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CHARACTERIZATION OF HUSBANDRY PRACTICES, ADOPTION AND IMPACT OF VILLAGE POULTRY TECHNOLOGY PACKAGES IN THE CENTRAL OROMIA REGION, ETHIOPIA

PhD Dissertation

By

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College of Veterinary Medicine and Agriculture

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PhD Program in Animal Production

December, 2015

Bishoftu, Ethiopia

CHARACTERIZATION OF HUSBANDRY PRACTICES, ADOPTION AND IMPACT OF VILLAGE POULTRY TECHNOLOGY PACKAGES IN THE CENTRAL OROMIA REGION, ETHIOPIA

A Dissertation Submitted to College of Veterinary Medicine and Agriculture, Addis Ababa University for Fulfillment of the Requirement of Degree of Doctor of Philosophy in Animal Production

By

Ermias Tekletsadik Demeke

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As members of the examination board of the final PhD open defense, we certify that we have read and evaluated the dissertation prepared by Ermias Tekletsadik entitled **‘Characterization of Husbandry Practices, Adoption and Impact of Village Poultry Technology Packages in the Central Oromia Region, Ethiopia’** and recommended that it be accepted as fulfilling of dissertation requirement for the Degree of **Doctor of Philosophy in Animal Production**.

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DEDICATION

I dedicated this PhD dissertation work to my wife Selamawit Lemma and to my daughter Tihitina Ermias for their love, patience, understanding and support throughout my study.

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STATEMENT OF THE AUTHOR

First, I declare that this dissertation is my own work and that all sources of materials used for this dissertation have been duly acknowledged. This dissertation has been submitted for fulfillment of the requirement for a PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University/College library to be made available to borrowers under the rules of the library. I solemnly declare that this dissertation is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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BIBLIOGRAPHICAL SKETCH

I, the author of this dissertation was born from farmer family on February 21, 1976 in Arsi Administrative Zone of Oromia Region. I attended my elementary education at Sole Uta Elementary School, and secondary and high school education at Ticho Secondary and High School. I joined then Awassa College of Agricultural in 1996 and graduated with BSc degree in Animal Production and Rangeland Management in 1999. After my graduation, I joined South Wollo, Tenta Wereda Agriculture Office in September 1999 and served for 2.8 years as expert till May 2003. Then in June 2003, I joined Bekoji Agricultural Technical Vocational Educational and Training College and served for 5 years as an instructor. Then I joined Haramaya University in 2006 and completed my MSc study in Animal Production in October 2008. Since April 2009, I was serving Mada Walabu University as a lecturer. Then, I joined Addis Ababa University, College of Veterinary Medicine and Agriculture (Department of Animal Production studies) in 2012 for my PhD study in Animal Production.

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LIST OF ABBREVIATIONS

AI	Adoption index
AIEI	African Impact Evaluation Initiative
AOAC	Association of Official Analytical Chemists
ATE	Average treatment effect
ATT	Average treatment effect on the treated
BL	Backward likelihood
CACC	Central Agricultural Census Commission
CC	Contingency coefficient
CIA	Conditional independence assumption
CIMMYT	International Maize and Wheat Improvement Centre
CP	Crude protein
CRC	Cooperative Research Centre
CSA	Central Statistics Agency
DAs	Agricultural development agents
DOs	Day-old chicks
DPPA	Disaster Prevention and Preparedness Agency
FCE	Facilitator of Change in Ethiopia
FDRE	Federal Democratic Republic of Ethiopia
g	Gram
GTZ	Deutsche Gesellschaft für Internatinale Zusammenarbeit
Ha	Hectare
ME	Metabolizable energy
MoARD	Ministry of Agriculture and Rural Development
NVI	National Veterinary Institute
OADB	Oromia Agricultural Development Bureau
OBoFED	Oromia Bureau of Finance and Economic Development
ONRSOP	Oromiya National Regional State Office of the President
OR	Odds ratio

PRA	Participatory rural appraisal
PSM	Propensity score matching
RIR	Rhode Island Red
SB	Standardized bias
VIF	Variance inflation factor

TABLE OF CONTENTS

Content **Page**

TABLE OF CONTENTS (*Continued*)

TABLE OF CONTENTS (*Continued*)

TABLE OF CONTENTS (*Continued*)

LIST OF TABLES

Table **Page**

LIST OF TABLES (*Continued*)

LIST OF FIGURES

Figure **Page**

LIST OF APPENDIX TABLES

Appendix Table **Page**

LIST OF APPENDIX FIGURES

Appendix Figure **Page**

CHARACTERIZATION OF HUSBANDRY PRACTICES, ADOPTION AND IMPACT OF VILLAGE POULTRY TECHNOLOGY PACKAGES IN THE CENTRAL OROMIA REGION, ETHIOPIA

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ABSTRACT

This study was conducted in three selected agro-ecologies to characterize the husbandry practices, adoption and impact of village poultry technology packages in the central Oromia Region, Ethiopia. Using multi-stage random sampling method, 180 technology participants were selected. Structured questionnaire, field observations and focus group discussions were employed to collect quantitative and qualitative information. Chemical composition of feed samples was analyzed using proximate analysis. Descriptive statistics was used to evaluate the husbandry practices of the technology. Binary logistic regression was employed to assess the determinant factors of technology adoption. Ranked variables were analyzed using NPAR1WAY Wilcoxon procedures. Logit model propensity score matching procedures was used to assess the impact of the technology. Scavenging chicken production system with some feed supplement was dominantly practiced by technology participants. Overall about 44.6%, 38.7% and 16.7% local, exotic and crossbred chicken breeds were kept in the production systems, respectively. A mean of 17.8(2.50), 13.4(2.17) and 11.2(1.25) chicken were owned per household in the highland, mid-altitude and lowland agro-ecologies, respectively. Most of the respondents (65.6%) practiced crossbreeding of these 59.4% conducted uncontrolled breeding. The supplement feeds had very good CP and ME contents but home mixed ration I had lower CP content. About ½ of the respondents constructed separate chicken house. However, during housing, 68.3% didn’t consider the space requirements of the chicken. Newcastle disease was the major challenging and killing disease in the study areas. Respondents received a mean of 4.7(0.80) pullets with cockerel and 10.1(1.25) pullets for the technology but their demands were

64.0(6.11) and 97.9(16.27) pullets with cockerels and only pullets, respectively. Technology inputs dissemination was not well organized. Improved chicken breed adoption was better as compared to other technology elements. Respondents residing in the mid-altitude agro-ecology were better adopters of improved chicken feeds and feeding, housing, healthcare and water provision. Bovan Brown chicken breed adoption was higher (26.1%) than other chicken breeds. The adoption of pullets with cockerels technology form was higher (22.2%) than the rest forms. The overall adoption status of the technology was 39.4%. The adoption level of the technology was categorized as low level. The overall technology adoption was significantly influenced by extension ($P<0.001$), healthcare ($P<0.05$) and training ($P<0.001$) services. The distance of veterinary clinics, unavailability of appropriate chicken feeding and watering equipment were the major limitations that negatively influenced the technology adoption. More of the covariates included in the model less likely influenced the probability of adoption. Adopters significantly ($P<0.001$) benefited from the technology by 68.5% and could produce 101 more eggs/layer/year, consumed 18 more eggs/household/year and got 168.65 Birr more income/layer/year as compared to non-adopters. In conclusion, to improve the husbandry practices of the technology package, more focus should be given to mothers. To improve the adoption status of the technology, technology inputs distribution should be well organized and more efforts are needed from concerned organizations, professionals and farmers. To increase the farmers' decision of technology adoption, more attention should be given to inputs supply, extension, healthcare and training services. Moreover, technical, financial, managerial and market supports are majorly needed.

Keywords: Adoption; Agro-ecology; Determinants of adoption; Husbandry practices; Impact of the technology; Village poultry package

1. INTRODUCTION

The total chicken population of Ethiopia is estimated to be 50.38 million (CSA, 2013), where 96.9%, 0.54% and 2.56% were reported indigenous, hybrid and exotic chicken breeds, respectively. According to CACC (2003), the average flock size of indigenous chicken at the national level is estimated at 4.1 birds per household. In Oromia Regional State, the flock size per household is 3.6 birds, even though some areas have a higher flock size per household. For instance in Rift Valley of Oromia region, an average flock size of 13 chickens (12 local chickens and 1 exotic chicken) per household has been reported (Dinka *et al.*, 2010). Oromia Regional State accounts for 36.4% of the total national chicken population which contributes 36% of the total annual national egg and poultry meat production (Demeke, 2008).

In Ethiopia, village poultry contributes 98.5% and 99.2% of the national egg and poultry meat production, respectively (Tadelle *et al.*, 2002). However, the modern poultry production system is very small, confined in urban and peri-urban areas and contributes less than 2% of eggs and meat production (Teklewold *et al.*, 2006b). Currently, there is an increased demand for chicken products and poultry production is becoming one of the major income generating enterprise and creating employment opportunities directly and/or indirectly through supplying different inputs. However, chicken production in Ethiopia is much lower than that of the fast-growing human population of the country (Thomas *et al*., 2009; Mengesha *et al*., 2011). In addition to egg and meat production, poultry production has positive impacts in maintaining soil fertility and has a relative advantage or a lesser impact on climate changes over the other livestock production because of its low greenhouse gas emission to the environment (FAO, 2010; Mengesha, 2011). According to Ethiopian green economy development strategic plan (FDRE, 2011), the current chicken meat consumption of 15% will be increased to 30% by 2030 indicating the huge emphasis given to poultry production sector in Ethiopia.

In Ethiopia, agricultural extension service has been started in 1953 in the former Imperial Ethiopian College of Agriculture and Mechanical Arts, currently called Haramaya University (Ibrahim, 2004) with three mandated responsibilities: teaching, research and extension. The extension was mandated in transferring local research outputs and technologies to farmers, importing technologies and improved practices from abroad and introducing them to the farmers. In 1963, the mandate was moved to the former Ministry of Agriculture. Then the first nationwide livestock extension development technology packages were initiated in 1970's (Ibrahim, 2004; Gebremedhin *et al.*, 2006) and were being implemented with the objectives of increasing food production and household income, ensuring food security and contributing to the development of the national economy (Mekonnen, 2005). The Minimum Package Project I was designed and implemented from 1971–1979 to provide smallholder farmers with extension and input supply services. In 1980, the Minimum Package Project II was initiated (Ibrahim, 2004). Then, the new approach of livestock development extension package has been initiated and implemented since 1997 (Mekonnen, 2005). The main strategy was to focus on the rural and pri-urban and urban areas. In the rural areas, meat, poultry, and honey production packages have been promoted, while in the pri-urban and urban areas, the focus is on milk, meat, and egg production.

Currently, the Ethiopia agricultural extension system is geared towards developing various packages that are suited to the different agro-ecological zones where both smallholder and large-scale agricultural activities are undertaken (Berhanu, 2012). Like other livestock development technology packages, egg production improvement technology package has been prepared and used through introduction of exotic chicken breeds in different agro-ecological zones of the country (Tegegne *et al.*, 2010). The technology packages mainly promote the distribution of exotic chicken breeds that perform better than local breeds in terms of meat and egg production with technical supports on proper feeding, housing and healthcare as well as provision of quality water at farmers' level. (Teklewold *et al.*, 2006b). Millions of improved chicken breeds have been distributed to smallholder farmers and urban-based small-scale chicken producers by higher learning institutions, research organizations, Ministry of Agriculture and Rural Development (MoARD) and Non-Governmental Organizations (NGOs) in the form of fertile eggs, baby chicks, pullets and cockerels since 1950s' (Yami and Dessie, 1997). Currently, Ethiopian

MoARD is mandated to poultry extension development package through distribution of exotic chicken breeds for smallholder farmers. Few numbers of NGOs such as Winrock International, GTZ and Facilitator of Change in Ethiopia (FCE) are also involved in the implementation of village poultry development programs to support poor households (Demeke, 2008; Tegegne *et al.,* 2010). However, according to Mekonnen (2005), farmers' participation in national poultry development extension package is very low (only 2.03 to 5.20%) whereby in Oromia Regional State only 5% farmers participated in poultry development extension package as compared with other livestock development extension packages. Even though the husbandry practices, extent of adoption and the impact of technology package are not well known in the Oromia Region about 26.95% farmers received exotic chicken breeds since poultry development extension packages started in the region (Mekonnen, 2005). However, Teklewold *et al.* (2006a) reported that about 41.5% smallholder farmers adopted exotic chicken breeds in east *Shewa* and *Welayeta* zones. Technology adoption might be changed overtime and the adoption level of other poultry technology package elements such as feeds and feeding, housing, healthcare and provision of water were not studied so far.

According to the districts (*Woredas)* Agricultural Offices livestock experts information (unpublished information), village poultry technology package was started in 1993, 1995 and 1999 in *Welmera, Ade'a* and *Boset* districts, respectively. However, the husbandry practices of the technology package and the nutritional quality of major chicken feed resources were not properly studied. Village poultry technology package adoption can be influenced by biological, agro-ecological, cultural, perceptional, socio-economical, technical and policy factors (Rahman, 2007; Jain *et al*., 2009; Grazhdani, 2013). In the past, only few studies were conducted on exotic chicken breed adoption for example by Teklewold *et al.* (2006a). There were no studies conducted on the adoption of different technology package elements and the limitations and constraints of the technologies. Moreover, the impact of the technology packages on the livelihood of the participants was not properly studied. Therefore, this study was aimed at addressing the following objectives:

General research objective

To generate information on the husbandry practices of village poultry technology packages, major poultry feeds resources, village poultry technology packages adoption and impact of the technology adoption on the livelihoods of the technology participants.

Specific objectives

1. To assess the husbandry practices of village poultry technology packages and major poultry feeds resources;
2. To Characterize the adoption of village poultry technology packages;
3. To investigate determinant factors influencing the adoption of village poultry technology packages;
4. To assess the impact of village poultry technology package adoption on the livelihood of smallholder farmers in the central Oromia Region, Ethiopia.

2. LITERATURE REVIEW

2.1. Importance of Poultry Production for Households

Due to their requirement of small feed, space, low cost and high turnover rates, poultry rearing is a suitable activity for the poor and their products are highly marketable (Mengesha *et al.*, 2008a) and playing important social and cultural roles in the life of rural people (Kryger *et al.*, 2010). In Ethiopia perspective, chicken rearing activity is one of the most appropriate activities for rural women, landless and poor farmers and it is a source of income, creates employment opportunities and increases the supply of high quality animal protein (Tadelle *et al.*, 1999). In most part of the country, village chicken significantly contributes to the livelihoods of the rural household as starting point of investment, as a means to recover from disasters (insurance against distresses), as an accessible protein source and for income and exchange purposes, food security, and socio-culturally functions, hospitality and exchange of gifts to strengthen social relationships (Tadelle *et al.*, 2003; Aklilu, 2007; Reta, 2009). Similarly, in Zimbabwe, chicken are a major source of income and other livelihood needs compared to other livestock species (Muchadeyi *et al.*, 2007).

Chicken products are affordable quality animal protein sources for the smallholder households (Alemu *et al.*, 2008). Eggs are a source of high quality protein for sick and malnourished children under the age of five (Delgado *et al.*, 1998), for women post-birth (Jennifer, 2006). Moreover, due to their small size and fast reproduction compared to most other livestock, chicken can be slaughtered and eaten in the household (Delgado *et al.*, 1998). However, in rural areas of Ethiopia, households consume a very limited quantity of chicken meat and eggs because they rank income as the primary purpose (Jennifer, 2006).

2.2. Village Poultry Production System in Ethiopia

According to Sonaiya *et al.* (1999) and Guèye (2000), poultry keeping practiced by rural households using family labor is referred as village poultry keeping also called rural poultry or backyard or village-level poultry or rural family poultry. In Ethiopia, village poultry production system is mainly characterized by low input with little or no supplemental feeding, no separate shelters except night shelter, low veterinary services, minimal level of bio-security, high off-take rates and high levels of mortality (Tadelle *et al.,* 2002; Alemu *et al*, 2008; Dana *et al.,* 2010; Kryger *et al.,* 2010). Moreover, village poultry does not need investments beyond the cost of the foundation stock. Mostly indigenous chickens are kept under this system although some hybrid and exotic breeds may be kept (Kryger *et al.,* 2010). There is no planned feeding of chickens and scavenging is almost the only source of diet. Reproduction entirely based on uncontrolled natural mating and hatching of eggs using local indigenous broody hens (Demeke, 2007; Dana *et al.,* 2010).

Village poultry production systems in Ethiopia are not business oriented rather designed for satisfying the various needs of the households. For example, Alemu *et al.* (2008) reported that the major purposes of eggs production in this system include eggs for hatching (51.8%), sale (22.6%), and home consumption (20.2%) while chickens for sale (26.6%) and home consumption (19.5%). Village chicken production has deep-rooted impact in the socio-cultural, economic profile and livelihood of the rural poor community (Dinka *et al.,* 2010; Samson and Endalew, 2010).

2.3. Factors Influencing Village Poultry Production

2.3.1. Agro-ecology

Agro-ecological pattern of Ethiopia is broadly divided into five zones (frost, highland, temperate, lowland and desert) based on altitude, temperature, rainfall pattern and distribution, and agricultural production systems (Berhanu, 2012). As a result, farming systems and management practices in the country can be influenced by the household needs, socio-economic variables and agro-ecological production conditions (Aklilu, 2007). Most of the sedentary agricultural practices are located in the highlands while the semi-arid and arid lowlands are dominated by agro-pastoral and pastoral production systems (Berhanu, 2012). The degree to which village chicken production is integrated in the smallholder farming systems differs depending on the socio-economic, cultural, agro-ecological and biological factors within each system (Muchadeyi *et al.*, 2007).

Chicken are among the most adaptable domesticated animals; however, there are few places in the world where climatic conditions make the keeping of chicken impossible (Bishop, 1995). In Zimbabwe, chicken flock size varies in different agro-ecological zones with an average of 16.7 chickens per household, where, the highest flock size was reported in highland and lowland agro-ecologies (Muchadeyi *et al.*, 2007). In Ethiopian, Moges *et al.* (2010) reported that in the Northwest part Ethiopia of Amhara Region, the chicken flock size per household is 11.6, 13.9 and 13.4 in highland, mid-altitude and lowland agro-ecological zones, respectively. Whereas, in Western Amhara Region, chicken flock size per household are 8.5, 7.4 and 8.4 in the highland, mid altitude and lowland areas, respectively, with high egg production per clutch is found in highland agro-ecology than in lowlands (Worku *et al.*, 2012). In lined, in lowland area of Oromia Region (Mid Rift Valley area), the mean chicken flock size per household is 13 chicken of these average flock size of exotic chicken breed per household was 0.76 (Leta and Bekana, 2010).

2.3.2. Crop production

In Ethiopia, poultry production is mostly concentrated in areas where crop production is concentrated (Gezahegn *et al.*, 2009), because crop and livestock production in the highlands of Ethiopia are highly integrated and mixed. Availability of grain supplement for chicken varies with activities such as land preparation, sowing, harvesting, grain availability in the household, season of the year (Dessie, 1996). According to Tadelle *et al.* (1999), in grain deficient countries like Ethiopia, adopting intensive poultry industry is discouraged by the severe shortage of grain unless the grain production in the country is improved considerably. Such a system cannot be economically sustainable and socially acceptable. In Western Amhara Region of Ethiopia, the type of grains used as chicken feed supplementation varies among agro-ecologies, which is related to the type of crops grown. In the lowland areas, households used about 70% and 22% of maize and wheat, respectively, as essential grain supplements for their chicken. However, about 48% of the households in the highland mainly used wheat as a common feed supplement followed by maize (Worku *et al.,* 2012). In Zimbabwe context, land size, types of crop cultivated and number of livestock species vary significantly among eco-zones (Muchadeyi *et al.*, 2007). The main livestock species kept by farmers across eco-zones were cattle, goats and chicken.

2.3.3. Family members

Approximately 80% of the chicken flocks in African countries are owned and controlled by women where, in sub-Saharan Africa, 85% of all households keep poultry, with women owning 70% of the poultry (Guéye, 1998) because village and small-scale poultry keeping use family labor, and women are major beneficiaries (Sonaiya and Swan, 2004; Mengesha *et al*., 2008b; Mengesha, 2011). Due to this, women have often an important role in the development of family poultry production. In addition to women, children are also more involved in chicken production in rural Africa (Kitalyi, 1998). This gender bias implies the existence of some variation in the valuing and management of chicken between male and female headed households (Muchadeyi *et al.,* 2004).

In Ethiopia, the majority of village chicken production (92.4%) are owned by females and children and most of the time the women and children are responsible for chicken rearing, while the men are responsible for other off-farm activities (Leta and Bekana, 2010; Moges *et al.,* 2010) because chicken are sources of self-reliance for women (Aklilu *et al.,* 2007). Mostly, men are responsible for few activities like construction of shelter (Moges *et al.,* 2010). Selling of chicken and egg is decided by women and children for an immediate income source (Mengesha *et al*., 2008b), often children own one or two birds to meet their costs of school materials (Hailemariam *et al.,* 2006). Regarding household heading and wealth status, in Tigray Regional State of Ethiopia, male-headed households keep larger chicken flocks than female-headed households

(Aklilu, 2007). In general, flock size per household ranges from 5-100 in Africa, 10-30 in South America and 5-20 in Asia. Moreover, flock size is related to poultry farming objectives such as home consumption only; home consumption and cultural reasons; income and home consumption; and income only (Sonaiya and Swan, 2004).

2.4. Village Poultry Technology Packages in Ethiopia

2.4.1. The need for village poultry technology packages

Ethiopian indigenous chicken have desirable characteristics such as thermo-tolerant, resistant to some disease, have good flavor of egg and meat, hard eggshells, high fertility and hatchability of eggs as well as high dressing percentage (Abera, 2000). However, the chicken are low in egg production, produce small sized eggs, have slow growth rate and low survival of chicks (Smith, 1990; Dessie, 1996). Under smallholder management systems, a hen only produces 40-60 small sized eggs per year (Dana *et al*., 2010; Melesse and Negesse, 2011). According to Worku *et al.* (2012), under village poultry production system, the average age at first lay for local chicken breeds is 6.6 months with an average clutch number of 3.2 with about 14 eggs are produced per clutch and about 43.2 eggs are produced per hen per year with an average weight of an egg is about 39.6 g. The carcass weight of local birds at 6 months of age is 559 g which is significantly lower than that of the White Leghorn (875 g) at the same age (Forsido, 1986). To improve this low productivity of local birds, appropriate interventions were being undertaken in improvement of feeding, housing, breeding and healthcare (Worku *et al.*, 2012).

2.4.2. Elements of village poultry technology package

Technology packages consist not only of the inputs but also the knowledge concerning their use (Eaton and Wiersinga, 2009). Thus, improvements in production involve a shifting of farmers to new technology packages. Village poultry has been attracted the attention of many people as a vehicle for rural development. In Ethiopia, for many decades development agencies, international organization, governments and NGOs have been interested in helping to develop village poultry. The pace and scope of such supports have expanded over years and some major initiatives have been undertaken (Mack *et al.*, 2005). To improve the productivity of village poultry, village poultry technology packages is the implementation of interdependent technology package elements such as distribution of selected exotic or improved chicken breeds with technical and some input supports on proper feeding, housing and healthcare as well as provision of quality water at farmers' level. The technology packages mainly promote exotic chicken breeds distribution that perform better than local breeds in terms of meat and egg production with extension follow up and technical supports (Teklewold *et al.,* 2006b).

Chicken breeds distribution

Poultry research and extension development program started in Ethiopia in the late 1950's by higher learning institutions (Yami and Dessie, 1997). The MoARD of Ethiopia has established 14 poultry breeding and/or rearing centers (Demeke, 2008); although more recently, Tegegne *et al.* (2010) reported 11 poultry breeding and multiplication centers. These centers are located in different regions; Mekelle and Adigrat in Tigray Region, Andassa and Combolcha in Amhara Region, Nazareth/Adama, Adelle, Bedelle and Nekemt in Oromia Region, Awassa in South Nation Nationalist and People Region and, Dire Dawa and Harar (Tegegne *et al.*, 2010) and they have a capacity of delivering nearly 1,236,150 day-old chicks (DOs) and 485,800 pullets and cockerels (Alemu *et al.*, 2008). The major objective of the centers was distribution of exotic chicken breeds' (Rhode Island Red, Bovan Brown and White Leghorn) fertile eggs, baby chicks, pullets and cockerels to smallholder farmers to increase egg and meat production, and genetically improve the native chicken breeds (Alemu *et al.*, 2008; Demeke, 2008 and Tegegne *et al.,* 2010). The centers also provide in-service training to farmers and extension workers, and provide about 50% price subsidy by giving the priority to women (Alemu *et al.*, 2008). However, since few years back, centers suffered a shortage of financial resources, lack of replacement breeding stocks and periodic disease. Currently, the centers give up provision of price subsidy to support farmers.

Previously, the extension development system had promoted schemes in which cockerels from selected strains were reared up to 15 to 20 weeks of age and then exchanged for local cockerels owned by rural farmers. However, the supply of exotic pullets and cockerels from the Government poultry multiplication centers has not been adequate with demand of the technology participants (Demeke, 2008). Few years back, the regional agricultural bureau included poultry technology package in their new extension development programs. The scheme involves on distributing of five pullets and a cockerel to individual farmers (Teklewold *et al.,* 2006b).

2.4.3. The role of institutions on village poultry extension program in Ethiopia

Since the beginning of poultry research and development in Ethiopia (in the mid 1950's), millions of exotic chicken breeds have been distributed in the different forms to smallholder farmers from different organization (Yami and Dessie, 1997). The past approaches were improving the genetic potential of local birds through distribution of exotic origin cockerels, pullets and fertile eggs. However, these approaches have had ill effect because of reducing the brooding ability of local hens, reducing adaptation to low input feeding system and endangering the genetic base of indigenous chicken population (Tadelle *et al.,* 1999). Few years back a genetic improvement program has been initiated by the national poultry research institute to improve the productivity of indigenous chickens of Ethiopia through selective breeding, as a means to improve the livelihood of poor people as well as conserve the existing genetic diversity through utilization (Dana *et al.,* 2010). Evaluation of the egg production performance of crossbreeds between local and exotic birds was conducted by different research and development organizations (Tadelle *et al*., 1999). Few numbers of NGOs are also involved in poultry development projects to support economically poor households (Demeke, 2008; Tegegne *et al.,* 2010). For example, FAO in collaboration with Ambo College of Jimma University launched a project to train disabled people on household poultry and provide a start up kits comprising chicks and pullets/cockerels of exotic breeds with a considerable technical support. Likewise, Winrock International carried out training on household poultry and distributed chicks and pullets/cockerels in Ginbo and Bonga zones of South Nations and Nationalities People Regional

State. Other donors and NGOs also involved in training of households, in distribution of exotic chick breeds and chick brooding hay-box technology (Demeke, 2008).

2.5. Husbandry Practices of Village Poultry

2.5.1. Chicken feeds and feeding systems

Village chicken in Africa survive by scavenging without supplementary feeds except, sometimes grain wastes and dish leftovers are offered and rarely supplemented with grain (Dwinger *et al.*, 2003). Since the birds are not offered nutrient balanced ration, the nutrient intake of scavenging birds varies from place to place depending on seasons, types of crop grown and availability of vegetation (Sonaiya and Swan, 2004). Even though ways of supplementation varies, feed supplements have a positive effect on egg production and body weight of scavenging birds **(**Sonaiya and Swan, 2004); therefore, regular supply of low-cost feed above maintenance requirements is essential for family poultry production.

In Ethiopia, the smallholder chicken production system is mainly characterized by free-ranging system with the major feed sources for birds are insect worms, seed and plant materials (Dessie 1996). The same author reported that based on the crop content (crop of the chicken) analysis of village scavenging local chicken of Ethiopia, the concentration of crude protein; calcium and phosphorus are below the recommended requirements for egg production. Furthermore, he reported that the feed resources are deficient in protein, energy and probably calcium for layer birds. Thus supplementation of local birds with feed sources containing energy, protein and a calcium source can bring a considerable increase in egg production. According to Demeke (2003), due to supplementation with a daily basic ration of 50% of normal requirements improved the growth performance of White Leghorn chicken kept under scavenging condition by 10 and 21% during the brooding and rearing periods, respectively.

Majority of the farmers found in Mid Rift Valley areas of Oromia Region, Ethiopia are practicing supplementary feeding systems usually offer mostly once per day mostly maize, wheat, sorghum and household waste products as the main supplements but they don't use formulated chicken feed (Leta and Bekana, 2010). Similarly, Aklilu (2007) reported that village chicken in Mekele areas of Ethiopia scavenge during daytime may be given cereal grains, cereal bran, broken grains and other house waste products as supplementary feed where most households (98%) provide partial supplementary feeding. Hussen (2007) also reported that 99.28% of farmers in North Western part of Ethiopia supplement their chicken mostly once per day with maize, barley, wheat, finger millet and household waste products. In Western Amhara Region, Ethiopia, all chicken owners provide supplementary feed. The majority (83.7%) of households spread the supplement feed on the ground while only 16.3% of them use local made feeders. About 57% households provide supplementation during rainy season while 38.8% of them provide year round (Worku *et al.,* 2012). However, in all cases, the quantity of supplementation per bird was not reported.

2.5.2. Chicken houses and housing systems

Space, ventilation, light, protection from weather and predators are basic requirements for poultry housing (Sonaiya and Swan, 2004). In rural areas of India, 97.5% households construct separate house for their chicken as night enclosure (Mandal *et al.,* 2006). In Zimbabwe, about 82% of the households provide separate housing for their chicken (Muchadeyi *et al.,* 2004). In some African countries, lack of housing is one of the major constraints of the smallholder poultry production systems (Dwinger *et al.,* 2003). In Ethiopia, because of lack of proper housing, predators cause higher proportion of village chicken mortality. Mortality of scavenging birds could be reduced by improved housing (Mekonnen *et al.,* 2011). According to Leta and Bekana (2010), only 14% of the households in Mid Rift Valley of Oromia Region, Ethiopia, shelter their chicken in separate sheds during night time. Similarly, in other study it was observed that 14% households in Rift Valley area of Oromia Region, Ethiopia, shelter their chicken in separate sheds made of cartoons and baskets bamboo or a round stick placed in the main house and perch for chicken (Dinka *et al.,* 2010). According to Fisseha (2009), only 22.1% of farmers in

Northwest of Amhara Region provide separate night shelter for their chicken. Also Hussen (2007) reported that in the Northwest part of Ethiopia, almost all farmers provide night shelter for their chickens either in kitchen (1.36%) or in the main house (39.07%), in hand-woven baskets (7.29%), in bamboo cages (1.51%), in separate sheds purposely-made for the chicken (50.77%). However, in the central highland of Ethiopia, there was no special housing provided for the birds (Tadelle and Ogle, 2001).

5.5.3. Chicken healthcare management

Even though Ethiopian local chicken breeds are resistant to diseases their egg production, weight gain and egg size are low compared exotic chicken breeds (Mekonnen, 2005). In Ethiopia, poultry disease is the most important constraint of village chicken production (Melesse and Negesse, 2009). Among poultry diseases, Newcastle disease is the most serious epizootic poultry disease in the world, particularly in developing countries. In developing countries, this disease occurs every year and kills on average 70 to 80% of unvaccinated village birds (Branckaert *et al.,* 2000). In Nigeria, Newcastle disease is claimed to be responsible for the death of 70 to 80% village chicken annually (Saliu *et al.*, 2009). Similarly, in the central highlands of Ethiopia, Newcastle disease was reported to be the major chicken killing disease (Tadelle and Ogle, 2001). According to Leta and Bekana (2010), the major causes of chicken death in Mid Rift Valley of Oromia Region, Ethiopia, was seasonal occurrence diseases, commonly Newcastle disease. The highest chicken death rate was observed during the rainy season (June, July and August) which is similar to the death rate reported in Northwestern Ethiopia (Hussen, 2007). In addition to Newcastle disease, other diseases also negatively affect poultry health and productivity at farmer level (Magwisha, 2003; Idi, 2004).

