Utilisation of maize-legume intensified systems among smallholder farmers in Malawi

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Dedication

For my children, Rachel and Ian

You are a beautiful team!

To Tawina Jane, my wife

The one great thing!

To my father, Stanley Amon

Almighty God reveals

To Valines (Nyamnyirenda II), my mother

For your hard work and vision

Abstract

Investment in soil fertility over the past three decades in southern African maize based systems has brought many novel technologies on legume diversification but has seen minimal uptake by smallholder farmers. This thesis investigates the utilisation of maize-legume intensified systems among smallholder farmers in Malawi using a mixed methods approach across three study questions: (i) What is the role of land size and use orientation of legumes in maize-legume intensified systems?; (ii) What is farmers' motivation for integrating legumes only to a part of their maize area?, and; (iii) What factors affect women farmers' intentions to increase area under improved maize-legume integration?

A conceptual framework on legume diversification is developed from the Theory of Planned Behavior (TPB) to explain farmers' motivation and intentions. The framework demonstrates how goal-related outcomes from legume diversification can be influenced by farmers' attitudes, subjective norms and perceived behavioural control when they can make informed choices on legume diversification. Furthermore, a metric for benchmarking partial legume diversification is developed to estimate the degree of utilisation at farmer level. Both of these form the theoretical foundation of this thesis. Focus group discussions were then used to develop research questions on motivation and intentions. From this basis, structured questionnaires, focus group discussions and key informant interviews were used to explore the specific study questions. The quantitative data was subjected to regressions (zero-one beta and structural equation modeling), while the qualitative data was subjected to content analysis.

The research finds that land size and use orientation for legumes are important factors affecting amount of legume diversification. Women farmers allocate more maize area to legume diversification than male farmers due to land limitations. Therefore, women farmers are less likely to increase maize area under legume diversification unless they trade off some of their cropping land to diversify more legumes. This is demonstrated in the strength of their intentions to increase legume diversification. A positive correlation between perceived behavioural control and their intentions to increase legume diversification is due to independence in decision making. A long history of utilisation of legumes by women in Malawi has made many women food security gate keepers. Therefore, they have received knowledge about agronomic and food security benefits from legumes through socialisation within their families and communities primarily.

The research also finds that farmers are motivated to increase legume diversification by immediate expected cash income benefits from legumes and not by the benefit of combined yield gains from both maize and legumes arising from sustainable cropping environments. Furthermore, even though farmers generally hold positive attitudes towards legume diversification, their actual decisions on utilisation are influenced by obligations to extension services; expectation of incentives, and; social pressure within their communities.

This study shows a strong correlation (r^2 = - 0.6) between land size and the amount of legume diversification of maize systems, and recommends that extension messages be customised on the basis of a farm-size typology. It also shows that adoption decisions are more influenced by expected economic outcomes than the inherent value of soil fertility unless there is social pressure influencing the latter. Furthermore, in a bid to encourage farmers to host on-farm trials, extension workers influence diversion of subsidised farm inputs under national food security initiatives as incentives to farmers hosting on-farm trials. Generally some institutional rules in promotion of agricultural adoption are violated in such ways: overriding village nomination and endorsement of lead farmers; conferring preferential access to subsidised inputs given to on-farm trial hosts, and; by-passing deserving farmers in bulk marketing of legumes. Exclusion has discouraged participation of other farmers in on-farm trials and other extension modalities for legume diversification.

The thesis recommends that both ecological and economic benefits from improved maize-legume integration should be emphasized to farmers in the promotion of legume diversification. This should be supported with attention to institutions within extension modalities facilitating the promotion.

This thesis brings new insights into smallholder farmer decision making on legume diversification of maize systems. It demonstrates the importance of customising legume diversification technologies according to gender of the farmer as well as land size. In addition it reveals that adoption decisions on legume diversification of maize systems are influenced by the actions of organisations promoting these as well as farmers' obligations to the organisations and their social networks.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Penjani S. Kamanga

27 March 2018

List of publications

- Understanding smallholder farmers' utilisation of maize-legume intensified systems.
  Journal: The Journal of Agricultural Extension and Education;
  Status: submitted 23 March 2018

- Utilisation of doubled-up legume rotations in Malawi. Do land size and use orientation for legumes matter?
  Journal: Agricultural and Food Economics
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- Identifying factors influencing women farmers' intention to increase doubled-up legume rotations in Malawi.
  Journal: Rural Sociology
  Status: submitted 23 March 2018

- Understanding smallholder farmers' motivation for increasing doubled-up legume rotations in Malawi.
  Journal: International Journal of Agricultural Sustainability
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- How do institutions within agricultural extension modalities impact on utilisation of agricultural innovations? A case of maize-legume intensified systems from Malawi.
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List of abbreviations

AEDO	Agricultural Extension Development Officer
CA	Conservation Agriculture
CFA	Confirmatory Factor Analysis
CIMMYT	International Maize and Wheat Improvement Centre
DFLD	Decision Framework for Legume Diversification
DLR	Doubled-up legume rotations
DLRPOP	Proportion of maize area under doubled–up legume rotations
EFA	Exploratory Factor Analysis
EPA	Extension Planning Area
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farmer Field School
FGD	Focus Group Discussion
FISP	Farm Inputs Subsidy Program
FPR	Farmer Participatory Research
ha	Hectare
IAD	Institutional Analysis and Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
KII	Key Informant Interview
MLE	Maximum Likelihood Estimation
N	Nitrogen
SD	Standard Deviation
SEM	Structural Equation Modeling
TPB	Theory of Planned Behaviour
UM	Utility maximising

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Chapter One: Introduction - Legume underdiversified maize systems

1.1 Overview

Despite advances in agricultural innovations, many agrarian communities in sub Saharan Africa still cannot access adequate food due to low agricultural production (Fisher & Kandiwa, 2014; Juma et al., 2013; Pretty et al., 2011). In this region, smallholder farmers are slow to adopt improved agricultural practices and, when they do adopt, they do not fully intensify the utilisation of the innovation (Friedlander et al., 2013; Grabowski & Kerr, 2014). They may even discontinue the innovation (Oladele, 2006). In light of this situation, it is believed that institutional support and proper promotion and implementation of agricultural practices are needed to improve adoption of innovations to increase food security of smallholders in sub Saharan Africa (Juma et al., 2013; Mulugetta et al., 2011). However, some institutional support have contributed to minimal utilization of agricultural practices (Grabowski & Kerr, 2014). This shows complexity in understanding farmer behaviour hence requiring a variety of approaches (Willock et al., 1999). The overall objective of this research is to understand limited utilisation of maize-legume intensified systems among smallholder farmers in Malawi.

Some of the foundational literature on adoption assumes that utility is maximised largely by increased yield or farm cash incomes (Feder et al., 1985; Griliches, 1957). Early agricultural adoption studies were based on behavioural analytical approaches that reduced adoption to a binary classification of adopters and non-adopters. Furthermore, there has been a proliferation of farmer behavioural analyses employing econometric methods (Dill et al., 2015; Doss, 2006; Grabowski & Kerr, 2014; Knowler & Bradshaw, 2007; Mendola, 2007; Pedzisa et al., 2015; Shiferaw et al., 2009) that estimate adoption by varying it between those who utilise a technology and those who do not. To effectively apply these methods the theory of utility maximisation (UM) is applied.

The classical approach to explaining agricultural adoption assumes a farmer seeks to maximise utility from adoption of one or more technologies. The approach estimates the probability that a farmer takes up an agricultural technology, given personal, biophysical and institutional characteristics (Doss, 2003, 2006; Feder & Umali, 1993). One advantage of UM approaches is that a large number of farmers are reached in a short period of time. In addition, hypotheses are presented over standard economic assumptions, allowing easy replicability of methods. Nevertheless, there are no universal variables determining farmer behaviour under these assumptions (Knowler & Bradshaw, 2007). Relying on these approaches alone has not adequately explained farmer behaviour (Borges & Oude Lansink, 2016; Glover et al., 2016). Inadequate understanding of farmer decision making results in insufficient recommendations to policy makers in agricultural research and extension (Ervin & Ervin, 1982). One way to deal with this is to employ a variety of approaches to studying farmer behaviour (Willock et al., 1999).

In furthering our understanding of farmer behaviour, this thesis investigates utilisation of maize-legume intensified systems among smallholder farmers in Malawi from a backdrop of minimal utilization and slow uptake of agricultural innovations. It employs a mixed methods approach across three study objectives. The research is premised on utility maximising behaviour of the farmer (expected yield increase in maize and legumes as well as inherent value of soil fertility from legume diversification). It focuses on farmers' perceptions, attitudes and motivation as decision drivers. Analytical approaches used in this research include econometric, socio-cognitive modelling as well as content analysis.

Some words that appear in different contexts in this thesis are defined as follows: 'Adoption' is not referring to a situation where old technologies have been replaced as in 'full adoption' as characterised by (Rogers, 2003). Rather it is a state where a farmer is using the technology to any degree. Following Feder et al. (1985) the degree of utilisation is determined by the ratio of the area under the technology to the potential area where it can be applied. 'Legume diversification' is the interaction of legumes and cereals in improved intercrops and rotations for the purpose of building nutrient base for maize (Mhango et al., 2013). 'Maize-legume intensified systems' refer to the ultimate maize-based system integrated with legumes in a pattern that achieves ecological and economical sustainability. 'Female household heads' referred to in this thesis are de-facto considering temporary migration of spouses to towns and cities in search of alternative livelihoods to agriculture.

1.2. Research background

1.2.1 Improved maize-legume integration

Maize cultivation dominates the smallholder farming systems of southern Africa due to its staple nature. Small landholding sizes, low resource endowment and human population increase put smallholder food production systems in this region at the margin. Increased maize productivity can be achieved by utilising low cost sustainable agricultural practices (Pretty et al., 2011). Furthermore, farmers should adopt and increase utilisation of improved soil management technologies that directly increase their access to food (Smith et al., 2016). An example is doubled-up legume rotations (DLR), a novel legume diversification technology in maize-based systems. This technology involves intercrops of two legumes with complementary growth habits for two years followed by a maize rotation in the third year.

Picture A: A doubled-up legume of groundnuts *(Arachis hypogaea)* and pigeon pea *(Cajanus cajan)* (soure: www.africa-rising.net)

Otherwise farmers in southern Africa have for a long time interacted legumes with maize in different ways including legume-maize intercrops and legume-maize rotations as shown in pictures B, C D and E. Mixed cropping of cereals and legumes has mainly involved grain legumes due to their multiple uses of soil fertility replenishment, food and fodder (Nyende & Delve, 2004; Schulz et al., 2003; Waldman et al., 2016). This fits well where landholdings are small so that legume technologies do not deprive farmers of land for staples like maize (Snapp et al., 2010).

Most food produced by African subsistent farmers is cultivated on 2ha average (Cromwell & Winpenny, 1993). In regions where maize cropping systems are dominant, up to 70% of the cropped area is allocated to maize and the other area takes legumes, other cereals and roots. In addition a few farmers may grow cash crops such as tobacco and cotton (Snapp et al., 2002). The effect of small land sizes; nutrient deficient soils; changing climate and increasing population have held many populations at risk of deeper poverty and starvation. Many maize and legume innovations have received great attention by national governments because of their role in household food security in this region. In light of this, institutional support to promotion of legume diversification technologies is a standard practice.

Picture B: maize-soybean intercrop (source: Penjani Kamanga)

Picture C: maize-groundnuts intercrop (source: Penjani Kamanga)

Picture D: A soybean plot to be rotated with maize in the background in a succeeding season (source: Penjani Kamanga)

Picture E. A Bambara nuts *(Vigna subterranean)* plot to be rotated with maize in the background in a succeeding season (source: Penjani Kamanga)

1.3 Institutional support to improved maize-legume integration in Malawi

The staple nature of maize and the importance of legumes in human and animal diet in Malawi have influenced agricultural policies that enhance research and extension on maize and legume technologies including varietal development and agricultural practices (Chinsinga, 2004, 2011; Chirwa, 2005; Ricker-Gilbert et al., 2014). The national farm inputs subsidy program has been implemented since 2005 and it has always involved maize, legumes and mineral fertilisers to improve national food security and propel an agricultural-led economic growth (Dorward & Chirwa, 2011). In addition to provision of free legume seed and subsidised maize seed, the government has implemented participatory on farm research on maize and legume combinations nationwide through Malawi Maize Productivity Task Force and Agricultural Sector-wide Approach – support project.

Similar programs have been implemented by international agricultural research institutes and other development partners. This has not only increased legume seed availability but has also enabled many farmers intensify legumes in their maize systems. However, many farmers continue to underutilise these legumes despite their proven soil and nutritional benefits (Waldman et al., 2016). Previous research in southern Africa has attributed this underutilisation to lack of germplasm, limited landholdings, inadequate labour, ecological adaptability issues (Mhango et al., 2013) and an inadequate enabling environment such as low legume prices or uncertain markets (Giller et al., 2011; Thierfelder et al., 2012). But controlling for ecological factors and farmers' preferences suggests that uncertain markets and low legume prices are the most important constraints.

This study was set on a background that maize-legume intensified systems have been promoted by external agencies to help farmers achieve food security while maintaining ecological resilience. Legumes have also been part of maize cropping systems since settled agriculture was introduced in Africa. In addition, maize and legumes have culturally formed an important part of human diet and animal feed in the southern African region, where women take an important role in food production and home management (Kerr et al., 2007).

Women farmers who are female household heads have the most land and labour constraints in sub Saharan Africa (Doss, 2001; Geisler, 1993). This shows that they face different contextual and institutional challenges from male farmers to utilise agricultural technologies. From this discourse, this thesis also singles out female household heads as women farmers to understand which factors affect their intentions to increase utilisation of maize-legume intensified systems.

The overall research objective is explored through these three research questions:

1. What is the role of land size and use orientation for legumes in maize-legume intensified systems?
2. What is farmers' motivation for intensifying legumes only to a part of their maize area?
3. What factors affect women farmers' intentions to increase area under improved maize-legume integration?

These research questions have been explored through the following papers that also comprise the pillars of chapters 2-6 in this thesis:

a. Understanding smallholder farmers' utilisation of maize-legume intensified systems. (Literature and methods).
b. Utilisation of doubled-up legume rotations in Malawi. Does land size and use orientation for legumes matter? (Literature, methods & results).

c. Identifying factors influencing women farmers’ intentions to increase doubled-up legume rotations in Malawi (Results).
d. Understanding smallholder farmers’ motivation for increasing doubled-up legume rotations in Malawi? (Results)
e. How do institutions within agricultural extension modalities impact on the utilisation of agricultural innovations? A case of maize-legume intensified systems from Malawi (Results).

In summary, the research questions cover smallholder farmers’ motivation for improved maize-legume intensified systems from the perspective of environmental and economic goal-related outcomes. Since many agricultural practices have been promoted by external organisations including governments and international agricultural research institutes in Africa, the thesis has also looked at how farmers’ perceptions of institutions within extension modalities impact on farmers’ utilization of improved maize-legume intensified systems. In Malawi, as in most sub Saharan African countries, there is a strong sense of social capital among rural communities. Some farming decisions are bound to be made in respect of the people who are leaders or regarded highly, even though they may not be in the interest of individual farmers. This behaviour may result from social pressure or just moral obligations (Mzoughi, 2011; Njuki et al., 2008).

1.4 Research significance

Common approaches to understanding smallholder adoption of legume diversification technologies rely on enumeration of farmers using the technologies. This research has gone further to estimate the amount of utilisation at farmer level and used that to benchmark the meaning of minimal legume diversification. A metric for assessing the extent of utilisation of improved maize-legume intensified systems is thus developed as a legume integration index following (Waldman et al., 2016). It is given as a ratio of the area under improved maize-legume intensified systems to total maize area considering that many farmers only dedicate a part of their maize area to legume diversification technologies. In addition, the thesis concludes that messages on promotion of legume diversification should be customised with respect to land holding sizes and gender of the farmer. Social pressure within a realm of social capital and farmers’ obligations to organisations promoting agricultural technologies are some of the factors that this research has revealed to influence farmers' adoption decisions on legume diversification.

Research questions have been logically sequenced in the following thesis structure comprising chapters 1-7

1.5 Thesis structure

Chapter one provides the research background, the research objectives, the significance of the research, and the structure of the thesis.

Chapter 2 is a manuscript that develops a conceptual framework for understanding the minimal legume diversification of smallholder farmer maize systems in southern Africa. This concerns decision making processes and the motivation for those decisions. The study recognises that a lot of adoption literature is based on utility maximisation theories hence it is centred on economic rationality. Even though this takes into account some psychological factors like preferences and motivation, the analytical methods are different from those developed by psychologists in measuring the same psychological factors. Most importantly, socio-psychological analytical approaches provide a detailed measure of latent. One pertinent socio-cognitive theory is the Theory of Planned Behaviour (TPB) (Ajzen, 1991). In this theory, intentions represent behaviour and they are determined by three psychological factors referred to as constructs namely: attitude, subjective norm, and perceived behavioural control. These constructs are derived from behavioural, normative and control beliefs in relation to a behaviour under investigation. This manuscript presents one main part of the theoretical foundation of this thesis.

Chapter 3 is a manuscript estimating the probability that a farmer increases area under doubled-up legume rotations (DLR). It sets out by establishing a metric for estimating amount of legume diversification using a case of DLR. The metric is established based on maize area under improved maize-legume integration based on doubled-up legume rotations (DLR). It is determined by the proportion of the area under maize-legume integration to total maize area. The metric can also be used to record progression in amount of utilisation of an agricultural technology considering that many farmers generally take up agricultural technologies as trials and slowly increase the area for the technology. The metric is tested against household level factors and perception of superiority of DLR to other legume diversification technologies; use orientation for DLR legumes; perception of the level of fertility of maize area; and, past utilisation of other green manures to estimate the probability that a farmer increases area under DLR.

Zero-one beta regression is used in this task because the dependent variable was bound between 0 and 1 including the thresholds. This chapter further completes the theoretical foundations. Three major findings from this chapter are used in further investigation in chapters four and five: (i) farmers with relatively more cropping land dedicate smaller areas of maize for legume diversification; (ii) Women farmers are less likely to increase legume diversification; (iii) Farmers with relatively more land grow the same DLR legumes in sole cropping and have little attention to green manures. Because women farmers belonged to farmer typologies with the least land holding sizes, Chapter 4 particularly targeted women farmers to identify factors affecting intentions in increasing DLR.

Chapter 4 is a manuscript investigating factors affecting women farmers' intentions to increase improved doubled-up legume rotations. This comes from land limitations (Chapter 3) yet they are responsible for managing food crops in the homes. And due to their status as household heads, they have independence of decision making hence better placed to make cropland trade-offs if they have to. The Theory of Planned Behaviour is applied to test correlations between direct and indirect constructs relating to attitude, subjective norms, perceived behavioural control and intention. The results show that women farmers have a strong perception of competence in legume diversification of maize systems and they show strong intentions to increase DLR.

Chapter 5 is a manuscript presenting farmers' motivation for diversifying their maize systems with legumes. This is from a backdrop that farmers with larger land sizes relatively integrate less legumes in their maize area as found in Chapter 3. Therefore, this part of the study was developed to investigate farmers' motivation for partial utilisation of DLR. Following (Bergevoet et al., 2004) motivation for DLR was conceptualised as goal-related outcomes from DLR: legume diversified crop systems and increased farm cash incomes. A structural model was developed between these two goals and attitudes, subjective norms and perceived behavioural control on DLR. Findings showed that the goal-related outcome concerning improved legume diversified cropping systems was significantly influenced by attitudes and subjective norms. Whereas the goal-related outcome concerning increased farm cash incomes was significantly influenced by perceived behavioural control and attitudes. Further to this modeling, a probit analysis followed two years later to test the probability of increasing DLR using the goal-related outcomes as main variables.

The sample of farmers was divided between those who had increased area under DLR and those who had not or had reduced. The second analysis validates the influence of positive perception of the goal-related outcome concerning improved legume diversified cropping systems on the likelihood of increasing area under DLR. The results show that promotion of legume diversification technologies such as DLR should target fora with rich social networks. Social networks, social norms and influence of organisations promoting agricultural technologies led to Chapter 6. This chapter investigates farmers' perceptions of three agricultural extension modalities impacting the promotion of maize-legume intensified systems.

Chapter 6 is a manuscript investigating farmers' perceptions of institutions impacting the utilisation of maize-legume intensified systems in Malawi. This chapter looks at three extension modalities on promotion of legume diversification among smallholder farmers: on-farm trials; use of lead farmers and facilitation of legume marketing. Many on-farm trials come with inputs support to farmers hosting the trials. However extension workers have in some cases used farm inputs from some national farm inputs subsidy programs to encourage good management of the trial. This has led to antipathy in these situations hence threatened continued attention to consistent legume diversification. On use of lead farmers this work finds that lead farmers do not always have the correct information about integrating legume diversification with other maize innovations. They are also not approved by other farmers in their community particularly if extension workers influenced their identification. Legume marketing was facilitated by agents promoting legume diversification. Not all farmers accessed such a facility and did not sell most of legumes like soybean. This chapter marks the end of the manuscripts. Chapter 7 discusses the major findings and presents conclusions and recommendations.

Chapter seven discusses the major study findings by integrating the findings presented in Chapters 2- 6.
Figure 1.1 presents a logical sequence of the chapters.

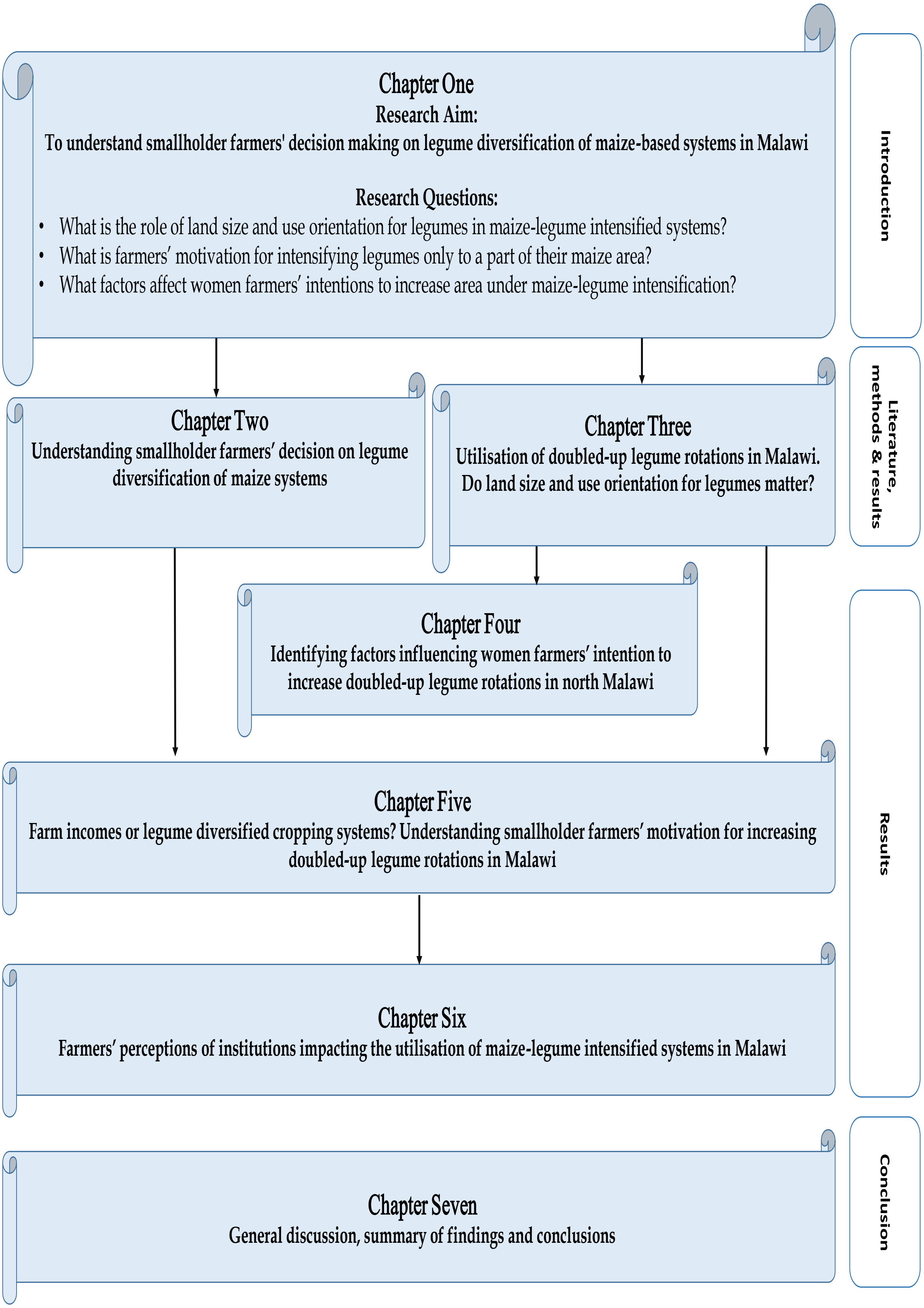

Figure 1.1 Sequence of chapters

1.6 References

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Chapter Two: Understanding smallholder farmers’ utilisation of maize-legume intensified systems

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Understanding smallholder farmers' utilisation of maize-legume intensified systems

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ABSTRACT

This paper proposes and tests a framework for analysing smallholder farmers' decisions on legume diversification of maize systems from a background of legume under diversification among smallholder farmers despite decades of research and promotion in Malawi. This is important for designing relevant strategies for technology diffusion as well as stimulating increased utilisation. The framework adapts two decision models: (i) the Theory of Planned Behaviour with a hypothesis that goal-related outcomes from utilisation of maize-legume intensified systems represent farmers' motivation; and (ii) the action situation of the Institutional Analysis and Development framework due to the influence on decision making arising from interactions between farmers and proponents of agricultural technologies. The framework is applied to data from 380 smallholder farmers diversifying legumes using doubled-up legume rotations in Malawi. Perceived benefits from legume diversification (attitudes) influence farmers' perceptions of goal-related outcomes concerning increased farm incomes, better soil health and crop diversity. Perception of institutions and social norms on legume diversification (subjective norms) under external support influenced goal-related outcomes dealing with soil health and crop diversity only. While perceived competence to manage legume diversification technologies (perceived behavioural control) only influenced the pursuit of increased farm incomes. The framework demonstrates that social pressure, incentives and moral obligations are some of the key factors raising positive perceptions on institutions and social norms regarding legume diversification. It identifies decision areas for stimulating increased utilisation of sustainable agricultural practices from the viewpoint that external agencies provide social spaces for farmers' interaction. This has implications on their commitment to adoption or continued utilisation of agricultural technologies.

