

An Economic Analysis of the Factors Influencing Adoption of Climbing Beans Varieties and Challenges of Smallholder Farmers in Rwanda: A Case Study of Burera District

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Abstract: Agriculture plays an important role in the economic growth and development prospects of a vast majority of developing countries including Rwanda. Grain legumes also serve as rotation crops with cereals, reducing soil pathogens and supplying nitrogen to the cereal crop. Food legume crops are considered vital crops for achieving food and nutritional security for both poor producers and consumers. One of the important legume crops grown in Rwanda is common bean (*Phaseolus vulgaris* L.) which is the most priority crop occupying the largest arable land and consumed by majority of people. It is an important food legume for direct consumption as well as a source of farm income in Rwanda. The study was conducted in Burera district of Northern Province of Rwanda. A multistage sampling technique was employed in this study. Eighteen (18) farmers were randomly selected from each of the seven sectors making one hundred and twenty six (126) farmers do agriculture of common beans as commercial purpose as sample size. The main objective of the present study was to analyse the factors influencing the adoption of climbing beans and challenges of smallholder farmers in Rwanda. The results indicated that out of 126 respondents the majority were female. The findings indicated that, the majority of farmers grow their beans on less than 0.5ha. The results show that eight variables out of nine positively influence beans adoption while two variables negatively influence the adoption of climbing beans. The results show that land size, family size, high yield, educational level, off-farm income, output, price, farming experience, and extension services were significant in influencing adoption of climbing beans varieties. The results indicated that climbing beans produce up to three times more than the bush beans varieties. Many farmers mention staking as a major challenge to growing climbing beans. Afforestation, increasing agroforestry trees, adoption of poles and ropes, which can be used as staking materials, should be reinforced in study area. This will help to improve soil fertility through N-fixation, erosion control, environmental protection. Climbing bean residues complement animal feeds and organic manure production.

Keywords: Economic Analysis, Factors Influencing, Adoption, Climbing Beans, Smallholder Farmers

1. Introduction

Agriculture plays an important role in the economic growth and development prospects of a vast majority of developing countries including Rwanda. More than 85% of the Rwandan population resides in the rural areas and is engaged in agricultural production as the main source of livelihood [16]. Increasing agricultural production at the household level is vital to achieve food security [3]. Beans are the second-most popular crop (after banana) cultivated in Rwanda; they are grown by about 86 percent of farmers and occupy about 40 percent of cultivatable land [2].

Common bean is a priority crop in Rwanda, occupying the largest arable land and consumed by majority of people. The common bean (*Phaseolus vulgaris* L.) is a major grain legume produced and consumed worldwide for its edible seeds and pods. According to [1], the crop is grown in East and South African countries and it is the second staple food after maize. Bean production in Sub-Saharan Africa is largely done by small-scale farmers (less than 2 ha), predominantly by women for both household food security and cash [13]. Common bean is a crop whose production and marketing could be a potential pathway for improving rural livelihoods.

Common beans are important for direct consumption because they grow all over the world and are consumed as dry and snap beans. The world major common beans producers are India, Brazil, Myanmar, and China. Ethiopia is the third largest producer of common beans in Eastern and Southern Africa or COMESA countries and the leading exporter in Africa.

In developing countries, beans are often cultivated by smallholder farmers for food consumption without the use of fertilizers where quarter to one-third of the households sell their beans [9], with around 20% surplus being marketed [4]. Common bean is a popular crop among small-scale farmers because beans are a short duration crop (2.5-4 months) which permits production even when rainfall is erratic [2]. In Rwanda, climbing beans are grown in the highlands of Northern Province in Burera, Gakenke, Gicumbi, and Rulindo districts [11].

The climbing bean technology has been adopted in Northern Province mainly as a coping strategy due to the problems of land scarcity and land degradation leading to reduced food insecurity and poverty. Beans are the main staple food and a major source of protein and calories for majority of people in Rwanda. Due to limited available agricultural land, the Government of Rwanda has put a lot of emphasis on the promotion of growing of climbing bean varieties. It is estimated that between 50,000 to 100,000 hectares in Rwanda are under climbing bean varieties [11].

