Farmers' use of improved agricultural inputs and practices: review and synthesis of research in Ethiopia

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Abstract

Ethiopia's agriculture is typically subsistence, low input-low output, and rainfed. In the light of a renewed government strategy to use improved inputs and practices to enhance smallholder agricultural productivity and production, strengthening the evidence-base for the design and implementation of such a strategy becomes central. This paper reviews and synthesizes the findings of seven recent graduate theses researched in Ethiopia, and aims to identify underlying factors influencing the use of improved agricultural inputs among farmers. It shows that farmers' education strongly influences improved input use across activity areas. Smallholder farmers who used such inputs for commercial production of crops and livestock products are better able to assess market opportunities, have more assets and/or income, and have better access to extension services and credit. However a large number of factors that influence improved inputs use were technology or location specific. The evidence suggests that transforming subsistence, low input-low output agriculture into market-oriented, high input-high output agriculture entails diverse strategies including promoting cross-cutting factors like education, infrastructure and participation from women in agricultural development, and equally, targeting interventions like credit to the specific needs of farmers, their local contexts and technological attributes.

Key words: agricultural inputs, technology adoption use, IPMS, Ethiopia

1 Introduction

It is common knowledge that high-yielding varieties of seeds, the use of chemical fertilizers and pesticides, irrigation and improved planting and weeding practices provide higher yields than conventional technologies (UNCTAD, 2010). In recent years Ethiopia has shown a sustained increase in the use of improved inputs notably seed varieties and chemical fertilizer, and farm credit (Gebreselassie, 2006; EEA, 2006; FDRE, 2010). Despite this, improved input use in Ethiopia is still lower than that of many other countries. For example, chemical fertilizer use in Ethiopia was only three kg per hectare while the corresponding figures for Kenya and India were seven and 107 respectively (WB, 2007). Productivity levels of major Ethiopian crops and animals are therefore low, and agricultural value added per worker stands at a mere 56.6 per cent of the sub-Saharan average. Agriculture, the livelihood of 85 per cent of Ethiopians, contributes only 43 per cent of gross domestic product, often leaving millions of Ethiopians food insecure (WB, 2010; Belay and Abebaw, 2004). Successive Ethiopian governments have promoted technology-led initiatives to enhance productivity, particularly in smallholder agriculture (Gebreselassie, 2006; FDRE, 2010). Over the past two decades the government has been reforming the research and extension systems, and pursuing other relevant strategies such as irrigation, credit and allied services, to benefit farmers. Moreover, as part of its current Growth and Transformation Plan, it has renewed its commitment to increase agricultural production and productivity through a combination of strategies, including by focusing on high productive areas, high value crops, and farmers' increased use of improved inputs. It has also placed emphasis on smallholder agriculture commercialization (FDRE, 2010).

As will be shown in section two, studies in Ethiopia which explain factors holding up the use of improved inputs and practices are limited in number and scope. The last five years have, however, seen an increase in the number of adoption study theses by MSc graduates. The project 'Improving Productivity and Market Success' (IPMS), implemented by the International Livestock Research Institute on behalf of the Ethiopian Ministry of Agriculture and Rural Development, played a key part in sponsoring students. Primarily aimed at increasing the uptake and impact of technologies for smallholder farmers, IPMS was designed as a research-for-development project and has been implemented in ten Pilot Learning Woredas (districts) in

four regions since 2005 (see details in: http://www.ipms-ethiopia.org/default.asp). As part of the fulfillment for their master's degrees, students undertook empirical studies in the woredas. By early 2011 at least 60 had successfully defended their theses (see: http://www.ipms-ethiopia.org/Documents-Publications/Msc-Thesis.asp; Tesfaye *at al*. 2011) but the findings lack coherence, and are not readily useable in a policy-making processes. Based on seven successfully defended theses, the purpose of this paper is therefore to review and synthesize scattered evidence in theses related to factors influencing farmers' use of improved inputs and practices, and propose policy options to enhance the use of such inputs and practices.

The following section provides a brief review of the field of adoption studies, noting the relevant findings and limitations, and sets the context for the subsequent review and synthesis. It also outlines the review and synthesis methods used. Section three discusses the background to the theses including the agroecologies of the districts where the relevant technologies and practices were promoted. Section four reviews and discusses theses findings, section five synthesizes them, and section six provides the conclusions.

2. Factors influencing farmers adoption behaviour, and review and synthesis methods

There has been continued interest in studying and describing farmers' adoption behaviour (Feder *et*. *al*., 1985; Marra *et al*. 2003; Knowler and Bradshaw, 2007) but no simple answer has emerged as to the determinants. As Marra *et*. *al*. (*ibid*) note, one challenge has been that the voluminous theoretical and empirical literature on farmers' adoption behaviors tend to be static in nature, and are limited to the disciplinary backgrounds of researchers. Those in traditional sociology focus on the characteristics of potential adopters, opinion leaders, and attributes of innovations, while others such as economists and social geographers focus on variables such as prices, farm sizes and crop yields, and infrastructure. Economists mainly explain farmers' adoption decisions in terms of maximizing expected utility or expected profit, given such constraints as land, credit and labour, or employ dynamic models. Nonetheless many, for example Kelley *et*. *al*. (2003), suggest that improved agricultural inputs use can be positively influenced by government investment in agricultural research, extension, credit, and developing input delivery systems. On the other hand, factors such as inadequate information

or weak knowledge about the inputs or cost reasons limit adoption (see, for example, Nwankwo *et*. *al*. 2009).