Keywords: adoption; farmer behaviour; institutions; motivation; soil fertility.

1. Introduction

Low soil fertility due to many years of continuous maize cultivation is a barrier to increasing maize yields in southern African cropping systems (Snapp et al., 1998). Limited landholdings and general low resource endowment in this region suggest that maize productivity can only be increased through carefully managed low-cost sustainable production systems (Pretty et al., 2011). Rising fertilizer prices and varying climatic conditions over the past three decades in southern African region have led to the increased attention from national governments to low-cost sustainable agricultural practices such as legume diversification of maize-based systems (Ortega et al., 2016; Smith et al., 2016). In this paper we have shortened the description of the technology change that we are referring to — the interaction of legumes and cereals in improved intercrops and rotations for the purpose of building nutrient base for maize (Mhango et al., 2013)— to 'legume diversification'. This occurs because nitrogen fixing legumes that are incorporated into maize systems can improve soil fertility and soil organic matter through natural fixation and residue incorporation (Snapp et al., 2002).

Despite the positive role of legumes in rehabilitation of soils and improving food security, adoption remains low in southern African smallhoder maize-based systems (Mhango et al., 2013; Waldman et al., 2016). The adoption of legume diversification technologies have been limited to what may be considered trials for years. Explanation for low uptake of these technologies in southern Africa has been: minimal landholdings; low legume prices; thin markets for legumes; inadequate legume germplasm; high labour requirements, and; poorly adapted legume varieties (Giller et al., 2011; Grabowski & Kerr, 2014; Mhango et al., 2013; Snapp et al., 2002). This is against a backdrop that sustainable agricultural practices have environmental benefits and when consistently utilised, provide a long term solution to fighting food insecurity whilst achieving environmental sustainability (Pretty et al., 2011).

The purpose of this paper is to propose and test a framework for understanding how smallholder farmers' decision on the amount of legume diversification can be influenced. Doubled-up legume rotation (DLR) is an example of legume diversication technology that is used in the proposed framework. This technology involves intercrops of two legumes varieties that each have complementary phenology for two years and rotating them with maize in the third year (Kerr et al., 2007; Snapp et al., 1998). Typically pigeon pea has been used for 'doubling up' with soybean and groundnuts due to its long maturity characteristics and minimal competition for nutrients (Snapp et al., 2010).

2. Literature review

Before presenting the theoretical foundation for the proposed framework we discuss decision frameworks on environment related practices on farms. Ervin & Ervin (1982) were the first to develop a model that integrated personal, institutional, physical and economic factors to explain farmers' decisions on soil and water conservation practices. They observed that previous approaches leaned on particular disciplines and did not adequately inform U.S.A policy makers. Their approach centred on matching farmers' perception of the problem of soil erosion with effort on soil conservation effort. Perception of the degree of soil erosion; education; attitude towards risk; estimated cash gains to the farm, and; participation in conservation projects were positively associated with the amount of conservation effort. This study laid a foundation for farmer behavioural modelling on environmental management practices as it combined cost-benefit and attitude related models. Later scholars substantiated some of these findings by concluding that farmers' commitment to investment in soil erosion practices could be investigated using farm level and personal factors (e.g., Rahm & Huffman, 1984; Uri, 1997).

Ervin and Ervin (1982) conceptualised their decision model on a variety of soil conservation practices including cereal-legume rotations. Both of these and the later scholars cited above studied American farmers. It is important to also include literature from Africa, particularly conceptualising legume adoption in maize systems in this review. Haigis et al. (1998) proposed that smallholder farmer understanding utilisation of sustainable agricultural technologies should incorporate factors across biophysical (soils, rainfall patterns), technical (management requirements), institutional (input and output markets, extension services, land tenure) and sociological variables (gender issues, cultural values, prestige) and also expected farm incomes. Similarly Ojiem et al. (2006) noted that the poor adoption of legumes in Africa was due to lack of simultaneous address to constraints in biophysical, socio-economic and institutional environments. However, Schlecht et al. (2006) noted that such approaches were only identify knowledge gaps for further specific research in the areas proposed by the frameworks. These authors gave an account of various modelling that followed Haigis et al. (1998) ideas and identified their shortfalls. These are not presented in this literature review. In brief, the later models analysed by Haigis et al. (1998) show that adoption decisions are ultimately made regardless of proponents' evaluation of a technology or its bio-physical and economic characteristics as well as the existing institutional environment.

Further analysis on earlier agro-ecological models on soil fertility management showed that socio-economic factors were skipped and only became incorporated when it became apparent that potential benefits of environmental management practices were necessary to stimulate adoption (Ruben et al., 1998). Dent et al. (1995) had earlier argued that leaving out socio-economic component becomes complex in standardisation of factors in a farming system context with inconsistent preferences, and various beliefs of farmers and organisations. However, individual farmers' decisions are based on their resource endowments, farming goals and socio-economic environments (Stoorvogel et al., 1995). In addition, the decisions are influenced by friends, neighbours, family members as well as social networks (Dent et al., 1995).

From this literature three psychological variables stimulating utilisation of agricultural innovations can be identified: perception of risk, perception of benefits, and; obligation to agencies promoting agricultural innovations and to farmers' social networks. Since decision making lends itself to various socio-economic and psychological variables, a diversity in approaches to behavioural analysis (Willock et al., 1999) furthers our understanding of factors affecting agricultural adoption. Socio-psychological analytical methods provide more detailed measures of psychological factors like perceptions, attitudes, intentions and even motivation. These approaches provide alternative explanations to utility maximisation, which has informed an array of agricultural adoption since the analysis of diffusion of hybrid corn in the U.S.A by Griliches (1957). This paper proceeds as follows: theory, framework development, case study and conclusion.

3. Theoretical foundation

The view that farmers adopt agricultural innovations to improve farm productivity and farm incomes (Rahm & Huffman, 1984) has influenced farmer behavioural analytical approaches that put economic rationality at the centre of decision making (Doss, 2006; Feder et al., 1985). However, by only emphasising on the opportunity cost of not taking up an agricultural innovation other behavioural influences are overlooked (Borges et al., 2015). For example, adoption decisions may be influenced by obligations to organisations promoting agricultural practices (Mutenje et al., 2016). In addition, they may be influenced by perceived benefits from adoption. However, these benefits have often been perceived differently between farmers and proponents of agricultural technologies (Borges et al., 2015). Due to this, some farmers have only minimally utilised the technologies or even abandoned them (Graham & Vance, 2003).

Lastly, adoption decisions are affected by resource endowment as commonly held in the random utility framework. With this background we seek to demonstrate how farmer behaviour may be explained by drawing insights from the Theory of Planned Behavviour (TPB) and the action situation of the Institutional Analysis and Development framework (IAD). The TPB demonstrates the influence of personal, sociocultural, and control factors on decision making. The IAD framework demonstrates the influence of formal and informal institutions within decision situations.

The assumption of economic rationality has been fundamental both in large scale market-oriented farming (Feder et al., 1985) and in smallholder subsistent farming (Juma et al., 2013; Pretty et al., 2011) under utility maximising theories. However, it is inadequate to explain all of what influences decision making in smallholder farming context (Juma et al., 2013; Umar, 2014). Other aspects of human behaviour arise from motives that may be perceived irrational by others (Vanclay & Lawrence, 1994), such as social pressure or moral obligations (Mzoughi, 2011). Therefore, adapting theories dealing in multiple drivers of behaviour enables us to explain other factors that may influence farmer decision-making than perceived economic gains.

One of the behavioural theories describing volitional human behaviour is the Theory of Planned Behaviour (TPB) (Ajzen, 1991). This is a socio-psychological theory that has evolved from the Theory of Reasoned Action (Fishbein & Ajzen, 1975). It explains a person's behaviour whether rational or not, in terms of their attitudes, perception of social norms and perception of control on the intended behaviour. These three constructs are estimated through expectance-value based judgement enquiry. The TPB accounts for constraints to accomplishing a behaviour. Due to this element it overlaps with utility maximising theories (Borges et al., 2015). The components of the TPB touch on the key areas affecting farmers' decision making on agricultural practices that have been summarised in the literature review in section *one*.

3.1. The Theory of Planned Behaviour (TPB)

Behavioural intentions are determined by attitudes; subjective norms or social pressure; and perception of control on implementation of behavioural tasks (Ajzen, 2011), Figure 1 is a schematic presentation of the TPB.

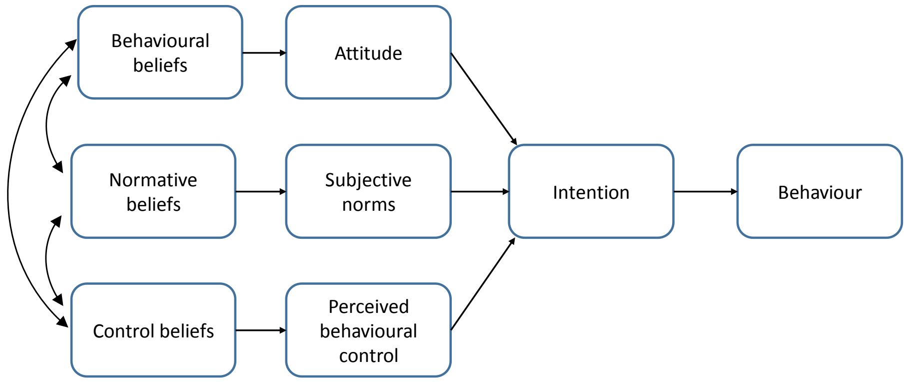

Figure 1. The Theory of Planned Behaviour (Adapted from Ajzen, 2005)

Attitudes are an evaluation of behavioural task beliefs (Ajzen, 1991). The fact that attitudes are a person's subjective evaluation of a behavioural task demonstrates the overlap between expectancy-value and utility maximising theories (Läpple & Kelley, 2013). Subjective norms are an individual's beliefs of: (i) whether or not people highly regarded would approve a behavioural task; and (ii) how these people would behave in regard to that task. The beliefs are weighted against the individual's motivation to comply with the opinions of those they regard highly (Ajzen, 2011). In the context of African smallholder farming, the people that may be highly regarded are: model farmers; agricultural extension workers; and, council or traditional leaders. One can argue that subjective norms are closely linked with perception of institutions on promotion of agricultural innovations. This is because subjective norms may be influenced by both the support given to farmers to facilitate the attainment of objectives of those innovations (Pretty et al., 2011) and the lack of it (Ojiem et al., 2006).

Perceived behavioural control refers to the strength of belief in the ability to perform a behaviour (Ajzen, 1991). It is based on perception of abilities, skills, environmental factors and access to resources for converting an intention to behaviour (Chatzisarantis & Biddle, 1998). For example, a person with a strong positive attitude towards a behaviour yet weak self-efficacy and inadequate resources will have a weak behavioural intention (Miller, 2005).

3.2. How institutions may influence utilisation of agricultural practices

Institutions as defined in this paper mean "… enduring regularities of human action in situations structured by rules, norms, and shared strategies, as well as by the physical world" (Crawford & Ostrom, 1995, p.582). These are revealed through institutional arrangements such as policies and strategies governing interactions between people and also between people and organisations in pursuit of individual or shared goals.

Institutional arrangements are common in promotion of agricultural innovations. In Africa they have operationalised farm-trials; distribution of farm inputs; farmer trainings; and even advocacy on farm produce prices. Institutions are embedded in these programs to enhance coordination and networking between farmers and agricultural organisations to achieve some set objectives (see Pretty et al., 2011). Termination of such coordination and networks impacts on utilisation of agricultural technologies following loss of attachment or obligations (see Ojiem et al., 2006). Therefore, understanding farmers' evaluation of institutions on an agricultural innovation should reveal some insights into their adoption decisions. Subsequently, this affects their subjective norms on the innovation. This makes the analytical steps in the action situation of the IAD framework (Figure 2) relevant. The IAD is a multidisciplinary framework that was developed for analysing people's behaviour regarding common pool resources such as forestry and fisheries, but it has been adapted to different social areas including public services and governance (Polski & Ostrom, 1999). Through its methodology we can understand the impact of both formal and informal rules on farmers' actions.

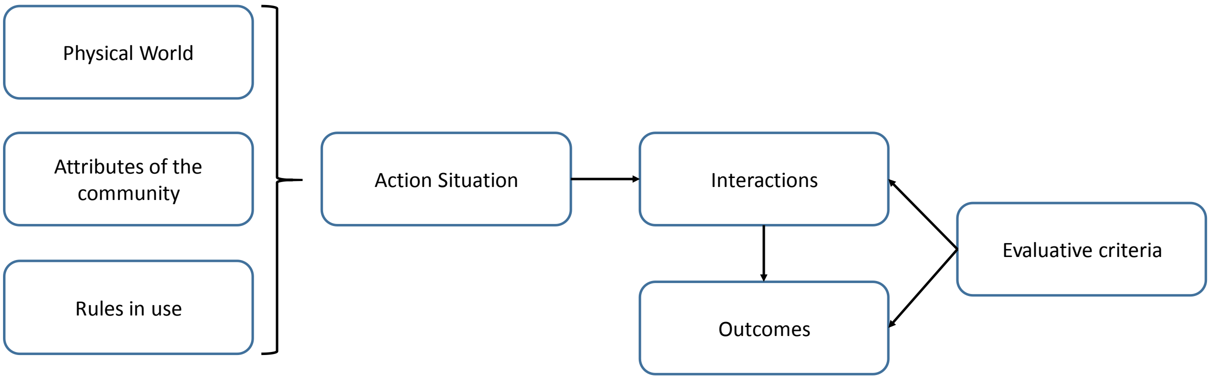

Figure 2. Institutional Analysis and Development Framework (adapted from Ostrom et al., 1994)

The focal area of the IAD framework is the 'Action Situation'[3]. People interact in various ways to attain desirable outcomes from utilisation of a resource or a program. This depends on individuals' or groups' perception of benefits and costs from within the: physical world; community, and; rules-in use (Polski & Ostrom, 1999). The evaluative criteria of the action situation starts from understanding the patterns of interaction among individuals and also between individuals and organisations that have a stake in the activities of the individuals relating to particular behaviour (Ostrom, 2011). This evaluative criteria determines the direction of action of an individual in terms of negative or positive.

To contextualise the action situation of the IAD framework in smallholder farming, we illustrate its three basic components. The 'physical world' constitutes organisations, research institutes, farmers, agro-dealers, farms, and climatic conditions. The 'attributes of the community' are the characteristics of farmers that can be identified in relation to the focus of a study (e.g. smallholders, women farmers or young farmers, or maize and legume farmers). Finally, 'rules-in-use' may concern criteria for: accessing farm inputs; accessing information on prices; selection of participants for trials; selection of participants for marketing of agricultural produce, and; mode of operation (e.g. using farmer cooperatives). Rules-in-use may not always be written in any document but generally comprise the dos and don'ts that depict shared norms and operational strategies from which people behave in a certain way, usually to achieve both shared and individual goals (Ostrom, 2009). Through finding ways to achieve individual goals variations in adherence to institutions can be observed. Therefore, studying individual response to institutions leads to understanding aggregated response from a group - in this case smallholder legume diversification farmers.

In this adaptation the action situation concerns the management of an agricultural practice to achieve identified objectives as suggested in the physical world by its proponents and also by the farmers. Patterns of interaction could concern activities for: improving soil fertility; raising farm productivity, or; raising farm incomes. Outcomes from the interactions can be: improved soils; food-secure households; improved nutrition; improved marketing of agricultural produce; expansion of agricultural land; establishment of farmer cooperatives, and; increased production of certain crops and their complements. During interactions individual participants

[3] A detailed description and illustration of the action situation is given by (Ostrom, 2011).

may make independent decisions on whether and how to obey the institutions and they react positively where an institutional arrangement is perceived favourable (Ostrom, 2011).

Institutional changes have been proposed to promote utilisation of agricultural practices including in agricultural credit administration; agricultural extension services and agricultural marketing services (e.g., Gowing & Palmer, 2008). They have also been used to stimulate adoption (e.g., Dent et al., 1995; Haigis et al., 1998; Ojiem et al., 2006). One area in which such change is implied concerns general operations. Institutions may impact differently on resource allocation decisions between farmers directly participating in activities within the institutional arrangement and those not. The next section presents a decision framework for legume diversification adapted from the TPB with insights from the action situation of the IAD framework.

3.3. A decision framework for legume diversification

Following the TPB, a farmer's decision on resources to allocate to an agricultural practice, which is the amount of utilisation can be explained by factors that influence their behavioural intention. The stronger the behavioural intention predictors the stronger the likelihood of behavioural prediction. Following a causal relationship between motivation and behaviour in Self-Determination Theory (see Deci & Ryan, 1985) and the similarity between behavioural intention and behaviour (Ajzen, 1991), motivation for the behavioural intention can be presented as goals sought from undertaking a behaviour (Bergevoet et al., 2004). Therefore, to understand an active behaviour we present the behavioural intention as goal-related outcomes from legume diversification. The goals mediate behavioural intention predictors and the behaviour. The behaviour is expressed as decision on size of maize area under legume diversification in the framework shown in Figure 3.

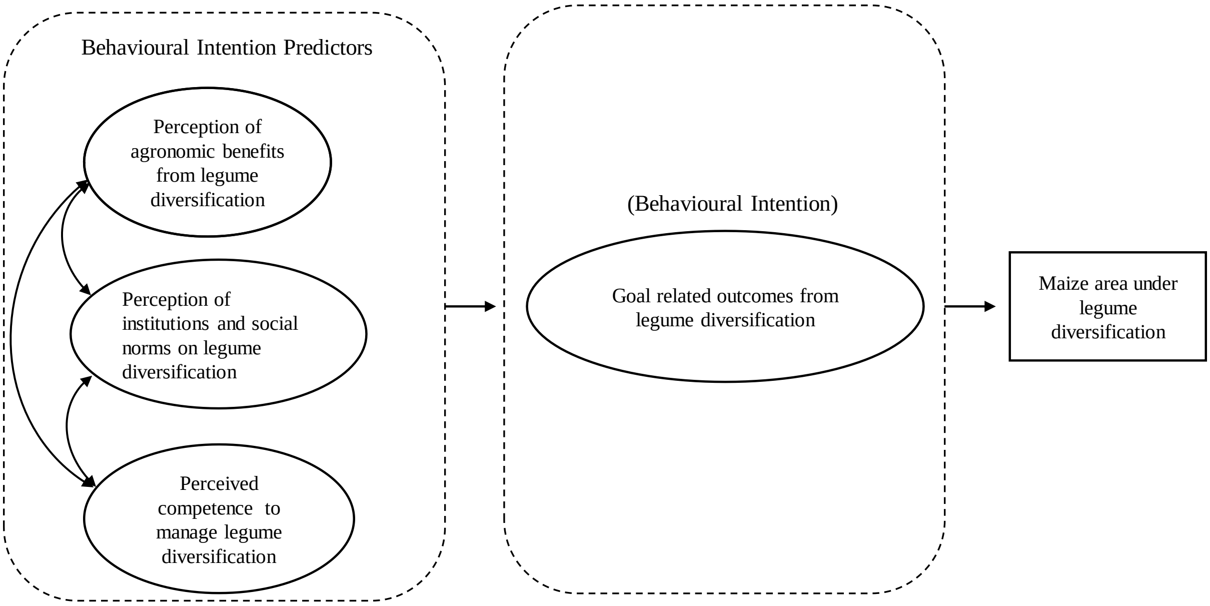

Figure 3. A decision framework on legume diversification (Adapted from TPB and IAD)

The decision framework serves to show that behavioural intention predictors of the TPB modelled on legume diversification behaviour, influence farmers' pursuit of goal-related outcomes from legume diversification of their maize systems. To contextualise this, we have adapted the behavioural intention predictors in structural equations with farmers' goal-related outcomes from legume diversification following a behavioural modeling by Bergevoet et al. (2004). The behavioural intention predictors are discussed with legume production-related literature.

Even though farmers perceive benefits from legume diversification including soil attributes and food, reduced diversification may follow where farmers switch to other crop enterprises to respond to a market opportunity. For example, when smallholder farmers were allowed to grow tobacco in Zimbabwe, land on which women grew legumes reduced (Muchena, 1994). This was because male family members, notably husbands took over control of bigger cropping land to cultivate tobacco while the land remained a family capital. This does open gender debates on access to production resources by women. But in this perspective we consider that a farm family goal of increasing farm incomes was pursued except it was at the expense of legume production. In this regard, discontinued or declined utilisation of an agricultural innovation may result from increased opportunities for improvement of agricultural livelihoods.

A second scenario where perceived benefits from legume diversification would influence behavioural intention is where farmers fail to make use of extra grains that follow increased legume diversification, particularly on those legumes seldom consumed in the homes. The primary objective of legume diversification as identified by its proponents is to improve soil fertility in order to improve cereal yields. This is possible when improved ways of integrating maize and legumes are followed and legume cultivation is increased. However, increased legume production has faced a problem of uncertain (Giller et al., 2011; Thierfelder et al., 2013) and imperfect agricultural markets (Mutenje et al., 2016) in many in southern African countries.

Unsatisfactory market prices negatively impact farmers' perception of enterprise viability. Subsequently, utilisation of agricultural practices in those enterprises declines too unless there are external agencies encouraging farmers to select those enterprises. In which case this may be facilitated through some institutional arrangements on marketing such as establishment of farmer cooperatives for effective market links between farmers and buyers (Pretty et al., 2011). Institutions and social norms on utilisation of a legume diversification technology under external support comprise the subjective norms. Further to influence of this is farmers' expectations of incentives or other support from engaging with external agencies promoting agricultural development. For example, lack of incentives to utilisation of agricultural practices in Tanzania saw most farmers abandon agricultural practices when some agricultural projects phased out (Maguzu & Recoda, 2013).

Lastly, perceived competence for legume diversification concerns access to production resources to enable continued utilisation. Farmers have control over resources that they directly access unlike those which they only expect such as gifts, remittances, or farm inputs subsidies. Therefore, farmers may only minimally or even intermittently practice legume diversification if they rely on other sources of inputs than their own.

We have illustrated the three core areas of behavioural intention predictors (attitude, subjective norms and perceived behavioural control) customised to legume diversification. An exploratory case study is presented to test the decision framework on legume diversification among smallholder farmers.