Beans are grown twice a year in diverse farming systems throughout Rwanda. They are intercropped with banana, cassava, maize, peas, and other crops, and cultivated under various agro-ecological zones. Because of environmental diversity, two types of beans are grown by farmers that include bush and climbing beans. Climbing beans grow vertically, requiring staking material for support. They

mature at different stages and are harvested over a continuous period in a year compared to bush beans that all mature at the same time are harvested once.

Climbing Beans give higher yield than bush beans because they are tolerant to diseases and too much rain, and can be intercropped with other crops like maize. Beans are consumed at home in different forms such as; dry seed, green pods, green leaves. The excess is sold in the market for household income generation. Smallholder farmers indicate that crop residue of climbing beans after harvest is used as fodder for animals, making farmyard manure, and mulching for other crops like coffee, banana, tomato [12].

Smallholder farmers encounter multiple constraints such as inadequate capital, high rainfall, flooding, unreliable climatic conditions, pests and diseases, poor access to farm inputs, poor marketing infrastructure, and inadequate labour. This has led to low agricultural productivity and low supply of beans to the market. In the developing countries, the low national average yield of beans is contributed by several factors including low adoption of improved bean varieties and agricultural technologies, insufficient use of basic agricultural inputs, lack of improved varieties, poor agronomic practices, pests and disease. Increasing bean production and sustainable land management will improve food security and household income [8].

Maximizing climbing bean yield potential requires the beans to be supported by stakes or grown in association with other crops on which they climb. In order to meet this growing demand, adoption of better production technologies focusing on improving production and marketing of beans is necessary. Increasing production of beans will be realized if the growers adopt the improved varieties and good agricultural practices [12].

The objective of this study was to analyse the factors influencing adoption of climbing beans and the challenges of smallholder farmers in Rwanda. Comparative analysis was done between the climbing bean and Bush beans grown in the area.

2. Materials and Methods

Burera district is one of the five districts of Northern Province with a total area estimated at 664.5 km². It is bordered by the Republic of Uganda in the North and East, by Gakenke and Rulindo districts in the South and by Musanze district in the West. Seventeen administrative Sectors make up Burera District. Its average altitude is 2100 meters. The relief is characterized by steeply sloping hills connected either by valleys steep sided or by flooded marshes. Annual precipitations reach 1400 mm; the temperature varies between 9°C and 29°C, according to the places and the season. Subsistence farming is the main activity of the district. It is practiced by more than 80.2% of the total population in the district. Burera's comparative advantage lies in bean production, as the volcanic climatic zone is favourable to beans production. Other commonly grown horticultural crops include; cabbage, onion, tomato, eggplant, amaranths,

	Frequency	Percentage
Total	126	100
Fam size		
≤ 0.5	74	58.7
0.6-0.8	35	27.8
0.9-1	13	10.3
≥ 1	4	3.2
Total	126	100
Age		
≤ 30	18	14.3
31-40	39	30.9
41-50	55	43.7
≥ 51	14	11.1
Total	126	100
Education level		
Illiterate	41	32.5
Primary	59	46.8
Secondary	12	9.6
Vocation	10	7.9
University	4	3.2
Total	126	100
Farming Experience		
1-10	34	26.9
11-20	42	33.3
21 and above	50	39.8
Total	126	100

The majority of people engaged in farming were females 55.6% compared to males 44.4% (Table 1). Majority of the farmers interviewed were in the middle age bracket ages of the farmers interviewed. With the results, out of the 126 farmers interviewed, 43.7% were in range between 41-50 followed by 30.9% in range between 31-40, followed by 4.3% were in range equal and less than 30 while the last class is in range of 51 and greater ages with 11.1%. Thus, findings revealed that a majority of the farmers interviewed were in years of working.

