POTENTIAL IMPACT ANALYSIS OF PURDUE IMPROVED COWPEA STORAGE TECHNOLOGY ON INCOME OF USERS IN NORTH CENTRAL NIGERIA

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS OF SCIENCE DEGREE IN AGRICULTURAL ECONOMICS.

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DECLARATION

I hereby declare that this thesis titled "**Potential Impact Analysis of Purdue Improved Cowpea Storage Technology on Income of Users in North Central Nigeria"** was written by me and it is a record of my research work. No part of this work has been presented in any previous application for another degree or diploma at any institution. All citations and sources of information are duly acknowledged by means of references.

....

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CERTIFICATION

This thesis titled '**Potential Impact Analysis of Purdue Improved Cowpea Storage Technology on Income of Users in North Central Nigeria,** by Ayodeji Michael BOLAJI meets the regulations governing the award of the Degree of Master of Science, Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to Almighty God, the giver of wisdom and knowledge and my wife (Lucy) and children (Ayobami, Ayomide, Ayomikun and Ayomiposi) for their endurance, tolerance and support during the course of my study.

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TABLE OF CONTENTS

Title Page……..…….....i

Declaration…….……...……ii

Certification ……...……...……...……...…iii

Dedication ……..…..…….. iv

Acknowledgement …….....…..…… v

Table of contents…….....vii

List of figures.....xi

List of tables…….....……...…….xii

Abstract……...…..xiv

CHAPTER 1…….....…….…….....1

1.0 INTRODUCTION …….....…….……..…….....1

1.1 Background of the study …….....…….……..….....1

1.2 Problem Statement……..…….....3

1.3 Objectives of the study.…….....…….……..……...5

1.4 Justification of the Study …….....…….……..……..6

1.5 Research Hypotheses …….....…….……...7

CHAPTER 2……..…….....….8

2.0 LITERATURE REVIEW…….....……......……..…….....8

2.1. Economic importance of cowpea in Nigeria…….....…….....8

2.2. Cowpea Storage Methods …….....…….....9

2.2.1 Traditional storage …….....9

2.2.2 Plastic bags method …….…….13

2.2.3 Earthen silos method …….....……14

2.2.4 Pusa bin method …….…….....…….15

2.2.5 Metal drums method ……..…….....…15

2.2.6 Small metal silos method. ……..…..…….…..…16

2.2.7 Brick and cement silos methods…….....….…….16

2.2.8 Thai ferrocement silo method …….…….....17

2.2.9 Concrete multicelled silos method.....18

2.2.10 Sun drying method 18

2.2.11 Solar heater method..... 18

2.2.12 Chemical methods 19

2.2.13 The Hermetic storage system 19

2.2.14 Triple bagging method 22

2.3. Background to PICS Technology ……..……..…..... …….. .. 22

2.4. The PICS Technology..... 24

2.5. Impact Assessment of Agricultural Technology. ……..……..…….. 26

2.6 Impact assessment methods. 30

2. 6.1 Social experiment ……...……...…..……...…. 30

2.6.2 Cross sectional and longitudinal comparison …….……..……..… 31

2. 6.3 Double difference method……...…….……..…….. 32

2. 6.4 Econometrics methods of impact evaluation ……..……..…….…. 35

2. 6.5 Qualitative methods of impact evaluation ……..……...….. 36

2.7 Propensity Score Matching (PSM). 37

2.8 Empirical studies on impact of PICS technology: 41

CHAPTER 3 …….…….....…..……...44

3.0. Methodology ……...……44

3.1. Description of the Study Area ……..……...… 44

3.2. Sampling procedure and sample size ……..……...…..….. 46

3.3. Method of data collection ……..……..……..…….…….. 48

3.4. Analytical techniques …….……...…… 48

3.4.1 Gross margin analysis 49

3.4.2 Double difference estimator method 50

3.4.3 Propensity Score Matching (PSM) 52

3.4.4 Paired t – statistics.....53

CHAPTER 4 ……...……...……..…... 55

4.0. RESULTS AND DISCUSSION …….……...55

4.1. Socio-economic Characteristics of Sampled Cowpea Farmers/Dealer ….....55

4.1.1 Age of users of respondents …….....……..….54

4.1.2. Gender of respondents …….....…….. 57

4.1.3. Educational level of respondents ……...…….....57

4.1.4. The occupation of respondents ……...……...…… . …59

4.1.5 Membership of association of respondents 59

4.1.6 Cowpea production experience of respondents 61

4.1.7 Respondents' experience in using PICS technology 62

4.2. The Basic Information on Items and Values Used in Profitability Analysing.... 63

4.2.1 The profitability of storing cowpea in PICS bags..... 64

4.3 Impact of PICS Technology on Users Income ……..…….. 67

4.4 Test of Hypothesis on Impact of PICS Technology on Users' Income…….....72

4.5 Constraints Encountered by Users of PICS Technology…….……...…..… 73

4.6 Reasons for not using PICS technology 74

CHAPTER 5 ……....……..……77

5.0. Summary, conclusion, and recommendations ……..…….77

5.1. Summary ……..…….... 79

5.2. Conclusions ……..…..…...79

5.3. Contribution to knowledge ……..…….....…….79

5.4 Recommendations.....80

REFERENCES ……...……....……..……81

APPENDIX I ……..…….....83

APPENDIX II ……..…….....89

LIST OF FIGURES

Figure 1: Drop of oxygen in hermetic bags with different oxygen permeability 21

Figure 2: The North Central States of Nigeria 45

Figure 3: The selected settlements in North Central States of Nigeria 46

LIST OF TABLES

Table 1: Shows the Selection of PICS users in the study areas…….48

Table 2: Distribution of users and non – users of PICS technology by age 56

Table 3: Distribution of users and non – users of PICS technology by gender 57

Table 4: Distribution of users and non – users of PICS technology by educational level.....58

Table 5: Distribution of users and non – users of PICS technology by occupation . …59

Table 6: Distribution of users and non – users of PICS technology according to years of experience in association 60

Table 7: Distribution of users and non – users of PICS technology according to cowpea production experience..... 62

Table 8: Distribution of users and non – users of PICS technology according to years of experience..... 63

Table 9: Basic information on items and values used in analysing profitability of storing cowpea in PICS bag. 64

Table 10: Profitability of PICS technology users 65

Table 11: Difference in mean gross margins of users and non – users of PICS technology……...67

Table 12: Estimates for Impact of PICS Technology on Users Income……. 69

Table 13: Propensity score matching result un-adjusted..... 70

Table 14: Propensity score matching result adjusted 71

Table 15: Difference between propensity score matching for users and non users of PICS bags 72

Table 16: Paired t - test results showing impact of PICS Technology on users' income……73

Table 17: Constraints encountered in using PICS technology..... 74

Table 18: Reasons for lack of participating/ using PICS technology by non – users …76.

Abstract

The post-harvest grain storage is a recurrent constraint for increased cowpea production. This is often identified as the key challenge for small scale cowpea growers because it has significantly reduced the quality and quantity of cowpea, resulting in cuts in the food supply for millions of households in the study area. This has affected cowpea trade and has severe implication on the economy. This study thus aimed at assessing the potential impact of Purdue Improved Cowpea Storage (PICS) technology on income of users in North Central Nigeria. The specific objectives were to describe the socio-economic characteristics of users and non – users of PICS technology, determine the profitability of storing cowpea with PICS bags, determine the impact of PICS technology on the income of users and identify the constraints associated with the use of PICS bags in the study area. To achieve these objectives, a multi-stage sampling technique was employed in the study. Primary data were used and these were collected with the aid of structured questionnaire. Descriptive statistics, gross margin, double difference method, propensity score matching and paired t – test statistics were employed to analyse the data. The result revealed that the average age of users was 35 years while that of non – users were 38years. More than half (54% for non – users and 52% for users) of the respondents sampled were male. The result indicates a higher profitability index for users (2.36) than that of the non – users (0.74). However, lack of information on the PICS technology, high cost and scarcity of PICS bags tend to slow down the usage of PICS bag in the study area. The results call for policies aimed at encouraging the use of PICS technology to provide an improved alternative for insecticide – free and long – term storage of cowpea for food security and sustainability. This would invariably improve the adoption of PICS technology since chemicals were not used in the storage method; hence the issue of afloxins and phospins toxicity is eliminated.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Cowpea is the most important indigenous African grain. It is consumed on a daily basis as a staple family food in both urban and rural West and Central Africa (Hallensleben *et al*., 2009). It is also an important cash crop that withstands the harsh growing conditions of West Africa. This legume provides an important source of both protein and nutrition for the rapidly growing population. Cowpeas are also a critical economic driver. According to official statistics, nearly 300,000 metric tons of cowpeas were traded in West Africa in the 1990s (Fulton *et al.,* 2009). The seeds are a major source of plant proteins and vitamins for man, feed for animals, and also a source of cash income. The young leaves and immature pods are eaten as vegetables.

Cowpea is the most economically important indigenous African legume crop. About 87 percent of the 8.7 million hectares planted with cowpea worldwide are planted in Africa. (Moussa *et al.,* 2012). Nigeria is the largest cowpea producer in the world with about 3 million metric tons on 4.4 million hectares annually (FAOSTAT, 2006). Most of the cowpea production in Nigeria is in the northern part of the country. Official statistics indicate that cowpea grain production in Nigeria has increased substantially in the last five years. Annual production has more than doubled from the 1,300,000–1,400,000 metric tons reported in the early 1990s to 2,815,000 metric tons in 2005 (FAO 2007). There is high consumption of cowpea in the North Central of Nigeria, compare to the low production in this area. In addition to being the transit region between the northern and southern parts of Nigeria,

One of the greatest problems encountered in cowpea production is weevil infestation in storage, which can infest stored cowpea and ruin an entire harvest within two to four months. At harvest, 1 – 5% of cowpea seeds are infested by the most prominent species, *Callosobruchus maculates F.* (Sanon *et al.,* 2005). Storage of cowpea is a challenge for farmers in West and Central Africa. Insect pests infest the cowpea grain both in the field and in storage and degrade its nutritional quality and economic value. Thus, producers often sell at low harvest prices to avoid storage losses (Moussa *et al.,* 2012). Farmers often use a variety of traditional storage methods which results in about 25% loss (Moussa, 2006 and Boys, 2005). Storage insecticides are commonly used to control cowpea weevils, but farmers that lack resources often do not have access to these insecticides and when they do, they may misuse them (Baribitsa *et al*., 2012). Therefore, apart from posing hazards to farmers themselves, also contribute to soil degradation, water contamination, the loss of beneficial insects and bio-diversity in the complex farming systems of rural farmers.

It is on this ground that Bill and Melinda Gates Foundation propagated the use of cowpea storage techniques to farmers, traders (wholesalers, retailers) and processors of cowpea in 10 countries in West Africa, to address the problem of cowpea storage without the use of chemicals. The innovation tagged Purdue Improved Cowpea Storage (PICS) technology is a hermetic storage technique with air tight triple layer bags that eliminate damage from the weevils by restricting the oxygen supply to the insects. This study therefore, is an attempt to evaluate the usage and impact of Purdue improved cowpea storage (PICS) technology on income of farmers in North Central of Nigeria. The north central comprises of the following states Benue, kogi, Kwara, Nasarawa, Niger and Plateau. Usage in this case is a term referring to adoption of PICS

technology, while users are the farmers, traders (wholesalers, retailers) and processors of cowpea along the value – chain. But for this study, emphasis will be on producers of cowpea in the North Central of Nigeria. To regain its competitiveness, cowpea yield would have to increase substantially using yield enhancing technologies including varieties tolerant or resistant to biotic and abiotic stresses.

1.2 Problem Statement

The post-harvest grain storage is a recurrent constraint for increased cowpea production. This is often identified as the key challenge for small scale cowpea growers. Cowpea grains are severely damaged during storage by insect pests mostly bruchids (cowpea beetles). This has significantly reduced the quality and quantity of cowpea, resulting in cuts in the food supply for millions of households in north central states in particular. This has affected cowpea trade and has severe implication for the economy. Many farmers sell cowpea grain at low prices during harvest time rather than risk losses to bruchids infestation during storage (Baribitsa *et al*., 2012).

Grain damage generally defined as insect emergence holes in beans, results in significant price discounts, reaching up to a 2.3% decrease in price for every hole per 100 beans (Mishili *et al*., 2011). To combat these storage pests, many extension offices promote pest control strategies such as insecticide use and/or solar disinfection, though certain botanicals such as cypress, marigold, tagetes, and neem tree show moderate potential as storage treatments (Azadirachta indica) (Paul *et al*., 2009). This problem has been brought about by the ineffectiveness and unreliability of other storage methods. Some obsolete traditional methods like metal and mud silo, metal drums, jute bags etc are effective for small quantities but are difficult to scale up. Some effective

storage chemicals are available like Phostoxin, but they are regularly misused which has led to food poisoning, environmental hazards and eventual death (Coulibaly *et al*., 2012). Ash is also used for cowpea storage, but only for small quantities due to labour requirement. Many people often consider ash as "dirty" and refuse to eat food stored in ash.

Recently, there has been a decline in metal drum use due to their cost, rusting and the inflexibility of drum storage to production quantities. However, the moderate effectiveness of botanicals as storage protectants, the possible health concerns from insecticide use, and the labor intensity of solar disinfection practices provide shortcomings in their efficacy for common bean storage (Paul *et al*., 2009). A new technology, Purdue Improved Cowpea Storage (PICS) triple-layer hermetic storage bags, may provide an improved alternative for insecticide-free, long-term storage of common beans with minimal grain damage (Murdock *et al*., 2003; Hell *et al*., 2010; Ognakossan *et al*., 2010).

To further improve cowpea storage and address some of the issues mentioned above. After more than two decades of interdisciplinary research and extension work started by Purdue University with its partners, the PICS project was initiated. The goal of the project is to have 50% of farm-stored cowpea in hermetic storage without insecticides in West and Central Africa by 2012. The benefits from improved storage include increased cowpea trade in the region, hence, enhanced incomes of small-holder farmers and the food supply to consumers in the region. In Nigeria, this project is implemented by IITA and PROGREEN with many partners. The conservative estimates stipulate the savings of this technology to yield $255 million dollars annually, if utilized by 50% of the

population in Africa (Fulton *et al.*, 2009). Direct benefits will include avoiding loss of cowpeas by the weevil, on-site storage of cowpeas until market price is deemed attractive. Results could include higher incomes for African families, as well as increased levels of available food on the African family table.

Over the years, little empirical information is available on the potential impact analysis of PICS technology on the income of users and the factors that influence the usage of the technology. This is important because only with a proper understanding of these factors can further insight be developed concerning strategies to promote improved technologies. Therefore, it has become very necessary for a study of this nature to be carried out in order to fill in the existing research gap, by providing empirical information on the profitability of storing cowpea using PICS and the constraints associated with the use of PICS technology. In order to examine these issues raised, the following research questions have been put forward:

i What are the socio-economic characteristics of users and non – users of PICS technology in the study area?

ii What is the profitability of storing cowpea with PICS bags?

iii What is the impact of PICS technology on the income of the users in the study area?

iv What are the constraints associated with the use of PICS bag in the study area?

1.3 Objective of the Study

The broad objective of the study was to determine the potential impact of Purdue improved cowpea storage (PICS) technology on the income of users in north central Nigeria.

The specific objectives were to:

i describe the socio-economic characteristics of users and non – users of PICS technology in the study area,

ii determine the profitability of storing cowpea with PICS bags,

iii determine the impact of PICS technology on the income of users in the study, area; and,

iv identify the constraints associated with the use of PICS bags in the study area.

1.4 Justification of the Study

Cowpea is an important crop commodity in Nigeria which is one of the most sort-after grain legumes. It is a detribalized food eaten throughout Nigeria in one form or the other. Cowpea has continued to contribute to the enhancement of income, food security, nutrition and economic livelihood of the dealers/farmers. However, in spite of the past effort geared towards having weevil – free cowpea, cowpea storage is still largely problematic in this country. A variety of commercial and traditional methods used to control bruchids have restricted value due to cost, labour and potential toxicity. These eventually reduce the economic value of cowpea leading to low income. The declining state of cowpea quality and income in Nigeria has led to the implementation of PICS project in the nineteen states of the federation.

