	0(0)
<b>Selling of Irish potato:</b>			

(1) On-farm	15(17)	12(13)	15(17)
(2) On-farm gate	0(0)	0(0)	0(0)
(3) Home	0(0)	3(3)	0(0)
(4) Market place	0(0)	0(0)	0(0)
(5) Bulk/whole sell	0(0)	0(0)	0(0)
<b>Mean (%)</b>	<b>8</b>	<b>10</b>	<b>11</b>

*In brackets/parentheses are the percentages (%) of each category of the parameter*

### 3.2.3 Economic, cultural settings, and farmer's attitude

The economic factors hindered the adoption of Irish potato production innovations and hence affecting Irish potato production were access to capital and credits in the magnitude of 14% Ndaga and Ntokela and 10% Nzunda villages (Table 4). This was closely followed by access to conventional inputs which acquired 11% for Ndaga and 10% in Ntokela and Nzunda villages. However, access to field extension services was another problem in Nzunda

village (14%) followed by Ntokela village (7%) and Ndaga village (6%). On the other hand, other factors were awareness among farmers 6% for Ndaga and Ntokela and 4% in Nzunda villages, climatic condition 5% for Ndaga, 4% Nzunda and 1% Ntokela villages. Farming experience was also reported by respondents with decreasing magnitudes of 4% Ndaga, 2% Ntokela and 1% Nzunda villages. Results also indicated that availability and access to reliable and friendly markets was 1% for all three villages.

*Table 4: Economic and other factors affecting Irish potato production in Rungwe district*

Description of Factors	Villages		
	Ndaga (N=15)	Ntokela (N=15)	Nzunda (N=15)
<b>Economic factors affecting Irish potato production:</b>			
Capital and/or access to credits	12(14)	12(14)	10(12)
Availability of reliable and friendly markets	1(1)	1(1)	1(1)
Access to conventional inputs	9(11)	8(10)	8(10)
Access to field extension services	5(6)	6(7)	12(14)
Farming experience	3(4)	2(2)	1(1)
Awareness	5(6)	5(6)	3(4)
Climatic conditions	4(5)	1(1)	3(4)
<b>Cultural/traditional settings hindering adoption of innovations on Irish potato production:</b>			
Poor cooperation between husband and wife in producing Irish potato	15(18)	15(18)	15(18)
<b>Farmers' attitude towards adoption of innovations in Irish potato production:</b>			
(1) Good	13(15)	13(15)	15(18)
(2) Poor	2(2)	2(2)	0(0)
<b>Attributes of innovations on improved Irish potato production:</b>			
(1) Below average	6(7)	5(6)	6(7)
(2) Average	8(10)	10(12)	9(11)
(3) Improved	1(1)	0(0)	0(0)
<b>Mean (%)</b>	<b>8</b>	<b>8</b>	<b>9</b>

*In brackets/parentheses are the percentages (%) of each category of the parameter*



Results indicated beyond doubt that cultural and traditional settings which hindered the adoption of Irish potato production innovation were the poor cooperation between family parents that is husband and wife.

### 3.3 Constraints hindering the adoption of improved practices for Irish potato production

Results indicated that effect of socio-economic and institutional factors were significant ( $LSD_{0.05} = 1.8$ ) in

determining Irish potato production in Ntokela village (Fig. 2). In addition, the effect of institutional and land tenure factors were significant ( $LSD_{0.05} = 6.6$ ) for Irish potato production in Nzunda village. However, none of these factors were significant ( $LSD_{0.05} = 32.9$ ) in Ndaga village.

