Asian Journal of Agricultural Extension, Economics & Sociology

39(10): 336-348, 2021; Article no.AJAEES.73761
ISSN: 2320-7027

Socio-Economic Factors Influencing Usage Ofclimate Driven Seed Maize in Zimbabwe

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2021/v39i1030700
Editor(s):
(1) Dr. Sailendra Narayan Goswami, Natural Resource Management, India.
Reviewers:
(1) Santosh Kumar Samantaray, Odisha University of Agriculture & Technology, India.
(2) Kalinca da Silva Oliveira, Federal University of Health Sciences of Porto Alegre (UFCSPA), Brazil.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73761

Original Research Article

Received 27 July 2021
Accepted 01 October 2021
Published 04 October 2021

ABSTRACT

The study sought to analyze the factors influencing the use of climate specific certified seeds by maize farmers in Zimbabwe. In terms of the specific objectives the study determined the level of certified seeds produced and utilized in Zimbabwe and examined the factors that influence the level of climate specific certified seeds by farmers in Zimbabwe (2010-2016) farming seasons. In terms of the research methodology, the study adopted an explanatory and gathered data from 53 participants within the maize value chain using a questionnaire. Drawing from the findings, the study revealed that the certified seed maize production increased significantly although utilization declined in the same 2010-2016 period and the surplus gap between supply and demand of certified seed was exported due to low local utilization level. The research concluded that 11.38% of the variance in certified seed maize utilized by farmers under unions are explained by the price of hybrid seed maize, quantities of fertilizer, seed maize, herbicides produced by agricultural companies as well as age differences, educational differences, backward and forward markets within the maize value chain. In order to address the gap between seedmaize produced and adopted by farmer unions, the government, must develop exist strategies which involves rural financing and lending options and prioritize a culture of investing innovations among farmer unions. Such investment strategies must provide access to

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climate specific certified seeds such as high analysis maize blend fertilizers, hybrid seeds, herbicides and irrigation equipment required as a package to improve maize production in Zimbabwe.

Keywords: Certified seeds; maize value chain; production; utilization.

1. INTRODUCTION

1.1 Categorization of Zimbabwean Farming Sector

Zimbabwe is one of the agricultural based nation located in the southern part of Africa with approximately 386 850 km^2 arable land with maize grown as a strategic crop on 40% of the land [1]. Vincent and Thomas in Chinhamora and Choga [2] categorized Zimbabwean farming regions into agro-ecological regions on the basis on rainfall regime, soil quality and vegetation, among other factors. The quality of the land resource, distribution of rainfall and vegetation cover declines from agro-ecological Region 1 through to agro-ecological Region 5 of Zimbabwe [3]. Chinhamora and Choga [2] argues that the rainfall patterns highlighted by Vincent and Thomas were applicable in the period 1960 until 1980s which is the period climate change effects started to affect nations across the Southern African Development Community (SADC) region.

1.2 Changes in the Climatic Patterns and Demand for Innovative Certified Seeds

Taking research conducted in early 2000, Chinhamora and Choga [2] argues that climatic conditions in Zimbabwe now require commercial farmers to put their focus on new techniques, climate specific certified seed maizesuch as hybrid seed maize and other agricultural process innovations to improve maize productivity in the agricultural sector. This is also emanating from the studies conducted by Metrological department of Zimbabwe since 1998 which is providing evidence that Zimbabwe as an agro-based nation used to receive an effective rainfall between October and March in the early 2000s with effective rainfall of 990 mm in agro-ecological zones 1 and 2, whereas 457 mm in agro-ecological region 3, 4 and 5 [4]. Drawing from the Meteorological Department [4], Zimbabwe has been and is still experiencing chronic droughts associated with erratic and undistributed rain since 2002 which is a critical concern in Zimbabwe as maize is regarded as a strategic crop which contributes both to household and national food security as well value chain development. It still holds that maize production among other crops such as tobacco, cotton and some horticultural crops is still required in abundance to meet the pressurizing demand driven by backward market linkage from consumers for achieving a higher food self-sufficiency and a forward linkage from maize output processors such as National Foods Private Limited (Pvt. Ltd) for industrialization along the maize value chain [5].

According to Rukuni [6], the uncertain climatic conditions in Zimbabwe are affecting maize crop production patterns and levels in agro-ecological Regions 1 - 5. The rainfall pattern in Regions 4 and 5 is undistributed and erratic which makes crop production, maize production risky [7]. However, farmers in regions 4 and 5 are now affected as they are not economically earning marginal benefits out of maize production as well as livestock production due to perennial rivers dry-out, and poor pastures which is now a threat to their sustainable livelihoods. The agro-ecological Region 1 and 2 of Zimbabwe where most of the commercial maize and other cash crops like tobacco, tea, coffee, rice and potatoes are grown has been affected since 2000 with undistributed rainfall patterns affecting farmer decisions to produce annually and seasonally [8]. Based on the unbearable climatic conditions in Zimbabwe, adoption of innovations such as climate specific certified varieties has become a prime driver to commercial maize productivity under farmer unions [8]. Having understood the prime driver for the need to facilitate innovation within maize production in the Zimbabwean maize value chain it is imperative to have a background on the farmer union's demographic characteristics in relation to the level of innovation. Therefore, in terms of the purpose of the study this paper looked into the analysis of the factors influencing the use of climate specific certified seeds by maize farmers in Zimbabwe.

2. RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

The specific research objectives were as follows:

1. To determine the level of certified seeds produced and utilized in Zimbabwe (2010-2016) farming seasons
2. To examine the factors that influence the level of climate specific certified seeds by farmers in Zimbabwe (2010-2016) farming seasons.

The research question were as follows:

1. At what level do price of certified seed price influence level of seedmaize utilization by farmers in Zimbabwe?
2. At what level do quantities of fertilizer, seed maize, herbicides production influence level of seedmaize utilization by farmers in Zimbabwe?
3. At what level do age and educational differencesinfluence level of seedmaize utilization by farmers in Zimbabwe?
4. At what level do backward and forward marketsinfluence level of seedmaize utilization by farmers in Zimbabwe?

3. LITERATURE REVIEW AND THEORETICAL BASIS

According to Max [3], low innovation adoption is one of the factors explaining lagging agricultural productivity growth in Africa. In 2002, the most recent year for which data are available, the average intensity of certified seed maize use in Sub-Saharan Africa was only 8 retained seed is common in developing regions. Even when countries and crops in similar agro ecological zones are compared, the rate of innovation use is much lower in Africa than in other developing regions, and crop yields are correspondingly lower. However, there is a weak relationship between fertilizer and other inputs production and fertilizer usage [9]. Some of the associated factors are primarily costs incurred in acquiring fertilizers as suggested by Keller [10].

Manro [11] in his research noted that the average innovation production level is positively and significantly correlated with the innovation adoption rate in most developed countries which are production driven. This confirms from an empirical point of view the theoretical link between innovation adoption and innovation production. Manro [11] suggests that there is no clear relationship for the countries with low levels of productivity especially with low demand for innovation demand. From literature, it seems, therefore, that the adoption of innovation production affects innovation adoption in those countries that already experience high levels of productivity, probably due to the presence of other intangible assets such as human capital, social capital and entrepreneurship, that is, absorptive capacities.

Drawing from Bass [12], many empirical researchers afterwards tried to provide evidence on the certainty of their hypothesis to explain innovation production and innovation adoption: while the development of the technology frontier reflects the rate at which new discoveries are made, the adoption of such technologies depends on the implementation/adaptation of these discoveries, and varies positively with the distance between the technology frontier and the level of current productivity [13].

Therefore, much empirical literature on innovation adoption has focused on its impact on productivity or productivity growth leaving out innovation production. In one set of papers, if RandD of firm j is positively correlated with total firm productivity in firm i, all else being equal, this is consistent with technology spill overs from firm j to firm i [10]. A variant of this approach replaces total firm productivity by the number of patents in region i to patents in other regions, where the latter is instrumented by RandD expenditures [14], and (Peri, 2014).

3.1 Underpinning Theory: Diffusion Innovation Theory

Diffusion of Innovation (DOI) theory, developed by E.M. Rogers in 1962, is one of the oldest social science theories [12]. It originated in communication to explain how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system. The end result of this diffusion is that people, as part of a social system, adopt a new idea, behaviour, or product. Adoption means that a person does something differently than what they had previously done such as, purchase or use a new product, acquire and perform a new behaviour. The key to adoption is that the person must perceive the idea, behaviour, or product as new or innovative. It is through this that diffusion is possible [15].

The adoption of a new idea, behaviour, or product does not happen simultaneously in a social system; rather, it is a process whereby some people are more apt to adopt the innovation than others. Researchers such as Bryn [15] have found that people who adopt an innovation early have different characteristics than people who adopt an innovation later. Therefore, this theory is a support theory to

Giddens [16] in the sense that the theory emphasizes that when promoting an innovation to a target population (maize value chain players as suggested in the conceptual framework), it is important to understand the characteristics of the target population (Corporate Culture and Leadership) that will help or hinder the adoption of the innovation. There are different established adopter categories, and while the majority of the general population tends to fall in the middle categories, it is still necessary to understand the characteristics of the target population [17]. When promoting an innovation, there are different strategies used to appeal to the different adopter categories, the following three were adopted in the study:

1. **Early Adopters** - These are people who represent opinion leaders. They enjoy leadership roles, and embrace change opportunities. They are already aware of the need to change and so are very comfortable adopting new ideas. Strategies to appeal to this population include 'how-to' manuals and information sheets on implementation. They do not need information to convince them to change.
2. **Late Adopters** - These people are skeptical of change, and will only adopt an innovation after it has been tried by the majority. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully.
3. **Laggards in innovation adoption** - These people are bound by tradition and very conservative. They are very skeptical of change and are the hardest group to bring on board. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups.