North Central States cowpea farmers/dealers participated actively in the PICS project intervention. However, there is yet to be much research work carried out on whether the PICS project intervention has positively affected the cowpea farmers'/ dealers' income and food security in the North Central States. This informs the decision to do an in

depth study of the impact of PICS technology on the income of dealers/farmers in North Central States.

The findings of this study will assist in evaluating the effectiveness of PICS technology in increasing or improving farmers'/ dealers' income, profitability and food security. Also policy makers at all levels of the government could benefit from the information gathered in this study especially with respect to agricultural development policy aimed at food sufficiency and poverty alleviation. The finding of this study could serve as a good reference point for researchers in the area of storage with particular reference to impact assessment studies.

1.5 Hypotheses

The following hypotheses were tested in the study;

i There is no significant difference in the profitability of users and non–users of PICS bag for cowpea storage.

ii PICS technology has no significant impact on the income of farmers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Economic Importance of Cowpea in Nigeria

Cowpea is the most economically and nutritionally important indigenous African grain legume, grown by millions of resource-poor farmers (Baribitsa *et al*., 2012). Legumes like cowpea serves as alternatives or supplements to animal proteins, particularly in parts of the world where there is paucity of animal proteins due to socio economic constraints. A major staple crop in Eastern and Southern Africa, the common bean is estimated as the third-largest source of calories and the second-largest source of dietary protein (Hillocks *et al*., 2006).

Cowpea provides protein and thus prevents nutritional diseases particularly in poor people, which can also lead to economic gains. From its production, rural families derive food, animal feed, and cash income. It provides nutritious grain and an inexpensive source of protein for both rural poor and urban consumers. Hence, has a tremendous potential to contribute to the alleviation of malnutrition among resource-poor farmers. Nigeria is the largest cowpea producer in the world with about 3 million metric tonne on 4.4 million hectares annually (FAOSTAT, 2006).

Cowpea grains are consumed directly following boiling, or as a component of meals which also include porridge made from cereals or root crops. Cowpea has the potential to contribute to food security and to poverty reduction in West Africa. The demand for cowpea is increasing because of high population growth, mainly from the urban areas, and also because of poverty and the demand for low-cost food. The high protein content

of cowpea and its use as a staple in the diets of Sahelian and coastal populations make it also a crop with high potential for food security. It is also a significant source of vitamins. A drought-tolerant and warm-weather crop, cowpeas are well-adapted to the drier regions of the tropics, where other food legumes do not perform well. Its ability to withstand drought, short growing period and multi-purpose use make cowpea a very attractive alternative for farmers in marginal, drought-prone areas with low rainfall and less developed irrigation systems (Hallensleben *et al.*, 2009). Cowpea forage contributes significantly to animal feed mainly during the dry season when the demand for feed reaches its peak. This crop provides food, animal feed and cash for the rural populace in addition to benefits to farmlands via *in situ* decay of roots residues and ground cover from cowpea's spreading habits.

Cowpea has a great value in the internals trade in country because it promotes trade between the production area and non producing area. It also serves as a source of income for middlemen who embark on transportation from one place to another. Cowpea becomes an important crop in the international market because of its wide acceptance. Even the National Aeronautics and Space Administration (NASA) is on the cowpea bandwagon. With the plant's ability to produce nutritious leaves in only about 20 days, NASA scientists are considering sending cowpeas to the international space station, where they could be cultivated to provide food for astronauts.

2.2 Cowpea Storage Methods

Storage is one of the marketing functions that must be carried out along the production cycle by farmers and traders involved in handling of cowpea. This is necessary towards

attaining the agricultural objectives of ensuring food security for the rapidly growing population.

2.2.1 Traditional storage

There are several traditional methods of protection that are available at the farm level:

Botanical method: Botanical alternatives for bean storage are the focus of new scholarly attention (Paul *et al*., 2009).Grains are often mixed with botanicals (leaves, fruits or bark) of several plants, such as the neem tree (Azadirachta indica) to prevent insect infestation. Botanical and plant material of varying protectant efficacy may include cypress, marigold, tagetes, and neem, among many others (Paul *et al*., 2009). Other treatments receiving scholarly attention include utilization of diatomaceous earth (DE) products such as Keep Dry, a silica dioxide inert dust from fossilized rock. Laboratory experiments with DE products display a high *Z. subfaciatus* mortality rate at application rates of 0.75g/kg and 1.00g/kg (Lazzari and Ribeiro-Costa, 2006).

Ash method: Ash storage has also been a common traditional technique used to fight post-harvest insects. It involves the mixing of cowpea grain with sieved ash from cooking fires prior to storage. However, as traditionally used, the amount of ash and how it was mixed with the grain varied greatly from farmer-to-farmer. Therefore, research of this technique was conducted at Purdue, and it was concluded that proportions of three volumes or more of cooking ash spread on four volumes of cowpeas was the minimum required to suppress the development of a weevil infestation. Ash storage works well for small quantities of cowpea.

Murdock *et al.* (2003) pointed out that many farmers in sub-Saharan Africa mix their cowpea with sieved ash from cooking fires to protect the grain from insect damage and also stressed that the mode of action of ash is not to kill the cowpea weevil larvae within the seed but to arrest population growth. According to Murdock *et al.* (2003) the problem the Purdue CRSP team observed was that the way ash was used varied widely among farmers and its effectiveness had not been established. He reported that CRSP scientist at Purdue found after experimenting with different proportions of ash to grain, they recommended that equal volumes of sieved ash and cowpea grain be mixed, placed in a container and covered by a 3cm layer of ash.

Murdock *et al.* (2003) also reported that the experiments showed that adult bruchids that developed within the grain being stored in this way are physically unable to shove their way out of the seeds and die without mating and therefore, the population growth is arrested.

Clay pots method: Cowpea grain has been stored in clay pots with small mouths, such as those used for holding water, with a layer of ash or sand to prevent entry of bruchids (Hayma, J. 2003). This method is partially effective for storing a small amount of cowpea grain for use as seed the following year. In general, none of other methods is very effective and this encouraged people to consume or sell most of their cowpea grain within two months of harvest (Scheepens *et al., 2006*).

Earthen pots and gourds method: Especially in the dry tropics, earthenware pots and gourds are very useful for storing small quantities of cowpea (Hayma, J. 2003). They are kept inside or under a shelter or above the kitchen (a place where there are few

insects) is a good place. By sealing the lids of the pots and gourds with mud an airtight form of storage is obtained (Scheepens *et al., 2006*).This is suitable for small quantities of beans, and also for the storage of sowing seed. The Storage time is about one year and 5 - 30 litres capacity.

Baskets method: Baskets are especially usable in the dry tropics. In the humid tropics ventilation is good, so the baskets are separated from one another. They are raised off the ground on a platform, to prevent rodents attacking the basket. Baskets do not give enough protection against insects, but this can be improved by applying mud, clay to the in- and outside (Scheepens *et al., 2006*).

The cover should be tight, and sealed with plaster of the same material. The same effect is obtained by using a plastic bag inside the basket, which also makes storage airtight. If a basket is plastered, further ventilation is made impossible (Peter, F. 2011). If then a too moist product is stored it will go mouldy and rot quickly. Therefore one has to decide whether priority should be given to further drying or to more protection against insects. The outside layer of mud also gives protection against rodents. Ensure that the basket is well-protected from the rain. If it is made of grass or reed keeps it in the house or some other dry building. The Storage time is about 6 - 9 months and 25 - 2000 litres capacity (Hayma, J. 2003).

Jute sacks method: In general just sacks are cheaper than sacks made of cotton or sisal. These sacks are especially suitable for the dry tropics. Because of the danger of moisture uptake they should not be placed on concrete floors or on the ground, but on plastic sheets, waterproof canvas or on wooden pallets (Hayma, J. 2003). The latter

method is preferred because it also allows air to flow under the sacks. Do not stack sacks against the walls, as insects and termites can get into the grain from the walls. Stack the sacks in a neat manner in not too big quantities on top of and against each other. (Scheepens *et al., 2006*). Leave some space between the sacks so that air can move freely between them. Paths of 40 cm wide should be left open between the stacks for inspection, cleaning and control of insects and rodents (Peter, F. 2011).

Hayma, (2003) identifies the advantages of fibre sacks as follows: The product can have slightly higher moisture content than when put into airtight storage, provided the sacks are stacked in such a way that air can move through the sacks for continued drying and cooling. Sacks are easy to handle and label. These sacks allow gasses to pass through and therefore insects may be controlled by using fumigants in a closed room or underneath a plastic sheet covering the stack. This must be done by an expert. The main disadvantage is that fibre sacks do not give much natural protection against insects, rodents, fungi and moisture. They are also easily damaged during transport and handling. The grain can be mixed with sand or ashes if possible. Before storing the product the storage place should be made insect and rodent proof by sealing all holes and cracks with cement or mud. The Storage time is up to a year and 50 - 100 litres capacity (Hayma, 2003).

2.2.2 Plastic bags method:

Plastic bags are suitable for storage in the humid and dry tropics. The product has to be dried well because during storage further drying is impossible (Hayma, 2003). Even in open plastic bags the product does not dry because there is no air circulation. If the plastic bags are closed well airtight storage is obtained with all its advantages and

disadvantages. Plastic bags do not offer much protection against rodents so extra attention is required (Hayma, 2003). If the stored product is to be marketed and a lot of transport is involved, plastic bags are too weak. This depends on the thickness and strength of the plastic. If beans infected with dried-bean beetles are stored it is possible that the insects will puncture the plastic when trying to escape from the bag. This can be prevented by putting a bag of tightly woven cotton inside the plastic bag. Plastic becomes weak or brittle after continued exposure to ultra violet light; therefore no plastic package will last indefinitely in direct sunlight (Scheepens et al., 2006).

An advantage of transparent plastic is that the product remains visible, which makes checking the contents easier. Although the product may look alright from the outside, its quality may be disappointing when it is felt by hand, or it may be musty (Peter, 2011).. A disadvantage of transparent plastic is that lizards can see insects which may be moving about inside, and may snap at them, which will damage the plastic. The storage time is ab out 6 - 9 months and 50 - 100 litres capacity (Hayma, 2003 and Peter, 2011).

2.2.3 Earthen silos method

Storage in earthen structures is often practiced in the dry tropics. They are less suitable for the wet tropics because moisture may enter via the walls, which increases the chance of fungal growth. The product to be stored should be well dried before putting it in the silo as further drying is impossible. Earthen silos give better protection against insects (Hayma, 2003). The silo should be protected from rain as heavy rains may cause severe damage. The advantages compared with stone or concrete silos are that they are cheap, can be built with local materials and skilled labour is not needed (Hayma, 2003).

The disadvantages are: (1) Moisture uptake from a humid environment, unless certain precautions are taken. (2) During drying up cracks often appear in the walls. This can be improved by mixing the mud with chopped straw or grass or by constructing a bamboo frame first and smearing that with mud. (3)The lifetime is relatively short. The storage time is about 6 - 9 months and 100 - 260 litres capacity (Scheepens *et al.*, 2006 and Peter, 2011).

2.2.4 Pusa bin method

The Indian Pusa bin is a square silo, double-walled all the way round -including the floor and roof - with a separating layer of plastic sheet between the walls. The plastic protects against moisture and keeps air from entering the stored product, provided the fill- and outflow openings can be tightly closed. The walls are made of mud blocks, but can also be made of mud (90%) mixed with cement (10%), fired bricks or concrete (Hayma, 2003). It is suitable for the dry and wet tropics, provided it is protected from rain. It gives good protection against insects and rodents, especially if the bottom 50 cm of the outside walls and the bottom layer are made of fired bricks or concrete. The storage time is about 6 - 12 months and 400 - 3000 kg capacity (Hayma, 2003).

2.2.5 Metal drums method

If metal drums (water tanks or oil drums) are available, they can be used for storage after cleaning them well. The drums should never be placed in direct sunlight because of the dangers of the product becoming caked to the inside wall, of moisture changes and heating of the stored product. They should either be placed under a good roof or should be insulated with a layer of straw (Hayma, 2003 and Peter, 2011).

However, Boys (2005) more recent studies showed that the current rate of use is above 60% of cowpea production. They can be used in the dry and humid tropics. In warm, wet places the drums may rust quickly unless precautions are taken. If they are airtight when closed it is possible to combat insects without using insecticides. The storage time is up to one year and 50 - 200 litres capacity (Hayma, 2003). According to Murdock *et al*. (2003) the problems of drum storage is hard to find and expensive, therefore, poor farmers cannot afford to buy them which limits the spread of the metal drum storage technology.

2.2.6 Small metal silos method

For small metal silos the same applies as for metal drums. The content is bigger though, and can be up to about 5 tons. This model is made of sheet metal, 1 mm thick, welded together at the seams. This welding requires some skill, especially if the silo is to be airtight (Hayma, 2003 and Scheepens *et al.,* 2006). It has two openings, one for filling at the top and one for emptying at the bottom. Like metal drums, metal silos should never be placed in full sun (Hayma, 2003 and Peter, 2011). A good overhanging room is the best solution. The storage time is up to one year and capacity depends on the size (Hayma, 2003).

2.2.7 Brick and cement silos methods

These silos are suitable for both the dry and the wet tropics. They should be protected from rain by a roof and by a bottom floor made of (reinforced) concrete or (fired) bricks. The silos can provide air- and watertight storage if they are painted with for example chlorinated rubber-base paint, coal tar or bitumen. Brick and ferrocement silos can be built in many forms and sizes (Hayma, 2003).

Brick silo method: The brick silo is made of mortared concrete (sandcrete) bricks placed on a reinforced foundation. The cover with a manhole is made of concrete or, if available, of sheet metal for ease of handling. It is quite easy to build. The storage time is up to one year and capacity depends on the size (Hayma, 2003).

Cement staves silo method: This type of silo is more durable than the previous one. Because of the materials used it is more expensive, but less expensive than a sheet metal silo of the same capacity. It can be built raised on brick-made. The storage time is up to one year and capacity depends on the size (Hayma, 2003).

2.2.8 Thai ferrocement silo method

Ferrocement is a kind of reinforced concrete. It is made of wire mesh (for example chicken wire), sand, water and cement. It is strong and durable. Ferrocement silos can be made in almost any shape (Hayma, 2003). The Thai ferrocement silo has a conical shape and is waterproof and airtight. The base is saucer shaped and is made of two layers of reinforced concrete with a layer of bitumen, asphalt paper, plastic or metal foil in between. The frame of the walls is made of water pipes or bamboo poles and reinforcing rods, which support inside and outside layers of wire mesh. The mesh structure is filled and smeared with mortar of a paste-like consistency: 1 part of standard cement, 1.75 parts sand with the optional addition of a plasticizer to improve workability. Water-cement ration is approximately 0.3 by weight Ferrocement should be cured adequately: it must not dry too fast and should be kept moist and protected from the sun and wind for at least 5 - 7 days (Hayma, 2003).

2.2.9 Concrete multicelled silos method

Many farmers form cooperatives and store their products collectively in large bins. Multi - celled silo storage is an alternative to the larger, round silos. Each cell has an inside diameter of 2 m x 2 m x 2 m, and its own fill- and outflow openings. Storage time: 9 - 12 months and capacity is 4 - 6 tons, depending on the size (Hayma, 2003).

2.2.10 Sun drying method

In sun drying, the natural heat of the sun is collected in man-made prototype heaters - such as the one developed at Purdue involving black plastic sheeting - are employed to raise the temperature of the grain to the thermal death point necessary to kill all stages of the cowpea weevil (Murdock *et al*., 2003 and Mishili *et al*., 2011). Farmers comment on the extra labour required for solar disinfestations, compared to hermetic storage. The output is a simple but effective solarisation technique, which harnesses the power of the sun to reduce pest damage on stored cowpea to acceptable levels. In tropical regions, the sun is a powerful and reliable source of energy and simple technologies can make use of this free resource (Langyintou *et al*., 2003). Appropriate exposure of cowpeas to the sun can lead to a temperature rise sufficient to kill most if not all of the pests – eggs, larvae and adults – on and inside the grains (Mishili *et al*., 2011). Germination tests showed that grain stored for seed remains viable (Baribitsa *et al*., 2012).