The results indicated that out of the 126 respondents 51.6% had between 4-7 members of household, followed by 28.6% that eight and above members of household and the last class is between 1-3 members of household with 19.8%. This shows that a vast majority of the respondents of more members of family enabled farmers to engage more in agricultural production because of the labour force available in the household. Many times, it is farmers with more labour that are able to take advantage of high production in agriculture.

Findings revealed that, 46.8% of the farmers had attained primary school, 9.6% had attained secondary school education, 7.9% had attained vocational education. While only 3.2% of the farmers had achieved university. 32.5% were illiterate. This results show that the majority of 85% farmers attained formal education. While 32.5% were illiterate, which may contribute to poor adoption. However, according to [10] education is a significant factor in facilitating awareness and adoption of new or improved systems. High level of education enhances understanding of instructions given and improves farmer's level of participation in farming activities.

The findings indicated that, 58.7% grow their beans on less than 0.5ha, 27.8% grow beans on the area between 0.6-0.8ha while 10.3% of them grow their beans on the area between 0.9-1ha. Few farmers 3.2% grow their beans on 1ha and greater. These indicate that most beans farmers in Burera District are

small-scale farmers with majority having less than 0.5ha of land. Findings by [15] discovered a significant relationship between farm size and adoption of improved technology and stated that there was a positive correlation between farm size and adoption of improved production technology.

The experience of the household heads is very important in decision making, although it is noted that increase in years may only increase production or productivity to a certain level after which it may be negative. The study showed that 8% of the respondents had farming experience of 21 years and above, 33, 3% have experience between 11-20 years while the last class is in the range between 1-10 years with 26.9%. That is to indicate that majority of respondents have higher experience in beans farming.

3.2. Factors Influencing the Adoption of Climbing Beans in Study Area

The results in Table 2 show that eight factors over ten have significant influence on farmers' decision to adopt climbing beans varieties. The log likelihood for the fitted model is -42.16 and the χ^2 value of 87.19 indicates that all parameters are jointly significant at 5%, and Pseudo $R^2=0.45$. Thus, the overall model was significant and all the explanatory variables used in the model were collectively able to explain the farmer's decisions regarding adoption of climbing beans in study area. All variables were tested at three different levels of significance, which are 1%, 5% and 10%. The results show that land size, family size, high yield, educational level, off-farm income, output, price, farming experience, and extension services were significant in influencing adoption of climbing beans varieties.

Table 2. Probit Regression of Factors Influencing Adoption of Climbing Beans.

Variables	Coef.	Std. Err.	T	P>t
Farm size	0.371	0.445	0.834	0.000
Family size	0.264	0.803	0.328	0.000
High yield	0.026	0.085	0.314	0.004
Distance to market	-0.016	0.073	-0.219	0.010
Education level	0.125	0.041	3.048	0.007
Off-farm income	0.461	0.202	2.282	0.002
Output price	0.075	0.339	0.221	0.000
Age	-0.118	0.046	-2.565	0.003
Farming experience	0.033	0.025	1.32	0.035
Extension services	0.044	0.052	0.846	0.000
Intercept	0.257	0.1740	1.477	0.000

Log likelihood=-46.165945 Number of observation=126

Pseudo $R^2=0.45742$ Prob > $\chi^2=0.0000$

LR $\chi^2(10)=87.19$

The results in Table 2 show that eight variables out of nine positively influence beans adoption while two variables negatively influence the adoption of climbing beans. A large farm holding lead to increase in area under climbing beans. This facilitates farmers to get credit for farming activities. An increase in hectares reserved to climbing beans should increase the adoption of these varieties by 37.1%. Farmers who have big land are more likely to be adopters of climbing beans farming.

An increase in the number of family members who provide

farm labour by one person would increase adoption of climbing beans by 26.6%. Households with a high number of members working on the farm are more effective, given that household labour is the key source of labour supply among smallholder households.