The stages by which a person adopts an innovation, and whereby diffusion is accomplished, include awareness of the need for an innovation, decision to adopt (or reject) the innovation, initial use of the innovation to test it, and continued use of the innovation. There are different factors that influence adoption of an innovation, and each of these factors is at play to a different extent in the different adopter categories. Relative advantage which measures the degree to which an innovation is seen as better than the idea, programme, or product it replaces. Compatibility measures how consistent the innovation is with the values, experiences, and needs of the potential adopters. Complexity measures how difficult the innovation is to understand and/or use. Triability measures the extent to which the innovation can be tested or experimented with before a commitment to adopt is made. Observability measures the extent to which the innovation provides tangible results. Although literature has shown that there is a weak relationship between innovation creativity and adoption, little is known from Zimbabwean context with regards to production and utilization level of climate driven certified seed maize.

4. MATERIALS AND METHODS

The research was based on the interpretivism philosophical assumptions. Quantitatively, innovation was measured in terms of the level of utilization numbers of climate specific certified seed maize. The explanatory research design allowed the researcher to ascertain the association between agricultural innovations produced and utilized by farmers under unions. The sample of the study was as follows (Table 1).

However, the sample size was53 participants the maize value chain.In terms of the data analysis, in order to analyze the data a random effects panel regression model was adopted which assumptions of no perfect multicollinearity, no autocorrelation, and constant variance in error terms. The model variables were as follows (Table 2).

Table 1. Sample frame and total sample size of the study

	Sampled Participants
Seed Company Producers	5 Directors
Seed Brokers	5 Directors
Farmer Union Leadership	30 Leaders
Farmer Union Employees	10 Employees
Government Officials	3 Officials
Total	**53 Participants**

Sources: Researcher Computations

Table 2. Random effects regression model (Qit) variables

	Variables Specifications for a Random Effects Regression Model	
Independent Variables	Dummy variable for availability of seed maize at market *(0-Yes; 1-No)*	X_{1ijt}
	Dummy variable for availability of maize fertilizers at Market *(0-Yes; 1-No)*	X_{2ijt}
	Dummy variable for availability of maize herbicides at Market *(0-Yes; 1-No)*	X_{3ijt}
	Dummy variable for existence of backward markets *(0-Yes; 1-No)*	X_{4ijt}
	Dummy variable for existence of forward markets *(0-Yes; 1-No)*	X_{5ijt}
	Age difference within maize value chain	X_{6ijt}
	Dummy variable for education difference between within maize value chain (0-None; 1-Certificate/Diploma; 2-First Degree; 3-Postgraduate; 5-PhD)	X_{7ijt}
	Continuous variable price of innovation in $USD/Ha	X_{8ijt}
	Individual random effect - Average deviation of the (j^{th}) farmer's innovation use from the average for the product (i) per given period (t)	u_{ijt}
	Constant	B_0
	Coefficients or Parameters	B_{1-8}
Dependent Variable	Quantity of Climate specific certified seeds Utilized	Q_{1it}

Source: Researcher Computations

The data was presented in the form of line graph and statistical tables.

5. FINDINGS

5.1 Objective 1: Level of Certified Seed Maize Produced and used in Zimbabwe (2010-2016) Season

The first objective sought to determine the level of certified seeds produced and utilized in Zimbabwe (2010-2016) farming seasons. The following chart shows trend of certified maize production and utilization in Zimbabwe for the period 2010 to 2016.

From the trend analysis in terms of the quantities of seed maize produced and utilized the results has shown that seed maize companies produce more hybrid seed maize than OPVs. The results in Fig. 1 has shown that the production of hybrid seed maize increased at an increasing average rate of 21% rate between the seasonal periods 2010/11 and 2012/13 from 4210 metric tons to 5104 metric tons. During the same period adoption of such hybrid seed maize were lower and registered 959 metric tons during 2010/11 season and 1329 metric tons in the 2011/12 cropping season. From the results gathered and presented in the Fig. 1 the gap between hybrid seed maize produced and utilized was covered through exporting balances of 3251 metric tons and 3775 metric tons in 2010/11 and 2011/12 cropping seasons, respectively.

The seasons 2013/14 up to 2015/16 witnessed a sharp increase in the production of hybrid seed maize, although the adoption of such hybrid seed maize as agricultural product innovation was constantly declining at 15% from 1077 metric tons until 860 metric tons. Looking at the behaviour of export line, the chart is showing export behaving in the same manner as production which might suggest that demand of the produced seed maize as an agricultural product innovation in Zimbabwe might be predicted by exports rather than local demand from the value chain.

5.2 Objective 2: Factors that Influence the Level of Climate Specific Certified Seeds by Farmers in Zimbabwe (2010-2016) Farming Seasons

The second objective sought to examine the factors that influence the level of climate specific certified seeds by farmers in Zimbabwe (2010-2016) farming seasons. To confirm the factors that influence the level of climate specific certified seeds by farmers in Zimbabwe (2010-2016) farming seasons findings from a regression model for a panel data were as follows (Table 3).