2.2.11 Solar heater method

Sunlight is abundant in the western and central African regions and farmers used it to dry their harvested cowpea after the rains end which inspired CRSP Scientist to devise an optimal solar disinfection method against cowpea bruchids. Solar disinfection is

determined the most effective method on the basis that corn oil discoloured grain and reduced market value (Mishili *et al*., 2011). They also found out that the thermal death point of cowpea bruchids is a temperature of 57^{o}C which killed all life stages of the insects (egg, larvae, pupae and adult) when exposed for 1 hour. A unit of the heater of the size of 3m x 3m can be used to treat 50-60kg of grain at a time. Exposure to temperatures attainable in the solar heater does not change cooking time, rate of germination, or vigor of seedlings. With regards to the latter, exposures of several hours to 80^{o}C did not significantly reduce germination of the exposed seeds reflecting the high temperature hardiness of cowpea (Murdock *et al*., 2003).

2.2.12 Chemical methods

Insecticides are widely used to control storage insects; Phostoxin is still, the most commonly used storage insecticide. Some farmers use more than one chemical pesticide, while others use particular pesticides in both field and storage. Also, sudden deaths, blindness, and skin irritation are among the problems attributed to use of inappropriate storage chemicals in Nigeria (Daily Trust, 2006 and NAFDAC, 2006).

2.2.13 The hermetic storage system

Airtight grain storage is a proven method of controlling stored-product insect pests. Hermetically sealed storage involves putting grain into sealed containers that stop the movement of air (oxygen) and moisture between the outside atmosphere and the stored grain. The system can use special plastic containers (such as the volcanic cube and grain cocoons) or smaller containers made of plastic or steel or even clay water pots. The size of the systems can range from 25 litres to 300 metric tons (Gummert *et al*., 2004). The

system can be used for paddy, milled rice and other cereal crops such as corn. Hermetic storage improves grain quality and seed viability because it maintains the original grain moisture content and reduces pest damage (without the use of insecticides). Seed viability can be increased from 6 to 12months in Tropical environments (Gummert *et al*., 2004).

Sealed storage controls insects because the insects use the available oxygen during respiration and expire carbon dioxide (for example, oxygen levels can be reduced from 21% to less than 5% within 10 - 21days (Murdock *et al*., 2003). At this low oxygen, insect activity is minimal and reproduction ceases. Rodents and birds do not appear to be attracted to the grain in these types of storage (possibly because they are unable to smell the grain) (Murdock *et al*., 2003). Once the container is hermetically sealed the moisture content of the grain will be controlled. Respiration by the grain and insects inside the storage container change the inter-granular atmosphere by consuming oxygen and producing carbon dioxide. Depending on the number of insects, and type and size of the system, oxygen levels will be reduced from 21% to less than 10% within a short period of time (Murdock *et al*., 2003).

At oxygen levels below 10%, insects are curtailed and the viability of seed ensured. Because it minimizes biological activity inside the storage container hermetic storage also helps maintain milling quality (Gummert *et al*., 2004).

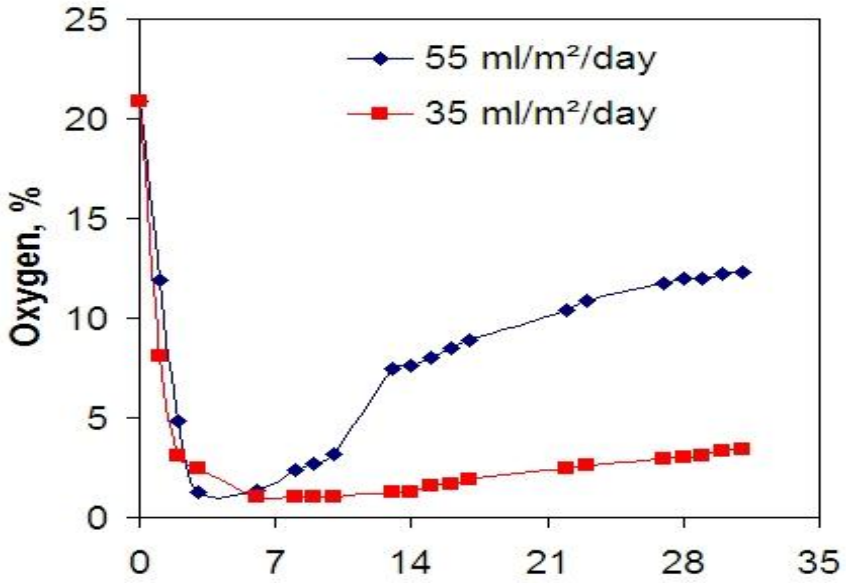


Figure 1 Drop of oxygen in hermetic bags with different oxygen permeability
Source: Jokthan *et al*., 2008.

Figure 1 shows how inside the hermetically sealed container the oxygen gets consumed rapidly after sealing. After a few days oxygen levels of 5-10% are reached at which time insect activity stops. In many cases oxygen levels go down to even less than 3% (Gummert *et al*., 2004). Oxygen density below 2% suffocates the insects thereby preserving the grains from further insect attack, aflatoxins and fungi. Any facility that ensures the existence of this environment is effective for hermetic storage (Jokthan *et al*., 2008). The worse the conditions, the better the system works. Many insects, for example, consume lots of oxygen and therefore the oxygen level drops fast. More moisture increases biological activity, which also reduced oxygen faster. Hermetically sealed grain storage systems improve grain quality and seed viability because they maintain the original storage moisture content and reduce pest damage without using pesticides. Seeds can be stored safely for 9-12 months or even longer resulting in high germination rates and head rice yields are typically increased by 10%. Bird and rodent damage are also reduced (Gummert *et al*., 2004).

2.2.14 Triple bagging method

The triple bagging consists of two polyethylene plastic bags that are 80 microns thick (inner bags) and a third sack (outer bag) made of woven polypropylene to protect against cowpea Bruchids. The triple bag technology allows very little air from outside to get to the grains (Murdock *et al*., 2003 and Mishili *et al*., 2011).

2.3 Background to PICS Technology

Purdue Improved Cowpea Storage technology is the bagging of cowpea grain in triple layer bag consisting of two polyethylene plastic bags that are 80 microns thick (inner bags) and a third sack (outer bag) made of woven polypropylene to protect against cowpea Bruchids (*Callosobruchus maculatus*) also known as the cowpea weevil, a major storage pest of cowpea in west Africa (Murdock *et al*., 2003 and Baributsa *et al*., 2012). By sealing the cowpeas in a plastic bag and then sealing that bag within two additional bags, the respiration of the feeding and growing weevils raise level of carbon dioxide in the bag while utilizing the oxygen. Ceasing to feed, grow, and reproduce in this environment, the weevil population remains small and inactive and so do not damage the grain. On-farm tests as a part of the Purdue/Cameroon Bean/Cowpea CRSP validated the effectiveness of this technology, and additional research by the Purdue team led to the recommendation of a triple bagging system in lieu of single or double bags (Murdock *et al*., 2003).

Triple-bagging of the cowpeas, using heavy-grade plastic bags, proved to be a cost effective storage method that could be adapted by farmers with varying amounts of cowpea to store. Purdue Improved Cowpea Storage technology was first developed by Purdue University/IRAD-Cameroon Cowpea Storage Project in the late 1980's by

Professor Larry Murdock and his team, with support from the Bill and Melinda Gates Foundation (Ibro *et al*., 2007). The high density polyethylene PICS bags, with ultra-thick walls of 80 microns, are produced in 50kg and 100kg capacity sizes and cost between $2 and $4, depending on the region (Baributsa *et al*., 2012).

This technology was originally created until the trademark "Purdue Improved Cowpea Storage (PICS) for West and Central African cowpea farmers to protect against extremely destructive cowpea bruchids, which prevented resource-constrained farmers from long-term storage to capture price increases later in the marketing season. The PICS is a five-year project to improve cowpea storage in West and Central Africa. The goal of the PICS project is to have 50% of cowpea in West and Central Africa stored with hermetic method by 2012. The project is being implemented in 10 different countries in West and Central Africa, including Nigeria, Niger, Burkina Faso, Ghana, Mali, Senegal, Cameroon, Benin, Togo and Chad. The PICS project plans to disseminate the triple-layer sack technology in 28,000 villages in West and Central Africa (IITA, 2008).

This project is a joint collaborative effort involving various partners including international agricultural research centres, international development NGOs, National Agricultural Research Institutes, government agencies, local NGOs, private entrepreneurs, and farmers. The PICS technology allows very little air from outside to get to the grain. The bruchids consumes the small amount of oxygen (O_2) and enriched carbon dioxide (CO_2) environment is created which stops the bruchids from causing the damage. The bruchids eventually die. The PICS project is also developing a supply chain system for the triple layer sacks in West and Central Africa. The development of

this system is providing business opportunities for manufacturers of sacks, distributors, and vendors. The PICS project has worked with five manufacturers of plastics in five West African countries to produce bags. In addition, Purdue has worked with local entrepreneurs to sell the storage technology through evaluation in their distribution networks so that it is easily available to the farmers.

2.4 The PICS Technology

Triple-layer hermetic Purdue Improved Crop Storage (PICS) bags were developed under the Bean/Cowpea CRSP project in the late 1980s through funding from USAID (Murdock *et al*., 2003). Hermetic technology works by creating an airtight seal in which oxygen levels dramatically decrease within days through insect, fungal, and/or seed respiration (Quezada *et al*., 2006). The high density polyethylene PICS bags, with ultra-thick walls of 80 microns, are produced in 50kg and 100kg capacity sizes and cost between $2 and $4, depending on the region (Baributsa *et al*., 2012). This technology was originally created until the trademark "Purdue Improved Cowpea Storage (PICS) for West and Central African cowpea farmers to protect against extremely destructive cowpea bruchids, which prevented resource-constrained farmers from long-term storage to capture price increases later in the marketing season.

The Improved Cowpea Project (PICS) aims to extend the technology of the triple bag storage system to 3.4 million African households – a total of 47.6 million people (Langyintuo *et al*., 2003). The program goal is to see 50% of all farm-level cowpea in West Africa stored utilizing non-chemical hermetic storage technologies by the end of the 5-year project. Conservative estimates prescribe the savings of this technology to yield $255 million dollars annually if utilized by 50% of the population in Africa

(Murdock *et al*., 2003). Direct benefits will include avoiding loss of cowpeas by the weevil as well as an option for on-site storage of cowpeas until market price is deemed attractive. Insecticide use on stored cowpeas should be reduced as well. Additional results could include a new entrepreneurial opportunity in the area of bag manufacturing and distribution, higher incomes for African families, as well as increased levels of safe, nutritious food on the African family (Hell *et al*., 2010). The development of a supply chain for the bag is expected to provide business opportunities to bag manufacturers, distributors, and vendors. And more families will have higher incomes, and that means better schooling for children, better health care, and meeting all the basic needs of the households.

In Nigeria, PICS technology was awarded in 2007 to Initiative for The Promotion of Green Resources (PROGREEN) but because of the newness of this NGO and in fulfilling the rules of donor of not entrusting funds to new organisation, International Institute for Tropical Agriculture (IITA) was appointed as the coordinator of this project. In implementing the project, IITA worked in collaboration with Initiative for The Promotion of Green Resources (PROGREEN), State Agricultural Development Programme (ADP) and other NGOs to extend the PICS technology in Nigeria. Project activities started in Nigeria in 2008, with the introduction of the project to some stakeholders, State Agricultural and Rural Development Authorities (ADP) of Katsina, Kano, Jigawa, Plateau states and National Stored product research institute (NSPRI) etc during the pilot phase (IITA, 2008). The main phase was expanded in 2009 – 2010, the extended phase in October, 2010 to April, 2011 while the final phase of the project was from September, 2011 to April, 2012, (IITA, 2008).

To ensure wider sensitization about PICS bags, audio cassette jingles were made in Hausa language that were later translated to other Nigeria languages and distributed to the State ADPs of the nineteen Northern States. The State Agricultural and Rural Development Authority took the jingles to radio stations for wider coverage in Northern Nigeria and some parts of Oyo state in their weekly agricultural programmes. IITA extended the technology in: Adamawa, Bauchi, Borno, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, Taraba, Yobe and Zamfara states. PROGREEN extended in: Benue, Federal Capital Territory, Kogi, Kwara, Nassarawa, Niger, Plateau and Taraba States.

2.5 Impact Assessment of Agricultural Technology

Impact assessment of agricultural project is viewed as an important activity to ensure accountability, maintain credibility and improve internal decision – making processes and the capability to learn from the past experience (Alene *et al*., 2006). Impact studies are of great importance in agricultural research because it is used to identify alternative technologies that would address the major production constraints while at the same time taking into consideration farmers preferences and farming condition (Simonyan, 2008). Impact assessment is seen as a critical component of agricultural research that helps to define priorities of researchers and those involved in technology transfer to have a better understanding of the way new technologies are assimilated and diffused into farming communities and show evidence that clients benefit from the research products (Nkonya *et al*., 2007).

Impact assessment is seen as a critical component of agricultural project that helps to define priorities of project and facilities resource allocation among programmes, guide

researchers and those involve in technology transfer to have a better understanding of the way new technologies are assimilated and diffused into farming communities, and show evidence that clients benefit from the project products (Manyong *et al*., 2001).

Research resource is scarce and most research managers are of the opinion that the benefits are obvious anyway. Given the high opportunity cost of doing impact assessment, research managers may feel that they should simply get on with the research. The fear that evaluation of research result would produce unfavorable benefit – cost ratios is of interest to stakeholders. Also, few impact assessments provide clear guidelines for future action, making them less valuable as research tools. Methodological difficulties in estimating the benefit from some types of research may yet be another reason for the reluctance to conduct impact assessment. The focus and methods of impart assessment have evolved overtime in response to agricultural development donor's interest and research mandate (Simonyan, 2008).

Using the same data base, the focus of impact assessment activities is said to have expended to estimating rates of return of research investment in the 1980s and to examining a wider range of impacts including environmental benefits and costs across different socioeconomic groups in the late 1980s and 1990s. However, the focus of impact assessment of agricultural research is not only for estimating rates of return to research investment and the goals of assessing the increasing food production but also has been the need to assess the potential impacts of agricultural research on poverty alleviation with a view to setting priorities of research (Alwang and Siegel, 2002).

Impact assessment studies on potential benefit of agricultural technology adoption on beneficiaries income is not always easy to evaluate because of the complexities involved in understanding the link between agricultural technology and rural livelihoods. This is because rural people generally have a lot of coping strategies of combining their assets and agricultural technologies to attain their life goals of food sufficiency and better livelihoods. For instance, a farmer beneficiary of a particular technology may be involved in other forms of business apart from being employer of agriculture that can improve his level of income. As such if an impact study is carried out on such farmer's income as a result of the new technology adopted it may be difficult to isolate the technology impact. Furthermore, respondents recall ability to subjective – qualitative questions often raised during survey often reveals biased (Chen *et al*., 2006). Yet examining the impacts and impacts pathways of different types of agricultural technologies are essential to guide future project in ways that will make the greatest contribution to poverty reduction (Simonyan, 2008).

Ex – ante impact assessment is undertaken before the project or programme is initiated as an aid in priority setting, based on the potential impacts of alternative research portfolio on aggregate net benefits or on poverty alleviations. Assessment of future impact includes measures of productivity impacts, distribution of economic benefits, and effect on environmental quality (Simonyan, 2008). Assessment of impact can be considered in two – stages: (1) scenarios are generated with the conditions expected in the future without the proposed research; and (2) the impact of potential research innovations is estimated. As such, Alwang and Siegel (2003) argued the fact that the greater emphasis has now been given to the assessment of the potential poverty alleviation impact of agricultural research with a view to research priority setting. The

ex – ante impact assessment is followed by the on – farm technology evaluation in which after research priorities have been set, researchers would embark on technology development that would involve the on – station development of new crop varieties, or pest management practices (Simonyan, 2008). The new technologies will undergo on – farm testing with farmers to ascertain the acceptability and profitability of the technology developed or technologies already available before they are promoted at a larger scale. On – farm testing is said to provide important diagnostic information about farmers' problem, preferences, and livelihood strategies and this technology generation help researchers to better understand the early adoption process involving the integration of farmer's indigenous knowledge into the scientific knowledge of researchers (Simonyan, 2008).

