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Meta-Analysis on Improved Livestock Technology Adoption in Ethiopia

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Abstract

The livestock sector known to be livelihood base for Ethiopian community in terms of income, social capital and food and plays significant role for the country economy, however, the production system is not yet improved due low improved technology utilization, market inefficiency and climate variability. It had taken half a century for the country in adopting improved livestock technology and lots of efforts were made in its transfer, but the level of technology adoption is not yet optimal. The meta-analysis was carried out to see the average size effect of explanatory variables over livestock technology adoption and reliability of certain published articles explanatory variable on explaining the expressed dependant variable and there by overview the adoption of improved livestock technology at country level. The study used 12 published research articles from the year of 2011 up to 2018 on the major livestock technology adoption study across the country. The five regions where the systematic review and meta-analysis carried out were Oromia, Amhara, SNNPR, Tigray and Benshangul Gumuz regional states. The meta-analysis result confirmed that in relation to measurement errors, heterogeneity of case studies, variability in interviewed farmers socioeconomic and institutional setup, the livestock technology adoption probability estimate depends on study period, model type used, and sample size. The inverse relationship between technology adoption rate and years of study period showed the increment of technological option in current years than previous periods and minimization of the risk aversion features of the small-scale farmers. The other finding from meta-analysis indicated average size effect result indicated that the probability of improved livestock technologies is positive function of family size, market and main road distance, training and income and inverse function of age, gender and distance from extension service centres. The other regression result also showed that the livestock adoption proportion determined by econometric model type used, sample size of respondent and study period. From meta-analysis study the pointed out for scholars that it is indispensable to give due attention on checking inclusion of all necessary variables and un omission of important variables and assuring not committing measurement errors in the variables that presumed and theoretically supported to affect the predictand. As remedial measure for suspected measurement errors, trying to include instrumental variables and collection of all related data assumed to the major assignment for all the next studies. The mean size effect results also pointed out that through awareness creation, expansion of demonstration centres in the vicinity, creating income opportunity and gender mainstreaming will have detrimental effect in farmers' choice and utilization of livestock technology.

Keywords: Adoption • Livestock • Meta-analysis • Small-scale farmer • Technology

Introduction

In relation to population growth, improvement in infrastructural, per capita income and urbanization, the demand for livestock products, such as milk, meat and eggs is growing in Ethiopia. The growing demand for milk products offers opportunities for smallholders to realize better livelihoods through creating demands for market opportunities. However, due to low productivities of dairy animals the sector has not been able to produce adequate milk to satisfy this demand of ever increasing population. The use of technological inputs, such as improved breeds of dairy cows and cultivation of improved forages, is often seen as a prerequisite to increasing livestock productivity and resource use efficiency in the smallholder livestock sector. However, there was mismatch between adoption rate of new technologies and demand by the sector, despite existence of numerous efforts to disseminate the technologies in the past [1,2].

Livestock supports Ethiopian communities' in terms of various benefits and values in their livelihood such as income, food, employment, prestige, transport, draft power, fertilizer, savings and insurance, clearing unwanted vegetation and the like. However, underestimation of livestock contribution to the community and little policy supports available for intervention complicated the sustainable resource utilization. The non-marketability value of livestock outputs in the farming system comprised of social value, breed maintenance value, draft power, manure, unwanted range land management, prestige and other social values. The underestimation linked with lack of access to improved inputs, technology, information and basic services were forced the farmers to not practice the optimal productivity improvement choices [3].

The study results by Kebebe justified that the failure of the majority of smallholder farmers in Ethiopia to take advantage of agricultural technologies and economic opportunities in the livestock sector remains an unresolved mystery and one of major causes for lower productivity in the sector [4]. There are different economic, social, environmental, political and organizational bottlenecks that challenged the transfer of technology in smallholder livestock production systems. The study also confirmed that the existence of weak innovation systems in terms of entrepreneurship, knowledge diffusion, market development, and policy advocacy mirror the low up take of improved technologies in the livestock sector. Shortage of domestic suppliers of key technological inputs and services, weak input and output markets and weak interaction among value chain actors have been the major hindrances to livestock development. The availability of technical knowledge and economic opportunities alone may not be enough to stimulate the uptake of technologies and commercialization of dairy production. The peculiar nature of inputs, services, and output in the livestock sector at country level requires innovative business models and demands different stakeholders' cooperation and working together that accelerate the transfer of the knowledge, skills, inputs, services and output markets in livestock value chains.