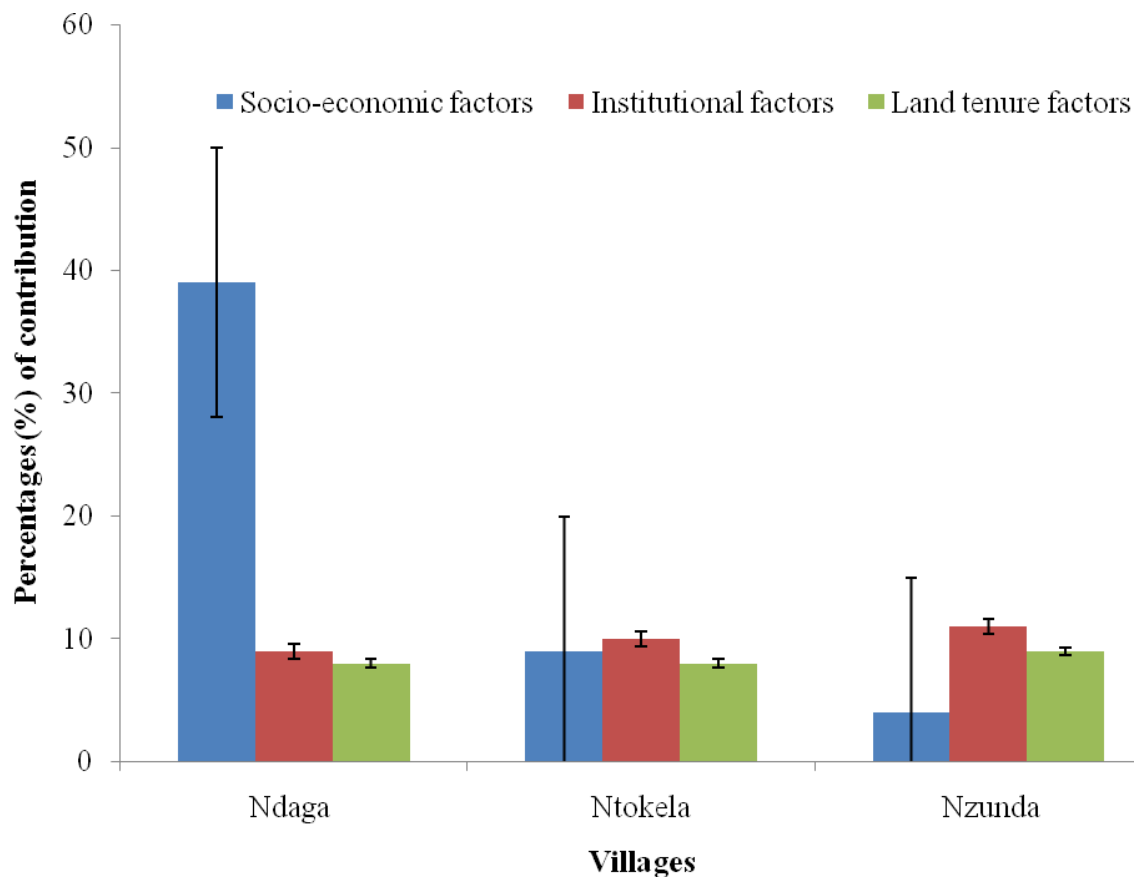


Fig.2: Comparison of the pooled percentages of the studied factors affecting Irish potato production in the study area.

### 3.4 Sorting of feasible options for up-scaling adoption of Irish potato production technologies

Results of the correlations among response variables are presented in Table 5. Results indicated that the quantity of Irish potato produced in Rungwe district was positively

correlated with some of explanatory variables. These variables are capital and/or access to credits ( $r = 0.700$ ), farming experience ( $r = 0.225$ ), awareness ( $r = 0.698$ ), contribution of innovations ( $r = 0.771$ ), sex-female ( $r = 0.96$ ), and innovative agricultural inputs ( $r = 0.525$ ).

Table 5: Correlation coefficients among variables of technological adoptions in Irish potato production in Rungwe district

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1	1																			
2	-	1.00																		
3	-	0.885	0.879	1																
4	-	0.840	0.847	0.491	1															
5	-	0.049	0.035	0.508	-	0.501	1													
6	-	0.405	0.393	0.784	-	0.156	0.933	1												
7	-	0.952	0.956	0.700	0.966	-	0.205	0.1	1											
8	-	0.999	1.000	0.864	0.862	0.006	0.365	0.964	1											
9	0.698	-	0.688	0.951	0.997	0.150	0.738	0.944	0.666	1										
10	-	0.346	0.358	0.131	0.800	-	0.920	0.718	0.616	0.386	0.431	1								
11	-	0.456	0.444	0.818	-	0.100	0.911	0.998	0.161	0.417	-	0.956	0.678	1						
12	0.225	-	0.212	0.652	0.340	-	0.984	0.982	0.084	0.183	0.855	0.837	0.970	1						
13	0.698	-	0.688	0.951	0.997	0.150	0.738	0.944	0.666	1.000	0.431	0.956	0.855	1						
14	-	0.924	0.930	0.641	0.983	-	0.335	0.026	0.997	0.940	-	0.372	0.677	0.082	0.163	-	0.372	1		
15	-	0.499	0.487	0.845	-	0.890	0.994	0.209	0.461	-	-	0.969	0.641	0.999	0.957	0.969	0.331	1		
16	0.771	-	-	-	0.599	0.271	-	-	0.081	-	0.216	-	0.081	-	0.068	-	0.168	1		