The majority of village poultry producers in Africa and Asia have poor access to veterinary and extension services; hence they are either unaware of the benefits of disease control or unable to access the vaccines and drugs needed to protect their birds (Magwisha, 2003; Idi, 2004). Due to insufficient veterinary service in the Mid Rift Valley areas of Oromia Region of Ethiopia, only 11% households get a chance to consult veterinarians when their chickens get sick. Only 31% of village chicken producer knows the presence of vaccine for chicken and almost no farmer vaccinated their chicken. When their chickens were sick, farmers usually treated them using traditional methods (Leta and Bekana, 2010).

2.5.4. Provision of water for chicken

In Western Amhara Region of Ethiopia, farmers provide drinking water to their chicken during the dry season (86.2%), rainy season (3.6%) and year round (10.2%) (Worku *et al.*, 2012). As a whole, 85.4% of the farmers found in same region provide water to their chicken only during the dry season and 14.3% throughout the year (Moges *et al.*, 2010). According to Hussen *et al.* (2007), 27.9%, 37.3% and 34.8% of chicken owners in North West part of Ethiopia use plastic, wooden made and clay made materials, respectively, to provide water for their chicken. In Mozambique, 66% of chicken owners use clay dish, 17% metal dish, 8% plastic dish, tin can 3% and 6% other materials to offer water for their chicken. None of these equipment maintain the quality of the water as they have been placed anywhere in an open place. As a result, the water is used by dogs, cats, wild birds, and even large animals, which may result in an easy transmission of pathogens particularly from wild birds to the chicken (Alders *et al.*, 1997).

2.6. Adoption of Agricultural Technologies

The definition of technology adoption has been the subject of debate in the agricultural literature (Doss, 2006). A common definition of technology adoption in the context of dummy variables is the presence or absence of the technology given to the farmer (Diagne and Groom, 2012). According to Feder *et al.* (1985), farmers adopt or practice new technologies when they expect more profitable outcome. In the context of adopting new technologies several possible measures have been suggested and employed in empirical analysis (Diagne and Groom, 2012). Adoption of a single technology without considering other technologies can be measured by the proportion the technology, but, whenever there is a mix together of many technologies, the measuring of adoption of these agricultural technologies becomes complex (Feder *et al.*, 1985). According to CIMMYT (1993), in designing an adoption study, defining of the criteria for adoption are the most important issues. For instance, what constitutes adoption? Are farmers who practice a few activities considered adopters, or do they have a certain minimum criteria? Therefore, in defining the criteria for adoption, it is also important to remember recommendations presented to farmers as a package of several practices, some components of the package may be adopted.

2.6.1. Adoption level

There are two types of technology adoption, namely individual adoption and aggregate adoption (Sodjinou, 2011). Adoption at the level of the individual farmer is defined as the degree of use of a new technology by the farmer when he/she has full information about the new technology, whereas, aggregate adoption is measured by the aggregate level of use of a specific new technology within a given geographical area or a given population (Feder *et al.*, 1985). A farmer will adopt a given technology if the expected utility obtained from the new technology exceeds that of the old one (Chebil *et al.,* 2009). The response of farmers' to the new technology can be explained using the theory of the maximization of expected utility and the decision to adopt or not adopt a given technology can be binary choice models, which assume that individuals are faced with a choice between two alternatives. The decision of the farmer is derived from the maximization of expected utility (Sodjinou, 2011).

2.6.2. Adoption index

Most adoption studies view the adoption decision in dichotomous terms (Feder *et al.*, 1985). The dichotomous response reflects the status of farmer awareness about improved technology rather than the actual adoption. For this reason, adoption of technologies can be quantified in the form of adoption index (Jain *et al.,* 2009). Adoption Index (AI) is an aggregation of adoption of different proportions of agricultural technology. The value of index is non-negative and lies between 0 and 1 where the value closer to zero indicates the lower level of adoption, while that closer to 1 indicates the higher level of adoption (Narain *et al.*, 1991). Base on adoption index, technology participants can be categorized into adopters and non-adopters or into nil adopters, low adopters, partial adopters and high adopter categories. For example, according to Rahman

(2007) and Zanu *et al.* (2012) based the level of pig technologies adoption the respondents were categorized into low adopters (having AI up to 0.33), partial adopters (having AI between 0.34 to 0.66) and high adopters (having AI between 0.67 to 1). Similarly, based on adoption index Quddus (2012), categorized dairy technology adopter into nil, low, medium and high adopters which have adoption index of 0%, greater than 0% and less than 35%, between 35% and less than 70% and 70% and above, respectively.

2.7. Determinants of Agricultural Technology Adoption

The extent of adoption of new technologies in agriculture can be mainly determined by the area and use of various inputs. For example, extension organizations, roads, telegraphic facilities, markets, credit, electricity and wages have impact on technology adoption (Jain *et al.*, 2009). Similarly, Rahman (2007) reported that socio-personal and economic characteristics can affect the adoption of the technology. Furthermore, Grazhdani (2013) revealed those farmers who have better income significantly more likely decide to adopt resource conserving agricultural technologies. According to Sanzidur (2003), the Chayanovian theory of the peasant economy, the higher subsistence pressure increases the tendency to adopt new technology. Experience of participant to the technology is one of the factors that determine farmers' decision to adopt the technology. For example, technology experience has interrelation with dairy technology adoption (Quddus, 2012). Similarly, Teklewold *et al.* (2006a) reported that poultry technology experience positively influenced exotic chicken breed adoption. Moreover, Dehinenet *et al.* (2014a) reported that farming experience played significant roles on the probability of dairy technology adoption. Generally, farm education exposure positively influenced the likelihood of adoption (Zanu *et al.*, 2012).

Age and educational level of the technology participant can affect the decision to adopt the technology. For example, farmers' decision to adopt exotic chicken breed in southern and central parts of Ethiopia was negatively influenced by age of household head (Teklewold *et al.*, 2006a). Similarly, Quddus (2012) reported that the probability of smallholder farmer dairy technology adoption in Bangladesh decreased as the of age household heads increases. In the highland of

Ethiopia, younger and literate household heads were more likely decide to adopt the utilization of commercial concentrate feeds for small ruminants (Legesse *et al.*, 2013). Similarly, Dehinenet *et al.* (2014a) reported that the age of household played significant roles on the probability of smallholder dairy technology adoption in selected zones of Amhara and Oromia Regions of Ethiopia. According to Grazhdani (2013), education measures human capital development that enables an individual farmer to assess information and to make decision. In agreement to this, secondary and higher educated smallholder farmers in Bangladesh were 9.7 times more likely decide to adopt improved dairy technologies compared to illiterate farmers (Quddus, 2012**)**. Similarly, improved pig technologies adoptions in Ghana are associated with education (Zanu *et al.*, 2012).

Among the socio-economic characteristics of the technology participants, family size is one of the expected variables that might influence the technology adoption. However, family size as proxy for labor availability is misleading because all household members can't participate on dairy technology activities (Mwamuye *et al.*, 2013). They further stated that looking at the labor availability never identified the family members who contributed directly to the dairy activity but focused on the total family members as a proxy to labor which can give a misleading impression. Having large family members did not necessarily mean they provided labor for dairy production, the inferences can be misleading. In contrary, Teklewold *et al.* (2006b) reported that as a good source of labour for poultry production management, households with more family size are more likely to be adopters than families with lower family size. Similarly, Dehinenet *et al.* (2014a) and Mekonnen *et al.* (2010) reported that the larger the family sizes the higher the adoption levels of dairy technologies.

Technology adoption can be influenced by technical support services. Degu (2012) reported that access to extension information could influence a farmer's decision to adopt a new technology. According to Ebojei *et al*. (2012), farmers who have frequent contacts with extension agents had a higher probability of participation in the innovation. For example, extension contact positively influenced exotic chicken breed adoption in Ethiopia (Teklewold *et al.*, 2006a). Dehinenet *et al.* (2014a) reported that availability of extension and training services play significant roles on the probability of dairy technology adoption. Similarly, Zanu *et al.* (2012) reported that improved pig technology adoption was associated with extension contact, scientific orientation and training. Moreover, training is the most important factor for adoption of technology (Chi and Yamada, 2002). The availability of training increases the level of technology adoption through creating awareness on the advantages of the technology (Dehinenet *et al.*, 2014a). Generally, government policies, technological change, institutional factors and technology inputs delivery mechanism can affect the probability of technology adoption (Wabbi, 2002).

Models used for adoption of technologies

The two models used in adoption studies are the logit and probit models which have a dependent variable lies between 0 and 1, and are convenient for dichotomous adoption variables where probit model is particularly well suited to experimental data while logit model is for observational data (Rahm and Huffman, 1984). The models provide empirical estimates of how an exogenous variables influence the probability of adoption and used to assess the effectiveness of technology adoption (Nkonya *et al*., 1997). Binary logistic model does not make assumption of linearity between dependent and independent variables; moreover, the model does not require normally distributed variables (Jera and Ajayi, 2008).

The results of the logit model estimates can be reported using odds ratio (OR) of the explanatory variables (Wooldridge, 2002; Blundell and Powell, 2003). The OR is a measure of association for 2×2 contingency table between an exposure and an outcome (Agresti, 2007). The OR implies the ratio of the probability (P_i) that the farmer adopt the technology to the probability ($1-P_i$) that the farmer doesn't adopt (Awotide *et al.*, 2012). The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure, moreover, odds ratios are used to compare the relative odds of the occurrence of the outcome of interest (Szumilas, 2010).

2.8. Impact of Technology Adoption

Measuring impact is essential to systematically evaluate the relative efficacy of various types of interventions but, there are no ‘gold standards’ for measuring many interventions impact (Catley *et al.,* 2008). However, a well designed impact assessment can capture the real impacts of interventions, be they are positive or negative, intended or unintended on the livelihood of the participants and the assessment process, can create an opportunity to develop learning partnership involving the donor, the implementing partner, and the participating communities. In addition, the assessment process can create space for dialogue, and results can provide a base for discussions on how to improve the program and to allocate future resources (Catley *et al.,* 2008). After determining the adoption of technology, the actual effect of a technology adoption on the livelihood of a technology participant can be assessed by comparing the variable difference between adopters and non-adopters (Wu *et al.,* 2010). The treatment effect of technology adoption on livelihood of households ’is defined as the difference between a variable technology adopters and non-adopters, whereas, the average treatment effect (ATE) is defined as the expectation of the treatment effect across all farmers (Mendola, 2007; Wu *et al.,* 2010).

Process or outcome indicators usually measure a physical aspect of new practice implementation, whereas, impact indicators (can be qualitative or quantitative) measure changes that occur as a result of intervention activities (Catley *et al.,* 2008). The result from impact assessments, when thoroughly applied, they can be used as a powerful supporting tool to influence the formulation of policy and best practice guidelines. For example, evidence based data derived from impact assessments was successfully used to develop Government endorsed best practice guidelines for drought response interventions in the livestock sector in Ethiopia (Behnke *et al*., 2008). Marginal effects technology intervention measures the expected instantaneous change in the dependent variable as a function of a change in a certain explanatory variable while keeping all the other covariates constant. Marginal effects are commonly used in practice to quantify the effect of variables on an outcome of interest (Wooldridge, 2002; Blundell and Powell, 2003).

Model used for impact assessment

Propensity scores matching

A major difficulty in assessing the impact of a specific technology consists of establishing a suitable counterfactual against which the impact can be measured. The impact of technology adoption must be separated from that of other socioeconomic factors that simultaneously determine the well-being of the households. Failure to do so will cause the corresponding impact estimates to be biased. A powerful econometric procedure for removing this bias is propensity score matching (Wu *et al.,* 2010). Propensity score matching (PSM) is a non-experimental method used for estimating the average effect of a treatment (Rosenbaum and Rubin 1983; Heckman *et al.*, 1998). Logit and probit models can be used to estimate propensity scores, and the statistical significance and pseudo-R^2 tests can be used to check the difference in average propensity scores between adopters and non-adopters (Wu *et al.,* 2010). Logit and Probit approaches produce similar results when estimating the probability of an individual farmer being an adopter or a non-adopter (Caliendo and Kopeinig, 2005). Propensity score matching can address the problem of 'self-selection,' because the treatment is not randomly assigned (Wu *et al.,* 2010).

According to Becker and Ichino (2002) and Khandker *et al.* (2010), the validity of the outputs of the PSM depends on conditional independence assumption **(**CIA) and the common support condition in propensity scores between the treated and untreated (in this study case between adopters and non-adopters). The CIA is crucial for correctly identifying the impact of the program, since it ensures that, although adopter and non-adopter groups differ, these differences may be accounted for in order to reduce the selection bias (Mulugeta and Hundie, 2012) where the non-adopter units to be used to construct a counterfactual for the adopter group.

Once propensity scores have been estimated, an algorithm to match the adopter groups with the non-adopter groups, based on the closeness of their propensity scores is needed (Wu *et al.*, 2010). According to Heckman *et al.* (1998) and, Smith and Todd, (2005) there are several matching algorithms. The most common matching algorithms used in PSM are nearest neighbor (NN) matching, caliper matching and kernel matching (Wu *et al.,* 2010; Mulugeta and Hundie, 2012) where each of the three matching methods has some shortcomings. The nearest neighbor matching matches each adopter group with non-adopter group having the closest propensity score. The matching can be done with or without replacement of observations (Mulugeta and Hundie, 2012). The nearest neighbor matching faces the risk of bad matches if the closest neighbor is far away. This risk can be reduced by using caliper matching, which imposes a maximum tolerance on the difference in propensity scores (Wu *et al.*, 2010). Kernel matching uses a weighted average of all in the adopter group to construct a counterfactual. A major advantage of this approach is that it produces average treatment effect estimates with smaller lower variance (Wu *et al.*, 2010; Mulugeta and Hundie, 2012).

3. MATERIALS AND METHODS

3.1. Description of the Study Areas

This study was conducted in three districts located in the central part of Oromia National Regional State, Ethiopia in *Welmera*, *Ade'a* and *Boset* districts (Figure 1). The districts are located between 8^{o}00' to 9^{o}30'N latitudes and 38^{o}00' to 40^{o}00'E longitudes (DPPA, 2006). *Welmera* district is found in Western *Shewa* administrative zone whereas *Ade'a* and *Boset* districts are found in Eastern *Shewa* administrative zone. *Welmera*, *Ade'a* and *Boset* districts are majorly characterized by highland, mid-altitude and lowland agro-ecologies, respectively (ONRSOP, 2011).

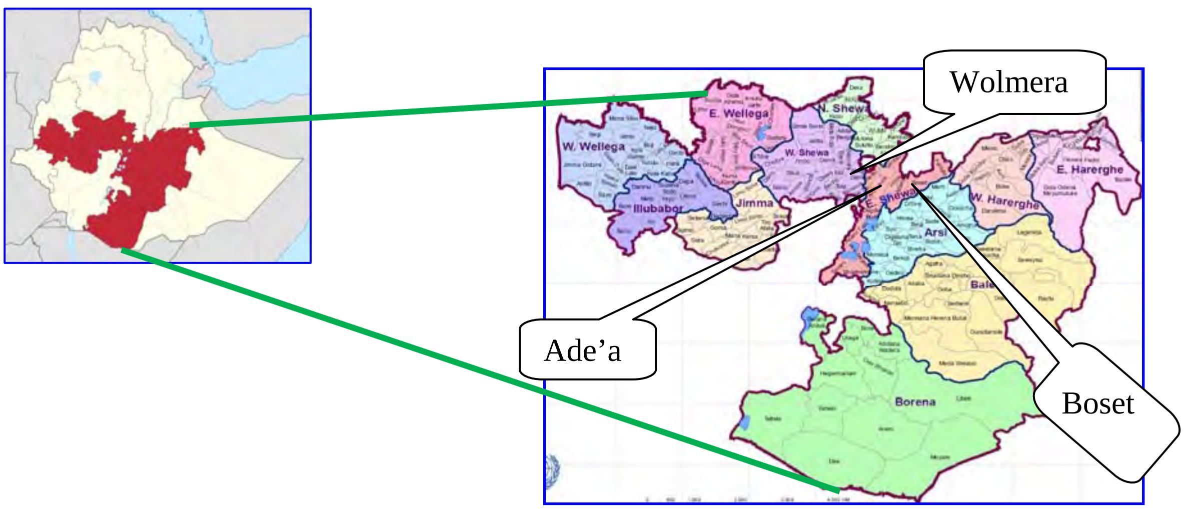

Figure 1. Selected districts for the study

3.2. Sampling Procedures

Three districts *Wolmera* (highland), *Ade'a* (mid-altitude) and *Boset* (lowland) were purposely selected based on their agro-ecology and village poultry technology package interventions (CSA, 2013). Five *Kebeles* were randomly selected from each district based on the technology package interventions. Using multi-stage random sampling method, 180 male and female technology package participants (12 participants per *Kebele*) were selected from village poultry technology package participant lists found in agricultural development agent (DA) offices and used for the study. The sample size was determined according Arsham (2005), 3.73% of standard error (SE).

3.3. Data Collection

Structured questionnaire together with Participatory Rural Appraisal (PRA) methods was used to collect detail information. Open-ended, closed-ended and ranking response questions were used. The questionnaire was pre-tested on 3 randomly selected technology package participants per each district (a total of 9 participants) and adjusted prior to the actual survey. A total of 15 DAs were trained and used as enumerator together with the participation and close supervision of the researcher. Face to face interview, field observation, open discussion with some randomly selected farmers and focus group discussion were used to collect sufficient information. The field observations were conducted by the principal researcher to crosscheck the respondents' response with the actual existing technology package practices.

The primary data collection focused on: socio-economic characteristics of the respondent, landholding, gender role on the technology, husbandry practices of the technology package, aim of production, chicken ownership, flock characteristics, breeding practices, chicken culling criteria, hatching of eggs using local broody hens, challenging chicken diseases, type of feeds used for chicken, awareness level and perception of the respondent to the technology, sources of technology inputs, chicken breeds and forms disseminated, number of chicken distributed per respondent for a package program, number of chicken demanded per respondent for a program, technical services, improved chicken breeds adoption, improved chicken feed and feeding adoption, chicken housing adoption, chicken healthcare adoption, water provision adoption, benefit from the technology, income changes, changes of egg productivity and changes of egg consumption per household (Table 1). Economically important chicken diseases were identified using their common symptoms as references. Samples of majorly used chicken feeds were collected from respondents and feed ingredients mixed were labeled. Secondary information was collected from the district agricultural and other concerned offices.

One PRA focus group discussion was conducted per district. Five randomly selected farmers, the researcher and 5 technology key actors (livestock DA, veterinarian, livestock expert, livestock team leader and poultry researcher) participated in focus group discussion. Open discussion was conducted to obtain detail information. Ranking method was used to distinguish the importance of the variables during discussion.

3.4. Feed Samples Analysis

Collected feed samples were clustered into their groups (13 feed sample groups) based on the type of feed ingredients mixed (home mixed ration I was a mix of maize, wheat, barley and teff; home mixed ration II was a mix of maize, wheat bran, soybean seedcake, bone and meat meal; home mixed ration III was a mix of wheat bran and noug seedcake; home mixed ration IV was a mix of maize, wheat bran and malt sprouts, and home mixed ration V was a mix of maize, wheat bran and noug seedcake). Each feed sample groups were bulked and composite samples were brought to the National Veterinary Institute of Ethiopia (NVI) nutrition laboratory. The feed samples were ground to pass through 1mm sieve to determine the dry matter (DM), ash, ether extract (EE), crude protein (CP) and crude fiber (CF) according to AOAC (1990) and calcium was determined by Talapatra method (precipitation, filtration and titration) according to Mudgal (2012). The DM was determined by oven drying the feed samples at 105^{o}C for 24 hours. The nitrogen content of each feed sample was determined by Kjeldahl procedure and CP was calculated by multiplying nitrogen content by 6.25. The metabolizable energy (ME) values of each feed were calculated indirectly according to the equation adopted from Wiseman (1987) as follows:

$$ME(Kcal/KgDM) = 3951 + 54.4 * EE - 88.7 * CF - 40.80 * Ash \ldots\ldots\ldots (1)$$

3.5. Definition of Variables Used for the Study

Table 1. Variable types and their definition

Variable type	Abbreviation	Variable definition
Dependent variables	CHICKADO	Adopted improved chicken breed (0=No, 1=Yes)
	FEEDADO	Adopted improved chicken feed and feeding (0=No, 1=Yes)
	HOUSEADO	Adopted improved chicken housing (0=No, 1=Yes)
	HELTHADO	Adopted chicken healthcare (0=No, 1=Yes)
	WATERADO	Adopted provision of water (0=No, 1=Yes)
Independent variables	SEX	Sex of the respondent (1=Male, 2=Female)
	AGE	Age of the respondent (years)
	FAMSIZE	Family size of the respondent (number)
	AGROZON	Agro-ecological zone of the study area (1=Highland, 2=Mid-altitude, 3=Lowland)
	ANNICOM	Total annual income of the respondent (Birr)
	EDUCAT	Education level (1=Illiterate, 2=Basic education, 3=Elementary education, 4=Secondary and above)
	LANDHOLD	Landholding of the respondent (hectare)
	CROPP	Did crop production affect you not to adopt the technology package? (0=No, 1=Yes)
	CHCKFEXP	Chicken farming experience of the respondent (years)
	TECHEXPI	Technology experience of the respondent (1=Up to 5year, 2=6-10 years, 3= More than 10 years)
	CREDIT	Did you get credit services? (0=No, 1=Yes)
	FRETECH	Frequency of technology received (1=Once, 2=Twice, 3=More than twice)
	EXTSERVI	Did you get extension services? (0=No, 1=Yes)
	HLTHSERV	Did you get healthcare services? (No=0, 1=Yes)
	LKCILIN	How far the livestock clinic from your house? (1=less than 10km , 2= 11-20km, 3= More than 20km)
	TRAINING	Did you get training for the technology? (0= No, 1=Yes)
	MARKETDS	How far the town market from your farm? (km)
Outcome variables	KNOWSKIL	Did the technology improve your knowledge and skill? (0= No, 1=Yes)
	BENEFIT	Did you benefit from the technology? (0= No, 1=Yes)
	LIVEHOOD	Did the technology bring a positive change on your livelihood? (0= No, 1=Yes)
	EGGPRO	How many eggs do you get per hen per year? (number)
	EGGCONS	How many eggs were used for family consumption per year?(number)
	INCOME	Income change per hen per year (Birr)

3.6. Definition of Adopters and Non-Adopters

To characterize adoption of village poultry technology packages, defining of adopters and non-adopters criteria was very essential. In agreement, CIMMYT (1993) reported that definitions of criteria are the most important issues and it is also important to remember recommendations presented to farmers as a package of several practices. Therefore, to call participants adopter of each technology package element (improved chicken breeds, feeds and feeding, chicken housing, healthcare and water provision), chicken breeds and forms, the farmer should fulfil the following minimum criteria at least for the last 5 years:

Chicken breed adopter: The farmer should receive improved chicken breeds more than once and had at least 5 exotic or crossbred chicken breeds in his/her production system. The chicken breeds includes: Bovan Brown, Fayoumi and crossbred of local and exotic chicken breeds.

Chicken forms adopter: Chicken forms includes: fertile eggs, day old chicks, only pullets (pullets without cockerel), pullets with cockerels and layers. The farmer should practice one or more of these forms.

Feeds and feeding adopter*:* The farmer should fulfill at least 3 of the following criteria: (1) Should supplement home mixed rations or formula rations or both for chicken; (2) Should use home available or appropriate feeding troughs; (3) Should know whether home available feeds can satisfy the chicken nutrient requirement or not; (4) Adjusted the feed according to age and productivity of chicken; (5) Should offer enough amount of feed per day.

Housing adopter*:* The technology participant must fulfill at least 3 of the following criteria: (1) Should construct the chicken house according to professionals' recommendations; (2) The chicken house should be separated from people and livestock houses; (3) Chicken should be kept in their house day and night or some hours during risky weather condition at day time and the whole night; (4) During housing, should consider chicken space requirement; (5) The house should be cleaned daily or when all out are for deep litter housing case; (6) Should be disinfect the house before the next batch entry.

Healthcare adopter: The participant should fulfill at least 3 of the following criteria: (1) Knew when chicken got vaccinations; (2) Vaccinated the chicken; (3) Isolated sick chicken; (4) Consulted a veterinarian; (5) Knew treatment doses.

Water provision adopter*:* The participant should fulfill at least 3 of the following criteria: (1) offered hygienic water for the chicken; (2) Should use hygienic watering trough; (3) Offered the water in *ad libitum* or throughout the day time*;* (4) Cleaned the trough daily; (5) Changed the water at least 3 times per day.

Non-adopter*:* Were those farmers who couldn’t fulfill the above mentioned minimum criteria.

3.7. Data Management and Models Used

3.7.1. Characterization of technology package adoption

Based on adopter and non-adopter definition criteria, those technology participants who adopted each of the package elements took a value 1, otherwise 0. Then, adoption levels of each poultry technology package element were computed for each agro-ecology and expressed in percentage. Based on adoption levels, technology elements were scored from 0 (nil adoption level) to 5 (highest adoption level). The total adoption score for a respondent was obtained by summing up the score obtained for each technology element. The minimum and maximum scores a respondent can score were 0 and 15, respectively. Then, adoption index (AI) was computed by dividing the sum of scores obtained for individual respondent to the total sum of the scores according to (Karthikeyan, 1994; Quddus, 2012; Zanu *et al.*, 2012) as follows:

$$Adoption\ index\ (AI) = \frac{\text{Respondent's total score}}{\text{Sum of total scores}} \ldots\ldots\ldots (2)$$

Based on computed AI, respondents were categorized into six adopter categories; nil adopters (AI=0), very low adopters (AI up to 0.20), low adopters (AI 0.21 to 0.40), medium adopters (AI 0.41 to 0.60), high adopters (AI 0.61 to 0.80) and very high adopters (AI greater than 0.80). The first three were categorized as non-adopters and the last three were categorized as adopters.

3.7.2. Determinants of technology adoption

3.7.2.1. Theoretical framework

This study hypothesized that social-economic characteristics of the respondents, accessibility of technology inputs, technical services and characteristics of technology might influence the probability of village poultry technology package elements adoption and the overall technology adoption. Based on these, sex, age, family size, annual income, education level, agro-ecology, landholding, crop production, chicken farming experience, technology experience, frequency of technology received, market distance, distance of veterinary clinic, credit, extension, healthcare and training services might influence the respondent decision to adopt the technology packages.

3.7.2.2. Econometric model

According to Rahm and Huffman (1984), the selection of econometric model depends on the objective of the study and the hypothesis to be tested. Therefore, Logit regression model was used. Because the model can provide empirical estimates of how exogenous variables influence the probability of technology adoption (Nkonya *et al.*, 1997). In this study, the response variable (adoption) was dummy variable (adopted or not adopted). If the farmer adopted each of the technology element and the overall technology, he or she was defined as 1 otherwise 0. Then, binary logistic regression model including odds ratio (OR) was used to assess the influence predictors on technology adoption because binary logistic model does not make assumption of linearity between dependent and independent variables; moreover, the model does not require normally distributed variables (Jera and Ajayi, 2008). The model used in the study was adopted from Jera and Ajayi (2008) and Quddus (2012). The probability to adopt the technology was expressed as:

$$P = P\left(Y = {}^{1}/_{X}\right) = \frac{e^{\beta_{c}+\sum_{i=1}^{17}\beta_i X_i}}{1 + e^{\beta_{o}+\sum_{i=1}^{17}\beta_i X_i}} \dots\dots\dots\dots\dots(3)$$

And the probability to not to adopt the technology was expressed as:

$$1 - P = P(Y = 0/X) = \frac{1}{1 + e^{\beta_{o}+\sum_{i=1}^{17}\beta_i X_i}} \dots\dots\dots\dots\dots(4)$$

The logit transformation of the probability of adoption, P(Y=1) was defined as:

$$\text{LogitP} = \log\left[\frac{P}{1-P}\right] = \beta_o + \sum_{i=1}^{17}\beta_i X_i \dots\dots\dots\dots\dots(5)$$

In the model:

Y_i = Adoption level of the technology (0= non-adopter, 1 =adopter)

β_0 = the intercept; e = 2.71828 (the base of natural logarithm); β_1 to β_{17} = regression coefficients; χ_1 to χ_{17}=explanatory variables; ${}_{e}{}^{\beta}{}_{0}$ to ${}^{\beta}{}_{17}$= odds ratio

3.7.3. The impact of technology package adoption

3.7.3.1. Theoretical framework

This study hypothesized that village poultry technology (improved chicken breeds) adoption has positive impact on the livelihood of technology participants. According to AIEI (2013), impact evaluation designs can be experimental, quasi-experimental and non-experimental where all are associated with the comparison of outcomes between the treated and untreated (control) groups. Since this study was observational study, non-experimental impact evaluation design was used to analyze the data using propensity scores matching (PSM) method (Rosenbaum and Rubin, 1983).

Propensity score is the probability of the participants for observed characteristic X and PSM method compares average outcomes of the adopters and non-adopters based on estimated propensity score values (Caliendo and Kopeinig, 2005). If technology was randomly assigned to farmers, the causal effect of technology adoption can be assessed by comparing the difference of variables between adopters (treated) and non-adopters (untreated). However, the technology is rarely randomly assigned in non-experimental studies which results self-selection bias (Wu *et al.*, 2010). When treatments were not randomly assigned, it was difficult to determine casual inferences whether the difference in outcome between the treated and control groups was due to the treatment effect or other characteristics. The PSM method can estimate average treatment effect of the technology adoption (Caliendo and Kopeinig, 2005).

3.7.3.2. Econometric model

Estimation of propensity score

Logit model was used to estimate propensity scores (pscores) for this study. According to Caliendo and Kopeinig (2005), in the implementation PSM five steps (pscores estimation, choosing matching algorithm, checking for overlap/common support, matching quality/effect estimation and sensitivity analysis) are required. After pscores were estimated, the adopted groups were matched with non-adopted groups on the basis of pscores and the average effect of the technology was calculated as the mean difference in outcome of the two groups. The analytical framework 'treatment effect' of outcome for individual was defined as the difference between farmer adopted the technology, $T_i = 1$ and not, $T_i = 0$ as follows:

$$\mathcal{T}_i = Y_i(1) - Y_i(0) \dots\dots\dots (6)$$

Where $\mathcal{T}_i$ was treatment effect, Y_i was the outcome on a participant i, whether a participant T_i had adopted village poultry technology package or not.