Livestock development efforts in Ethiopia have been based on

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unorganized and unequal treatment of the technologies interventions that deal with problems of feeding, breeding and animal healthcare at the production level. The smallholder farmers appear not to use agricultural technologies because of the multiple constraints that prevent them from taking advantage of productivity and profit opportunities offered by the technologies. The weak adoption probability and low rate of technology caused the failure of the majority of smallholder farmers in Ethiopia to take advantage of agricultural technologies and economic opportunities in the livestock sector that remains an unresolved puzzle.

Agricultural technology development accelerates increasing agricultural productivity, achieving food self-sufficiency and alleviating poverty and food insecurity among smallholder farmers in Ethiopia. In Ethiopia, farmers have been adopting and using various agricultural technologies, the adoption of technologies has not completely optimal yet. Different scholars summarized institutional, social and economic challenges as root cause for low adoption of agricultural new technologies by farmers comprised of age, land size, education level, family size, training and market access, farm size, extension service provision and credit access.

The Meta-analysis study is designed to provide the basis for understanding the Livestock Technology adoption analysis approaches and factors affecting technology transfer in Ethiopia livestock sector. A meta-dataset synthesized from the existing literature on livestock technology adoption in Ethiopia covering the period 2011-2018 is used for the empirical analysis. Summarizing these studies in a quantitative way can help to develop a clear picture of technology adoption study application and its drivers in the country context and answering the following questions based on the studies covering the period under investigation.

Research questions in meta-analysis of improved livestock technology adoption

i. what were the major livestock technologies had been transferred in livestock sector in Ethiopia?

ii. What is the impact of study specific characteristics such as choice of functional form, number of observations, size of inputs used, and the degree of aggregation of output variable on mean livestock technology adoption and utilization?

iii. Do differences exist in relation to technology adoption probability across study periods, model type used and sample size interviewed for different livestock sectors such as improved forage and feeding, poultry and apiculture technology adoption?

iv. Which small scale farmer socio-economic variables influence intensity and probability of technology adoption?

Review of improved livestock technology in Ethiopia

Review of adoption improved forage technologies: The household land and labour resource endowment, and market integration and crop intensification were important factors encouraging adoption of an oats–vetch forage technology. The land-saving technologies such as high-yielding crop varieties or modern soil fertility management practices and development of forage technologies are complementary to food crops in land utilization and development of livestock markets enhance adoption of improved forage technologies [5].

Future extension activities and agencies promoting fattening package in agro-pastoral and pastoral areas, should focus on targeting agro-pastoral with low perception on the availability of better breed, information and demonstration on the improved management practices, revision of credit supply criteria, making awareness and demonstration of the significant importance of small ruminants in the agro-pastoral and pastoral income and livelihoods contribution is important [6].

The study by Mamaru and Tadele showed that educational qualification, marital status, income, and age contributed significantly to the farmers' adoption and use of livestock technologies. The study report by Bashe revealed that adoption probability of improved forages increases with family size and slope on topography of land, and decreases with total land holding and distance from farmers' home to farmers training centre [7,8].

The survey result pointed out that access to agricultural extension services, participation in forage training sessions and higher cash income had the greatest positive influence on adoption of forage technologies, while higher numbers of male adult labour units and use of fertilizers had a lesser effect. In contrast, farmers remote from offices of development agents and possessing greater numbers of equines were less likely to adopt improved forage technologies [9].

Bassa justified that the access to formal education, training and number of dairy cattle owned promoted positively the household choice to take part in adoption of improved forages; while access to communal land, access to market point and farmers training centre negatively affected the improved forage adoption probability.

The study report by Hassen indicated that the intensity of use of improved forage in the study area was influenced by labour available, size of livestock ownership and farm size. Physical characteristics like distance from farmers' home to all weather roads, markets and input supply played a critical role in the adoption of improved forage technologies [10,11].