In terms of interpretation of the regression coefficients, the results in Table 3 and equation (i) show that utilization of hybrid seed maize by farmer unions increases by a unit if hybrid seed maize production by seed companies increase 0.562. In addition, an increase in hybrid seed maize utilization by farmer unions increases by a unit if quantity of fertilizer for maize production has been increased from fertilizer companies by

a factor 0.154. The results has revealed that an increase in utilization of hybrid seed maize by farmer unions increases by a unit if quantity of herbicides for maize production has been increased from fertilizer companies by a factor 0.125.

Furthermore, an increase in utilization of hybrid seed maize by farmer unions increases by a unit if farmers are exposed to forward-backward markets by 0.631 and 0.314, respectively. On the other note, the difference in ages between farmers under farmer unions and employees across the maize value chain has 0.124 effect towards utilization of hybrid seed maize. Moreover, the education variation within the value chain has 0.631 effect towards utilization of hybrid seed maize. From demographics it has been shown that farmers are lagged behind in terms of knowledge compared to other players in the maize value chain. The price of hybrid seed maize as a determinant of quantity utilization has a 0.461 effect towards utilization of hybrid seed maize.The results of the study has shown that utilization of hybrid seed maize is positively related to an price of seed maize, quantity of hybrid seed maize produced, quantity of maize fertilizers produced, quantity of maize herbicides produced, proportion of backward markets maize established for maize farmers and proportion of forward markets maize established for maize farmers, age difference and educational differences with a Pearson coefficient value of 0.3374. The seasonal coefficients have shown an increase at a decreasing rate in terms of the adoption of hybrid seed maize among maize farmers within the farmer unions suggesting that although the hybrid seed maize are produced for maize production in the value chain the rate at which they are adopted as a package is 33.74%.