4. A case study on legume diversification technology from Mzimba, Malawi

4.1. Study context and sample

The purpose of this case study is to test the hypotheses of the proposed farmer's decision framework on legume diversification. Fieldwork for the study was carried out in Ekwendeni watershed in Mzimba district in Malawi (Figure 4) between February and May 2015. The study district was purposefully sampled following a farmer participatory research under a legumes best bets project established in 1998 called Soils, Food and Healthy Communities (SFHC project). Sampled farmers were utilising various legume diversification technologies in their maize systems. Of particular interest to this study was the DLR technology, which has been described briefly in section *one*. The SFHC project in conjunction with government extension workers supplied free legume seeds and advisory services to farmers and by 2010 over 2000 farmers had been reached in the pilot area of Ekwendeni watershed.

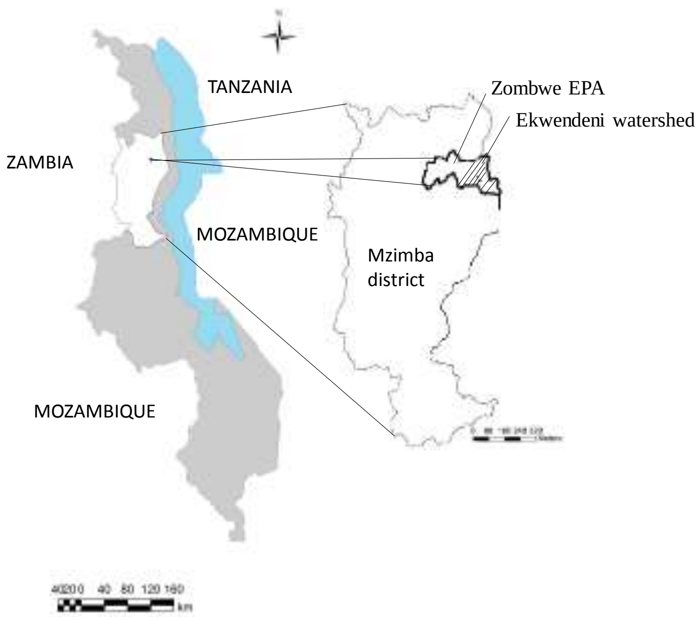

Figure 4. Map of Malawi showing Mzimba district and location of study villages

The study purpose was explained to village leaders to notify their subjects before identifying study farmers. Individual consent to take part in the study was sought from participating farmers themselves on the day of data collection. Using simple random sampling technique 390 farmers were sampled from 12 villages as shown in Table 1.

Table 1. Study villages and sample

Name of village	Number of farmers	Number utilising DLR	Number sampled
Mthakopoli Longwe	61	50	33
Hezekiah Longwe	57	57	33
Robert Mseteka	47	47	34
Chinombo Jere	51	51	32
Kaputa Longwe	63	58	32
Yesaya Jere	61	61	32
George Jere	58	43	32
Bandawe Tembo	42	42	32
Mwiza Tembo	64	49	33
Zimoni Jere	56	53	32
Sambo	48	48	32
Robert Ngwira	64	56	33
Total	672	615	390

4.2. Data collection methods

Following standard practice in implementation of a TPB questionnaire, elicitation for key questions was done through focus group discussions (FGDs) with 30 farmers from three villages. Responses from the FGDs were shortlisted for a household questionnaire and were based on questions that targeted (i) farmers' attitudes, subjective norms and perceived behavioural control on legume diversification technologies and (ii) perceived goals from legume diversification of maize systems. Consistent with importance of legume diversification three groups of goals from legume diversification were identified as; soil health, crop diversification and farm incomes as presented in Appendix Table A1.

4.3. Data analysis

Data were cleaned in MS excel and 10 questionnaires were removed from the sample due to inconsistencies in responses. Maximum likelihood Estimation (MLE) of Structural Equation Modelling (SEM) was used to analyse the data. This was done with Promax rotation to allow correlation between factors (Lowry & Gaskin, 2014). Structural equations can estimate the relative influence of constructs that are explained by the same factor (Borges & Oude Lansink, 2016). Furthermore, they test complex relationships between observed and unobserved (latent) variables (Lowry & Gaskin, 2014).

The structural component of the framework was tested in two-steps. Firstly, an Exploratory Factor Analysis (EFA) to identify the underlying relationships between measured variables and secondly, a Confirmatory Factor Analysis (CFA), to test whether the data fit the hypothesised measurement model leading to structural model). IBM SPSS Statistics 23 was used to generate descriptive statistics and to conduct EFA and CFA. In CFA unstable indicators were removed to minimise model errors. As an exploratory study, the analysis was aimed at demonstrating the adaptability of the TPB behavioural intention predictors in explaining farmers' need for continued legume diversification through the relevance of goal-related outcomes.

Each of the six factors shown in Appendix Table A1 represented a latent (factor) variable connected with observed variables thereby forming measurement models. The measurement models were theoretically grouped based on interrelationships between latent variables. In EFA, strength of factor loadings determine the relationship between measurable and latent variables. Only measurable variables loading consistently and beyond a selected threshold, usually above 0.350 for samples larger than 300, are selected for model estimation (Hair et al., 2010).

5. Results

5.1 Socio-economic characteristics

Only 21% of the interviewed farm households were headed by female members. Mean total land size was 1.3ha (standard deviation (SD) of 0.89). On average a farmer cultivated maize on 73% of their cropping area and only 38% of this area was under DLR. DLR utilisation experience was 7.87 years (SD of 2.43). Mean producer/consumer ratio was 0.45 (SD of 0.2). Access to information on DLR, which was estimated by the number of contacts with agricultural extension agents on the technology in the previous year was on average 2.34 (SD of 1.85). Lastly, on average farmers grew 3.0 food crops (SD of 1.1).

5.2 Descriptive statistics of constructs indicators

Appendix Table A2 presents within-construct correlations and means and standard deviations of the indicators. All within-construct correlations were significant at 0.01 level. In general, there was a stronger need for DLR in seeking crop diversification (least mean: 3.95) and soil fertility (least mean: 3.41) goal-related outcomes. Perception of benefits from DLR had the highest estimated mean (least mean: 3.85). This was expected for an agricultural technology that had already been adopted and with mean utilisation experience of over 7.0 years. The fact that estimated means for the need to increase yields and farm incomes were the least (least mean: 2.15) of all goal-related outcomes shows that farmers' perceived benefits from DLR was not associated with pursuit of increasing farm incomes.

5. 3 Measurement and structural model validation

In EFA, the final model had an acceptable Kaiser-Meyer-Olkin (KMO) value for sampling adequacy of 0.885, and Bartlett's test for sampling adequacy was significant (p = 0.000). Therefore the remaining measurable variables (indicators) shared substantial variance. All communalities had values of at least 0.380 (Appendix Table A3), and up to 69.7 % of Total Variance Explained (TVE) was extracted by the 6 factors with all registering eigenvalues above 1.0 (Appendix Table A7), hence adequate (see Lowry & Gaskin, 2014). The minimum value of factor loadings was 0.474, showing adequate convergent validity for a sample size larger than 300, as the minimum for such sample sizes is 0.350 (see Hair et al., 2010). Appendix Table A4 shows pattern matrix and correlation coefficients of all indicators retained in each construct. Appendix Table A5 shows factor correlation matrix and convergent validity test results.

The extracted model was valid and reliable following satisfactory average variance extracted (AVE), Maximum Shared Squared Variance (MSV) and composite reliability (CR) scores as shown in Appendix Table A5. The minimum AVE was registered on the factor of Perception of control (Pcontrol) (0.516). All factors recorded a CR of above 0.7. We checked for linearity of factors by running regressions and all were sufficiently linear (p=0.000). Multivariate collinearity was checked by testing Variable Inflation Factor (VIF) for all the exogenous variables simultaneously. This measured a value of *one* for all. Goodness of Fit statistics for the measurement and structural models are shown in Table 2.

Table 2. Goodness of Fit statistics for measurement and structural models

Statistic	Thresholds	Fit indices Measurement model	 Structural model	Meaning of statistic
CMIN/DF	1-3	2.166	2.153	ratio of Confirmatory Fit Index to degrees of freedom
IFI	≥ 0.900	0.960	0.960	Incremental Fit Index
TLI	≥ 0.900	0.953	0.953	Tucker-Lewis Index
CFI	≥ 0.950	0.960	0.960	Confirmatory Fit Index
RMSEA	≤ 0.06	0.055	0.055	Root Mean Square of Approximation
PCLOSE	≥ 0.05	0.096	0.107	the probability of getting a sample RMSEA as large as its calculated value in the given model

5.4. Structural model results

The goodness of statistics validated the proposed model. Table 3 shows that structural relations were all significant (p = 0.00) except between perception of institutions on promotion of legume diversification and a perceived benefit of increased farm incomes and between capacity to diversify legumes and meeting the need for soil attributes as well as to diversify crops. The rest of the structural relations were all significant (p = 0.00) and are presented in the appendix Table A6.

Table 3. Structural Model Results

Structural relationship			Estimate	S.E.	C.R.	P-value
Cropdiv	<---	Pbenefits	.466	.052	9.185	***
Soilhealth	<---	Pbenefits	.418	.059	7.637	***
Farmincome	<---	Pbenefits	.190	.067	3.267	.001
Cropdiv	<---	Pinstitutions	.322	.046	5.553	***
Soilhealth	<---	Pinstitutions	.213	.052	3.451	***
Farmincome	<---	Pinstitutions	-.113	.062	-1.639	.101
Farmincome	<---	Pcontrol	.416	.101	5.710	***
Cropdiv	<---	Pcontrol	.059	.069	1.051	.293
Soilhealth	<---	Pcontrol	.020	.078	.330	.741

6. Discussion and conclusion

Identifying goals from a behaviour enabled the current analysis to follow particular attributes of legume diversification as perceived by farmers and how these may affect the actual amount of utilisation in form of maize area dedicated to legume integration. Bergevoet et al. (2004) applied different analytical approach to show that farming goals were linked with milk quota. They explained the influence of intention predictors on milk quota, which was presented as behaviour in their modelling. In this study, the behaviour is the decision on amount of maize area under legume diversification. Our case for investigation was doubled-up legume rotations. For purposes of demonstrating the framework we only analysed how this behaviour may be influenced without comparing variations in the amount of utilisation among farmers. The variations in amount of utilisation need different analytical methods, which are not provided in this paper.

In this analysis, goals from legume diversification represent motivation for implementing legume diversification technologies. The modeling schematically presented motivation between behavioural intention predictors and the decision. Other scholars have proposed motivation to mediate behavioural intention predictors and behavioural intention and also behaviour intention and behaviour (e.g., Herath, 2010). Contrastingly, following Fishbein & Ajzen (2010) a behavioural intention is theoretically depicting the behaviour. The cause-effect relationship has been demonstrated through structural equations ending in goal-related outcomes from legume diversification as motivation. This modeling builds on the work on farmer behavioural analysis by Bergevoet et al. (2004).

These results suggest possible areas of further enquiry to understand low utilisation of legume diversification technologies in the study area and the larger smallholder farmer community in Malawi and southern Africa. For example, detailed analysis on perception of institutions through other techniques such as content analysis can be used. This is because there are various ways in which farmers may respond to institutions including; allegiance, dislike, suspicion, disapproval, or even boycott (see Ostrom, 2011). Farmers' attachments to organisation promoting an agricultural technology may encourage obligations to activities that associate with those organisations. Following this, farmers behave in expectation of that organisation (Maguzu & Recoda, 2013), and this may include hosting farm trials as a demonstration to other farmers. Many organisations promoting agricultural technologies in Africa give start up inputs to farmers and non-farm tools such as bicycles as well as branding materials (t-shirts, cloths, caps) (Ward et al., 2016). Many farmers receiving agricultural technology have expectations of these incentives too. Therefore, where they are provided farmers are likely to be obliged to fulfil the objective of the proponents (agents promoting agricultural technologies).

In this paper, we have condensed various influences on farmer behaviour from the cited literature into three areas affecting decision making based on the TPB and action situation of the IAD framework. These three areas directly affect farmers' orientation of farming goals from an agricultural technology and influence the extent to which they utilise it. The proposed analytical approach furthers the understanding of utilisation of agricultural innovations by paying attention to resource allocation decisions to an agricultural practice based on three areas concerning perceptions of behavioural, normative and control beliefs in the TPB. In addition, it incorporates the implications of the influence of external support through organisations on farming decisions. In many developing countries it is common to have organisations external to farmers' environments interfacing with farmers in promotion of agricultural technologies.

The framework stands on three core areas of the TPB. Firstly, farmers' perception of benefits from utilisation of the practice. These benefits can be direct as in achievement of its immediate objectives. For legume diversification, such objectives can be improving soil organic matter leading to increased maize yields. Secondly, farmers may feel indebted to continue utilising an agricultural practice to conform to social networks. They may also be indebted to the agencies that support farmers in promotion of the practice. This suggestion builds on the evidence that agricultural projects and organisations provide farm inputs as well as publicity materials (Ward et al., 2016). The role of institutions on farmer behaviour is adapted from the 'action situation' of Institutional Analysis and Development Framework by Ostrom et al. (1994). Thirdly, we considered farmers' constraints to utilisation of the agricultural practice as conventionally held in the random utility framework. The case study shows that farmer behaviour on an agricultural technology may reflect inadequacy in the enabling environment to fulfil their expectations despite positively identifying its attributes.

The purpose of the case study was to provide an empirical application of the decision framework on legume diversification. This framework can explain limited utilisation of agronomic practices among subsistent farmers in developing regions like Africa because of a huge presence of organisations aiding farmers to improve their livelihoods. Furthermore, it can be used to open a discussion for further analysis as illustrated in this study. The established linkages between behavioural intention predictors and goal-related outcomes suggest that researchers can determine which goals are most sought by farmers. A behavioural change intervention can then be aligned with goal-related outcomes most identified alongside intention predictors that influence them strongly. Since the framework is based on the close linkage between motivation and behavioural intention it can also be adapted for pre-agricultural adoption research to determine level of knowledge relating to a particular technology.

7. Appendix

Table A1. Measurement models, statements, and scales

Item	Statement	Scale (1-5)
	Perceived agronomic benefits from legume diversification	
Pbenefits1	Consistent legume intensification can reduce labour for maize production	strongly disagree---- strongly agree
Pbenefits2	Using legume intensification prevents disease incidences on maize crop	very unlikely------very likely
Pbenefits3	Soil fertility for maize production can be restored using legume intensification	strongly disagree---- strongly agree
Pbenefits4	There is weed suppression in maize crop following legumes	strongly disagree---- strongly agree
Pbenefits5	Other benefit to soils from legume intensification concerns soil organic matter	strongly disagree---- strongly agree
	Perception of institutions on legume diversification	
Pinstitutions1	It is important to follow advice from Extension workers on legume intensification	very unlikely------very likely
Pinstitutions2	I have participated in on farm demonstrations for legume intensification	strongly disagree---- strongly agree
Pinstitutions3	It is expected to take advice on legume intensification from volunteer farmers	very unlikely------very likely
Pinstitutions4	Project staff expect me to continue to do legume intensification	strongly disagree---- strongly agree
Pinstitutions5	It is important to my family members that I do legume intensification	strongly disagree---- strongly agree
Pinstitutions6	Most farmers near me are doing legume intensification	very unlikely------very likely
	Perceived competence for legume diversification	
Pcontrol1	I do not have to rent land to do legume intensification	strongly disagree---- strongly agree
Pcontrol2	It is easy for me to access seed for both legumes and maize every year	strongly disagree---- strongly agree
Pcontrol3	I am confident of legume intensification management techniques	strongly disagree---- strongly agree
Pcontrol4	I do not lack labour for legume intensification	strongly disagree---- strongly agree
Pcontrol5	I make decisions on the amount of legume intensification to do with my family	strongly disagree---- strongly agree
	Need for diversifying crop production	
CropDiv1	Increasing the number of crops on my farm is what I want	most definitely not---most definitely yes
CropDiv2	I would like to have a variety of crops on my farm	most definitely not---most definitely yes
CropDiv3	I want to grow different varieties of legumes to rotate with maize	most definitely not---most definitely yes
CropDiv4	I want to have other legumes that are not common here	most definitely not---most definitely yes
CropDiv5	I want to grow different types of legumes	most definitely not---most definitely yes
CropDiv6	I want to grow a lot of different food crops	most definitely not---most definitely yes
	Need for increasing soil fertility for maize production	
SoilHealth1	I want my soils to be rich in soil organic matter	most definitely not---most definitely yes
SoilHealth2	I want to make sure my crops stand on fertile soils	most definitely not---most definitely yes
SoilHealth3	I want to ensure that soil fertility is enriched particularly for maize	most definitely not---most definitely yes
SoilHealth4	All the crops I grow on my farm need rich soil organic matter	most definitely not---most definitely yes
SoilHealth5	I must maintain soil organic matter for all the crops in my farm	most definitely not---most definitely yes
SoilHealth6	Maintenance of soil organic matter mainly for maize is what I seek	most definitely not---most definitely yes
	Need for increased yield and farm cash incomes	
Fincomes1	I want to increase farm cash income using maize	most definitely not---most definitely yes
Fincomes2	I want to produce more legumes for the market	most definitely not---most definitely yes
Fincomes3	I desire to increase farm cash incomes from all food crops	most definitely not---most definitely yes
Fincomes4	I desire to increase grains whether legumes or otherwise	most definitely not---most definitely yes
Fincomes5	I desire to sell any legumes I produce	most definitely not---most definitely yes

Table A2. Mean, standard deviations (SD) and correlations of the indicators

	Pbenefits2	Pbenefits3	Pbenefits4	Pbenefits5	Pinstitution1	Pinstitution2	Pinstitution3	Pinstitution4	Pinstitution5	Pcontrol1	Pcontrol2	Pcontrol3	Pcontrol4	Fincomes1	Fincomes2	Fincomes3	Fincomes4	Fincomes5	SoilHealth1	SoilHealth4	SoilHealth6	CropDiv6	CropDiv7
Pbenefits2	1																						
Pbenefits3	.779**	1																					
Pbenefits4	.635**	.685**	1																				
Pbenefits5	.604**	.713**	.734**	1																			
Pinstitution1	.284**	.257**	.200**	.296**	1																		
Pinstitution2	.283**	.254**	.332**	.360**	.690**	1																	
Pinstitution3	.321**	.302**	.367**	.382**	.664**	.724**	1																
Pinstitution4	.338**	.259**	.314**	.366**	.654**	.786**	.746**	1															
Pinstitution5	.274**	.233**	.289**	.294**	.613**	.700**	.645**	.714**	1														
Pcontrol1	.163**	.179**	.138**	.178**	.270**	.238**	.277**	.252**	.287**	1													
Pcontrol2	.057	.064	.057	.109*	.221**	.277**	.229**	.240**	.263**	.527**	1												
Pcontrol3	.104*	.098	.158**	.185**	.333**	.297**	.342**	.352**	.351**	.503**	.497**	1											
Pcontrol4	.168**	.114*	.180**	.183**	.369**	.402**	.350**	.457**	.365**	.483**	.521**	.573**	1										
Fincomes1	.197**	.186**	.107*	.105*	.109*	.131*	.169**	.156**	.132**	.314**	.287**	.283**	.339**	1									
Fincomes2	.159**	.185**	.205**	.164**	.091	.043	.173**	.153**	.109*	.305**	.212**	.272**	.270**	.694**	1								
Fincomes3	.158**	.165**	.162**	.146**	.139**	.136**	.164**	.144**	.174**	.298**	.185**	.270**	.232**	.695**	.768**	1							
Fincomes4	.188**	.147**	.186**	.150**	.084	.071	.106*	.130*	.131*	.244**	.182**	.229**	.247**	.665**	.707**	.779**	1						
Fincomes5	.197**	.183**	.174**	.134**	.138**	.125*	.106*	.171**	.180**	.242**	.182**	.168**	.250**	.671**	.704**	.762**	.790**	1					
SoilHealth1	.426**	.422**	.355**	.417**	.285**	.312**	.303**	.277**	.292**	.143**	.068	.123*	.232**	.078	.086	.089	.081	.094	1				
SoilHealth4	.157**	.192**	.142**	.161**	.231**	.216**	.174**	.199**	.200**	.085	.113*	.058	.218**	.045	.070	.082	.056	.067	.542**	1			
SoilHealth6	.423**	.433**	.365**	.426**	.307**	.334**	.341**	.327**	.319**	.151**	.095	.121*	.227**	.093	.122*	.116*	.108*	.127*	.931**	.596**	1		
CropDiv6	.476**	.491**	.452**	.538**	.458**	.419**	.467**	.426**	.378**	.207**	.126*	.243**	.269**	.119*	.178**	.193**	.144**	.151**	.404**	.208**	.410**	1	
CropDiv7	.444**	.424**	.331**	.447**	.394**	.411**	.381**	.378**	.293**	.146**	.122*	.166**	.291**	.175**	.145**	.165**	.129*	.155**	.316**	.155**	.334**	.776**	1
Mean	3.84	3.85	3.73	3.72	3.45	3.45	3.49	3.66	3.33	2.71	3.07	2.74	3.09	2.35	2.27	2.15	2.17	2.23	3.87	3.41	3.95	3.96	4.05
Std. Deviation	.765	.766	.782	.739	.904	.944	.900	.846	.985	.797	.812	.858	.913	.908	.957	.806	.880	.867	.741	.792	.695	.705	.737

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A3. Communalities

Communalities		
	Initial	Extraction
PBC1E	.425	.474
PBC2E	.467	.552
PBC3E	.489	.535
PBC4E	.547	.593
CD6	.695	.714
FIPBC1	.633	.643
FIPBC2	.690	.706
FIPBC3	.751	.801
FIPBC4	.711	.750
FIPBC5	.718	.751
PN2	.767	.733
PN3	.714	.690
PN4	.760	.730
PN5	.709	.736
PN6	.759	.717
SH1	.869	.864
SH4	.443	.411
SH6	.881	.993
ATTM2	.671	.687
ATTM3	.736	.813
ATTM4	.644	.623
ATTM5	.663	.654
CD7	.657	.902
PN1	.605	.584
PN7	.783	.762

Extraction Method: Maximum Likelihood.