Review on adoption of dairy technology in Ethiopia: The survey result by Habtamu indicated that that herd size, farmland size, dairy training, and cooperative membership had significant effects on cultivating improved forages. Dairy production system, dairying experience, and herd size were significantly associated with rearing only crossbred dairy cows. Farmland size, dairy system, and awareness of manure handling were significantly associated with practicing good manure management [12].

The empirical study results by Kebede indicated that there is strong evidence of interdependencies in adoption decisions of dairy technologies. The adoption of improved dairy breed technology affected by the size of livestock holdings (negatively) and household income (positively associated with technology adoption). In addition to these individual household heterogeneities, inefficiencies in input and output markets and underlying institutional and policy constraints appear to play critical in technology adoption decision of farmers. Kassahun also indicated that Provision of improved forage seeds and veterinary services to the dairy producing households and Training of milk producing households would play important role in the adoption of dairy technologies [13].

The survey result revealed that distance to artificial insemination centre affected the adoption decision negatively. Economic factors such as land, labour and income affected positively on the adoption decision. On other hands, frequency of extension visits and training on dairy management affects the adoption decision positively. The result also pointed out that credit services affect extent of adoption positively and distance to market, distance to veterinary services and family size affects negatively [14].

The results finding by Dehinenet revealed that family size, farming experience, availability of dairy production extension services, availability of cross breed cows, accessibility of saving institutions, total income from milk and milk products, availability of training on livestock, age of household head and off-farm activity participation played significant roles on both the probability of dairy technology adoption and its level of adoption [15].

Review on adoption of improved animal health technologies: The finding by Jemberu showed that adoption of improved food and moth controlling measures practices affected by perceived susceptibility, perceived benefit and perceived barrier. In turn, the predicting perceived barrier on vaccination control varied significantly with the production system and the age of farmers. The significant HBM perception predictors on herd isolation and animal movement restriction control were significantly influenced only by the type of production system [16].

Review on adoption of improved apiculture technologies: The study result by Gebremichael and Gebremedhin indicated that non-farm activity, farmers beekeeping experience, credit access, livestock holding, age, distance to all weather roads, market distance and frequency of extension contact played significant role in adoption decision and intensity of utilization of improved box honey bee hive. Workneh found that credit, knowledge, education level of household head, perception and visits to demonstrations positively and significantly influenced adoption of box hive [17,18].

Tamirat (2015) reported that the main determinants of improved honey bee hives include farmyard size, number of local hives beekeepers possessed, training provided, participation on demonstration, wealth status of beekeepers, and participation of beekeepers on nonfarm income sources [19].

Review on improved poultry technology adoption in Ethiopia: Teklemariam found that family size, gender of the household head, education status of the household head, livestock holding size, extension contact, availability of exotic chicken breed, distance to the nearest market and availability of training on poultry production played detrimental role on the probability of improved exotic poultry breed adoption [20].

The probability of adopting exotic chickens directly related to access to off-farm income and inversely related to livestock income. The level of improved chicken breeds utilization of negatively affected by being male household head and having a larger farm size and having livestock income [21].

The socioeconomic factors such as sex and family size and institutional factors including distance from road and town, management system, number of poultries sold per year in the market and access to training played determinate role in probability of improved poultry breed. The level of improved exotic poultry breeds adoption that measure in terms of chicken number found to be function of sex, distance from road, distance from town, management system, number of poultry sold, access to training and year of adoption significantly affected the intensity of adoption [1].

Methodology

Steps adopted in analyzing data in meta-analysis

Calculating standard error (SE): All SE can be derived from the formula $SE = \frac{\sum(x^{-} - \mu)}{\sqrt{n}}$ and also it was already estimated by reviewed article and it directly copied from the papers. The SE are can be also simplified derived equations for different types of studies. Since we are using rates, we can use $Wi = \frac{1}{\sqrt{\text{var}}} = \frac{1}{\sqrt{se^2}}$, where es is size effect and n number of subjects.

