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# Effects of Integrated Support Programme for Arable Agricultural Development (ISPAAD) on the Income of Sorghum Farmers: Evidence from Kweneng District, Botswana

**Gaboinewe Motlhwa[1], Mgale Yohana James[1,2*] and Yan Yunxian[1]**

*[1]College of Economics and Management, Jilin Agricultural University, Changchun, China.*
*[2]Institute of Rural Development Planning, Dodoma, Tanzania.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. Author GM designed the study, wrote the protocol, performed the survey and managed literature. Authors MYJ performed the statistical analysis, wrote the first draft of the manuscript and helped in literature searches. Author YY supervised precisely the whole work. All authors read and approved the final manuscript.*

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## ABSTRACT

This paper examines the factors influencing participation decisions among the farmer's households of the Integrated Support Program for Arable Agricultural Development with the logistic model and assesses its effects on the agricultural sector in Botswana. Using random sampling, data were collected from 397 households at Kweneng District. The results showed that farm size, type of seed provided, amount of fertilizing, household size, access to extension services, availability of labour, sex of the farmer, risk attitude, total productivity per hectare and group participation were statistically significant at 1% or 5% level. Further analysis revealed that participation improves the income of small-scale farmers.

**Corresponding author: E-mail: mgaleyj@gmail.com;*

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## 1. INTRODUCTION

### 1.1 Background Information

Sorghum is the most important cereal crop grown globally [1], probably because of its diversity. Sorghum is mostly grown in the arid and semiarid areas of Africa and Asia for food security. The future of sorghum production is linked to its contributions to food security, income growth and poverty alleviation [2]. This is more relevant in sub-Saharan countries than in other nations.

In Botswana sorghum is a traditional crop, which is grown in many parts of the country, especially in the arid and semi-arid areas of the country. The crop lost favour with farmers when maize became the preferred crop and staple food after its introduction by the European settlers. However, due to the desire to stabilize food security in, which are known to be well adapted to the harsh environment with the assistance by the government. However, the performance of sorghum production among small-scale farmers has still remained low [3].

Cereal production in Botswana is based on rain-fed farming. However, the low and erratic rainfall patterns coupled with relatively poor soils make crop production, in general, a high-risk system with low productivity [4]. Arable crop production is carried out by both commercial and subsistence farmers with the domination of small traditional farms with an average farm size of 5 hectares or less [5]. Sorghum and maize are two of the major crops grown in terms of area planted. Traditionally, sorghum is the most important crop and best suited to Botswana's agro-climatic conditions [6].

The Government of Botswana has been investing in subsidy schemes to provide farmers with inputs such as seeds and fertilizers, draught power for tillage operations and assistance in land preparation and development in a bid to improve agricultural productivity and increase yields. These schemes, over the years, included Arable Land Development Program (ALDEP); Accelerated Rain-Fed Arable Program (ARAP); National Agriculture Master Plan for Arable Agriculture and Dairy Development (NAMPAAD) as well as the most recent Integrated Support Program for Arable Agricultural Development (ISPAAD). There have been some additional concerns that these schemes have failed to achieve the desired outcomes.

Thus, from a short foregoing review, it was clear that there was a need to conduct an empirical analysis by identifying and analyzing the various factors that affect small-scale farmers towards participation in ISPAAD subsidy programme together with the effects of such participation. These will help the government and development partners to implement favorable policies that support both farmers and input suppliers in sorghum production arrangements if agricultural commercialization and poverty reduction is to be achieved in Botswana.

### 1.2 Agricultural Input Subsidies: Theory and Evidence

Agricultural subsidy can be defined as the sum of money, goods or services from public funds to help the agricultural industry or business keep the price of a commodity or service low and affordable in order to achieve a specific goal [7]. Input subsidies have been one of the most common forms of subsidies used as policy instruments in both developed and developing countries, particularly in the 1960s and 1970s [6,8].

Government intervention in economic policy has been strongly supported by the Keynesian school [9]. For Keynes, the economic optimum is not obtained with markets left to themselves. Government interventions help to adjust prices in imperfect markets that respond slowly to fluctuations in supply and demand. In addition, subsidies can help build public goods, facilitate public investment, and improve the incomes of poor producers and consumers.

In the context of the functioning of the pure and perfect market, neoclassical and classical schools suggest that subsidies on private goods can create significant distortions in the markets and disadvantage one economic actor over another: increase prices to consumers, confer competitive advantages or distort market rules. Indeed, the fundamental question of the subsidy is its efficiency but also the costs associated with its implementation. The choice of a subsidy policy must therefore be based on a trade-off analysis that clearly identifies the gains and losses associated with this measure.