High yield of climbing beans was influenced adoption different varieties. An increase in varieties of high yielding by 1% would increase the adoption by 2.6%. Varieties of high yielding will be more adopted by farmers than those of low yields.

An increase in the distance by one kilometer to the market would reduce the adoption of growing climbing beans by 1.6%. This was also reported by [14] who found a negative correlation between distance to the nearest market and adoption of technology. If the distance to the market is far, it will have a negative influence in adopting high yielding varieties. The increase in education level by one year increases the adoption of climbing beans by 12.5%. The educated household heads are expected to understand new technologies in a shorter period and implement the technology than those with lower level of education [6].

Off-farm income has significant positive influence on adoption of climbing beans at 1% level. In the study area, for example income from other agricultural activities increases capital to the farmer to purchase inputs like fertilizer, pesticides as well as hiring labor, and technology. This raises the level of agricultural production. Good market price positively influenced the adoption of climbing beans in the study area at 1% level of significance.

The age of the household head negatively influenced adoption of climbing beans. The younger farmers are more willing to adopt climbing beans varieties than older farmers because, younger farmers are more likely to be risk takers and are more interested in trying out new agricultural technologies

than old farmers who are risk averse. An increase in age by one year would decrease the adoption of climbing beans by 11.8%.

Farming experience has a positive influence in adoption of climbing beans. This is because more experienced household head are expected to understand new technologies in a shorter period and implement the technology than inexperienced farmers.

Extension services positively influenced the adoption of climbing beans in the study area at 1% level of significance. This indicates the importance of extension services as a source of information and knowledge to the farmers. This implies that, an increase in the number of extension agents by 1% should increase the adoption of climbing beans by 4.4%. Extension service exposes farmers to new ideas in farming technologies and other related information to increase their level of production [7].

3.3. Comparative Analysis of the Production of Climbing and Bush Beans

Climbing beans is a priority crop in Rwanda, occupying the largest arable land and consumed by nearly all, the urban and the rural populations. It has multiple benefits of food and nutrition as well as income security. Climbing beans cultivation dominates in the Northern Province, which is characterized by high elevation, cooler temperatures, and precipitation throughout the year [5]. Bush beans are most frequently cultivated in the Eastern Province, a low-altitude area with warmer temperature. Bush beans are also commonly grown in areas surrounding Kigali and in a few districts in the Southern Province, which is mostly a low-altitude zone and less rainfall.



Figure 2. Climbing beans (a) and Bush beans (b) in the study area in 2018.

Both bush bean and climbing bean plants (plate 1) flower in about 55 days from planting for bush beans and 65 -70 days for climbing beans. Both climbing beans and bush beans are suitable for seeds multiplication, if you plant heirloom seeds to begin with. The main difference between climbing beans and bush beans is that climbing beans grow up tall and require a trellis for support whereas bush beans grow only about 2-3

feet tall in a bush and do not require any support. Climbing beans can also be trained into a teepee shape to make a green playhouse for children or as a screening fence. Because of vertical growth, climbing beans produce more beans in less space. They are also easier to pick by hand, and they are easier to see among plant leaves. Climbing beans take longer to mature and only produce a handful of beans at a time

but harvesting is extended over a long time. Climbing beans are more resistant to diseases and produce large pods.

Bush beans require less work in planting, staking and weeding. Bush beans produce all at once and may be

harvested by mechanical means, making them ideal for commercial purposes. Bush beans have a short growing period from planting to harvest 120 days according to the cultivars and so it is possible to have at least two harvests in one year.

Table 3. Comparative analysis of the production of climbing and bush beans area.