Adoption studies, the third stage of agricultural technology impact assessment cycle studies are carried out to monitor the level and pathways of adoption and the impact of proven technologies on farm – level productivity during the technology promotion stage. Studies on adoption can basically involve the following areas of evaluation of adoption studies: (1) levels and speed of adoption, and reasons for non – adoption of technology; (2) farmers perceptions of desirable traits or features of the technology options; (3) farmers level productivity and income gains due to the alleviation of biotic and abiotic constraints; (4) impact on the welfare of the farm household in terms of the intra – household distribution of income, nutrition, and health; and (5) infrastructural, institutional and policy hindering technology adoption. Adoption of improved agricultural technologies has a significant impact on crop income, although the impact on consumption expenditure is mixed (Asfaw, 2010).

Ex – post impact assessment is conducted after a technology has been widely adapted by farmers in the target areas (Simonyan, 2008). Nevertheless, for a good and successful impact studies to be adequately carried out, the role of baseline and panel surveys in providing data on benchmark – related household variables as the basis for adoption and impact cannot be overemphasized (Alene *et al*., (2006). Baseline data allows researchers to establish the current levels of poverty and the coping strategies for better livelihood of the target areas of project. Impact assessment studies face three interrelated challenges; establishing a viable counterfactual (the predicted outcome in the absence of the intervention – that is what would have happened to the beneficiaries had they not participated in the project); attributing the impact to an intervention; and coping with long and unpredictable lag times (Alston and Pardey, 2006).

2.6 Impact Assessment Methods

Impact assessment method is often classified into three broad methods namely quantitative methods which include first: (i) social experiments (ii) cross sectional and longitudinal comparison (iii) econometrics (iv) propensity score matching (v) double difference estimator; secondly, qualitative methods and ; the combination of qualitative and quantitative methods (Simonyan, 2008).

2. 6.1 Social experiment

This involves the use of experimental designs also known as randomization. In this method, intervention program is randomly allocated among eligible beneficiaries such that the assignment process itself will create comparable treatment and control groups that are statistically equivalent to one another, given appropriate sample size. The control groups generated through random assignment often serve as a perfect

counterfactual, free from selection bias that exist in all evaluations of this method (Simonyan, 2008). The main benefit of this method is said to be simplicity in interpreting results, because the programmme impact on the outcome being evaluated can be measured by the difference between the means of the treatment group and the control group. However, while experimental designs of social experiment method are considered, the optimum approach to estimating project, in practice there are several problems (Simonyan, 2008). These problems include the fact that randomization may be unethical owing to the denial of benefits or services to eligible members of the population for the purposes of the study. Secondly, it can be politically difficult to provide an intervention to one group and not the other.

Thirdly, the scope of the programmme may mean that there are no non – treatment groups such as with a project or policy change that is broad in scope, Fourth, individuals in control group may change certain identifying characteristics or contaminate the results. Fifth, it may be difficult to ensure that assignment is truly random. Finally, experimental designs can be expensive and time consuming in certain situations, particularly in the collection of new data.

2.6.2 Cross sectional and longitudinal comparison

These techniques are used to evaluate impact assessment of project when it is not possible to construct treatment and comparison groups through experimental design (Simonyan, 2008): Cross – sectional comparisons compare households in programme to those not in programme as such the expected income of those in programme is subtracted from the expected income of those not in programme. It was however argued that non – participants may differ from participant and that cross – sectional differences

may not only be due to the intervention programmme. On the other hand, longitudinal otherwise called reflexive is an impact assessment method in which a base line survey of participants is done before the programme and a follow – up survey of participant is done before the programme and follow – up survey is done after. The baseline provides the comparison group, and impact is measured by the change in outcome indicators before and after programme (Baker, 2000).

2. 6. 3 Double difference method

According to Nkonya *et al*. (2008), double difference method compares change in outcomes pre and post programme for participants and non – participant. It is mostly used especially if selection bias is additive and time invariant. Using this technique outcome is not affected by expectations of participation because it's usually nets out the selection bias (Nkonya *et al*., 2008). This method is said to be sensitive to data quality as measurement error is likely more serious in comparing changes in variables than comparing levels.

The double - difference analytical tool is a quantitative method often used to measure impact assessment study. The double difference estimator according to Mkonya *et al*. (2007), compares changes in outcome measures (changes from before to after the project) between project participants and non – participants rather than simply comparing outcomes levels at one point in time. The double difference estimator analytical tool is a quantitative method often used to measure impact of a project. It is used to estimate and compare change in outcome pre and post program for participant and non – participant (Chen *et al*., 2006).

In order to use the estimator in question, there must be information on both participants and non – participants and all individuals must be observed both before and after the program (Verner and Verner, 2005).The impact of a policy on an outcome can be estimated by computing a double difference, one over time (before – after) and across subjects (between users and non – users). The "double difference" method entails comparing a treatment group with a comparison group both before and after the usage of a technology. Therefore, to evaluate program impact, Verners in their double difference estimator model version gave the model as:

$$DD^S = \left[\frac{1}{P}\sum_{i=1}^{P}(Y_{1i}^{a} - Y_{1i}^{b})\right] - \left[\frac{1}{C}\sum_{i=1}^{C}(Y_{0j}^{a} - Y_{0j}^{b})\right] \quad \text{..... (1)}$$

Where;

DD^S is the difference between the average change in the income for the participant and non – participant

P is number of participants

C is the number of individual control group (non – participant)

Y_{1i}^{a} is the outcome variable of participants after the programme

Y_{1i}^{b} is the outcome variable of participants before the programme

Y_{0j}^{a} is the outcome variable of non - participants after the programme

Y_{0j}^{b} is the outcome variable of non - participants before the programme

a and b are the time after and before project respectively

In order to take observable heterogeneity of individuals into account, Verners calculated the double difference estimator from a regression model including other personal characteristics. They modeled the value of this variable as:

$Y_{ia} = \alpha + \beta P_i + \gamma X_{ia} + e_{ia}$..... (2)

Where:

Y_{ia} = outcome of a program

α = common error term

β = estimable effect for participation in the program

P_i = indicator for participation in the program

γ = outcome of a program

X_{ia} = vector of observable characteristic of the individual

e_{ia} = error term

Similarly, the value of variables before the program is modeled as:

$$Y_{ib} = \alpha + \beta P_i + \gamma X_{ib} + e_{ib} \quad \text{..... (3)}$$

The error term consist of two parts:

$$e_{ib} = \eta_{i} + \mu_{ii} \quad \text{..... (4)}$$

Where;

η = time invariant unobserved individual specific effect allowed to be correlated with the participant indicator

μ_i = innovation error assumed to be uncorrelated with all explanatory variables.

Hence, to obtain the change in outcome variable between the two periods (after and before) the difference over the two periods is taken as:

$$Y_{ia} - Y_{ib} = \beta P_i + \gamma(X_{ia} - X_{ib}) + e_{ia} - e_{ib} \quad \text{.....(5)}$$

Verners further specified that equation (12) could be used on the assumption that characteristics of an individual do not change overtime especially if the individual is interviewed only once. Also if equation (12) model is estimated by OLS, the resulting

estimates of β and γ are unbiased, because the potential bias from correlation between the unobservable and observables is limited as a consequence of the first – differencing. The estimate of β according to Verners is then the double difference estimate of the impact of the program, taking into accounts both observable and time invariant unobservable heterogeneity. In using double difference estimation model, there are inherent problems associated with it. These problems according to Nkonya *et al.* (2008) include: project placement or targeting bias, in which the location or target population of the project is not random and (2) self – selection bias, in which households chose whether or not to participate and thus may be indifferent in their experiences, endowment and abilities.

To solve the above selection bias problem, they subjected an experimental approach to construct an estimate of the counter – factual situation by randomly assigning household to treatment (beneficiary) and control (non – beneficiary) groups. Random assignment ensures that both groups are statistically similar (i.e., drawn from the same distribution) in both observable and unobservable characteristics, thus avoiding project placement and self – selection biases.

2. 6. 4 Econometrics methods of impact evaluation

The method according to Nkonya *et al.* (2008) is developed to address selection biases. Econometrics is said to account for effects of differences in observable characteristics across individuals or over time and it has controls for many variables simultaneously.

Maredia *et al*. (2003) on the other hand view econometrics methods of impact evaluation as an approach that employs a production function, cost function, or total factor productivity analysis to estimate the change in productivity due to investment in

programme. However, econometric methods of impact evaluation as an approach that employs a production function, cost function, or total factor productivity analysis to estimate the change in productivity due to investment in programme. Using the same data base, econometric studies of research impacts are conducted within the framework of a production that incorporates conventional inputs (land, labour, fertilizer, etc.), non – conventional inputs (education, Infrastructures, etc.) and the stock of technical knowledge (investment in research and extension) (Simonyan, 2008).

However, the problems associated with the use of econometrics method are the fact that parametric approaches often used depend on valid parametric assumptions (Nkonya *et al.,* 2008). Secondly, there is problem of validity of heterogeneity and exclusion assumptions about instrumental variables. Third, there is need to address endogeneity of participation in projects. Fourth, biases often introduced by comparing non – comparable observations.

2. 6. 5 Qualitative methods of impact evaluation

Qualitative techniques are used for carrying out impact evaluation with the intent to determine impact by the reliance on something other than the counterfactual to make a causal inference. The focus instead is on understanding processes, behaviours, and conditions as they are perceived by the individuals or groups being studied. Qualitative methods and particularly participant observation can provide insight into the ways in which households and local communities perceive a project and how they are affected by it (Simonyan, 2008). Qualitative approach is useful for organizational learning objective. It is worth nothing that participant in qualitative approach have limited ability

to attribute impacts to interventions and have problems of sampling and interviewer biases.

Nevertheless, qualitative impact assessment techniques are the techniques developed foe rapid rural assessment, which rely on participants knowledge of the conditions surrounding the project or program being evaluated, or participating evaluations in which stakeholders are involved in all stages of the evaluation, determining the objectives of the study, identifying and selecting indicators to be used, and participatory in data collection and analysis (Simonyan, 2008).

2.7 Propensity Score Matching (PSM)

Propensity score matching is a tool for causal inference in non-randomized studies that allow for conditioning on large sets of covariates (Thoemmes. 2012). The use of propensity scores in the social sciences is currently experiencing a tremendous increase; however it is far from a commonly used tool. Matching has become a popular approach to estimate causal treatment effects. It applies for all situations where one has a treatment, a group of treated individuals and a group of untreated individuals (Iza and Kopeinig, 2008). The nature of treatment may be very diverse. Every micro econometric evaluation study has to overcome the fundamental evaluation problem and address the possible occurrence of selection bias.

The first problem arises because we would like to know the difference between the participants' outcome with and without treatment. Clearly, we cannot observe both outcomes for the same individual at the same time. Taking the mean outcome of nonparticipants as an approximation is not advisable, since participants and

nonparticipants usually differ even in the absence of treatment. This problem is known as selection bias and a good example is the case where high-skilled individuals have a higher probability of entering a training programme and also have a higher probability of finding a job. The matching approach is one possible solution to the selection problem. It originated from the statistical literature and shows a close link to the experimental context. Its basic idea is to find in a large group of nonparticipants those individuals who are similar to the participants in all relevant pre-treatment characteristics *X*. That being done, differences in outcomes of this well selected and thus adequate control group and of participants can be attributed to the programme. Impact assessment studies face three interrelated challenges; establishing a viable counterfactual (the predicted outcome in the absence of the intervention – that is what would have happened to the beneficiaries had they not participated in the project); attributing the impact to an intervention; and coping with long and unpredictable lag times (Alston and Pardey, 2001; Salter and Martin, 2001).

Duflo *et al., (*2006), pointed out the problem of selection involving an unobservable by computing PSM with Average Treatment on the Treated (ATT) estimator. Combing PSM with ATT estimator controls for differences in pre – project observables characteristics can be established. A bias could still result from the heterogeneous or time – variant impacts of the unobservable differences between beneficiaries and non – beneficiaries. Such short comings are unfortunately inherent in all non – experimental methods of impact assessment (Duflo *et al.,* 2006). The underlying identifying assumption is known as unfounded, selection on observables or conditional independence. It should be clear that matching is no 'magic bullet' that will solve the evaluation problem in any case (Iza and Kopeinig, 2008). It should only be applied if

the underlying identifying assumption can be credibly invoked based on the informational richness of the data and a detailed understanding of the institutional set-up by which selection into treatment takes place.

Propensity score matching is a two-step procedure. First, a probability model for adoption of improved technology is estimated to calculate the probability (or propensity scores) of adoption for each observation. In the second step, each adopter is matched to a non-adopter with similar propensity score values, in order to estimate the average treatment effect for the treated (ATT). Any discrete choice model, such as a logit or probit model can be used to estimate the propensity score. The ATT is then estimated by matching the treated group with the control group based on the estimated propensity scores. Four methods are widely used: nearest neighbour matching, radius matching, kernel matching, and stratification matching (Becker and Ichino, 2002). However, the most common ones are:

(I) Kernel Matching Method (using the normal density kernel), which uses a weighted average of "neighbours" (within a given range in terms of the propensity score) of a particular observation to compute matching observations. Unlike the nearest – neighbor method, using a weighted average improves the efficiency of the estimator (Smith and Todd, 2001).

(II) Balancing Test which tests for statistically differences in the means of the explanatory variables used in the Tobit (Probit) models between the matched groups (Dehejia and Wahba, 2002).

The basic approach is to numerically search for "neighbours" of non-adopters that have a propensity score that is very close to the propensity score of the adopters. PSM is one

of the most commonly used quasi – experimental (non experimental) method which selects project beneficiaries and non – beneficiaries who are as similar as possible in terms of observable characteristics expected to affected the project participation as well as outcome. The difference in outcomes between the two matched groups can be interpreted as the impact of the project on the beneficiaries (Smith and Todd, 2001).

The major advantage of matching (over standard regression method) is that it is less demanding with respect to the modeling assumptions for the outcome equations (it is non – parametric). Further, with matching, there is no need for the assumption of constant additive treatment effects across individuals (Smith and Todd, 2001).

Few researchers have used the PSM/ATT in their evaluating projects/programmes, however, Pufahl and Weiss (2009) applied a semi – parametric Propensity Score Matching approach to evaluate the effects of agro – environmental programmes on input use and farm output of individual farms in Germany. The analysis reveals a positive and significant treatment effect of agro – environmental programmes on the area under cultivation, in particular grassland, resulting in a decrease of cattle livestock densities. While, Nkonya *et al*. (2009) used the PSM approach to evaluate the impacts of a Community Driven Development (CCD) project on household income and acquisition of productive assets in Nigeria. The study found that participation in the project (Fadama II) increased the income of beneficiaries by about 60 percent.

The impact treatment on the treated (causal effect of project beneficiaries was estimated by computing the differences across both groups (participants/non – participants) in equation7:

$$ATT = \frac{1}{N_1}(Y_1 - Y_0) \quad \text{..... (7)}$$

Where

ATT = Average impact of Treatment on the Treated

N_1 = Number of matches (from regression model)

Y_1 = Average income of users' income

Y_0 = Average income of non – users' income.

2.8 Empirical Studies on Impact of PICS Technology

Abdoulaye *et al*. (2010) carried out a study on the analysis of the determinants of assessing the re – use of PICS bags in Northern Nigeria, using the logit regression model. The choice of the explanatory variables in the model was based on the assessment of the re – use of the PICS bags. The result of the logit model as shown by Wald statistics was significant at 1% level of probability. The study discovered that the probability of reusing the bag was statistically increased by being demonstrators, being a male farmer (gender), experienced farmer (age), quantity of cowpea harvested and being a member of association. It also revealed among others that the probability of reusing the bag was statistically inverse of the education of the farmers and the level of reuse is independent of household size. Jokthan and Sanni, (2011) in their study on analysis of PICS bag intervention for cowpea storage in Nigeria, pointed out an increase in increase of farmers/traders by about 48% for cowpea stored within 4 – 6 months. They also discovered 5 – 10% increase in the price for cowpea stored in PICS bag.