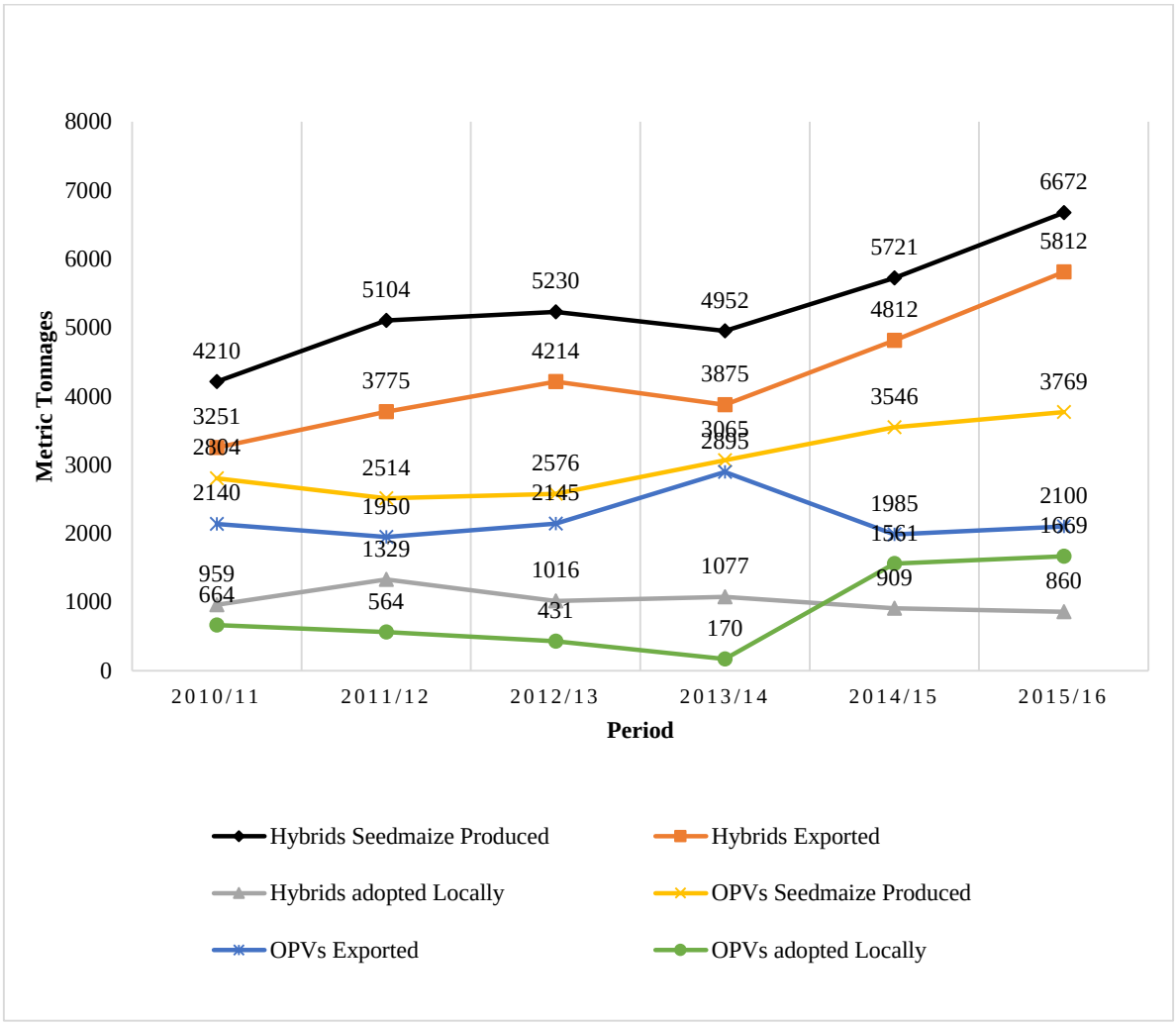

Fig. 1. Results on quantities of seed maize produced and utilised (2010-2016)
Source: Primary Data

Table 3. Random effects regression model output to predict usage for maize production

. xtreg Q_{ijt} x1, fe	Method: Random effects regression		
Periods included 5 years	Group variable (i) : Product_Innovations		
Cross Sections included 36	Number of obs 263		
Dependent Variable	**Quantity of Certified Seed Maize**		
Independent Variables	**Coef.**	**T**	**P> ltl**
Available Seed Maize	0.561	3.66	0.001
Available Fertilizers	0.154	0.91	0.003
Available Herbicides	0.124	2.49	0.000
Backward Markets	0.631	0.82	0.002
Forward Markets	0.314	0.12	0.019
Age Differences	0.124	2.49	0.000
Education Differences	0.631	5.21	0.002
Price of Innovation	0.461	3.66	0.001
2010/11 Year/Season	0.131	8.66	0.001
2011/12 Year/Season	0.154	5.91	0.003
2012/13 Year/Season	0.161	3.66	0.001
2013/14 Year/Season	0.164	6.66	0.002
2014/15 Year/Season	0.164	9.91	0.000
2015/16 Year/Season	0.165	2.49	0.004
Constant	2.154	7.86	0.000
F (5, 29)	254.27		
Prob > F	0.000		
Pearson Coef. (R)	0.3374		
R-Squared	0.1138		
Adjusted R-Squared	0.1102		

*Sig 95% sig level; * Sig at 99% sig level*
Source: Statistical Computation, SPSS

In terms of the goodness of fit of the results in Table 3 shows that random effects models innovation production is related to innovation utilization. Table 3 has shown the coefficient of determination (R^2) value of 0.1138 which suggest that the 11.38% of the variance in hybrid certified seed maize utilized by farmers under unions are explained by the price of hybrid seed maize, quantities of fertilizer, seed maize, herbicides produced by agricultural companies as well as age differences, educational differences, backward and forward markets within the maize value chain. The adjusted (R^2) value the results has shown a value of 0.1102 which suggest that 11.02% of the variation in hybrid certified seed maize utilized by farmers under unions are explained by price of hybrid seed maize, quantities of fertilizer, seed maize, herbicides produced by agricultural companies as well as age differences, educational differences, backward and forward markets within the maize value chain. In terms of the significance, since the p-value was less than 0.05, the results suggest that the relationship between innovation production and innovation utilization was statistically significant. The F-Statistic was large enough (254.27) and statistically significant (Prob >F = 0.000) showing that the model has a Goodness of Fit.

The findings from content analysis, interviews and focus groups were also integrated with quantitative findings. Looking at production of seedmaize from the perspective of Ministry of Lands, Agriculture, Water and Rural Settlement and other agricultural companies' different opinions and perceptions were drawn from the interviews. Findings through content analysis show the following common seedmaize made available for maize production between 2010 and 2016 (Table 4).

Based on the secondary data from seed company pamphlets and fliers the seed maize companies were engaged in the production of hybrid and certified seed maize which ranges from very early, early, medium and long seasoned maize varieties. Looking from interview guide, ministry officials were asked to specify their efforts regarding facilitation of hybrid seed maize, fertilizers and herbicides as climate specific certified seeds within maize value chain of Zimbabwe. According to Respondent A in the Ministry of Industry and Commerce Official:

Table 4. Results from reports on seedmaize varieties (2010-2016)

Company Category	Findings
Seed Companies **i.e.** Seed Co (SC), Pioneer (PG), Pannar (P) and Zadzamatura (DK)	**Very Early maturity seed maize** (60 days yielding 6-8 tons/Ha) - SC301; SC303; **Early maturity seed maize** (90 days yielding 8-10 tons/Ha) SC403; SC413; P3812 PAN 15; P3812W **Short maturity seed maize** (120 days yielding 8-11 tons/Ha) - SC513; SC529; SC537; DK9089; **Medium maturity seed maize** (160 days yielding 10-15 tons/Ha) SC608; SC627; SC637; SC633; SC643, P30G19; PAN56 **Long-term maturity seed maize** (190 days yielding 20 tons/Ha) SC719; SC727