Although limited in number, studies on Ethiopian farmers' use of improved inputs and practices focused on high yielding seeds such as maize and sorghum, and chemical fertilizers and herbicides (Howard *et*. *al*. ,2003, Wubeneh and Sanders, 2006, Dadi *et*. *al*.,2004, Feleke and Zegeye, 2006); and soil conservation and natural resource management practices (Asrat, *et*. *al*., 2010; Kassie *et*. *al*., 2009). Kassie *et*. *al*., (2009) found that farmers' decisions to adopt agricultural practices, among other things, depend on 'household endowments and access to information'. Farmers also appear to forego (short-term) income and yield for more environmentally sound and adaptable crop varieties (Asrat *et*. *al*., 2010). Results of adoption studies however do not always point in the same direction. For example, Dadi *et*. *al*., (2004) studied why some smallholder farmers in highland Ethiopia adopt new technologies (fertilizer and herbicide) sooner than others. They found that the length of time farmers wait before adoption is more influenced by economic incentives and returns but, unlike findings in other studies, farmers' characteristics (education, gender, age) appear to have had little or no effect on their adoption behavior (*ibid*, p. 613). Some researchers attribute low adoption to the predicaments of the extension system and its workforce, and mismatches between farmers' needs and technological attributes (Wale and Yalew, 2007; Belay and Abebaw, 2004). Wale and Yalew (*ibid*) noted that the extension system has been 'top-down', with limited participation of farmers and other stakeholders in needs and constraints assessment.

Turning to the seven theses, our approach was first to explore the IPMS theses repository (http://www.ipms-ethiopia.org/Documents-Publications/Msc-Thesis.asp) to select, review and synthesize them. Thesis selection focused on the timeliness and relevance of a policy-making theme. Also considered was the number of studies in a thematic area for reviewing and synthesizing. The repository produced relatively more (seven) studies on improved use of inputs and practices related to food and cash crops and animal production than, for example, feed resources development. As it happened all selected theses were conducted at Haramaya University (see: http://www.university-directory.eu/Ethiopia/Haramaya-University.html) – one of the oldest universities with an established tradition of teaching and research on agriculture

in Ethiopia (Belay and Abebaw, 2004). Second, following approaches in similar studies (see, for example, Knowler and Bradshaw, 2007) theses were grouped by technology focus, location, methods and results. Theses findings were then extracted and systematically organized by study and factors that seem to explain farmers' use of improved inputs.

3 Background to the graduate theses

To have any positive effect, technological applications must fit the biophysical and socioeconomic context. Chamberlin and Schmidt (2011: 12) note that, recognizing the importance of moisture, Ethiopian government's agricultural development strategies follow three zones: moisture reliable highlands, drought prone highlands, and pastoral lowland areas. Many including Chamberlin and Schmidt (*ibid*) also agree that *dega (*areas roughly between 2500-3000 meters above sea level (masl), and 1200 to 2200 mm annual rainfall) and w*eina dega (*areas between 1500 to 2500 masl, annual rainfall ranging from 800-1200 mm) are where most of the population and major agricultural activities are located. Spreading across the three zones, the graduate studies were conducted in seven districts of four regional states: Metema and Fogera (Amhara), Meisso (Oromia), Dale and Alaba (Southern Nations, Nationalities and Peoples Region (SNNPR), and Atsbi Womberta and Alamata (Tigray)(see below Table 1 and map).