There is, however, limited empirical evidence concerning the effectiveness and efficiency of input subsidy interventions on agricultural productivity and income in sub Saharan Africa. In Malawi, the subsidy program was found to increase production and farm household income [10,11]. Also in the assessment of Ghana GFSP program done by DANIDA [12], the study concluded that only few farmers actually benefited from the program, the outcome were uncertain, and the effects were likely to be temporary. On the other hand, a study done in Kano District in Nigeria finds that farmers who participate in the subsidy program tend to be poorer than non-participants [13].

### 1.3 ISPAAD Subsidy Package in Botswana

ISPAAD subsidy scheme offers several services packages to arable farmers who are 18 years and above. Subsistence farmers qualify for 100% of the subsidy on hybrid seed and open-pollinated seeds to plant up to 5ha and 16ha, respectively. They also receive a 100% subsidy of 200kg/ha of basal fertilizer and herbicides, for ploughing and row-planting, to treat up to 5ha. On the other hand, commercial farmers qualify for 30% subsidy on seed, and fertilizer to plant up to 500ha. Registered suppliers sell inputs to farmers and reclaim the subsidy amount from the Department of Agriculture whereby input costs are covered at market prices [14].

Furthermore, the government established the Agricultural Service Centers (ASCs) across the country to assist subsistence farmers to plough, harrow, and row plant a maximum of 5ha for free. Excess up to 16ha is provided at 50% subsidy. The ASCs also rent out machinery and associated implements to farmers at cheap cost, they also provide skills and knowledge. ISPAAD includes a provision for free potable water for arable production clusters by either drill and/or equip boreholes, or purchase and equip existing boreholes where possible. Cluster management committees are responsible for the operations and maintenance of boreholes and cluster fences.

ISPAAD facilitates access to seasonal loans to arable farmers by subsidizing interest rates through the National Development Bank (NDB). The credit facility covers agricultural inputs such as seeds, fertilizer, labour cost for planting, weeding, pesticides, diesel, bird scaring, harvesting, farm machinery repair, and maintenance. NDB provides seasonal loans to farmers at a prime interest rate and claims the difference between prime and market interest rates from the Ministry of Agriculture. Small-scale farmers are expected to produce 1ton/ha with all the service packages offered to arable farmers under ISPAAD.

## 2. METHODOLOGY

### 2.1 Study Area

This study was conducted in Molepolole Village, Kweneng District under ISPAAD Programme. Molepolole is one of the biggest villages in Botswana, in terms of its size and population of about 63,248 according to the Geo-Names Geographical database. The study area has also been selected based on the fact that the Kweneng District is the most suitable for the production of cereals, particularly sorghum because of its climate and environmental conditions.

### 2.2 Data Collection

A cross-sectional design was used to gather information from a representative sample of the population. The study involved ISPAAD beneficiaries and non-beneficiaries, these farmers were randomly selected from a list of names available to the extension officers. Both probability and non-probability sampling were employed. Under probability sampling, the simple random sampling method was used to select ISPAAD beneficiaries in the Southern Kweneng District whereby non probabilistic was used to select key informants.

The study used both primary and secondary data. A combination of four different methods (individual beneficiary interviews, focus group discussions, key informant interviews, and personal observations) was used to collect primary data. Primary data was mainly cross-sectional. Data were collected using different methods and sequenced data collection approach whereby in-depth insight on the performance of ISPAAD since its establishment in 2008. The formula by Yamane was used to determine the total sample size which includes the participants and non-participants population [15]. A total of 5 focus group discussions and 397 individual interviews were conducted with randomly selected ISPAAD beneficiaries and non-beneficiaries from Molepolole village and surrounding areas.