Sources: FAO [1]

"*Our Ministry of Industry and Commerce, Trade and Commerce has been receiving allocated budget through the Ministry of Finance which we as a Ministry has dedicated towards industrialization such that production of agricultural inputs like chemicals, fertilizers has been our key priority for the revitalization of the agricultural crop and livestock industry.*"

In another separate interview with Respondent B from Ministry of Lands, Agriculture, Water and Rural Settlement, Agriculture, Water and Rural Settlement the highlighted that:

"*The Ministry of Agriculture has been offering extension services such as field days, farmer trainings on quarterly basis to facilitate knowledge transfer on newly introduced seed maize varieties, fertilizers and herbicides. Our local Agricultural Extension Officers staff, work in maize farming wards sharing extensive knowledge which is key in adoption of innovation.*"

Furthermore, Respondent C in the Ministry of Information, Publicity and Broadcasting Services also highlighted on behalf of his ministry that:

"*We have been working with the seed maize companies such as Seed Co as a Ministry of Information, Publicity and Broadcasting Services, in creation of ICT based applications which farmers can use to acquire information on climate change and good agronomic practices.*"

From such responses, respondents highlighted that all three ministries who participated in this research were making efforts in promoting and facilitating climate specific certified seed maize. However, the researcher posed a follow-up question with the intention to gather data in terms of the climate specific certified seeds available specifically for maize production in Zimbabwe and whether there are variations with adoption of such innovations. From the interviews, Respondent B from Ministry of Lands, Agriculture, Water and Rural Settlement, Agriculture, Water and Rural Settlement mentioned that:

"*There are numerous seed maize companies to mention few, we have Seed Co, Pannar, Agriseeds, Zadzamatura, Klen Karoo (K2), Pioneer, Syngenta and Zimbabwe Super Seeds (ZSS) which has emerged and introduced several hybrid seed maize which are region specific and as the Ministry we have been trying to promote such hybrid seed maize to adapt to climate change and promote a culture of innovation but having done all that farmers are still lagged behind in terms of utilization of such hybrid seed maize*"

From the interview, the results suggested that the agricultural companies together with the Government Ministries who participated in this research are making efforts to facilitate climate specific certified seeds for maize production, however farmers are not well adopting such innovations. Therefore, the researcher gathered opinions and perceptions of maize farmers by interviewing senior leadership under farmer unions in terms of the use of certified seedmaize. The Respondent D who is a senior leader under large scale maize farmers highlighted that:

"*Most large scale maize farmers mainly use hybrid seed maize from companies like Seed Co, Syngenta, Klen Karoo, Pannar and other*

seed houses which is a different scenario when it comes to small scale commercial or communal farmers who are making use of retained seed which has lost vigor and desired genetic traits. If you are to make an assessment large commercial farmers are adapting to climate change by adopting certified very early seed maize while small scale remain stuck in old ways of farming expecting better results"

To confirm the perceptions that large scale maize farmers are adopting hybrid seedmaize although as individuals as drawn from ministry officials and large scale farmer leadership, findings from the large scale maize farmers under FGD pinpointed that:

"*I think for us as large commercial maize farmers planting hybrid seed maize such as SC727 which averagely yields 20 tons is the way to go although the choice is at individual level*"According to Respondent P, FGD 1

"*Hybrid seed maize to me has allowed me to produce effectively although I am a bit skeptical about adopting all new seed maize varieties without free trials as several companies are competing for the same farmers to procure their products*"

According to Respondent T, FGD 2

To have a small scale perspective, the researcher also gathered opinions from the Respondent C, a senior leader under small scale maize farmer, who highlighted that:

"*From the small farmers' perspective, I can testify as one of the small scale that, maize hybrids we have heard of them, the agronomists from seed companies like Seed Co and Agriseeds visits our members, educate them on use of such innovating hybrid seeds but majority of the small scale maize farmers are still trapped in the old ways of doing farming. This is obviously different when it comes to large scale maize farmers I have observed, taking for example, we have heard several field days in local communities were large farmers have managed to attain 21 tons using SC727 as hybrid certified seed maize and better fertilizers but we have never had or heard any of such field days were our small scale maize farmers had make use of such seed maize varieties*"

Although the small scale maize farmer senior leadership and Ministry Officials were of the view that small scale maize farmers have a negative perception towards use of hybrid seed maize to adapt to climate change and improve productivity. This was also confirmed with the responses from the small scale FGDs which provided the following views in general during discussions:

"*The existing hybrid seeds are not solution to our climate problem and will not use such seed maize. At least the seed companies must go back to our old R52 variety which used to perform that to keep on introducing their so called new seed maize varieties which we are not comfortable with*"

According to the anonymous respondents under FGD 1 and 5.

"*We have heard of climate change from our the Agricultural Extension Officers, and as farmers we have attended a couple of trainings on such topics but generally we believe our own local retained seed which we used to grow long back was the best and getting new seed maize varieties might not be of our great concern*."