Since both Y_i (T=1) and Y_i (T=0) couldn't be observed at the same time on the same participant, there was unobserved outcome called counterfactual outcome. Therefore, estimating individual treatment effect $\mathcal{T}_i$ was not possible. For this shifting to estimating the average treatment effects of the population was required than the individual. Based on this, the average treatment effect on the adopted ($\mathcal{T}_{ATT}$) was computed as:

$$\mathcal{T}_{ATT} = E(\mathcal{T}|T = 1) = E[Y(1)|T = 1] - E[Y(0)|T = 1] \dots\dots\dots (7)$$

And average treatment effect (ATE) of the outcome on the overall population was computed as the difference between average treatment effect of adopters and non-adopters as follows:

$$\mathcal{T}_{ATE} = E[Y(1) - Y(0)] \dots\dots\dots (8)$$

In non-experimental study since the treatment was not assigned randomly, there was a possibility of self-selection bias. To solve this self-selection bias, the true ATT was computed as:

$$E[Y(1)|T = 1] - E[Y(0)|T = 0] = \mathcal{T}_{ATT} + E[Y(1)|T = 1] - E[Y(0)|T = 0] \dots\dots\dots (9)$$

The true $\mathcal{T}_{ATT}$ is only identified if and only if $E[Y(0)|T = 1] - E[Y(0)|T = 0] = 0$ (i.e., there was no self-selection bias). To solve self-selection bias, the following two strong assumptions were used (Caliendo and Kopeinig, 2005):

1. **Conditional independence assumption (CIA)**

In CIA, a set of observable covariates were not affected by the technology assignment and the potential outcomes were independent of the technology assignment which could be defined as:

$$Y(0), Y(1) \coprod T|X, \forall X \dots\dots\dots\dots\dots\dots (10)$$

Where $\coprod$ denotes independence; $\forall$ denotes for both groups (adopters and non-adopters)

This implies, selection was only based on observable characteristics and all variables that influenced technology assignment and potential outcomes were simultaneously observed. According to Rosenbaum and Rubin (1983) balancing scores assumption, if potential outcomes are independent of treatment conditional covariates X, they are also independent of treatment conditional on balancing score *b(X)*. Therefore, based on the probability of propensity score, CIA could be defined as:

$$Y(0), Y(1) \coprod T | P(X), \forall X \ldots \ldots \ldots \ldots (11)$$

Where P and ∀ denote probability and for both groups, respectively

2. **Common support**

The second strong assumption was checking overlaps and identification of common support region for both adopters and non-adopters. The common support condition requires the existence of sufficient overlap in the characteristics of the adopter and non-adopter units to find adequate matches (Mulugeta and Hundie, 2012). Since common support condition was one of the further required for perfect predictability of treatment for a given covariate X, it was defined as:

$$0 < P(T) = 1 | X < 1 \ldots \ldots \ldots \ldots (12)$$

Then, 11 explanatory variables and 6 outcome variables that fulfill CIA and common support were selected and used for the analysis. By considering CIA and common support assumptions, the PSM estimator for ATT was the mean difference in outcomes over the common support (p-score distribution) which could be expressed in as follows:

$$\mathcal{T}_{ATT}^{PSM} = E_p(X) | T = 1 \{E[Y(1)|T = 1, P(X)] - E[Y(0)|T = 0, P(X)]\} \ldots \ldots \ldots (13)$$

Where P(X) was the propensity score computed on the covariate Xs.

Choosing of matching algorithm estimator

Choosing of matching algorism was the second step of PSM. To choose the best matching algorism calliper radius, nearest neighbour and kernel matching estimators were conducted. All matching estimators compare the outcome of adopted individual with outcomes of non-adopted (Caliendo and Kopeinig, 2005). Therefore, after estimating the pscore values on the observable covariates, matching was done using selected a matching algorithm based on the data. Even though different matching algorisms estimators were used, the final decision to choose the appropriate matching estimator was based on three major criteria according to Dehejia and Wahba (2002). These were balancing test (all covariates should be included in the estimator), relatively low pseudo-R^2 value and largest matched sample size.

Checking overlap/common support region

Identifying the common support region was the third step used in PSM method. According to Caliendo and Kopeinig (2005), in PSM average treatment effect on adopted (ATT) and average treatment effect (ATE) on population are only defined in the common support region. The common support region is the region within the minimum and maximum propensity scores of the two groups, respectively. The common support region was identified done by discarding those observations whose propensity scores were smaller than the minimum and greater than the maximum of both the adopters and non-adopters (comparison groups).

Assessing match quality/effect estimation

After choosing the best fitted matching estimator, the next procedure in PSM analysis was testing the covariate balance to check the balancing property of the covariates by comparing the significant test difference before and after matching using the selected matching algorism. To check the balance distribution of relevant variables in both the non-adopter and adopter groups, the before and after covariates matching should be checked (Caliendo and Kopeinig, 2005). This study assessed the matching quality to check the balance distribution of the variables. Balance test was a test conducted to know whether there was statistically significant difference in mean value of per-treatment characteristics of both adopter and non-adopter respondents. According to Rosenbaum and Rubin (1985) standardized bias (SB) is used to assess the marginal distance of covariates and *t*-test is used to check whether there is a significant difference in covariate means for both adopters and non-adopters in the common support region (check matching quality). According to Tolemariam (2010), a matching estimator having insignificant mean differences in all explanatory variables was preferred as a best matching quality. According to (Caliendo and Kopeinig, 2005) testing the statistical significant of treatment effects and computing their standard errors is not straightforward. One way to solve this problem is to use bootstrapping method (popular method) to compute the standard error for the estimate of the technology impact (Lechner, 2002; Mulugeta and Hundie, 2012). Since the matching quality test this study suggests that the chosen matching algorithm was relatively best for the data, estimating the average treatment effect on the treated (ATT) was the next task.

Sensitivity analysis

Sensitivity analysis was the final (fifth) step conducted in order to check the robustness of the estimation (whether there were hidden biases affected the estimated ATT or not). The t-test showed the impact of adoption on respondent knowledge and skill improvement (KNOWSKIL) insignificant, therefore it was not considered in the sensitivity analysis. According to Keele (2010), when outcome indicators showed significant, two things should be done in sensitivity analysis in order to check whether there are hidden biases or not. These are sensitivity analysis on the p-values and see how the p-value increases for increasing values of degree of departure from random assignment of treatment (Γ) and how the magnitude of the treatment effect changes with an increasing Γ where each sensitivity test is built on a specific randomization test for a type of outcome. Since the lower bounds underestimated the true treatment effect, upper bound Hodges-Lehmman point estimates were used according to Becker and Caliendo (2007). Based on CIA, the treatment effect could be estimated with matching estimators on selected observable characteristics. However, unobserved variables which affect assignment into treatment and the outcome variable simultaneously might result hidden bias called unobserved heterogeneity

(Caliendo and Kopeinig, 2005). Since it was not possible to estimate the magnitude of selection bias with non-experimental data, this problem was address using “rbounds” bounding approach proposed by Rosenbaum (2002).

3.8. Statistical Analysis

Quantitative data sets such as age, family size, annual income, landholding, chicken farming experience, quantities of chicken forms received and demanded, adoption index and level were analyzed using means procedure of SAS version 9.0 software packages. Ranked variables were analyzed using SAS NPAR1WAY wilcoxon procedures of Kruskal Wallis test. Ranked means were analyzed using SAS means procedure. Statistical package for social science (SPSS) version 20.0 software packages was used to analyze categorical data sets and for univariate and multivariate logistic regression analyses. Characterization of the technology package elements, chicken breeds and forms adoption was done using descriptive statistics cross-tabulation procedures to compare the proportion of adopters and non-adopters to a particular technology element, chicken breed and form across the study agro-ecologies. Propensity score “pscore” command of STATA version 12.0 software packages was used to estimate the p-scores. Propensity score matching “psmatch2” command was used to assess the impact of technology adoption on the livelihood of smallholder farmers.

To assess determinant factors of adoption and impact of technology adoption, 17 and 11 explanatory variables were used, respectively. Prior to the analyses of data that required models, whether there is problem of multicollinearty among independent variables, variance inflation factor (VIF) test for continuous independent variables and contingency coefficient (CC) test for the discrete variables were conducted to see the association between variables according to (Gujarati, 2004; Berhanu, 2012). Similarly, whether there is problem of hetroscedasticity among independent variables, Breusch-Pagan/Cook-Weisberg “hottest” test was carried out (Wooldridge, 2002). Before univariate and multivariate logestic regression analyses (to investigate determinant factors of adoption), first cross-tabulation analysis was used to identify the reference (first or last) of each explanatory variable category. Two stages logistic regression analyses procedures were used to identify explanatory variables fitted to the model and significantly influenced the probability of technology elements adoption. First, univariate logistic regression analysis was performed. Univariate analysis creates candidate variables for the multivariate analysis. According to Bursac *et al.* (2008) and Hosmer and Lemeshow (2000), variables whose $p<0.25$ were selected as candidate variables for multivariate analysis. Secondly, multivariate logistic regression analysis was carried out. In multivariate analysis, backward likelihood (BL) elimination procedure with Hosmer and Lemeshow goodness-of-fit test was used. If Hosmer and Lemeshow goodness-of-fit test was not significant ($P>0.05$) the model was fit well to the data (Peng *et al.,* 2002) and if Pseudo-R^2 was above the statistical threshold of 20%, adoption could be attributed to the covariates fitted (Ochieng *et al.,* 2012). Finally, variables significantly influenced the probability adoption and confounder variables were kept in the final model but variables insignificantly influenced the adoption and non-confounder variables were excluded from the model according to Bursac *et al.* (2008). To locate the significant difference among means and categorical variables, LSD means comparison and chi-square tests were used, respectively. Results that didn't show significant differences among the study agro-ecologies were summarized as overall results and reported.

4. RESULTS

4.1. Socio-Economic Characteristics of the Respondents

About 65.6% and 34.4% of the respondents used for this study were male and female farmers, respectively. The age of the respondents ranged from 19-74 years with overall mean of 42 years (Table 2). Based on age categories, 14.4% of them were less than 30 years, 35.0% were 31-40 years, 32.8% were 41-50 years and 17.8% were above 50 years. The family size of the respondents ranged from 1-12 per household with overall mean of 6. Family size did not vary ($P>0.05$) among agro-ecologies. Most of the respondents (48.9%) had a family size of 4-6 and followed by greater than 6 family sizes (38.9%) and smaller group of respondents (12.2%) had less than 4 family sizes. The total annual income of the respondents ranged from 7,000-250,000 Birr with overall mean of 55,826.34 Birr. Households residing in mid-altitude and lowland agro-ecologies had significantly ($P<0.05$) higher total annual income as compared to households found in the highland agro-ecology. Most of the respondents (39.4%) attended secondary and above school education followed by respondents who attended elementary school education (36.7%). About 17.2% the respondents attended basic educations (reading and writing) and very small proportions (6.7%) of the respondents were illiterate. The chicken farming experience of the respondents ranged from 5-58 years with overall mean of 20.8 years. Most of the respondents (47.8%) had 16-30 years of chicken keeping experiences. About 46.1%, 38.9% and 15.0% of the respondents had up to 5 years, 6-10 years and over 10 years of village poultry technology package experiences, respectively.

Table 2. Socio-economic characteristics of the respondents

Variable	Agro-ecology			Range	Overall mean (N=180)	P-value
	Highland (N=60)	Mid altitude (N=60)	Lowland (N=60)			
Age (year)	40.7(1.31)	41.4(1.51)	44.3(1.16)	19-74	42.1(0.77)	0.1266
Family size	5.8(0.33)	5.8(0.29)	6.4(0.28)	1-12	6.0(0.18)	0.2632
Annual income (1000 Birr)	$37.0(0.49)^{b}$	$66.8(0.76)^{a}$	$62.3(0.73)^{a}$	7-250	55.8(0.41)	0.0445
Landholding per household (ha)	$1.8(0.18)^{b}$	$1.5(0.16)^{b}$	$2.6(0.22)^{a}$	0-7	2.0(0.11)	0.0003
Chicken farming experience (year)	19.4(1.40)	21.0(1.37)	22.0(1.11)	5-58	20.8(0.75)	0.3790

Figures outside and inside parenthesis represent respondent means and standard errors, respectively; Means in the row with the same letter are not significantly different.

Older farmers hold better farmland size as compared to younger. About 38.9% of the respondents had nil or less than 1 hectare farmland and most (65.6%) of the respondents had less than 2 hectares farmland. Farmers residing in lowland agro-ecology owned better (P<0.001) farmland size as compared to farmers found in highland and mid-altitude agro-ecologies (Table 2). Due to farmland scarcity, about 4.4% of the respondents in the highland and mid-altitude agro-ecologies didn't have any farmland. These people conducted their agricultural practices either by renting farmland or by doing some agreements with farmland owners.

4.2. Major Cultivated Crops

Wheat, barley and *teff* in the highland agro-ecology (*Welmera* district), *teff*, chickpea and wheat in the mid-altitude agro-ecology (*Ade'a* district) and *teff*, sorghum and haricot bean in the lowland agro-ecology (*Boset* district) were the three majorly cultivated crops in terms of farmers growing the crops (Table 3).

Table 3. Major cultivated crops across the study agro-ecologies

	Study agro-ecologies		
Crop name	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)
Wheat	93.3	56.7	33.3
Teff	41.7	95.0	93.3
Sorghum	0.0	0.0	70.0
Barley	86.7	10.0	25.0
Haricot bean	0.0	0.0	46.7
Chickpea	0.0	63.3	0.0
Maize	3.3	15.0	28.3
Lintels	0.0	26.7	0.0
Faba bean	23.3	15.0	0.0
Pea	3.3	6.7	0.0
Lathyrus or grass pea	0.0	3.3	0.0

Figures represent percentage.

4.3. Village Poultry Technology Packages

4.3.1. Sources of information about the technology packages

As shown in Table 4, because of their closer contact with farmers, Development Agents (DAs) were the first major source of information for most farmers (71.7%) about village poultry technology packages followed by farmer to farmer information exchange (18.3%). The contributions of mass media, experts, researchers and, written materials about poultry and NGOs as first source of information about the technology packages were very low.

Table 4. First source of information about the technology packages

Source of information	Agro-ecology			
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	Overall (N=180)
Farmers	6.7	20.0	28.3	18.3
DAs	83.3	71.7	60.0	71.7
Mass media	3.3	1.7	1.7	2.2
Livestock experts	0.0	3.3	6.7	3.3
Researchers	0.0	3.3	0.0	1.1
Written materials	3.3	0.0	0.0	1.1
NGOs	3.3	0.0	3.3	2.2

Figures represent percentage.

4.3.2. Sources of technology inputs

About 25.6% of the respondents of the overall of study areas received exotic/improved chicken breeds more than twice, 45.0% received twice and 29.4% received only once. As shown in Table 5, agricultural office for *Welmera* (highland) and *Ade'a* (mid-altitude) districts and NGOs for *Boset* (lowland) district were major sources of improved chicken breeds for technology packages. The contribution of Agricultural Research Centers, farmer cooperatives, farmers and private organizations as sources of improved chicken breeds was not this much significant. Even though some farmers got improved chicken breeds from different sources (agricultural office, NGOs, farmers, Agricultural Research Centers, private organizations, farmer cooperatives and market), their demand was not satisfied. Most of the technology participants (91.7%) couldn't get balanced chicken rations. Home available feeds and home mixed rations were mostly used to supplement the chicken breeds. However, farmer cooperatives and private organization in highland agro-ecology (*Welmera* district), Agricultural Research Centers and private organization in mid-altitude agro-ecology (*Ade'a* district), and agricultural office and model farmers in lowland agro-ecology (*Boset* district) were the better sources of formula feeds. Although chicken breeds, balanced feeds, vaccines, credit and poultry equipment were the major limited inputs, agricultural office in highland agro-ecology and National Veterinary Institute (NVI) in mid-altitude agro-ecology were better supplier of chicken vaccines. Across the study agro-ecologies, only 2.5 % of the respondents got credit service and only 18.9% got the technology inputs with price subsidy. Technology inputs dissemination was not well organized. As shown in Table 5, agricultural offices were the major source of technical support. The market support was very low, but few private organizations provided some market support for participants found in highland and mid-altitude agro-ecologies.

Table 5. Sources of technology inputs and supports across the study agro-ecologies

Sources of technology	Technology inputs							
	Chicken breed	Balanced feed	Drug	Vaccine	Credit	Equipment	Technical support	Market support
Highland agro-ecology								
Agricultural Office	53.3		53.3	66.7			90.0	
Research Center	1.7					1.7	1.7	
NGOs	8.3	8.3	3.3			1.7		
Cooperatives	23.3	31.7			1.7	13.3		1.7
Private organization	3.3	20.0	20.0			15.0		11.7
From different sources	10.0							
Mid-altitude agro-ecology								
Agricultural Office	45.0		3.3	10.0			53.3	
Research Center	8.3	11.7	10.0	10.0		10.0	1.7	
NGOs	18.3					1.7		
Private organization	6.7	33.3	23.3		3.3	18.3	6.7	13.3
Farmers	6.7							
NVI				21.7				
From different sources	15.0						16.7	
Lowland agro-ecology								
Agricultural Office	25.0	43.3	46.7				80.0	
NGOs	51.6	6.7	3.3	3.3	3.3			
Private organization		5.0	1.7		1.7			
Farmers	1.7							
From different sources	21.7							

NVI= National Veterinary Institute; figures represent percentage.

4.3.3. Number of chicken forms disseminated and demanded

Table 6 shows forms and numbers of improved chicken breeds disseminated and demanded per respondent per package program. The technology participants residing in the mid-altitude agro-ecology obtained ($P<0.01$) more number of day old chicks (DOs) as compared to participants residing in the highland and lowland agro-ecologies. Comparative to other chicken technology forms, better numbers of DOs and pullets were obtained per respondent across the study agro-ecologies. The numbers of fertile eggs, pullets with cockerels, only pullets and layers chicken forms distributed per respondent were not significant ($P>0.05$) across the study agro-ecologies. Most of the technology participants (82.8%) were not satisfied with number of chicken forms distributed per individual per program. As shown in Table 6, the numbers of chicken forms demanded per respondent were much higher as compared to numbers disseminated so far. There were no significant differences ($P>0.05$) on the numbers of chicken forms demanded for a package program across the study agro-ecologies.

Table 6. Chicken technology forms supplied and demanded per participant for a program

Chicken forms	Agro-ecology			Overall	
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	mean (N=180)	P-value
Number supplied					
Fertile eggs	0.26(0.20)	1.4(0.67)	1.3(0.46)	1.0(0.28)	0.1905
DOs	16.8(4.44)^{b}	34.0(9.20)^{a}	3.7(1.60)^{b}	18.2(3.55)	0.0019
Pullcocker	4.2(1.11)	5.5(1.83)	4.3(1.14)	4.7(0.80)	0.7492
Only pullets	8.4(2.89)	14.9(6.91)	6.9(0.65)	10.1(1.25)	0.3819
Layers	9.6(8.41)	0.6(0.25)	0.5(0.24)	3.6(2.81)	0.3187
Number demanded					
Fertile eggs	13.0(1.69)	10.5(2.21)	11.3(1.82)	11.6(0.99)	0.5708
DOs	203.9(40.87)	218.7(53.75)	88.0(31.69)	170.2(22.17)	0.0694
Pullcocker	79.6(23.26)	65.1(12.75)	47.3(8.04)	64.0(6.11)	0.3940
Only pullets	109.3(30.97)	124.5(42.91)	59.7(19.99)	97.9(16.27)	0.3468
Layers	91.8(23.87)	93.6(42.36)	42.5(7.86)	76.0(14.04)	0.3423

DOs= day old chicks; Pullcocker= Pullets with cockerels; Figures outside and inside parenthesis represent means and standard errors, respectively; means in the row with the same letter are not significantly different.

Preferred chicken breeds and forms for the technology

Bovan Brown chicken breed was the most (P<0.001) preferred chicken breed in the highland and mid-altitude agro-ecologies, whereas, Fayoumi chicken breed was the most (P<0.001) preferred breed in the lowland agro-ecology (Table 7). The preference for crossbred chicken (local chicken breeds crossbreed with exotic chicken breed) was not significant (P>0.05) across the study agro-ecologies.

Table 7. Chicken breeds preference of the respondents (1= Most preferred; 5=Least preferred)

Chicken breed	Preference across agro-ecologies			P-value
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Rhode Island Red	4.2(0.17)[b]	4.9(0.09)[a]	4.7(0.14)[a]	0.007
Bovan Brown	1.7(0.16)[b]	1.9(0.14)[b]	2.5(0.18)[a]	0.001
White Leghorn	3.4(0.18)[b]	4.0(0.17)[a]	4.3(0.16)[a]	0.002
Fayoumi	4.2(0.18)[a]	3.5(0.21)[b]	1.8(0.13)[c]	0.000
Crossbred	2.7(0.19)	2.3(0.17)	2.6(0.15)	0.134

Figures outside and inside parenthesis represent ranked means and standard errors, respectively; ranked means in the row with the same letter are not significantly different.

Layers, pullets with cockerels and only pullets were the first three chicken technology forms most preferred by respondents (Table 8). The respondents residing in the lowland agro-ecology preferred ($P<0.01$) layers most. Fertile eggs technology form was the least preferred one followed by day old chicks.

Table 8. Chicken forms preferences of the respondents (1= Most preferred; 5=Least preferred)

Chicken forms	Preference across agro-ecologies			P-value
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Fertile eggs	4.6(0.08)	4.5(0.09)	4.7(0.08)	0.319
Day old chicks	3.3(0.18)	3.4(0.15)	3.9(0.10)	0.057
Only pullets	2.6(0.14)	2.6(0.12)	2.8(0.12)	0.316
Pullets with cockerels	2.4(0.14)	2.1(0.13)	2.1(0.11)	0.132
Layers	2.0(0.13)[a]	2.2(0.16)[a]	1.6(0.11)[b]	0.003

Figures outside and inside parenthesis represent ranked means and standard errors, respectively; ranked means in the row with the same letter are not significantly different.

4.4. Husbandry Practices of Village Poultry Technology Packages

4.4.1. Role of family members on the technology packages

This study found that in the husbandry practices of village poultry technology package, there were activities that could be conducted by the participations of two or more family members' (Table 9). Fathers participated mostly in training, chicken house construction and buying of technology inputs, whereas, mothers mostly participated in chicken management, making decision to sell technology outputs, selling of technology outputs and on treating of sick birds. The participation of boys and girls in technology activities was very small (ranging from nil to 5%). Boys relatively participated more in chicken house construction while girls participated more in chicken management. Regarding the working hours in the production system, approximately ½ of the respondents (50.6%) work less than 1 hour per day on chicken management activities, whereas, ¼ of the respondents work between 1-2 hours per day but the remaining ¼ (24.4%) didn't spend any hour per day in chicken management activities.

Table 9. The role of family members on the technology package production systems

Activity	Participations			
	Fathers	Mothers	Boys	Girls
Participate in training	47.8	27.8	2.2	0.6
Chicken house construction	64.5	8.3	5.0	0.0
Buying of technology inputs	54.4	35.6	2.8	1.1
Chicken management	6.7	64.4	2.2	2.8
Decision to sale technology outputs	7.8	68.9	2.8	0.0
Selling of technology outputs	6.1	75.0	3.3	0.6
Treating of sick birds	36.7	43.3	2.8	1.7

Figures represent percentage.

4.4.2. Production systems of the technology packages

As a whole, most of the respondents (65.0%) in the study areas practiced scavenging poultry production system with some feed supplementation. About 15.0%, 7.2% and 12.8% of the respondents practiced semi-intensive, intensive and only scavenging without any supplementation poultry production systems, respectively. The objectives of the production were mainly for income source (78.3%) followed by for income source and home consumption (21.7%). Most respondents kept either local chicken breed only or exotic chicken breeds together with local chicken breeds (Table 10).

Table 10. Proportion of respondents keeping chicken breeds in their production system

Description	Agro-ecology			Overall
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	(N=180)
Keep no chicken	6.7	13.3	3.3	7.8
Keep only local breeds	10.0	33.3	31.7	25.0
Keep only exotic breeds	16.7	8.3	10.0	11.7
Keep both local and exotic breeds	46.7	20.0	25.0	30.6
Keep only crossbred	3.3	5.0	3.3	3.9
Keep both local and crossbred	10.0	11.7	6.7	9.4
Keep all three breeds together	6.7	8.3	20.0	11.7

Figures represent percentage.

4.4.3. Chicken ownership and flock structure

As shown in Table 11, among the family members mothers, ranked 1st in chicken ownership across the study agro-ecologies. In the highland and in the mid-altitude agro-ecologies, fathers ranked 2nd ($p<0.01$) but in the lowland agro-ecology girls ranked 2nd. Among the family members, mothers and boys chicken ownership was insignificant ($P>0.05$) across the study agro-ecologies.

Table 11. Chicken ownership across the study agro-ecologies

Family member	Agro-ecology			P-value
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Fathers	2.4(0.14)^{b}	2.7(0.15)^{ab}	3.0(0.13)^{a}	0.006
Mothers	1.6(0.11)	1.6(0.0.11)	1.4(0.08)	0.091
Girls	3.0(0.08)^{a}	2.6(0.10)^{b}	2.5(0.11)^{b}	<0.000
Boys	3.0(0.10)	3.2(0.11)	2.9(0.10)	0.260

Figures outside and inside parenthesis represent ranked means and standard errors, respectively; ranked means in the row with the same letter are not significantly different.

As indicated in Table 12, layers were kept dominantly in the production systems across the study agro-ecologies ranging between 21.7-72.9% followed by pullets (15.0-30.4%). Chicken flock size in general and exotic chicken breed in particular owned per household in the highland agro-ecology were (P<0.05) higher than in lowland agro-ecology. As a whole, a mean of 17.8, 13.4 and 11.2 chicken were owned per household in the highland, mid-altitude and lowland agro-ecologies, respectively, with an overall mean of 14.2 chicken per household. Regarding the proportions of chicken breeds kept in the production system, 44.6%, 38.7% and 16.7% were local, exotic (Bovan Brown and Fayoumi) and crossbreds, respectively (Table 12). About 59.4% of the respondents kept less than 5 exotic or crossbred chickens and about 40.6% kept 5 or more exotic/crossbred chicken.

Table 12. Chicken flock structure and size per household

Parameter	Agro-ecology			Overall	
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	mean (N=180)	P-value
Local chicken breeds					
Chicks	1.0(0.37)	0.7(0.36)	1.5(0.35)	1.1(0.21)	0.304
Pullets	0.6(0.22)	1.0(0.25)	1.2(0.26)	0.9(0.14)	0.300
Cockerels	0.2(0.06)^{b}	0.6(0.14)^{a}	0.5(0.12)^{ab}	0.4(0.07)	0.037
Layers	2.9(0.42)	3.4(0.42)	2.9(0.40)	3.1(0.24)	0.609
Cocks	0.4(0.09)	0.6(0.17)	0.5(0.10)	0.5(0.07)	0.334
Total	5.1(0.78)	6.3(0.86)	6.5(0.77)	6.0(0.46)	0.387
Exotic chicken breeds					
Chicks	0.0(0.00)	0.2(0.17)	0.2(0.12)	0.1(0.07)	0.445
Pullets	1.9(1.18)	1.5(0.94)	0.2(0.08)	1.2(0.50)	0.344
Cockerels	0.1(0.02)	0.1(0.08)	0.1(0.09)	0.1(0.04)	0.702
Layers	8.1(2.23)^{a}	2.9(1.30)^{b}	1.9(0.35)^{b}	4.3(0.89)	0.008
Cocks	0.3(0.12)	0.2(0.17)	0.1(0.07)	0.2(0.07)	0.406
Total	10.4(2.47)^{a}	4.8(2.11)^{b}	2.5(0.40)^{b}	5.9(1.11)	0.011
Crossbred chicken					
Chicks	1.1(0.86)	0.0(0.00)	0.9(0.41)	0.7(0.32)	0.313
Pullets	0.2(0.20)^{b}	1.5(0.59)^{a}	0.4(0.14)^{b}	0.7(0.22)	0.033
Cockerels	0.1(0.10)	0.4(0.17)	0.2(0.08)	0.2(0.07)	0.267
Layers	0.7(0.24)	0.4(0.17)	0.5(0.21)	0.5(0.12)	0.439
Cocks	0.1(0.09)	0.1(0.02)	0.3(0.17)	0.2(0.06)	0.377
Total	2.3(1.02)	2.3(0.80)	2.2(0.64)	2.3(0.48)	0.998
Overall	**17.8(2.50)^{a}**	**13.4(2.17)^{ab}**	**11.2(1.25)^{b}**	**14.2(1.20)**	0.0468

Figures outside and inside parenthesis represent means and standard errors, respectively; means in the row with the same letter are not significantly different.

4.4.4. Record keeping practices

Farmers who participated in village poultry technology packages had very poor record keeping skill. About 74.4% didn't keep records, only ¼ kept records mostly on income, expenses, egg production and mortality although their record keeping systems were very poor. This study tried to investigate egg production characteristics of different chicken breeds kept for the technology packages. Due to farmers' poor record keeping experience, the study couldn't get satisfactory information on production and reproduction traits such as age at first egg, number of clutch per year, number of eggs per clutch and age of culling.

4.4.5. Factors affecting chicken husbandry and productivity

The respondents mentioned many problems that hindered them to keep the technology packages chicken and that affected the productivity of chicken in the study agro-ecologies. In the highland agro-ecology, cold weather stress (July to November) was the major problem to keep chicken of technology package. Due to cold weather, chicken consumed more feed and took long time to reach to the age at first egg. Moreover, they replied that cold weather caused low egg productivity and high chick mortality. In mid-altitude agro-ecology, respondents replied that there were no serious factors that negatively affected them to keep the package chicken. In lowland agro-ecology, respondents replied that disease outbreak and heat stress (April and May) were the major problems to keep the technology package chicken.

Overall, respondents believed that feed quality and quantity (31.2%), disease problems (35.8%) and chicken managements (10.7%) were the major problems that affected chicken egg productivity. Still there were farmers (1.6%) who didn't know what factors negatively affected their chicken egg productivity. About 2.8% of respondents said that the presence or absence of cock with layers could influence the hens' egg laying performance. They believed that cocks could stimulate pullets to come to first egg very early and stimulate layers to lay more eggs. Farmers (3.8%) believed that total confinement of layers (intensive system of production), reduce layers egg productivity.

Chicken culling criteria

As shown in Table 13, low egg production was the 1st ranked criterion (P<0.001) to cull chicken (layers) from the production system in the highland and mid-altitude agro-ecologies. Whereas, disease problem (P<0.001) was the 1st ranked criterion to cull chicken from the production system in the lowland agro-ecology followed by low egg production. Culling of chicken due to space problem was the least criterion across the study agro-ecologies. Chicken culling due to space problem and for extra money need did not vary across agro-ecologies.

Table 13. Chicken culling criteria from the production system across agro-ecologies

Criteria	Agro-ecology			P-value
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Old age	2.8(0.12)[b]	3.3(0.16)[a]	3.3(0.14)[a]	<0.000
Space problem	5.4(0.10)	5.5(0.11)	5.3(0.13)	0.297
Low egg production	1.7(0.12)[c]	2.3(0.15)[b]	2.7(0.14)[a]	<0.000
Disease problem	3.7(0.21)[a]	2.5(0.17)[b]	1.8(0.15)[c]	<0.000
Extra money need	3.2(0.15)	3.2(0.20)	3.0(0.18)	0.715
Feed shortage	4.6(0.14)[ab]	4.5(0.14)[b]	4.9(0.12)[a]	0.050

Figures outside and inside parenthesis represent ranked means and standard errors, respectively; ranked means in the row with the same letter are not significantly different.

4.4.6. Breeding practices

To improve the productivity of local chicken breeds, about 65.6% of the technology participants carried out crossbreeding of exotic chicken breeds with the local once. About 59.4% the respondents carried out uncontrolled breeding. About 86.1% of the respondents didn’t know the effect of uncontrolled breeding on genetic traits of their local chicken breeds. However, only 13.9% of the respondents understood the effect of genetic dilution of local chicken breeds due to crossing of local ecotypes with exotic chicken breeds. They replied genetic dilution will reduce disease resistance of crossbreds, crossbreds may not as hardy as local birds to the environment and may increase the chance of new disease transmission, brooding ability of local hens will decrease and reduce good taste quality of local chicken meat and eggs.

4.4.7. Egg incubation practices

Based on season of incubation (rainy or dry season) and good chicks hatching ability, all respondents incubated a mean of 12.2 eggs (7-20 eggs) per local broody hen. Dry season was the most preferred season (September to May) for egg incubation. Respondents believed that incubating eggs during dry season increased egg hatchability and decreased chicks' mortality. If eggs were incubated during rainy season, eggs might not get enough warming from the broody hen, more eggs would rot due to cold stress and there was high chick mortality. Some respondent replied that sound of thunder storm could cause more incubated eggs to get rot and due to fear of thunder storm large number of chicks will die. Not only seasons but also days and times of the day were considered to incubate eggs using local broody hens. Respondents believed that to get more male chicks, either Wednesday or Friday were preferred days for egg incubation, whereas, if more female chicks were needed, the eggs could be incubated either on Monday, Tuesday, Thursday or Saturday. On Sunday eggs were not incubated at all. Moreover, farmers believed that if the eggs were incubated in the morning time, most of the chicks will be females but if the egg incubation time was in the afternoon, most chicks will be male and if the eggs were incubated in the mid day, equal sex ratio chicks could be obtained.