Local name	Average yield (Kg/ha)	Average farm gate price (Rwf)	Gross total revenue (Rwf)	Variety
Injyamane/Koruta	2350	500	1175000	Climbing beans
Kenyerumpure	2175	450	978750	
Nyiragatuku	1950	420	819000	
Nyiragahondo	1807	420	758940	
Gacwekano	975	350	341250	
Nyiragakara	928	350	324800	Bush beans
Kivuzo	920	350	322000	
Kabonobono	735	350	257250	

The local names of commonly grown climbing bean varieties in study area are; Injyamane/Koruta, Cyenyerumpure, Nyiragatuku, and Nyiragahondo while bush bean varieties are Gacwekano, Nyiragakara, Kivuzo, and Kabonobono. The average yield Climbing beans varieties is 2350 kg/ha while the average yield for bush bean varieties is 975 kg/ha (Table 3). In addition to high yields, climbing bean varieties have better resistance and tolerance to diseases and drought. They are highly preferred by farmers because of sweet taste, and easy to cook. Among the climbing bean varieties, Injyamane/Koruta is superior to the others, and to bush bean varieties due to its high yields and high market price. The Gross total revenue per hectare (USD) for farmers growing Climbing beans varieties and bush beans are USD 1,238.95 and USD 359.82 respectively.

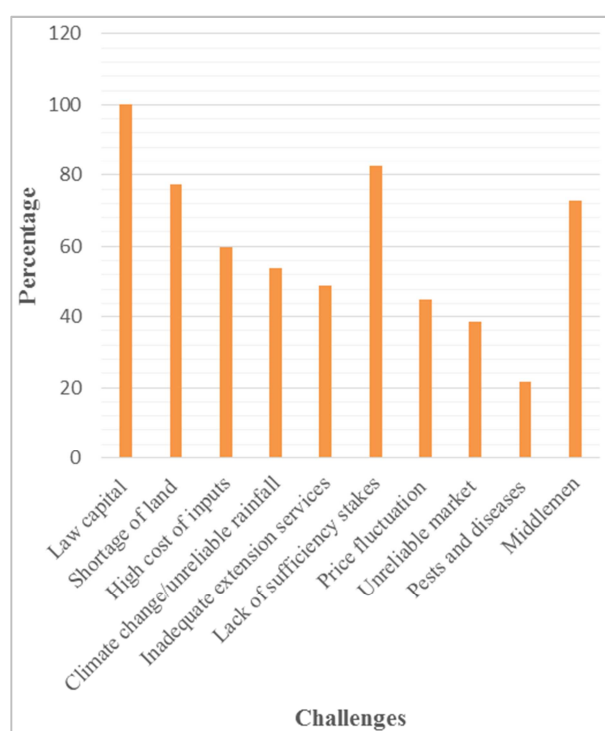


Figure 3. Challenges facing smallholder farmers in climbing bean farming.

Many farmers mentioned different challenges in adoption of climbing beans production Figure 2. Therefore, this reduce

adoption and production of this potential crop. To overcome this problem different challenges are identified in table below. About 100% of respondents indicated low capital as the main challenge climbing beans cultivation. Most of smallholder farmers use traditional methods of cultivation due to limited capital for purchase of farm inputs (improved seeds, fertilizer and agro-chemicals) and modern equipment (mechanization) for increasing production.

More than 82.6% of the farmers reported having problems in getting sticks for support to the climbing beans, which is critical for increasing yield. Farmers explained that sticks are scarce and very expensive due to deforestation in region. Due to high population pressure in the area, the land reserved for forests and agroforestry have been completely cleared for other land uses. The situation has been aggravated by social constraints included theft of sticks in the stores and arsonists setting fires to burn sticks.

About 77.4% of respondents identified shortage of land as one of the challenges of climbing beans production (Figure 2). Most farmers in the area cultivate on average about 0.5 ha and grow different crops. Land fragmentation into smallholdings limits expansion and increase beans production.

High cost of inputs was also indicated among the challenges identified by the respondents in the study area (Figure 2). About 57.9% of farmers reported high cost of farm inputs among other challenges met by producers. The price of fertilizers, improved seeds and agrochemicals is too high in the study area which many farmers cannot afford leading to the low productivity of climbing beans.