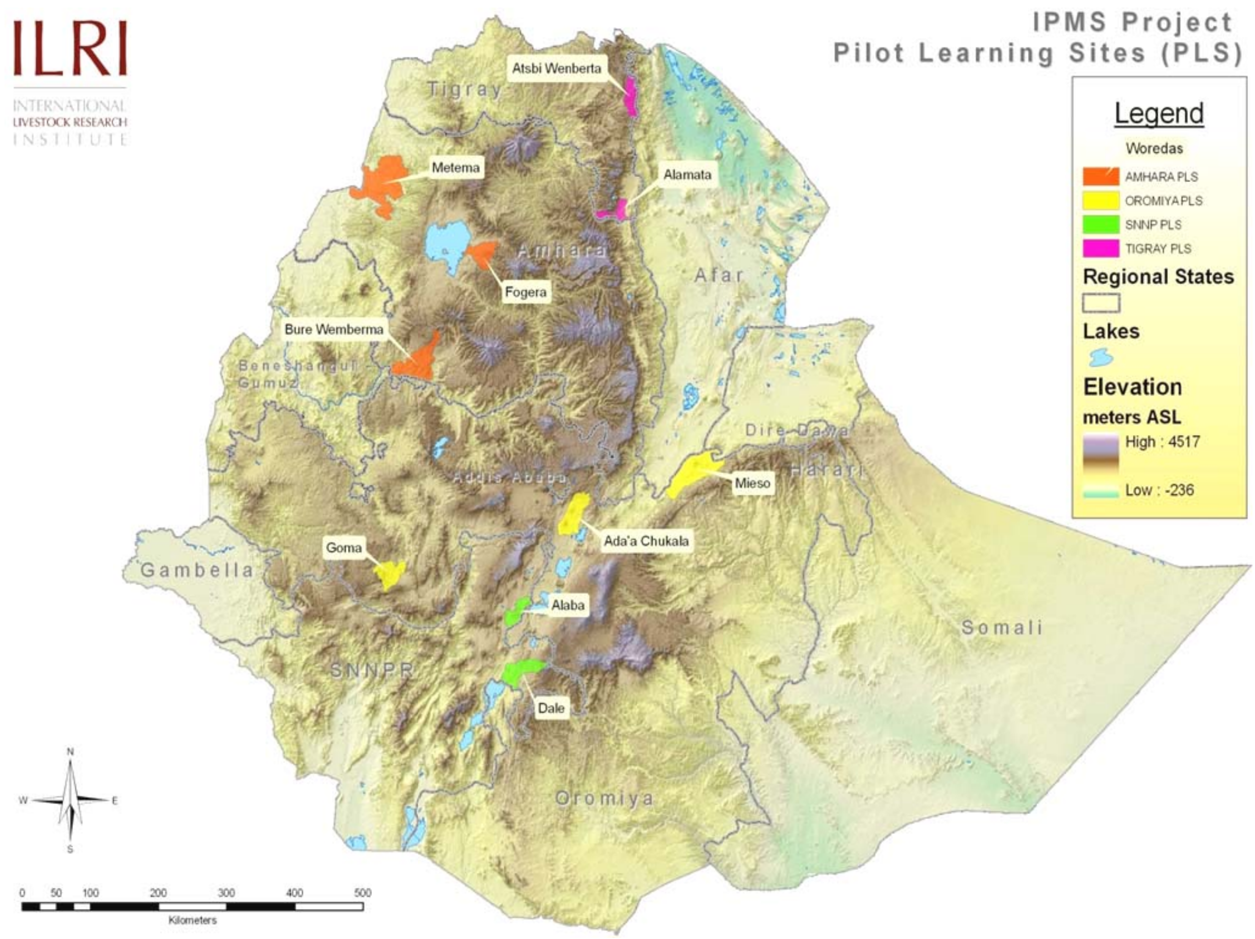
Metema is predominantly lowland with altitude ranging from 550 to 1608 masl and mean annual temperature of 31^0C[1]. Because of its expanse of arable land over the last two-three decades the district has been the focus of resettlement of farmers from drought affected highland areas. Driven by the desire to reduce food insecurity, improved varieties of sorghum seeds, chemical fertilizers, etc. have been promoted. Sorghum is the third (after *teff* and maize) widely cultivated crop in the country and it fits the Metema plains as it is drought tolerant relative to other cereals (Chamberlin and Schmidt, 2011). However, according to Dessalegn

[1] More information on the agro-ecological and socio-economic features of the districts is available at: http://www.ipms-ethiopia.org/default.asp.

(2008) settlers are said to face difficulties in adapting to the lowland agro-ecology and growing sorghum as opposed to highland crops such as *teff*. With altitude ranging from 1774 up to 2410 masl, Fogera district is mainly plain land. The area is favourable for growing a range of cash and staple crops and livestock rearing. The availability of irrigable farmlands adjacent to Lake Tana, market opportunities in regional and national markets provide the district with potential for onion cultivation (Taddesse, 2008). Meisso's altitude ranges between 1107 and 3106 masl with mean annual temperature of around 21^{o}c. Average annual rainfall is between 635 and 945 mm but the area is frequently affected by drought. As in many particularly low land areas of Ethiopia, in Miesso livestock are a major source of livelihood, and contribute to food and nutrition, income, crop production and soil fertility management, raw material for industry and export earnings. Small ruminants are more adapt to the needs of the poor as, at times of need, they are quicker to sell than cattle (Zelalem, 2007).