Prior to incubation, some farmers construct egg incubating structure from mud and straw having a side view opened for ventilation. The best broody hen was selected based on her past egg hatching performance. Some respondents incubated all the laid eggs per clutch without taking care of the size and shape of eggs. Some other respondents incubated only eggs laid by the broody hen. If eggs of other hen were included with her own laid eggs, they said the hen will select her own eggs for hatching and allow the rest of the eggs to rot. About 80.0% of the respondents incubated odd number of eggs whereas, 1.7% and 18.3% of the respondents incubated both even number and odd, and even number of eggs, respectively. To incubate eggs, most of the respondents carried out the following procedures: The egg incubating area was bedded with straw, eggs were put on sieve and exposed to sunset for few seconds, the broody hen was threatened as if to be killed using opposite sharp edge of knife and then eggs were incubated. If the hen was confined in egg setting structure, it will be allowed to go out in every 3 days interval for droopy and feeding. On 21th day of egg incubation, chili pepper and *Injera* were moistened with water and offered for the broody hen to eat, so that it will hatch most of the incubated eggs. Farmers believed that these practices will increase the hatchability of eggs.

Eggs hatchability problem

According to respondents, eggs from exotic chicken breeds mostly of Rhode Island Red (RIR) and occasionally of Bovan Brown had hatchability problems when they were set using local broody hens (Table 14). About 23.9% of the respondents believed that hard eggshell was the main factors that negatively affected eggs hatchability but 76.1% of the respondents didn't know what caused the problem. Respondents said that all crossbred chicken eggs had no hatchability problem when they were set using local broody hens. This study tried to examine the problem in relation to agro-ecology, eggs storage duration, storage place, defects and size difference or due to number of eggs incubated per hen. As shown in Table 14, there was some significant difference in the hatchability of eggs between agro-ecologies for RIR and Bovan Brown chicken breeds. There was no a big variation in the duration of eggs storage before incubation across the agro-ecologies. Farmers stored eggs on average for 1.7 weeks (1-3 weeks) before incubation. Before eggs were incubated, about 55.0%, 26.1% and 18.9% of the respondents stored them in cold place, inside the grain and anywhere, respectively. The reason for farmers to store eggs inside the grain was to find cold place but the storage temperature was not well known. However, about 87.8% of the respondents didn't give care on defects and size difference of eggs (big and small egg sizes) during incubation. Respondents incubated a mean of 12.2 eggs per local broody hen but to get more chicks, some farmers set up to 20 eggs.

Table 14. Egg hatchability problem of exotic chicken breeds in the study agro-ecologies

Breed type	Agro-ecology			Overall
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	(N=180)
Rhode Island Red	78.3[a]	68.3[b]	65.0[b]	70.6
Bovan Brown	23.3[b]	28.3[b]	40.0[a]	30.6
Fayoumi	1.7	8.3	3.3	4.4

Figures represent percentage; figures in the row with the same letter are not significantly different (P>0.05)

4.4.8. Feeds and feeding systems of chicken

About 90.6% of the respondents provided supplementary feeds for their chicken where most of them (60.1%) used home available feeds, 16.6% used either home mixed or commercial chicken rations and about 13.9% used both commercial and home mixed rations as supplements. Maize and wheat were the majorly used grains as supplements in highland and mid-altitude agro-ecologies. In lowland agro-ecology maize and sorghum were the mainly used supplements. As shown in the Table 3 and 15, the major types of crops produced in the study areas were related with major grains used to chicken feeding. However, during open discussion respondents said when the feeds were continuously offered for chicken, some effects were observed on feed intake and egg production characteristics of layers (Table 15). According to respondents' observation, if layers continuously and excessively fed with wheat and wheat bran, they got too fat and their egg production gets declined and in worst cases gets stopped egg laying. However, most respondents said that feeding of maize increases egg production next to barley. As compared to other grains, barley feeding for layers results in higher egg production. Moreover, feeding of whole barley without processing increases egg production and layers lay egg with strong eggshell.

Commercial chicken feeds were better used in the mid-altitude but for most respondents (73.3%), the feeds were not accessible and affordable. Among respondents who used commercial chicken feeds (25.6%) said commercial chicken feeds had some quality problems. The major observed quality problems were low egg productivity, diarrhea, mold development and fed chicken became weak. In the lowland agro-ecology, both white and yellow sorghums were used for chicken feeding. Few respondents (1.7%) offered green plants (green vegetables, *Melia azedarach* and *Leucaena leucocephala*) and about 3.3% offered premixes for their chicken.

Table 15. Common feed types used for chicken feeding and effects observed by farmers

	Agro-ecology			
Feed type	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	Farmers observation
Wheat	68.3	78.3	65.0	Reduced egg production
Maize	56.7	48.3	96.7	Increased egg production
Sorghum			78.3	Less preferred by chicken
Barley	35.0	3.3	5.0	Highly increased egg production
Wheat bran	23.3	23.3	16.7	Reduced egg production
Home mixed feeds	16.7	21.7	6.7	Increased egg production
Commercial feeds	15.0	33.3	10.0	Increased egg production
Noug seedcake	1.7	8.3	5.0	Increased egg production
Dish leftover	8.3	6.7		
Teff	6.7		3.3	
Green plants	3.3		1.7	
Common salt		5.0	3.3	
Premix		8.3	1.7	
Haricot bean			1.7	
Lime stone			8.3	

Figures represent percentage.

4.4.8.1. Nutrient composition of majorly used chicken feeds

As shown in Table 16, there was big variability in nutritional composition of majorly used supplement feeds for chicken. Except home mixed ration I (cereal mix), the rest home mixed rations had a very good CP composition for chicken. Offering of wheat bran had comparatively a better source of CP than cereal grains. Home mixed ration II (mix of maize, wheat bran, soybean seedcake, and bone and meat meal), home mixed ration IV (mix of wheat bran, maize and malt sprout) and commercial layer rations had better mineral matter and calcium compositions. Home mixed ration III (mix of wheat bran and noug seedcake) had very high CP content which was beyond CP the requirement of any age groups and breeds of chicken. All the supplement feeds had very good ME composition.

Table 16. Chemical composition of majorly used chicken feeds in the study areas

Feed type used	Chemical composition (%)						ME
	DM	Ash	CF	CP	EE	Ca	(kcal/kg DM)
Barley	91.1	3.6	9.1	13.8	2.3	1.098	3122.1
Wheat	90.5	1.6	3.4	16.1	3.4	0.921	3769.1
Yellow maize	90.1	1.7	6.6	9.5	5.3	0.925	3584.5
White maize	89.8	1.6	4.7	10.8	6.0	0.835	3795.2
Yellow sorghum	90.4	1.6	4.4	14.9	3.7	0.738	3696.7
White sorghum	90.8	1.7	4.0	14.0	3.5	0.846	3717.2
Wheat bran	90.4	4.5	10.3	18.2	4.0	1.106	3071.4
Commercial layers ration	92.4	15.2	8.8	22.7	8.0	3.879	2985.5
Home mixed rations							
Home mixed ration I	90.5	2.0	4.3	10.4	4.6	1.289	3738.2
Home mixed ration II	92.3	14.3	3.6	23.7	5.2	2.888	3331.1
Home mixed ration III	90.1	6.7	7.7	29.8	5.5	1.284	3293.9
Home mixed ration IV	91.4	7.3	7.1	19.6	4.1	2.006	3246.4
Home mixed ration V	92.1	5.5	11.0	18.5	6.3	1.085	3093.6

Ca= Calcium; CF= Crude fiber; CP= Crude protein; DM= Dry matter; EE= Ether extract Kcal= Kilo calories; ME= Metabolizable energy.

About 75.6% of the respondents believed that home available feeds (cereal grains) couldn't satisfy nutrient requirements of their chicken. However, about 15.0% of the respondents believed that home available feeds could satisfy the nutrient requirements of their chicken. About 9.4% of the respondents didn't know whether home available feeds could satisfy the nutrient requirement or not.

4.4.8.2. Feeding systems

In the study areas, most of the respondents (88.3%) didn't adjust the amount of feed offered according to age and productivity of the chicken, and most didn't offer enough quantity of feed per chicken per day. Even those (11.7%) who adjusted the amount according to age and productivity of chicken, the amount of feed offered per head per day was beyond the daily requirement (for a chick 30 g to *Ad libitum* with a mean of 55 g/day; for a pullet 30 g to *Ad libitum* with a mean of 108.5 g/day and for a layer 60 to 400 g with a mean of 183.7 g/day) that might cause feed wastage. Regarding the feeding system, 86.1% of the respondents used hours interval feeding system, 4.4% used *Ad libitum* feeding and the remaining 9.4% didn't use any feeding system (only scavenging). About 18.9% of the respondents offered the feed only once per day, whereas, 42.6% and 28.9% offered twice and three times per day, respectively. The time of offering was during morning time for once feed offering, in the morning and in the afternoon for twice times offering and for three times per day offering, the feed was offered in the morning, at the middle of the day and nearly at sunset. However, one of the problems in feed offering was systems of offering. Most of the respondents (53.3%) spread the feed on the ground without using any feeding trough. About 6.1% of the respondents spread the feed on any available sheets, 19.5% used home available feeding troughs and 11.7% of the respondents used appropriate chicken feeding troughs. The remaining 9.4% didn't use any feeding troughs (free ranging). Respondents found in the mid-altitude better used appropriate and home available chicken feeding troughs followed by respondents found in the highland agro-ecology.

4.4.9. Chicken housing

This study found that about 96.7% of the respondents kept their chicken in the house where only half (50.6%) of the respondents constructed the chicken house separately from people and livestock houses. There were few farmers (3.3%) that didn't shelter their chicken at all; when night comes, the chicken look for any place to shelter (Table 17). About 71.1% of the respondents kept chicken in their house during risky weather condition (during cold and rainy seasons). Out of the respondents that constructed the chicken house, about ¼ of them constructed the house according to the technology package recommendation. The reason why most of the respondents didn't construct the house according to the technology recommendation was that most (45.6%) replied there was no recommendation from professionals instead we were asked to construct any type of chicken house, 37.8% and 16.7% replied chicken house construction was expensive and due to workload, respectively.

Table 17. Chicken sheltering places in the study agro-ecologies

Sheltering place	Agro-ecology			
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	Overall (N=180)
In the chicken house	41.7	50.0	60.0	50.6
In the livestock house	3.3	8.3	5.0	5.6
In the kitchen	28.3	13.3	18.3	20.0
In the family house	3.3	10.0	3.3	5.5
In the family corridor	20.0	16.7	8.3	15.0
Not sheltered at all	3.3	1.7	5.0	3.3

Figures represent percentage.

As indicated in Table 18, most of the respondents (32.2%) used chicken housing system which didn't have bedding material but did have some roosting (perching). During chicken housing, about 68.3% of the respondents didn't consider the space requirements of the chicken. Regarding the time of housing, 17.8%, 65.5% and 16.7% of the respondents housed their chicken the whole day and night time, only night time and some hours at day time, and the whole night time, respectively. As to the frequency of house cleaning, most of the respondents (73.3%) cleaned the chicken house but only 39.4% cleaned the house at daily interval. The remaining 13.9% of the respondent cleaned the house at weekly interval, 7.2% after a week, 3.3% after two weeks, 11.7% when all chicken out and 24.4% didn't clean the chicken house at all. One of the problems that this study observed was disinfecting of the chicken house. Only 28.9 % of the respondents disinfected their chicken house mostly by using 5% sodium hypochlorite solution (cloth detergent called "*Berekina*"*)* and to eradicate external parasites of chicken, fumigated the house using selected herbaceous plants. The reason why most of the respondents do not disinfect the chicken house was majorly due to lack of knowledge and information (1st ranked). Absences and scarcity of appropriate disinfectants was their second ranked reason. Few farmers (2.8%) said that the disinfectants may not be good for chicken health.

Table 18. Types of chicken housing systems in the study areas

Types of housing system	Agro-ecology			
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	Overall (N=180)
Deep litter	10.0	18.3	1.7	10.0
No bedding material with some roosting	36.7	25.0	35.0	32.2
No bedding material and roosting	5.0	15.0	5.0	25.0

Figures represent percentage.

4.4.10. Chicken healthcare management

The major challenge of village poultry technology packages in the study areas was chicken health problem. About 86.1% of the respondents lost their chicken due to disease problems. Newcastle disease called *Fengil* (Amharic name) was the first ranked most challenging and killing disease mainly outbreak during short rainy season (March to May) and during main rainy season (July to September). Infectious coryza (Appendix Figure 3) was the next challenging disease which occurs occasionally. Regarding seasons of prevalence, in the highland agro-ecology some respondents said coryza occurs during cold season and in mid-altitude and lowland agro-ecologies some said it can occur at any time (the season of occurrence was not known). This study couldn't find enough information on Salmonellosis and coccidiosis. Even though Newcastle disease was very challenging, for half (51.6%) of the respondents, the veterinary clinic was found at more than 20 km away from their homestead. Only 26.1% of the respondents got healthcare services and only 32.8% vaccinated their chicken. However, most respondents (77.8%) didn't know when their chicken should be vaccinated.

4.4.10.1. Treatment of sick chicken

When their chicken became sick, 58.3% of the respondents isolated the sick one from the healthy flock but 41.7% leaved the sick birds with the healthy birds. About 40.6% of the respondents consulted veterinarians. To treat their sick birds, about 27.2%, 30.6% and 42.2% of the respondents used traditional, pharmaceutical and, both traditional and pharmaceutical medicaments, respectively. Most respondents (73.3%) said the medicaments were affordable but 61.7% of them didn't well know how much dose should be given per a bird. The treatment expenses ranged from no expense up to 40.00 Ethiopian Birr with a mean of 10.10 Birr per bird per year. Regarding the effectiveness of the medicaments, about 14.4%, 32.2% and 3.3% of the respondents replied that traditional, pharmaceutical and, mix of traditional and pharmaceutical medicaments were more effective to treat sick birds (Newcastle disease), respectively. However, ½ of the respondents replied that none of the medicaments were effective. They said both traditional and pharmaceutical medicaments were good only for prevention not for treatment.

During disease outbreak seasons to prevent diseases transmission, proper hygiene and confinement of birds (not allowing birds to go outside before dew evaporated) were measures taken by the farmers. Farmers believed that dew could facilitate the outbreak of Newcastle disease.

4.4.10.2. Types of traditional medicament commonly used for treatments

Garlic (*Allium sativum*), *feto* (*Lepidium sativum*) seeds, lemon juice, melia (*Melia azedarach*) leaves, vinegar juice, chili pepper (*Capsicum frutescens*) called *Mitmita* (Amha), aloe juice, *Milas golgul (*Amha), neem tree (*Azadirachta indica*) leaves, vernonia (*Vernonia amygdalina*) leaves and food oil were commonly used as traditional medicaments to treat sick birds. Some of these medicaments were mixed with water and *Injera*, and fed to sick birds. Some respondents said melia leaves were better to treat Newcastle disease, whereas others said melia leaves together with chili pepper was effective to treat Newcastle disease.

4.4.11. Water Provision for chicken

Almost all respondents (93.9%) provided drinking water for their chicken throughout the year. The sources of water were river (11.7%), spring (15.0%), ponds (5.0%), tap water (53.3%) and well (15.0%). About 75.0% and 18.9% of the respondents used any home available and appropriate chicken watering troughs, respectively. Few respondents (6.1%) didn't use any watering trough (chicken were left to look for water by themselves). Most of the respondents (63.3%) took cares on the hygiene of the water and 76.7% of the respondents cleaned the watering troughs, where 17.2%, 8.3%, 8.9%, 6.1% and 32.2% cleaned the watering troughs once, twice, three times, four times and every day per week, respectively, whereas 27.3% of the respondents didn't clean the watering troughs at all. About 77.8% of the respondents allowed the water to be available throughout the day and 12.8% of them changed the water three times per day. Most respondents (36.0%) changed the water twice per day and 23.9% of them changed the water once per day whereas 27.3% of them didn't change the drinking water at all.

4.5. Adoption of Village Poultry Technology Packages

4.5.1. Awareness level of the respondents to the technology

Before they participated in the technology packages, 49.4% of the respondents knew about the technology. When this study was conducted, most of the respondents were aware of improved chicken breeds (77.2 %), improved chicken feeds and feeding (86.7%), improved chicken housing system (85.6%), presence of chicken vaccinations (82.2%), improved chicken management systems (88.3%) and the presence of chicken diseases and parasites (100%).

4.5.2. Perception of the respondents to the technology

Before the respondents participated in the technology packages, most (85.0%) of them had positive perception to the technology but 12.8% and 0.6% had negative and neutral perception, respectively. After farmers tried the technology, 95.7% of the respondents had positive perception, 0.6% had negative perception and 2.8% had neutral perception to the technology.

4.5.3. Adoption of technology package elements

Improved chicken breeds adoption was higher than the adoption of the rest technology package elements (Table 19). Improved chicken breeds adoption in the highland agro-ecology was higher ($P>0.05$) than the adoption in the mid-altitude and lowland agro-ecologies. Heat stress in May and disease outbreaks (mainly Newcastle disease) were the major problems that hindered chicken breeds adoption in the lowland agro-ecology, whereas, cold stress during cold season (July to October) and long time to come to first egg were the main problems that affected improved chicken breeds adoption in the highland agro-ecology. As a whole, 40.6% of the respondents adopted improved chicken breeds. The adoption levels of improved chicken breeds, feeds and feeding, chicken housing and water provision were not significant across the agro-ecologies. Respondents residing in the mid-altitude agro-ecology were better adopters of improved chicken feeds and feeding, chicken housing, healthcare and water provision, whereas, respondents residing in lowland agro-ecology were comparatively least adopters. Chicken healthcare adoption in the mid-altitude was significantly (P<0.05) better as compared to the lowland agro-ecology. The overall technology elements adoption was not significant among the study agro-ecologies. As shown in the Table, the overall adoption level of the technology package elements was 39.4% with the highest (48.3%) for highland agro-ecology and the least (33.3%) for the lowland agro-ecology. Regarding adoption rate, 47.2% of the respondents replied that the rate of technology adoption was increasing from year to year, whereas, 25.6% and 27.2% replied that the rate of adoption from year to year was decreasing and not changed, respectively.

Table 19. Adoption level of poultry technology package elements across agro-ecologies

	Agro-ecology				
Technology element adoption	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	Overall (N=180)	P-value
Chicken breeds	51.7	33.3	36.7	40.6	0.093
Feeds and feeding	26.7	36.7	25.0	29.4	0.317
Housing	35.0	41.7	25.0	33.9	0.152
Healthcare	18.3[ab]	30.0[a]	11.7 [b]	20.0	0.040
Water provision	36.7	41.7	26.7	35.0	0.386
Overall elements	48.3	36.7	33.3	39.4	0.210

Figures represent percentage; values in the row with the same letter are not significantly different.

Improved chicken breeds adoption shown in Table 19 was crude adoption level. All respondents that had 5 or more exotic or crossbred chicken breeds for the last 5 years were categorized under chicken breed adopters. A farmer might have two or more chicken breeds in his/her production system and could practice one or more chicken technology forms. As a result, the respondent might adopt one or more chicken breeds and forms of the technology. When crude chicken breeds adoption was fractionated into chicken breeds and forms of technology package, the adoption level of Bovan Brown breed was higher (P<0.01) in the highland agro-ecology than the adoption in the mid-altitude and lowland agro-ecologies (Table 20). Fayoumi chicken breed adoption was better in the lowland agro-ecology but not statistically significant (P>0.05). Their better accessibility and adaptability were the respondents' main reason that made Bovan Brown chicken breed to be better adopted in the highland agro-ecology. Similarly, their better adaptability, easiness of their management and better egg productivity under smallholder production system made Fayoumi chicken breed to be better adopted in the lowland agro-ecology. However, since Fayoumi chicken breed had light weight, when they were culled from the production systems, no one can buy them for meat consumption. Similarly, when crude improved chicken breed adoption was fractionated into chicken forms of technology, pullets with cockerel adoption was better (22.2%) than the rest forms followed by fertile eggs adoption. Respondents found in the highland agro-ecology significantly (P<0.01) better adopted layers technology forms.

Table 20. The adoption levels of chicken breeds and forms across the study agro-ecologies

Adoption	Agro-ecology				
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	Overall (N=180)	P-value
Breeds adopted					
Bovan Brown	41.7^{a}	18.3^{b}	18.3^{b}	26.1	0.004
Fayoumi	8.3	5.0	13.3	8.9	0.934
Crossbred	16.7	13.3	20.0	16.7	0.887
Forms adopted					
Fertile eggs	11.7	6.7	18.3	12.2	0.696
DOs	6.7	10.0	11.7	9.4	0.937
Pullcocker	28.3	15.0	23.3	22.2	0.658
Only pullets	3.3	13.3	8.3	8.3	0.804
Layers	15.0^{a}	8.3^{b}	3.3^{b}	8.9	0.002

DOs: Day old chicks; Pullcocker= Pullets with cockerels; figures represent percentage; values in the row with the same letter are not significantly different.

4.5.4. Adoption level and index of the technology package

Based on adoption level and index categories (Table 21), most of the respondents were nil adopters (37.8%), however, respondents found in the highland and mid-altitude agro-ecologies were better adopters of the technology package as compared to respondents found in lowland agro-ecology.

Table 21. Adoption level and index categories of the respondents

Adoption level category	Adoption index category	Agro-ecology			Overall (N=180)
		Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Nil	0	35.0	38.3	40.0	37.8
Very low	>0 up to 0.20	1.7	6.7	11.7	6.6
Low	0.21 to 0.40	21.7	10.0	16.7	16.1
Medium	0.41 to 0.60	16.7	18.3	15.0	16.7
High	0.61 to 0.80	11.7	0.0	15.0	8.9
Very high	> 0.80 to 1	13.3	26.7	1.7	13.9

Figures represent percentage.

The mean adoption index of the technology across the study agro-ecologies ranged from 0.28 to 0.38 with overall mean of 0.34 (Table 22). Similarly, mean adoption level ranged from 0.33 to 0.48 with the overall mean of 0.39. As a whole, the adoption index and levels were not significant among the study agro-ecologies.

Table 22. The overall means adoption index and level of the technology across agro-ecologies

Variable	Agro-ecological zone			Overall mean	P-value
	Highland	Mid-altitude	Lowland		
Adoption index	0.38(0.04)	0.37(0.05)	0.28(0.04)	0.34(0.03)	0.204
Adoption level	0.48(0.07)	0.37(0.06)	0.33(0.06)	0.39(0.04)	0.213

Figures outside and inside parenthesis are means and standard errors, respectively.

4.6. Determinants of Technology Package Elements Adoption

Variance Inflation Factor (VIF) association test for continuous explanatory and contingency coefficient (CC) test for categorical variables were less than 10 and 0.75, respectively, implying that there was no multicollinearity problem existed between explanatory variables thus no variable was dropped from the statistical model.

4.6.1. Determinants of improved chicken breeds adoption

Multivariate logistic regression analysis result (Table 23) showed that the probability of improved chicken breeds adoption was significantly and positively influenced by agro-ecology, technology experience, frequency of technology received, extension, training and healthcare services. Technology participants found in the highland agro-ecology ($P<0.05$) more likely decided to adopt improved chicken breeds by 3.2 folds as compared to farmers found in lowland agro-ecology. Technology participants who had more than 10 years village chicken technology package experiences ($P<0.01$) 8.4 times more likely decided to adopt improved chicken breeds as compared to farmer who had up to 5 years. Similarly, the probability of improved chicken breed adoption was more likely influenced by 6.5 folds as a result of getting healthcare services as compared to those farmers who couldn’t get the services.

Table 23. Multivariate logistic regression result of improved chicken breeds adoption

Variable	β	SE	Wald	P	OR	95% CI
Agro-ecology						
Lowland					1	
Mid-altitude	0.386	0.536	0.520	0.471	1.471	0.515-4.203
Highland	1.164	0.536	4.724	0.030	3.203	1.121-9.148
Technology experience						
Up to 5years					1	
6-10years	0.086	0.541	0.026	0.873	1.090	0.378-3.148
>10years	2.132	0.713	8.947	0.003	8.429	2.085-34.070
Frequency of technology received						
Once					1	
Twice	1.642	0.595	7.625	0.006	5.164	1.610-16.560
>Twice	1.877	0.735	6.516	0.011	6.531	1.546-27.589
Get extension services	1.452	0.481	9.103	0.003	4.270	1.663-10.966
Get healthcare services	1.876	0.470	15.953	0.000	6.530	2.600-16.399
Get training service	1.569	0.524	8.957	0.003	4.804	1.719-13.427
Constant (intercept)	-5.358	0.899	35.508	0.000	0.005	

CI= Confidence interval; OR= Odds ratio; P=probability; β=Regression coefficient; SE=Standard error; Model summary: Nagelkerke R^2=0.544; Hosmer and Lemeshow test: χ^2=5.173; P=0.739.

4.6.2. Determinants of improved chicken feeds and feeding adoption

As indicated in Table 24, the probability of improved chicken feeds and feeding technology adoption was significantly and positively influenced by educational level of farmers, frequency of technology received and getting training service before starting the technology. The probability of adoption increased as the level of education increased. Farmers who attended up to elementary education 2.2 times (P>0.05), and farmers who attended secondary and above education 5.7 times (P<0.05) more likely decided to adopt improved chicken feeds and feeding technology as compared to illiterates. Farmers who received the technology more than twice ($P<0.05$) more likely decided to adopt improved chicken feeds and feeding technology by 3.4 folds as compared to those farmers who received the technology only once. Similarly, providing training service before starting the technology increased the likelihood of village poultry feeds and feeding technology adoption by 12.3 folds.

Table 24. Multivariate logistic regression result of chicken feeds and feeding adoption

Variable	β	SE	Wald	P	OR	95% CI
Educational level						
Illiterate					1	
Basic education	0.608	0.936	0.422	0.516	1.837	0.293-11.496
Elementary	0.800	0.862	0.862	0.353	2.226	0.411-12. 057
Secondary +	1.732	0.848	4.169	0.041	5.650	1.072-29.783
Frequency of technology received						
Once					1	
Twice	1.142	0.517	4.877	0.027	3.134	1.137-8.638
>Twice	1.225	0.555	4.873	0.019	3.404	1.147-10.098
Get training service	2.541	0.638	15. 842	0.000	12.343	3.632-44.365
Constant (intercept)	-4.934	1.109	19.831	0.000	0.007	

CI= Confidence interval; OR= Odds ratio; P=probability; β=Regression coefficient; SE=Standard error; Model summary: Nagelkerke $R^2=0.371$; *Hosmer and Lemeshow test:* $\chi^2= 8.659$; *P=0.372*

4.6.3. Determinants of improved chicken housing adoption

As shown in Table 25, the probability of improved chicken housing adoption was significantly and positively influenced by annual income, landholding, getting extension, healthcare and training services. As the annual income of the technology participant increased, the likelihood of farmer's decision to adopt improved chicken housing increased. Farmers who had small farmland or rented farmland could decided ($P<0.001$) 2.4 to 4.4 times more likely decided to adopt improved chicken housing as compared to farmers who hold more than 2 ha. As landholding increased, the likelihood respondents decided to adopt improved chicken housing declined. Getting healthcare services significantly ($p<0.05$) increased the probability of improved chicken housing by 4.3 folds.

Table 25. Multivariate logistic regression result of improved chicken housing adoption

Variable	β	SE	Wald	P	OR	95% CI
Annual income						
<25,000 Birr					1	
25,000-50,000 Birr	0.540	0.458	1.391	0.238	1. 717	0.699-4.213
>50,000 Birr	1.181	0.484	5.944	0.015	3.258	1.261-8.421
Landholding						
0-1ha	1.492	0.462	10.443	0.001	4.444	1.798-10.982
1.1-2.0 ha	0.866	0.496	3.045	0.081	2.376	0.899-6.282
>2.0 ha					1	
Get extension services	0.785	0.398	3.886	0.049	2.192	1.005-4.785
Get healthcare services	0.846	0.387	4.777	0.029	2.331	1.091-4.979
Get training service	1.450	0.461	9.906	0.002	4.263	1.728-10.515
Constant (intercept)	-3.658	0.728	25.242	0.000	0.026	

CI= Confidence interval; Ha=Hectare; OR= Odds ratio; P=probability; β=Regression coefficient; SE=Standard error; Model summary: Nagelkerke R^2=0.409; Hosmer and Lemeshow test: χ^2= 9.555; P=0.298

4.6.4. Determinants of chicken healthcare adoption

Agro-ecology, frequency of technology received, getting extension, healthcare and training services and distance of veterinary clinic were the determinant factors that significantly and positively influenced the probability of chicken healthcare adoption in the study agro-ecologies (Table 26). The likelihood of farmer decision to adopt the healthcare was better in the highland (2.4 folds) and mid-altitude (13.4 folds) as compared to in the lowland agro-ecology. Getting extension services ($P<0.05$) increased the probability of chicken healthcare adoption by 4.1 folds. Getting training service before starting the technology increased ($P<0.05$) the likelihood of chicken healthcare adoption by 4.8 folds. Similarly, getting healthcare services increased the likelihood ($P<0.001$) of chicken healthcare adoption by 5.1 folds. The probability of chicken healthcare adoption more likely increased (by 6 folds) as the proximity of veterinary clinic closer to farmers.

Table 26. Multivariate logistic regression result of chicken healthcare adoption

Variable	β	SE	Wald	P	OR	95% CI
Agro-ecology						
Lowland					1	
Mid-altitude	2.593	0.744	12.133	0.000	13.374	3.108-57.540
Highland	0.894	0.634	1.987	0.159	2.445	0.705-8.474
Frequency of technology received						
Once					1	
Twice	0.136	0.670	0.041	0.839	1.146	0.308-4.258
>Twice	1.221	0.704	3.003	0.083	3.389	0.852-13.479
Get extension services	1.401	0.615	5.180	0.023	4.058	1.215-13.556
Get healthcare services	1.637	0.497	10.867	0.001	5.142	1.942-13.613
Get training services	1.563	0.698	5.012	0.025	4.775	1.215-18.768
Veterinary clinic distance						
Up to 10 km	1.859	0.591	9.889	0.002	6.417	2.014-20.440
11-20km	1.894	0.918	4.256	0.039	6.644	1.099-40.164
>20km					1	
Constant(intercept)	-7.179	1.280	31.467	0.000	0.001	

CI= Confidence interval; OR= Odds ratio; P=probability; β=Regression coefficient; SE=Standard error; Model summary: Nagelkerke $R^2 = 0.473$; *Hosmer and Lemeshow test:* $\chi^2 = 6.218$; $P=0.623$

4.6.5. Determinants of water provision adoption

As indicted in Table 27, the probability of practicing proper water provision for chicken was significantly and positively influenced by educational level of the technology participant, family size, frequency of technology received, extension, healthcare and training services. As the level of education increased, the probability of proper water provision also increased. Technology participants who attended secondary and above education more ($P<0.05$) likely decided to adopt proper water provision for chicken by 6.3 times as compared to illiterate technology participants. Technology participants who had family sizes of less than 4 more likely decided to adopt proper way of water provision for their chicken by 5.1 folds ($P<0.05$) as compared to technology participants who had more than 6 family size. Farmers who received the technology twice more likely decided to adopt proper way of water provision by 3.2 folds as compared to those farmers who received the technology only once. However, the probability of adoption seemed decreasing as the frequency of technology received was more than twice.