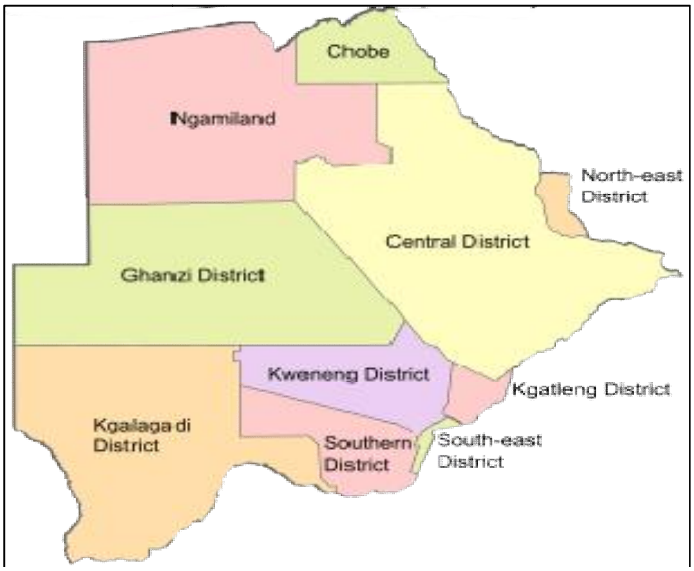


**Fig. 1. The map of Botswana districts**

## 2.3 Methods

Both descriptive and inferential statistics were analyzed. The descriptive analysis used to substantiate the information between the variables across two groups (beneficiaries and non-beneficiaries of ISPAAD programme).

A binary logistic regression model was used to test the hypothesis that farming households' socio-economic variables influence farming households' decision to participate in input subsidy programmes. Farmers' decision to participate in any production activity or not, is influenced in part by the perceived balanced of benefits, opportunities, and constraints. The model was used in the analysis because it allows one to predict a discrete outcome, such as group membership, from a set of variables that may be continuous, discrete, dichotomous, or a mix of any of these [16].

Using a model adapted from Gujarat,

$$P_i = E\left(Y_i = {}^{1}/_{X_i}\right) = \frac{1}{1+e^{-(\alpha_0+\sum_{i=1}^{k}\alpha_i X_i)}} \quad (1)$$

Where, $P_i$ represents the probability of household $i$ to make the decision to participate in subsidy program or not $(1 - P_i)$, $Y_i$ is the level of participation by household $i$, $X_i$ represents a set of explanatory variables that influence the household $i$ to participate in subsidy program activities (such as; farmer and farm-specific characteristics, institutional, geographic and political factors), and $\alpha_i$ represents the parameters to be estimated.

Taking the natural logarithm of odd-ration $P_i / (1 - P_i)$ gives rise to the logarithm of the odds ratio as:

$$L_i = \frac{P_i}{(1-P_i)} = \alpha_0 + \sum_{i=1}^{k}\alpha_i X_i + \mu_i \quad (2)$$

Where $L_i$ is called the logit – hence the term "logit model". Upon rearranging equation (2), with the dependent variable in log-odds ($P_i$), the logistic regression can be manipulated to calculate the conditional probabilities. Given the calculated conditional probabilities for each sampled household, the partial (marginal) effects of the discrete (categorical) variables on the probability of the household participated in the subsidy program is determined from the expression:

$$\frac{\partial P_i}{\partial X_i} = P_i(1 - P_i)\alpha_i \quad (3)$$

Hence, the partial effects are calculated by taking the differences of the mean probabilities estimated for the respective discrete variables, i.e. when $X_i = 0$ and$X_i = 1$. The partial effects of the continuous variables on the probability of the household participated in the subsidy program are determined by rescaling the parameter estimate from the logistic regression with a scale factor by simply subtracting the coefficient from the scale factor.

Furthermore, Propensity Score Matching (PSM) was used to evaluate the impact of input subsidy on the net income of sorghum farmers with participation in the subsidy program as the treatment. PSM being a non-experimental method, it is suitable for this study as the subsidy program doesn't have investigational farmers who act as the control group [17].

The expected treatment effect of participation in the input subsidy program or Average Treatment effect on Treatment (ATT) is the difference between the actual income and the income if they did not participate in the subsidy program. This is given as;

$$ATT = E\left(Y_{1i} - {}^{Y_{0i}}/_{P_i}\right) = 1 \quad (4)$$

Where $Y_{1i}$ denotes income when the $i^{t\square}$ farmer participates in the subsidy program, $Y_{0i}$ is the income when the $i^{t\square}$ farmer did not participate in the input subsidy program, and $P_i$ denotes participation, 1= participate, 0 = otherwise, $ATT$ is also called conditional mean impact.