According to Respondent G and the majority, FGD 2 and 4.

The data from the questionnaires from agricultural companies, Government Ministries were in consistent with the interview data from Presidium under farmer unions. Although the farmer union Presidium acknowledged that agricultural companies are making climate specific certified seeds available, despite the fact that, farmers whether in commodity associations under small scale maize farmers or large scale maize farmers are lagged behind in terms of adoption of such innovation.

However, the findings from the focus groups show that small scale maize farmers are not utilizing climate driven certified seed maize despite the fact that such agricultural product innovation has been made available to the farmers. The other segment of large scale commercial farmers partly adopt the climate specific certified seeds as lack of trials might be hindering as well the rate at which they are adopting such agricultural product innovations. The next section provided a discussion of the qualitative findings presented integrating with the quantitative results and guided by the literature.

6. DISCUSSION

In terms of the relationship between seedmaize production and utilization based on the panel data gathered for the period 2010-2016 in Zimbabwe, findings has revealed from a model point of view that utilization or adoption of hybrid seed maize is positively related to an price of seed maize, quantity of hybrid seed maize produced, quantity of maize fertilizers produced, quantity of maize herbicides produced, proportion of backward markets maize established for maize farmers and proportion of forward markets maize established for maize farmers, age difference and educational differences with a Pearson coefficient value of 0.3374. In another words, drawing to Zimbabwean maize value chain considering 2010-2016 season it can be explained that adoption of hybrid seed maize increased at a decreasing rate suggesting that although the hybrid seed maize are produced for maize production in the value chain the rate at which they are adopted as a package is 33.74%. Such findings contradict John [18] who focused on the adoption of hybrid certified maize seed and herbicides as agricultural product innovations in Vietnam for maize production along the value chain. In his study he highlighted that production of seed maize is strongly linked to utilization of the seed maize with 95% correlation coefficient.

The existing certified seed maize during 2010-2016 for maize production according to the findings presented was seed maize produced by the seed companies such as Seed Co (SC), Pionner, Pannar, Klen Karoo (K2), Agriseeds, Mukushi, Zimbabwe Supper Seeds (ZSS) and Syngenta. The secondary data through content analysis has shown that the seedmaize in most cases across Zimbabwean maize farming regions varies with season as much as it varies with agro ecological zones. From the study the most adopted by large scale farmers in Zimbabwe is the hybrid seed maize such as SC737 and SC701 well known as *"Nzou"* which is a long seasoned hybrid seed maize yielding close to 20-22 tons/ha while maturing in 4 months. Findings from Zimbabwean maize value chain has shown that long seasoned varieties suits best in the agro ecological zone 1 with a minimum annual rainfall of 1000mm or alternatively for large scale irrigation maize farmers in Zimbabwe with Centre Pivot and horse rill irrigation systems.

In addition, medium scale seed maize varieties which mature in two and half months is another group of agricultural product innovations produced during the 2010-2016 seasons in preparation for maize production in Zimbabwe. This agricultural product innovation targeted farmers in the Mashonaland Provinces which is part of agro ecological zone 2 with minimum of 800mm annual rainfall or alternatively such small scale irrigation farmers who are into flood and sprinkler irrigation. From the study PAN53 from Pannar, P30G19 from Pioneer, SC633 and SC637 *(Shumba)* from Seed Co are amongst the medium seasoned varieties which yields 10-15 tons/ha on an average basis. Furthermore, in terms of the seed maize hybrids which resist diseases and pests the seed companies also designed some new seed maize varieties which fell into the category of early seasoned varieties that can mature in 90 days. From the Seed Co perspective, primary data has shown that SC413 and SC513 *(Tsoko)* are early seasoned varieties yielding 8-10 tons/ha and designed as agricultural product innovation to cater for maize farmers in the Region 3 and other parts of Region 4 which receive an average annual rainfall of 500 mm.

The last seed maize category introduced as an agricultural product innovation to adapt to climate change and drought effects was a very early seasoned variety. The results through content analysis has shown that Seed Co is the only company which has introduced such short-seasoned seed maize varieties that mature in 60 days. The results of the study showed that Seed Co introduced in 2015/2016 season very early seasoned variety such as SC301 *(Tsuro)* yielding 6-8 tons/Hawhich is an agricultural product innovation designed from a dry season or dry areas such as Masvingo and Matabeleland regions under agro ecological Zones 4 and 5 which used to receive an average amount of rainfall of 350-400 mm annually.