		79	86	93		29	97		64	48		55							
17	-	0.9	0.9	0.7	0.1	0.5	0.9	0.9	-	0.2	0.5	-	-	0.8	0.6	-			
	0.9	90	38	62	79	21	04	85	0.7	20	68	0.3	0.7	67	08	0.6	1		
	91								85			50	85			81			
18	0.9	-	-	-	0.2	-	-	-	0.4	-	-	-	0.4	-	-	0.9	-		
	56	0.9	0.7	0.9	0.2	0.1	1.0	0.9	0.4	0.6	0.1	0.0	0.4	0.9	0.2	0.9	0.9	1	
		60	11	62	45	20	00	68	58	05	76	69	58	96	24	23	10		
19	0.5	-	-	-	0.8	0.5	-	-	-	-	0.5	-	-	-	0.4	0.9	-	0.7	
	24	0.5	0.0	0.9	0.8	0.5	0.7	0.5	0.2	0.9	0.5	0.7	0.2	0.8	0.4	0.9	0.4	0.7	1
		36	68	03	25	66	60	61	44	80	19	12	44	09	76	47	09	50	

Key: 1 = Amount (t/ha) of Irish potato produced, 2 = Periods (years) of farming, 3 = Size of HH, 4 = Seeds (seeding rate), 5 = Hardship in storability, 6 = Market reliability, 7 = Profitability in production, 8 = On-farm markets, 9 = Capital and/or access to credits, 10 = Access to conventional inputs, 11 = Access to field extension services, 12 = Farming experience, 13 = Awareness, 14 = Climatic conditions, 15 = Good attitude of farmers, 16 = Average contribution of innovations, 17 = Male, 18 = Female, 19 = Other agricultural inputs

#### IV. DISCUSSION

##### 4.1 Socio-characteristics of the respondents

This study revealed that most of the households were headed by men and because most of these are the farming drivers, widowed women were likely to face difficulties in Irish potato production in the study areas. In addition, most of the respondents aged above 16 years old suggesting high ability of engaging in production activities. Similar previous studies have also indicated age as a determinant attribute of economic production given other factors. According to Lupilya [16] and Namwata et al. [1] the middle age above 16 years old are still energetic and hence can actively engage in production activities.

Education and awareness was also a variable attribute of Irish potato production. A study conducted by Mpogole and Kadigi [17] found that farmers with higher levels of education such as at least secondary level were expected to be more profitable than farmers with low level of education. This also associated with the awareness on the production activities and the inputs to be involved. Seasonal timing of production is also very pertinent in any agricultural activities. Based on the findings of the present study, the low levels of Irish potato production in the study areas could be attributed to the low level of education of most respondents as most of them had attained only primary education.

The findings of this study revealed that most of the respondents depend largely on farming activities related to crops production and keeping of livestock. However, some of them are involved in mixed activities that could not provide them with enough cash to meet the needs of the family and production costs of Irish potato. These findings

are in agreement with those of Nyunza and Mwakaje [3] who found that the main occupation of the respondents in Ndaga and Ntokela villages was agriculture with 49.5% depending on Irish potato, 33.3% on maize and 10.5% on cabbage. These findings indicate that most of the people in the study area engage fully in Irish potato production and this could be attributed to the fact that they are not bound to other occupations. Furthermore, the findings give an indication that the community in the study area encounters some difficulties in attaining maximum potential benefits from Irish potato production due to limited capital to purchase the required inputs. This is because most of the respondents in the study area depend largely on their own savings as capital of production from the previous production.

##### 4.2 Effect of socio-economic factors

Most of the respondents own their lands which they use for various production activities. However, the size of land owned is very small ( $\approx 0.8$  ha) and ability to expend their production area is not feasible because of low capital of buying and/or renting the land from a few who own large portions of land. This gives a clear indication that there is a shortage of enough possessed land for Irish potato production among the residents and this caused them to spend a lot of funds to hire the land that would have been used in purchasing conventional inputs for Irish potato production. Similarly, the findings revealed that most of the land present in the study area whether owned or hired was allocated to production of Irish potato. The production is mostly intercropping except in fields during long rainy season in April through July and these findings are in agreement with those of Nyunza and Mwakaje [3].

However, the findings indicated that there was high variation in the yields of Irish potato obtained per hectare ranging from 11.6 t/ha to 25.32 t/ha depending on the amount and/or type of inputs used and the variety of Irish potato grown. Similar findings were also reported by Nyunza and Mwakaje [3] through analysis of round potato marketing in Rungwe District.

#### **4.3 Effect of institutional factors**

The findings of the current study revealed that there was inadequate access to extension services from VAEOs. The presence of extension services related to agricultural activities is likely to increase Irish potato production. This could be related to improvement in awareness and knowledge on Irish potato production among farmers as well as adoption of appropriate technological advancement pertaining to Irish potato production. These findings are in agreement with the findings generated by Namwata et al. [1] who found that lack or inadequacy of extension services was among the major impediments to most farmers in rural Tanzania.