The mean difference between observable and control is written as;

$$D = E\left(\frac{Y_1}{P_i} = 1\right) - E\left(\frac{Y_0}{P_i} = 0\right) = ATT + \varepsilon \quad (5)$$

Where $\varepsilon$ is the bias, also given by:-

$$\varepsilon = E\left(\frac{Y_1}{P_i} = 1\right) - E\left(\frac{Y_0}{P_i} = 0\right) \quad (6)$$

The true parameter of $ATT$ is only identified if the outcome of treatment and control under the absence of subsidy are the same. This is written as:

$$\left(\frac{Y_1}{P_i} = 1\right) - E\left(\frac{Y_0}{P_i} = 0\right) \quad (7)$$

## 3. RESULTS AND DISCUSSION

### 3.1 Description of the Variables Specified in the Model

The survey elicited information about farmers including age, gender, experience in sorghum production, total farm size under cultivation, labour used, extension contact, etc. Table 1 present a summary of the socio-economic characteristics of subsidy beneficiaries and non-subsidy beneficiaries in the study area. Using descriptive analysis, the farmers were generally homogeneous with regard to household characteristics. Out of the 397 respondents 148, representing 37.3% were female with the remaining 62.7% being males. All the respondents were literate and had some form of education or formal training. Indeed, more than half of the respondents (66.3%) had received basic education and 33.6 had received secondary education and above, indicating a relatively good level of literacy among sorghum farmers. The survey also revealed that most sorghum producers, about 77.9% are full-time farmers engaged basically in growing and managing their crops. It is therefore not surprising to find from the results that while 38.9% indicated they earned off-farm income, 61.1% of the farmers declared that their sole source of income was from sorghum production. The major sources of off-farm income and activity that the other farmers engaged in were trading, carpentry, gardening and employment as civil servants. In total 265 (66.8%) out of the 397 respondents declared that they had one form of extension contact or the other. The extension contacts either came from the regular government source or from NGOs.

Further analysis in Table 1 presents the socio-economic profile of beneficiaries and non-beneficiaries of the ISPAAD Subsidy programme. The ages of both categories of farmers ranged from 20 to 65 years with a mean age of 44 years. There was no significant difference between the years of farming experience in the survey area with a mean of 13.64 years. Beneficiaries' ad non-beneficiaries farmers also do not differ significantly in terms of their endowments with labour.

Farmers participating in ISPAAD Program used an average of nine (9) per head compared to the average of seven (7) labourers by non-subsidy farmers. Similarly, farmers participating in the programme tended to cultivate comparatively large acreages, an average of about 5.69 acres whiles non-subsidy farmers cultivated on average of 3.61 acres. This result suggests that indeed availability of land is an incentive or a major determinant of a farmer's decision to participate in ISPAAD arrangements.

### 3.2 Activity Participation Patterns

In this study, activities were divided into five major categories namely; sorghum production, cultivation of other crops like maize and sunflower, livestock keeping, small business and other activities (wages and salaries from non-agricultural activities). Table 2 shows

participation rate, income share and that mean income by sources for the household sampled. From the Table, it is clear that participation in multi activities was a common phenomenon among households in the area of study, which is line with other observations in rural Africa with crop production as the main source of income.

### 3.3 Factors Influencing Farmers' Decision to Participate in the Subsidy Programme

The logistic regression was used to analyze the influencing factors on farmers' decision to participate in subsidy programs. Table 2 shows the estimated coefficients (β values), standard error, significance values correlation coefficient ($R^2$), Chi-test ($\chi^2$) statistics and odds ratio of independent variables in the model. Results shows the correlation coefficient ($R^2$) value of about 0.5614 which means that about 56.14 percent of the variation in participation in subsidy program is explained by financial assets (total sorghum production), human capital assets (labour, farming experience, extension services), physical assets (farm size, household size, amount of fertilizer, type of seed) and social assets (grouping).

**Table 1. Descriptive statistics of the different variables of the model**

| Qualitative variables | | | | Quantitative variables | | | |
|---|---|---|---|---|---|---|---|
| **Criteria** | **Description** | **No of farmers** | **% farmers** | **Characteristic** | **Mean** | **Mean (SB)** | **Mean (NSB)** |
| **Gender** | Male | 249 | 62.7 | Age | 43.81 | 44.29 | 43.21 |
| | Female | 148 | 37.3 | No. of years in farming | 13.64 | 13.49 | 13.90 |
| **Education status** | Basic | 263 | 66.2 | No. of labours used | 8.25 | 9.24 | 7.67 |
| | Secondary & above | 134 | 33.8 | Total farm size | 6.13 | 5.35 | 6.68 |
| Farmers dependents on agriculture only | | 309 | 77.8 | Household Size | 5.3 | 5.6 | 5.1 |
| Farmers with extension contact | | 265 | 66.8 | Yield per acre harvested | 365.72 | 381.32 | 220.89 |