Weather related constraint was heavy rain, which leads to rotting of stakes and strong winds that cause lodging of the crop. Crop. Unreliable rainfall was identified among the challenges by 54% of the farmers. Unreliable rainfall is critical because bean production in the study area is predominantly rain-fed. The rainfall patterns have changed recently and at times rains come too late in the season and only for a short period. Sometimes rain occur during the off-season when farmers have not prepared to plant a crop. This causes farmers to get low yields due to erratic rainfall and high post-harvest losses due to high quantity of rotten grains if it rains during the harvesting period.

Inadequate extension services were identified among the

challenges. This limits awareness of the availability of improved bean varieties and improved production technology. Extension agents play vital roles in disseminating information on new technologies and good agronomic practices for capacity enhancement to the farmers.

About 45% of the respondents identified price fluctuation of climbing bean varieties as one of the challenges by producers. The prices of staple foods rise significantly during the period between harvests. Prices are lowest immediately after harvest and highest before the next harvest. High market price in one season may lead to high production in the following season leading to a glut and hence low market price in the subsequent season. This is a serious constraint because farmers are often forced to sell at low prices that affect their profit margin.

Unreliable market for climbing beans was identified as a challenge to the farmers. Most of the farmers sell their produce soon after harvesting at low price because of the law of supply and demand. Due to this unstable market, intermediaries reduce the prices of produce even before harvesting. This challenge causes farmers get low returns on their investment in beans production as well as in other crops like peas and sorghum.

Pests and diseases are a challenge to the farmers. They lower the yields and quality. About 72.8% of farmers indicated that intermediaries offer very low market prices as early as when the crops start the flowering. This lowers the morale of farmers to increase beans production.

4. Conclusion and Recommendations

The results showed that majority of the people who participated in this study were Female compared to Men. The findings indicated that the majority of farmers grow their beans on the area less and equal to 0.5ha. The results revealed that eight variables out of nine were positively influences beans adoption while two variables were negatively influenced the adoption of climbing beans. The most climbing bean varieties grown in study area are Injyamane/Koruta, Cyenyerumpure, Nyiragatuku, and Nyiragahondo while bush beans grown are Gacwekano, Nyiragakara, Kivuzo, and Kabonobono.

The results indicated that the average yield for farmers using Climbing beans varieties 2350kg/ha while the average yield for bush beans varieties is only 975 kg/ha. The results indicated that climbing beans produce up to three times more than the bush beans varieties. Injyamane/Koruta is statistically superior to the other climbing varieties, and more adopted due to its high yield, high price and proximity to the local and regional market.

The results also indicated that, the majority of respondents in the study area reported low capital, stakes, Inadequate extension services, shortage of land, middlemen, high costs of inputs, price fluctuation, climate changes and pests and diseases are the main challenges meet in the cultivation of climbing beans varieties. These challenges reduce both quality and quantity of beans in study area. The stakes are scarce and very expensive due to the deforestation in region caused main

by high population pressure and use of tress as the main source of energy.

Based on the conclusion, the following recommendations are suggested towards increasing adoption of climbing beans varieties in study area.

1. Afforestation, increasing agroforestry trees, adoption of poles and ropes, which can be used as staking materials, should be reinforced in study area. This will help to improve soil fertility through N-fixation, erosion control, environmental protection. Climbing bean residues complement animal feeds and organic manure production.
2. Strengthen agriculture extension services in study area; the focus should be more on Farmer Field School, demonstration plots, trainings to help farmers to become expert themselves.
3. The government and other agencies especially RAB should improve the price of farm inputs for smallholder farmers as well as to increase the number of farmers to enter the sector.
4. Police makers should provide standard measures, high and strong strategies to fight against the middlemen in agriculture sector as well as to increase the income for smallholder farmers.
5. Farmers should be encouraged to leave the bush beans and adopt climbing beans that provide high production and productivity per unit area due to its use of more air space than land.

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