Table 1: Basic information about the studies

Type of improved inputs, practices or package studied by author	Location	Sample size (N = number of farmers) and methods
Dessalegn (2008): sorghum technologies (improved seeds, fertilizer, etc.).	Metema - Amhara	N = 160; methods: logistic regression; descriptive statistics
Mikinay (2008): commercial production of vegetables using spate irrigation	Alamata Tigray	N = 150; methods: logistic regression; descriptive statistics
Mulugeta (2009): old coffee stumping technologies	Dale - SNNPR	N = 160; methods: tobit models, descriptive statistics
Rahmeto (2007): improved seeds of haricot beans (with practices of seeding, spacing, and fertilizer application)	Alaba - SNNPR	N = 160; methods: tobit model; descriptive statistics
Taddesse (2008): improved varieties of onion with packages (of land preparation, weeding practices, fertilizer application, use of irrigation)	Fogera Amhara	N = 140; methods: tobit model; descriptive statistics
Workneh (2007): improved box hives	Atsbi Womberta - Tigray	N = 130; methods: logit model and descriptive statistics
Zelalem (2007):small ruminants fattening technologies and practices (feed, vet services, management practices)	Meisso - Oromia	N = 151; methods: tobit model and descriptive statistics



Source: IPMS

The altitude for Dale district ranges between 1170 and 3200 masl, and mean annual rainfall is 1314 mm. It grows crops like barley, *teff* and vegetables, and perennial crops such as *enset*, coffee and *chat*. Livestock are also an important source of livelihood. It is a high potential coffee area in the region and the country (Mulugeta, 2009). With altitude ranging from 1554 to 2149 masl, Alaba district also has suitable agricultural land for crop and livestock production but rainfall has been a major problem. Haricot beans are cash and protein source crops, and grown in central and low land parts of Ethiopia. The crops have domestic and export market potential (Rahmeto, 2007). Atsbi Womberta is mostly highland, altitude ranging between 2400 and 3000 masl, and has an average temperature of 18^0C. The climate is favourable for beekeeping as it supports vegetation and crops that are sources of nectar and pollen for honeybees. Ethiopia produces about 28,500 tons of honey annually, and it is a leading producer in Africa, with 23 and 2 per cent shares of Africa and the world respectively (Workneh, 2007). Alamata is largely

lowland, with 1500 masl altitude or below. It is a drought prone area but has potential underground water for irrigation, hence the government has been investing in water structures to boost irrigation farming including market-oriented vegetable production in the area (Mikinay, 2008).

Coffee, haricot beans, sorghum, honey, vegetables and small ruminants have importance in one or more areas as a source of food and nutrition, income and foreign exchange earnings, and employment. The theses highlight potential benefits from using improved inputs, for example, improved onion varieties yield from 2.5-3 tonnes per hectare as opposed to national average of 0.8 tonnes per hectare (Rahmeto, 2007); the national (annual) average for honey yield per traditional beehive is 5-7 kg can increase to 20-25 kg should farmers use improved box hive (Workneh, 2007), and on-farm income for adopters of onion technologies, on average, was *birr* 15 575 as opposed to non-adopters earning *birr* 9930 per year (Taddesse (2008). However the common challenge has been poor adoption of the relevant technologies and practices hence graduate students' motivations to investigate factors holding up adoption.

All the graduate studies followed fairly similar conceptual frameworks to show factors that seem to affect the use of improved inputs and practices. With the exception of Zelalem (2007) and Mulugeta (2009) who used adoption indices[2], researchers defined and measured dependent variables such as farmer's adoption of an improved technology or practice (as in Table 1 above) where the value 1 denoted adoption and 0 otherwise. Adoption (or non-adoption) of improved inputs were hypothesized to be influenced by a set of independent variables[3]:

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[2] Zelalem (2007) used three components of fattening packages, namely feed, veterinary services and management practices. Score values 1-5 were used to measure frequency (and intensity) of using each component (ranging from 1 = never used to 5 = regular use). Thus for all three components values ranging 3-15 were developed, where a farmer with a score value of 3 was classified as a non adopter but those with score values of 4 or more were classified as adopters. Mulugeta used a similar approach.

[3] Appendix 1 gives a brief guide to values and operational definitions.

- farmer and household characteristics (such as age, gender, education level, and family size).
- psychological factors (like attitudes to and perceptions of improved inputs).
- socio-economic factors (like farm size, number of livestock and income).
- institutional factors (credit, extension, and infrastructure like access to roads).

The hypotheses thus were that independent factors (like farmer's income) influence the use of improved inputs one way or another. The gender or social groups dimension of the studies is also worth mentioning. For example, Mikinay (2008) hypothesized that, unlike men who tend more to be in formal networks and employment, women are more connected in informal networks and self help groups like *ekub* and *edir*, and they tend to have less access to information and inputs. To generate evidence to allow the statistical testing of their respective hypotheses, the researchers used two staged sampling techniques whereby specific peasant associations from the respective woredas were selected, followed by a random selection of 130-160 farmers (see Table 1). They used multiple methods for capturing data including household surveys and focus group discussions. Principal analytical methods were tobit, logit or logistic regression models which were also supplemented by descriptive statistics and qualitative data analysis[4]. Before moving into the review we note that detecting potential methodological limitations such as multicolinearity was available to the researchers, but not to us, and the researchers noted that they had addressed them. Hence our review and synthesis below depend on their claims.