Table 27. Multivariate logistic regression result of water provision adoption for chicken

Variable	β	SE	Wald	P	OR	95% CI
Educational level						
Illiterate					1	
Basic education	-0.302	0.998	0.092	0.762	0.739	0.104-5.232
Elementary	0.831	0.872	0.908	0.341	2.295	0.416-12.671
Secondary+	1.841	0.861	4.579	0.032	6.306	1.167-34.060
Family size						
<4	1.638	0.671	5.955	0.015	5.147	1.381-19.191
4-6	0.294	0.412	0.510	0.475	1.342	0.598-3.012
>6					1	
Frequency of technology received						
Once					1	
Twice	1.177	0.493	5.694	0.017	3.245	1.234-8.535
>Twice	0.668	0.547	1.492	0.222	1.951	0.668-5.703
Get extension service	1.151	0.442	6.782	0.009	3.161	1.329-7.516
Get healthcare services	1.173	0.414	8.022	0.005	3.232	1.435-7.279
Get training service	0.899	0.453	3.393	0.047	2.457	1.011-5.969
Constant (intercept)	-4.591	1.027	19.995	0.000	0.010	

CI= Confidence interval; OR= Odds ratio; P=probability; β=Regression coefficient; SE=Standard error; Model summary: Nagelkerke R^2*= 0.412; Hosmer and Lemeshow test:* χ^2*= 9.980; P=0 .266*

4.6.6. Determinants of the overall technology package elements adoption

As indicated in Table 28, extension, healthcare and training services were major determinant factors that significantly and positively influenced the probability of overall village poultry technology package elements adoption in the study areas. Educational levels of the farmer was not significantly influenced the probability of overall village poultry technology package elements adoption but it had a confounding effect on extension, healthcare and training services.

The probability of the overall technology adoption more ($P>0.05$) likely increased by 3.6 folds for those technology participants who attended up to secondary and above education. Getting training service before starting the technology package and getting extension services could increase the likelihood ($P<0.001$) of overall technology package adoption by 17.7 and 7.2 folds, respectively. The negative coefficients of the intercept indicate that more of the covariates included in the model less likely influenced the probability of adoption. Moreover, Psuedo-R^2 (Nagelkerke R^2) values indicate covariates included in the model explained 37.1% to 54.4% of the probability of farmer's decision to adopt technology.

Table 28. Multivariate logistic regression result of overall poultry technology adoption

Variable	β	SE	Wald	P	OR	95% CI
Educational level						
Illiterate					1	
Basic education	-0.961	0.887	1.172	0.279	0.383	0.067-2.178
Elementary	0.196	0.767	0.065	0.799	1.216	0.271-5.467
Secondary+	1.271	0.764	2.770	0.096	3.564	0.798-15.917
Get extension services	1.971	0.475	17.226	0.000	7.175	2.829-18.195
Get healthcare services	0.868	0.438	3.920	0.048	2.381	1.009-5.620
Get training service	2.874	0.594	23.425	0.000	17.707	5.530-56.703
Constant (intercept)	-4.761	0.971	24.047	0.000	0.009	

CI= Confidence interval; OR= Odds ratio; P=probability; β=Regression coefficient; SE=Standard error; Model summary: Nagelkerke R^2= 0.533; Hosmer and Lemeshow test: χ^2= 6.831; P= 0.555.

4.6.7. Limitations and constraints of the overall technology adoption

Absence of veterinary clinic at proximate distance was the major limitation (1st ranked) that negatively ($P<0.01$) influenced the respondents not to expand the adoption of village poultry technology packages in all agro-ecologies (Table 29). For most respondents (51.6%), the veterinary clinic was found more than 20 km from their homestead. Unavailability of appropriate chicken feeding and watering equipment was the 2nd ranked limiting factor. The limitations of socio-cultural, land size and transportation were very minimal.

Table 29. Limitations that affected the adoption of the technology packages (1=Very important, 5=Least important)

Variable	Agro-ecology			P-value
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Land size	4.0(0.11)	3.8(0.05)	4.1(0.07)	0.097
Poultry equipment	2.3(0.14)	2.3(0.10)	2.3(0.12)	0.928
Veterinary clinic	1.6(0.10)[a]	1.2(0.07)[b]	1.4(0.10)[b]	0.005
Socio-cultural	3.7(0.12)	3.9(0.04)	4.0(0.09)	0.113
Transportation	3.3(0.12)[b]	3.7(0.05)[a]	3.2(0.10)[b]	0.000

Figures outside and inside parenthesis are ranked means and standard errors, respectively; ranked means in the row with the same letter are not significantly different.

As indicated in Table 30, scarcity of improved chicken breeds, chicken health problems (Newcastle disease) and lack of nutrient balanced chicken feeds were the majorly ranked constraints in highland and mid-altitude agro-ecologies that negatively influenced the farmer decision not to extend the adoption of technology. Moreover, chicken health problems, lack of chicken vaccines and medicaments supply and shortage of improved chicken were majorly ranked constraints in the lowland agro-ecology.

Table 30. Constraints that hindered the adoption of technology package (1=Very important, 10=Least important)

Constraints	Agro-ecology			P-value
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Lack of knowledge	6.0(0.36)[a]	6.4(0.32)[a]	4.9(0.30)[b]	0.003
Lack of advisory services	7.3(0.25)[a]	6.6(0.26)[b]	7.2(0.25)[ab]	0.049
Chicken breeds shortage	3.7(0.25)[a]	2.4(0.23)[b]	3.4(0.19)[a]	0.000
High input price	4.4(0.25)	4.7(0.25)	4.9(0.24)	0.363
Credit service	5.5(0.37)[b]	6.5(0.29)[a]	6.6(0.24)[a]	0.018
Lack of balanced rations	4.2(0.31)[b]	3.6(0.29)[b]	5.6(0.25)[a]	<0.000
Lack of vaccine and drug	4.3(0.27)[b]	5.3(0.27)[a]	3.0(0.17)[c]	<0.000
Health problem	4.1(0.32)[a]	3.7(0.30)[a]	1.6(0.17)[b]	<0.000
Lack of market access	6.6(0.38)[b]	6.3(0.36)[b]	8.7(0.13)[a]	<0.000
Workload	8.90(0.28)	9.5(0.11)	9.1(0.19)	0.064

Figures outside and inside parenthesis are ranked means and standard errors, respectively; ranked means in the row with the same letter are not significantly different.

As shown in Table 31, in order reduce or alleviate the limitations and constraints that negatively affected the overall adoption of the technology packages and to improve the extent of adoption, training, technical and financial supports were majorly needed by the technology participants. Managerial (administrational) and market supports were needed as secondary supports to push the level of adoption to the higher level.

Table 31. Major supports needed to improve the extent of technology adoption (1= very important; 6=less important)

Support	Agro-ecology			P-value
	Highland (N=60)	Mid-altitude (N=60)	Lowland (N=60)	
Technical	3.0(0.16)^{a}	2.3(0.15)^{b}	2.2(0.12)^{b}	<0.000
Financial	3.1(0.19)	3.2(0.17)	3.4(0.18)	0.635
Managerial	3.6(0.14)^{b}	4.7(0.13)^{a}	4.8(0.13)^{a}	<0.000
Training	1.6(0.11)^{b}	2.4(0.19)^{a}	1.3(0.06)^{b}	<0.000
Transportation	5.2(0.13)^{a}	5.5(0.10)^{a}	4.6(0.15)^{b}	<0.000
Market	4.3(0.22)^{a}	2.8(0.18)^{b}	4.7(0.14)^{a}	<0.000

Figures outside and inside parenthesis are ranked means and standard errors, respectively; ranked means in the row with the same letter are not significantly different.

On PRA focus group discussion, it was identified that agricultural office, farmer cooperatives, farmers, NGOs and private organizations were key actors of the technology packages. They were networked or communicated each other mostly through agricultural development agents. Sometimes, they were communicated through meeting and model farmers but their communication through discussion forum and regular visit were very weak. As a whole, the linkage among the actors was identified as weak. Moreover, in the PRA focus group discussion (Table 32), technology inputs scarcity was the 1^{st} ranked and high cost of technology inputs was the 2^{nd} ranked major constraints that hindered the adoption of the technology followed by chicken health problem (3^{rd} ranked). In the PRA focus group discussion the participants indicated technology inputs costs increment, respondents ranked chicken house construction material, commercial poultry feed and improved chicken breed costs as 1^{st}, 2^{nd} and 3^{rd} ranked, respectively. Technology inputs cost increment was observed from year to year. However, medicament, feeding and watering equipment and labor costs took the 4^{th}, 5^{th} and 6^{th} ranks.

Table 32. PRA focus group discussion ranked constraints and limitations of the technology adoption (1= Very important; 9 = Least important)

Constraints and limitations	Rank in agro-ecology			Overall rank
	Highland	Mid-altitude	Lowland	
High cost of technology package inputs	1.0	3.0	4.0	2.7
The package quantities were not enough	2.0	1.0	1.0	1.3
Inputs were not easily accessible	3.0	4.0	5.0	4.0
Technology requires high management skill	9.0	7.0	9.0	8.3
The technology was not socially acceptable	8.0	9.0	8.0	8.3
The chicken breeds were not adaptable	4.0	8.0	3.0	5.0
Chicken breeds easily attacked by disease	5.0	2.0	2.0	3.0
The technology brought us new problems	7.0	5.0	7.0	6.3
The return from the technology was low	6.0	6.0	6.0	6.0

4.7. The Impact of Village Poultry Technology Package Adoption

As indicated in section 4.6, there was no multicollinearity problem existed between the selected explanatory variables and Breusch-Pagan/Cook-Weisberg test for heteroskedasticity among explanatory variables had P=0.9754 which was insignificant. These implied that there was no multicollinearity and heteroskedasticity problem existed among explanatory variables. Since there was no heteroscedasticity problem existed among explanatory variables, no need to run the standard error robust.

4.7.1. Propensity score estimation

The estimated propensity scores (pscores) of explanatory variables are indicated in Table 33. The pseudo-R^2 value of the model was 0.1108 which was fairly low. The estimated pscore values showed that respondents who were older, had more chicken keeping experience and far from market were less likely to participate in improved chicken breed technology. Participation in improved chicken breed technology was positively and significantly influenced by extension

(P<0.01) and training (P<0.05) services. The logit estimated intercept was (-0.567) negative and insignificant. Figure 2 shows the distribution of the household with respect to the estimated propensity scores. Most of the adopters were distributed to the right side while most of non-adopters were distributed to the left side. There was wider area in which both the groups had in common.

Table 33. Estimated propensity score for explanatory variables

Variable	Coefficient	SE	Z-value	P-value
SEX	0.292	0.359	0.81	0.416
AGE	-0.027	0.025	-1.10	0.272
FAMSIZE	0.023	0.079	0.29	0.772
LANDHOLD	0.059	0.129	0.45	0.650
CHCKFEXP	-0.00005	0.023	-0.00	0.998
TECHEXPI	0.180	0.362	0.50	0.620
FRETECH	0.559	0.399	1.40	0.161
EXTSERVI	1.063	0.352	3.02**	0.003
HLTHSERV	0.061	0.384	0.16	0.873
TRAINING	0.730	0.350	2.09*	0.037
MARKETDS	-0.029	0.024	-1.22	0.223
Constant	-0.567	0.930	-0.61	0.542
Number of observation = 180; LR χ^2 (11) = 27.02; Prob > χ^2 = 0.0046; Pseudo-R^2 = 0.1108; Log likelihood = -108.39801				

** =p≤0.01, *=p≤0.05

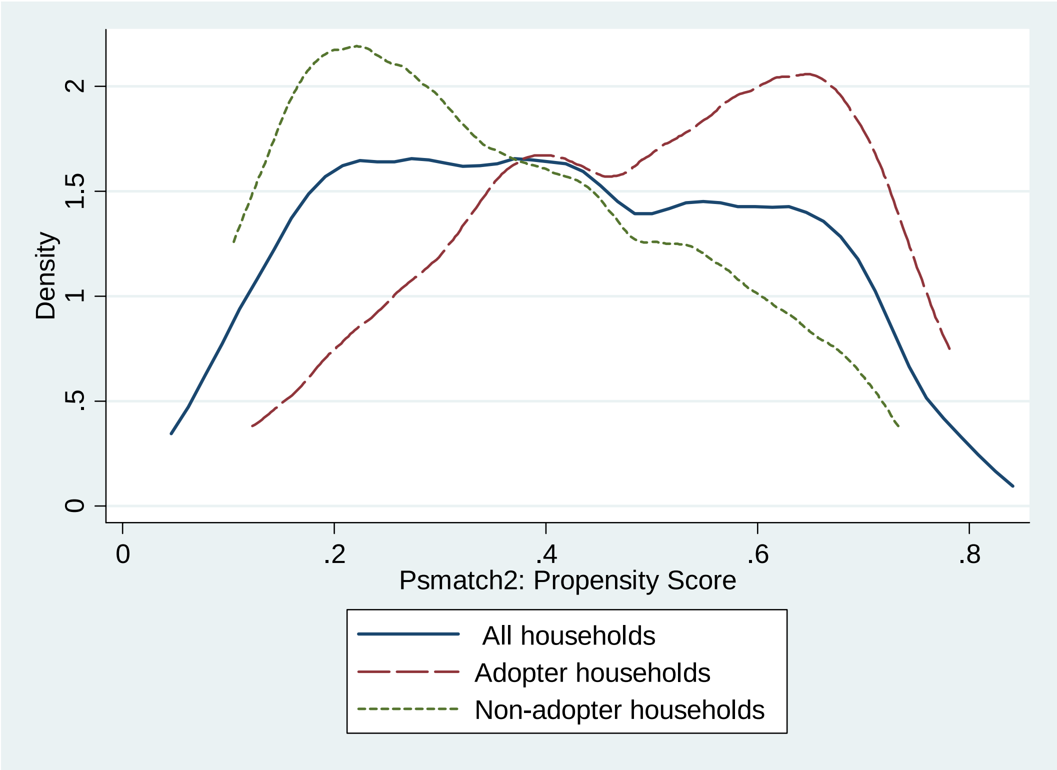

Figure 2. Kernel density estimated pscores distribution

4.7.2. Choosing of matching algorithm estimator

As indicated in Table 34, nearest neighbor 5 (NN 5) matching estimator without replacement fulfilled the balancing test (equal means) indicating that all explanatory variables were included in the model, the insignificant mean differences between the two groups after matching had relatively low pseudo-R^2 value and resulted in largest sample size (matched sample size). Based on these, NN (5) was identified the best model fitted matching estimator for this study. Even though, Kernel band width 0.1 matching was not selected as estimator, it was the second candidate matching estimator for this study. In pscores estimation and performing balance of the covariate, 4 numbers of blocks were identified that ensured the mean propensity scores were not different for adopters and non-adopters in each blocks.

Table 34. Matching performance of different estimators

Matching estimator	Performance criteria		
	Balance test*	Pseoud-R^2	Matched sample size
Radius caliper			
0.1	11	0.068	123
0.25	11	0.080	128
0.5	11	0.078	142
Nearest neighbor			
NN (1)	11	0.040	169
NN(2)	11	0.020	169
NN(3)	11	0.018	169
NN(4)	11	0.012	169
NN(5)	11	0.008	169
Kernel			
Band width 0.1	11	0.011	169
Band width 0.25	10	0.049	169
Band width 0.5	9	0.072	169

**Number of explanatory variables with insignificant mean difference between the matched groups of adopter and non-adopter.*

4.7.3. Common support region

As shown in Table 35, the estimated propensity scores ranges from 0.123 to 0.782 with a mean of 0.495±0.17 for adopter households and for non-adopter ranged from 0.105-0.735 with a mean of 0.352±0.17. Common support region ranged 0.123 to 0.735 which means households whose estimated propensity scores less than 0.123 and larger than 0.735 were not considered for the matching purposes. As a result, 11 households (3 adopters and 8 non- adopters) were discarded from the analysis. Figure 3 and 4 show the distribution of estimated propensity scores of the adopters and non-adopters, respectively before and after the common support condition. Most of the adopters had propensity score around 0.6 while majority of the non-adopters had around 0.2.

Table 35. Distribution of estimated propensity scores

Groups	Observation	Mean	SD	Minimum	Maximum
Total households	180	0.406	0.186	0.105	0.782
Adopters	73	0.495	0.173	0.123	0.782
Non-adopters	107	0.352	0.173	0.105	0.735

SD=standard deviation

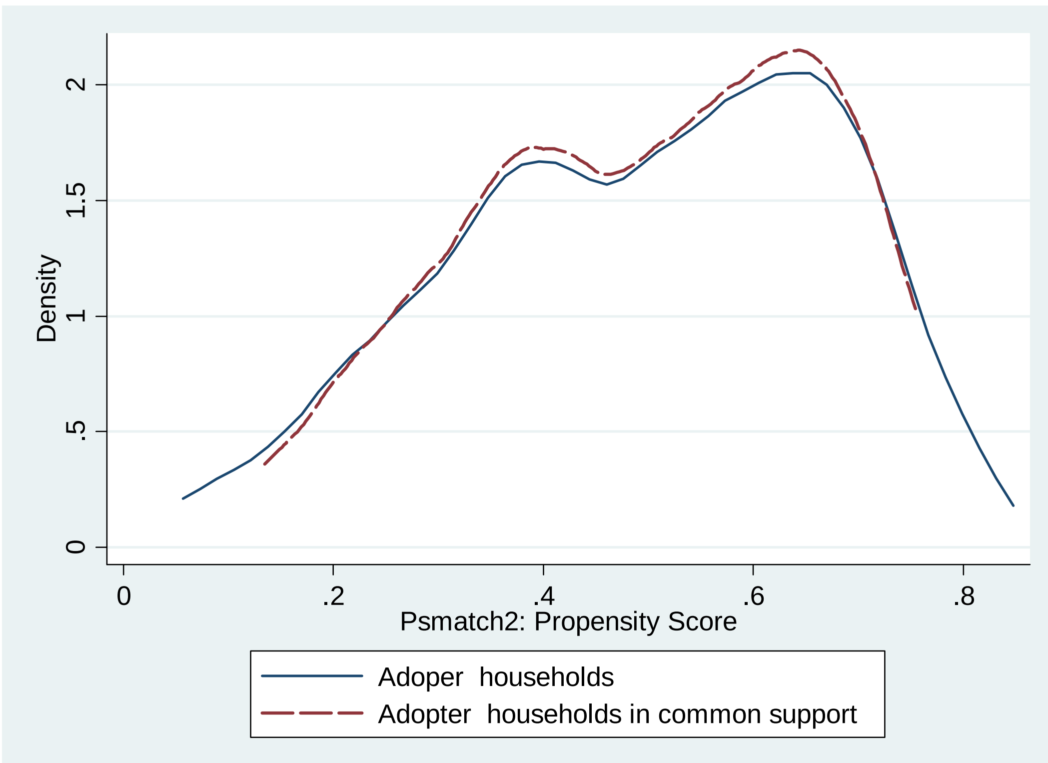

Figure 3. Kernel density of adopter households in the common support region

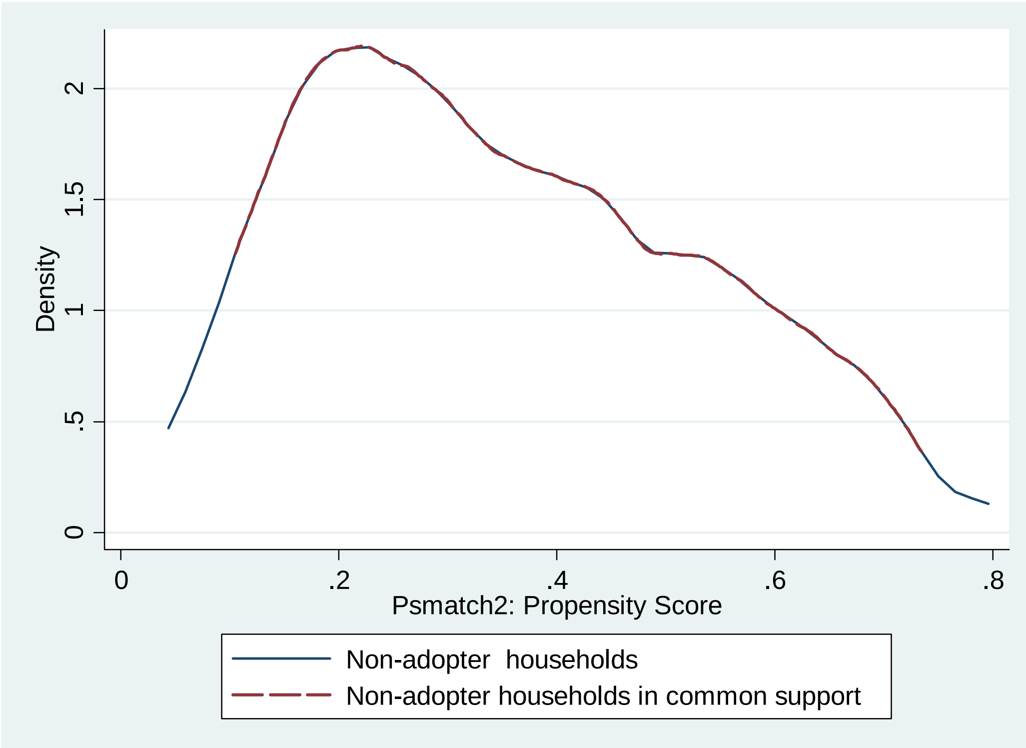

Figure 4. Kernel density of non-adopter households in the common support region

4.7.4. Matching quality/effect estimation

As shown in Table 36, before matching, 27.8% of the covariates estimated pscores showed significant but after matching all covariates showed insignificant. Since, the balancing efficiency of the estimator was determined by considering the reduction of the mean standardized bias (SB) between the matched and unmatched respondents and equality of means (adopters and non-adopters) was tested using t-test. As shown in Table 36, fifth column indicated the mean BS before and after matching while sixth column shown the total mean bias reduction obtained by the matching procedure. The absolute value of unmatched means difference ranges from 4.4-82.6% and 3 of the explanatory variables (27.3%) were significant. However, after the variables were matched, the absolute value of SB reduction ranged from 0.1-9.6% and for all explanatory variables the t-test shown insignificant with low Pseudo-R^2 value (0.008) that means all explanatory variables were included (balanced) in the model. Similarly, the joint significance and Pseudo-R^2 tests for explanatory variables in Appendix 3 show similar results.

Table 36. Testing of covariates balance for adopters and non-adopters

Variable	Unmatched Matched	Mean		%bias	%reduction /bias/	t-test	
		Adopters	Non-adopers			t	P>/t/
pscore	Unmatched	0.495	0.352	82.6		5.45***	0.000
	Matched	0.484	0.482	1.1	98.6	0.07	0.945
SEX	Unmatched	0.378	0.321	12.0		0.80	0.426
	Matched	0.366	0.392	-5.3	56.0	-0.31	0.758
AGE	Unmatched	41.205	42.896	-16.4		-1.08	0.281
	Matched	41.538	41.786	-2.4	85.3	-0.15	0.879
FAMSIZE	Unmatched	6.068	5.962	4.4		0.29	0.768
	Matched	6.028	6.025	0.1	97.3	0.01	0.994
LANDHOLD	Unmatched	1.986	1.917	4.4		0.29	0.768
	Matched	1.985	1.913	4.6	-4.6	0.27	0.784
CHCKFEXP	Unmatched	20.108	21.245	-11.3		-0.74	0.459
	Matched	20.521	19.555	9.6	15.0	0.60	0.547
TECHEXPI	Unmatched	0.547	0.514	6.7		0.44	0.658
	Matched	0.521	0.482	7.9	17.2	0.47	0.641
FRETECH	Unmatched	0.770	0.623	32.3		2.11*	0.036
	Matched	0.761	0.744	3.7	88.6	0.23	0.817
EXTSERVI	Unmatched	0.689	0.406	59.1		3.88***	0.000
	Matched	0.676	0.676	0.0	100.0	0.00	1.000
HLTHSERV	Unmatched	0.284	0.245	8.7		0.58	0.565
	Matched	0.282	0.296	-3.2	63.4	-0.18	0.854
TRAINING	Unmatched	0.721	0.500	48.3		3.16***	0.002
	Matched	0.718	0.707	2.4	95.1	0.15	0.883
MARKETDS	Unmatched	11.291	12.276	-14.0		-0.92	0.356
	Matched	11.535	11.300	3.4	76.1	0.20	0.840

***=P≤0.001, * =P≤0.05

4.7.5. Estimation of the average adoption effects

The average a adoption effect on treated/adopter due to improved chicken breeds adoption (CHICKADO) on the outcome variables is indicated in Table 37. As shown in the Table, CHICKADO didn't bring significant difference on knowledge and skill (KNOWSKIL) improvement between the adopters and non-adopters. Adopters and non-adopters showed 73.2% and 72.7%, respectively, on knowledge and skill improvement due to the technology intervention. However, technology adoption had significant (P<0.001) impact on adopters as benefited from the technology (BENEFITD), changes on the livelihood of the household (LIVEHOOD), changes on egg production (CHANGEGG), consumption (EGGCONS) and as income change (INCOME) indicators. Adopters were significantly benefited from the technology by 68.5% (difference value/adopters value*100) as compared to non-adopters. Moreover, due to adopting the technology, adopters could produce 101 more eggs/layer per year, consumed 18 more eggs/household per year and got 168.65 Birr more income per layer/year as compared to non-adopters. The average treatment effect on adopted (ATT) and the overall average adoption effect (ATE) on the study population. The ATE of improved chicken breeds intervention on the population improved knowledge and skill by 3.6%, egg production by 97.4 eggs/layer per year, egg consumption by17.2 eggs/household per year and income by 163.05 Birr/layer/year.

Table 37. The average treatment effect of improved chicken breeds intervention on the outcome indicators

Treatment	Outcome	Adopters	Non-adopters	Difference	S.E.^{bs}	t-stat
CHICKADO	KNOWSKIL	0.732	0.727	0.006	0.076	0.07
	BENEFITD	0.958	0.301	0.656	0.126	10.62***
	LIVEHOOD	0.831	0.079	0.752	0.066	12.86***
	CHANGEGG	157.87	56.57	101.30	7.92	15.42***
	EGGCONS	38.04	19.91	18.13	2.81	6.61***
	INCOME	249.74	81.09	168.65	24.18	12.04***

****=P≤0.001; ^{bs} bootstrapped S.E. obtained for 100 replications.*

4.7.6. *Sensitivity analysis*

As shown in Table 38 the Rosenbaum sensitivity test for upper bound had significance level for improved chicken breed technology participation on outcome variables. Each column showed the critical value of Γ (gamma) which bears statistical difference between treated and control households. As shown in Table, when Γ = 1 = OR (assuming of no hidden bias due to an unobserved confounder), the sensitivity analysis estimated p-value was quite close to matching analysis estimated p-values (***=p<0.001) as shown in Table 37. When Γ value increases (measures of the degree of departure from random assignment of treatment) by 0.5 to Γ=3, the p-values changes were significant which was below 0.05 (usual threshold).

Table 38. Rosenbaum sensitivity test for upper bound significance level

	Γ(Gamma)				
Outcome variable	Γ =1	Γ =1.5	Γ =2	Γ =2.5	Γ =3
BENEFITD	0.000	2.4e-15	5.9e-12	6.5e-10	1.5e-08
LIVEHOOD	0.000	4.2e-12	1.6e-09	6.1e-08	6.8e-07
CHANGEGG	0.000	0.000	1.1e-16	8.8e-14	8.9e-12
EGGCONS	0.000	0.000	2.2e-16	1.5e-13	1.4e-11
INCOME	0.000	0.000	1.1e-16	9.5e-14	9.4e-12

Γ = log odds of differential due to unobserved factors; 1, 1.5....and 3 are measures of the degree of departure from random assignment of treatment.

Table 39 shows the upper bound Hodges-Lehmman point estimates (treatment effect median estimates). As shown, the median estimates were smaller than the estimated mean differences reported in Table 37. However, except the impact of the treatment on the livelihood changes of the participants, the estimates were slightly more robust and the upper bounds didn't bracket zero. The Hodges-Lehmman point estimates for livelihood changes was smaller than the estimated mean difference in Table 37 and shows slightly more robust as Γ value of 1.5 before the upper bound brackets zero. If there was no hidden bias, Hodges-Lehmman point estimates was 0.50, however, as Γ value increased more than 1.5, the estimated upper bounds bracket zero implying there was possible hidden bias due to an unobserved confounder on LIVEHOOD.

Table 39. Rosenbaum upper bound sensitivity test for Hodges-Lehmann point estimate

Outcome variable	Γ(Gamma)				
	Γ =1	Γ =1.5	Γ =2	Γ =2.5	Γ =3
BENEFITD	0.50	0.50	0.50	0.50	0.50
LIVEHOOD	0.50	0.50	-3.7e-07	-3.7e-07	-3.7e-07
CHANGEGG	95	77.5	65	60	57.5
EGGCONS	25	23	22	20	19
INCOME	130	107.8	94.5	85.75	79

**Hodges-Lehmann point estimates are upper bound estimates; Γ = log odds of differential due to unobserved factors; 1, 1.5....and 3 are measures of the degree of departure from random assignment of treatment.*

5. DISCUSSION

5.1. Socio-Economic Characteristics of the Respondents

The family size of the respondents ranges from 1-12 per household with overall mean of 6 family sizes. In agreement with the current study, comparable family sizes were reported per household in different rural parts of Ethiopia who were involved on mixed agricultural activities (Moges *et al.*, 2010; Guraga, 2011; Worku *et al.*, 2012; Melesse *et al.*, 2013). The big variation in household annual income between study sites might be due to better access of respondents in mid-altitude agro-ecology (*Ade'a* district) to other off-farm activities so that their annual income becomes better. Respondents found in lowland agro-ecology (*Boset* district) might be due to better farmland hold that could maximize their agricultural productivity for better income source. In this study, most respondents attended secondary and above education. In agreement, Melesse *et al*. (2013) reported that the majority of dairy technology participants in mid-altitude agro-ecology were either completed secondary school or higher level education. This implies that educated farmers have been emerging in smallholder farming systems in Ethiopia and educated farmers were most probably selected to participate in agricultural technologies because these people have better interest to practice modern agricultural technologies.

Farmers residing in lowland agro-ecology hold better farmland size as compared to farmers found in highland and mid-altitude agro-ecologies. Comparable results of 1.68, 1.41 and 1.86 ha/household in the highland, mid-altitude and lowland agro-ecologies of Ethiopia, respectively, were reported by Guraga (2011). Similarly, Negatu (2005) reported that most Ethiopian rural farmers hold less than 2 hectares of farmland per household. There was less population density and availability of vast farmland in lowland agro-ecology, whereas there was high population density and vast expansion of industries in *Ade'a* and *Welmera* districts, which might be the reason for less farmland holding per household.

5.2. Village Poultry Technology Packages Intervention

Farmers in mid-altitude agro-ecology got little information about the technology from agricultural researcher but farmers in highland and lowland agro-ecologies couldn't get any information. This indicates the existence of weak linkage between Agricultural Research Centers and farmers towards the technology intervention.

According to Ethiopian MoARD, 5 pullets and 1 cockerel or 5 pullets improved chicken breeds were mostly distributed per a participant for a single technology package program. The main reasons were to address large number of participants at a time and to get more fertile eggs by crossing local chicken breeds with the improved once so that farmers can hatch the crossbred eggs using local broody hens to replace their flocks. The technology participants found in the highland and mid-altitude agro-ecologies received relatively more number of day old chicks (DOs) and pullets as compared to participants found in lowland agro-ecology. This might be due to the proximity to *Ade'a* district the poultry production belt areas of the country and the effectiveness of the district agricultural offices to disseminate the technology packages. Moreover, since some farmers could get improved chicken breeds from private farms, they obtained more number of chicken forms for the technology package. However, most of the technology participants (82.8%) were not satisfied with the number of chicken forms distributed by agricultural offices per individual farmer per a program. There was a huge gap and mismatch between numbers of disseminated chicken forms and the demand of the participants. This indicates technology approach should be improved for the future development program. Among chicken technology forms, the number of DOs demanded by the respondents was much higher than other forms. This was due to low price of DOs as compared to other forms and respondents believe that DOs will adapt the environment through their growth. This chicken forms demand was followed by layer and pullet forms. The main reasons were to use local cocks to produce fertile eggs and pullets will come to first egg production soon. Starting few years back, there was no price subsidy for the technology inputs from government side but few NGOs provided technology inputs with price subsidies. Small proportion of the respondents got credit service. This indicates the existence of very limited credit service for the technology.