Table A4. Pattern matrix

Pattern Matrix[a]

	Factor					
	1	2	3	4	5	6
Cronbach's alpha	0.941	0.816	0.895	0.875	0.816	0.877
Pinstitutions7	.916					
Pinstitutions5	.912					
Pinstitutions6	.858					
Pinstitutions4	.828					
Pinstitutions3	.806					
Pinstitutions2	.800					
Pinstitutions1	.700					
Fincomes3		.908				
Fincomes5		.889				
Fincomes4		.882				
Fincomes2		.823				
Fincomes1		.733				
Pbenefits3			.928			
Pbenefits4			.837			
Pbenefits2			.798			
Pbenefits5			.743			
SoilHealth6				.987		
SoilHealth1				.904		
SoilHealth4				.675		
Pcontrol 2					.782	
Pcontrol 3					.711	
Pcontrol 4					.696	
Pcontrol 1					.662	
CropDiv7						.998
CropDiv6						.717

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Table A5. Convergent validity test and factor correlation matrix

	CR	AVE	MSV	MaxR(H)	Farmincome	Pinstitutions	Pbenefits	Pcontrol	Soilhealth	Cropdiv
Farmincome	0.930	0.726	0.156	0.934	*0.852*					
Pinstitutions	0.920	0.697	0.287	0.964	0.180	*0.835*				
Pbenefits	0.893	0.677	0.361	0.974	0.229	0.398	*0.823*			
Pcontrol	0.810	0.516	0.272	0.976	0.395	0.522	0.203	*0.719*		
Soilhealth	0.885	0.729	0.253	0.988	0.130	0.387	0.503	0.217	*0.854*	
Cropdiv	0.879	0.785	0.361	0.989	0.202	0.536	0.601	0.320	0.437	*0.886*

Table A6. Standardised Regression Weights for the structural model

Structural relationship			Estimate	P-value
Cropdiv	<---	Pbenefits	.466	***
Soilhealth	<---	Pbenefits	.418	***
Farmincome	<---	Pbenefits	.190	.001
Cropdiv	<---	Pinstitutions	.322	***
Soilhealth	<---	Pinstitutions	.213	***
Farmincome	<---	Pinstitutions	-.113	.101
Farmincome	<---	Pcontrol	.416	***
Cropdiv	<---	Pcontrol	.059	.293
Soilhealth	<---	Pcontrol	.020	.741
CropDiv6	<---	Cropdiv	.946	
CropDiv7	<---	Cropdiv	.821	***
Pinstitution2	<---	Pinstitutions	.879	
Pinstitution3	<---	Pinstitutions	.836	***
Fincomes5	<---	Farmincome	.863	
Fincomes4	<---	Farmincome	.872	***
Fincomes3	<---	Farmincome	.892	***
Soilhealth1	<---	Soilhealth	.944	
SoilHealth4	<---	Soilhealth	.570	***
SoilHealth6	<---	Soilhealth	.987	***
Pbenefits2	<---	Pbenefits	.843	
Pbenefits3	<---	Pbenefits	.911	***
Pbenefits4	<---	Pbenefits	.753	***
Pcontrol1	<---	Pcontrol	.678	
Pcontrol2	<---	Pcontrol	.682	***
Pcontrol3	<---	Pcontrol	.740	***
Pinstitution5	<---	Pinstitutions	.794	***
Fincomes2	<---	Farmincome	.840	***
Fincomes1	<---	Farmincome	.787	***
Pbenefits5	<---	Pbenefits	.774	***
Pcontrol4	<---	Pcontrol	.770	***
Pinstitution1	<---	Pinstitutions	.775	***
Pinstitution4	<---	Pinstitutions	.884	***

Where no p-values are shown, the predictors were set to the coefficient of 1 by default in AMOS

Table A7. Total Variance Explained

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.705	34.820	34.820	4.733	18.934	18.934	6.972
2	3.634	14.538	49.358	5.376	21.505	40.439	4.401
3	2.702	10.807	60.164	3.236	12.943	53.381	5.079
4	1.625	6.501	66.665	1.923	7.690	61.071	4.127
5	1.466	5.863	72.528	1.011	4.046	65.117	4.483
6	1.001	4.004	76.531	1.141	4.564	69.681	4.474
7	.605	2.420	78.951				
8	.563	2.252	81.203				
9	.536	2.145	83.348				
10	.480	1.920	85.268				
11	.433	1.732	87.000				
12	.402	1.609	88.609				
13	.379	1.517	90.126				
14	.327	1.309	91.435				
15	.297	1.186	92.621				
16	.270	1.080	93.700				
17	.265	1.059	94.759				
18	.229	.915	95.674				
19	.208	.833	96.507				
20	.195	.781	97.289				
21	.173	.693	97.982				
22	.164	.655	98.637				
23	.152	.609	99.246				
24	.124	.495	99.741				
25	.065	.259	100.000				

Extraction Method: Maximum Likelihood.

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

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Chapter Three: Utilisation of doubled-up legume rotations in Malawi. Do land size and use orientation for legumes matter?

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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate to include the publication in the thesis; and

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Utilisation of doubled-up legume rotations in Malawi. Do land size and use orientation for legumes matter?

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ABSTRACT

Investment in soil fertility over the past three decades in southern African maize-based systems by international agricultural research institutes has brought many novel technologies on legume diversification but has seen minimal uptake of these technologies by smallholder farmers. Doubled-up legume rotations (DLR) is a legume technology for maximising N input from grain legumes that takes advantage of complementary phenology of short and long duration legumes. This study uses a zero-one beta regression model to investigate the potential for increasing utilisation of DLR at farmer level in Malawi. The model was applied to data from a sample of 282 farmers from Mzimba district. The results showed that positive perceptions of the superiority of DLR significantly predicted increased utilisation. However, there was a statistically significant negative relationship between land size and production orientation of the DLR legumes. Furthermore, women farmers are unlikely to increase utilisation of DLR because they generally have smaller land holdings. These findings suggest that agricultural extension can develop messages on DLR using a farmer typology based on land size and gender to enhance utilisation. Women farmers and farmers with smaller landholding sizes have the highest utilisation index of legume diversification technologies. Farmers with larger land sizes tend to grow most crops for the markets including legumes. Our findings revealed that when such farmers are recipients of a legume technology they maintain a small portion of their maize area under the technology and grow the same legumes in monocrop for market purposes. In the case study decisions on the amount of DLR utilisation depended more on farmers' expected cash income benefits from legumes than from combined expected yield gains from both maize and legumes as presented by agronomists.

Keywords: adoption; maize; soil fertility; legume diversification.

1. Introduction

The problem of low soil fertility continues to threaten food production in sub-Saharan African maize-based systems partly due to continuous maize cultivation with little attention to soil fertility management (Smith et al., 2016). A growing population and limited land has put smallholder farmers at risk of food insecurity and malnutrition (Ricker-Gilbert et al., 2014). Land limitation and the call for sustainable agricultural intensification in Africa (Pretty et al., 2011) could be countered by smallholder farmers adopting or increasing the use of improved soil management technologies that directly increase their production of food (Smith et al., 2016).

Doubled-up legume rotations (DLR) is novel technology involving intercrops of two legumes with complementary phenology for two years before rotating them with maize in the third year (Kerr et al., 2007; Snapp et al., 1998). Typically, pigeon pea/soybean and pigeon pea/groundnut intercrops are used in DLR. The superiority of DLR to other legume diversification approaches relies on pigeon pea's unique growth habit leading to enhanced soil fertility benefits (Snapp et al., 2010). DLR systems have better fertiliser use efficiency and higher grain yields than maize sole cropping or single legume-cereal intercrops and or rotations (Snapp et al., 2010).

Despite the superiority of DLR to other legume diversification technologies (such as maize-legume intercropping, maize-legume rotations, maize-legume-legume intercropping) as demonstrated through farmer participatory research (FPR) in Malawi farm area devoted to legume technologies was estimated on aggregate to fall below 25% after 10 years of continuing promoting (Mhango et al., 2013). This study investigates cropland allocation decisions to legume diversification of maize systems using a case of DLR among smallholder farmers in Malawi.

The study investigates the degree of utilisation of the DLR at farmer level with the application of zero-one beta regression. Findings from this study are helpful in the promotion of DLR technology and sustainable agricultural intensification practices among smallholder farmers in southern Africa. The findings fit in the wider agricultural adoption literature on sustainable agricultural intensification. The rest of the paper proceeds as follows: background, methodology, results and discussion and conclusion.

2. Background

Land limitations force smallholder farmers to grow edible legumes in order to increase access to food while improving soils. Consequently they are seen to prioritise food grains and crop sales over soil fertility benefits (Snapp et al., 2002). However, edible grain legumes contribute less nitrogen to maize-systems as compared to non-edible legumes due to human consumption. In addition, the popular harvesting methods of grain legumes lead to loss of biomass that could otherwise remain on the soil (Kerr et al., 2007). FPRs on legume diversification in Malawi developed legume technologies that enhance nitrogen fixation and biomass incorporation without risking losses to maize productivity (Snapp et al., 2010).

Pigeon peas (*Cajanus cajan)* has a potential to provide more soil N due to its long duration characteristic than soybean (*Glycine max)* or ground nuts (*Arachis hypogaea)*. Utilisation of pigeon pea in African smallholder farming systems has largely been limited to intercrops with maize (Snapp et al., 2010). However, there is little yield benefit of maize from pigeon pea intercrop due to resource competition (Morris & Garrity, 1993; Rusinamhodzi et al., 2012). On the other hand a short duration legume like groundnut or soybean does not significantly affect maize yield in an intercrop arrangement as it is less competitive for resources (Snapp & Silim, 2002). The combination of pigeon pea and soybean or groundnuts offers improved biological nitrogen fixation and also fertiliser use efficiency (Snapp et al., 2010).

The FPRs in Malawi have helped smallholder farmers choose legume and maize combinations based on adaptability, yield and even marketability (Kamanga et al., 2014; Kerr et al., 2007; Pircher et al., 2013; Snapp et al., 2002). Through rigorous farmer participatory legume variety selection the FPRs addressed farmer and market preferred varieties and traits (Waldman et al., 2016). Research approach on the DLR was carried out under farmer-researcher managed 'mother' trials and follower farmer managed 'baby' trials. For a detailed description of these trials refer to Snapp (2002).

Most smallholder farmers in Malawi grow maize and grain legumes as main food crops (Waldman et al., 2016) with knowledge passed from parents as well as agricultural extension services. But positive perception of the superiority of DLR technology to previous or other legume diversification approaches is enhanced through participation in on farm trials under the FPRs.

3. Methodology

3.1. A metric for estimating the amount of legume diversification under DLR technology

One important element of the DLR is consistent rotation of area under legumes (soybean/pigeon pea or groundnut/pigeon pea intercrops) with an equivalent area under maize cultivation every third year. While smallholder farmers in Malawi grow a variety of crops, maize is prioritised for its staple nature (Ricker-Gilbert et al., 2014), occupying up to 70% of their arable land (Snapp et al., 2002). With national average landholdings of around 1ha land is an important factor limiting agricultural production in Malawi (Cromwell & Winpenny, 1993). Nevertheless, smallholder farmer heterogeneity suggests that DLR may not be utilised on all maize area.

Consistent with diffusion of innovations theory (Rogers, 1983), DLR utilisation may be partial or full depending on farmer characteristics, biophysical and institutional factors. In light of this, the scale of technology utilisation can be defined according to study design (Doss, 2003). In this study the degree of utilisation of DLR at farmer level is a ratio, expressed as a proportion, of the area under doubled-up legume intercrops (soybean/pigeon pea or groundnut/pigeon pea) to total maize area (DLRPROP). This can be expressed as: ${A_{DLi}}/{\sum A_{mi}}$ where, A_{DLi} is area in hectares under intercrop of legumes (soybean/pigeon pea or groundnut/pigeon pea), A_{mi} is total area in hectares under maize cultivation for farmer i respectively.

3.2 Model

Choice of study farmers was based on evidence of utilisation of DLR on at least 0.1 ha of maize area. This size is standard for on-farm trial plot for maize and legumes in Malawi. As a proportion, DLRPROP can take values above zero but not exceeding one as it is bound between zero and one (see Fig. 1). A zero-one inflated beta regression was most relevant to fit a maximum likelihood function to include observations at value of 1.0 (Wooldridge, 2015). In this study a farmer with DLRPROP value of 1.0 is assumed to have no maize area to expand DLR technology to without renting land or reducing area for other crops following land limitations.

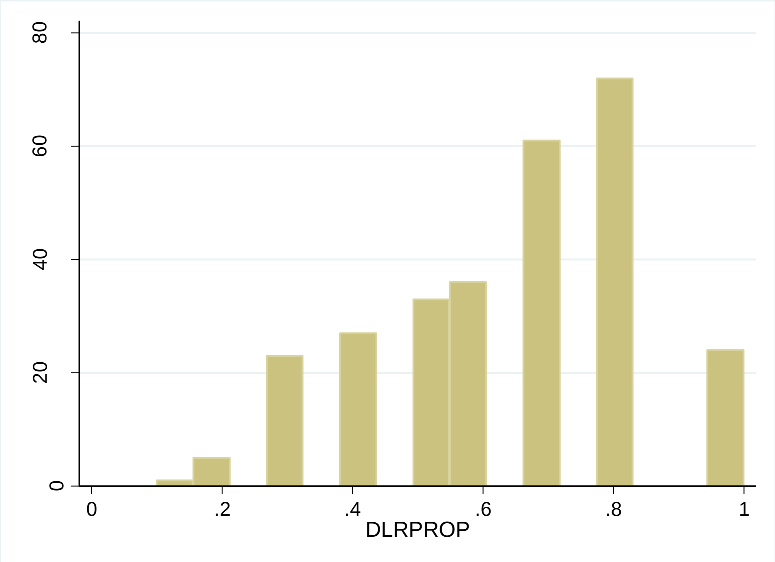

Fig. 1 Distribution of DLRPROP, Ekwendeni, Mzimba

3.3 Selection of explanatory variables

The empirical model is based on farmers' perceptions of agricultural technology (Adesina & Baidu-Forson, 1995; Adesina & Zinnah, 1993) and utilisation of sustainable agricultural practices in developing countries as reviewed by (Knowler & Bradshaw, 2007). FPRs on legume technologies in Malawi identified legume attributes including taste, soil fertility, adaptability, yield, ease of storage, and marketability. Of these, only soil fertility attribute was acknowledged by farmers in a recent study (Waldman et al., 2016).

However, an earlier study in central Malawi found that farmers did not report any changes in maize yield resulting from diversification of legumes in their maize systems (Pircher et al., 2013). From these two findings about farmer experiential knowledge on legume utilisation we identify perception of the superiority of DLR technology to other legume diversification technologies in terms of contribution to soil fertility (FERTILITY) (Smith et al., 2016; Snapp et al., 2002) as the main variable on utilisation of the DLR. Other variables on legume utilisation were: use orientation for legumes (LEGMONO) because legume market opportunities can affect adoption decisions (Pircher et al., 2013); perception of the level of fertility of their maize area (PESFERT) (Mponela et al., 2016); past utilisation of other green manures (OTHERFERT) following linkages between past and current behaviour (Bergevoet et al., 2004).

To control for heterogeneity the model included some of the socio-economic and institutional variables associated with adoption of sustainable agricultural practices in developing countries (see Knowler & Bradshaw, 2007; Manda et al., 2016; Marenya & Barrett, 2007). Gender of the farmer (GNDHH) is associated with low probability of agricultural adoption where the farmer is female and the agricultural technology requires use of more capital inputs and labour than existing technologies (Doss, 2001; Fisher & Kandiwa, 2014). However, the relationship between gender of the farmer and DLR utilisation decisions could not be predetermined in this study as it was carried out in a region where legumes were considered 'women's crops' (Kerr, 2005; Orr et al., 2014), hence it could take either direction of relationship. Both land size (LANDTOT) and family labour (LABOR) represent resource endowment (Marenya & Barrett, 2007). More resource-endowed farmers have a higher probability of adopting and or trialling out agricultural technologies (Haggblade et al., 2011) and so are farmers with more land. Labour was estimated as the number of family members aged between 14 and 65. The lower threshold for age was consistent with national regulation on outdoor agricultural work (Malawi Government, 2000).

Access to seed for legumes (ACCESS) has also been identified to constrain diversification of legumes among smallholder farmers (Mhango et al., 2013). The common means of accessing legume seed in Malawi among smallholder farmers are market purchase, recycling (retained from previous harvest), and from soil fertility projects or national farm inputs subsidy programs

Other variables concern institutional factors like access to information (EXTENS). This was estimated as the number of times a farmer attended group activities on DLR management presided by an agricultural extension worker in the year before the study (Manda et al., 2016). This was verified in volunteer farmers' register books. Consistent contact with extension agents keeps farmers in check of their farm operations but also enables them access updated information timely (Marenya & Barrett, 2007). Related to information and knowledge about an agricultural technology is skills for proper management, which improve with time (Adesina & Zinnah, 1993). This was represented by the number of years of using DLR technology (EXPDLR). Lastly, because farmers are reluctant to invest in rented land without ownership rights (Gebremedhin & Swinton, 2003), we included a variable on whether a farmer rented land for DLR technology in the past two years (RENTLAND). Descriptions of all study variables are presented in Table 1.

Table 1. Variable description

Variable type/ name	
	Variable Label
Dependent variable	
DLRPROP	Maize-legume integration index
Explanatory variables	
LEGMONO	Use orientation for legumes used in the DLR : 0 = home consumption 1 = market
GNDHH	Gender of the farmer: 0 = female; 1= male
LABOR	Number of adult workers in the farmers' household (age range: 14-65)
EXPLEG	Number of years utilising DLR
EXTENS	Number of times a farmer attended an extension modality for DLR presided by an extension agent in the previous year
ACCESS	If farmer accessed enough legume seed by their own means in the most recent year they planted DLR legumes: 0 = no; 1 = yes
FERTILITY	Perception that DLR is superior to other legume diversification technologies: 0 = no; 1 = yes
OTHERFERT	Past utilisation of green manure technologies 0 = no; 1 = yes
PESFERT	Perception of quality of soils of the maize area : 0 = fertile; 1= less fertile
LANDTOT	Total cropping land (ha)
RENTLAND	If a farmer rented land for DLR in the previous two years: 0 = no; 1 = yes

3.4 Study area and context

Data for this study were collected during 2014-2015 agricultural season during a farm household survey of 288 farmers in Mzimba district, Malawi. The study farmers came from Ekwendeni watershed from eight villages under Zombwe Extension Planning Area (Figure 2). The study targeted farmers who participated in a legumes 'best bet' project on FPR and had adopted DLR at least six years after establishment of the project. This was to minimise biases in responses on perceptions of the superiority of the DLR as initial project participants were purposefully targeted. In addition, only farmers who had rotated doubled-up legumes with maize at least twice consecutively (a total of six years of utilisation of the DLR technology) were sampled. Each farmer who was utilising DLR in each village was assigned a number. These numbers were shuffled and picked in pairs by two farmers until the maximum number of farmers was reached in each village. Approximately 70% of farmers utilising DLR were sampled in each village. Table 2 describes the study sample.

Table 2. Study sample description

Name of village	Number of farmers	Number of farmers utilising DLR	Number of farmers sampled
Mthakopoli Longwe	61	50	36
Hezekiah Longwe	57	57	40
Robert Mseteka	47	47	33
Chinombo Jere	51	51	36
Kaputa Longwe	63	58	40
Yesaya Jere	61	61	43
George Jere	58	43	31
Bandawe Tembo	42	42	29
Total	440	409	288

Ekwendeni watershed was one of the early sites for 'legumes best bet' projects using FPR in Malawi beginning late 1990s. All project participating farmers received free legume seeds, and were also targeted for extension advisory services on DLR trial plots. By 2015 over 2000 farmers had adopted DLR within and around Ekwendeni watershed.

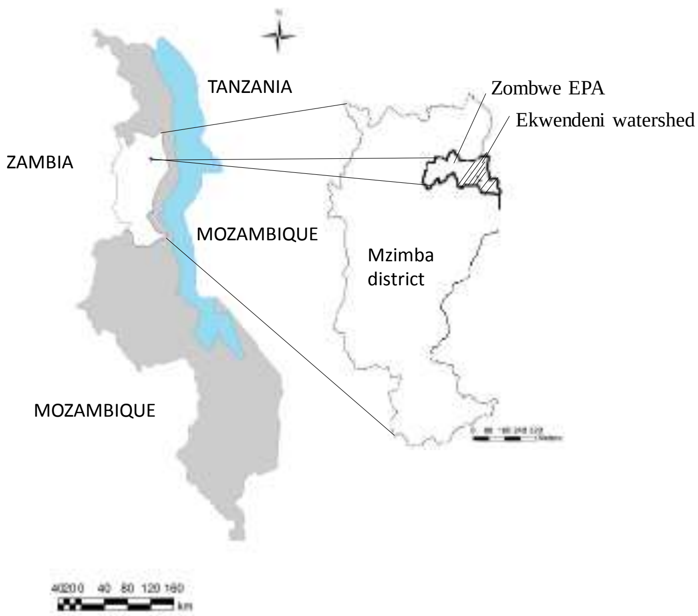

Figure 2. Map of Malawi showing Mzimba district and location of study villages

3.5 Data collection and analysis

For research ethics considerations, farmers' consent to take part in the study was individually sought. Survey data included household composition (age, gender and number of household members); cropping patterns (maize varieties and types of legumes used in the DLR system including area dedicated to these; legumes grown outside the DLR system; total farm area); land tenure, and; use orientation for legumes. Table 1 shows descriptive statistics for all explanatory variables except RENTLAND as it was dropped due to lack of standard deviation. The final sample of farmers was 282 because six were dropped from analysis for being outliers on land size.

The survey was conducted while crops were still standing in the fields. This made it easy to measure cropland. Land size is a major variable in this study. Actual plot measurements were carried out in coordination with agriculture extension staff. If a sampled farmer had grown maize only in the survey year, we estimated area planted to DLR legumes in the previous year by checking farmers' records on quantities planted against the standard seeding rates. For a soybean/pigeon pea double up system: 90kg/ha soybean and 8kg/ha pigeon pea. While for a groundnut/pigeon pea double up system: 80-90kg/ha for groundnut and 8kg/ha for pigeon pea (www.africa-rising.net, 2018).

4. Results and Discussion

4.1 Descriptive statistics of model variables

Table 2 presents descriptive statistics of the explanatory variables. In terms of human capital and resource endowments, farmers with less than a hectare of land were mostly (66%) female and their total landholding averaged 0.6 ha. Farmers with relatively more land (over 2 ha) were mostly male (91%) and their average landholding was 2.6 ha. In terms of labour, farmers with the least landholdings had the least, at 1.8 workers on average. Participation in extension modalities for DLR was least in the category of farmers with less than a hectare of land at 1.8 times in the year preceding the study year. The least experience in DLR was in the category of farmers with the most land at 7.5 years.

Table 2. Descriptive statistics

Variable type/ name	All farmers N= 282		A N = 53		B N = 106		C N = 84		D N = 39	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Dependent variable										
DLRPROP	0.643	0.201	0.789	0.165	0.759	0.103	0.531	0.140	0.374	0.124
model										
LEGMONO	0.443	0.498	0.151	0.361	0.170	0.377	0.702	0.460	1.000	0.000
GNDHH	0.617	0.487	0.340	0.478	0.491	0.502	0.821	0.385	0.914	0.284
LABOR	2.099	0.903	1.811	0.786	2.189	0.967	2.179	0.959	2.114	0.676
EXPLEG	7.805	2.431	7.623	2.544	8.019	2.673	7.821	2.118	7.457	2.292
EXTENS	2.319	1.838	1.792	1.791	2.283	1.717	2.738	1.989	2.286	1.775
ACCESS	0.691	0.463	0.736	0.445	0.858	0.350	0.619	0.489	0.343	0.482
FERTILITY	0.674	0.470	0.887	0.320	0.981	0.137	0.405	0.494	0.114	0.323
OTHERFERT	0.674	0.470	0.679	0.471	0.623	0.487	0.714	0.454	0.743	0.443
PESFERT	0.706	0.457	0.887	0.320	0.877	0.330	0.560	0.499	0.314	0.471
LANDTOT	1.465	0.692	0.596	0.174	1.159	0.180	1.823	0.167	2.609	0.280

Farmer typology based on landholding size: A (< 1 ha); B (1-1.59 ha); C (1.6 – 2 ha); D (> 2 ha)
Std. dev: standard deviation

Perception variables had varying statistics across the four categories of land holdings sizes. Generally the proportion of farmers reporting positive perceptions of DLR reduced with increasing size of landholdings. Up to 88% and 97% of farmers in type A and B respectively held positive perceptions of the superiority of the DLR. This corresponds to the proportion of land area dedicated to DLR. As shown in Table 2, DLRPROP was highest among category A and B farmers at 79% and 76% respectively with 32% and 6% respectively of farmers reaching full utilisation.

The highest DLRPROP in farmer typology C and D were only 53% and 37% respectively with no farmer reaching full utilisation. No farmer in C and D dedicated all their maize area to DLR Farmers in C and D owned above national average land sizes averaging1.8 ha and 2.6 ha respectively. According to the study variables C and D farmers were relatively more resource endowed (Marenya & Barrett, 2007). Further description of land size is presented in relation Figures 3, 4a and 4b.

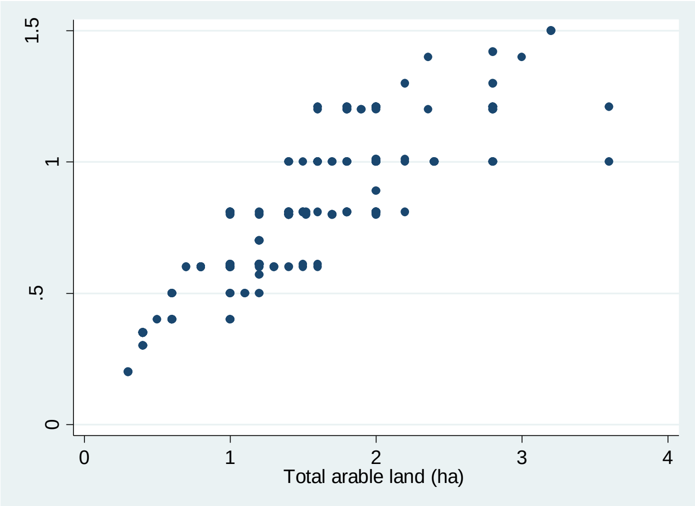

Fig. 3 Maize area and total cropping land, Ekwendeni, Mzimba, Malawi.