4 Factors that seem to influence improved inputs use: a review of theses findings

To facilitate the review and the subsequent synthesis, variables with potential influence on the use of improved inputs and practices which turned out to be statistically significant at least

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[4] Findings drawn from the descriptive statistics and qualitative data were found less amenable to the review and synthesis work, hence have only occasionally been used to discuss some of the econometric findings.

once, are listed in Table 2. We also adopted common labels for variables that seem to be measuring similar phenomena. Columns show variables tested per study, and a blank cell indicates a variable that has not been statistically tested. Regardless of the statistical tools used, variables that turned out to be either positively or negatively significant at 1, 5 and 10 percent (from most strong to least strong) are respectively denoted by 1%, 5% and 10%. Those variables that are negatively significant are marked with (-). Variables that are not statistically significant are denoted by (n/s). Columns also reveal the importance of certain factors to the adoption of a specific technology or practice. For example, in the case of beehive technology, farmer's education and knowledge, involvement in field visits, and availability of credit were crucial. Likewise technologies relevant to cash crop or high value commodity production (such as coffee and vegetables) clearly require favourable market conditions or positive perception of farmers about markets. In line with the objective of the paper, and also for brevity, below we analyze across study results.

(i) farmer and household characteristics

As predicted farmers' 'education level' was associated with the ability to obtain, understand, and use agricultural inputs and information. Better educated farmers had more contact with development agents, and served as demonstration farmers, increasing their use of improved inputs. According to Dessalegn (2008), however, better educated Metema farmers were more interested in cash crop technologies (such as sesame) as opposed to the staple crop sorghum technologies that were promoted. Dessalegn (2008) and Mikinay (2008) showed that married respondents had relatively more networks and better access to new technologies than unmarried, divorced or widowed farmers, as did those with many relatives and friends. Family size also had an impact – the larger the better. Descriptive statistics and qualitative data showed that male-headed households tend to use more improved inputs. This, according to Mikinay (*ibid*) is due to cultural barriers where female-headed households are less free to engage in formal networks and hence have limited access to improved inputs.

Both 'knowledge' – farmers' ability to access and understand information about improved inputs or the use of inputs, and occasionally, their 'experience' of an activity appear to have had a positive influence on improved input use - those with better knowledge and experience seem

to be more confident in applying it and minimising the risk of failure. For example, knowledge associated with activities of beekeeping has had a positive influence on adoption of the improved box hives. Likewise farmers whose current management practices (such as feeding and sheltering their animals) close to the recommended practices were found to be pro-change and experienced the benefits from previous practices (Zelalem, 2007). Many settlers who lived in Metema for over 15 years also chose to adopt technologies of more profitable cash crops and not sorghum (Dessalegn, 2008).

(ii) psychological factors

There seems a positive and statistically significant relationship between use of a technology and farmers' attitude towards it. Tamrat (2007) assessed the perceived effects of improved inputs in areas like body weight of animals, availability and affordability of inputs, and positive attitude to these pointers, seems to speed up acceptance and adoption. For Rahmeto (2007) perceived disadvantages related to high cost of inputs and low local demand for sorghum produce, and both seem to undermine the positive attributes of varieties of high yield potential and diseases and pests resistance. Mulugeta (2009) also noted that the majority of farmers who preferred not to adopt coffee stumping practices were concerned that stumping could kill the tree all together.

Table 2: Summary of results from seven studies on farmers' use of improved inputs and practices in Ethiopia

Variable (1)	Workneh (2007) box hive tech (2)	Mulugeta (2009) coffee tech (3)	Dessalegn (2008) sorghum tech (4)	Mikinay (2008) veg tech (5)	Rahmeto (2007) haricot beans tech (6)	Taddesse (2008) onion tech (7)	Zelalem (2007) fattening tech (8)
Farmer and household characteristics							
education	1%	1%	5%(-)	10%		5%	
marital status			5%	1%			
family size	n/s	n/s	1%				n/s
relatives and friends			1%	5%			
time spent in locality			1%(-)				
knowledge	1%				1%		
farming experience		n/s					5%
Psychological factors							
perception of technology	10%	n/s			1% (-)	1% (-)	10%
attitude towards technology					1%		
Socio-economic factors							
farmers perception of coffee oldness		1%					
access to (coffee) common lands		1%					
old coffee trees (area)		5%					
coffee seedling production		10%					
livestock keeping (TLU)		n/s			n/s		10%
labour shortage		1%					
farm income		n/s		1%			
Institutional factors							
participation in social groups		10%		n/s		n/s	
participation in co-operative society			5%			10%	
access to credit	1%		n/s		1%	10%	10% (-)
training	n/s	n/s				1%	
extension event participation		5%		10%	10%	5%	

participation in field days		**5%**					
visiting other farmers' apiary	**5%**						
contact with development agent				**5%**			
outside village orientation						**5%**	
village security							**10%**

(iii) farm size, labour, assets and income

The prediction was that, as inadequate farm sizes could limit adoption, farmers, for example, with larger coffee land would be more willing to stump the old plant, while still maintaining production. The study on use of coffee stumping did fit the expectation (Mulugeta, 2008). However in the rest of the studies farm sizes did not conclusively influence adoption as the inputs in question seem to be divisible and/or farmers seemed to have applied less than recommended amounts. Being a labour intensive activity, the availability of household or hired labour was strongly associated with the adoption of coffee stumping technologies. Regarding veterinary services, farmers with large number of herds (measured in tropical livestock units, TLU) seem to have accessed more credit than those with a small number of TLU. Farm income either positively influenced improved inputs use as inputs can be purchased with the income earned or for resources endowed farmers it did not matter.