Computing variance (Var): This formula is simple: Var=SE^2. In Excel it was calculated by squaring the estimated standard error, Var=squarer of SE.

Computing individual study weights (w): We must weight each study with the inverse of its variance, so $Wi = \frac{1}{\sqrt{\text{var}}} = \frac{1}{\sqrt{se^2}}$

Computing each *weighted effect size* (w*es): This is computed multiplying each effect size that equals to coefficients by the study weight. Therefore $W_iY_i = W_i * Y_i$, where W_i is the weighted effect size and *Yi* the value of coefficients over study results.

Other necessary variables (w*es^2 and w^2 and M*): These two important variables estimated by just multiplying the calculated results. This is to mean that w*es and w^2. From these values the Mean size effect calculated by the formula.

$M^* = \frac{\sum Yw}{\sum w}$ where y is the value of coefficients and w is the weight.

Calculating variance, standard error and t value: The variance can be calculated by $\text{var} = \frac{1}{\sum w}$ and from this SE calculated by excel sheet $SE = SQRT(Varience) = SQRT\left(\frac{1}{\sum w}\right)$. To test its significance, the t value calculated by $t = \frac{M*}{SE}$

Empirical model: The adoption probability of the specific technology defined as function of sample size, model used, data type and year of publications. The mathematical expressions of defining the adoption rate function can be written as: $y = f(n, x_1, x_2, x_3)$

Where n is the sample size for the specific study, x_1 is the model type (defined as 1 if logit and 0 otherwise, x_2 is the year of the publications (labelled as 1 if the study undertaken after 2015 and 0 otherwise) x_3 referred to data category (labelled as 1 if cross-sectional and 0 otherwise).

The empirical model of the meta-analysis regressed using multiple linear regression procedure. The empirical model considered adoption rate of livestock technology as dependant variable and study region, model type used, livestock technology type used, study period, sample size as explanatory variables. The mathematical expression of livestock technology adoption rate (Y) as function of sample size, model type, region), technology type and study period written as: $y = f(x_1, x_2, x_3, x_4)$

Where x_1 referred to region (defined as 1 for Oromia and 0 other wise and it can further also defined as 1 for Oromiya,2 for amahara,3 for SNNPR,4 for Tigray and 5 for Benshangul-gumuz regions), x_2 for model type (defined 1 if logit and 0 otherwise), x_3 technology type (defined as if 1 for dairy technology,2 if forage technology,3 if poultry technology and 4 if apiculture technology), x_3 study period (that defined 1 for period 2015 to 2018) and 0 if it carried out back from 2014 to 2011) and x_4 stands for sample size.

Data source and description: The data sources were the published articles from Google. The technology types considered in livestock technologies were improved dairy breed, improved forage, improved poultry and Hive box. The published article study was carried out in five major regions of Ethiopia namely Oromia, Amhara, SNNPR, Tigray and Benishangul Regional States. The meta-analysis article directly browsed from internets and that carried out from 2011 up 2018.

Results and Discussion

Discussion and mean size effect of significant variables

The meta-analysis average size effect result indicated that the probability of improved livestock technologies is positive function of family size, market and main road distance, training and income. The result also showed that the probability and intensity of improved livestock technology is inverse function of age, gender and distance from extension service centres. Out of nine independent variables estimated mean size effect on adoption of livestock technology, seven found significantly affect the probability (Table 1).

Training accesses

The result indicated that access to training provokes the farmers to adopt improved livestock technology at their field. The result also supported by Simegnew and Bassa pointed out improving access to training accelerated the probability of household choice in the adoption of improved forages. The summary report reminds that the knowledge gap on the improved livestock technology has to be the policy area for farmers to be supported by respected stakeholders [1,10].

Variables	Mean size effect	Standard error	t-values
Family Size	0.09	0.02	3.96***
Gender	-0.37	0	-367.00***
Distance from main market	0.02	0	13.09***
Distance from extension	-0.01	0	-3.06***
Livestock Size	-0.02	0.01	-1.6
Training	0.07	0.02	3.91***
Age	-0.02	0.01	-2.10**
Income	0	0	8.90***
Land size	0.14	0.16	0.88

Table 1. Regression results of mean size effect on adoption rate.