Figure 3 presents an overview of land distribution for maize cultivation across the sample. Most farmers allocated more than half of their cropping land to maize alone. This corroborates earlier studies that on average smallholder farmers in Malawi allocate up to 70% of their cropping land to maize (Snapp et al., 2002). A general impression of the degree of integration of doubled-up legumes in maize area shows that farmers who had higher DLRPROP values owned relatively smaller land sizes (see Figs. 4a and 4b). This suggests that the variable, use orientation for maize and legumes is most relevant among farmers with relatively larger landholdings.

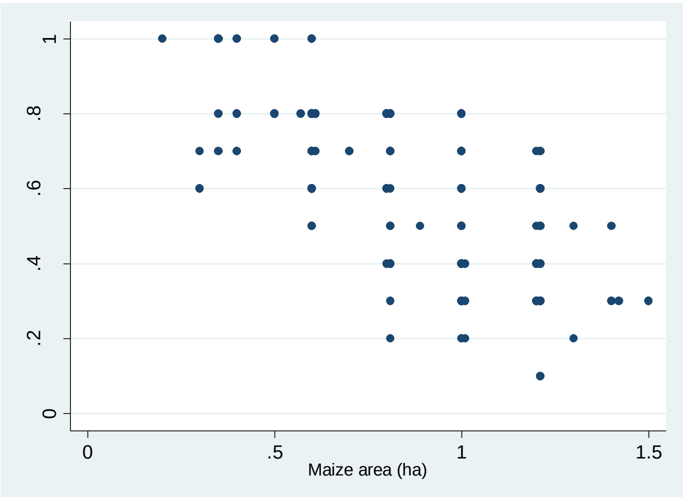

Figure 4a. Integration of DLR legumes in maize area, Ekwendeni, Mzimba

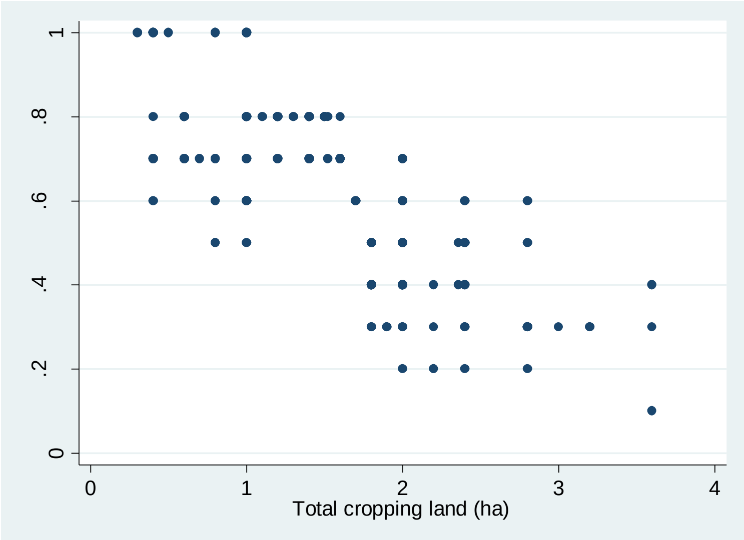

Fig. 4b. Integration of DLR in total cropping area, Ekwendeni, Mzimba

One reason for the inverse relationship between DLRPROP and total cropping area is that smallholder generally grow a diversity of crops for food sources as well as production risk management (Di Falco & Chavas, 2009).

4.2 Crops grown in the Ekwendeni watershed

Crops grown in Ekwendeni watershed are listed in Table 3. The array of crops reflects the choices that smallholder farmers encounter when adopting new patterns of growing crops such as the DLR. Of relevance are the complexities in decision making if farmers increase land allocation to DLR at the expense of other crops. Table 3 further shows that farmers in Ekwendeni watershed grew other grain legumes than those for DLR as well as other food crops than maize. Out of the 13 crops listed, bambara nuts *(Vigna subterranean)*, cowpeas, finger millet *(Eleusine coracana)* and banana were the only crops not supplied to markets. The small number of farmers growing these crops and the use for domestic consumption shows that they occupied smaller portions of farmers' land, nevertheless important.

Table 3. Marketing of common crops: Ekwendeni, Mzimba district, Malawi

Name of crop	No. of farmers growing	Proportion of farmers supplying crop to markets (%)
Maize	282	40
Pigeon pea	274	70
Groundnuts	265	50
Soybean	254	90
Common beans	201	40
Tobacco	146	100
Sweet potatoes	139	12
Cassava	123	15
Banana	123	-
Cow peas	76	-
Bambara nuts	61	-
Cotton	48	100
Finger millet	41	-

Crops not supplied to markets were used both in home consumption and in non-cash use like gifts, or contributions to social activities.

4. 3. Zero-one inflated beta regression results

Table 4 presents model estimation results. The variables of land size, gender of the farmer, and use orientation for legumes all presented a significant negative relationship with increasing area under DLR. On the other hand, significant positive relationships were found for capacity to acquire seed, perception of superiority of DLR, past utilisation of green manures, and perception of level of soil fertility of part of maize area. Overall, the estimates show that marginal changes in use orientation for DLR legumes (soybeans, pigeon peas and groundnuts) and in land holding sizes decrease the probability of increasing the area allocated to DLR.

Table 4. Zero-one inflated beta regression results

	Proportion				Oneinflate							
Variables	Coefficient	RSE	z	P>z	Coefficient	RSE	z	P>z	Marginal effects	DMSE	z	P>z
LEGMONO	-0.644	0.052	-12.34	0.000	-15.871	1.018	-15.590	0.000	-0.163	0.013	-12.100	0.000
GNDHH	-0.058	0.041	-1.42	0.000	-17.136	0.578	-29.620	0.000	-0.036	0.012	-3.060	0.002
LABOR	0.013	0.023	0.59	0.556	0.102	0.427	0.240	0.811	0.003	0.006	0.590	0.555
EXPLEG	-0.003	0.008	-0.41	0.681	-0.112	0.122	-0.920	0.359	-0.002	0.002	-0.830	0.408
EXTENS	-0.009	0.010	-0.92	0.357	0.141	0.195	0.730	0.467	-0.001	0.003	-0.220	0.823
ACCESS	0.202	0.042	4.78	0.000	1.676	1.113	1.510	0.132	0.053	0.011	4.710	0.000
FERTILITY	0.454	0.071	6.36	0.000	-0.577	1.389	-0.420	0.678	0.086	0.024	3.620	0.000
OTHERFERT	0.097	0.037	2.65	0.008	0.091	0.674	0.130	0.893	0.020	0.009	2.150	0.031
PESFERT	0.231	0.047	4.91	0.000	16.867	1.188	14.190	0.000	0.068	0.013	5.230	0.000
LANDTOT	-0.218	0.045	-4.85	0.000	-4.851	0.927	-5.230	0.000	-0.082	0.011	-7.650	0.000
_cons	0.541	0.151	3.57	0.000	-14.214	2.249	-6.320	0.000				
ln_phi												
constant					4.041	0.105	38.400	0.000				

Dependent variable: DLRPROP (proportion of maize area under DLR technology)
N = 282: Wald chi2 (10) = 1492.46; Prob >chi2 = 000; Log likelihood = 327.179; RSE: robust standard error; DMSE: Delta-method standard error

Land size hinges on the need to rotate the legume intercrop in the doubled-up legume technique with maize hence reducing the area for cultivation of other crops including maize. This corroborates recent research on maize-legume rotations when land limitations are taken into account where farmers prioritise staple crops (Moti et al., 2017). Generally farmers with smaller landholdings face the most challenge to increasing agricultural production (Marenya & Barrett, 2007). With many farmers growing a diversity of crops (Table 3), increasing DLR land among land limited subsistence farmers affects cropping patterns and future choices on crop enterprises. It appears that the participatory trials and extension messages of the soil benefits and economic contribution from DLR to food security are not yet convincing enough farmers.

The negative relationship between use orientation of the DLR legumes and increasing area under DLR implies no attention to management aspects of the whole technology as farmers are not committed to rotations. One reason for this could be land limitations as earlier discussed. Another reason concerns maximising economic returns to the farm when farmers respond to demand for particular legumes. Farmers may abandon some management aspects of a legume technology to focus on maximising supply (Pircher et al., 2013).

The results further show that, despite legumes being most associated with women and home consumption in the study region (Kerr, 2005), there was a negative relationship between gender of the farmer and utilisation of DLR. This may indicate general low resource endowment disadvantaging women farmers in agricultural adoption (Doss, 2001). Taking land and labour as proxies for resource endowment Table 2 shows that more female farmers belonged to lower land holding size farmer types: (66% in A; 51% in B; 18% in C, and; 9% in D).

The perception that DLR technology was superior to alternative legume diversification approaches in improvement of soil fertility has a positive effect on the probability that farmers increase its utilisation. Furthermore, holding other factors constant, farmers are likely to increase utilisation of DLR technology if they have used other soil fertility technologies before and also if they considered that part of their maize area to be less fertile. Lastly, if the farmer had the capacity to access seed for DLR legumes, aside from receiving from organisations or the government, they were likely to increase utilisation of DLR.

Based on these results, the marginal effects show that the probability of increasing the DLR technology reduces by 8% for every unit increase in landholding size. The probability of increasing utilisation of DLR decreases by 16% when use orientation of DLR legumes changes by 1 unit, holding other factors constant. As expected, the perception of the superiority of the

DLR technology shows positive effect on the probability of increasing DLR utilisation at 8%. The positive perception could arise from practical experience with the technology or conviction resulting from technology promotional efforts by projects and agencies (Ojiem et al., 2006; Pircher et al., 2013).

The marginal effects also show that the probability of increasing DLR increases if farmers perceive part of their maize area as less fertile and if they have used other green manures before. These findings are consistent with literature on farmer level determinants of adoption of soil fertility technologies (Mponela et al., 2016). Lastly, the fact that farmers who had the capacity to access legume seed for DLR legumes had a likelihood of increasing DLR confirms that seed access limits adoption or increased utilisation of soil fertility technologies requiring purchase of inputs (Mhango et al., 2013; Mpepereki et al., 2000).

Overall, these results partly explain why farm area dedicated to legume diversification was estimated to fall below 25% in north Malawi. The study findings show that problems of soil fertility and food insecurity may be identified in participatory research studies but farmer realities dictate how they integrate new technologies in their cropping systems (Pircher et al., 2013). The findings also show that farmers' perception of the importance of various crops in their farm household system regardless of their contribution to food security or soil improvement can limit utilisation of proven soil fertility technologies such as DLR. Farmers may forgo the agronomic benefits from integrating more legumes for production of other non-legume crops for other purposes.

4.4 General discussion

Even though smallholder farmers need to diversify crop production for production risk management as well as maintain certain crops as party of traditional cropping systems, they do not integrate more legumes in their maize areas due to limited landholding size. There are similarities in dimension of relationship between use orientation for DLR legumes and area under DLR and between total land size and maize area under DLR. DLR was mostly applied to legumes and maize grown for domestic consumption. This is because the same DLR legumes were also grown in continuous monocrops for market use orientation. Table 2 shows that on average 70% and 100% of farmers with 1.6 - 2 ha and over 2ha respectively grew the DLR legumes in monocrop too in addition to interacting them with maize as per the DLR management principles. This study did not record the amount of land allocated to sole-cropped soybean, groundnuts and pigeon peas separately. But learning from a previous study on legume diversification of maize-based systems in central Malawi, larger areas are allocated to sole-legume cropping than to maize-legume intercrop or rotation (Pircher et al., 2013). Similar results were reported from Zimbabwe on willingness to increase diversification of soybean in maize systems (Mpepereki et al., 2000).

One argument for limiting utilisation the DLR to only maize area where it is consumed in the home is that farm cash income is the main production goal for these legumes whether in DLR or not. This may be obvious particularly among farmers with relatively more land because they can make choices unlike those with smaller landholdings. This observation is consistent with earlier studies that legume technologies may be perceived as business opportunities (Pircher et al., 2013).

While it may appear economically rational, continued maize mono crops, or associations with non-legume crops, can lead to the very same problem of overreliance on inorganic fertilisers in maize production, which leads to nutrient mining. This is critical for ecological resilience and sustainability of smallholder cropping systems. On the other hand farmers with smaller landholdings have no area to increase sole cropping of legumes neither DLR due to land limitation (Rusinamhodzi et al., 2012).

Our results are in agreement with arguments that farmers adopt improved agricultural practices to maximize utility of the whole farm (Shaxson & Tauer, 1992). Nevertheless, the utility of the whole farm should include inherent value of soil fertility as well. Efforts to persuade farmers to utilise maize-legume intensified systems should also focus on the integral value of legume diversification to maize environments apart from increased crop yields. These values include soil organic matter and mitigation of nutrient mining. From this study one can argue that farmers with smaller land sizes understood the inherent value of DLR on soil fertility. The limited options on cropping land influenced these farmers to pay attention to the management practices of the technology. By doing that they positively evaluated its performance (Table 2). On the other hand, farmers with relatively more land did not appear to pay attention to the agronomic benefits of DLR. This could be due to availability of options on what crops to grow and most importantly aiming for market, as discussed on use orientation of DLR legumes.

The results show that farmers may positively perceive the superiority of a sustainable agricultural technology but only minimally utilise it due to unmet expectations, which may even be different from its proponents' (Ghadim et al., 2005; Graham & Vance, 2003). Above all, the study findings corroborate the assertion that despite a sustainable agricultural practice achieving its ecological objectives, limited utilisation may still occur as farmers cite various reasons on their choices (Pannell et al., 2014). Some of these require different analytical approaches because farmers' decisions may be influenced by expectations from highly regarded community members regardless of economic importance (Borges & Oude Lansink, 2016). This can be deduced from the fact that DLR was neither abandoned nor increased among farmers with options. The fact that study farmers were associated with a project promoting DLR imply some obligations and commitment to this project and agencies dealing in DLR. Different study approaches such as content analysis may bring more insights to farmers' motivation for partial legume diversification of maize systems.

In land limited environments DLR may be seen as a technology for farmers who have adequate land to dedicate to an intercrop of legumes for two years within which period no maize is grown in that land. This study did not undertake a benefit-cost analysis of the forgone maize in a two year period under which only legumes are grown as per the DLR technology management principles. However, the superiority of the DLR to other grain legume technologies is that in a three year period there are more grains harvested from both maize and legumes than from yearly rotations of maize and legumes or from continuous maize-legume intercropping (Snapp et al., 2010). Therefore, farmer awareness of legume technologies in maize based systems should account for these dimensions of benefits to allow farmers make informed choices.

5. Conclusion

This study was aimed at estimating the probability that a smallholder farmer increases area under DLR. The superiority of this technology to other legume technologies lies in the complementary growth habits between an intercrop of a short and a long duration legume enabling more nitrogen fixation and more biomass. Even though the DLR technology has not entered mainstream agricultural extension in Malawi some of its components on farmer research approach: the mother-baby trial approach has already been adopted by the government as an innovation in maize production. Nevertheless there are plans to roll out the DLR (Smith et al., 2016). The DLR technology is also being implemented in Ghana, Tanzania, Ethiopia and Zambia (www.africa-rising.net, 2018).

The current study findings are relevant in promotion of the DLR technology and other sustainable agricultural intensification technologies in smallholder farming systems in sub Saharan Africa. They are important where farmers prioritise staple crops in land limited yet nutrient constrained environments. In these environments farmers' acceptance of legume diversification is constrained by land sizes. The study findings are also important in understanding use orientation for legumes and increased legume diversification. When farmers select legumes in response to market opportunities, there is a high likelihood of not paying attention to integration with maize to make use of the soil benefits contributed by the legumes.

The success of DLR technology lies in the consistent management of its technique. Considering that the technology has a bearing on landholding sizes this study came up with a metric and tested the variation in utilisation of the DLR technology based on this metric. This metric can be adapted to other agricultural technologies where adoption can be classified as partial or full. By identifying the basis for the size of utilisation as maize area in this study, it was possible to compare the DLR utilisation across farmers with a diversity in landholding sizes.

Farmers with more land do not diversify more legumes in their maize areas because they grow some of their maize for cash or equivalent use, e.g., payment for farm labour. They emphasise on integrating maize and legumes in plots where use is largely subsistence. Their minimal utilisation of DLR is lack of concern for rebuilding soil fertility of maize environments as most of them had no knowledge of the superiority of DLR. The results suggested that these farmers maintain use of a DLR to keep connected with their social networks. Using the metric developed in this paper we have demonstrated that land size does not matter for smallholder farmers to increase utilisation of a legume technology like DLR but use orientation for the legumes is the main determinant. Farmers with relatively smaller land holding sizes are confined to subsistence use of the legumes incorporated in DLR and appear to have the highest utilisation. While those with relatively more land have the lowest utilisation proportionately as they grow most of the legumes in monocrops. Within this, women farmers have limited opportunities to increase DLR and find themselves in a category of small land sizes due to socio-cultural vulnerabilities resulting in imbalances in resource endowments disadvantaging women.

It is clear from the estimation results that farmer preferences and socio-economic situations dictate the extent of utilisation of an agricultural technology despite knowledge of its benefits. In light of this, resource endowment does not always represent positive response to proven technologies. Nevertheless, legume diversification of maize systems supports maize systems of low resource farmers more than those with relatively more resources as the latter have attention to both subsistence and markets.

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Chapter Four: Identifying factors influencing women farmers' intention to increase doubled-up legume rotations in Malawi.

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Overall percentage (%)	85		
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By signing the Statement of Authorship, each author certifies that:

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ii. permission is granted for the candidate to include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Identifying factors influencing women farmers’ intention to increase doubled-up legume rotations in Malawi.

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ABSTRACT

Despite the promotion of maize-legume integration including free legume and subsidized maize seeds over 25 years in Malawi, uptake and increased utilisation have been limited among smallholder farmers. The dominance of maize in Malawian diets and the characterization of legumes as 'women's crops' suggests that participation of women in maize-legume technologies is important to attainment of food security in traditional farming systems. Owing to this background, this paper uses the Theory of Planned Behaviour (TPB) to understand which factors affect the intention of women farmers (female headed households) to increase doubled-up legume rotations in Malawi. Results showed that the strength of the women farmers' intention to increase doubled-up legume rotations originates from their confidence in utilisation of this technology. This comes from women's familiarity with maize and legumes owing to cultural association with both crops. Legume diversification of maize systems is enhanced by pre-existing knowledge of rotations and intercrops of crops for soil fertility improvement and pest and disease control. Furthermore, the dominance of maize and legumes in Malawian diets influences women's attention to these crops for food security. Understanding which psychological factors play key roles in influencing women farmers' interest to utilise legume technologies is important for promotion of the technologies. For women who are household heads utilisation of such technologies is further enhanced following their status as sole decision makers hence confident to try out different agricultural technologies.

Key words: beliefs; Theory of planned behaviour; legumes; women farmers

1. Introduction

Grain legumes are most preferred by farmers in land limited environments of sub Saharan African smallholder farming systems due to their dual purposes of soil fertility and food (Mhango et al., 2013; Snapp et al., 2002). In these environments women face a challenging task to feed their households without external support from food projects and government programmes (Doss, 2001; Fisher & Kandiwa, 2014). This has a negative impact on their access to new agricultural technologies (Doss, 2001; Knowler & Bradshaw, 2007).

The promotion of improved maize-legume integration is most relevant to enable resource poor farmers boost their access to food while rebuilding their soils (Kerr et al., 2007; Rusinamhodzi et al., 2012). The low cost nature of maize-legume integration technologies under this practice are easily adapt to the conditions of nutrient constrained smallholder farmers (Snapp et al., 1998) many of whom are women (Doss, 2001; Fisher & Kandiwa, 2014). Doubled up legume rotations (DLR) is a novel technology involving rotations of maize and an intercrop of short and long duration grain legume lasting in a three year period (Kerr et al., 2007). Field research has shown that it is superior to other legume technologies (Snapp et al., 2010).

This paper investigates women farmers' intentions to increase the area for DLR for its ecological and or food grains benefits. The targeted women farmers in this study are female household heads. We do not examine women farmers who are living with their spouses so that we control for independence of choices in cropland allocation to various crops. Women play a key role in production and post-harvest handling activities of maize and legumes in southern African smallholder farming communities (Kerr et al., 2007). Furthermore, a recent study in Malawi benchmarked the degree of utilisation of DLR at farmer level and found that on average farmers allocated 64% of their maize area to the technology (Kamanga et al., 2017b). Within this it was found that women farmers were unable to increase utilisation without reducing areas for other crops including non-DLR legumes. This was likely due to relatively smaller land holding sizes: 31% of the women farmers in the cited study sample owned less than 1 ha and 50% owned between 1 ha and 1.5 ha.

Without adequate resources farmers cannot adopt or increase utilisation of agricultural practices, although not all non-adoption or minimal utilisation of maize-legume intensified systems results from resource constraints (Kamanga et al., 2017b). In this study we investigate farmers' intentions to increase a DLR from the perspective of their attitudes towards it, social pressure from their communities and perceived competence on the technology.

Consistent with socio-cognitive theories, without strong perceived control on utilisation of the DLR women farmers' intentions would be weak hence risking abandonment or declined use. Women's' role as farmers and household heads put them in a critical decision making situation regarding food access and welfare. Therefore, this study uses this discourse to understand which psychological factors would strongly determine their intentions to increase DLR as a sustainable agricultural intensification technology that also increases access to food grains.

One of the pertinent theoretical developments in studies of human decision making is the Theory of Planned Behaviour (TPB), developed by Ajzen (1991). In this theory intentions represent behavior and they are determined by three psychological factors referred to as constructs namely: attitude, subjective norm, and perceived behavioral control. These constructs are derived from behavioural, normative and control beliefs in relation to a behaviour under investigation. The strength of women farmers' intentions to increase DLR rotations can be determined by the TPB framework. Furthermore, this framework can be used to analyse farmers' evaluation (attitudes) of DLR, explore how perceived social pressure may affect decisions on its utilisation (subjective norm), as well as understand their perceptions about their abilities and skills to increase utilisation (perceived behavioural control).

2. Materials and methods

2.1 Theory

It is widely acknowledged that people's behaviour arise from a reasoned formulation of their intentions (see Ajzen, 1991; Bagozzi, 1985, 1992; Bandura, 1977, 1991; Fishbein & Ajzen, 1975, 2010; Ryan & Deci, 2000). Behavioral intentions are primarily formed by attitudes and social norms on the anticipated behavior. In Social cognitive theory (Bandura 1977), the behavior is informed by the interaction of external stimuli (environmental factors) and inner self (personal factors). The notion of expectance-value based judgement and also of self-efficacy is commonly represented in these theories.

The TPB (Fig. 1) similarly shows that peoples' behaviours can be predicted by estimating their behavioral intentions. The TPB has shown accuracy in predicting behavior and it has been popular in farmer behavioural analysis as an alternative to utility maximising frameworks. (e.g., Borges et al., 2014; Borges & Oude Lansink, 2016; Läpple & Kelley, 2013).

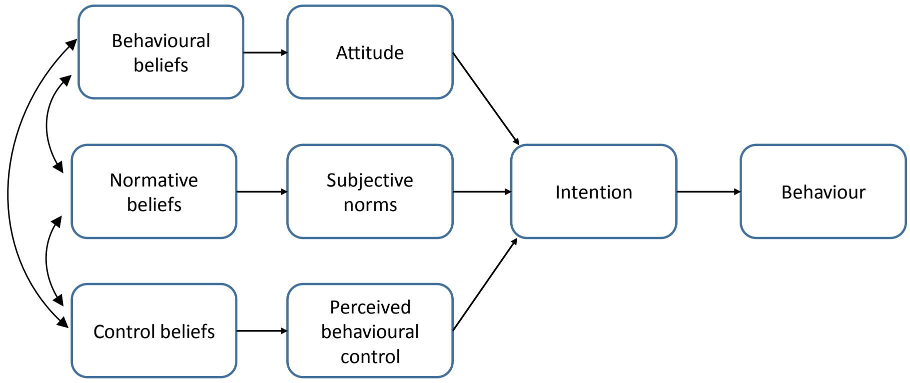

Figure 1. Schematic presentation of the TPB (Adapted from Ajzen, 2005)

When the measurement of behavioural intention is consistent with aspects of action, target, time and context, the estimated intention equals the actual behaviour (Fishbein & Ajzen, 2010). Behavioural intention is measured as; $BI = A + SN + PBC$, where, A is the attitude towards a behaviour, given by; $A = \sum b_i . e_i$ where b_i is the belief in outcome i concerning a task related to a behaviour under study and e_i is the subjective evaluation of that outcome. SN is subjective norms on the behavioural task. These norms are an individual's perception of (i) whether or not their important referents would approve the intended behaviour and (ii) how their important referents are behaving regarding the identified behavioural task (Fishbein & Ajzen, 1975).
In both ways the norms are weighted against the individual's motivation to comply with the important referents. It is given by; $SN = \sum nb_i . mc_i$, where nb_i is the belief about ideas from significant others on behavioural task i and mc_i is an individual's level of compliance with the demands of behavioural task i. PBC is perceived behavioural control. It is the strength of an individual's belief in their ability to perform a behavioural task (Ajzen, 1991). It is given by; $PBC = \sum cb_i . icb_i$, where PBC is perceived behavioural control, cb_i is the belief in access to control factor for behaviour i and icb_i is the strength of influence in control factor facilitating or inhibiting performance of behavioural task i.