(iv) institutional factors and infrastructure

'Participation in social groups' refers to famer's involvement in formal institutions such as village level administration and agricultural cooperatives, and informal networks such as community based self-help groups like *iqub* and *edir*. Farmer's engagement as an active member or in the leadership of those associations and groups, in turn, was expected to provide more exposure to new information that would inform decisions to use improved inputs. As cooperative societies are principal channels of information and input in many parts of rural Ethiopia, participation in cooperative societies had a positive influence on input access and use (Dessalegn, 2008; Taddesse, 2008). The position held by a participant in social groups also positively influenced adoption (Mulugeta, 2009) but participation in social groups *per se* did not

seem to have any influence on adoption. However the descriptive statistics and qualitative data (for example, in Dessalegn, 2008; and Mikinay, 2008) showed that relatives, friends and neighbours, as well as participation in cooperative societies, were important sources of information, mutual support and inputs like seeds.

Access to credit generally had a positive influence on the use of improved agricultural inputs as farmer's accessed seeds, fertilizers and other inputs on credit. Notably where the cost of inputs was the main constraint to adoption (such as improved beehives and irrigation technologies) credit played a key role in enhancing adoption (Workneh, 2009; Mikinay, 2008). But where farmers primarily purchased inputs within their own means credit did not matter to adoption. Zelalem (2007) reported that credit for vet services had a negative influence on the adoption of small ruminant fattening package as it was captured by farmers who kept relatively large ruminants. 'Extension services' when assessed without breakdowns into components like 'participation in field days' turned out to be statistically not significant due to the widespread misconception and weaknesses in delivering extension services. However, when extension was assessed by components it was positively related to using improved inputs and practices. For example, beekeepers were more likely to adopt improved box hives if they saw it working on a neighbouring farmer's backyard. Similarly, where farmer training was made relevant to an activity and adequate, it has had a positive influence on use but otherwise does not seem to have any effect.

(v) assessed but statistically not significant factors

Variables like gender, age and market distance were assessed in the majority of the studies but did not turn out to be statistically significant. However, descriptive statistics and qualitative data showed that, due to the prevailing view that farming in Ethiopia is 'a man's job', or given the constraints limiting women's time for participation, extension workers supported fewer women headed households (see, for example, Dessalegn, 2008; Mikinay, 2008). The variable 'age' showed no relationship with the use of improved inputs and practices, as both younger and older farmers seem to have tried out new ideas. Furthermore, in Metema longer-term settlers had more contact with the development agents, had accumulated assets, and better understood the agro-ecology of the area. But new settlers (and female-headed households)

barely accessed or used improved inputs as many of them did not think extension service solutions addressed their needs. Many of the relatively new settlers did not seem keen to stay in the area as their expectations of getting plots of land, oxen and housing were rarely met. Mikinay (2008) and others also reported some mistrust between farmers and extension workers for the latter's work appear to have been driven by meeting targets set in a 'top-down' fashion. Distance to nearby markets was hypothesized to have a negative influence on farmer access and use of inputs as it adds cost to purchasing inputs and/or selling produce and this was confirmed in descriptive statistics. Finally, in some of the studies descriptive statistics showed that information accessed via public media (notably radio) seems to have had a positive influence on farmer use of improved inputs for it gave more and relevant information. Other information channels (TV and newspapers) were rarely available to farmers.

5 A synthesis of factors influencing improved inputs use

Knowledge about determinants of adoption is believed to provide essential information into the speedy application of improved inputs and practices, and hence has been driving adoption studies. Results of adoption studies are also expected to support setting research priorities, focusing on technologies that farmers are taking up (see, for example, Batz et al. 2003). However, as Knowler and Bradshaw (2007) found, results from the seven theses reviewed showed ambiguities and inconsistencies, posing challenges to the generation of insights to policies on extension, research, farmers' education, and smallholder commercialization. As observed in a similar synthesis of adoption studies (*ibid*) there are at least two potential explanations for the differences and inconsistencies in results. The first set of differences could be due to the methods of statistical analysis employed. However, despite showing differences in the variables considered for assessment, the seven theses followed static models and fairly similar conceptual frameworks; hence 'methods' could not have been the main source of differences in results. Contextual factors provide more potent explanations for the differences in results.