Due to their better adaptability and productivity, Bovan Brown was mostly preferred chicken breed in the highland and mid-altitude agro-ecologies, whereas, Fayoumi chicken breed was mostly preferred in the lowland agro-ecology. However, Mekonnen *et al.* (2011) reported higher acceptances of Fayoumi breed by farmers in the mid-altitude agro-ecology in the southern part of Ethiopia. The breed with its best egg production and best scavenging ability was also appreciated by farmers. In the current study, Rhode Island Red (RIR) and White Leghorn chicken breeds were the least preferred for village poultry technology. Most respondents said that RIR was very adaptable to the agro-ecologies but their eggs have hatchability problem when they were set by local broody hen. In agreement, Mulugeta (2006) reported that RIR chicken eggs have poor fertility and hatchability under natural incubation but the reasons for the poor fertility and hatchability of eggs were not well understood. This might be one main reason why village poultry technology of the country shifted to Bovan Brown chicken breed. The low preference for White Leghorn chicken breed was due the fact that it is easily attacked by predators and diseases.

Regarding chicken technology forms, respondents preferred layers as 1st as compared to other forms. The reason was farmers needed them for immediate egg production and to avoid wastage of time by waiting chicks or pullets till they come to first egg production. Pullets with cockerels were the 2nd preferred chicken technology form by the respondents. The reason for this was that farmers believe the presence of cockerels with pullets stimulates pullets to come to first egg production shortly and the presence of cock with layers stimulates layers for more egg production. Moreover, cocks could be used to mate local hen so that crossbred eggs will be obtained to incubate them with local broody hens. Only pullets were the third ranked technology form preferred by respondents. The reason was that pullets can come to egg production shortly as compared to chicks.

5.3. Husbandry Practices of the Technology Package

Among family members, mothers mostly participated in chicken management, made decision to sell technology outputs (egg and birds), participated in selling of technology outputs and on treating of sick birds. However, fathers mostly participated in training, chicken house construction and buying of technology inputs. In agreement, Leta and Bekana (2010) and Moges *et al.* (2010) reported that village poultry production systems in Ethiopia men were responsible for few activities like construction of chicken shelter but most of the time the women and children were responsible for most of chicken rearing. Similarly, in many rural areas of Nigeria (Lawal, 2011) and rural areas of Western Kenya (Okitoi *et al.*, 2007), all family members provided labor to a rural poultry production, mostly men participated in input purchase but women mainly involved on daily routines poultry managements, treatment of sick chicken, make decision on selling of eggs and chicken and on money obtained from chicken sale. Moreover, Mengesha *et al.* (2008b) reported that village poultry keeping uses family labor, women had often an important role in the development of family poultry production, make decision to sale eggs and chicken, and they were major beneficiaries.

Due to village poultry technology packages intervention, few respondents practiced semi-intensive and intensive production systems. This indicates that farmers were trying to practice better chicken production systems. However, intensive poultry production system was very low (7.2%). This might be due to expensiveness of the system and lack of inputs. In agreement, Muchadeyi *et al.* (2007) reported that village chicken production depend on the socio-economic factor within each system. This study found that proportion of local (44.6%) and exotic (38.7%) chicken breeds kept in the production system was different from reported by CSA (2013) for the entire chicken population of the country (which were 96.9% local breeds, 0.54% hybrids and 2.56% exotic breeds). This difference was due to the variation in respondents used for the study. The current study used only respondents who participated in village poultry technology package who had 5 or more exotic chicken breeds for the technology, whereas, the former study considered both technology participants and non-participants.

5.3.1. Chicken flock size and ownership

In the study, layers were dominantly kept in the village poultry technology package production system across the study agro-ecologies. The main reason was to get more eggs and when they become broody, some broody hens were used to incubate eggs so that newly hatched chicks were used to replace their parents. In contrary to the current study, Guraga (2011) reported higher proportion of chicks (37.3%) followed by hens (20%) that dominated the flock structure in different parts of Ethiopia. Similarly, CSA (2013) reported chicks were dominantly kept in the production system (38.91%) followed by hens (35.8%). The current study found that households residing in the highland agro-ecology owned more chicken flock compared to households residing in the lowland agro-ecology. This might be due to agro-ecological influence on chicken production and high incidence of chicken diseases in lowland agro-ecology. Moges *et al.* (2010) reported comparable chicken flock size per household in the lowland (13.4 chicken) and mid-altitude (13.9 chicken) agro-ecologies of Northwest rural part Ethiopia (Amhara Region) but in the highland agro-ecology was lower (11.6 chicken) than the current study finding. Similarly, Dinka *et al.* (2010) and Leta and Bekana (2010) reported in lowland area of Oromia Region (Mid Rift Valley area), 13 chicken flock size per household. Worku *et al.* (2012) reported lower chicken flock size per household in the highland (8.5), mid altitude (7.4) and lowland (8.4) rural areas of Western Amhara Region of Ethiopia. Guraga (2011) reported that 13.0, 22.3 and 14.7 chicken were owned per household in the highland, mid-altitude and lowland agro-ecologies, respectively. These differences might be related to farming objectives such as home consumption only, home consumption and cultural reasons, income and home consumption or might be due to agro-ecological influence on chicken keeping and frequent incidence of chicken diseases. Regarding chicken ownership in the family, most chickens were owned by mothers, because of their major involvement in chicken managements. Fathers, girls and boys also owned some chicken flock. Approximately 80% of the chicken flocks in African countries are owned and controlled by women (Guéye, 1998). However, Leta and Bekana (2010) and Moges *et al.* (2010) reported that in Ethiopia, the majority of village chicken productions were owned by females and children.

5.3.2. Factors affecting chicken keeping and productivity

Several factors were mentioned by the respondents that influencing the technology package chicken keeping and their productivity in the study agro-ecologies. In the highland agro-ecology, cold stress (July to November) was the major factor that influenced chicken keeping. In lowland agro-ecology respondents replied that disease outbreak and heat stress (April and May) were the major factors for chicken farming. In agreement, in North Wollo of Amhara Region (Addisu *et al.,* 2013) and in the Rift Valley of Oromia Region (Dinka *et al*., 2010) of Ethiopia, disease problem (Newcastle disease) was the major identified health constraint that hinders the expansion of village chicken production. Respondents believed that absence of cock with layers and intensive system of production reduces egg laying performance of layers. This might be one reason most farmers practiced scavenging chicken production system.

In the lowland agro-ecology, disease problem was the first ranked criteria to cull chicken from the production system. This indicates disease problem might be the major chicken production constraints in the lowland agro-ecology. In lined with the current study Addisu *et al.* (2013) reported that slaughtering and selling were the major means of culling less productive chicken from the flock in North Wollo of Amhara Region of Ethiopia. Similarly, Bogale (2008) reported that in Fogera district of Amhara Region of Ethiopia, home consumption and selling were the main culling means of poor productive, old age and sick chicken from their flock.

In agreement with the current study, in rural areas of North Wollo of Amhara Region, Ethiopia most farmers (80.0%) practiced crossbreeding to improve the productivity of their chicken (Addisu *et al.,* 2013). Besides, Dana (2011) reported that village chicken breeding in Ethiopia is completely uncontrolled and there is no systematic mating. Similarly, Dana *et al*. (2010) and Demeke (2007) reported that in Ethiopian village poultry production system, reproduction is entirely based on uncontrolled natural mating. In the current study, respondents understood the effects of uncontrolled breeding on desirable phenotypic characteristics of local chicken breeds. Local chicken breeds are low productive but they have excellent genetic merits for their hardness to harsh environment, disease resistance and very good tastes of egg and meat. In agreement

Abera (2000) reported that Ethiopian indigenous chicken have desirable characteristics such as thermo-tolerant, resistant to some disease, have good egg and meat flavor, hard eggshells, high fertility and hatchability of eggs as well as high dressing percentage.

5.3.3. Eggs incubation practices

Respondents of the current study selected best broody hen based on its past best egg hatching performances. In agreement, Addisu *et al.* (2013) reported that in North Wollo of Ethiopia, broody hen selection is based on body size and mainly on broodiness ability. In agreement with the current study, Dessie and Ogle (2001) reported that in the central highland of Ethiopian village chicken production systems, a mean of 13 eggs (7-19 eggs) were incubated per local broody hen. Similarly, Habte *et al.* (2013) and Tadesse (2014) reported that in Northern Central Tigray and in Western Wollega of Ethiopia a mean of 10.2 and 11.32 eggs (6-20 eggs) were set per broody hen, respectively. The number of eggs set per broody hen depends on availability of eggs, size of eggs and size of broody hen and the maternal instinct behavior of the broody hen. Similarly, Tadelle *et al.* (2003) reported that the number of eggs set per hen depends on season, experience and size of the hen. Most respondents in the current study preferred dry season (September to May) for egg incubation. In agreement, in *Nole Kabba* district, Western Wollega of Ethiopia, eggs are mostly incubated in dry seasons (Habte *et al.*, 2013). Similarly, Dessie and Ogle (2001) reported that in the central highland of Ethiopian village chicken keepers were not interested to set eggs for hatching before onset of rainy season (from mid of June to mid of September). This was because of the risk of cold weather for eggs spoilage. Similarly, in the Western Zone of Tigray of Ethiopia, June to February was the most preferred period while March to May was the worst months to incubate eggs and to achieve best hatchability of eggs (Markos *et al.*, 2014). According to Kitalyi (1998), differences in eggs hatchability performance of local broody hens might be attributed to the time or season of the year, since hatchability of eggs using broody hens can be highly affected by season of incubation.

In the current study, most respondents incubate odd number of eggs traditionally as it will increase the chance of chick hatchability. Some respondents said when odd numbers of eggs are incubated, some eggs may rot. The probability of getting even number of chicks and more female chicks will be higher. Some said, incubating even numbers of eggs results in reduced eggs hatchability. In agreement, Dessie and Ogle (2001) reported that in the central Ethiopian highland village poultry production, about 88% of the respondents set odd number of eggs, owning to a belief that this increases the chance of successful hatching.

In agreement with the current study, Mulugeta (2006) reported that eggs from RIR chicken breed have poor fertility and hatchability under natural incubation. In the current study, egg storage temperature and duration before incubation might be one reason for poor hatchability of eggs. Because the storage temperature was not well known and eggs were stored up to 3 weeks (approximately a mean of 2 weeks) before they were incubated to local broody hens. Furthermore, most of the respondents in the current study didn't give care on defects and size difference of eggs and didn't check whether eggs were fertile or not. These might be another problem for poor hatchability. In addition, to get more number of chicks, farmers set up to 20 eggs per hen which might be beyond the broody hen capacity. From the current and previous studies, local broody hens have a capacity to incubate a mean of 11-13 eggs. Therefore, number of eggs incubated per broody hen might be one factor that caused a problem of eggs hatchability.

5.3.4. Feeds and feeding systems

This study found that the major types of crop produced in the study areas had some relationship with the majorly used chicken feeds. The type of grains used for chicken supplementation varies among agro-ecologies, which was related to the type of crops grown. In the lowland areas, maize and wheat are used as essential grain supplements for their chicken, however, in highland areas wheat is mainly used followed by maize. Dessie (1996) reported that in Ethiopia, grain supplement for chicken varies with grain availability in the household and season of the year. Similarly, Hussen (2007) reported that almost all farmers in North Western part of Ethiopia supplement with maize, barley, wheat, finger millet and household waste products. Leta and

Bekana (2010) similarly reported that in Mid Rift Valley areas of Oromia Region of Ethiopia, majority of the farmers used mostly maize, wheat, sorghum and household waste products as the main supplements for their chicken. In the lowland agro-ecology, both white and yellow sorghums were mainly used for chicken feeding. Sorghum grain is known by its anti-nutrient content (tannins) that can cause reduction in voluntary feed intake due to reduced palatability, reduced digestibility and utilization of nutrients, adverse effects upon metabolism and toxicity (Etuk *et al*., 2012). Because of their proximity to large and small scaled chicken farms, respondents found in mid-altitude agro-ecology (*Ade'a* district) had better access to commercial chicken rations although the feeds were not affordable. Few respondents offered green plants and premixes for their chicken. This indicates that few farmers have better knowledge on the importance of green feed and premix for their chicken.

In the current study, the reason why wheat was mainly used as supplement for chicken was because of its availability on farmer hand. Similarly, even though it was not majorly produced crop, maize was one of majorly used feed supplement for chicken. The reasons were that maize price was low and chicken like it as compared to other grains. Respondents said feeding of whole barley without processing, increases egg production and improves the eggshell. This might be true because, whole barley had better Ca content (1.098%) as compared to other cereal grains (see Table 30). In agreement to the current study comparable CP, EE, ash and ME composition were reported by Bediye *et al*. (2007) and Leeson and Summers (2005) for barley, wheat, maize, sorghum and wheat bran but lower Ca content was reported by Leeson and Summers (2005). Similarly, Tesfaye *et al*. (2013) reported comparable nutrient compositions but lower Ca contents for maize and wheat bran. The difference might be due to variety and the method used, atomic absorption method used for the former studies but Talapatra method was used for the current study. Home mixed ration III (mix of wheat bran and noug seedcake) had very high CP content (29.8%) as compared to other home mixed rations which was beyond CP the requirement of any age groups and breeds of chicken. This might be respondents might mix higher proportion of noug seedcake in the ration.

Since most of the respondents used cereals solely as feed supplement for their chicken, only the ME requirement of all age groups of chicken could be satisfied (Leeson and Summers, 2005). Except for home mixed ration I, all home mixed and commercial rations can satisfy the nutrient requirements of all chicken age groups except Ca requirement for layers (Leeson and Summers, 2005. The major problem observed in home mixed rations was that they were not formulated to meet the nutrient requirements of the chicken. As a whole, all the supplementary feeds had very good content of ME. Home mixed ration I, III and V could satisfy Ca requirement of starter, grower and developer age groups of chicken but not layers requirement. Commercial layers ration and home mixed ration II could satisfy Ca requirement of layers. Respondents offered all home mixed and commercial chicken rations for all age groups of chicken without considering their nutrient requirements.

In the current study, few respondents adjusted the amount of feed according to age of chicken and their productivity. The amount offered per head per day was beyond the daily requirement and may result in feed wastage. Most of the respondents offered the feed twice or three times per day. In agreement, in North Wollo of Amhara Region of Ethiopia, most farmers provided feeds two times per day (morning and evening) (Addisu *et al.*, 2013). Farmers in North Western part of Ethiopia supplement their chicken mostly once per day Hussen (2007) and in Mid Rift Valley areas of Oromia Region of Ethiopia, mostly feed supplements were offered once per day (Leta and Bekana, 2010). These differences might be due to the awareness of the respondents. For example, respondents of the current study were village poultry technology participants where most of them got training on village poultry technology package, whereas, the previous studies used respondents that participated and not participated in village poultry technology package (the whole production system). Most of the respondents in the current study offered feeds for their chicken by spreading the feed on the ground without using any feeding trough. This indicates the technology participants were not good in using feed troughs. However, respondents found in the mid-altitude and highland agro-ecology were better in using adopted and home available chicken feeding troughs. This might be due to better accessibility of chicken feeding equipment.

5.3.5. Chicken housing

This study found that most of the respondents kept their chicken in the house where only ½ of the respondents constructed the chicken house separately from people and livestock houses. There were few respondents that couldn't shelter their chicken at all. In agreement, Hussen (2007) reported that in Northwest Amhara Region of Ethiopia, almost all farmers provide night shelter for their chickens and about ½ of respondents provide separate sheds. In contrary, Dinka *et al.* (2010) and Leta and Bekana (2010) reported that in Mid Rift Valley of Oromia Region of Ethiopia, only 14% of the households shelter their chicken during night time in separate sheds. Moreover, in Northwest Amhara Region of Ethiopia, Fisseha (2009) reported that only 22.1% of farmers provide separate night shelter for their chicken, whereas, in India backyard poultry farming 97.5% households, construct separate house for their chicken as night enclosure (Mandal *et al.,* 2006) and in Zimbabwe, about 82% of the households provide separate housing for their chicken (Muchadeyi *et al.,* 2004). From these, it can be concluded that the Ethiopian village poultry housing system was not good as compared to comparable production systems in other countries.

5.3.6. Chicken healthcare management

In agreement with the current study, Dessie and Ogle (2001) reported that in the central highlands of Ethiopia, Newcastle disease is the major chicken killing disease. Similarly, in Mid Rift Valley and in *Ade'a* district of Oromia Region of Ethiopia, the major causes of chicken death is due to Newcastle disease which occurred seasonally (Leta and Bekana, 2010; Selam and Kelay, 2013). Moreover, in Northwestern of Ethiopia, Hussen (2007) reported that Newcastle disease causes the highest death rate during the rainy season (June, July and August). Branckaert *et al.* (2000) reported that among poultry diseases, Newcastle disease is the most serious epizootic poultry disease in the world, particularly in developing countries where in developing countries, this disease occurs every year and kills on average 70 to 80% of unvaccinated village birds. Vaccine production was not the major problem in Ethiopia. Vaccines are available in the National Veterinary Institute starting from 50 doses and the selling price of vaccine is very low

(0.21 to 0.82 Birr per dose). The major problem was district agricultural offices were not well organized and equipped to supply the vaccine for technology participants.

Respondents in the current study used both traditional and pharmaceutical medicines to treat sick chicken. In agreement, most of the households in *Ade'a* district of Ethiopia used traditional medicine such as garlic, *feto*, lemon, melia, chili pepper, vernonia and food oil to treat sick chicken (Selam and Kelay, 2013). Similarly, in North Wollo of Amhara Region of Ethiopia, households used local drinking alcohol called *Arekie*, *damakasie*, lemon, garlic to treat sick chicken (Addisu *et al.,* 2013).

5.3.7. Provision of water for chicken

In the current study, almost all respondents provided drinking water for their chicken throughout the year. In agreement, in Western Amhara Region of Ethiopia, farmers provide drinking water to their chicken during the dry season (86.2%), rainy season (3.6%) and year round (10.2%) (Worku *et al.,* 2012). However, Moges *et al.* (2010) reported that 85.4% of the farmers found in same region provide water to their chicken only during the dry season and 14.3% throughout the year. Most of the respondents in the current study used any home available chicken watering troughs. Similarly, Hussen *et al.* (2007) reported that chicken owners in North West part of Ethiopia use plastic, wooden made and clay made materials to provide water for their chicken.

5.4. Adoption of Village Poultry Technology Package

In the current study after the technology participants tried the technology their awareness level (after awareness level) about the technology showed an improvement as compared to the before awareness level. However, the after awareness level of this study indicates still respondents have information gaps towards the technology. Awareness about the technologies was most consistently and significantly affected by extension input levels (Floyd *et al.,* 1999). Similarly, Okunlola (2010) reported that awareness is the first stage of adoption before the respondents develop interest in the technology and later decide on adoption. Farmer awareness can significantly influence the adoption of new technology (Oladele and Fawole, 2007; Mathialagan and Senthilkumar, 2012).

Before farmers participated in village poultry technology package, 13.4% of them had either negative or neutral perception on the technology. The reasons were mainly related with agro-ecological reason (1st rank) and less feasibility of the technology (2nd rank) in the highland and lowland agro-ecologies, whereas, in the mid-altitude agro-ecology the main reason was related to only technology feasibility. After farmers tried the technology, most had positive perception but still there were few respondents who had either negative or neutral perception. These before and after perception of the respondents indicate how much was done on the technology, the gap between farmer and technology, limitations and constraints of the technology. Sinja *et al.* (2004) reported that the perception of farmers on the technology affects their adoption decisions and their perception may provide a better understanding of technology adoption. The perception of farmer about the technology can be affected by the farmer awareness (Oladele and Fawole, 2007; Mathialagan and Senthilkumar, 2012).

The adoption levels of technology elements varied but not significantly different (except healthcare adoption) across the study agro-ecologies. The better overall adoption level was found in the highland agro-ecology and the least adoption level was found in the lowland agro-ecology. There was no study reported on the adoption level of village poultry technology elements in Ethiopia. As compared to the current study, better chicken housing (49.70%), feeding and watering (59.17%), healthcare (27.44%) and overall (49.28%) poultry technology elements adoptions were reported in backyard poultry rearing in India (Khandait *et al*., 2011). According to Chebil *et al.* (2009) and Feder *et al.* (1985), farmers adopt new technologies when they expect more profit would be gained than that previously existing activity or if the expected utility obtained from the new technology would exceed that of the old one. Moreover, Jain *et al*. (2009) revealed that the extent of adoption of new agricultural technologies can be mainly determined by the area and use of various inputs. Similarly, social and economic characteristics can affect the adoption of the technology (Rahman, 2007).

The overall improved chicken breeds adoption of this study was comparable with Teklewold *et al*. (2006a), who noted that about 41.5% smallholder farmers adopted exotic chicken breeds in East *Shewa* and *Welayeta* zones of Ethiopia. Similarly, comparable chicken breeds adoption (43.48%) was reported by Khandait *et al.* (2011), in backyard poultry rearing in Bhandara district of India. These indicate that chicken breeds adoption under village poultry production systems might be influenced by common factors regardless of geographical location. Respondents found in mid-altitude were better adopters of chicken healthcare as compared to the respondents found in highland and lowland agro-ecologies. This might be due to the proximity of the mid-altitude agro-ecology (*Ade'a* district) to NVI and to the National Poultry Research Coordinating Center (Debre Zeit Agricultural Research Center) for technology participants. Moreover, since the district is found in the area called poultry production belt area of the country, technology participants might be benefited directly or in directly from the system that promote poultry production and technology transfer.

Forms of chicken breed technology adoption were a factor of technology affordability, accessibility, immediate source of income, easiness of their management and profitability of the technology forms. Pullets with cockerels adoption was statistically higher than the rest of technology forms. The main reasons were this technology form was mostly distributed for village poultry technology packages so far. Next to pullets with cockerels technology form adoption, fertile eggs technology form was the second better adopted technology form. This was due to affordability, ease of availability of fertile eggs in village poultry production systems and availability of local broody hens to set eggs and to replace their flock. Layers, pullets with cockerels and only pullets technology forms were the first, second and third ranked preferred forms by the respondents, respectively.

Based on adoption index criteria, village chicken technology packages adoption in the study agro-ecologies was categorized as low adoption level and the respondents were categorized under low adopters. Quddus (2012) reported that dairy technology practicing respondents who had less than 35% adoption index were categorized under low level of adopters. Similarly, Rahman (2007) and Zanu *et al.* (2012) categorized adoption index up to 0.33 for improved pig technologies adoption as low level of adopters.

5.5. Determinants of Technology Package Elements Adoption

In the current study, the probability of improved chicken breeds adoption was significantly influenced by agro-ecology, technology experience of the farmer, frequency of technology received, extension, training and healthcare services. Teklewold *et al.* (2006a) reported that extension contact and poultry technology experience positively influenced exotic chicken breed adoption in Ethiopia. Also, Zanu *et al.* (2012) reported that improved pig technology adoption was associated with extension contact, scientific orientation and training. Similarly, Dehinenet *et al.* (2014a) reported that extension services were positively associated with crossbred dairy technology adoption. In the current study, age didn't significantly influence the probability of improved chicken breeds adoption. In contrary, Teklewold *et al.* (2006a) reported that farmers' decision to adopt exotic chicken breed was negatively influenced by age of household head. In this study, technology participants found in the highland agro-ecology decided more likely to adopt improved chicken breeds. This might be due to agro-ecology that might be better suited to exotic chicken breeds (Bovan Brown breed) except cold stress during cold season which could cause to take long time to first egg and to produce low egg during cold season. Technology experience and frequency of technology received influenced chicken breed adoption. Quddus (2012) reported that technology experience had interrelation with dairy technology adoption.

In the current study, the probability of improved chicken feeds and feeding adoption was significantly increased as the level of education increased. Legesse *et al.* (2013) reported that literate households were more likely decided to adopt the utilization of commercial concentrates for small ruminants in the highland of Ethiopia. Similarly, Zanu *et al.* (2012) reported that improved pig technologies adoption in Ghana was associated with education. Distribution of small number of improved chicken breeds per household per a program, frequency of chicken distribution, inaccessibility of balanced chicken feeds, un-affordability of commercial poultry feeds and knowledge gap of the farmers might be other determinate factors that negatively influenced the adoption of chicken feeds and feeding technology.

In the current study, farmers were advised by animal science professionals to construct appropriate chicken house for the technology and to practice better housing systems. As the annual income increased, the likelihood of farmer's decision to adopt improved chicken housing systems increased too indicating, farmers who could get better annual income could have a better probability to buy house construction materials and could construct the recommended chicken house. Farmers who had better income were more likely to decide to adopt resource conserving agricultural technologies (Grazhdani, 2013). In the current study, farmers who hold small farmland or rented farmland for agricultural activities more likely decided to adopt improved chicken housing as compared to farmers who hold more than 2 ha farmland. Grazhdani (2013) reported that farmers having farm size between 1 and 2 ha had significantly adopted resource conserving agricultural technologies as compared to farmers who had more than 2 ha farmland. As landholding increased, the probability of improved chicken housing adoption showed a declining trend. This indicates that intensification of agricultural technologies on the available farmland and farmers who had better farmland might focus more on agricultural activities such as crop and other livestock productions that could need large area of farmland. Getting healthcare services increased the adoption probability of improved chicken housing. This indicates the close relationship of chicken healthcare service with improved chicken housing system. Giving low value for chicken, expensiveness and unavailability of house construction materials might be other factors that negatively influenced the probability of farmer decision to adopt improved chicken housing.

Technology participants found in the mid-altitude agro-ecology more likely adopted chicken healthcare as compared to participants found in the lowland agro-ecology. In line with the current study of chicken healthcare adoption, access to extension information could influence farmer's decision to adopt a new technology (Degu, 2012). Also Zanu *et al.* (2012) reported that extension contact, farm education exposure and training positively influenced the likelihood of pig technology adoption.

In the current study, most respondents didn't see provision of water as major element of the technology package. Paying no attention to water provision can negatively affect chicken growth, productivity and health. More family size meant more labor force. However, in this study, respondents who had less family size were more likely provided water for their chicken as compared to respondents with more family size. This indicates that more family size didn't have affect on water provision of village poultry. Mwamuye *et al.* (2013) revealed that family size as proxy for labor availability can have been misleading as not all household members participated in dairy technology activities In contrary, Teklewold *et al.* (2006a) reported that family size as a good source of labour for poultry production management. Households with more family size were more likely to be adopters of exotic chicken breeds than families with lesser family size. Similarly, Mekonnen *et al.* (2010) reported that the larger the family sizes the higher the adoption levels of dairy technologies.

5.5.1. Determinants of the overall technology package elements adoption

Among the selected explanatory variables for this study sex, age, chicken farming experience, crop production, credit service and market distance didn't significantly influence the probability of any of the technology package elements adoption. In agreement to the current findings, Ebojei *et al.* (2012) reported that farmers who have frequent contacts with extension agents have a higher probability of participation in the innovation. Similarly, Zanu *et al.* (2012) reported that improved pig technologies adoption were associated with education, extension contact and training. Chi and Yamada (2002) reported that training is the most important factor for adoption of technology. Similarly, Dehinenet *et al.* (2014a) reported that training increased the level of dairy technology adoption through creating awareness on the advantages of the technology. According to Berhanu (2012), currently agricultural extension in Ethiopia is geared towards developing various packages that are suited to the different agro-ecological zones where both smallholder and large-scale agricultural activities are undertaken. This indicates that how much the agricultural extension services are working to meet the technology package goals in the country. Wabbi (2002) stated that government policies, technological change, institutional factors and delivery mechanism can affect the probability of technology adoption.

In the current study, logistic regression analysis coefficients of the intercept (constant) for all technology package elements and the overall adoption were negative and the intercept p-value was <0.05. This indicates that odds ratio was less than zero and covariates were fitted to the model but more of the covariates made the adoption less likely. Moreover, in model Psuedo-R^2 (Nagelkerke R^2) ranged from 0.371 to 0.544. These estimations imply that the variables included in the model could explain 37.1% to 54.4% of the probability of farmer's decision to adopt village poultry technology package elements and the overall technology, and the determinant factors were fitted to the model. Ochieng *et al.* (2012) reported that if Pseudo-R^2 was above the statistical threshold of 20%, adoption could be attributed to the covariates fitted.

The probability of technology package elements and overall technology adoption were more likely influenced by extension, healthcare and training services indicating their importance to increase the farmers' decision to adopt the technology packages in the study areas. Dissemination of insufficient quantities of technology inputs (*eg.* improved chicken breeds) per household, frequent chicken disease outbreaks (Newcastle disease), long time interval between technology input supply, less attention of farmers to the technology and less preference of exotic chicken eggs and meat for consumption might be influencing factors that negatively affected the overall technology package elements adoption.

5.5.2. Limitations and constraints of the overall technology packages

Respondents mentioned many limitation and constraints that affected their decision to adopt village poultry technology package. Absence of veterinary clinic at proximate distance was the major limiting factor that negatively influenced respondents to adopt the technology in the study areas. The limitation of farm size and transportation were very minimal. Similarly, chicken health problem, lack of vaccines and medicaments, shortage of improved chicken breeds and lack of balanced chicken ration were the major constraints that affected the extent of technology adoption across the study agro-ecologies. Degu (2012) reported that chicken diseases, shortage of feed and lack of veterinary services were the major problems of poultry extension packages in

Southern Region of Ethiopia. According to Mengesha *et al.* (2011), many poultry development projects in Ethiopia didn't meet their objectives due to fore mentioned constraints.

5.6. The Impact of Village Poultry Technology Adoption

In the current study, there is no need to make the standard error robust because there was no heteroscedasticity problem existed among explanatory variables. In agreement, Borga (2011) and Tolemariam (2010) reported that if there is no heteroscedasticity problem among the covariates, there was no need to make the standard error robust. Moreover, the estimated model pseudo-R^2 of the current study was fairly low (0.1108). This indicates the pscore estimation could result in very good match between adopters and non-adopters for the selected explanatory variables. Similarly, Tolemariam (2010) reported that a low pseudo-R^2 value shows that households do not have much distinct characteristics overall and as such finding a good match between treated and non-treated households. Moreover, Caliendo and Kopeinig (2008) revealed that low pseudo-R^2 value indicates that the allocation of the treatment has been fairly random and the result suggests that treatment households do not have diverse characteristics overall and hence obtaining a good match between treatment and control households.

The coefficient of pscores estimated for age, chicken keeping experience and market distance show negative values indicating that older farmers were reluctant to participate in village poultry technology packages, more chicken keeping experience didn't mean farmers could participate in the technology and as market becomes distant from the farmers homestead, the likelihood of farmers participation in the technology become less. Participation in improved chicken breed technology was positively and significantly influenced by extension and training services. These imply that as the respondents got better extension and training services, the probability their participation in improved chicken breed technology increased too. The current study overall estimated pscores intercept (constant) was negative and insignificant. This indicates more of the covariates included in the model less likely influenced the population to participate in improved chicken breed technology.

5.6.1. Matching quality

In the current study, after matching all covariate pscores show insignificant. This indicates that there was no characteristics difference between adopters and non-adopters after the estimated pscores were matched. After matching there should be no systematic differences in the distribution of covariates between both groups (Caliendo and Kopeinig, 2008). Tolemariam (2010) reported that the main purpose of the pscore estimation is not to obtain a precise prediction of selection into treatment, but rather to balance the distribution of relevant variables in both groups. In the current study, after matching mean standardized bias (SB) reduction ranges from 0.1-9.6% which was fairly below the critical level of 20% suggested by Rosenbaum and Rubin (1985). Moreover, very low Pseudo-R^2 (0.008) after matching agreed with the report of Borga (2011) after matching the pseudo-R^2 should be fairly low implying that the matching procedure is able to balance the characteristics of the treated and non-treated. Therefore, in the current study matching had high degree of covariate balance that shows similar observed characteristics between the adopter and non-adopter groups to use in the estimation procedures.