In summary, people's behaviour can be determined by measuring their intentions. The intention to fulfil a behaviour is stronger when all the three constructs: attitude, subjective norms and perceived behavioural control significantly predict the intention (Ajzen, 1991). The elicitation of the constructs can be direct or derived from beliefs (Läpple & Kelley, 2013). However, to correlate the scores for the constructs both measures can be used (Borges et al., 2014).

2.2 Hypotheses

Consistent with the TPB a behaviour is derived from a number of tasks hence these form the foundations of the salient beliefs with respect to attitudes, subjective norms and perceived control. In the context of this study, a strong intention to increase the area under DLR will be derived following: favourable evaluation of the attributes of DLR; compliance with social pressure on DLR utilisation, and; perceived capacity to manage the change in resource allocation as well as demands following expansion of area under DLR.

Following the formulae for indirectly estimating the constructs, this hypothesis is derived as:
H1. The intention of women farmers to increase the area for DLR is positively correlated with direct measures of attitude, subjective norms and perceived behavioural control.
Because this study seeks correlation between direct and indirect measures of intention, another hypothesis is identified as:
H2. The intention of women farmers to increase the area for maize-legume rotations is positively correlated with indirect measures of their attitude, subjective norms and perceived behavioural control.
Since both ways to arrive at these intention estimations result from the three constructs it follows that the direct measures are positively correlated with indirect measures hence:
H3. There is a positive correlation between direct and indirect measures of attitude.
H4. There is a positive correlation between direct and indirect measure of subjective norms.
H5. There is a positive correlation between direct and indirect measure of perceived behavioural control.

2.3 Study design

2.3.1 Measurements of TPB constructs

Indirect measures of the TPB constructs were identified through elicitation using a semi-structured interview administered through focus group discussions with a total of 12 women farmers in two groups. In consultation with extension workers these farmers were purposefully selected to represent the majority of the women farmers who were practicing DLR technology in the study area. They included volunteer women farmers and those who had practiced the technology for at least six years. Elicitation sought possible outcomes from utilisation of DLR technology hence deriving the attitudes. For subjective norms, elicitation identified groups of people as well as institutions perceived influential in regard to DLR decisions in the area. Lastly, the perception of control on increasing DLR was elicited by identifying hindrances and enablers. The elicitation exercises led to an individual household questionnaire for quantification of perception responses consistent with TPB constructs. The questionnaire was administered to 61 women farmers from four villages as listed in section 2.3.2.

Following responses from the elicitation exercise Table 1a, b and c show the behavioural outcomes [b_i] and their evaluations [ei]; important people and groups [nb_i] and the motivation to comply with their opinions or conduct [mci] as well as hindrances or enablers [cb_i] and their corresponding influences [$icbi$]. Following Fishbein and Ajzen (2010) two differently designed scales were used to rate responses but each had seven-points. One scale ranged from *one* to *seven* where *one* was least desired and *seven* most desired. The other scale ranged from negative *three* to positive *three* crossing zero as a neutral point. To derive the indirect measures for each construct the summation of the products of the belief items and their evaluation or perceived influence were calculated.

Table 1a. Behavioural beliefs and outcome evaluations

Behavioural beliefs (b_i)	Outcome evaluation (e_i)
very unlikely - very likely and strongly disagree - strongly agree scale: [1 - 7]	*extremely undesirable - extremely desirable* scale: [(-3) - (+3)]
Doing DLR technology improves soil fertility for maize	Improving soil fertility on my farm is…
Doing DLR technology improves maize yield	Improving maize yield through DLR technology is…
Doing DLR technology improves legume yield	Improving legume yield through DLR is…
Doing DLR technology brings more food grains	Producing more food grains (from legumes and maize) is…
Doubled-up legumes prepare a good base for my maize	Preparing a good base for my maize is…
DLR technology leaves little space for planting maize	Reducing maize planting space is …
DLR technology contributes to labour saving on the farm	Saving labour on the farm is…

Table 1b. Normative beliefs and their influence

Normative beliefs (nb_i)	Motivation to comply with normative beliefs (mc_i)
Injunctive norms *(would/would not);* scale: [(-3) - (+3)]	*(not at all – very much);* scale: [1 – 7]
Extension workers ….recommend increasing area for DLR technology	Extension worker's approval matters to me
Volunteer farmers ….	What volunteer farmers recommend is very important to me
Other farmers near me …..	Doing what my fellow farmers do is important to me
Descriptive norms (*is/are likely/unlikely)*	
Volunteer farmers …increase area under DLR technology	Copying what volunteer farmers do is important to me
Extension worker …to do more maize-legume rotations	Doing what Extension workers would do matters to me

Table 1c. Control beliefs and their influence

Control beliefs (cb_i)	Perceived influence of control beliefs (icb_i) (Scale: [(-3) - (+ 3)]
strongly disagree – strongly agree (scale: 1 – 7)	*Least likely – most likely*
Accessing legume seed is difficult	It is … that I would scale down or abandon DLR technology in the next 2 years if I find it hard to access legume seed
I feel that DLR takes up more land than maize/legume intercrops	I would ….. find it difficult to allocate more land for DLR technology in the next 2 years is
Some of the legumes under DLR are not marketable	I am …to scale down or abandon DLR technology in the next 2 years if I do not sell DLR legumes
DLR demands more money on farm inputs than other legume technologies	Using more money on farm inputs for DLR technology in the next 2 years will…make me abandon this technology

2.3.2 Study area, sampling and survey

The study data comes from Ekwendeni area in Mzimba district of Malawi and were collected from 61 women farmers between April and May 2015. The study sample is drawn from farm households that were intensifying legumes in their maize cropping area using DLR technology. A project on legume diversification of maize based systems (legumes best bet) had operated in the area for over 15 years initially through farmer participatory research methodology and later enhanced extension of the good practices through government extension workers and volunteer farmers (Kamanga et. al, 2017). Volunteer farmers were farmers who had hosted on-farm trials for legume diversification leading to DLR technology.

To fulfil the study objective sampling of farmers was limited to female headed households who were using DLR. The female household heads were identified using village registers supplied by a government agricultural extension officer these villages: Robert Mseteka; Yesaya Jere; Chinombo Jere, and; Bandawe Tembo. With the help of volunteer farmers under the legumes best bet project and a government extension officer we purposefully sampled women farmers in each village on the following criteria: household heads and adopters of DLR technology with a minimum experience of utilisation of at least six years to minimise effect of uncertainty on the evaluation of the performance of the technology. The utilisation experience excluded the year in which data was collected as crops were still standing in the field at the time of data collection. Consistent with management practices of DLR technology, a two year intercrop of soybean/pigeon pea or groundnut/pigeon pea is rotated with maize in the third year. Therefore, a minimum of six year period of utilisation of DLR allowed study farmers to have rotated the legume intercrops with maize at least twice. Land area was measured with assistance of agricultural extension officers.

2.4 Data analysis

Data analysis followed validation of the scales that were used to measure the TPB constructs using Cronbach's alpha coefficient. A coefficient with value of 0.6 or higher validates measurement items in both direct and indirect assessment of the constructs (Borges et al., 2014). A non-parametric test of the study hypotheses was conducted using the Spearman rank correlation coefficient (*r*) following (Borges et al., 2014; Martínez-García et al., 2013). Tests were ran in IBM-SPSS 23.

3. Results

3.1 Descriptive statistics on demographics and maize-legume cropping

Table 2 shows background factors on household demographics and maize and legume cropping for the women farmers. Average landholding size was estimated at 1.5 ha. Apart from DLR legumes cow peas and common beans were also widely grown. Up to 75% of the women farmers received farm inputs (inorganic fertilisers and maize and legume seed) in the previous year as part of a government initiative to improve food security while diversifying legume in maize systems (Kumwenda et al., 1996).

Table 2. Farm household characteristics and maize-legume cropping

	Min	Max	Mean	Std. Deviation
Age of the household head (farmer) (Years)	27	82	47.79	15.67
Size of household	1	10	4.61	1.88
Total Land Size (ha)	0.8	6	1.53	1.1639
No. of years of formal schooling	0	16	7.02	4.36
Experience in using DLR technology (Years)	6	12	7.05	4.25
Participation in information platform on DLR in the previous year	3	8	4.0	2.0
Proportion of maize area under DLR technology	0.5	1	0.74	0.42
Number of legume crops grown	3	5	3.6	0.72
Quantities of legumes harvested in recent year (kg)				
Groundnuts	250	1600	445.88	116.53
Pigeon peas	270	1240	386.32	71.51
Cow peas	85	360	130.30	94.81
Common beans	300	1020	360.45	63.85
Soybeans	280	1050	114.5	103.71
Amount of maize harvested previous year (kg)	560	6000	1215.77	743.42
Household received free legume seed in the last 2 years (1 = Yes; 0 = No)			0.59	0.49
Household received FISP* coupons in the last 2 years (1 = Yes; 0 = No)			0.75	0.43

N = 61

*Farm inputs subsidy program coupons entitling the holder to subsidised inorganic fertilisers (100 kg) plus free maize seed (10 kg) and legume seed (10 kg)

Soybean, groundnuts and pigeon pea grown under DLR technology was recorded for recent harvest. During data collection some farmers had the DLR legumes in the first year and others in the second year of intercrop before rotating with maize

3.2 Direct measures of intention, attitude, subjective norms and perceived behavioural control on DLR

Intention to increase area for DLR was measured on four statements as shown in Table 3. A Cronbach's alpha value of 0.65 was acceptable for the mean of these statements to represent the construct of intention in the analysis. The mean value of intention measure shows that the women farmers generally displayed a moderate intention to increase DLR area in the next two years. The intention statement with the least score (*two*) was selected by 66% of the women farmers and it was 'How strong is your intention to increase DLR area in the next two years?' While two intention statements had similar scores of *three* each and were selected by 82% and 83% of the women farmers. These were 'I intend to increase the area for DLR in the next two years' and 'I plan to increase the area for DLR within the next two years' respectively.

Table 3. Descriptive statistics for direct intention on DLR utilisation in two years

Intention	Scale (1-5)	Mean	SD	Median	IQR
I intend to increase the area for maize-legume rotations in the next two years	definitely not - definitely yes	6.4	0.79	7	1
How strong is your intention to increase maize-legume rotation area in the next two years?	very weak - very strong	6.3	0.73	6	1
How likely is it that you will increase the area for maize-legume rotations in the next two years?	very unlikely - very likely	6.3	0.80	6	1
I plan to increase the area for maize-legume rotations within the next two years	strongly disagree - strongly agree	6.4	0.74	7	1
Cronbach's alpha: 0.7					
Grand intention mean: 6.3					

Table 4. Descriptive statistics for direct attitude on DLR

Direct attitude	Scale (1 - 7)	Mean	SD	Median	IQR
(DirectATT1) Increasing area for DLR technology is	worthless - useful	6.39	0.822	7	1
(DirectATT2) Increasing area for DLR technology is	least beneficial - most beneficial	6.07	0.981	6	2
(DirectATT3) Increasing area for DLR technology is	unpleasant - pleasant	6	1.14	6	2
Cronbach's alpha 0.6					
Overall direct attitude mean: 6.15					

The women farmers had a positive attitude towards utilisation of DLR as they generally expressed themselves favourably towards increasing the area for the technology (see Table 4). Up to 59 % of the women farmers gave the highest score (*seven*) for the first attitude statement 'DirectATT1'. For each of the other direct attitude statements 42% of the women farmers scored highest scores. The value of the Cronbach's alpha was adequate hence the mean of the attitude statements represented direct attitude.

Table 5 shows that there was generally high social pressure to increase the area for DLR as over 40% of the women farmers scored high on the Likert scales: *seven* for DirectSN6 and DirectSN8 and *six* for DirectSN7. There was a fair distribution of responses for the rest of the direct subjective norms statements with 26% and 25% of the women farmers indicating no social pressure in statements DirectSN5 and DirectSN6. The Cronbach's alpha value was adequate for continued analysis.

Table 5 Descriptive statistics for direct subjective norms on DLR

Direct subjective norm	Scale (I - 7)	Mean	SD	Median	IQR
(DirectSN4) Most people important to me wish that I increase DLR area	strongly disagree - strongly agree	4.28	2.303	5	5
(DirectSN5) It is expected of me from members of my village to do DLR	strongly disagree - strongly agree	4.03	1.932	4	4
(DirectSN6) I feel under social pressure to increase DLR	strongly disagree - strongly agree	6.39	0.822	7	4
(DirectSN7) The Extension worker wishes that I increase the area for DLR	strongly disagree - strongly agree	5.41	1.687	6	1
(DirectSN8) Every farmer doing DLR may increase it	strongly disagree - strongly agree	6.05	0.99	6	2
Cronbach's alpha: 0.6					
Overall perceived norm mean: 5.03					

Generally the women farmers displayed a strong perception of control on DLR as presented in Table 6. High scores of *seven* were given by 67%, 46%, 38% and 38% in: DirectPC1, DirectPC2, DirectPC3 and DirectPC4 respectively. Less than 2% of the women farmers scored below four across all the direct perceived control statements. The Cronbach's alpha value was also adequate for this construct.

Table 6. Descriptive statistics for direct perceived behavioural control on DLR

Direct perceived control	Scale (1-7)	Mean	SD	Median	IQR
(DirectPC1) I am confident to increase area for DLR in the next two years	strongly disagree - strongly agree	6.44	0.922	7	1
(DirectPC2) For me to do the tasks demanded by DLR in the next two years is	very difficult - very easy	5.95	1.203	6	2
(DirectPC3) Decisions on DLR in my farm household are done by me	strongly disagree - strongly agree	5.89	1.199	6	2
(DirectPC4) Whether I can increase DLR in the next two years is beyond my control	strongly disagree - strongly agree	5.89	1.199	6	2
Cronbach's alpha: 0.61					
Grand direct perceived control mean: 6.04					

Results of the Spearman rank correlation coefficients (r_s) in Table 7 show that only direct attitude (DirectATT) towards and direct perceived control (DirectPC) of DLR were positively and significantly correlated with intention. Therefore, the first study hypothesis, H1 was partly rejected: the intention of women farmers to increase DLR is positively correlated with direct measures of their attitude, subjective norms and perceived behavioural control.

Table 7. Correlation between direct measures of attitude, subjective norms and perceived behavioural control with intention mean

Construct	Correlation with intention mean
DirectATT	0.536**
DirectSN	0.043
DirectPC	0.395**

** Correlation is significant at the 0.01 level (2-tailed).

3.3 Correlations of indirect measures of TPB intention predictors with means of direct attitude, subjective norms and perceived behavioural control

Table 8 shows that six of the seven indirect measures of attitudes were significantly correlated with direct attitude. Only *be1* was not significantly correlated with direct attitude. Therefore, hypothesis H3 was partially rejected: the direct measure of attitude is positively and significantly correlated with behavioural beliefs. Cronbach alpha coefficient for the seven behavioural beliefs was acceptable for incorporation in the analysis. Hence the sum of these seven behavioural beliefs represented indirect attitude.

Table 8. Correlation between indirect measures of attitude and mean direct attitude

Behavioral beliefs *($b.e_i$)*	Correlation with DirectATT mean
be1	0.299*
be2	0.346**
be3	0.462**
be4	0.460**
be5	0.378**
be6	0.251
be7	0.408**

Cronbach's alpha: 0.8

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 9 shows that only two measures of subjective norms were positively and significantly correlated with the mean of direct subjective norms using the Spearman rho's coefficient. Therefore, hypothesis H4 was partially rejected: the direct measure of subjective norms is positively and significantly correlated with subjective norms. However, the Cronbach's alpha value allowed summation of the five normative beliefs to represent the indirect measure of subjective norms.

Table 9. Correlation between indirect subjective norm items and mean direct subjective norm

Normative beliefs ($nb_i.mc_i$)	Correlation with mean DirectSN
nbmc1	0.183
nbmc2	0.142
nbmc3	0.096
nbmc4	0.267*
nbmc5	0.357**

Cronbach's alpha: 0.8

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

On the correlation between direct and indirect measure of behavioral control (Table 10), a statistically significant positive relationship was found between the direct and indirect measure of behavioural control. Therefore, Hypothesis H5 was retained. The Cronbach's alpha was valid for continued analysis at a value of 0.61.

Table 10. Correlation between indirect perceived behavioural control measures and mean direct perceived behavioural control

Control beliefs ($cb_i.icb_i$)	Correlation with mean DirectPC
cbicb1	0.542**
cbicb2	0.530**
cbicb3	0.843**
cbicb4	0.157*

Cronbach's alpha: 0.61

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Lastly, the correlation between indirect measures of intention predictors and intention was found to be positively significant as shown in Table 11. Therefore, hypothesis H2 was retained.

Table 11. Correlation between indirect attitude, subjective norms and perceived behavioural control and intention on increasing DLR

Construct	Correlation with intention
IndirectATT	0.518**
IndirectPN	0.344**
IndirectPC	0.369**

** Correlation is significant at the 0.01 level (2-tailed).

4. Discussion

Only two direct intention predictors could be associated with the intention of women farmers to increase DLR in the next two years in Mzimba district in Malawi. These were attitude and perceived control. On the other hand, all the indirect predictors of intention have shown significance in estimating the likelihood that the women farmers would increase the area under DLR in the next two years. In the absence of a follow-up survey on the same women farmers at the end of two years after this data was collected we cannot be certain of the achievement of their intentions. However, the strength of the prediction of these intentions is reliable as the indirect predictors have demonstrated significance in correlation with intention. In addition, the nature of agricultural practice may be important here. DLR may be limited by land size but perceived control was significant for both direct and indirect measures. This implies that the women farmers did not foresee any hindrances to increased utilisation, be it seed access neither land.

A previous study in the area found that no farmers rented extra land for their farming including DLR (Kamanga et al., 2017b). Therefore, if we assume that no women farmers rented land to increase DLR we can conclude that expansion of DLR was possible through trade-offs on cropland allocation. The other possibility on expansion of DLR area is that smaller portions of land were dedicated to DLR hence there was room for expansion and that access to seed was guaranteed.

The significant correlation between direct measure of attitude and the intention indicates that women farmers' evaluation of the benefits from increasing DLR influenced their intentions. Similarly, there was a positive significant correlation between indirect measure of attitudes and intention hence the outcomes from the behavioural beliefs from utilising and increasing DLR influenced intentions too. Considering the ecological benefits from maize-legume intensified systems (Snapp et al., 1998) and the household consumption needs of the women farmers (Fisher & Kandiwa, 2014), it was expected that they would favourably evaluate increasing DLR. Therefore, to encourage more women farmers increase DLR in their maize systems, extension agents could target messages that emphasize on such farmers' experiential knowledge. These results are consistent with literature on farmer decision making on technologies. Borges et al. (2014) found that farmers' intention to utilise improved natural grasslands in Mexico was strongly correlated with both direct and indirect attitude measures. Several scholars that have used this analytical technique have found positive correlation between attitudes and intention to adopt (Garforth et al., 2004; Martínez-García et al., 2013).

The insignificance of the correlation between direct subjective norms and intention suggests that social pressure could not influence intention to increase DLR by the end of two years. However, the results were different for indirect measures as indirect subjective norms were significant and positively correlated with intention. The positive and significant relationship between indirect subjective norms and intention demonstrates that the normative beliefs concerning people or groups highly regarded influenced the women farmers' intentions to increase the area for DLR. In this regard we can rely on indirect measures as the questioning does not reveal who might directly influence a behaviour. Even so the lack of significance of one intention predictor is not an unexpected (Ajzen, 2012). The role of subjective norms on intention has had mixed results reported in literature. While many scholars report significance (e.g., Borges et al., 2014; Martínez-García et al., 2013; Rehman et al., 2007; Van Hulst & Posthumus, 2016), there has also been evidence of no relationship in other studies (e.g., Bruijnis et al., 2013).

The fact that our results show no significant correlation between direct measures of subjective norms and intentions may suggest two things: Firstly, that no persons or groups could influence the women farmers to increase area under DLR. Secondly, this could result from reluctance to display what would appear as low self-esteem if important referents appear to influence a behavioural intention (Garforth et al., 2004). Direct questions such as 'I feel under social pressure to increase maize-legume rotations' and 'It is expected of me to increase DLR from members of my village' suggest that farmers who want to depict independence of any influence on DLR decisions would opt for responses that show this. In our questions this would be a response towards the negative end of the Likert scale.

The positive and significant correlation between intention and direct perceived behavioural control shows that the women farmers' perception of their capacity to increase DLR influenced their intentions. The positive correlation suggests that the higher the perceived ability to manage expansion of DLR, the stronger the intention to do so. This is also supported by the correlation between indirect perceived behavioural control and intentions. Therefore, the women farmers' intentions were influenced by control beliefs about potential factors that could allow or hinder increased utilisation of DLR. This relationship corroborates an earlier finding by Borges et al. (2014) on the significance of indirect measure of perceived behavioural control and intention.

To understand the drivers of these intention predictors on DLR among the women farmers we ran correlations between direct measures of intention predictors and behavioural, normative and control beliefs respectively. The mean of direct attitude was positively and significantly correlated with six of the seven behavioural beliefs. Hence these were the main drivers of the women farmers' direct attitude: (i) DLR improves legume yield, (ii) DLR improves maize yield, (iii) DLR brings more food grains, (iii) Doubled up legumes prepares a good base for maize, (iv) DLR improves soil fertility for maize, and (v) DLR saves labour on the farm. Therefore, to influence farmer behaviour on DLR such statements can be incorporated in messages on its promotion. The behavioural belief 'DLR rotations reduces area for maize' was not correlated with direct attitude. This may actually mean that if increased utilisation has to be achieved, some area for growing maize has to be reduced. This is consistent with earlier econometric analysis on land area relationship with utilisation of DLR (Kamanga et al., 2017b).

Direct perceived norm was positively and significantly correlated with only two of the five normative beliefs. These two were the drivers of women farmers' direct subjective norms. The beliefs were suggested to be influenced by the people or institutions that the women farmers had respect for in as far as DLR utilisation was concerned. These included extension workers, volunteer farmers and neighbouring farmers. Farmers may behave in expected ways in order to conform to shared values (Martínez-García et al., 2013), and also in anticipation of other benefits particularly where agricultural practices are promoted by external organisations (Kamanga et al., 2017a). The important referents for DLR listed here are traditionally used in extension of agricultural technologies and practices in Malawi. Therefore, our suggested recommendations from this finding is that policy makers and extension experts should strengthen institutions connecting women farmers and extension contact points such as extension platforms, extension field workers' scope as well as collaboration and farmer trainings in DLR. Consistent with the TPB farmers are most likely to learn from the people they have respect for in their community. Garforth et al. (2004) notes that identification of important referents for an agricultural technology is a good step for identifying institutional factors that are critical to encouraging farmers to adopt technologies or increase utilisation.

The two belief statements that significantly correlated with direct subjective norms were descriptive in nature. Our argument for this result relates to the activeness of the statements for descriptive norms on the TPB questionnaire. While those statements that did not significantly correlate with direct subjective norms were asked in the passive form as they arose from injunctive norms.

Direct perceived behavioural control was positively and significantly correlated with all the control beliefs. All these influenced the direct perceived behavioural control of the women farmers hence enabled them use and intend to increase utilisation of DLR. These factors included confidence in the management of the practice, which was expected to be positive as the mean number of years of using the practice was 12 years. In addition, the characterisation of legumes as women crops and its importance in Malawian diet may have enhanced this confidence. Other control beliefs were derived from the single status of the women farmers implying independence in decision making in the farm household. The statement with the highest correlation with direct perceived behavioural control was 'The decision to do DLR is entirely determined by me'. Again this is a demonstration of independence in decision making and confidence in legume diversification of maize systems using DLR. Following Garforth et al. (2004), confidence in an agricultural practice is a strength in utilising that practice hence positively contributes to intentions even without influence of significant others.