With a view to generating insights into policy, Table 3 is constructed for nine variables with more than two incidences of being assessed and turned at least two statistically significant results. The frequency count has an obvious limitation as the studies are too few in number to

make any statistical conclusions but the tallying is used as a pointer to the cross-activity nature of variables.

(i) factor regularity and influence

A closer look at Table 3 shows that, first, some variables seem more frequently assessed than others – these include education, credit, and aspects of extension services. However the fact that a variable is frequently assessed does not necessarily lead to convergence towards a particular outcome (positive or otherwise). For example access to credit was assessed in five studies and was statistically significant in four (one of which was negative). Lack of convergence is consistent with previous studies. For example, Knowler and Bradshaw (2007: 38) showed that frequently assessed variables tend to show more mixed results. Second, although less frequently assessed, some variables like knowledge showed significant (and positive) association with use of improved inputs.

Table 3: Synthesis of factors that seem to be influencing inputs use

Variable	Significance		Insignificant	Total
	(+)	(-)		
access to credit	3	1	1	**5**
education	4	1	-	**5**
family size	1		3	**4**
extension event participation	4			**4**
perception of technology	1	2		**3**
relatives and friends	2			**2**
participation in co-operative society	2			**2**
knowledge	2			**2**
marital status	2			**2**

(ii) cross-cutting and contextual factors

Furthermore, Table 3 also reveals that, first, some factors that seem to be influencing adoption are cross-cutting in nature, and tend to be relevant to more than one locale, commodity or technology area. These factors include education, and market and infrastructure related variables. Second, some of the factors are however context-specific (locale/commodity or social group) – these include village/community context, technology characteristics such as farmer's

attitude or perception to a specific technology. The presence (or otherwise) of such a variable advances (or constrains) particular adoption. For example, factors like credit that appear to be assessed in some of studies have a context specific nature as their need depends on, for example, the nature of the technology or farmer's resource endowments.

(iii) policy implications

Based on the above characterization of factors, we outline two sets of policy options: first, promoting 'cross-cutting' factors such as farmer education regardless of the locale or commodity or social group specificities. Similarly, despite being not statistically significant, a gender-aware policy should also be promoted across the board as ample evidence from the theses showed that formal extension systems as well as cultural barriers prevent more women than men from accessing and using improved inputs and practices. Moreover, education, infrastructure such as roads, and gender appear to have a 'public good' or 'quasi public good' nature, or address social inequities - and the gains from promoting these factors are likely to generate additional benefits to adopting specific improved inputs and practices. For factors whose presence advances (or constrains) particular adoptions (like credit), interventions should be targeted at specific farmer conditions, locale or commodity and/or technology type. Here the message is essentially about understanding farmer characteristics (their human capital, assets, social networks, and perceptions and attitudes) and then targeting improved inputs to those characteristics. Technologies also need to fit the biophysical features of a locale. The extension system in particular should be strengthened to be able to work with farmers, jointly assess their needs and support them in adopting relevant improved inputs.

6. Conclusion and implications of synthesis work

This review and synthesis work was, like previous adoption studies, motivated by the underlying assumption that widespread use of effective and improved agricultural inputs and practices can boost agricultural productivity and production. Based on the graduate theses, this paper showed that a number of factors influence farmers' use of improved inputs and practices, however there were some ambiguities and inconsistencies about the results - which we argue are realities of human behavior. People are 'messy' to study and it is difficult to

determine regularity in behavior (Hazell and Wood, 2000:391). Indeed the results resonate with the comment Feder *et*. *al*. (1985: 256) made some 25 years ago: that farmers' adoption behavior differs across socio-economic groups and over time. The fact that many of the variables assessed were not consistently statistically significant mean that no blanket solution exists to determine farmers' use of improved inputs.

That said, from the evidence presented, we infer that smallholder farmers who have used improved inputs for commercial production of crops and animal produces were fairly educated and able to assess market opportunities, and have relatively more assets and/or income. They also had better access to extension services and credit. Farmers' education seems particularly relevant, cross-cutting activity areas and locales. However a large number of factors that influence improved input use were technology or location specific. Shifting a subsistence, low input-low output, and rainfed agriculture like Ethiopia's into a successful market-oriented one thus entails diverse strategies. First, the government should continue investing in cross-cutting areas such as education, infrastructure, and increasing women's participation in agricultural development. In particular policy should promote the provision of farmers' basic literacy and numeracy for, as Knight *et. al*. (2003) have shown, it not only benefits those with education but may also have external benefits. It makes farmers early adopters, who are also likely to be copied by others. Education is also likely to reduce risk averse behaviour as literate and numerate farmers are better positioned to 'receive, decode and understand information' (*ibid*, p. 2). Second, factors that influence adoption in a specific manner (target groups, technology type, location, etc.) should be tailored to suit the particular context or locale. For example, quality extension services and credit could be provided to farmers who need it. Further, the value chains in which smallholders participate many need to be organized to identify and exploit opportunities as well as address potential inefficiencies such as getting farm produces out to the market.