Yakubu (2010) examined the income of PICS and non-PICS users (adopters) in Jigawa, Kano and Katsina states of Nigeria using the gross margin analysis, the value of the total cowpea yield was used as a measure of the gross income (revenue) and the total variable cost was taken as the summation of the cost. The result showed that PICS farmers makes more profit than non – PICS farmers. In Jigawa state, PICS farmers realized additional N 9,078 ahead of the non – PICS farmers. However, PICS farmers in Kano State have additional increase in profit by 18%. Moreover, each one naira invested by PICS farmers in Jigawa and Kano States fetched ₦3.7 and ₦5.5 respectively. The result in Katsina State is also similar to that of Jigawa and Kano State. The PICS farmers in Katsina State have additional increase in profit by ₦3, 858. On the return on naira invested, PICS farmers have only ₦3.1 while non – PICS farmers have ₦2.7 on each naira invested in Katsina State.

Jones *et al.* (2011) in their study on profitability of hermetic PICS bags for African common bean producers reported that PICS bags have the potential to provide substantial returns to storage for marketing producers. Moussa (2006) conducted an impact assessment of the Bean/Cowpeas CRSP project and estimates that, due to the introduction of hermetic technology in the region, over 500,000 additional tons of cowpea are now conserved per year, resulting in $100 million in annual additional cowpea income. The success of PICS bags with cowpeas has induced producers and researchers alike to begin experimentation with storage of other commodities. To date, PICS bags have displayed 50% lower cassava chip storage losses compared to conventional polypropylene bags over a two month period (Ognakossan *et al*., 2010). Research by Ognakossan *et al*. (2010) is still in progress at the time of this analysis and will yield more long-term results soon.

Hell *et al*. (2010) also displayed that PICS bags can provide extremely high rates of protection for maize grain, remaining under 0.5% dry weight loss after a six month period. While no direct studies have thus far been conducted with PICS bags for common bean storage, field experiences allow for estimations (based on cowpea losses) of about 0.6% dry weight loss in long-term storage.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

The study was conducted in North Central States of Nigeria, which is a human geographical term designating the region of central Nigeria. It stretches across the country longitudinally, with a population of 19,572,406 million people in 2006 (NPC, 2006) and a projected population of 20, 686, 310 people in 2012 at a growth rate of 3.2 percent per annum. It covers a total land area of 238,791 square kilometers (NPC, 2006). It lies between latitudes 7^0 N to 12^0 N and longitude 2^0 30^1 E to 12^0 E, with Benin republic boarding it to the west and Cameroun republic to the east. This area falls within the Guinea savanna vegetation zone of Nigeria and the topography is upland, hilly, undulating to plane land.

The States within the north central are: Benue, Kogi, Kwara, Nassarawa, Niger and Plateau (figure 2). Its climate is characterized by two distinct seasons; rainy and dry seasons. The rainy season lasts from April to November with annual average rainfall of between 500 mm and 1200 mm. The southern part of the zone has higher rainfall percentage than the northern parts. The daily minimum and maximum temperatures range between 27 ^{0} C and 37 ^{0} C (night and day). The relative humidity ranges from averages of about 70% to 130%. There is however, the usual drop in relative humility during the period of harmattan, from November to March. Climatic and soil conditions of this zone favour the cultivation of rainfed crops like maize, sorghum, rice and millet and legumes like cowpea, soya bean and groundnuts. On the wetlands, crops like yams, cassava, vegetables, peas and rice are grown.. This zone though, small producer of cowpea but high consumer apart from being

the transit states between the northern and southern part of Nigeria. Agriculture is considered as the major economic activity and over 70% of the population is engaged in farming and animal husbandry.

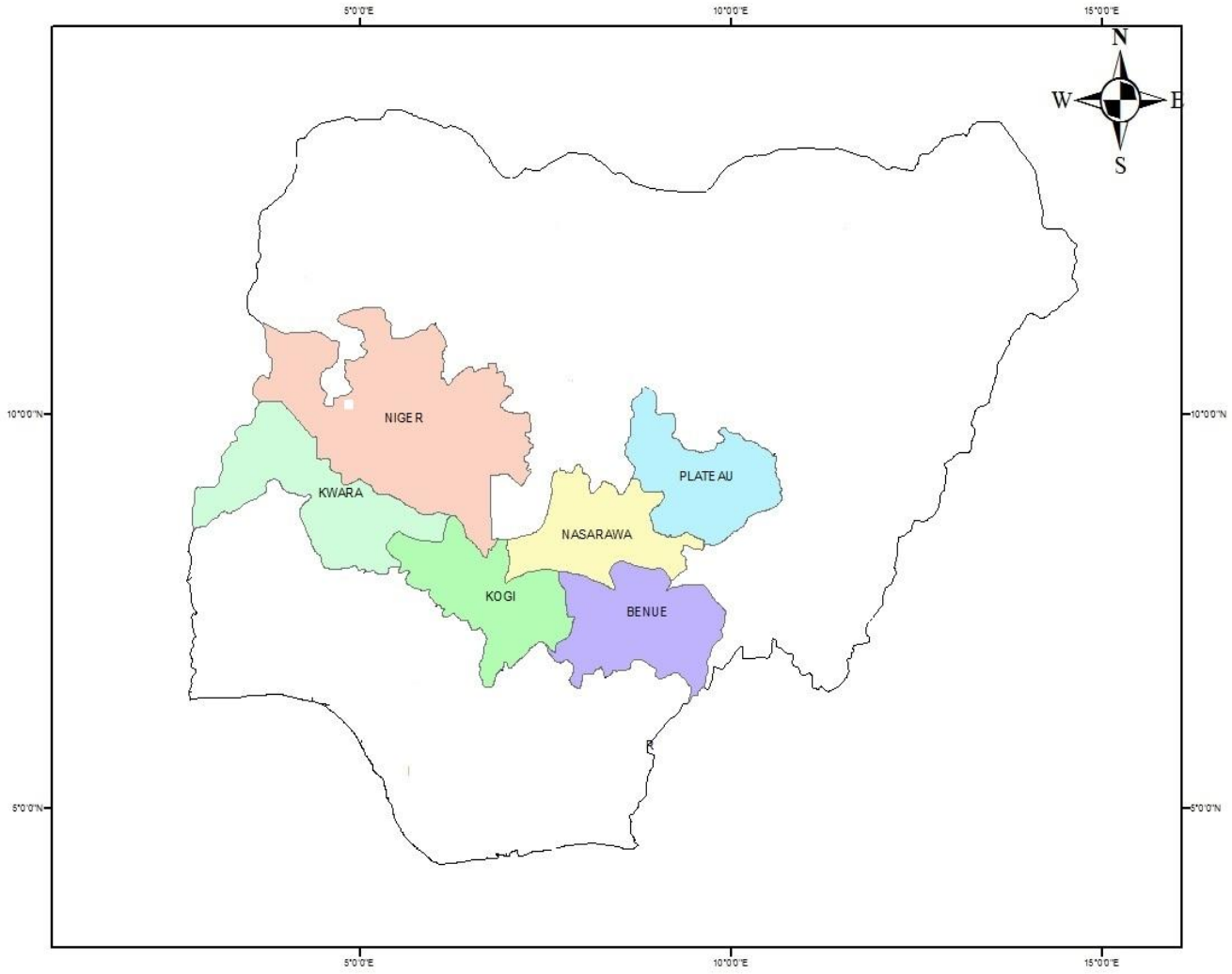


Figure 2: The north central states of Nigeria
Source: Adapted and Modified from Administrative Map of Nigeria, 2012

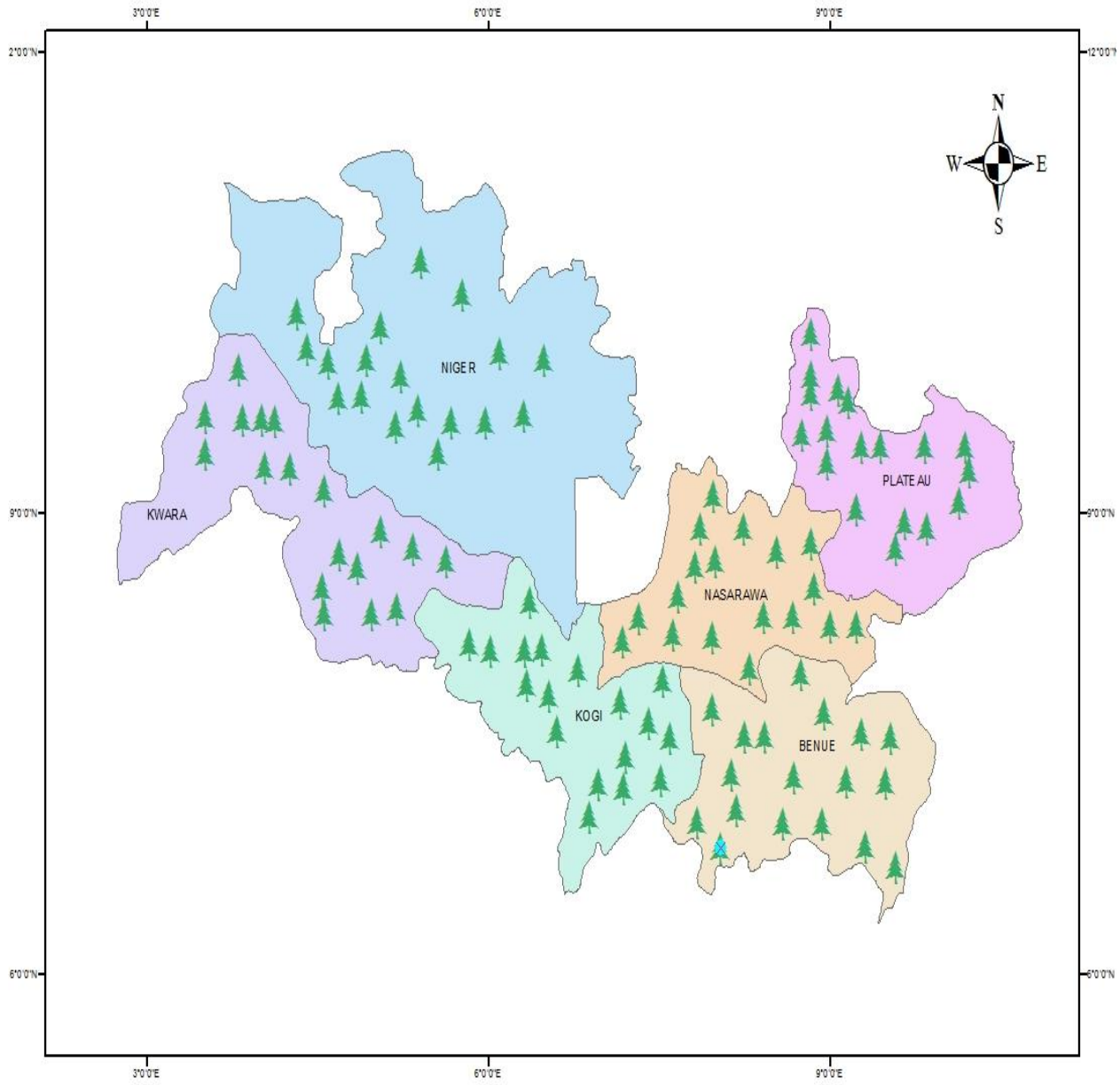


Figure 3: The selected settlements in north central states of Nigeria
Source: Adapted and Modified from Administrative Map of Nigeria, 2012

3.2. Sampling Procedure and Sample Size

A multi-stage sampling technique was employed in the study. The first stage was the purposive selection of three Local Government Areas (LGAs) from each of the three senatorial districts of the north central states. The north central states were selected for this

study because of the high consumption rate of cowpea, participation in PICS project and the link states between the northern and southern part of Nigeria.

A total of 18 Senatorial Districts were chosen to be able to cover large parts of the States and have a good representation of the respondents. These Local Government Areas were selected on the basis of being the most prominent cowpea producing areas of the states. Secondly, 108 villages were purposively selected (two from each local government) on the basis of their output performance in cowpea production as shown in appendix I.

Thirdly, 10% of the 2220 (1240 farmers and 960 traders) population of the cowpea farmers/dealers were randomly selected by balloting based on their high intensity of cowpea production activity, involvement in the PICS project and accessibility. The selection of the respondents was assisted by the list of recognised farmers/dealers of cowpea collected from the State Agricultural Development Projects (ADPs). Fourthly, the same number of non – users of PICS technology were randomly selected from the study area through balloting. In all, a total of four hundred and forty (440) respondents were selected for this study that is, two hundred and twenty (124 farmers and 96 traders) users of PICS technology and two hundred and twenty (124 farmers and 96 traders)) non - users of PICS technology were selected as shown in Table 1.

Table 1: Selection of PICS users in the study areas.

States	Selected LGA	Selected Villages	Population		Selected Users		Selected Non – Users	
			Farmers	Traders	Farmers	Traders	Farmers	Traders
Benue	9	18	210	170	21	17	21	17
Kogi	9	18	120	170	12	17	12	17
Kwara	9	18	120	160	12	16	12	16
Nasarawa	9	18	230	140	23	14	23	14
Niger	9	18	300	180	30	18	30	18
Plateau	9	18	260	140	26	14	26	14
Total	**54**	**108**	**1240**	**960**	**124**	**96**	**124**	**96**

3.3 Methods of Data Collection

The study made use of primary data. Primary data collected through the use of structured questionnaire. The questionnaires were administered by trained enumerators under the supervision of the researcher. The data collected during the field survey were on the quantity of cowpea (kg), income, labour used (man-hour), access to agricultural extension services, price of PICS bags and other bags, number of bags used, length of storage for season before and after the introduction of PICS bags for users and non – users alike. Data on socioeconomic characteristics of the respondents were also collected. Major constraints facing respondents and Costs of transaction variables (harvesting, transportation, storage, threshing and bagging costs) were also collected.

3.4 Analytical Techniques

The following analytical tools were used to achieve the stated objectives of the study.

i Descriptive statistics was used to achieve objectives i and v

ii The gross margin was used to achieve objective ii.

iii The Double Difference Estimator was used in achieving objective iii.

iv The Propensity Score Matching (PSM) was used to further achieve objective (iii).

3.4.1 Gross margin analysis

Profitability of any investment is based on comparison of the returns and costs of the investment. Hence, costs and returns analysis is the basis for measurement of profitability of any enterprise. Profit maximization is the most important goal of farm business. Profit is generally described as the difference between Total Revenue (TR) and the Total Costs (TC). The total revenue is the product of output sold and price. Total cost is divided into fixed and variable costs. According to Olukosi and Ogungbile (2004), fixed costs are those costs incurred on fixed inputs which cannot be used up during one production process, while variable costs are those costs associated with variable inputs and do change with changes in output level.

Farm budgeting technique is one of the simplest and oldest tools of analysis in farm management and production economics studies. According to Olukosi and Ogungbile (2004), net farm income gives an overall level of profitability of an enterprise. It involves the determination of total revenue and total costs. Gross margin analysis forms an alternative basis for farm profitability analysis. It involves accurate collection of different costs of variable inputs and the gross income obtained from a particular enterprise in order to obtain the net returns (Bernard, 2003). Essentially, gross margin is a budgeting tool needed to estimate total variable costs of agro – business and total revenue. Gross margin is the difference between the Total Revenue (TR) and the Total Variable Costs (TVC), assuming fixed cost is negligible.

Gross Margin was used to determine the profitability of storing cowpea using PICS technology. This is the difference between the Total Revenue *(TR)* and the Total Variable Costs *(TVC),* assuming fixed cost is negligible as shown in equation 6.

GM = TR – TVC..... (8)

Where:

GM = Gross Margin (₦/Kg)

TR = Total Revenue from the sale of cowpea at the end of the storage period *(*₦/Kg*)*

TVC = Total Variable Cost *(*₦/Kg*)* from cost of bag, Bait, cowpea, transportation, labor, storage materials.

Profitability index was also computed (equation 9), to quantify the amount of value created per unit of investment.