Family size

The meta-analysis result indicated that the active labour force played significant and positive role in livestock technology adoption. The parameter estimate (0.087) indicated that ten unit increase in average family size, increase the probability of livestock technology adoption by 8.7%, holding other variables fixed. This implies that the probability of livestock improved technology choice supported by the labour force that used for land preparation for forages, adopting improved livestock feeding practices and better in husbandry practices, compared to the household that own less family size, holding other explanatory variables fixed. Similarly Abebe observed that relatively larger family size supports the technology adoption through land preparation and handover of the improved practices. The study result by Gebremedhin also justified that labour, land and other resources ownership promote adoption of improved forages crops in Ethiopian Highlands [5,9].

Gender

The analysis result showed that adoption probability is a negative function of being female. This indicates that male household heads adopted the livestock technology more than the counterpart, female headed households. Since male farmers more exposed to extension services, trainings and demonstration session, their probability to adopt the livestock technology, higher than that of female headed farmers, holding another variables constant. Wondmeneh also reported institutionally supported male farmers are better in adoption of improved livestock technology [21].

Market and main road distance

The estimated parameter implied that the livestock technology adoption related directly with market and main road distance. This is to mean that, the adopted farmer's major production is for subsistence not for market. More over proxy measure for market distance for the researchers also indicated the availability of measurement errors. In other way of interpreting, since the distance to the market can be measured in terms of km or walk hour, it could have incorrect information. If the researchers measure the distance in terms of walk hours it can have different value depending on the respondents age, transport means, health conditions of the land and waling time. If the distance measured in terms of km, the farmers' knowledge on the km expected to yield measurement errors.

Distance from extension centre

The parameter estimates implied that if the farmers house somewhat nearer to extension service centres, their level of adoption increases, holding another variables constant. The result pointed out that through expansion of demonstration and farmers training centres, it is possible to increase the probability of improved livestock technology transfer. Bashe also stated that there is indirect relationship between distance from extension centres and adoption probability [8].

Age

The result of estimate showed that as age increase, the farmers' choice of adoption of improved livestock technology decreases. Since the young farmers are more of active labour force category and challenged by land shortages, they prefer to adopt livestock technology in better manger, than the aged farmers, holding other variables constant. This also indicated that the through time, the probability of livestock technology expected to increase and that ease the adoption challenges if more supported by demonstrations and technical supports. This also supported by Dehinenet that pointed indicated age of household played significant roles on both the probability of dairy technology adoption [15].

Income

The meta-analysis results implied that adoption proportion of small-scale farmers with more income known to be the better adopter of improved livestock technologies. When income level increased for farmers, their level of adoption also increases, holding the other factors fixed. The study analysed from different articles, therefore pointed out that, through increased income, the producer's ability and need to improved technology increase and that accelerated the chance of using the best practices. The result is in line with Abebe, Kebebe, Wondmeneh and Dehinenet that expressed ability to earn more additional income for farmers provokes the household to choose of improved livestock technologies (Table 2). [2,9,15,21].

The extent of livestock technology adopted and used varies in the country. The livestock adoption study found in more proportion for improved dairy technology than other types (improved forage, poultry and apiculture).

The table indicated that out of total data used, Oromia region by its own accounted for 42.5% and the remaining regions (Amhara, Tigray and Benshanugl gumuz) accounts for 57.5%. This indicates that the level of livestock adoption study found different proportion across the region of the country (Table 3).

Discussions on regression results and its findings

The Table 4 indicated that the explanatory variable included in the regression explained about 54% variations on dependent variable. This is somewhat moderate and enough for further procedures (Tables 4-6).

Interpretation of Empirical model from regression

From five explanatory variables, three found to significantly affect the

Improved technology type adopted	Frequency	Percent	Cumulative percent
Improved forage	28	26.4	26.4
Improved dairy	36	34	61.3
Improved poultry	28	26.4	87.7
Improved hives	13	12.3	100
Total	106	100	

Table 2. Proportion of improved technology reviewed across regions in the country.