Constraints to adoption also appear interrelated. For example, incomplete information about a technology could adversely influences farmer's perception of a technology. Remedial solutions therefore should consider influencing factors in a holistic manner. Furthermore, 'social networks' seem attuned to the needs of smallholder (notably female-headed household)

farmers as they tend to be gender sensitive and mediate access to crucial inputs like credit – hence development actors need to exploit the strength of such networks in promoting improved input uses. However we warn against portraying 'social networks' as magic bullets. While important to smallholder farmers, social networks do not seem to have strong links to information sources outside of farmers' own communities, and any links farmers have within their own communities tend to reinforces traditional activities (Wall, 2007). That said, improving the productivity of (smallholder) agriculture is not all about technical solutions (Gebreselassie, 2006; Hazell and Wood, 2000). For example, famers' use of irrigation water depends on local institutional arrangements (and government policy) for access to water, hence the promotion of improved inputs and practices needs to be supported by enabling policies and institutions. Similarly, a strategy that promotes improved input use should also be coupled with demand side measures that sustainably increase per capita income, overall economic growth, and expanding and exploiting domestic and external market opportunities for smallholder farmers.

Finally, the graduate studies reviewed and synthesized here demonstrated possibilities for generating many kinds of relationships and significant results. Caution however must be exercised in interpreting the results - for example, better educated farmers did not adopt new sorghum varieties - not because they were uninformed but because they preferred to engage in cash crop production. Further, Tesfaye and colleagues (2011) noted that IPMS sponsorship involved students in 'demand-driven' research and learning in 'real-life settings'. That may be the case but we think that there is still a long way to go to make graduate studies more relevant to development. For a start, the theses reviewed and synthesized were more positivist in approach and more extractive, with the focus on theoretical merits rather than praxis. We suggest additional new lines of study that advance academic rigour as well as being relevant to development praxis. Such focus areas might include, or be in tune with, current thinking in such areas as agricultural commodities value chains and/or innovation processes.

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Annex 1: Brief operational definitions of key variables and value measures

Variable	Vale and brief operational definition
gender	0 = female,1 = male (or 1 = female,2 = male).
age	respondent's age.
education	formal schooling of respondents - 0 for 'illiterate' and 1 for 'read and write'. Or 1=illiterate, 2=functionally literate, 3=primary school, 4=secondary school and others..
marital status	1 = married, 2 = divorced, 3 = widowed, 4 never married.
family size	number of members of respondent's household.
relatives and friends	number of respondent's relatives and friends that they approach and interact with.
experience	number of years a respondent was engaged in the relevant activity(ies).
knowledge (of farming)	respondent's prior exposure to and understanding of relevant innovation – measurement ranging from very high = 5 to very low = 1.
farm size	total land holding (or land committed to specific use like growing coffee) measured in hectares (or *timad* where 4 *timads*=1 ha).
labour	continuous number.
income	measured in *birr* – Ethiopian currency unit, approx. 1US$=16.50 *birr* in 2011. Also (a) 'on-farm income'= annual farm income obtained from sale of farm produces, and (b) 'off-farm income' =income earned as hired labourer in off-farm activities, and (c) 'total income' = sum of (a) and (b).
livestock holding (TLU)	continuous number in tropical livestock unit (TLU), 1 TLU = 1 camel, 1.43 cattle, 10 sheep/goats, etc. (see, for example, Zelalem, 2007).
attitude towards technology	farmer's degree of liking or disliking of a technology or a practice - measured in scores of continuous number (see, Zelalem, 2007).
perception of technology	perceived advantages and disadvantages of a new technology or practice (like its benefits or costs). Measured using scales, for example, 1= very much true, 2= sometimes true, 3= undecided, 4= mostly incorrect and 5= not at all.
outside village orientation	frequency of visits a farmer made outside of own village. Such visits are expected to enhance exposure to external information.
time spent in the locality	number of years spent in the area (district) by the respondent.
participation in coop. society	respondent's membership in economically oriented cooperatives. Values take 1= member; 0 = not a member.
participation in social groups	respondent's involvement in formal and/or non-formal organizations, 0= never participated; 1 sometimes; and 2= regularly; also status of participation 1= member, 2= committee member, 3= leader).
access to credit	measured in *birr* but some researchers (like Taddesse, 2008) used value 1, if a person has access to credit and 0 otherwise.
market distance	measured in km (or working hrs to/from nearest road).
social security	1 if a farmer feels secure and 0 otherwise (mainly used to capture level of insecurity that sometimes arises duty conflicts over resources like grazing lands).
contact with extension agent	contact a farmer had with development/extension agents for advice. 1 = received extension service; and 0 otherwise. In Taddesse (2008) no contact = 0; once a week =1, twice a week = 2, only during planting season = 3, only during input distribution = 4, only during credit distribution = 5.

participation in extension event (field days, demonstration site, visits)	1 = yes to participation in field days, or visited apiary, etc. and 0 otherwise.
training	1 = yes to receiving training and 0 otherwise. Or the number of times a farmer participated in training during the last three years.