5.6.2. Estimation of the average adoption effects

The average adoption effect (ATT) due to improved chicken breeds intervention on the outcome variables results showed indispensably significant impact on technology participants. Positive values of ATT difference (adopter value minus non-adopter value) indicate that the technology participants have been benefited from the intervention in the study area. Even though, the t-test didn’t show significant difference on knowledge and skill, adopters and non-adopters show knowledge and skill improvement due to the technology intervention. This implies that technology intervention benefited both the adopters and non-adopters on improved village poultry production in terms of knowledge and skill. Adopters were significantly benefited from the technology as compared to non-adopters. Moreover, adopters could be able to produce more eggs/layer per year, consumed more eggs/family per year and got better income per layer/year as compared to non-adopters. Dehinenet *et al.,* (2014b) reported that dairy technology adopters significantly consumed higher milk, sold more milk and got better income per annum as compared to the non-adopters. Moreover, Tolemariam (2010) reported that the quantity of cotton meal used as feed supplements for sheep fattening brings significant impact on treated households as compared to control households and market oriented sheep fattening had significant impact on number of sheep fattened.

5.6.3. Sensitivity analysis

The t-test on knowledge and skill improvement between adopters and non-adopters shows insignificant differences, due to this it was not considered in the sensitivity analysis of this study. In agreement, Hujer *et al.* (2004) reported that, sensitivity analysis for insignificant ATT effects is not meaningful and therefore not considered. For significant outcome variables, the sensitivity analysis p-values showed similar significance test as compared to before sensitivity analysis. As Γ (gamma) value increases by 0.5 to $\Gamma=3$, the p-values changes were significant which was below 0.05. This indicates that adopters and non-adopters were correctly matched and there was no hidden bias due to an unobserved confounder. Further, it indicates that important covariates that affected both participation and outcome variables were considered. According to Keele (2010), in sensitivity analysis, p-value is valid if there are no unobserved confounders that is, if the data are correctly matched, there should be no differences between the treated and control groups. In the current study, upper bound p-values were used to see changes in p-values. This was according to Keele (2010) the lower bound is not that interesting since it is always lower than the observed p-value. Since the lower bounds underestimated the true treatment effect, upper bound estimates were used. Becker and Caliendo (2007) revealed that the lower bounds estimates under the assumption of true treatment effect were underestimated and less important to be reported. The Hodges-Lehmman point estimates of livelihood changes smaller than the estimated mean differences and showed slightly more robust as Γ value of 1.5 before the upper bound brackets zero. If there is no hidden bias, Hodges-Lehmman point estimates was 0.50, however, as Γ value increases more than 1.5, the estimates upper bounds bracket zero. This implies there was possibility of hidden bias due to an unobserved confounder on the livelihood changes. DiPrete and Gangl (2004) reported that, if sensitivity analysis gamma value is lowest and encompasses zero, the probability of an unobserved characteristic is relatively high and the estimated impact is therefore sensitive to the existence of unobservable.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

- From this study, it can be concluded that the technology inputs dissemination was not well organized, accessible, affordable and didn't adequately satisfy the demand of the technology participants.

- Improved chicken breeds, balanced chicken feeds, vaccines, credit and poultry equipment were the major limited technology inputs.

- Disseminated chicken breeds and forms for the technology packages didn't consider the technology participants preferences and the agro-ecologies conditions.

- The overall husbandry practices of village poultry technology packages were not very much different from the usual village chicken husbandry practices in Ethiopia and women played the major roles in the packages production systems.

- Egg storage temperature, number of eggs incubated per broody hen, egg defects and duration before incubation might be the reason for poor hatchability of exotic chicken breed eggs.

- Home mixed chicken rations were not formulated based on the nutrient requirements of the chicken and feeds were not offered using appropriate feeding troughs.

- The chicken houses constructed separately from human and livestock houses makes the chicken housing system a bit different from the commonly known village chicken housing system of the country.

- Because of vaccines were not properly supplied to the technology participants, Newcastle disease was the major challenging and killing chicken disease. Agricultural offices were not well organized and equipped to supply the vaccine for technology participants.

- Improved chicken breeds adoption was better than the adoption of the rest technology package elements. Improved chicken breed adoption can be influenced by chicken breed types and forms of technology accessibility, affordability as well as technologies preferences. The overall adoption level of village chicken technology packages was categorized as low and adopters were categorized as low adopters. Respondents residing in the highland and mid-altitude agro-ecologies were better adopters of technology packages.

- Absence of veterinary clinic at proximate, unavailability of proper chicken feeding and watering equipment were the major limiting factors of the technology adoption. Shortage of improved chicken breeds, chicken health problems, lack of chicken vaccines, medicaments and nutrients balanced chicken feeds were the major constraints that influenced farmers not to adopt the technology package.

- Agricultural office, farmer cooperatives, farmers, NGOs and private organizations were key actors of the technology packages but their linkage was weak.

- More of the covariates included in the model influenced the adoption less likely and explain 37.1% to 54.4% of the probability of farmer's decision to adopt technology. Based on these, the probably of the technology adoption might be more likely influenced by of technology inputs supply (adequacy, frequency of supply and affordability).

- Adopters more benefited from technology package as compared to non-adopters. The intervention improved the participants' knowledge and skill, livelihood, egg production, egg consumption and income per household. From sensitivity analysis the study concluded that except for livelihood changes, the significant difference between adopters and non-adopters on outcome variables was due to adoption of improved chicken breed technology.

6.2. Recommendations

To improve the level and extent of village poultry technology packages adoption, the following points can be recommended:

- Technology inputs dissemination should be well organized and supplied in adequate quantities.
- The number of chicken technology forms distributed per farmer for a program should optimize the demands of the technology participants.
- Since mothers (women) played the major role in the husbandry practices village poultry technology packages, more focus should be given to women in order to improve the husbandry practices of the technology package.
- To improve the husbandry practices of the technology package, affordable and nutrients balanced poultry feeds, poultry equipment, vaccines and medicaments should be available for the technology participants.
- To conserve desirable genetic merits of indigenous chicken breeds and to improve egg and meat production from crossbreds, breeding practices should be selective and controlled.
- To formulate home mixed rations that meet the nutrient requirements of the chicken, farmers should be trained and village poultry technology packages should be provided to them with list of feed ingredients with their proportions.
- Farmers' observation on the effects of feed resources on chicken feed preference and layers egg production performance should be further studied.

- Selected herbaceous plants used as fumigant to eradicate external parasites from the house chicken should be further identified and studied.

- Chicken vaccines are available starting from 50 doses with affordable price. Therefore, agricultural offices should be well organized and equipped to supply the vaccines for the technology participants.

- Newcastle disease outbreak seasons were identified. Therefore, technology participants need to be educated to vaccinate their chicken before the disease outbreak seasons.

- To increase the farmers' decision to adopt technology, more attention should be given to adequate and frequent technology input supply, extension, healthcare and training services. Moreover, technical, financial, managerial and market supports are needed for the technology participants.

- As a whole, in order to improve the husbandry practices of the technology, level of adoption and impact of the technology, more efforts are needed from Ministry of Livestock and Fishery Resources, Agricultural Research Centers, district agricultural offices, NGOs, private organizations, small-scale chicks growing associations, farmer cooperatives, professionals and famers.

- The linkage among the actors of the technology packages need be strengthened.

7. REFERENCES

Abera M. (2000). Comparative studies on performance and physiological responses of Ethiopian indigenous (*Angete Melata*) chickens and their F_1 crosses to long term heat exposure. PhD dissertation, Martin-Luther University. Halle-Wittenberg, Germany, 182p.

Addisu H., Hailu M. and Zewdu W. (2013): Indigenous chicken production system and breeding practice in North Wollo, Amhara Region, Ethiopia. *Poult. Fish Wildl. Sci.* ***1:108.***

Adeoti, A.I. (2009). Factors influencing irrigation technology adoption and its impact on household poverty in Ghana. *J. Agri. Rurl. Dev. Trop. and Sub-trop.* ***109:*** *51–63.*

Agresti, A. (2007). An introduction to categorical data analysis. Second Edition, Wiley, Inc., New York. 400p.

AIEI (2013). Impact evaluation methods. http://go.worldbank.org/J35S3J8B60. Retrieved October 12, 2014

Aklilu H. (2007). Village poultry in Ethiopia: Socio-technical analysis and learning with farmers. PhD thesis, Wageningen University, the Netherlands. 178P.

Alders, R.G., Fringe, R. and Mata, B. (1997): Village chicken production in Bilene District, Mozambique: Current practices and problems. Pp. 189-195. Proceedings of IFPD workshop.

Alemu D., Degefe T., Ferede S. and Nzietcheung S. (2008): Overview and background paper on Ethiopia's poultry sector: Relevance for HPAI Research in Ethiopia. HPAI Africa/Indonesia Team Working Paper 1. http://www.hpai-research.net/docs/Working_papers. Retrieved August 01, 2013.

AOAC (1990). Official methods of analysis. Association of Official Analytical Chemists, Washington DC. 1298p.

Arsham, H. (2005). Questionnaire design and survey sampling. http://home.ubalt.edu/ntsbarsh/stat-data/surveys.htm. Retrieved September 21, 2013.

Awotide, B.A., Diagne, A. and Omonona, B.T. (2012): Impact of improved agricultural technology adoption on sustainable rice productivity and rural farmers' welfare in Nigeria: A local average treatment effect technique. Department of Agricultural Economics, University of Ibadan, Nigeria. Pp. 1-23. A paper Prepared for Presentation at the African Economic Conference October 30-November 2, 2012, Kigali, Rwanda.

Becker, S.O. and Caliendo, M. (2007): "Sensitivity Analysis for Average Treatment Effects." *The Stata Journal* ***7****: 71-83.*

Becker, S.O. and Ichino, A. (2002): Estimation of average treatment effects based on propensity scores. *The stata journal* **2**: 358–377

Bediye S., Silashi Z. and Fekadu D. (2007): Composition and nutritive value of Ethiopian feedstuff. Research report no.73. Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia. 24p.

Behnke, *R*., Kervan, C. and Teshome A. (2008): Evaluation of USAID pastoral development projects *in* Ethiopia, Addis Ababa*:* Odessa Centre Ltd. and USAID Ethiopia.

Berhanu K. (2012). The political economy of agricultural extension in Ethiopia: Economic growth and political control. May 2012, Working Paper 042. www.future-agricultures.org. Retrieved December 14, 2014.

Bishop, J.P. (1995). Chickens: Improving small-scale production. Echo technical note. Poultry development services. Marysville.

Blundell, R. and Powell, J.L. (2003): Endogeneity in non-parametric and semi-parametric regression models. Advances in Economics and Econometrics, Cambridge: Cambridge University Press.70p.

Bogale K. (2008). In-situ characterization of local chicken eco-type for functional traits and production system in Fogera District, Amhara Regional State MSc thesis Department of Animal Science, Haramaya University, Haramaya, Ethiopia.107p.

Borga F. (2011). Impact of microfinance services on household income: The case of Digaf Micro Financing Company. MSc. Thesis, Haramaya University, 80p.

Branckaert, R.D.S., Gaviria, L., Jallade, J. and Seiders, R.W. (2000): Transfer of technology in poultry production for developing countries. In FAO Sustainable Development Dimensions, October 2000 and Proceedings WPC2000 Montreal, Canada.

Bursac, Z., Gauss, C.H., Williams, D.K. and Hosmer, D.W. (2008): Purposeful selection of variables in logistic regression. *Sour. Code Biol. Medi.* **3:17**.

CACC (2003). Statistical report on farm management practices, livestock and farm managements Central Statistical Authority, Addis Ababa, Ethiopia.

Caliendo, M. and Kopeinig, S. (2005): Some practical guidance for the implementation of Propensity Score Matching. Discussion paper series, No. 1588, Germany, 29p.

Caliendo, M. and Kopeinig, S. (2008): Some practical guidance for the implementation of propensity score matching. *J. Econ. Surv.* ***22:*** *31–72.*

Catley, A. (1999). Monitoring and impact assessment of community-based animal health projects in Southern Sudan: Towards participatory approaches and methods. A Report for Vétérinaires Sans Frontières Belgium and Vétérinaires Sans Frontières Switzerland. 60p.

Catley, A., Burns, J., Abebe D. and Suji, O. (2008): Participatory impact assessment: A guide for practitioners. Feinstein International Center, Tufts University. 64P.

Chebil, A., Nasr, H. and Zaibet, L. (2009): Factors affecting farmers' willingness to adopt salt-tolerant forage crops in south-eastern Tunisia. *Afjare* **3**: 19-27.

Chi, T.T.N. and Yamada, R. (2002): Factors affecting farmers' adoption of technologies in farming system: A case study in OMon District, Can Tho province, Mekong Delta. *Omonrice* **10**: 94-100.

CIMMYT (1993). The adoption of agricultural technology: A Guide for survey design. Mexico, D.F. CIMMYT. 98P.

CSA (2013). The Federal Democratic Republic of Ethiopia Central Statistics Agency. Agricultural sample survey 2012/13 [2005 E.C].Vol. II. Report on livestock and livestock characteristics. Addis Ababa, Ethiopia.188p.

Dana N. (2011). Breeding programs for indigenous chicken in Ethiopia: Analysis of diversity in production systems and chicken populations. PhD thesis. Wageningen, The Netherlands Wageningen University, 148p.

Dana N., Dessie T. van der Waaij, L.H. and van Arendonk, J.A.M. (2010): Morphological features of indigenous chicken populations of Ethiopia. *J. Anim. Gen. Reso. Info.* **46**:11-23.

Degu G. (2012). Assessment of the livestock extension service in Ethiopia: The case of Southern Region. *Inter. J. Sci. Tech. Res.,* **1:**24-30.

Dehejia, R.H. and Wahba, S. (2002): Propensity score-matching methods for non experimental causal studies. *The Review of Economics and Statistics***, 84**: 151–161.

Dehinenet G., Mekonnen H., Kidoido M., Ashenafi M. and Bleich, E.G. (2014a): Factors influencing adoption of dairy technology on small holder dairy farmers in selected zones of Amhara and Oromia National Regional States, Ethiopia. *Disco. Agri. Food Sci.* **2**:126-135.

Dehinenet G., Mekonnen H., Ashenafi M., Kidoido M. and Bleich, E. G. (2014b): The impact of dairy technology adoption on small holder dairy farmers' livelihoods in selected zones of Amhara and Oromia National Regional States, Ethiopia. *Glob. J. Agri. Econ. Economet.* **2**:104-113.

Delgado, C.L., Courbois, C.B. and Rosegrant, M.W. (1998.): Global food demand and the contribution of livestock as we enter the new millennium. Markets and structural studies division, International Food Policy Research Institute. 36p.

Demeke S. (2003). Growth performance and survival of local and white leghorn chickens under scavenging and intensive systems of management in Ethiopia. *Liv.Resea. Rur.Dev.,***15 (11).**

Demeke S. (2007). Suitability of hay box brooding technology to the rural household poultry production system. *Liv. Resea. Rur.Dev.,* **19(1).**

Demeke S. (2008). Poultry sector review: Analysis of the poultry sector in Ethiopia. Jimma, Ethiopia. 40p.

Dessie T. (1996): A survey of village poultry production in the central highlands of Ethiopia. MSc Thesis, Swedish University of Agricultural Sciences. 70p.

Dessie T. and Ogle B. (2001): Village poultry production systems in the central highlands of Ethiopia. *Trop. Anim. Health Prod.* ***33(6)****, 521-537.*

Diagne, A. and Groom, B. (2012): Understanding the impact of agricultural technology adoption: K-factors, pitfalls and spillovers. Impact Assessment pre-conference, Foz de Iguacao, Brazil, 18th August 2012. 29p.

Dinka, H., Chala R., Dawo F., Leta S. and Bekana E. (2010): Socio-economic importance and management of village chicken production in Rift Valley of Oromia, Ethiopia. *J. Liv. Resea. Rur.Dev.* **22(11)**.

Diprete, T.A. and Gangl, M. (2004): Assessing Bias in the estimation of causal effects: Rosenbaum bounds on matching estimators and instrumental variables estimation with imperfect instruments. *Sociol. Methodol.* ***34****:271-310.*

Doss, C. R. (2006). Analyzing technology adoption using micro studies: limitations, challenges, and opportunities for improvement. *Agricultural Economics **34**:207-219.*

DPPA (2006). Administrative map of Oromia region. www.dppc.gov.et/downloadable/map/administrative/Atlas_Oromiya.pdf. Retrieved September 21, 2013.

Dwinger, R.H., Bell,J. G. and Permin, A. (2003): A program to improve family poultry production in Africa. Animal Production and Health Section, Joint FAO/IAEA Division, IAEA, Vienna, Austria. http://aciar.gov.au/files/node/2131/pr103chapter26.pdf . Retrieved October 21, 2013.

Eaton, D. and Wiersinga, R. (2009): Impact of improved vegetable farming technology on farmers' livelihoods in tropical Asia. *Acta Horticulturae*, **809**:77-90.

Ebojei, C.O. Ayinde, T.B. and Akogwu, G.O. (2012): Socio-economic factors influencing the adoption of hybrid maize in Giwa Local Government area of Kaduna State, Nigeria. *J. Agri. Sci.* **7**: 23-32.

Etuk, E.B., Okeudo, N.J., Esonu, B.O. and Udedibie, A.B.I. (2012): Anti-nutritional factors in sorghum: chemistry, mode of action and effects on livestock and poultry. *J. Anim. Feed Res.* **2**:113-119.

FAO (2010): Poultry meat and eggs: Agribusiness Handbook. Director of Investment Centre Division, FAO, Rome, Italy. 77p.

FDRE (2011). Ethiopia's climate-resilient green economy: green economy strategy. Addis Ababa, Ethiopia. 188p.

Feder, G.R., Just, R. E. and Zilberman, D. (1985): Adoption of agricultural innovations in developing countries: A survey. *Econ. Dev. Cult. Chan., **33:**255-298.*

Fisseha M. (2009). Studies on production and marketing systems of local chicken ecotypes in Bure Woreda, Northwest Amhara Regional State, Ethiopia. MSc Thesis. Hawassa University. 126p.

Floyd, C.N., Harding, A.H., Paddle, K.C., Rasali, D.P., Subedi, K.D. and Subedi, P.P. (1999):The adoption and associated impact of technologies in the western hills of Nepal. Agricultural Research & Extension Network Paper *No. 90*, 15p.

Forsido, T. (1986): Studies on the meat production potential of some local strains of chickens in Ethiopia. PhD Thesis, Justus-Liebig Universitat Giessen, Germany, 210p.

Gebremedhin B., Hoekstra D. and Tegegne A. (2006): Commercialization of Ethiopian agriculture: Extension service from input supplier to knowledge broker and facilitator. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project. Working Paper 1. ILRI, Nairobi, Kenya. 32p.

Gezahegn A., Dorene, A.M., Ekin B. and Devesh, R. (2009): Investigating the role of poultry in livelihoods and the potential impact of HPAI on livelihoods in Ethiopia. Research Report. Addis Ababa, Ethiopia.

Grazhdani, D. (2013). An analysis of factors affecting the adoption of resource conserving agricultural technologies in Al-Prespa Park. *Natu. Monten., Podgo.,* **12**:431-443

Guey, E.F. (2000). Approaches to family poultry development. Proceeding of the 21st World's poultry congress. Montreal Canada.

Guéye, E.F. (1998). Village egg and fowl meat production in Africa. *J. Wo. Poul. Sci.* **54** : 73-86.

Gujarati, G. (2004). Basic Econometrics. Fourth Edition. The McGraw−Hill Companies. 1003p.

Guraga S.Z. (2011). Mapping of QTL for egg laying performance in a crossbred chicken population and analysis of genetic diversity of Ethiopian local chicken ecotype. PhD dissertation, Humboltd University, Berlin. 178p.

Habte M., Ameha N. and Demeke S. (2013): Production performance of local and exotic breeds of chicken at rural household level in Nole Kabba Woreda, Western Wollega, Ethiopia. *Afri. J. Agri. Res.,* ***8***:1014-1021.

Hailemarium T., Legesse D., Alemu Y., Negusse D. (2006): Adopting poultry breeds in the highlands of Ethiopia. Ethiopian Institute of Agricultural Research, Research Report 65. Addis Ababa: Ethiopia. 26p.

Hassen H., Neser, F.W.C., Van Marle-Koster, E. and De Kock, A. (2007): Village-based indigenous chicken production system in North-West Ethiopia. *Trop. Anim. Health Prod.,* **39**: 189-197.

Heckman, J., Hidehiko, I. and Petra, T. (1998): Matching as an Econometric Evaluation Estimator. *Rev. Econ. Stud.,* **65**:261-294.

Heckman, J., Ichimura H., Smith, J. and Todd, P. (1998): Characterizing selection bias using experimental data. *Econometrica*, **66**, 1017–98.

Hosmer, D.W. and Lemeshow ,S. (2000): Applied logistic regression. John Wiley and Sons Inc, Second Ed., New York, 500p.

Huang, Z., Subbaih, F., Abdul, S.Y. and Siba, K.S. (2004): A recombinant Newcastle virus (NDV) expressing VP2 protein of infectious Bursal Disease Virus (IBDV) Protect Against NDV and IBDV. *J. Virol.*, ***78:*** *10054-10063.*

Hujer, R., Caliendo, M. and Thomson, S.L. (2004): New evidence on the effects of job creation schemes in Germany: A matching approach with threefold heterogeneity. *Res. Econ*. ***58:*** *257–302*.

Hussen H. (2007): Phenotypic and genetic characterization of indigenous chicken populations in Northwest Ethiopia. PhD dissertation, Department of Animal, Wildlife and Grassland Sciences, University of the Free State, Bloemfontein, South Africa. 175p.

Ibrahim M. (2004). Extension experiences in Ethiopia. Paper presented at Improving Productivity and Market Success (IPMS) of Ethiopian Farmers project launching conference, 30^{th} June 2003, ILRI, Addis Ababa, Ethiopia.

Idi, A. (2004). Effect of micronutrient and diets on the establishment and pathogenicity of Ascaridia galli in chickens. PhD thesis, Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Jain, R., Arora, A. and Raju, S.S. (2009): A novel adoption index of selected agricultural technologies: Linkages with infrastructure and productivity. *Agri. Econ. Res. Rev.,* **22**: 109-120.

Jennifer, B. (2006). The threat of avian flu predicted impacts on rural livelihoods in Southern Nation, Nationalities and Peoples Region, Ethiopia. The Food Economy Group. May 2006.

Jera, R .and Ajayi, O.C. (2008): Logistic modeling of smallholder livestock farmers' adoption of tree-based fodder technology in Zimbabwe. *Agrekon***. 47**:379-392.

Karthikeyan, C. (1994). Sugar factory registered growers: an analysis of their involvement and impact, MSc thesis TNAU, Coimbatore.

Keele, L., (2010). An overview of rbounds: An R package for Rosenbaum bounds sensitivity analysis with matched data.www.personal.psu.edu/ljk20/**rbounds**%20vignette.pdf Retrieved June 22, 2015

Khandait, V.N., Gawande, S.H., Lohakare, A.C. and Dhenge, S.A. (2011): Adoption level and constraints in backyard poultry rearing practices at Bhandara District of Maharashtra (India). *Res. J. Agri. Sci.*, **2**: 110-113

Khandker, S.R., Koolwal, G.B. and Samad, H.A. (2010): Handbook on impact evaluation: quantitative methods and practices. The World Bank, Washington DC. 239p.

Kitalyi, A. J. (1998). Village chicken production systems in rural Africa household food security and gender issues. FAO, Rome, Italy. 81p.

Kryger, K.N., Thomsen, K.A., Whyte, M.A. and Dissing, M. (2010): Smallholder poultry production livelihoods, food security and socio-cultural significance: Network for Smallholder Poultry Development. FAO, Rome, Italy. 76p.

Lawal, A.O. (2011). Women's benefits from agricultural technologies: evidence from poultry production among Nigerian fisher folk, Development in Practice, **21**: 371-378

Lechner, M. (2000). A Note on the common support problem in applied evaluation studies. Discussion paper, Swiss Institute for International Economics and Applied Economic Research, University of St. Gallen. 25p.

Lechner, M. (2002). Some practical issues in the evaluation of heterogenous labour market programmes by matching methods. *J. Roya. Stat. Socie. Seri.*, **165**: 59-82.

Leeson, S. and Summers, J. (2005): Commercial poultry nutrition. 3rd Edition, Nottingham University Press, England. 413p.

Legesse G., Siegmund, S.M., Abebe G. and Zárate1, A.V. (2013): Determinants of the adoption of small ruminant related technologies in the Highlands of Ethiopia. *Trop. Subtro. Agroecosyst.*, **16:** 13 –23.

Leta S. and Bekana E. (2010): Survey on village based chicken production and utilization system in Mid Rift Valley of Oromia, Ethiopia**.** *Glob. Vet.* **5**: 198-203.

Mack, S., Hoffmann, D. and Otte, J. (2005): The contribution of poultry to rural development. J. *Worl. Poul. Sci.* **61**: 7-14.

Magwisha, H. B. (2003): The impact of helminth infections in free-range chickens with special focus on the pathogenicity of *Tetrameres americana*, University of Agriculture. Morogoro, United Republic of Tanzania. PhD Thesis

Mandal, M. K., Khandekar, N. and Khandekar, P. (2006): Backyard poultry farming in Bareilly district of Uttar Pradesh, India: An analysis. J. *Liv. Rese. Rur. Deve.* **18(7).**

Markos S. Belay B. and Dessie T. (2014): Incubation and brooding practices of local chicken producers in Ethiopia: The case of Western Zone of Tigray. *Bio. Agri. Healt.*, **4**:114-126.

Mathialagan, P. and Senthilkumar, K. (2012): Extent of awareness and adoption of disease prevention and control by poultry farmers. *Inter. J. Food Agri. Vet. Sci.* **2**: 1-4.

Mekonnen G. (2005): Assessment of extension and its impact: the livestock production sub-sector. Working Paper Series, www.eeaecon.org/Downloads/Working%20Papers/WP3-2005.htm. Retrieved August 13, 2013.

Mekonnen H., Dehninet G. and Kelay B. (2010): Dairy technology adoption in small holder farms in 'Dejen' District, Ethiopia. *Trop. Anim. Health Prod.* **42**:209-16.

Mekonnen S., Berhanu T. and Argaw A. (2011): Introduction and evaluation of modified hay-box brooder, Fayoumi chicken and layers housing, addressing small-scale semi-intensive poultry farming at Beresa Watershade, Gurage Zone, Ethiopia. *J. Liv. Prod.,* ***2*****:**124-128.

Melesse A. and Negese T. (2011): Phenotypic and morphological characterization of Indigenous chicken population in Southern region of Ethiopia. *J. Anim. Gen. Reso. Info.* **49**: 19-31.

Melesse A. and Negesse T. (2009): Study on the characterization of local chickens found in Southern Ethiopia. *In*: Pp. 1-15 Proceedings of Annual Research Review Workshop, Hawassa University, Awassa, Ethiopia, May 16-17, 2009.

Melesse K., Jemal J. and Melesse A. (2013): Factors affecting the level of adoption of dairy technologies in Ada'a and Lume Districts, East Shoa Ethiopia. *Agri. Sci. Res.*, **3**:237-243.

Mendola, M. (2007). Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. *Food Policy.* **32:**372–393.

Mengesha M. (2011). Climate change and the preference of rearing poultry for the demands of protein foods. *Asian J. Poult. Sci.* **5**: 135-143.

Mengesha M., Tamir B. and Dessie T. (2008a): Village chicken characteristics and their seasonal production situation in Jamma District, South Wollo, Ethiopia. *Liv. Res. Rur. Dev.*, **20(8)**.

Mengesha M., Tamir B. and Dessie T. (2008b): Socio-economical contribution and labor allocation of village chicken production of Jamma district, South Wollo, Ethiopia. *Liv. Res. Rur. Dev.* **20(10)**.

Mengesha M., Tamir B. and Dessie T. (2011): Village chicken constraints and traditional management practices in Jamma District, South Wollo, Ethiopia. *Liv. Res. Rur. Dev.* **23 (2**).

Moges F., Mellesse A. and Dessie T. (2010): Assessment of village chicken production system and evaluation of the productive and reproductive performance of local chicken ecotype in Bure district, North West Ethiopia. *Afri. J. Agri. Resea.* ***5:****1739-1748.*

Muchadeyi, F.C., Sibanda, S., Kusina, N.T., Kusina, J.F. and Makuza, S. (2004): The village chicken production system in Rushinga District of Zimbabwe. *Liv. Res. Rural Dev.* **16 (40)**.

Muchadeyi, F.C., Wollny, C.B.A., Eding, H., Weigend, S., Makuza , S. M. and Simianer, H. (2007): Variation in village chicken production systems among agro-ecological zones of Zimbabwe. *Trop. Anim. Health Prod.* **39***:*453–461.

Mudgal, V. (2012). Practical in animal nutrition. New India Publishing Agency, New Delhi, India. 150p.

Mulugeta S. (2006). Survey and rectification of the causes of poor hatchability of eggs from Rhod Island Red (RIR) chicken breed in selected zones of Ethiopia. Msc. Thesis, Alemaya University, Ethiopia.

Mulugeta T. and Hundie B. (2012): Impacts of adoption of improved wheat technologies on households' food consumption in South Eastern Ethiopia. Selected Poster prepared for presentation at the International Association of Agricultural Economists Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Mwamuye, M.K., Kisimbii, J. and Otieno, M. (2013): Factors influencing adoption of dairy Ttchnologies in Coast Province, Kenya. *Inter. J. Busi. Comm.* **2**: [01-36].

Narain P., Rai S.C. and Sarup S. (1991): Statistical evaluation on socio-economic front, *J. Indian Soci. Agri. Stati.,* **43**: 329-345.

Negatu W. (2005). Land tenure and technology improvement in smallholder agriculture of Ethiopia. Paper presented on symposium on land and sustainable development in Ethiopia organized on August 5, 2005.Addis Ababa.

Neupane, R. P., Sharma, K. R. and Thapa, G. B. (2002): Adoption of agro-forestry in the Hills of Nepal: a logistic regression analysis.' *Agri. Syst.*, **72**: 177-196.

Nkonya, E., Schroeder, T. and Norman, D. (1997): Factors affecting adoption of improved maize seed and fertilizer in Northern Tanzania. *J. Agric. Econ*. **48**: 1-12.

Ochieng, J., Owuor, G., and Bebe, B.O. (2012): Determinants of adoption of management interventions in indigenous chicken production in Kenya. *AfJARE.* **7**:33-50.

Okitoi, L.O., Ondwasy, H.O., Obali, M.P. and Murekefu F. (2007): Gender issues in poultry production in rural households of Western Kenya. *Liv. Rese. Rur. Dev.* **19 (2).**

Okunlola, J.O. (2010). Factors influencing adoption of rubber based technologies among smallholder farmers in Delta state Nigeria. *Food, Agri. Envi.* **8**: 391-394.

Oladele, O.I. and Fawole, O.P. (2007): Farmers perception of the relevance of agriculture technologies in South-Western Nigeria. *J. Hum. Ecol.* **21**: 191-194.

ONRSOP (2011). Socio economic profile of Oromia National Regional State districts. www.oromiyaa.com/english/index.php?option=com..id. Retrieved September 21, 2014.

Peng, C.Y.Y., Lee, K.L. and Ingersoll, G.M. (2002): An introduction to logistic regression analysis and reporting. *J. Educ. Res.*, **96**:3-14.

Quddus, M.A. (2012). Adoption of dairy farming technologies by small farm holders: practices and constraints. *Bangladesh. J. Anim. Sci.* **41:**124-135.

Rahm, M.R. and Huffman, W. E. (1984): The adoption of reduced tillage: The role of Human capital and other variables. *American J. Agri. Econ.*, **66**: 405- 413.

Rahman, S. (2007). Adoption of improved technologies by the pig farmers of Aizawl district of Mizoram, India. *Liv.Rese. Rur. Dev.* **19 (1)**.

Reta D. (2009). Understanding the role of indigenous chickens during the long walk to food security in Ethiopia. *Liv. Resea. Rur. Dev.* **21(8).**

Rosenbaum, P.R. and Rubin, D.B. (1983): The central role of the propensity score in observational studies for causal effects. *Biometrika*, **70**:41-55.

Rosenbaum, P. R. (2002). Observational studies. Springer, 2nd Edt., New York, 377p.