*Standard deviations are in parenthesis; SB = Subsidy Beneficiary, NSB = Non – Subsidy Beneficiary*

**Table 2. Activities participation rates, mean incomes, and shares in total household income**

| Activity | Beneficiaries | Non-beneficiaries |
|---|---|---|
| **Sorghum production** | | |
| Participation rate | 100% | 100% |
| Mean income (BWP) | 1,382.79 | 973.65 |
| Income share | 33.34% | 26.46% |
| **Cultivation of other crops** | | |
| Participation rate | 100% | 100% |
| Mean income (BWP) | 1,241.94 | 1146.37 |
| Income share | 26.16% | 22.63% |
| **Livestock keeping** | | |
| Participation rate | 23.7% | 17.3% |
| Mean income (BWP) | 355.08 | 504.68 |
| Income share | 7.48% | 15.30% |
| **Small business** | | |
| Participation rate | 22.8% | 35.3% |
| Mean income (BWP) | 522.17 | 1,087.76 |
| Income share | 15.83% | 22.92% |
| **Other activities** | | |
| Participation rate | 14.6% | 9.7% |
| Mean income (BWP) | 479.33 | 652.25 |
| Income share | 10.09% | 19.78% |

The value of $R^2$ shows there is a correlation between participation in subsidy programme and factors influencing farmers' decision to participate. Further analysis shows that, of the fourteen independent variables used in the model, only ten variables were statistically significant at 1% and 5% significance level. Almost all variables were positively related to a dependent variable [participation in SP] but only three variables [labour, farm size] are negatively related to the dependent variable. In all but one of the cases, the signs of the estimated coefficients are consistent with the prior expectations.

The household size variable is positively significant at 1%, which means that if the household size increases by one unit, the probability of participating in the subsidy program increases by 7%. This result can be explained by the fact that most households use family labour, so the more the labour increases, the more the cultivated area increases and the more their use of fertilizer increases. The area planted variable is negatively significant at 5%, which means that the more the area increases by one unit, the more the probability of participating in the subsidy program decreases. This result can be explained by the fact that the subsidy programme is done by population targeting. So the larger the area, the more the producer is classified as a major producer because only small-scale producers participate in the programme.

The variable amount of fertilizer used is positively significant at 1%, so if the amount of fertilizer used increases by one unit the probability of participating in the subsidy programme increases by 0.672. This result shows that the lower price of this input allows producers to use it more. The risk attitude variable is positively significant at 5%, which means that the risk-averse farmers are more likely to participate in the subsidy programme. This result can be explained by the fact that most farmers would like to transfer their risk to the second part which is ISPAAD. Sex is positively significant at 1% meaning that men are more likely to participate in the subsidy program than women. This result can be explained by the fact that the majority of the heads of household are men and the only condition that can make the woman head of the family is the death of her spouse. The type of seed variable is positively significant at 1%, so the use of one more unit of improved seed increases the likelihood of participating in the subsidy programme. This can be explained by the fact that the fertilizer subsidy and the improved seed subsidy are done jointly, hence proves that those receiving the fertilizer subsidy are benefiting from the improved seeds at the same time.

As far as human capital is concerned, the variable family and hired labor also negatively affect the likelihood of participation in the subsidy programme at 5 percent level of significance. This implies that households with bigger family labor and who are capable of hire labor are more likely to cultivate large farms, hence disqualify from being small-scale producers. A positive and significant relationship at 5 percent level of significance between participation in subsidy programme and the availability of extension services implies that households who are visited more by extension officers have larger chances of gaining more information on ISPAAD related issues, hence increase their participation chances compared to their counterpart farmers.

### 3.4 Effects of Participation in ISPAAD Subsidy on Farmers' Income

To assess the effects of the ISPAAD subsidy programme on the income of small-scale farmers, propensity score matching (PSM) was applied. First, propensity scores were estimated for all the 397farmers including 257 non-beneficiaries (control) and 140 subsidized farmers (treatment). The result shows that the predicted propensity score for beneficiaries ranges from 0.0225 to 0.8612, with a mean of 0.4925. While the predicted propensity score ranges from 0.0031 to 0.7380, with a mean of 0.3672 among non-beneficiaries of ISPAAD Programme. The results indicating that all the individual that participated in the subsidy programme found a suitable match among those who did not participate. Thus, the common support assumption is satisfied in the region of [0.0031, 0.7380].