However, although the study has shown that in Zimbabwean maize value chain the average production levels of seed maize in the seed companies was 8361 metric tons with minimum production and 10 441 metric tons being the maximum for the maize seasons 2010-2016. However, from this study it was shown that production seed maize were increasing at an increasing rate of 56% although the upward trend in the seed maize production were not perfectly related to the adoption or utilization of the seed maize in Zimbabwean maize value chain. As

much as production was increasing at 56%, adoption had a steady increase at a decreasing rate of 22%, averaging 1868 metric tons with 1247 metric tons being minimum tonnage adopted and 2529 metric tons being maximum tonnage between 2010 and 2016 farming seasons. Therefore, it can be shown that there is a very weak relationship between the production of seed maize and utilization of such certified seed maize in Zimbabwe. The findings also contradicts literature by Bass [12], who is of the view that production of seed maize among other agricultural products is driven by demand. However, this was different with Zimbabwean case as production was increasing while utilization of the certified seed maize was low.

The adoption rate of certified seed maize stood at 22% from the total seed maize produced under seed companies in the Zimbabwean maize value chain. The other 88% is further absorbed by the export market as the Seed Co among other seedmaize producers is now export oriented due to low demand of seedmaize locally in Zimbabwe for local production. To confirm the perceptions of the maize farmers together with senior leadership under unions towards utilization of seed maize hybrids the research has noted that majority of maize farmers are not making use of the hybrid seeds such as SC5; 6 and 7 series which yields best yields per hectare. The farmers who are adopting seed maize on an early stage only make use of SC413 only which is one of the old early seasoned varieties. The study has shown that majority of the small scale farmers were not even aware of the existence of drought tolerant seed maize varieties such as SC301 which was introduced by Seed Co. This could also be explained by education difference as it was noted to contribute to adoption from the model point of view. From the demographics it was noted that small-scale farmers are less educated relative to all other players in the maize value chain and findings has shown that education has 0.124 effect on the adoption of every I unit of seedmaize. Such findings are consistent with literature by Belkins (2015) who suggested that education plays a critical role in technology acceptance. The higher the education the earlier the adoption of innovation [17].

Furthermore, the study has shown that that although large scale maize farmers are making efforts to adopt hybrid seed maize, majority of small scale maize farmers are still backward in terms of adopting hybrid seed maize, rather they are still making use of retained seed maize and based on such results there is a gap between seed maize produced as innovation produced by seed companies and seed maize utilized for maize production in Zimbabwe. From the statistics computed a 63.5% variance was noted between seed maize as agricultural product innovation created and adopted within the maize value chain between the farming period 2010 and 2016.

7. CONCLUSIONS AND RECOMMENDA-TIONS

Firstly, the study sought to determine the relationship between climate specific certified seed maize created or produced by the agricultural companies and the adoption of such innovation by maize farmers. The conclusions on this objective were made based on the exact climate specific certified seed maize within the maize value chain. The study revealed that the upward trend in the seed maize production under Seed Co was not perfectly related to the adoption or utilization of the seed maize as production innovation by the maize farmers. In that case, the results showed a steady increase at a decreasing rate in the adoption of seed maize varieties introduced by seed companies at an average rate of 22% with 1247 metric being minimum tonnage adopted and 2529 metric tons being maximum tonnage adopted for maize production by maize farmers in the value chain between 2010 and 2016 farming seasons. Looking from the trend analysis of production against utilization of seed maize, the study has concluded that there is a very weak positive relationship between the production of seed maize and utilization of seed maize in the maize value chain. In that case, it was established from a model point of view that an increase in seed maize production by a single unit will only increase the adoption of the seed maize as an agricultural product innovation by 56.2%.

1. In order to address the gap between innovation produced by agricultural companies and innovation adopted by farmer unions in the maize value chain, the following recommendations were put forward to improve the facilitation of innovation within the maize value chain:
2. The Ministry of Lands, Agriculture, Water and Rural Settlement through its extension departments, must develop exist strategies which involves rural financing and lending options with strict payback measures and

move away from aid and free input schemes to bring a new culture of investing in certified seeds among farmer unions. Such investment strategies will provide access to climate specific certified seeds in the value chain.

3. Farmer union leadership and their maize commodity association leaders must conduct frequent regional, continental and global exchange visits to learn from how other unions under SACAU who are performing are performing in terms of innovation adoption. Such regional or global networking can create supply chains in the form of backward and forward markets to increase access to climate specific seed maize. This can also increase knowledge and exposure among both large and small scale maize farmers to improve the adoption of climate specific certified seeds. Such exchange visits may also be key in dealing with adaptability as a cultural value and uninstalling a culture of impossibilities.
4. To promote diffusion of innovation and increase farmer confidence in the agricultural product innovation, the agricultural companies must engage in product education, awareness and sensitization to reduce information paucity among maize farmers in Zimbabwe.

8. LIMITATIONS

Since the study was not funded by any organization cost and time constraint were the two major limitations faced during the course of the study. However, to manage cost and time the researcher adopted a combination of focus group discussions, interviews and questionnaire to gather much of the data in given farmer associations than to deal with individual farmers.

ACKNOWLEDGEMENTS

I acknowledge the government ministries, organizations and companies in the maize value chain of Zimbabwe who provided data for the research. In addition, I also acknowledge the co-authors Dr. P Siwadi and Dr. M Twum-Darko who significantly contributed to the completion of the research paper.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73761