Profitability index (PI) is the ratio of Gross Margin to initial investment of a proposed project. The ratio is calculated as follows:

$$Profitability\ Index = \frac{\text{Gross Margin}}{\text{Initial Investment (Total Cost)}} \quad \text{..... (9)}$$

Therefore, the higher the ratio, the more cash flow to investment. An index of 1.0 means the rate of return is exactly, an index greater than 1.0 means the goal has been exceeded and an index less than 1.0 means the goal has not been achieved. Hence, to meet the investment goal a profitability index of 1.0 or better is necessary.

3.4.2 Double difference estimator method

The double - difference analytical tool is a quantitative method often used to measure impact assessment study. The double difference estimator according to Mkonya *et al.* (2007) compares changes in outcome measures (changes from before to after the project) between project participants and non – participants rather than simply comparing outcomes levels at one point in time. The double difference estimator

analytical tool is a quantitative method often used to measure impact of a project. It is used to estimate and compare change in outcome pre and post program for participant and non – participant (Chen *et al.*, 2006).

In order to use the estimator in question, there must be information on both participants and non – participants and all individuals must be observed both before and after the program (Verner and Verner, 2005).The impact of a policy on an outcome can be estimated by computing a double difference, one over time (before – after) and across subjects (between users and non – users). The "double difference" method entails comparing a treatment group with a comparison group both before and after the usage of a technology. Therefore, to evaluate program impact, Verners in their double difference estimator model version gave the model as:

$$DD = \left(Y_{P_1} - Y_{P_0}\right) - \left(Y_{nP_1} - Y_{nP_0}\right) \quad \text{..... (10)}$$

Where

Y_{P_1} = Income of users after PICS technology

Y_{P_0} = Income of users before PICS technology

Y_{nP_1} = Income of non – users after PICS technology

Y_{nP_0} = Income of non - users before PICS technology

The double difference estimator was employed to achieve objective (iv) of the study, that is, the impact of PICS technology on the income of users in the study area.

The model as specified by Verner and Verner is as follows:

3.4.3 Propensity score matching (PSM)

This was used in association with the Verners' method estimator to achieve objective (iii) of the study. Two-step is involved in PSM: (1) probability model for adoption of improved technology is estimated to calculate the probability (or propensity scores) of adoption for each observation. (2) Each adopter is matched to a non-adopter with similar propensity score values, in order to estimate the average treatment effect for the treated (ATT). Any discrete choice model, such as a logit or probit model can be used to estimate the propensity score. The ATT is then estimated by matching the treated group with the control group based on the estimated propensity scores. The basic approach is to numerically search for "neighbours" of non-adopters that have a propensity score that is very close to the propensity score of the adopters.

Propensity Score Matching (PSM) involves identifying a sample of comparators non – participants that are similar as possible to participants in their predicted livelihood of participation then comparing the mean outcomes. In other words, one picks an ideal comparison group on the basis of a set of of observed characteristics ("propensity score") (Ravallion, 2001). The most common evaluation parameter of interest is the Average Treatment Effect on the Treated (ATT), which is defined as;

$$ATT = E(Y_1 - Y_0/\ P = 1) = E\ (Y_1/\ P = 1) - E\ (Y_0/\ P = 1). \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

The Propensity Score is the probability of participation for farm household, i given a set $X = x_i$ of characteristics $P(X) = Pr\ (P = 1/X = x_i)$ (Pufahl and Weiss, 2009). The propensity scores are derived from the regression models in which these characteristics were compared.

The impact treatment on the treated (causal effect of project beneficiaries was estimated by computing the differences across both groups (participants/non – participants) in equation 28:

$$ATT = \frac{1}{N_1}(Y_1 - Y_0) \quad \text{..... (12)}$$

Where

ATT = Average impact of Treatment on the Treated

N_1 = Number of matches (from regression model)

Y_1 = Average income of users' income

Y_0 = Average income of non – users' income.

A positive (negative) value of ATT suggests that users' of PICS bags have higher (lower) outcome variable than non – users. This was used to further achieve objective (iii).

3.4.4 Paired t - statistics

The paired t-test compares the paired groups. It calculates the differences between each set of pairs, and analyses that list of differences based on the assumption that the differences in the entire population follow a Gussion distribution (Graph, 1999 in Simonyan, 2008).The paired t-test is generally used when measurements are taken from the same subject before and after some manipulations are done. It can also be used to compare samples in each pair (David, 2005).It provides a hypothesis of difference between population means for a pair of random and samples whose differences are approximately distributed. The reason behind the use of paired sample (before and after)

and a paired test is to control for experimental variability due to error of measurement, hence by analysis on the differences between before and after a treatment intervention, a paired test corrects for those sources of scatter (Goulden, 2007). The application of paired t-test is ensured provided certain conditions are met; the number of points in each set must be the same and they must be organised in pairs in which there is a definite relationship between each pair of data points; if data were taken as random samples, you must use the independent test even if the number of data points in each set is the same, if a given data point in group one could be paired with any data point in the two groups, we cannot use a paired t-test (Goulden, 2007).

According to Weistein (2006), the test can be applied as specified in equations 22 to 24:

$$\widehat{X_1} = X_1 - \bar{X} \quad \text{..... (13)}$$

$$\widehat{Y_1} = (Y_1 - \bar{Y}) \quad \text{..... (14)}$$

Then defined t as

$$t = = (Y_1 - \bar{Y}) \sqrt{\frac{n(n-1)}{\sum_{i=1}^{n} (\widehat{X_{1\,i}} - \widehat{Y_{1\,i}})^2}} \quad \text{..... (15)}$$

Where,

X_1 and Y_1 = two paired sample sets

n = sample size

n – 1 = degree of freedom

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter deals mainly with the presentation and discussion of the research results obtained from the data analysis.

4.1 Socio Economic Characteristics of Sampled Cowpea Farmers/Dealers

The socio economic characteristics of the project users and non users of PICS technology examined in this study are presented in this section. The variables considered include age, gender, educational status, occupation, membership of association and cowpea handling experience, experience in using PICS technology and household size.

4.1.1 Age of respondents

Age distribution of the users and non - users of PICS technology ranged from a minimum of 18 years and a maximum of 65years. The study revealed that 56% of the users of PICS technology in the study area were farmers while 44% were traders. It was also discovered that about 62% of the farmers belong to the age bracket of 18 – 40 years, while about 10% were above 60 years. About 61% of the users were also traders who were within the age bracket of 18 – 40 years, 31% were between 41 – 60 years and 7% were above 60 years. However, the larger number (50%) of the non – user's traders and farmers were between 30 - 40 years. The mean age of users and non – users were 35 years and 38 years respectively as shown in Table 2. The implication is that young people were more involved in farming and trading in the study area which implies that

they were strong enough for tedious farm operations like farming, processing and storage. Bolaji, (2000) observed that an increase in the average age of the farmers can affect the amount and quality of labour supplied by the farm families. This implies that as the farmer's/trader's age increases their ability to participate in energy tasking work like farming and trading begins to diminish and this will greatly impact on the level of output and income. It can be inferred that the younger the farming/trading population the more the productivity as their youthful energy can be channelled towards productive agricultural enterprises that will increase their income. The results also indicate that large numbers of respondents were young, active and are likely to be more adventurous; therefore, given adequate levels of innovations, they have the potential to turn their fortune to success. The fact that the mean age of users and non – users were in the age bracket of thirty plus (30+) shows that there is great potential of PICS technology having higher economic advantage in the study area.

Table 2: Distribution of users and non- users of PICS technology by age

	Users				**Non-users**			
Age(years)	**Farmers**	**%**	**Traders**	**%**	**Farmers**	**%**	**Traders**	**%**
< 30	11	8.9	7	7.2	18	14.5	12	12.5
30 - 40	66	53.2	52	54.1	62	50.0	48	50.0
41 - 50	25	20.1	17	17.1	18	14.5	12	12.5
51 – 60	10	8.1	14	14.4	10	8.1	11	11.5
61 & above	12	9.7	6	6.2	16	12.9	13	13.5
Total	**124**	**100**	**96**	**100**	**124**	**100**	**96**	**100**
Mean age	35.016		36.063		38.35		39.827	
Min. age	26		26		26		28	
Max age	53		51		58		58	
Std Dev.	5.6525		5.8666		7.9671		6.8056	

4.1.2 Gender of respondents

More than half (53%) of the users and non users (54%) of PICS technology in the study were males while 47% of the users and 46% of the non – users were females. Grain traders/farmers in the study area comprised of male (53%) and female (47%) as shown in Table 3. Both male and female compliment themselves by the different roles they play within the household or family such as processing food crops and collecting water and firewood, food storage and transport from farm to home, hoeing and weeding, harvesting and marketing. This conforms to Bonabana – Wabbi, (2002) that effort in improving women's working skills does not appear warranted as their technical efficiency is estimated to be equivalent to that of males. Since adoption of a practice is guided by the utility expected from it, the effort put into adopting it is reflective of this anticipated utility. It might then be expected that the relative roles women and men play in both 'effort' and 'adoption' are similar, hence suggesting that males and females adopt practices equally.

Table 3: Distribution of users and non – users of PICS technology by gender

	Users				Non-users			
Gender	**Farmers**	**%**	**Traders**	**%**	**Farmers**	**%**	**Traders**	**%**
Male	65	52.4	51	53.6	66	53.2	53	55.2
Female	59	47.6	45	46.4	58	46.8	43	44.8
Total	**124**	**100**	**96**	**100**	**124**	**100**	**96**	**100**

4.1.3 Educational level of respondents

Respondents' distribution by their educational level as presented in Table 4 showed that more than half (51%) of the users attended primary school. In the case of the non users,

majority (98%) do not have formal education. According to Imonikhe (2004), education would significantly enhance farmer's ability to make accurate and meaningful management decisions, it could also enhance knowledge of improved techniques such as how to read and interpret recommended packages. Education has been shown to be a factor in the adoption of yields increasing modern farm practices. The low proportion of illiterates in the respondents' group implies that the majority of them are in a better position to be aware of, understand and adopt improved cowpea technologies.This may be one of the reasons why users of PICS bags understood the need to use PICS technology. Furthermore, the literate farmers will be able to adopt improve technologies that will impact on their output and income while those not educated may find certain farm practises too complex to comprehend. According to Mathew and Adebayo, (2008) education influences the quality of labour and it could also explain why the farmers do not keep appropriate farm records. Education can enables an individual take informed decision that will help him improve his crop output and to avoid risk of crop failure.

Table 4: Distribution of users and non- users of PICS technology by educational level

	Users				**Non-users**			
Education level	**Farmers**	**%**	**Traders**	**%**	**Farmers**	**%**	**Traders**	**%**
No education	5	4.0	3	3.1	41	33.1	31	32.2
Informal Education	20	16.1	16	16.7	55	44.4	43	44.8
Primary Education	63	50.8	49	51.0	18	14.5	14	14.6
Secondary Education	24	19.4	18	18.8	7	5.6	6	6.3
Tertiary Education	12	9.7	10	10.4	3	2.4	2	2.1
Total	**124**	**100**	**96**	**100**	**124**	**100**	**96**	**100**

4.1.4 The occupations of respondents

The study revealed also that majority of the users (77%) and non – users (72%) had farming as their main occupation while about 23% of non – users and about 29% of users had trading as their main occupation, that 22% of users and 12% of non – users were civil servant while 34% of non – users and 29% had teaching as their main occupation as shown in Table 5. Economically, agriculture in the study area, offers employment to the large number of the people both as part – time and full – time at subsistence basis. Along with other activities such as craft and trade, PICS technology is practiced by most of the respondents irrespective of the type of occupation they do. The adoption of PICS technology encouraged increase income and sustainability of the entire locality irrespective of the mode of usage (full – time and part – time or subsistence).

Table 5: Distribution of users and non- users of PICS technology by occupation

	Users				**Non-users**			
Major occupation	**Farmers**	**%**	**Traders**	**%**	**Farmers**	**%**	**Traders**	**%**
Farming alone	95	76.6	0	0	89	71.7	0	0
Trading	0	0	70	72.9	0	0	75	78.2
Civil servant	12	9.7	11	11.5	11	8.9	8	8.3
Teaching	17	13.7	15	15.6	24	19.4	13	13.5
Total	124	100	96	100	124	100	96	100

4.1.5 Membership of association of respondents

The result in Table 6 shows that 70.3% and 69% of the users and non – users respectively had been members of association in the last 1 – 2 years. About 25% and

22% of the non - users and users were members in the last 3 - 4 years while only 2% of both users and non – users did not belong to any form of association. Due to the fact that majority of the respondents belong to association and cooperative indicates that member farmers/traders benefit as a group rather than individually because information on innovations are easily disseminated among them. According to Agwu (2004), farmer organizations offer an effective channel for extension contact with large number of farmers, as well as, opportunities for participatory interaction with extension organizations.

Association also help the farmers/traders in getting along with others to discuss current issues and from where knowledge about new technologies or ways of earning better income from agricultural activities (Bolaji, 2000).

Table 6: Distribution of users and non – users of PICS Technology according to years of experience in Association.

	Users				**Non -users**			
Years	**farmers**	**%**	**Traders**	**%**	**Farmers**	**%**	**Traders**	**%**
Non-members	2	1.6	3	3.1	2	1.6	3	3.1
1-2	86	69.4	68	70.9	86	69.4	65	67.7
3-4	29	23.3	20	20.8	32	25.8	24	25
5 and above	7	5.7	5	5.2	4	3.2	4	4.2
Total	**124**	**100**	**96**	**100**	**124**	**100**	**96**	**100**
Mean			2.135		2.169		2.198	
Std. Dev.	2.306		1.202		1.201		1.219	

4.1.6 Cowpea production experience of respondents

Table 7 shows the distribution of the respondents based on their years of experience in cowpea production. The results showed that 79% of farmers and traders had between 5 – 10 years of experience in cowpea production while 27% of them had 21 years and above cowpea production experience. The implication here is that most of the farmers/traders were highly experienced in cowpea production as such they could better manage their production process to get better output and income. According to Rahman and Mali, (2003) length of time in business can be linked to age further more they observed that age, access to capital and experience in farming may explain the tendency to adopt new technology. The result also shows that majority of the cowpea farmers/traders had long period of farming experience and therefore would be conversant with constraints to increased cowpea production. This could increase their level of acceptance of new ideas as a means of overcoming their production constraints and hence could serve as an advantage for increased cowpea production (Agwu, 2004). Experience is very important in cowpea production, risk evaluation and management as such the more experience a farmer/trader is the better he is able to take informed decision based on experience. It also means that the farmer will be able to incorporate innovations that will enable products to be stored properly.

Table 7: Distribution of users and non – users of PICS Technology according to cowpea production experience

	Users				Non-users			
Experience (Years)	**Farmers**	**%**	**Traders**	**%**	**Farmers**	**%**	**Traders**	**%**
< 5	22	17.7	17	17.7	15	12.1	10	10.4
5 - 10	49	39.5	38	39.7	18	14.5	16	16.7
11-15	17	13.7	13	13.5	19	15.3	15	15.6
16 - 20	20	16.2	15	15.6	28	22.6	22	22.9
21 and above	16	12.9	13	13.5	44	35.5	33	34.4
Total	**124**	**100**	**96**	**100**	**124**	**100**	**96**	**100**
Mean	9.516		9.813		13.653		13.844	
Std. Dev.	6.593		6.476		7.016		6.470	

4.1.7 Respondents' experience in using PICS technology

The result showed that majority of the users (73%) and non – users (55%) respectively had less than 2 years experience in using PICS technology. This implied that majority of the PICS bag users in the study area were early adopters and had confident in the PICS technology and may probably be engaged in the use of the PICS technology for adventure or to get extra income. Hence, the high level of adoption associated with the use of PICS technology implies that farmers in the area were aware of the fact that storing their cowpea in PICS bag provides an attractive opportunity for them to make better economic gains in terms of increase income.