Study region	Frequency	Percent	Cumulative percent
Oromia	45	42.5	42.5
Amhara	31	29.2	71.7
SNNPR	10	9.4	81.1
Tigray	13	12.3	93.4
Benishangul-gumuz	7	6.6	100
Total	106	100	

Table 3. The regions of country where the systematic reviewed articles study done.

Model	R	R square	Adjusted R square	Std. error of the estimate	Durbin-Watson
1	.538[a]	0.289	0.254	16.1127	0.271

a. Predictors: (Constant), REGIONI, sample size, Model=1=logit, Technology Type 1if dairy, Data period=1 If after 2015

b. Dependent variable: adoption proportion

Table 4. Model summary.

Model	Sum of squares	Df	Mean square	F	Sig.
Regression	10561.786	5	2112.357	8.136	.000[b]
Residual	25962.019	100	259.62		
Total	36523.806	105			

a. Dependent Variable: adoption proportion

b. Predictors: (Constant), REGIONI, sample size, Model=1=logit, Technology Type 1 if dairy, Data period=1 If it done from 2015 to 2018 0 if it carried out from 2014 to 2011.

Table 5. Anova.

Coefficients	Unstandardized coefficients		Beta	T	Sig.
	B	Std. Error			
(Constant)	69.602	6.147	Std. Coef.		
Technology Type 1 if dairy	1.458	1.583	0.089	0.921	0.359
Model 1 if logit and 0 other wise	7.475**	3.662	0.199	2.041	0.044
Data period 1 If 2015-2018.	-21.778***	4.835	-0.552	-4.505	0
sample size	-.077***	0.02	-0.396	-3.835	0
Region defined as 1 if Oromiya and 0 otherwise	-2.239	4.03	-0.06	-0.556	0.58
The regressed output shows that variables are significant at (*) 1% and (**) 5% significance level respectively.					

Table 6. Coefficients of regression results of adoption proportion.

adoption proportion of livestock technology. The independent variable that owned positive association with adoption proportion value was model type. The amount of sample size and study period owned inverse relation with adoption proportion. The inverse relation between model type selected and adoption proportion is the probable availability of measurement errors, heterogeneity across sampled producers and study cases. In addition to these, the appropriate selection of model owned detrimental role over the value of regress and regressors that calls systematic and scientifically based model selection for scientific result outputs. The parameter estimates of sample size that assured the indirect relationship with adoption proportion value implied that their study articles indulged with measurement errors and related model specification bias. The inverse relation between years of study and adoption rate probability showed that the result of more technological scope wildness in current years than the years before four years ago. Since the newer and variety of technology that is not found in currents years than earlier years produced, the small-scale proportion of adoption decrease for fears of adaptability that expressed in risk aversion feature of farmers that the usual characteristics of the majority small-scale farmer that supported by unpredictable weather and rain fed farming system. More over there is higher environmental shocks and climate variability in more current years imposed negatively the adoption of livestock technology at country level.

Summary and Conclusion

The meta-analysis indicated that that the major livestock technology that better studied and complied and transferred to the farmer level comprised of improved dairy technology, forage, poultry and apiculture technology adoption. The meta-analysis result confirmed the existence of variability of interviewed farmers and socio-cultural and producers interviewed, measurement errors and heterogeneity of case studies come up with inverse relation of adoption rate to sample size and model type used. The indirect relationship between technology adoption rate and years of study period manifested the increment of technological option in current years than previous periods and farmers fears of risks that expressed as the risk aversion due to unpredictable environmental shocks, climate variability and poor tendency to be familiar with new livestock technology as usual. The other finding from meta-analysis indicated average size effect of income the probability of improved livestock technologies is positive function of family size, market and main road distance, training access and income and inverse function of function of age, gender and distance from extension service centres. From meta-analysis study the points summarized as it is indispensable to give due attention on checking inclusion of all necessary variable and not to commit omission of important variables from inception of proposals up to competing write-up of the paper. The mean size effect results also pointed out that through awareness creation, expansion of demonstration centres in the vicinity, creating income opportunity and gender mainstreaming will have detrimental role in farmer's choice and utilization of livestock technology.

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