Rosenbaum, P.R. and Rubin, D.B. (1985): Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *American Stat*. **39:**33–38.

Saliu, O.J., Sanda, M.E. and Audu, S.I. (2009): Adoption of vaccination against Newcastle disease by rural poultry women farmers in the North Central Zone of Nigeria. *Inter. J. Poul. Sci.* **8**:500-503.

Samson, L. and Endalew B. (2010): Survey on village based chicken production and utilization system in Mid Rift Valley of Oromia, Ethiopia. *Global Vet.* **5**:198-203.

Sanzidur, R. (2003). Environmental impact of modern agricultural technology diffusion in Bangladesh: An analysis of farmers' perceptions and their determinants. *J. Envi. Manag.*, **68***:*183-191.

SAS (2002). Statistical Analysis System, version 9, Institute, Inc., Cary, NC, USA.

Selam M. and Kelay B. (2013): Causes of village chicken mortality and interventions by farmers in Ada'a District, Ethiopia. *Inter. J. Liv. Prod.,* **4**:88-94.

Sinja, J., Karugia, J., Baltenweck, I., Waithaka, M., Miano, M.D., Nyikal, R. and Romney, D. (2004): Farmer perception of technology and its impact on technology uptake: The case of fodder legume in central Kenya highlands. African Association of Agricultural Economists. Proceedings of the Inaugural Symposium, 6-8 December 2004, Nairobi, Kenya.

Smith, A.J. (1990). Poultry tropical agriculturist series. CTA, Macmillan Publishers, London.

Smith, J. and Todd, P. (2005): Does matching overcome LaLonde's critique of non-experimental estimators? *J. Econ.*, **125**:205–53.

Sodjinou, E. (2011). Poultry based intervention as tool for poverty reduction and gender empowerment. PhD thesis, University of Copenhagen, 227p.

Sonaiya, E., Branckaert, R. and Guèye, E. (1999): Research and development option for family poultry. INFPD/FAO Electronic Conference on Family Poultry.

Sonaiya, E.B. (1990). ANRPD proceedings international network for family poultry development (INFPD): origins, activities, objectives and visions. Poultry as a tool in poverty eradication and promotion of equality. Workshop, March 22-26, 1999, Tune Landboskole, Denmar.

Sonaiya, E.B. and Swan, S.E.J. (2004): Small-scale poultry production: technical guide. Food and Agriculture Organization of the United Nations, Rome, Italy, 57p.

SPSS (2011). Statistical package for the social sciences. Vision 20. IBM Corporation, SPSS Inc., Chicago IL.

STATA (2012). STATA statistical software. STATA Corporation, version 12.0, Lakeway Drive College Station, Texas, USA.

Szumilas, M. (2010). Explaining odds ratios. *J. Acad Child Adol. Psychiatry,* **19:** 227-229.

Tadelle D. and Ogle B. (2001): Village poultry production systems in the central highlands of Ethiopia. *Tropi. Anim. Health and Prod.* ***33:*** *521-537*

Tadelle D., Alemu Y. and Peters K. J. (1999): Indigenous chicken in Ethiopia: their genetic potential, attempts made in the past for improvement and future areas of research. *Biodiv. Develo. Anim. Genet. Resou., Paper review*. 11p.

Tadelle D., Million T., Alemu Y. and Peters, K. J. (2003): Village chicken production systems in Ethiopia: 1. Flock characteristics and performance. *Liv. Resea. Rur. Dev.* **15 (1)**.

Tadelle D., Negussie D., Alemu Y. and Peters, K.J. (2002): The feed resource base and its potentials for increased poultry production in Ethiopia. J. *World Poult. Sci*. **58:** 77-87.

Tadesse A. (2014). Production and reproduction performance of rural poultry in lowland and midland agro-ecological zones of central Tigray, Northern Ethiopia. *British J. Poult. Sci.* **3**: 06-14.

Tegegne A., Gebremedhin B. and Hoekstra, D. (2010): Livestock input supply and service provision in Ethiopia: Challenges and opportunities for market oriented development, ILRI, Addis Ababa, Ethiopia.

Teklewold H., Dadi L., Yami A. and Dana N. (2006a): Determinants of adoption of poultry technology: a double-hurdle approach. *Liv. Resea. Rur. Dev.* **18(3).**

Teklewold H., Dadi L., Yami A. and Dana, N. (2006b): Adopting poultry breeds in the highlands of Ethiopia. Ethiopian Institute of Agricultural Research.

Tesfaye E., Animut G., Urge M. and Dessie T. (2013): *Moringa Olifera* leaf meal as alternative protein feed ingredient in broiler ration. *Inter. J. Poult. Sci.* **12**: 287-297.

Thomas, M., Diao X. and Roy, D. (2009): Impact of a potential avian flu outbreak in Ethiopia: A multimarket model analysis. Controlling Avian Flu and Protecting People's Livelihoods in Africa and Indonesia http://www.ifpri.org/sites/default/files/publications/hpairb13.pdf. Retrieved September 22, 2013.

Tolemariam A. (2010). Impact assessment of input and output market development interventions by IPMS Project: The case of Gomma Woreda, Jimma Zone. MSc Thesis, Haramaya University, 97p.

Uaiene, R. N. (2011). Determinants of agricultural technology adoption in Mozambique. Post-doctoral research fellow, International Food Policy Research Institute, paper presented at “Dialogue on Promoting Agricultural Growth in Mozambique”. International Food Policy Research Institute, 30p.

Wabbi, J. B. (2002). Assessing factors affecting adoption of agricultural technologies: The case of integrated pest management in Kumi District, Eastern Uganda. Msc Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University, 135p.

Wiseman, J. (1987). Feeding of Non-ruminant livestock. Butterworths , London, 214 p.

Wooldridge, M.J. (2002). Econometric analysis of cross section and panel data. The MIT Press, Cambridge, Massachusetts London, England. 752p.

Worku Z., Melesse A. and T/Giorgis Y. (2012): Assessment of village chicken production system and the performance of local chicken populations in West Amhara Region of Ethiopia. *J. Anim. Prod. Adv.* **2**: 199-207.

Wu, H., Ding S., Pandey, S. and Tao, D. (2010): Assessing the impact of agricultural technology adoption on farmers’ wellbeing using propensity score matching analysis in rural China. *Asian Econo. J.* ***24***: 141–160.

Yami A. and Dessie T. (1997): The status of poultry research and development. Research Bulletin No. 4. Poultry Commodity Research Program, Debre Zeit Agricultural Research Center, Alemaya University of Agriculture. 62p.

Zanu, H.K., Antwiwaa, A. and Agyemang, C.T. (2012): Factors influencing technology adoption among pig farmers in Ashanti region of Ghana. *J. Agri. Tech.* **8**: 81-92.

8. APPENDICES

8.1. Supplementary Tables

Appendix Table 1. Variance Inflation Factor (VIF) for continuous explanatory variables

Variable	VIF	1/VIF (degree of collinearity tolerance)
AGE	2.29	0.437
CHCKFEXP	2.06	0.486
LANDHOLD	1.56	0.640
FAMSIZE	1.18	0.847
ANNICOM	1.16	0.863
MARKETDS	1.02	0.983
MEAN VIF	1.54	

Appendix Table 2. Contingency coefficient (value C) for categorical variables

Variable	EDUCAT	AGROZON	CROPP	TECHEXPI	FRETECH	CREDIT	EXTSER	LKCILIN	HLTHSERV	TRAINING
SEX	0.151	0.06	0.004	0.110	0.061	0.003	0.042	0.090	0.086	0.066
EDUCAT		0.224	0.104	0.188	0.131	0.120	0.125	0.231	0.100	0.145
AGROZON			0.130	0.227	0.112	0.106	0.145	0.263**	0.089	0.131
CROPP				0.049	0.104	0.024	0.077	0.076	0.014	0.066
TECHEXPI					0.477***	0.109	0.060	0.095	0.004	0.133
FRETECH						0.032	0.141	0.100	0.118	0.230**
CREDIT							0.009	0.046	0.104	0.000
EXTSERVI								0.159	0.120	0.215**
LKCILIN									0.215**	0.144
HLTHSER										0.177*

***=P≤0.001, **=P≤0.01, *=P≤0.05

Appendix Table 3. Joint significance and Pseudo-R^2 tests for explanatory variables

Matching algorithm	Sample	Pseudo R2	LRchi^2	P>chi^2
Radius caliper (0.1)	Unmatched	0.111	27.06	0.008
	Matched	0.068	10.91	0.537
Radius caliper (0.25)	Unmatched	0.111	27.06	0.008
	Matched	0.080	13.94	0.305
Radius caliper (0.5)	Unmatched	0.111	27.06	0.008
	Matched	0.078	14.69	0.259
NN (1)	Unmatched	0.111	27.06	0.008
	Matched	0.040	7.83	0.798
NN(2)	Unmatched	0.111	27.06	0.008
	Matched	0.020	3.88	0.986
NN(3)	Unmatched	0.111	27.06	0.008
	Matched	0.018	3.55	0.990
NN(4)	Unmatched	0.111	27.06	0.008
	Matched	0.012	2.33	0.999
NN(5)	Unmatched	0.111	27.06	0.008
	Matched	0.008	1.60	1.000
Kernel (0.1)	Unmatched	0.111	27.06	0.008
	Matched	0.011	2.08	0.999
Kernel (0.25)	Unmatched	0.111	27.06	0.008
	Matched	0.049	9.58	0.653
Kernel (0.5)	Unmatched	0.111	27.06	0.008
	Matched	0.072	14.12	0.293

Appendix Table 4. Unmatched and matched average treatment effect of outcome variables

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
knowskil	Unmatched	.743243243	.547169811	.196073432	.072155868	2.72
	ATT	.732394366	.726760563	.005633803	.084941169	0.07
	ATU	.591836735	.648979592	.057142857	.	.
	ATE			.035502959	.	.
Benefitd	Unmatched	.959459459	.198113208	.761346252	.050418382	15.10
	ATT	.957746479	.301408451	.656338028	.06178963	10.62
	ATU	.204081633	.955102041	.751020408	.	.
	ATE			.711242604	.	.
Livehood	Unmatched	.837837838	.075471698	.76236614	.047430605	16.07
	ATT	.830985915	.078873239	.752112676	.05848412	12.86
	ATU	.071428571	.797959184	.726530612	.	.
	ATE			.737278107	.	.
Changegg	Unmatched	156.337838	57.0377358	99.300102	5.59746435	17.74
	ATT	157.873239	56.5690141	101.304225	6.56757751	15.42
	ATU	57.4081633	152.004082	94.5959184	.	.
	ATE			97.4142012	.	.
Eggcons	Unmatched	38.0405405	19.0188679	19.0216726	2.24241873	8.48
	ATT	38.0422535	19.9098592	18.1323944	2.74472829	6.61
	ATU	19	35.5510204	16.5510204	.	.
	ATE			17.2153846	.	.
Icome	Unmatched	245.359459	73.2853774	172.074082	11.4022165	15.09
	ATT	249.740141	81.0860563	168.654085	14.0134593	12.04
	ATU	74.1841837	233.166122	158.981939	.	.
	ATE			163.045385	.	.

Appendix Table 5. Bootstrap statistics of outcome variables

Variable	Replication	Observed	Bias	Std.err
KNOWSKIL	100	-0.0135135	0.003779	0.0762852
BENEFITD	100	0.6891892	-0.0412688	0.1264766
LIVEHOOD	100	0.8243243	-0.0638434	0.0660152
CHANGEGG	100	95.5946	2.611715	7.916085
EGGCONS	100	17.77027	-0.2013661	2.813683
INCOME	100	147.6635	20.99421	24.1766

8.2. Supplementary Figures

Appendix Figure 1. Dominant production system of the technology package in the study areas

Appendix Figure 2. Dominant feed offering system without feeding trough in the study areas

Appendix Figure 3. Chicken infected by infectious coryza obtained in highland agro-ecology

8.3. Published Articles

1. Husbandry practices of village poultry technology package and the nutritional quality of majorly used poultry feeds in the Central Oromia Region, Ethiopia. *Livestock Research for Rural Development 27 (4): 2015*

Ermias T.Tsadik, Berhan Tamir and Zemelak Sahle

2. Determinants of Village Poultry Technology Package Adoption; Limitations, constraints and Opportunities in the Central Oromia Region, Ethiopia. *International Journal of Development Research, 5(5): 4436-4443, May, 2015*

Ermias T.Tsadik, Berhan Tamir and Zemelak Sahle

3. The Impact of Village Poultry Technology Adoption on the Livelihood of Smallholder Farmers in the Central Oromia Region, Ethiopia. *Journal of Animal production Advances, November, 2015*

Tsadik T.E., Tamir B. and Sahle Z.

8.4. Questionnaire Used for Study

A. Questionnaire used for face to face interview

1. General information

1.1. Questioner code:___________________ Date of interview: _____________________

1.2. Enumerator's name: ______________________________ Mobile:_____________________

1.3. Participant name:________________________________ Mobile:_____________________

1.4. Study area: Zone:_____________________________ Woreda:______________________
Kebele:____________________________ Village:_____________________

2. Socio-economic characteristics of the respondent

2.1. Sex: 1. Male ☐ 2. Female ☐

2.2. Age: ______years.

2.3. Family size: ___________

2.4. Total annual income ____________ birr

2.5. Education level of the respondent (put√ mark)

1.Illiterate	
2. Basic education (Read and write)	
3.Elementary education (grade 1-8)	
4.Secondary education and above	

2.6. Landholding __________ hectares

2.7. What are major crops you produced? 1.___________________ 2._____________________
3.________________________ 4.____________________

3. Village poultry technology package

3.1. Agro-ecological zone: 1. Highland ☐ 2. Mid-altitude ☐ 3. Low land ☐

3.2. How long since you started chicken farming? ___________years

3.3. How long since you participated in poultry technology package? 1. Up to 5year ☐ 2. 6-10 years ☐ 3. More than 10 years ☐

3.4. Did you get training before you started the poultry package? 1. Yes ☐ 2. No ☐

3.5. Did you get credit service for the package so far? 1. Yes ☐ 2. No ☐

3.6. How many times you received poultry technology package? 1. Once ☐ 2. Twice ☐ 3. More than twice ☐

3.7. Where did you get the technology package inputs so far? (Put√ mark)

Input	Source of inputs						
	Agri-Office	Research Centers	Cooperatives	Farmers	NGOs	Private orgs	Others
Chicken breeds							
Feed							
Vaccine							
Drug							
Credit							
Equipment							
Technical support							
Market							

3.8. Which technology package inputs were limited? (Rank them 1-6)

Chicken breeds	Feed	vaccine	Drug	Credit	Equipments

3.9. Did you get price subsidies for inputs from organizations? 1. Yes ☐ 2. No ☐

3.10. What quantity of each chicken forms you received for a package program?

Fertile eggs	Day old chicks	Pullets only	Pullets with cockerels	Egg layers

3.11. Were the quantity enough for a package program? 1. Yes ☐ 2. No ☐

3.12. If no, what is your demand for the future single package program?

Fertile eggs	Day old chicks	Pullets only	Pullets with cockerels	Egg layers

3.13. Which form do you prefer for the future? (Rank; 1=mostly demanded, 5=least demanded)

Fertile eggs	Day old chicks	Pullets only	Pullets with cockerels	Egg layers

4. Husbandry practices of village poultry technology package

4.1. Roles of family members

4.1.1. What are the roles of family members in the technology systems? (put √ mark)

Activity	Responsibilities			
	Father	Mother	Boys	Girls
Participate in poultry package trainings				
Poultry house construction				
Buying poultry technology packages				
Chicken management (feeding, house cleaning, collecting eggs..)				
Make decision to sell the technology output (chicken and eggs)				
Selling of chicken and eggs				
Treating of sick chicken				

4.2. Production systems of the technology package

4.2.1. What type of production system you used for the technology package?

1. Scavenging system ☐ 2. Scavenging with some feed supplementation system ☐
3. Semi-intensive system ☐ 4. Intensive system ☐

4.2.2. What was the objective production system? (Rank) 1. Income source ☐
2. Income source and home consumption ☐ 3. Other________________________

4.2.3. How long did you work in the package farm per day**?** 1. Less than an hour ☐
2. 1-2 hours ☐ 3. 2-4hours ☐ 4. 4-6 hours ☐ 5. Over 6 hours ☐ 6. Not at all ☐

4.2.4. What types of chicken breeds do you keep in your poultry farm? (put √ mark)

1. No chicken ☐ 2. Local breed ☐ 3. Exotic breed ☐ 4. Crossbred ☐

4.2.5. How many chickens do you have in your farm?

Age group	Local breeds	Exotic breeds	Crossbreds	Total
Chicks				
Pullets				
Cockerels				
Layers				
Cocks				

4.2.6. From the family members, who owned more number of chicken (Rank orderly 1-4)

1. Father ☐ 2. Mother ☐ 3. Girls ☐ 4. Boys ☐

4.2.7. In your poultry package farm, did you keep records? 1. Yes ☐ 2. No ☐

4.2.8. If yes, which types of record? 1. Expense records ☐ 2. Egg production records ☐

3. Income records ☐ 4. Health records ☐ 5. Mortality records ☐ 6.others________

4.3. Egg production characteristics (RIR= Rhode Island Red, WLH= White Leghorn)

Production factor	RIR	WLH	Bovan Brown	Fayoumi	Local	Crossbred
1. Age at first egg (month)						
2.Number of clutch per year						
3. Number of eggs per clutch						
5. Age of culling (year)						

4.3.1. What were your criteria to cull chicken from the production system? (Rank 1-6)

If old aged	If space problem	If low egg production	If disease risk	To get extra money	If feed shortage

4.4. **Breeding practices**

4.4.1. Did you cross breed exotic chicken breeds with local once? 1. Yes 2.No ☐

4.4.2. Did you carry out cross breeding without limitation? 1. Yes ☐ 2. No ☐

4.4.3. Did you know the effect of uncontrolled breeding? 1. Yes ☐ ☐ 2. No ☐

4.4.4. If yes, what is its effect? 1.______________________________ 2.____________________

4.5. **Egg incubation and hatchability problem**

4.5.1. On average, for how long do you store the eggs before you incubating them? ____weeks.

4.5.2. Where do you store the eggs? 1. Any where ☐ 2. Cold place ☐ 3. Inside the grain ☐ 4. Warm place ☐ 5. Other (specify) ____________________

4.5.3. How many eggs do you incubate per local broody hen? ______eggs

4.5.4. Do you take care on the size and shape uniformity of the eggs to incubate local broody hen? 1. Yes ☐ 2. No ☐

4.5.5. What number of eggs do you incubate per local broody hen? 1. Odd number ☐ 2. Even number ☐ 3. Us we like ☐

4.5.6. If odd or even number of eggs why? 1____________________ 2. __________________

4.5.7. Which season is preferred to incubate eggs? 1. Rainy season ☐ 2. Dry season ☐

4.5.8. Why? 1. ________________________________ 2. ________________________

4.5.9. Which chicken breed eggs have hatchability? 1. RIR ☐ 2. White Leghorn ☐ 3. Bovan Brown ☐ 4. Fayoumi ☐ 5. Crossbred ☐

4.5.10. Did you know the reason why the eggs are not hatched? 1. Yes ☐ 2. No ☐

4.5.11. If yes, mention the reasons 1.______________________ 2. ___________________

4.6. **Feeds and feeding systems**

4.6.1.Did you provide supplementary feeds for your chickens? 1. Yes ☐ 2. No ☐

4.6.2.If yes, what type feeds did you supplement for them? 1. Home available feeds ☐
2. Commercial feeds ☐ 3. Home mixed ration ☐ 4. Both commercial& home available feeds ☐

4.6.3. If you use home available feeds, put them orderly starting from the major one 1.__________________ 2. _______________ 3. ________________ 4.______________

4.6.4. Do you think home available feeds can satisfy the nutrient requirements of your chicken? 1. Yes ☐ 2. No ☐ 3. I don't know ☐

4.6.5. Were the commercial poultry feeds accessible? 1. Yes ☐ 2. No ☐

4.6.6. Is the price of commercial poultry feeds affordable? 1. Yes ☐ 2. No ☐

4.6.7. Did you face quality problems on commercial poultry feeds so far? 1. Yes ☐ 2. No ☐

4.6.8. If yes, what problems you observed? 1.________________________ 2.________________

4.6.9. What type of feeding system did you use for your chickens?
1. Feeding without time limit (*Ad libitum*) ☐ 2. Hour's interval feeds offering ☐
3. No feed offering ☐

4.6.10. How many times you offered the feed per day? 1. Once ☐ 2. Twice ☐
3. Three times ☐ 4. Four times ☐ 5.five times ☐ 6. Not offered at all ☐

4.6.11. Did you adjust the amount of feed according to the age & productivity of your chickens? 1. Yes ☐ 2. No ☐

4.6.12. What amount of supplement feed you offered for 5 chickens per day?

Chicken type	Home available feeds (kg)	Commercial poultry feed(kg)
Chicks		
Pullets/cockerels		
Layers/cocks		

4.6.13. How did you offer the feed for your chicken? 1. Spreading the feed on the ground ☐
2. Spreading the feed on any sheet ☐ 3. Using any home available feeding trough ☐
4. Using appropriate chicken feeding trough ☐ 5. No feed offering ☐

4.7. **Housing managements**

4.7.1. Did you keep your chicken in the house? 1. Yes ☐ 2. No ☐

4.7.2. Was the house separated from human or other livestock houses? 1. Yes ☐ 2. No ☐

4.7.3. Where you did shelter your chicken?

In the chicken house	In the livestock house	In the kitchen	In the family house	4.In the family veranda	5.Not sheltered at all

4.7.4. Did you construct the house according to package recommendation? 1. Yes ☐ 2. No ☐

4.7.5. If no, why? 1. There was no package recommendation ☐ 2. Space problem ☐
3. House construction is expensive ☐ 4. Workload to construct the house ☐

4.7.6. What type of housing system did you use? 1. Cage system ☐ 2. Deep litter system ☐
3. No bedding material with some roosting ☐
4. No bedding material without roosting housing system ☐

4.7.7. During chicken housing, did you consider their space requirement? 1. Yes ☐ 2. No ☐

4.7.8. When did you keep your chicken in their house? 1. Day and night time
2. Only night time ☐ 3. Some hours at day time and whole night time ☐

4.7.9. Did you keep chicken in their house during risky weather condition? 1. Yes ☐ 2. No ☐

4.7.10. Did you clean the chicken house? 1. Yes ☐ 2. No ☐

4.7.11. If yes, in what time interval? 1. Daily ☐ 2. Weekly ☐ 3. After a week ☐
4. After 15 days ☐ 6. When all chicken out ☐

4.7.12. Did you disinfect the chicken house? 1. Yes ☐ 2. No ☐

4.7.13. What type of disinfectant did you use? 1. ____

4.7.14. If no, why? 1.____________________________ 2.____________________________

4.8. **Healthcare management**

4.8.1. Have you lost some of your chickens due to disease problem? 1. Yes ☐ 2. No ☐

4.8.2. Which diseases were the major challenging diseases in your area? (Rank 1-5 orderly)

Newcastle	Infectious coryza	Salmonellosis	Fowl pox	Coccidiosis

4.8.3. Which diseases were the major chicken killing diseases?(Rank 1-5 orderly)

Newcastle	Infectious coryza	Salmonellosis	Fowl pox	Coccidiosis

4.8.4. In which seasons the diseases were very common?

Disease name	Season of prevalence from__ to__ (month)
1.	
2.	
3.	

4.8.5. Did you get appropriate healthcare services? 1. Yes ☐ 2. No ☐

4.8.6. How far the livestock clinic from your house? 1. < 10km ☐ 2. 11-20km ☐ 3. >20km ☐

4.8.7. Did you vaccinate for your chicken? 1. Yes ☐ 2. No ☐

4.8.8. Did you know when chicken should be vaccinated? 1. Yes ☐ 2. No ☐

4.8.9. What measure did you take when your chickens become sick?

1. Leave the birds as they are ☐ 2. Chicken isolation ☐

4.8.10. Did you consult a veterinarian? 1. Yes ☐ 2. No ☐

4.8.11. What type of medicaments did you use? 1. Traditional ☐ 2. Pharmaceutical ☐ 3. Both traditional and pharmaceutical ☐ 4. None of them ☐

4.8.12. If you use traditional medicines, what are they? 1.____________ 2. ___________ 3.______

4.8.13. Did you know how much doses should be given? 1. Yes ☐ 2. No ☐

4.8.14. Which medicament was more effective to cure the diseases? 1. Traditional ☐ 2. Pharmaceutical ☐ 3. Mixes of the two ☐ 4. None of them are effective ☐

4.8.15. Was the treatment cost affordable to you? 1. Yes ☐ 2. No ☐

4.8.16. On average, how much birr you spend per chicken per year? ______Birr per year.

4.9. **Provision of water**

4.9.1. Did you provide drinking water for you chicken? 1. Yes ☐ 2. No ☐

4.9.2. What type of water source did you use? 1. River ☐ 2. Spring ☐ 3. Pond ☐ 4. Tap water ☐ 5.Lack ☐ 6. Well water ☐

4.9.3. Did you use watering trough? 1. Yes ☐ 2. No ☐

4.9.4. If yes, what type of watering trough did you use? 1. Home available any trough ☐ 2. Appropriate chicken watering trough ☐ 3. No watering trough ☐

4.9.5. Did you care about the hygiene of the water? 1. Yes ☐ 2. No ☐

4.9.6. Did you use hygienic watering trough? 1. Yes ☐ 2. No ☐

4.9.7. Did you clean the watering trough? 1. Yes ☐ 2. No ☐

4.9.8. How often you cleaned the watering trough per a week? 1. Once ☐ 2. Twice ☐ 3. Three times ☐ 4. Four times ☐ 5. Five times ☐ 6. Every day ☐ 7. Not at all ☐

4.9.9. Was the water available for the chicken via day and night? 1. Yes ☐ 2. No ☐

4.9.10. How many times did you change the water per a day? 1. Once ☐ 2. Twice ☐ 3. Three times ☐ 4. Four times ☐ 5. More than five times ☐ 6. Not at all ☐

5. Awareness level of the participant to the technology package

5.1. Before participating in the package technology, did you aware about it?

1. Yes ☐ 2. No ☐

5.2. What was the first source of information for you? 1. Farmers ☐ 2. DAs ☐ 3. Mass media ☐ 4. Experts ☐ 5.Researcher ☐ 6. Poultry books ☐ 7. NGO ☐

5.3. Currently, do you aware of: (Put √ mark)

	Do you aware of:	Yes	No
1	About improved chicken breeds?		
2	About improved chicken feeds and feeding?		
3	About improved chicken housing?		
4	About aware of chicken vaccinations?		
5	About aware of improved chicken management?		
6	About aware of chicken diseases and parasites control?		

6. Perception of the participants to the technology package

6.1. What was your perception to the technology before participation? 1. Positive ☐ 2. Negative ☐ 3. Neutral ☐

6.2. If negative, why? (Rank 1-5; 1= very important, 5=least important)

No	Reasons	Rank
1	The technology may not be feasible	
2	Agro-ecological reasons	
3	Religious reasons	
4	Socio-cultural reasons	
5	Others	

6.3. What is your perception to the technology after your participation? 1. Positive ☐ 2. Negative ☐ 3. Neutral ☐

7. Village poultry technology package adoption

7.1. Have you tried the following poultry technology package elements so far? (Encircle)

Chicken breeds		Feeds & feeding		Housing		Healthcare		Provision of water	
1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	1.Yes	2.No

7.2. Which poultry technology package elements were adopted? (Encircle)

Chicken breeds		Feeds & feeding		Housing		Healthcare		Provision of water	
1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	1.Yes	2.No

7.3. Which exotic/improved chicken breeds were adopted (Encircle)

Rhode Island Red		White Leghorn		Bovan Brown		Fayoumi		Other (specify)
1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	

7.4. Why you adopted them? (Rank; 1=first rank, 5=least rank)

They are accessible	They adaptable to the agro-ecology	They are disease resistant	They are highly productive	Their management is easy

7.5. Which technology package form/s was/were adopted? (Encircle)

Fertile eggs		Day old chicks		Pullets only		Pullets with cockerels		Egg layers	
1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	1.Yes	2.No	1.Yes	2.No

7.6. Why you adopted them? (Rank; 1=very important, 5=least or no important)

No	Reason for adoption	Rank
1	They are affordable	
2	They are easily accessible	
3	They are immediate source of income	
4	Their management is easy	
5	They are very profitable	

7.7. Which chicken breed do you prefer for the future? (Rank 1-6)?

1. Rhode Island Red ☐ 2. Bavan Brown ☐ 3. White Leghorn ☐ 4. Fayoumi ☐
5. Crossbred with local chicken ☐ 6. Other (specify) ____________

7.8. Which chicken forms do you prefer for the future? (Rank 1-6 orderly)

Fertile eggs	Day old chicks	Pullets only	Pullets with cockerels	Laying hens	None of them

7.9. What were the main agro-ecological influences not to adopt poultry technology? 1.______________________ 2. _________________________ 3. __________________

7.10. Did crop production affect you not to adopt the poultry package? 1. Yes ☐ 2. No ☐

7.11. In your observation, how is the rate of poultry package adoption in your Kebele from year to year? 1. Increasing ☐ 2. Decreasing ☐ 3. No change ☐

8. Limitations, constraints and opportunities of the technology package

8.1. Rank limitations that affected the technology adoption (Rank 1-4; 1=very important, 4=Least important)

1.Farn size	2.Poultry equipments	3. Veterinary clinic	4. Transportation

8.2. Rank constraints that hindered the technology adoption (Rank 1-10 orderly; 1=very important, 10=least important)

Lack of knowledge	Lack of advisory services	Improved chicken shortage	High inputs price	Credit service	Lack of feed	Vaccines & drug supplies	Health problems	Market access	work load

8.3. Did you get appropraite extension services for the technology? 1. Yes ☐ 2. No ☐

8.4. To improve the technology adoption, what support you need? (Rank;1= very important; 6=less important)

Technical	Financial	Managerial	Training	Transportation	Market

9. Impacts of the technology package

9.1.1. Did the technology participation improve your knowledge and skill? 1. Yes ☐ 2. No ☐

9.1.2. Did you benefit from the technology package participation? 1. Yes ☐ 2. No ☐

9.1.3. Did the technology bring a positive change on your livelihood? 1. Yes ☐ 2. No ☐

9.1.4. On average, how many eggs do you get per hen per year?

Before participation	After participation	Changes of production

9.1.5. On average, how many eggs were used for family consumption per year?

Before participation	After participation	Changes of consumption

9.1.6. How far the town market from your farm? ____________km

9.1.7. Income changes per layer per year

Before participation			After participation			Income change
Total egg sold	Unit price	Total	Total egg sold	Unit price	Total	

Thank you very much for your cooperation!!

B. Check list for PRA focus group discussion

1. Who are key actors involving in the process of poultry technology package?
   a.____________________________ b. ____________________________
   c. ____________________________ d. ____________________________

2. How is the intensity of the linkage among the key actors? 1. Weak ☐ 2. Moderate ☐
   3. Strong ☐

3. How they are networked? (Rank 1-6, 1=the first; 6= the least)

Meeting	Discussion forum	Model farmers	Extension agent	Regular visits	Telephone

4. Constraints and limitations observed on the poultry technology packages so far? (Rank 1-9; 1=very important, 9=least or no important)

No	Drawback	Rank
1	High cost of technology package inputs	
2	The package quantities were not enough	
3	The package inputs were not easily accessible	
4	The technology requires high management skill	
5	The technology was not socially acceptable	
6	The chicken breeds were not adaptable to the agro-ecology	
7	The chicken breeds were easily attacked by disease	
8	The technology brought us new problems	
9	The return from the packages is low	

5. The cost of technology package inputs increment from year to year (Rank 1-6)

Feed cost	Chicken cost	Medicament cost	Construction cost	Equipment cost	Labor cost

6. Additional points to be said to improve the technology package adoption
   a.____________________________ b. ____________________________

   c.____________________________ d. ____________________________