Secondly, the total income (farm and non-farm) were adjusted in relation to the household size and tested for significance by using $t-test$. The results in Table 4 indicate both the mean adjusted household income and household size for the beneficiaries and non-beneficiaries of ISPAAD program. A $t-test$ show that, the adjusted household size was significant at 1% with t-value of 4.215 while there was no significant difference between the two means of adjusted income between the beneficiaries and non-beneficiaries of the subsidy program.

**Table 3. Results of logistic estimation**

| Variables | Coef. | Std. Error. | $P > \|z\|$ |
|---|---|---|---|
| Sex | 3.207 | 0.363 | 0.001* |
| Age | -0.013 | 0.015 | 0.389 |
| Type of seed | 1.225 | 0.091 | 0.011** |
| Farmers income | -0.402 | 0.348 | 0.248 |
| Availability of Family labour | -1.150 | 0.503 | 0.022** |
| Availability of Hired labour | -0.413 | 0.172 | 0.016** |
| Farm size under cultivation | -0.739 | 0.062 | 0.023* |
| Number of extension visit | 0.221 | 0.096 | 0.021** |
| Farming experience | -0.343 | 0.195 | 0.078 |
| Household size | 0.683 | 0.258 | 0.008* |
| Risk attitude | 0.005 | 0.632 | 0.023** |
| Amount of sorghum harvest | 0.021 | 0.008 | 0.014** |
| Amount of fertilizer | 0.672 | 0.377 | 0.001** |
| Membership of agricultural group | 0.141 | 0.359 | 0.695 |
| _cons | 0.193 | 1.282 | 0.000 |

*Note: *, ** and *** means statistically significant at 1%, 5% and 10% respectively*

**Table 4. $t-$ test results on adjusted household income and size**

| Variables | Mean for beneficiaries | Mean for Non-beneficiaries | $t-$values |
|---|---|---|---|
| Adjusted income | 799.86 | 892.94 | 0.238 |
| Adjusted household size | 2.4708 | 2.1537 | 4.215*** |

*Note: *, ** and *** means statistically significant at 1%, 5% and 10% respectively*

**Table 5. Income average treatment effects on the treated (stratification matching) results**

| Beneficiaries | Non-beneficiaries | ATT | S.E. | $t-values$ |
|---|---|---|---|---|
| 140 | 257 | 337.9515 | .325641 | 4.11*** |

Third, to determine the impacts of the inputs subsidy on the farmers' income, the adjusted household income was input into the propensity score model and matched using the stratification approach. The results are presented in Table 5.

The t-statistic was greater than two hence showing that there was a significant difference between the beneficiaries and non-beneficiaries after matching. The results indicate that the ISPAAD subsidy programme had a positive effect on the farmers who were in the program with the farmers having an additional mean annual income of BWP. 337.95. The results are in line with the study done in Anambra State which evaluated the performance of the scheme among food crop farmers [18]. The study revealed that farmers realized mean annual incomes of ₦ 433,974.87 and ₦ 717,796.48 before and after joining the scheme respectively. Also, the study conducted in Malawi [19], found that the Agricultural Input Subsidy Program increased the income of farmers by 1,567 to 1,705 Malawian Kwacha. From the study, the increase in income has helped farmers to increase their consumption expenditure on education, health, construction of modern houses, purchasing of household assets and saving in various.

## 4. CONCLUSION

This paper intended to examine the determinants of access to the Input subsidies in Botswana under the Integrated Support Program for Arable Agricultural Development (ISPAAD) and evaluate the impact of the subsidy programme on the income of small-scale farmers. The logistic regression estimation variables, such as sex, risk attitude of farmers, availability of labor (family and hired), household size, the area planted, the quantity of fertilizer, type of seed, and access to extension services were found to be significant to explain the decision of small-scale farmers to participate in the subsidy programme. The results of propensity score matching also

identified that participation in the subsidy program indeed improves the income of participating farmers. The implication of these findings is that the input subsidy programme can reduce rather than entrench rural poverty as some studies have suggested [18-20].

In view of these results, the Botswana government is encouraged to expand its subsidy budget to meet the input needs of small-scale farmers who cannot get their supplies from the market with the aim of promoting agricultural input intensification. Furthermore, the government needs to monitor these policies/programs closely by strengthening existing agricultural support network and introducing transparency standards in the distribution of subsidized inputs to ensure the cost of the subsidy are bearable for the government and intended results are achieved.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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