One can argue that the direct measures provided weaker intentions than the indirect measures. Nevertheless, the variation in these two measures may have resulted from the very error that the indirect measures seek to control. Since people may not like to portray low self-esteem during face to face interviews even if their identities remain confidential. Therefore, our results are robust when taken from the perspective of the indirect measurements of the three intention predictors of the TPB.

5. Conclusion

This research work originated from concerns about underutilisation of legumes in maize systems, which could otherwise improve soil fertility and organic matter content while also providing food grains from both legumes and maize. The intensification of legumes in maize systems, which this study focused on concerned rotations. The study purposefully identified women farmers who were household heads to understand their intentions to continue and increase maize legume rotations. Using the TPB theoretical framework we have demonstrated that attitudes and perceived behavioural control are the main drivers of the women farmers' intentions on utilisation of the DLR. Furthermore, indirect measures of subjective norms have been found to correlate with farmers' intention when asked in the descriptive form.

The status of the women farmers as heads of their households is a strength for enhancing perceived behavioural control relating to DLR utilisation because they can make their own decisions. This may further be strengthened by the characterisation of some legumes as 'women crops' in Malawi and the southern African region. These two factors can be used in extension programmes to enhance attitudes towards maize-legume intensified systems among women farmers generally. These factors are well supported by the confidence in management of maize-legume rotations owing to a long history of the existence of legumes in traditional southern African farming systems. Further to this, institutions and contact points for promotion of maize-legume intensified systems have been found to support subjective norms on utilisation of maize-legume rotations hence important entry points for promotion of the DLR among women farmers.

Our choice of socio-psychological theory to understand this farmer behaviour was based on the fact that decision making lends itself to various socio-economic and psychological factors (Willock et al., 1999). Our first investigation on underutilisation of DLR in the same study area used a regression analysis to list socio-economic and institutional factors associated with farmers' decision to increase utilisation (Kamanga et al., 2017b). This present study has used correlation analysis of behavioural intention predictors and intention following the analytical approach in TPB. This was to capture other decision making influences such as expressive needs, social pressure, and habit.

Within the agricultural adoption discourse, not all non-adoption or minimal utilization results from resource constraints (Edwards-Jones, 2006; Kamanga et al., 2017b). In conformity with this and the status of legumes as ‘women’s crops’ in Malawi this study has demonstrated the strength of perception of control on decision making by women farmers as farm household heads. All control beliefs were significant with direct measures of perceived behavioural control. In addition perceived behavioural control significantly correlated with women farmers’ intention to do DLR.

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Chapter Five: Understanding smallholder farmers' motivation for increasing doubled-up legume rotations in Malawi

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Understanding smallholder farmers' motivation for increasing doubled-up legume rotations in Malawi.

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ABSTRACT

Doubled-up legume rotations (DLR) is a novel technology of intercropping legumes with complementary growth habits for two years then rotated with maize in the third year. This study adapts the Theory of Planned Behaviour to investigate whether smallholder farmers' attitudes, subjective norms and perceived behavioural control regarding DLR influence their perceptions of its goal-related outcomes (farm incomes from whole farm and improved legume diversified cropping systems). It also applies a probit model to estimate the probability of increasing area under DLR given these goal-related outcomes. This two-step analysis is applied to smallholder farmers who adopted DLR under support from a legume project called Soils, Food and Health Communities in Malawi. The first analysis finds that farmers held positive attitudes towards DLR but continued utilisation of the technology was most influenced by institutional variables: obligations to and expectations from the project; and obligations to extension services and to social networks. The second analysis validated the influence of farmers' positive perception of goal-related outcome of improved legume diversified cropping systems on the amount of land dedicated to DLR. Findings show that the promotion of DLR should target fora with rich social capital. The significance of perceived control on attainment of increased farm incomes as well as positive attitudes towards legume diversified cropping systems are strengths that can be used by extension agents to increase farmers' awareness on the ecological benefits of maize-legume integration using DLR.

Keywords: soil fertility; goal-related outcome; legume diversification.

1. Introduction

Changing climate and rising inorganic fertiliser prices in southern Africa in the last 25 years has directed agronomists' attention towards more sustainable agricultural practices such as legume diversification of maize based systems (Sakala et al., 2003) which can improve soil organic matter and soil nitrogen availability (Giller & Cadisch, 1995; Snapp, Kanyama-Phiri, et al., 2002)and can lead to lower nitrogen fertiliser rates without risking economic losses from lower maize yields (Smith et al., 2016).

Despite a well-established relationship between legume cultivation and soil fertility (Snapp, Rohrbach, et al., 2002) of the benefits to soil fertility do not motivate farmers to diversify more legumes in their maize systems. Instead it is legume prices that dictate whether farmers increase legume diversification (Giller et al., 2011; Mhango et al., 2013). On the other hand some farmers will only integrate maize and legumes if they are using them primarily for home consumption (Kamanga et al., 2017).

In other cases, farmers give little attention to maize-legume integration opting for crops with higher expected returns such as tobacco, cotton and vegetables (Shaxson & Tauer, 1992), even when legume seeds are supplied freely (Chibwana et al., 2012). Farmers' motivations to increase improved maize-legume integration concern influence other than farm level socio-economic factors. Furthering understanding of low utilisation of maize-legume intensified systems, this paper adapts the theory of planned behaviour (Ajzen, 1991) to investigate whether farmers' attitudes, subjective norms and perceived behavioural control on doubled-up legume rotation (DLR) influence specific goal-related outcomes from the technology. Doubled-up legume rotation is a maize–legume integration technique where two varieties of legumes of complementary phenology are intercropped for two years and then rotated with maize in the third year in order to maximise soil nitrogen.

In this study a multivariate model of motivation for maize-legume integration was developed and applied to the data from a sample of 380 farmers who had adopted DLR under a support from Soils Food and Healthy Communities legumes best bet project in north Malawi. A probit regression analysis was also conducted to verify the factors describing farmers' motivation against their actual behaviour. The paper proceeds as follows; background, theory, methodology, results and discussion and conclusion.

2. Background

Previous work to explain low uptake of improved maize-legume integration in southern African cropping systems had mostly focused on legume adoption. This is because maize is widely grown in this region and dominates smallholder cropping systems making legumes a missing link to the concept of improved maize-legume integration. Mafongoya et al. (2007) noted that adoption of certain grain legumes like soybeans and groundnuts was negatively affected by lack of viable markets in Zimbabwe. Similarly Giller et al. (2011) found that farmers had interest in growing more soybeans but were discouraged by low prices. In the Angonia highlands of Mozambique such constraints that are external to the farm household have also been noted (Grabowski & Kerr, 2014). In Malawi, where landholdings are generally smaller than in the neighbouring countries, there is evidence of low legume utilisation for improvement of soil fertility due to uncertain markets (Waldman et al., 2016). With smaller landholdings, one can argue that uptake of grain legumes would be high to increase access to food grains.

Other constraints to increased maize-legume integration concern lack of good quality germ plasm; insufficient labour; minimal landholdings (Mhango et al., 2013; Snapp, Rohrbach, et al., 2002). Adequate labour supply is very important for all agricultural activities and maize-legume integration is no exception (Deressa et al., 2008). Snapp, Kanyama-Phiri, et al. (2002) found that grain legumes with local marketability were preferred in areas of severe land limitation in central Malawi. While in northern Malawi, where landholding sizes are relatively higher, farmers' lack of interest in the practice was partly due to lack of legumes that fixed more nitrogen in the soils (Kerr et al., 2007). In this area, a legumes best bet project established farmer participatory research (FPR) trials on improved maize-legume integration (leading to the development of the DLR technology) to better respond to soil fertility problems (Snapp, Kanyama-Phiri, et al., 2002).

The primary need for diversifying legumes in maize systems is to build soil fertility (Giller et al., 2011; Smith et al., 2016; Snapp et al., 1998; Snapp, Rohrbach, et al., 2002). However, food security and expected cash incomes from legume production are most prioritised among African smallholder farmers (Giller et al., 2011; Grabowski & Kerr, 2014; Snapp et al., 1998). This may be one cause of the disparity between promotional efforts to win farmers to adopt or increase the utilisation of improved maize-legume intensified systems and farmers' actual behaviour.

The objective of this paper is achieved by first identifying goal-related outcomes from DLR and examining farmers' perceptions of these outcomes against their attitudes, subjective norms and perception of behavioural control. This is consistent with the theory of planned behaviour (TPB) (Ajzen, 1991). Secondly, an examination of farmers' actual decisions on DLR utilisation was carried out two years later between farmers who had increased area under DLR and those who had not using probit regression. To achieve the study objectives a two-step analysis is conducted; firstly, a structural equation modelling based on an expectance-value decision model adapted from the TPB is applied. The choice of this theoretical foundation is based on the role of social pressure and farmers' obligations in agricultural adoption decisions where farmers interface with organisations promoting agricultural technologies (Kamanga et al., 2016). Organisations that promoted DLR technology in north Malawi were Soils, Food and Health Communities in partnership with the Ministry of Agriculture under a legumes best bet project.

3. Methodology

3.1 Theory

A farmers' decision making framework integrating farming goals and the intention predictors of the TPB was developed by Bergevoet et al. (2004) and further adapted by (May et al. (2011). The multivariate model proposed in this study is an extension to both of these contributions by studying how goal-related outcomes from an agricultural practice are influenced by farmers' perceptions of the practice based on the primary intention predictors of the TPB model. As shown in Figure 1, goal-related outcomes from DLR mediate the decision to increase utilisation of the technology and the primary intention predictors. Fishbein & Ajzen (2010) establish that background factors including household socio-economic factors influence the normative, subjective and control beliefs leading to formation of attitudes, subjective norms and perceived behavioural control. However, in a cause-effect modeling these factors moderate the decision (Lowry & Gaskin, 2014). We can argue that when uncertainty on an agricultural technology is minimal the household factors are most important in moderating the decision on amount of utilisation. On the other hand when uncertainty is high the same factors influence farmers' foundations of attitudes, and behaviour towards the technology. In this study these factors primarily impact on the decision (Figure 1). This is because the study is conducted among farmers who had at least six years of experience in utilising DLR. It was assumed that uncertainty on this technology was minimal. Besides the farmers had always cultivated maize and legumes and what was novel in the DLR technology was the intercropping of two legumes. The framework also shows that household socio-economic factors can influence the foundations of the TPB intention predictors but this is when farmers have high uncertainty as discussed. In this study we focus on the moderating role of these factors on the DLR decision in a probit analysis.

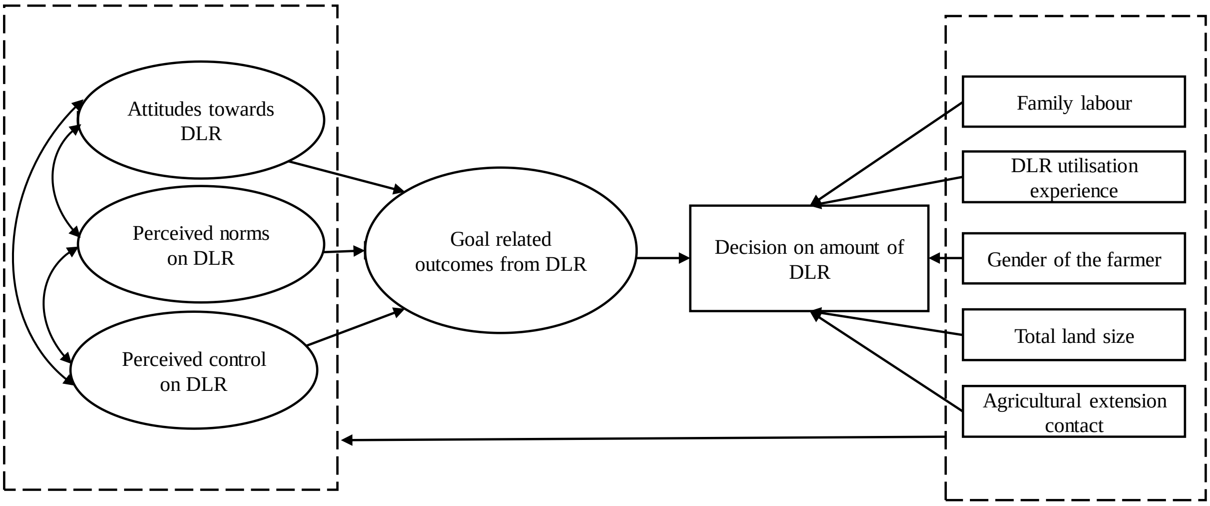

Figure 1. Multivariate model for decision on amount of utilisation of doubled-up legume rotation technology (based on Bergevoet et. al., 2004 and May et. al., 2011).

The following hypotheses can be tested from this model:

H1: Farmers' pursuit of farm incomes from DLR is affected by attitudes towards the practice.

H2: Farmers' pursuit of farm incomes from DLR is affected by perceived norms on practice.

H3: Farmers' pursuit of farm incomes from DLR is affected by perceived control on the practice.

H4: Farmers' pursuit of an agro-ecologically DLR is affected by attitudes towards DLR.

H5: Farmers' pursuit of an agro-ecologically managed farm system is affected by perceived norms on DLR.

H6: Farmers' pursuit of an agro-ecologically managed farm system is affected by perceived control on DLR.

H7: The amount of DLR depends on farmers' perceived goal-related outcomes from the technology and farm household level socio-economic factors (land size, gender, farming experience, contact with agricultural extension, family labour).

Hypotheses H1 to H6 are tested using maximum likelihood estimation under Partial Least Squares regression - Structural Equation Modeling (PLS-SEM), simply referred to as SEM in this paper. SEM combines analytical properties of both factor analysis and ordinary least squares regression and it can test complex relationships of observed and latent variables, and even chains of effects (mediation) (Lowry & Gaskin, 2014).

Consistent with socio-cognitive theories, motivational factors, whether intrinsic or extrinsic affect the determination in pursuing a behaviour (Chatzisarantis & Biddle, 1998). Following this, our modelling incorporates farmers' goal-related outcomes from DLR, as motivation for utilising DLR after (Bergevoet et al., 2004). These outcomes are farm cash incomes and legume diversification of maize systems. For example, we assume that farmers are motivated to continue using DLR to attain farm incomes and to diversify their cropping system using legumes in a pattern that contributes to soil fertility for maize production.

Hypothesis H7 was tested using the maximum likelihood of the probit function because the decision on amount of DLR concerned whether within two years a farmer had increased the area under DLR. Farmers who had increased this area were assigned a value of *one* and those who had not or had reduced it were assigned a value of *zero*. The probit function estimates the inverse standard normal distribution of the probability as a linear combination of predictor variables. Hence $\Pr(y|x) = \phi(x\beta)$, where ϕ indicates the cumulative distribution of the standard normal distribution and $x\beta$ are predictor variables (Greene, 2003). Other household level variables (Figure 1) were added to the probit model based on agricultural adoption literature (Knowler & Bradshaw, 2007; Marenya & Barrett, 2007) apart from the variables concerning goal-related outcomes from DLR.

3.2. Study context

3.2.1 Study area and design

This study uses data from a survey of 390 farmers who utilised DLR technology in Mzimba district in Malawi. Bwengu and Zombwe Extension Planning Areas were identified following FPR impact areas in the district. A legumes best bet project under an organisation called Soils, Food and Health Communities oversaw these trials and extension services alongside the Ministry of Agriculture. The project was established in 1998 following with a hypothesis that poor child nutrition resulted from nutrient deficient soils and inadequate nutritional diversity (Kerr et al., 2007).

The study required voluntary participation of farmers and written consent was given in both data collection rounds including in focus group discussions. To minimise biases of responses study farmers were randomly sampled from a list of farmers who had adopted DLR six years after establishment of the legumes best bet project. These may not have been as socio-economically vulnerable as the earlier project participants who had been purposefully identified according to level of vulnerability in their communities. Study villages were selected on the basis of having hosted on-farm trials for DLR as part of FPR. This was important to widen the sampling frame to sample farmers that had utilised DLR for at least six years as described in section 3.1.

3.2.2 Data collection

Data for this study was collected in two rounds of household surveys. The first round covered questions for SEM analysis and was carried out between February and March 2015. Data collection followed elicitation of responses to cover attitudes, subjective norms, perceived behavioural control, and the two goal-related outcomes from DLR: legume diversification for soil fertility and increased farm incomes as well as demographic characteristics. Elicitation was done through focus group discussions with a total of 37 farmers from four villages. Following Läpple and Kelley (2013) direct elicitation for measurable items was done to control for heterogeneity effects on belief statements (for basic factors of the TPB). Elicitation questions are shown in appendix. The responses from these questions were first tallied and those with the highest frequencies were structured into a questionnaire (appendix Table A1) that was subsequently administered in 10 villages as shown in Table 1.

Table 1 study villages and sample

Name of Village	Number of farmners	Number utilising DLR	Number sampled
Mthakopoli Longwe	61	50	40
Hezekia Longwe	57	57	40
Robert Mseteka	47	47	35
Chinombo Jere	51	51	40
George Jere	58	43	40
Yesaya Jere	61	61	50
George Jere	58	43	35
Bandawe Tembo	42	42	35
Robert Ngwira	64	56	35
Chinyama Nyirenda	62	58	40
Total	561	508	390

In addition to the structured questions, demographic and agronomic data were collected. Of importance was land size on which DLR was utilised. This was measured with the help of agricultural extension staff. Areas for both maize and intercropped legumes were recorded with the help of extension workers.

The structured questionnaire contained Likert-scale statements ranging from one to five, where *one* was least desirable and *five* most desirable situation. The statements were pretested on 20 farmers and later modified in consultation with extension staff from both ministry of agriculture and LBB project before administering the questions to a larger sample. This was to minimise errors arising from misunderstood statements. The final structured questionnaire for the first round of data collection that was used in the SEM analysis is presented in Appendix Table A1. 10 questionnaires were not used in the SEM analysis due to inconsistencies. This made a final sample of 380 farmers for SEM analysis.

The second round followed two years later between June and July 2017 to the same farmers with questions mainly for probit analysis. In the second round of data collection only 374 farmers were interviewed as others were not available. Data was collected on whether a farmer had increased area under DLR or not as a dependent variable for the probit model. For explanatory variables data included perception variables on legume diversification: whether a farmer considered it a priority; and increased farm incomes regardless of legume technology being used: whether a farmer considered this a priority. The rest of the variables were gender of the farmer, land size, labour, contact with agricultural extension officers or their representative and experience in utilising DLR The perception variables were assigned values of *one* in the affirmative and *zero* otherwise. The rest of the observable variables were recorded accordingly as shown in Table 2.

DLRPROP, which was the proportion of maize area integrated with legumes is a metric developed by Kamanga et al. (2017). It measures the relative amount of maize-legume integration and can be used to compare utilisation across farmers of different landholding sizes. DLRPROP is not used in this probit analysis because the change in DLRPROP between 2015 and 2017 is closely associated with the dependent variable, increase in DLR. From Table 2, one can argue that there was some influence on DLR decision from the perceived outcomes from utilising DLR as the area under increased after a period of two years as hypothesised in section 2.

Table 2: Variables and description

Variable	2015		2017			Description of variable
	Mean	SD	Mean	SD	P>Z	
GNDHHH	0.62	0.5	0.7	0.5	0.312	Gender of the farmer (0 = female; 1 = male)
LANDSZ	1.5	0.7	1.4	0.7	0.468	Size in hectares
LABOR	2.1	0.9	2.1	0.8	0.883	Number of adult workers in a farm household
DLRPROP[a]	0.43	0.2	0.65	0.2	0.043	Proportion of maize area under DLR
EXTENS	2.4	1.8	2.6	1.8	0.105	Frequency of contact with extension personnel last year
EXPLEG	7.8	2.43	8	2.4	0.563	DLR utilisation experience in years
INCREASEDLR	-	-	0.64	0.5		Whether area for DLR had increased in the last 2 years (0 = No; 1 = Yes)
FIAVE	0.32	0.47	-	-		Pursuit of farm incomes from DLR (measured on 1-5 scale)
CDAVE	0.73	0.45	-	-		Pursuit of legume diversified crop system (measured on 1-5 scale)
ATT	3.8	0.69	-	-		Attitudes towards DLR (measured on 1-5 scale)
PN	3.5	0.8	-	-		Perceived norms on DLR (measured on 1-5 scale)
PBC	2.8	0.67	-	-		Perceived behavioural control for DLR (measured on 1-5 scale)

[a]Not used in the probit estimation

3.3 Data analysis

Likert scale questions were analysed using SEM by directly linking the TPB intention predictors with the perceived goal-related outcomes from DLR (farm incomes and crop diversification). A similar approach has been used by in which farming goals represented intention for decision on milk quota among Dutch dairy farmers (Bergevoet et al., 2004). In this study, the SEM analysis followed two steps; Exploratory Factor Analysis (EFA) followed by Confirmatory Factor Analysis (CFA) (Anderson & Gerbing, 1988).

Descriptive statistics and EFA were ran in IBM SPSS Statistics 23 and CFA in IBM SPSS AMOS 23. The maximum likelihood estimation of models was done with Promax rotation to allow correlation between factors (Lowry & Gaskin, 2014). A detailed application of path analysis following CFA and EFA can be referred from Borges and Oude Lansink (2016). Data for probit model was analysed in STATA 14. It can be observed in appendix Table A4 that issues of multicollinearity were minimal as the highest coefficient was 0.3131. A detailed application of the probit model relevant to this study is given by (May et al., 2011).

4. Results and discussion

4.1 Socio-economic characteristics of the farmers

Gender, family labour and land are proxies for human capital and they impact on farming decisions (Marenya & Barrett, 2007). Table 2 shows that in both data collection rounds female farmers were fewer than 50% of the sample. However, no big changes in land size and labour were recorded in the second round. There were no significant changes in land size and family labour after a two year period. Similarly, contact with extension services on DLR and the average number of years of using this practice did not change significantly. But we see that on average the proportion of maize area that was integrated with legumes increased by 0.12 units.

4.2 Statistics of the measured items of the structural model.

Table A2 in the Appendix presents means and standard deviations of the measurable items and inter and intra-construct Pearson correlations. It shows that farmers had a positive attitude towards DLR as the lowest mean for attitude measure was 3.73. This was 'DLR contributes to improvement of soil organic matter'. The other measures received considerably high scores indicating that farmers were generally aware of the agronomic attributes of legumes. The within construct correlations of attitude items were generally high, ranging from 0.635 to 0.779 and were all significant at 0.01. Subjective norms were also favourable as the lowest mean was 3.45 with intra-construct correlations significant at 0.01 and ranging from 0.200 to 0.786. While the perception of control on maize-legume integration had the smallest mean with the least mean at 2.71. Lastly, the results show a stronger motivation for maize-legume integration though crop diversification outcome (least mean: 3.41) than through the outcome from DLR concerning farm cash incomes (least mean is 2.15). Based on these results we can make a preliminary conclusion that there is a positive correlation between the favourable scores on two of the behavioural intention foundations and goal-related outcome concerning crop diversification. This is further explored through SEM analysis in section 4.4 where the implications for promotion of maize-legume integration among smallholder farmers in southern Africa are discussed.

4.3 Validation of structural and measurement models

The final measurement model had an acceptable Kaiser-Meyer-Olkin (KMO) value of 0.818, and a significant (p = 0.000). Bartlett's test for sampling adequacy with the least communality of 0.369. The Total Variance Explained (TVE) by the 5 factors was adequate at 69.4 % with all having eigenvalues above 1.0 (Lowry & Gaskin, 2014). The minimum value of factor loadings was 0.655 hence adequate convergent validity (see Hair et al., 2010).

Reliability and validity of model parameters were checked by average variance extracted (AVE), maximum shared squared variance (MSV) and composite reliability (CR) (see appendix Table A3). The minimum AVE was registered on perception of control (PBC)

(0.509). All factors recorded a CR of at least 0.7 hence no further model modifications were necessary (Lowry & Gaskin, 2014). Model fit indices were acceptable for hypotheses testing as presented in Table 3.