Table 8: Distribution of Users and Non – users of PICS Technology according to Years of Experience

	Users				Non-users			
Experience (Years)	**Farmers**	**%**	**Traders**	**%**	**Farmers**	**%**	**Traders**	**%**
Non	11	8.9	8	8.3	37	29.9	29	30.2
< 2	91	73.4	71	74.0	68	54.8	53	55.2
2-4	20	16.1	14	14.6	16	12.9	12	125
5 and above	2	1.6	3	3.1	3	2.4	2	2.1
Total	**124**	**100**	**96**	**100**	**124**	**100**	**96**	**100**
Mean	1.226		1.292		1.113		0.948	
Std. Dev.	0.882		1.015		1.257		0.944	

4.2. The Basic Information on Items and Values Used in Profitability Analysing

Table 9 shows the basic information on items and values used in the analysis of profitability of storing cowpea in PICS bag. Total quantity of cowpea stored by users and non –users of PICS technology per kilogram was 2,677.83 kg for 4 – 6 months. The selling price per kilogramme of cowpea before storage was ₦145.00 while the selling price after storage was ₦170.00 - ₦160.00/kg. It is imperative that even the price difference noticed after storage clearly shows value added through storage of cowpea. The total quantity stored by users of PICS technology was 1,433.10 kg for period of 4 – 6 months; with a selling price of ₦145.00/kg before storage and selling price of ₦170.00 after storing in PICS bag in the study area. The non – users stored 1,244.83 kg quantity of cowpea for 4 – 6 months period with a selling price of ₦145.00/kg before storage and selling price of ₦160.00 after storage using other means. Literarily, looking at these basic information, storage is very essential for farmers/traders of cowpea to be able to get the maximum benefit accrued for their upliftment.

Table 9: The Basic information on items and values used in analysing profitability of storing cowpea in PICS bag.

Items	Values
General Information	
Total quantity of cowpea stored by users and non –users of PICS technology (Kg)	2,677.83
Duration of storage (Months)	4 – 6
Selling price at/before storage of cowpea (₦/Kg)	145.00
Selling price after storage of cowpea (₦/Kg)	160.00 – 170.00
Users' of PICS Technology	
Quantity of cowpea stored by all users (₦/Kg)	1,433.10
Duration of storage (Months)	4 – 6
Selling price at/before storage of cowpea (₦/Kg)	145.00
Selling price after storage of cowpea (₦/Kg)	170.00
Non – users' of PICS technology	
Quantity of cowpea stored by all non – users (₦/Kg)	1,244.73
Duration of storage (Months)	4 – 6
Selling price at/before storage of cowpea (₦/Kg)	145.00
Selling price after storage of cowpea (₦/Kg)	160.00

4.2.1 The profitability of storing cowpea in PICS bags

The details of profitability of storing cowpea in PICS bags are presented in table 10. The total variable costs incurred by users and non – users of PICS technology were ₦1,292.21/bag (₦12.92/Kg) and ₦1,529.88/bag (₦15.30/Kg) respectively, while their total revenues were ₦3,812.94/bag (₦38.13/kg) and ₦2,207.51/bag (₦22.08/Kg) respectively. The result indicates a higher gross margin of the users (₦26.79/Kg) than that of the non – users (₦9.38./Kg). The difference in gross margin for the users of PICS bag and the non – users of PICS bags may be attributed to the increase in quality and market price of cowpea stored in PICS bags. The profitability index revealed that

users of PICS technology had 2.36 while non – users had 0.71kobo.This implies that for every one naira invested ₦1.36 kobo was made as profit, further showing that using PICS technology in storing cowpea is more profitable in the study area. This manifests the potential benefit of PICS technology in the study area thereby enabling improve food security and self sustainability in meeting the domestic needs of the household.

Table 10: Profitability of PICS Technology Users

	Mean cost (₦)			
	Users		Non - users	
Item	**Value Before(₦) 2012**	**Value After(₦) 2013**	**Value Before(₦) 2012**	**Value After(₦) 2013**
A. Returns				
Total Revenue	351,833	868,806	380,350	532,207
B. Variable Cost				
Bait	2,174	2,118	2,175	5,297
Cowpea	207,800	243,627	180,500	199,173
Transportation	1,500	1,706	1,300	1,844
Labour	13,612	8,836	13,312	60,200
Storage Material*	3,128	2,154	3,036	39,461
Total Variable Cost	228,214	258,441	230,549	305,975
Gross Margin (A–B)	123,619	610,365	149,801	226,232
Profitability index	0.54	2.36	0.65	0.74

* Storage materials include PICS bags or ordinary bag, pesticides etc

The comparison of difference in the mean profit between users and non – users shows that those using the PICS technology had mean gross margin of ₦ 610,365, while non –

users had ₦ 226,232. It is obvious that PICS bag users on the average (₦384,133) were better than non – users. The analysis of the mean of gross margins as presented in table 11 revealed that there was statistical significant difference between the mean gross profit of users and non – users of PICS technology in the study area at 10% level of significance. This has encouraged the use of this technology among farmers/traders in the area due to the fact that using PICS bags in storing cowpea provides an attractive opportunity for making better economic gains in terms of income generation, increase standard of living and ensuring food security.

Hence, the hypothesis (1) that "There is no significant difference in the profitability of users and non–users of PICS bag for cowpea storage" is rejected and alternative hypothesis that "there is significant difference in the profitability of users and non–users of PICS bag for cowpea storage" is accepted. Farmers/ traders in the study area stored in PICS bags and generated more income for household use, payment of bills and further investment than the non - users. The study confirms the findings of Moussa (2006), who conducted an impact assessment of the Bean/Cowpeas CRSP project and estimated that, due to the introduction of hermetic technology in the region, over 500,000 additional tons of cowpea is now conserved per year, resulting in $100 million USD in annual additional cowpea income. According to Paul *et al*. (2009) PICS bags do provide the highest return, whether used for one or two years, when losses are scaled to higher estimates.

Table 11: Difference in Gross Margins of users and Non – users of PICS Technology

	Users	**Non – users**
Mean	3949.118182	2419.122727
Variance	4122093.812	1199911.414
Observations	220	220
Pooled Variance	2661002.613	
Hypothesized Mean Difference	219	
Df	438	
t Stat	8.428977178	

4.3 Impact of PICS Technology on Users Income

To further establish that the difference in income between users and non – users of PICS technology was due to participation in PICS project, the double difference evaluation method was used. A positive mean difference of about ₦1,205.12 in income was realized between users and non – users before and after using PICS technology. The difference in income was significant at 1% level (of t – test = 12618.30). The finding showed that there was an impact of the project on users of PICS bag in the study area. This conforms to the finding of Joktan and Sanni (2011) who observed that an increase in income of users (farmers/traders) of PICS technology by about 48% for cowpea stored within 4 – 6 months period.

The development of PICS bag had remarkable features of ensuring that cowpea farmers/dealers achieve good storage, increase prices leading to an appreciable increase in income. Therefore, to further assess the impact of PICS technology on income of users a Propensity Score Matching (PSM) was conducted using probability of participation (prediction) along with some other socio – economic variables.

The result in Table 12 shows that seven (7) of the variables (age, education status, PICS technology experience. labour, income, quantity of cowpea and membership of association) used in the analysis were significant; age had a positive coefficient of 0.002 which was significant at 1% level. All things been equal, labour productivity is a function of age, it is believed that old people tends to adhere strictly to traditional methods of production while young people tends to be more willing to adopt new production methods in order to increase output and income. Furthermore, elderly farmers often have different goals other than income maximization, in which case, they will not be expected to adopt an income-enhancing technology. As a matter of fact, it is expected that the old that do adopt a technology do so at a slow pace because of their tendency to adapt less swiftly to a new phenomenon (Bonabana – Wabbi, 2002).

The education status had a coefficient of 0.008 which was significant at1% level. Education is known to facilitate farmers/traders ability to read and understand sophisticated information that may be contained in a technological package hence, and use of improved technology practices to better their lots. The respondents had one form of formal education or the other, at least primary school education which contributed greatly to their adoption of PICS technology in the study area.

The coefficient of income was significant at 1% level, this implies that as the income of the farmers/dealers' increase the likelihood of using PICS technology increases because with more income the farmers/traders can invest more to increase their output.

Membership of association has a coefficient of 0.004 and significant at 1 %. This implies that membership of associations offer an effective channel for extension contact with large number of farmers/traders, as well as, opportunities for participatory

interaction with extension organizations. Membership of association is necessary, to enhance the use of PICS technology. Association popularizes the technology through the provision of necessary information, knowledge and discussion that assist farmers/traders to use the innovation to better their lots. Thus, the Logit model confirms that the variables with positively significant coefficients enhance the adoption (usage) of technology.

Table 12: Estimates for Impact of PICS Technology on Users Income

Variable	**Co-efficient**	**S.E.**	**Wald**	**Sig.**	**Exp(B)**
Access to Credit	0.967	0.006	0.078	0.297	0.752
Age	0.002***	0.025	0.889	0.024	1.953
Educational Status	0.008***	0.002	0.691	0.004	0.940
PIC experience	0.004***	0.006	0.741	0.389	2.385
Employment status	-0.067	0.030	-2.536	0.012	0.060
Labour	0.001***	0.004	3.510	0.001	0.596
Users Income	0.007***	0.006	3.944	0.002	1.021
Quantity of Cowpea	0.001***	0.036	0.233	0.629	2.677
Membership of Association	0.004***	0.003	5.350	0.005	0.040
R^2	0.888				

***= Significant at 1% level of probability

Table 13 shows the propensity score matching (PSM) for users and non-users of PICS technology with unadjusted pool mean values of 0.9998 and 0.7875 respectively. The standard deviation for users was 0.5786 while the value for non-users was 0.6401. The standard errors for users and non-users were 0.0040 and 0.0051 respectively. The PSM unadjusted was highly correlated with value of 0.950 and significant at 1% level. This means that the PICS technology in the study area had higher impact on the users than

non – users. The likely reason for this could be due to the significant increase impact on income of the users.

Table 13: Propensity score matching result un-adjusted

Descriptive Parameters	**Predictive Users**	**Predictive Non Users**
Mean	0.999	0.7875
N	220	220
Std. Deviation	0.5786	0.6401
Std. Error Mean	0.0040	0.0051
Correlation	0.950	
Sig.	0.000***	

***P<0.05%

Table 14 shows the propensity score matching (PSM) adjusted with constant coefficient value of 1.000 and is significant at 1% level. It also has a standard error of 0.095. If the predictive probability were added the coefficient becomes 4.966 and a constant of -2.47 which is significant at 1% for both coefficients. The standard errors were 0.512 and 0.276 respectively. Since the average impact of PICS technology on users is negative (-2.470). The reason for this unexpected result could be due to the uneven dissemination of the PICS technology in the study area to make any meaningful impact on the income of users of PICS technology.

Table 14: Propensity score matching result adjusted

	Step 0	Step 1	
Adjusted propensity score result	**Constant**	**PRE_1**	**Constant**
B	1.000	4.966	-2.470
Significance	0.000	0.000	0.000
Standard Error	0.095	0.512	0.276
Wald	0.000	94.072	80.034
Exp(B)	1.000	143.472	0.085

The difference in PSM between users and non – users is presented in Table 15. It was observed that pool mean for users and non-users was 0.2569 with a pool standard deviation of 0.7678 and pool standard error of 0.00518. The t – value was 49.63 which is highly significant at 1% level using two- tailed. The PICS technology is an alternative strategy usually adopted by farmers/traders to increase their income and improve their standard of living. The finding also showed that there was an impact of the technology on the income of users of PICS bag in the study area. This indicates that (assuming there is no selection bias due to unobservable factors) level of impact of PICS technology on the income of users (farmers/traders) is significantly higher than the non – users. This result further confirmed the potential advantage of PICS technology in the study area thus, ensuring increase cowpea storage and prevention of health hazard as a result of the residual effects of storage chemicals.

Table 15: Difference between propensity score matching for users and Non users of PICS bags

Predictive matching score - for Users & Non Users	**Score**
Mean	0.25691
Std. Deviation	0.07678
Std. Error Mean	0.00518
t- value	49.630
Degree of freedom	219
Sig. (2-tailed)	0.000***

***P<0.01%

4.4 Test of Hypothesis on Impact of PICS Technology on Users' Income

Having established that there was an impact of PICS technology on users' income, further analysis was carried out using paired t – test statistic to confirm the difference between users' and non-users' income. The results show that the mean difference between users and non-users were 0.740875 and –1.626152 respectively. The variances were 0.01929 and 0.241737 respectively while the pooled variance was 0.130513. The t-statistic was 49.2492; this was significant at 1% level. This indicates that difference exists in income between users and non – users, therefore, the null hypothesis was rejected by accepting the alternative, suggesting that PICS technology has significant impact on the income of farmers.

Table 16: Paired t - test results showing impact of PICS Technology on Users' Income

	Users	Non Users
Mean	0.740874602	-1.626152478
Variance	0.01929012	0.241736858
Observations	113	113
Pooled Variance	0.130513489	
Hypothesized Mean Difference	0	
Df	224	
t value	49.2492647	

4.5 Constraints Encountered by Users of PICS Technology

The study revealed that PICS technology had a significant impact on the users in the study area based on the improvement in their net farm income when compared to non - users of the PICS technology. The major constraint encountered by users of the technology are scarcity of PICS bag, this problem was accounted by about 62% of the respondents, high cost of bag 16% of the respondents agreed that the bag is expensive. This result further confirm the reason why there was under utilization of PICS bag in the study area. Problems identified by about 12% and 10% of the respondents were lack of ready market for cowpea stored in PICS bag stored cowpea and manufacturer defects of PICS bags. Jokthan and Sanni (2008) reported that the major constraints faced by farmers/traders are due to disconnect in information flow between the producer and the end users. Inadequate number of vendors, the price of 300.00 naira/bag is considered too high by most farmers and grain merchants, high cost of the bags appear to be the major reason for poor adoption by grain merchants, the bag company is not favourable

to any reduction in retail price associated with possible mass production (Jokthan and Sanni, 2008).

Table17: Constraints encountered in using PICS technology

Variables	Frequency*	Percentage
Bag is expensive	75	16.2
Manufacturing Defect	47	10.2
Scarcity of Bag	286	61.8
No Ready Market	55	11.8
Total	463	100

* Multiple responses were allowed

4.6 Reasons for not using PICS technology

The study also found out why non – users of PICS bags did not participate in the PICS project, in spite of the awareness of the technology by majority of them. Result presented in Table 19 shows that 30% of the respondents claimed that they did not participate in the project based on their perceived idea that the PICS bag is too costly. According to Jokthan *et al* (2008), the price of 300.00 naira/bag is considered too high by most farmers and grain merchants. High costs of the bags appear to be the major reason for poor adoption by grain merchants. The bag company is not favourable to any reduction in retail price associated with possible mass production (Jokthan *et al*., 2008). Twenty six (26%) of the respondents agreed that lack of credit to purchase PICS bag and pay for other miscellaneous expenses also contributed to not using the technology. If credit is not available or interest rates are prohibitively high, farmers/traders may sell early to pay post-harvest expenses. However, the whole quantity of cowpea that is sold at harvest period rarely meets immediate cash needs.

When necessary, farmers/traders tend to sell a portion of stocks and store the remainder as a highly liquid asset. This asset has the potential to appreciate in value after harvest, peaking generally in the lean months before the following harvest, if maintained without damage. By selling early, the forfeited potential gain from commodity price increases over the marketing season may be interpreted as the "defacto" interest rate on liquidating these assets after harvest (Stephens and Barrett, 2009). Nineteen percent (19%) of the respondents claimed that there was no awareness on PICS technology. To adopt the newly introduced varieties, farmers need to be aware of the available varieties as adoption is sometimes hampered not only by the inherent characteristics of the innovation but also by lack of awareness of the end users of the technologies (Asfaw *et al*., 2011).

Farmers'/traders' awareness about the available PICS technology is an important factor for the adoption to take place. Knowledge of improved varieties was statistically significant in explaining the level of adoption. The study revealed that 15% of the respondents complained of bad experience from previous projects which could have a great influence on their using the PICS technology. The complaint on the size of the PICS bags were reported by 11% of the respondents. This implied that Farmers/traders in the study area have various quantity of cowpea for bagging (25kg, 50kg, 100kg, etc) and may find the exiting bags too big or small. This will affect the use of PICS technology.