Furthermore, the findings of this study revealed that some of the respondents depended on their own savings, credits and loans from banks as their sources of funds. However, the main source of funds for Irish potato production to the most of the respondents is savings from the output obtained in the previous season for the subsequent season. This affects production of Irish potato especially when a farmer encounters losses in the preceding season as most of these farmers have no feasibility to access to reliable sources of credits. On the other hand, most of the communities producing Irish potato have reliable markets. Yet then, most of these markets are on-farm based with only a few (3%) of them from Ntokela village selling their produce at home. On-farm sales of Irish potato are hastened by bulk buyers from Tunduma border for Zambia, Blantyre Malawi, Dar es Salaam, Zanzaibar and Kenya. This practice affects Irish potato production and its expected income because wholesalers decide on the price.

This study indicated that farmers use different agricultural inputs such as fertilizers, pesticides, fungicides, herbicides and seeds for production of Irish potato. In addition, road infrastructures are fairly accessible to the fields of some farmers but others indicated difficulty to their farms. This has a great impact on the Irish potato production and earnings from the crop because of high transport cost and/or drive of trucks by bulk buyers to the fields during harvesting. The study also found that it was difficult to store Irish potato as raw material because of too cold climatic condition which results sometimes causes moulds on

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potatoes. However, some respondents indicated that they locally store Irish potato in their homes by burying them in underground pits and cover the pits with soil thereby preventing entrance of air into the pits. On the other hand, the alternative to those who want to store potatoes for food is to retain them in the field during harvesting. These are only harvested portion-wise when needed for food for families.

#### **4.4 Feasible options of adopting Irish potato production innovations**

This study revealed that access to credits/capital, access to conventional agricultural inputs such as seeds, fertilizers, herbicides, pesticides, fungicides, and farming experience of the farmer and awareness on the technology could be the main factors influencing the adoption of Irish potato production. Sex of the farmer was also important in the adoption of these technologies and female are the most favoured group. In addition, the actual contribution of the innovations to Irish potato production in the study area was pertinently reported. This implies that if these factors addressed by farmers could be adopted for Irish potato production innovations as access to credits enables them to buy the required inputs. Contact with extension agents enables farmers to have awareness of new technologies and the ways by which they might be applied. These findings are in agreement with those of Namwata et al. [1] who found that increased income was a strong drive for adoption of improved agricultural technologies. Experience enriches the farmer on the major production aspects such as a sound knowledge of agronomic practices. Some of the respondents indicated that farming experience is one of the attributes towards the adoption of Irish potato production innovations together with awareness. In addition, some respondents indicated that climatic condition is a factor for adoption of Irish potato production innovations. It was also found that farmers had good attitude towards the adoption of technological innovations in Irish potato production though improvements of the adoption of innovations vary with socio-economic settings of each household and geographical location.

Gender attribute is very sensitive in adoption of technologies for Irish potato production in the study area. This study found that females would be an important group in technologies of Irish potato production in the study area and hence there was no cooperation between husbands and their wives in the field activities. This could be attributed to the ability of female to consolidate their minds in learning because of existing society's perception that women are the inferior group, which advantages this group in

concentrating in learning. Women also are the feeding group of the family who in no means have to invest most of their efforts on food production activities. In connection to this, the study revealed that in households with a husband and a wife each of them produces in separate pieces of land with perception that wife produces for family food and husband for business even though most of these produce are very small. The reason for this could be related with the commercial nature of Irish potato production and the high competition among farmers towards fetching attractive prices from buyers [17] [18].

## V. CONCLUSIONS AND AREAS FOR FURTHER INVESTIGATIONS

### 5.1 Conclusions

Irish potato production is a serious socio-economic activity in Rungwe district but the production is very variable because of factors such as socio-economic, institutional, and land tenure aspects. The survey found that use of agricultural inputs such as fertilizers, pesticides and insecticides, and planting spacing were already in place and adopted by farmers. This study found that access to capital and/or credits, extension services to impart awareness, inclusion of female household head, continuity in supply of innovative agricultural inputs and farming experience are pertinent in adoption of Irish potato production technologies.

### 5.2 Areas for Further Investigations

This study investigated the factors affecting Irish potato production in Ntokela, Ndaga and Nzunda villages to represent a large heterogeneity and diverse Rungwe District in Mbeya Region. It also investigated the feasible options for technological transformation and adoptions by farmers in Irish potato producing areas in the same district. Based on the findings of this study it is recommended that further research should be conducted on factors affecting all agricultural systems and allied socio-economic attributes. It is also recommended that further study be conducted on the same study focusing on other aspects other than only those on Irish potato. These should be those dealing with financial services in order to disclose or unveil real situation that reflects both positive and negative impacts of socio-economic factors and contribution of stakeholders on Irish potato production.

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