Table 18: Reasons for not using PICS technology by non - users

Variables	Frequency	Percentage
High cost of bag	65	29.5
Lack of credit	56	25.5
No awareness	42	19.0
Bad experience from previous projects	32	14.6
Bag size (short)	25	11.4
Total	220	100.0

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The broad objective of the study is to determine the potential impact analysis of Purdue improved cowpea storage (PICS) technology on the income of users in north central Nigeria. To achieve this objective, a multi-stage sampling technique was employed in the study. The first stage was the purposively selection of three Local Government Areas (LGAs) from each of the senatorial district of the north central states on the basis of being the most prominent cowpea producing areas of the states. Secondly, 108 villages were purposively selected (two from each local government) on the basis of their output performance in cowpea production. The selection of farmers/dealers was done randomly on their high intensity of cowpea production activity, involvement in the PICS project, accessibility and the list of recognised farmers/dealers of cowpea collected from the state Agricultural Development Projects (ADPs) and cowpea stakeholders meetings. A total of four hundred and forty structured questionnaires were administered on both the beneficiaries and non – beneficiaries in the study area. Data for the analysis was based on before and after PICS technology usage of the respondents.

Data were analyzed using descriptive statistics, gross margin, double difference method, propensity score matching and paired t – test statistics. The result of the analysis showed that the average age of users was 35 years while that of non-users was 38years. More than half (54% for non – users and 52% for users) of the respondents sampled were male. Respondents engaged in farming and non – farm activities such as trading, household keeping and government work.

The profitability analysis result showed significant difference between farmers'/dealers' cost and returns before and after the usage. The total variable cost (TVC) and the total revenue (TR) generated by PICS technology users before using PICS bag were ₦ 228,214 and ₦ 351,833 respectively while the total variable cost (TVC) used and the total revenue (TR) generated during the same period after using the PICS technology were ₦258,441 and ₦ 868,806 respectively. The gross margin analysis revealed that the use of PICS technology in the study area was profitable with a gross margin of ₦610,365 and profitability index of 2.36 on every one naira invested respectively.

Double difference analysis result further proved the fact that the increase in the income realized by the beneficiary farmers/dealers was attributed to their using PICS technology based on the positive mean income value obtained which was highly significant at 1% level of probability with t – statistics of 12618.30. Therefore, the null hypothesis with regard to no impact of PICS technology on users' profits and incomes is rejected. The propensity score matching result also revealed that the pooled mean for users and non-users was 0.2569 with a pooled standard deviation of 0.7678 and pooled standard error of 0.00518. The t – value was 49.63 which were highly significant at 1% level using two- tailed.

Majority of the users (69%) encountered scarcity of bag while 21% agreed that the bag is expensive. This result further confirm the reason why there was under utilization of PICS bag with respect to the beneficiaries of the PICS project. Constraints identified by about 6% and 5% of the respondents were lack of ready market for cowpea stored in PICS bag and manufacturer defects of PICS bags.

The study also found out why non – users of PICS bags did not participate in the PICS project. Result showed that 30% of the respondents claimed that their lack of participation in the project was based on their perceived idea that the PICS bag is too costly, 26% of the respondents agreed that lack of credit to purchase PICS bags and pay for other miscellaneous expenses also contributed to not using the technology while 19% agreed that there was no proper orientation, i.e., awareness about the PICS technology. Other reasons include bad experience from previous projects (15%) and size of the PICS bag (11%).

5.2 Conclusion

From the findings of the study, it has been possible to establish the fact that users' profits and incomes increased significantly after the introduction of PICS technology compared to the non – users profits and income. This manifests the potential benefit of PICS technology in the study area thereby enabling improve food security and self sustainability in meeting the domestic needs of the household. The results call for policies aimed at encouraging the use of PICS technology to provide an improved alternative for insecticide – free and long – term storage of cowpea for food security and sustainability.

5.3 Contribution to Knowledge

1. The use of PICS technology improves the profitability of users by achieving profitability index of 2.36 on every one naira invested compared to non – users 0.54.

2. The income of the users is more by 62% than that of the non – users when cowpeas are sold after 4 - 6 months later.

3. The respondents (62%) complained of scarcity of the PICS bags which is critical for the use technology.

5.4 Recommendations

Based on the findings, the following recommendations are made:

1. Various bag sizes (25kg, 50kg, 100kg, etc) should be introduced to the market to suite different categories of users (small, medium and large farmers/traders).

2. The development of sustainable supply chain for PICS technology to make the technology available to farmers/traders is very crucial. Identification of major distributors in each senatorial district of the country will help in sustaining the effective distribution of the PICS bags and establishment of bags special point (SP) should receive more attention

3. There is need to increase the level of awareness of the PICS technology to cover a greater percentage of farmers/traders This can be effectively done through the use of Agricultural Development Programmes (ADP), Non Governmental Organizations (NGOs) and attending farmer's stakeholders meeting for sensitization;

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APPENDIX I

The Senatorial Districts, Selected L.G.A and Selected Villages.

North-Central States	**Senatorial Districts**	**Selected LGA**	**Selected Villages**
Benue	Benue North – east, Benue North - west Benue South	Ohimini, Apa, Oturkpo, Makurdi,Bunuku,Gboko, Ushongo, Vandikya.	Ipiga, Ameji, Obu, Eloga, Ugbokpo, Amoke, Aieya, Aukpa, Kanshio, Mbasaraka, Garagboghol, Tyowanye, Tyogbena, Ujon, Lobi, Lessel, Kargba, Anyegbor.
Kogi	Kogi West Kogi North Kogi Central	Kabba Bunu, Mopa Amuro, Isanlu, Dekina, Ankpa, Igalamela, Ajaokuta, Koton karfe.	Kabba, Odolu, Orokere, Mopa, Idofin, Okegada, Ayigba, Agbenema, Akwu,Ogodo, Atuma, Ejegbo, Eganyi, BassaVadoko, Koto karfe, Abebe.
Kwara	Kwara North Kwara South Kwara South	Baruten, Kaiama, Edu, Moro, Ilorin East, Ilorin South, Ifelodun, Irepodun, Oyun	Kosubosu, Yashikira, Gwaria, Vobera, Kokodo, Wondata, Bode Saadu, Jebba, Maya, Oke – Ose, Gaa – Akanbi, Kabba – Owode, Igbaja, Share, Ajase – Ipo, Oro, Erinle, Ilemona.

Nasarawa	Nasarawa West Nasarawa North Nasarawa Central	Karu, Keffi, Toto Akwanga, Wamba, Nasarawa Egon Lafia, Doma, Keana.	Kanje, Akwanga, Kayarda, Giza, Keana, Lafia, Doka, Doma, Ngare, Gwagi, Mararaba, Toto, Karu, Masaka, Keffi, Karshi, Papari, Ushata
Niger	Niger North Niger South Niger East	Bida, Mokwa, Agaie, Lapai, Wushishi, Rijau, Kotangora, Borgu, Mariga	Dabarako, Ndakama, Mokwa, Kpaki, Loguma, Wunakan, Lapai, Cece, Kaliko, Madagi, Zugurma, Ibbi, Jama'are, Sahoma, Ganawa, Madengyan, Fakun, Lubararu, Kumbashi
Plateau	Plateau North Plateau South Plateau Central	Riyom, Jos North, Bassa, Langtang North, Mikan, Wase, Kanam, Amper, Mangu	Kuru, Ganawuri, Rayfield, Babale, Jengre, Jengre, Zamko Ganawuri, Garkawa, Garkaw, Wase, Mavo, Bankilon, Dengi, Amper, Dangkang, Mangu, Panyam

APPENDIX II

POTENTIAL IMPACT ANALYSIS OF PURDUE IMPROVED COWPEA STORAGE (PICS) TECHNOLOGY ON INCOME OF USERS IN NORTH CENTRAL NIGERIA.

Farmers Questionnaire: PICS Bag users [ ] or PICS Bag Non - users [ ]

This questionnaire is designed for the purpose of obtaining necessary information needed for the above mentioned research topic. Please kindly give appropriate answer by ticking (□) or filling where necessary. All information provided will be kept confidential.

Background Information

Form number: .....

1. Enumerator Name_____

2. State _____

3. Local Government Area_____

4. District _____

5. Zone/ Region: _____

6. Town/Village Name: **(VILLAGE)** _____

I. Socio-economic characteristics of users and non – users of PICS technology in the study areas.

7. Socio-economic characteristics of users and non – users of PICS technology

Questions	Answers	
Respondent Name		
Gender of the	Man=1	

respondent	Woman=0		
Respondent's Age			
Marital status of the respondent	Married = 1. Divorced = 2.		
Household size			
Number of working people in the household	Adult Men	Adult Women	Children
Do you have any contact with extension service?			
If so, which?	1 = extension agent 2 = research 3 = NGO 4 = other project 5 = other (specify).....		
How often in a year?			
Level of education	1 = No formal education, 2 = primary, 3 = secondary, 4 = NCE/OND 5 = HND/University		
Village Association	1 = Yes		

Member Yes/No	0 = no	
How many of these association do you belong	1. Farmers association 2. Discussion group 3. Cooperative Others (specify)	
For how long have you belong to this association (years)		
Main activities of the Association	1 = agriculture, 2 = trade, 3 = Crafting 4 = other.....	
Years of experience in the production of or dealing in Cowpea		
What is your major Occupation?		
Do you have other sources of income?	1 = agriculture, 2 = trade, 3 = Crafting 4 = other.....	

II- Questions On the profitability of PICS technology in the study areas.

8. Have you sold Cowpea in 2011/2012 harvest season? Yes _____ No _____

If yes,

PICS Storage Method	Unit price/kg	quantity sold(kg)	Period

9. Where was the Cowpea sold?

Market	Means of transport	Transport cost

10. In what measurement do you sell your cowpea?

(a)Bags { } (b) mudus { } (c) Tiya { } (d) Paint container { }

11. How much do you sell your cowpea in unit per measure as indicated above? _____

12. What was the quantity of cowpea stored in 2011/2012 season? _____

13. What was the cost of cowpea per mudus/tiya before storage? _____

14. What was the cost of cowpea mudus/tiya after storage? _____

15. What was the unit price of PICS bag in your local market?_____

Conversion function

1 paint container = 3mudus

2 mudus = 1 tiya

1 mudu = 1.2kg.

16, did you incur any cost in storing cowpea in 2011/2012 season? Yes___ No ____

17. If yes, how much did storage cost?

storage method	Quantity(kg)	Unit cost/kg(₦)
PICS Technology		
Others		

18. What is the quantity of labor used for each type of storage?

storage method	Labor (in Man hour)	
	Family Labor	Hired Labor
PICS Technology		
Others		

19. Indicate the quantity and cost of labour for various activities indicated in the tables below?

a. Hired Labour

	ADULT MALE			ADULT FEMALE			CHILDREN		
	No	Day	C/D	No	Day	C/D	No	Day	C/D
Harvesting									
Threshing									
Cleaning									

Packing									
Bagging									
Transportation									

Key : No=Numbers of workers, C/D=cost per day, TC =Total Costs

b. Family labour

	ADULT MALE			ADULT FEMALE			CHILDREN		
	No	Day	C/D	No	Day	C/D	No	Day	C/D
Harvesting									
Threshing									
Cleaning									
Packing									
Bagging									
Transportation									

Key : No = Numbers of workers, C/D=cost per day, TC =Total Cost

Conversion function

1 man day = 6 hours

1 woman/children day = 4 hours

20. Is there any observable difference in the PICS bagged cowpea? Yes___ No ____

21. If yes, what is the nature of the difference? (a) Odour free (b) No risk of weevil damage (c) Neatness of the grains (d) High quality grains (e)others (specify) _____

22. If given the opportunity will you teach others the PICS bags? Yes___ No ____

23. How long have you been using the PICS bags?

(a) 1year (b) 2years (c) 3years (d) 4years (e) 5years

24. What other Cowpea storage methods do you know apart from PICS?

(a)Chemical (b) Sun drying (c) Ash method (d) Drum Storage (e) Solar heater

(f) Other (specify) _____

25. For how long have you been using this storage technique?

Other Methods	Period

26. For how long did you store cowpea using PICS bags?

27. How often do you use the cowpea stored in PICS bags9 opening and retying after use)? (daily, weekly etc…?)

28. Have you encountered problems with the improved storage methods?

1= Yes___ 0=No___

29. If yes, list the problems and possible solutions?

Problems	Possible solutions

PROBLEM:

(a) Expensive (b) Difficult (c) labor requirement (d) Insects attacks (e) others

(specify)_____

III Questions on the factors influencing the usage of PICS technology in the study areas.

30. Do you have other sources of income/business? Yes___ No ____

31. Is the PICS bag readily available in the locality? Yes___ No ____

32. How much is a set of PICS bag in the study area? _____

33. Is the PICS bag expensive? Yes___ No ____

34. Have you seen any fake/ imitation of PICS bag in the local market? Yes__ No ____

35. Is this technology easy to handle? Yes___ No ____

36. Where did you store your PICS Bagged cowpea? (a) farm store (b)living room (c) specify others

37. Do you easily get information about the PICS technology? _____ Yes___ No____

38. If yes, what type of information and the source?

Information	Source

IV. Questions on the impact of PICS technology adoption on the income of the users in the study area.

38**.** Do you experience increase in market price of cowpea stored in PICS bags / kg after months of storage? Yes___ No ____

39. If yes, indicate in the table below:

Quantity of Cowpea stored	Before the use of PICS Technology			After the use of PICS Technology		
	2 Months	4 months	6 Months &	2 Months	4 months	6 Months &

(kg)	(₦)	(₦)	above(₦)	(₦)	(₦)	above(₦)

40. What is the main use of the cowpea stored in PICS bags? (List starting from most important)

(a) Sale (b) home consumption (c) donation (d) seed

(e) Others (specify) _____

41. With the use of this technology, are you able to meet your household needs? Yes___ No ____

42. What are the effects of this technology on your livelihood? _____

43. What is the main use of the money from cowpea sales? (a). Family expenses (b). Agricultural inputs (seed, fertilizers etc.) (c).Savings (buy animal, saving account etc.), (d). Other_____

44. How did you know about PICS technology?

Information source: (a) Extension service (b) Research (c) NGO

(d) Project (specify) _____ (e) Farmers (f) other _____

45. What are the reasons for choosing PICS technology?

(i)_____

(ii) _____ (iii) _____

46. What actually attracted you to this PICS technology? (a)To be self-employed (b) To supplement household income (c) My parents are into cowpea production (d)

People say it is highly profitable (e) Others (specify)

_____

47. What is the quantity of cowpea you have for storage? _____

48. Is there any credit facility you enjoy? Yes ( ) No ( )

49. If yes, what is the source of the loan? (i) Bank (ii) Family/Relatives

(iii) Personal savings (iv) Specify _____

50. How much interest rate are you paying on the loan? (a) 5% (b) 10% (c) 15 % (d) 20%

(e) 25% (f) Specify _____ _____

51. Is market information readily available to you in the following areas?

(a) Where to sell cowpea Yes___ No ____

(b) Market price of cowpea Yes___ No ____

(c) Others_____

52. Which of the following possession do you have before the use of PICS technology?

(a)Bicycle { } (b) Motor cycle { } (c) Car { } (d) TV { } (e) Radio { }

(f) Video player{ } (g) Fan { } (h) gas cooker { } (i) stove { }

53. Which of the above possessions do you have after the use of PICS technology?

(a)Bicycle { } (b) Motor cycle { } (c) Car { } (d) TV { } (e) Radio { }

(f) Video player { } (g) Fan { } (h) gas cooker { } (i) stove { }

V. Questions on the constraints associated with the use of PICS technology in the study areas.

54. List the reasons for using PICS bags: (i)_____

(ii) _____(iii)

_____

55. What are the constraints for the use of this PICS bag?

(a) Expensive (b) Not reliable (c) Insects damage (d) Not availability

(e) Others (specify) _____

56. What are the reasons for abandonment of PICS bags?

(a) Expensive (b) Not reliable (c) Insects damage (d) Not availability

(e) Others (specify) _____

57. What are the reasons for not using PICS bags?

(a)Expensive (b) Not reliable (c) Insects damage (d) Not availability

(e) lack of information (f) Others (specify) _____

58. Are there local sellers or suppliers of PICS bag in your locality? Yes___ No ____

59. Are they far from your location? Yes___ No ____

60. Is the bag effective in storing cowpea? Yes___ No ____