Table 3 Model fit indices

Statistic	Thresholds	Fit indices Measurement model	 Structural model	Meaning of statistic
CMIN/DF	1-3	1.848	1.902	ratio of Confirmatory Fit Index to degrees of freedom
IFI	≥ 0.900	0.980	0.978	Incremental Fit Index
TLI	≥ 0.900	0.974	0.972	Tucker-Lewis Index
CFI	≥ 0.950	0.980	0.978	Confirmatory Fit Index
RMSEA	≤ 0.06	0.047	0.049	Root Mean Square of Approximation
PCLOSE	≥ 0.05	0.644	0.559	the probability of getting a sample RMSEA as large as its calculated value in the given model

4.4 Structural modelling results

The SEM analysis (Table 4) shows that farmers' attitudes towards DLR were significantly related to pursuit of both farm incomes and diversification outcomes. Overall, increasing attitude towards DLR with 1 unit was associated with increased motivation to use DLR for diversification of legumes and to increase farm incomes by 0.39 and 0.21 standard deviations respectively. Farmers' positive attitudes towards DLR is a strength in the promotion of DLR that agricultural extension can focus on. The positive attitudes were embedded in farmers' knowledge of primary attributes from legumes and maize-legume interaction; e.g., 'DLR reduces weed occurrence in maize'. The favourable attitudes towards DLR suggests that promotion of this technology can utilise forums that enhance connectedness of the farming community in order to increase awareness on the agronomic benefits from DLR to maize and soil.

Table 4. Structural model results.

Structural relationship			Estimate	S.E.	C.R.	P
Farmincome	<---	ATT	0.205	0.072	3.395	***
Farmincome	<---	PN	-0.067	0.064	-0.992	0.321
Cropdiverse	<---	PN	0.230	0.055	3.945	***
Cropdiverse	<---	PBC	0.002	0.066	0.041	0.967
Farmincome	<---	PBC	0.352	0.081	4.895	***
Cropdiverse	<---	ATT	0.391	0.064	7.175	***

Farmers may focus on the outcomes from a legume technology as motivation for utilisation (Snapp et al., 1998). But acknowledging the occurrence or existence of its primary attributes is essential in influencing resource allocation for the technology (Snapp, Rohrbach, et al., 2002). The study findings show that farmers were knowledgeable of primary attributes of legumes, which made them favourably perceive DLR as deduced from their high attitude scores. Nevertheless, knowledge of positive attributes of an agricultural technology may not always lead to increased utilisation even when farmers face no socio-economic constraints (Pannell et al., 2014). This is particularly true with utilisation of legumes for enhancement of soil fertility for maize production (Giller et al., 2011; Mhango et al., 2013; Ortega et al., 2016). Minimal utilisation may arise from unfulfilled expectations and these may be different from agricultural scientists' (Graham & Vance, 2003).

Subjective norms relating to DLR had a positive significant relationship with crop diversification outcome only. The positive relationship between subjective norms and legume diversification outcome suggests that farmers were encouraged to continue utilising DLR by people whom they regarded highly. These people included agricultural extension workers, lead farmers and family members. This corroborates literature that farmers' decisions on technologies are also influenced by those people who are regarded highly (Bergevoet et al., 2004; Borges & Oude Lansink, 2016) and often interact with them in their communities. Local and personal contacts play an important role in influencing agricultural adoption decisions (Garforth et al., 2004). Furthermore, farmers were obligated to maintain maize-legume integration through participating in extension modalities such as on-farm trials.

Through such extension modalities farmers received farm inputs and branding materials as well as bicycles. Such items otherwise called incentives have been used to encourage adoption of particular agricultural innovations with uncertain or indirect economic benefits (Ward et al., 2016; Wellard et al., 2013). While farm inputs support is important for kick starting adoption and continued utilisation of agricultural innovations, there is a need to balance between incentives and farm inputs support to show that farmers use the innovations following their importance to their farms. Brown et al. (2017) noted that such approaches to promotion of agricultural practices shadow different farmer typology in utilisation of agricultural practices. This presents difficulties in estimation of amount of utilisation.

Subjective norms influenced the pursuit of outcomes from DLR on legume diversification. However, the use of incentives suggests that farmers would continue utilising DLR regardless of whether they attained direct economic benefits from it. It is clear in this case study that participation in on-farm trials was important in accessing incentives from the proponents of DLR. Learning from institutional economics incentives affect people's participation in activities where no individual benefit is definite (Polski & Ostrom, 1999).

Where benefits accrue to the individual as in DLR one can argue that expectations of incentives by farmers from participating in on-farm trials can mean that farmers are not certain of the performance of the technology. It can also mean that farmers were not aware of the contribution to farm incomes from the DLR technology in a period of three years as presented by researchers. Nevertheless, the strength of the subjective norms suggest that farmers' participation in on-farm trials was an obligation to people whom they held in high regard.

These findings suggest that pathways for enhancing awareness on the ecological benefits of integrating legumes in maize systems should extend to family members as often these contribute their labour to various agricultural tasks including legume cultivation In addition, volunteer farmers or other farmers nominated in their communities to help in agricultural technology transfer (lead farmers), are important points of contact for promotion of maize-legume integration too.

As observed by Lalani et al. (2016), multiple sources of social influence contribute to reduction in uncertainty on the performance of an agricultural technology. This enables farmers to make informed decisions (Marra et al., 2003). Further to sources of social influence is the element of social learning that naturally occurs in participatory farm trials. Consistent participation in group agricultural activities has shown that farmers keep up to date with information and have a higher chance of implementing technical recommendations timely than those who seldom interact (Marenya & Barrett, 2007). These extension modalities can influence farmers' decisions on maize-legume intensified systems. This brings important consideration for agricultural extension policy in identification of institutional innovations in promotion of low cost sustainable agricultural practices such as legume diversification of maize systems southern Africa.

Perceived behavioural control significantly influenced goal-related outcome from DLR of raising farm incomes only. This suggests that farm resource allocation decisions for DLR depended most on farm household level factors and farmers' attitudes than social pressure. It further corroborates that smallholder farmers prioritise farm incomes than soil benefits in legume utilisation for soil fertility (Giller et al., 2011; Grabowski & Kerr, 2014; Snapp et al., 1998). These perceptions can be improved to align them to crop diversification outcome from DLR. This can be done by demonstrating to farmers how DLR contributes to whole farm productivity. This can be done through the farm trials or other social learning fora such as farmer field schools. A case of reference here is Mozambique, where general conditions of smallholder farmers are similar to Malawi's it was found that farmer field schools were instrumental in promotion of conservation agriculture (Lalani et al., 2016).

The lack of significant influence between perceived behavioural control and goal related outcome concerning legume diversified cropping system is a window for research on smallholder farmers' commitment to restoration of soil fertility using legumes in maize based systems. While farmers had land, seed, skills and information for DLR the path analysis suggests no significant influence to legume diversification outcome. One can argue that their abilities and resources were not drawn towards achievement of soil fertility-oriented outcomes from utilisation of legumes. Consistent with the study objective a further analysis was carried out to explore the relationship between perceived priorities of the two goal-related outcomes from DLR and household level socio-economic and institutional factors with the decision to increase DLR.

4.5 Probit estimation results

The purpose of the probit analysis was to validate the influence of the perceived goal-related outcomes from DLR on the actual DLR decisions regarding increased utilisation. The goal-related outcomes were hypothesised to motivate farmers to increase the area under DLR (Fig. 1). Table 5 presents estimation results. Only crop diversification outcome from DLR was positively significant at 0.01. Therefore, the perception that DLR leads to diversified cropping systems has a significant positive influence on maize-legume integration decisions. Inferring from the SEM analysis in section 4.4 one can argue that this resulted from the influence of subjective norms on as well as positive attitudes towards DLR for the purpose of diversifying cropping systems. This validates the role of other people and groups personal decision drivers in agricultural adoption decisions as generally held in the TPB model.

Table 5. Probit estimation results

Variable	Coefficients	Robust Standard Errors	Marginal effects	Delta-method Standard Errors
LABOR	0.202**	0.088	0.047**	0.020
EXPLEG	-0.030	0.034	-0.007	0.008
EXTENS	0.096**	0.046	0.022**	0.011
LANDTOT	-1.458***	0.164	-0.339***	0.025
CDAVE	0.774***	0.191	0.180***	0.041
FIAVE	0.265	0.173	0.061	0.040
GNDHHH	-0.376**	0.186	-0.087**	0.044
_Constant	1.729***	0.444		

Number of observations: 374; Log pseudo likelihood: -155.46676; Pseudo R2: 0.36;
Dependent variable: Increased area for maize-legume integration; Wald chi2(7): 125.89; **P<0.05; ***P<0.01

Table 5 further shows that four out of five socio-economic factors were significant but with different coefficient signs. Both number of adult workers in the farm household and frequency of contact with extension personnel were significant and positive (p = 0.05). This suggests that increasing family labour and contact with agricultural extension personnel has a positive contribution towards decision to increase DLR. Inferring from the SEM results, the extension worker was highly regarded, thereby increasing value of social capital in driving farmers' participation in extension modalities. Readily available family labour is necessary for handling various agricultural tasks (Deressa et al., 2008), which may result from expansion of the area under DLR. Regarding agricultural information, the significant positive relationship is consistent with other estimations of agricultural adoption (Manda et al., 2016; Marenya &

Barrett, 2007). Consistent contact with agricultural extension personnel keeps farmers in check of their practices and enables them access knowledge about other agricultural services.

The estimation results show that total land size and gender of the farmer negatively influenced DLR decisions at 0.01 and 0.05 alpha levels respectively. These findings corroborate findings from a recent study on DLR utilisation in Malawi (Kamanga et al., 2017). Total land size was found to be inversely related to area under DLR. One can question whether African smallholder farmers can commit to improvement of soils using grain legumes for inherent value of soil fertility.

The negative relationship between gender of the farmer and decision to increase DLR shows that women farmers are less likely to increase legume technologies holding other factors constant. This may be attributed to resource endowment hence closely associated with total land size. Women farmers are more likely to have smaller landholdings (Doss, 2001). They do not have area for expansion of crop enterprises including maize and legumes. Such farmers would have higher index of legume integration in maize area (Kamanga et al., 2017), as up to 70% of their minimal landholdings is allocated to maize alone (Snapp, Rohrbach, et al., 2002).

From the SEM results, the favourable attitudes and perceived norms towards DLR suggest that promotion of this technology should utilise fora that enhance connectedness of the farming community to increase awareness on the agronomic benefits of integrating more legumes with maize thereby building inherent value of soil fertility. While farmers may have limited land and access to seed for DLR, our results show that perception of control on DLR did not correlate with the goal-related outcome of improving soil fertility. This shows that farmers also utilised other ways than consistent integration of legumes in maize area following DLR technology, to improve their soils for maize production. This is deduced from earlier studies that reported that farmers sole-cropped both maize and legumes on larger areas than where these crops were integrated (Kamanga et al., 2017; Pircher et al., 2013). These farmers were relatively well-off. These findings can be compared to studies on farmers' intentions to adopt an agricultural practice such as CA. A recent study on CA in Mozambique found that lower income group of farmers held stronger intentions to use CA within 12 months. This was because they had smaller areas to trial out the practice on.

The influence of farmers' attitudes and perceived norms on the pursuit of outcomes from DLR show to be key drivers of their motivation to increase this technology. These findings are relevant for smallholder farming systems in other developing countries too. It would be necessary for agricultural extension officers to emphasise that what may be considered as a high investment cost in soil nutrient stock of maize systems is less than the cost of lost economic opportunities arising due to less attention to soil fertility.

The implications of this study findings on the promotion of improved maize-legume integration include the importance of social capital in influencing change. Agricultural extension should take advantage of situations where agricultural social capital is robust, to disseminate information on the importance of managing soil fertility using legumes. This should be supported by farmer training in improved ways of incorporating legume residues and leaf litter that maximise gains in soil benefits from legumes (Pircher et al., 2013). Improved maize-legume integration like DLR has proven to be a low cost practice that significantly makes a contribution towards soil organic matter and fertility.

5. Conclusion

This study investigated farmers' motivation for utilising DLR as derived from two goal-related outcomes from the technology; farm incomes and legume diversified cropping systems. We applied a two-step analysis starting with an expectance-value based model based on the TPB and followed by a probit analysis between farmers who had and those who had not increased the area under DLR. In addition to understanding the influence of the TPB intention predictors on goal-related outcomes from DLR as motivation the study examined whether these goal-related outcomes influenced farmers' decisions to increase the DLR after two years. One novelty of this paper is the demonstrable analytical framework whereby farmers' motivations were validated through a follow up survey on their decisions using a probit analysis.

The study findings take on broader significance within the literature on legume utilisation for improvement of soil fertility in maize based cropping systems among land limited farmers. The findings show that DLR decisions may be influenced by personal decision drivers as well as social pressure. These factors are critical to identifying approaches of reaching out to farmers on utilisation of legumes as an investment in soil fertility.

The findings from the behavioural modelling illustrated in this paper provide an extension to previous work on farmer behaviour (e,g,. Bergevoet et al., 2004; May et al., 2011). Following normative economic modelling, DLR can be associated with expected gains in maize yields if maximisation of these gains is assumed to be the paramount decision driver. However, this is only relevant to farmers with choices on farming enterprises such as those better resource endowed. This is consistent with utility maximisation theories. Even so, it is common to incentivise farmers to adopt some agricultural technologies that do not yield economic gains in the short run or those which do not benefit individual farmers. This is different from utilisation of improved maize-legume integration as its immediate outcome is directly consumed or sold by the farmers themselves. Therefore, this case study provides empirical evidence of minimal utilisation of an agricultural technology despite farmers having positive attitudes towards it. This paper found that farmers are motivated to increase area under DLR following social pressure.

6. Appendix

Table A1. Measurement models, statements, and scales for the structural model

Item	Factor/Statement	Scale (1-5)
	Attitude towards improved maize-legume integration under DLR	
ATT2	Improved maize-legume integration (DLR) improves soil fertility	strongly disagree---- strongly agree
ATT3	Improved maize-legume integration (DLR) reduces weed occurrence in maize	strongly disagree---- strongly agree
ATT4	Improved maize-legume integration (DLR) contributes to improvement of soil organic matter	strongly disagree---- strongly agree
	Perceived Norms on improved maize-legume integration under DLR	
PN1	Family members encourage me to integrate maize and legumes	strongly disagree---- strongly agree
PN2	I have received farm inputs for participating in on-farm trials for improved maize-legume integration	strongly disagree---- strongly agree
PN3	Volunteer farmers in my village are integrating their maize with legumes	very unlikely------very likely
PN4	Project (LBB) staff expect me to integrate maize and legumes	strongly disagree---- strongly agree
	Perceived Control on improved maize-legume integration under DLR	
PBC1	I have adequate land to increase maize-legume integration under DLR	strongly disagree---- strongly agree
PBC2	I am able to source seed for both legumes and maize every year	strongly disagree---- strongly agree
PBC3	I have adequate labour to carry out farm activities for improved maize-legume integration (DLR)	strongly disagree---- strongly agree
	Pursuit of increased farm incomes from DLR	
FI3	I desire to increase cash incomes from the whole farm	most definitely not---most definitely yes
FI4	I desire to increase production of grains	most definitely not---most definitely yes
FI5	I desire to sell some of the legumes I produce	most definitely not---most definitely yes
	Pursuit of crop diversification from DLR	
CD1	I seek to grow a lot of food crops	most definitely not---most definitely yes
CD2	I seek to grow different types of legumes	most definitely not---most definitely yes
CD3	I seek to grow hybrid and local maize all years	most definitely not---most definitely yes

Table A2. Mean, standard deviation (SD), and correlations of the indicators

	CD1	CD2	CD3	FI3	FI4	FI5	PN1	PN2	PN3	PN4	PBC1	PBC2	PBC3	ATT2	ATT3	ATT4
CD1	1															
CD2	.542**	1														
CD3	.931**	.596**	1													
FI3	0.089	0.082	.116*	1												
FI4	0.081	0.056	.108*	.779**	1											
FI5	0.094	0.067	.127*	.762**	.790**	1										
PN1	.285**	.231**	.307**	.139**	0.084	.138**	1									
PN2	.312**	.216**	.334**	.136**	0.071	.125*	.690**	1								
PN3	.303**	.174**	.341**	.164**	.106*	.106*	.664**	.724**	1							
PN4	.277**	.199**	.327**	.144**	.130*	.171**	.654**	.786**	.746**	1						
PBC1	.143**	0.085	.151**	.298**	.244**	.242**	.270**	.238**	.277**	.252**						
PBC2	0.068	.113*	0.095	.185**	.182**	.182**	.221**	.277**	.229**	.240**	.527**	1				
PBC3	.123*	0.058	.121*	.270**	.229**	.168**	.333**	.297**	.342**	.352**	.503**	.497**	1			
ATT2	.426**	.157**	.423**	.158**	.188**	.197**	.284**	.283**	.321**	.338**	.163**	0.057	.104*	1		
ATT3	.422**	.192**	.433**	.165**	.147**	.183**	.257**	.254**	.302**	.259**	.179**	0.064	0.098	.779**	1	
ATT4	.355**	.142**	.365**	.162**	.186**	.174**	.200**	.332**	.367**	.314**	.138**	0.057	.158**	.635**	.685**	1
Mean	3.87	3.41	3.95	2.15	2.17	2.23	3.45	3.45	3.49	3.66	2.71	3.07	2.74	3.84	3.85	3.73
Std. Deviation	0.741	0.79	0.70	0.81	0.88	0.87	0.90	0.94	0.90	0.85	0.80	0.81	0.86	0.77	0.77	0.78

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table A3. Convergent validity test and factor correlation matrix

	CR	AVE	MSV	MaxR(H)	Cropdiverse	ATT	PN	PBC	Farmincome
Cropdiverse	0.891	0.740	0.230	1.013	*0.860*				
ATT	0.878	0.708	0.230	1.015	0.480	*0.841*			
PN	0.909	0.714	0.207	1.017	0.384	0.393	*0.845*		
PBC	0.757	0.509	0.207	1.019	0.172	0.186	0.455	*0.713*	
Farmincome	0.913	0.777	0.125	1.023	0.133	0.226	0.166	0.354	*0.882*

Table A4

Variable	LABOR	EXPLEG	EXTENS	LANDTOT	CDAVE	FIAVE	GNDHH	_CONS
LABOR	1							
EXPLEG	-0.0690	1						
EXTENS	-0.0284	-0.1732	1					
LANDTOT	-0.0417	0.1012	-0.0527	1				
CDAVE	0.2823	-0.0525	-0.0215	0.0106	1			
FIAVE	-0.0802	0.0572	0.0308	0.0187	-0.1159	1		
GNDHH	-0.2249	0.0629	-0.1218	-0.3131	-0.0426	-0.0424	1	
_CONS	-0.3822	-0.6052	-0.0493	-0.5148	-0.381	-0.0886	0.0022	1

Elicitation questions

Attitudes: What do you consider as benefits from improved maize-legume integration using DLR

Perceived norms: Which important people have influence in utilisation of DLR your area?

Perceived behavioural control:

(a) What factors within farm households would enable increasing the area under DLR in the next two years?

(b) What factors within farm households would hinder increasing the area under DLR in the next two years?

Motivation: What specific outcomes are expected from improved maize-legume integration under DLR?

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Chapter Six: How do institutions within agricultural extension modalities impact on utilisation of agricultural innovations? A case of maize-legume intensified systems from Malawi

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How do institutions within agricultural extension modalities impact on utilisation of agricultural innovations? A case of maize-legume intensified systems from Malawi.

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ABSTRACT

Current agricultural adoption research in southern Africa shows that smallholder farmers have not adopted maize-legume intensified maize systems as expected despite over two decades of promotion including farmer participatory research. This study uses content analysis to investigate how institutions within extension modalities (on-farm trials, use of lead farmers and facilitation of legume marketing) promoting maize-legume intensified systems affect farmers' adoption decisions in Malawi. Data was collected from eight farmer focus group discussions, two focus group discussions with agricultural officers, and interviews with six lead farmers. The study finds that incentives given to farmers hosting on-farm trials deter agricultural adoption. Lead farmers are keen on their roles following incentives. Lastly, despite a general outcry on certainty of markets for grain legumes we find inconsistencies in facilitation of legume marketing through unfair regulations such as illegal fees, inevitably discouraging farmers from choosing some legumes. This study concludes that it is necessary to monitor institutions fostering maize-legume intensified systems in different spheres of influence including the farm and policy levels to allow farmers benefit from results from agricultural research and efforts of promoting legume diversification.

Keywords: extension modalities, institutions, lead farmers

1. Introduction

Maize-legume intensified cropping systems, which involve improved intercrops and rotations of maize and legumes have a well-established potential to improve maize yields (Manda et al., 2016; Smith et al., 2016). Direct soil benefits from intensifying legumes in maize systems include nitrogen fixation; soil organic matter enrichment; weed suppression and pests and disease control (Snapp et al., 2002). In addition, as farmers gain from nitrogen fixation in the longer run this system is expected to lower maize production costs (Sakala et al., 2003; Smith et al., 2016). Legume diversification of maize based systems is important for enhancing ecological resilience (Snapp et al., 1998) and improving access to food grains (Ortega et al., 2016; Snapp et al., 1998). It is also a sustainable way to addressing the nutrient mining of maize resulting from continuous cropping (Thierfelder et al., 2012).

Land limitations and the staple nature of maize in southern Africa (Ricker-Gilbert et al., 2014) force many smallholder farmers to dedicate more than half of their cropping area to maize alone (Ito et al., 2007). This puts pressure on the nature of legume diversification. Most diversification has been limited to maize-legume intercrops in southern Africa (Thierfelder et al., 2012). However, there are more soil benefits from rotations of monocrop maize with legume-legume intercrops such as doubled-up legume rotations (Smith et al., 2016). This is being promoted in Tanzania, Malawi, Ghana and Zambia (https://africa-rising.net/). Regardless of the options and programs promoting legume diversification, there are still limits on their adoption (Smith et al., 2016).

This limited adoption has been attributed to uncertain or lack of markets for some of the legumes that intercrop well with maize, especially in Zimbabwe, Malawi and Kenya (Giller et al., 2011; Mhango et al., 2013; Ojiem et al., 2006). Adoption of innovations generally is influenced not just by markets, but many of factors such as farmers' preferences (Waldman et al., 2016) and also farmers' interactions with programs promoting the innovations (Kamanga et al., 2016, 2017a). Of particular interest in this study is the role of institutions in extension modalities fostering legume diversification of maize systems in Malawi. Our use of the word institutions in this paper refers to "… enduring regularities of human action in situations structured by rules, norms, and shared strategies, as well as by the physical world" (Crawford & Ostrom, 1995, p.582). Understanding adoption of legume diversification technologies should also deal with farmers' interaction with organisations promoting the technologies. Learning from institutional economics such interactions create new institutions, or reshape existing ones, as individuals seek rational outcomes (Ostrom, 2011). The interactions are created in social spaces provided by agricultural services providers in message in farmer trainings, of information dissemination, training, inputs access, they present social situations for interactions that will affect farmers' motivation to diversify more legumes (Kamanga et al., 2017b; Ojiem et al., 2006). In Malawi, three of the most common extension modalities for legume diversification are: on-farm trials, use of lead farmers and facilitation of legume marketing. Examples of the formal institutions, or rules of engagement, in the delivery of these modalities are presented in Table 1.

Table 1. Examples of formal institutions in extension modalities

Extension modality	Established institution
On farm trials	Farmers to volunteer themselves to host a trial
Lead farmer	Farmers to be nominated to the role of lead farmer in their community by a majority of members
Marketing	Where a bulking facility is provided by a project, farmers to bring the minimum quantity for supply to the market, otherwise buyers to offer at least the minimum prices set by the government

The objective of this paper is to examine the strength of these institutions in ensuring the sustained and wide-spread promotion of maize-legume intensified systems. Our hypothesis is that interactions between extensionists and farmers lead to the creation of informal institutions that result in a negative impact on wider agricultural adoption processes. Findings from this study are relevant for promotion of legume diversification of maize systems as well as other sustainable agriculture practices in the developing countries. To wider literature the findings contribute to understanding how institutions influence agricultural adoption decisions regardless of the superiority of existing or alternative agricultural technologies and practices. The following background material describes the context of legume diversification programs in Malawi. This will be followed by a description of the method used test our hypothesis; i.e. content analysis of in-depth focus group discussions and key informant interviews.

2. Background

Maize-legume intensified systems have been promoted by the national government in Malawi as part of national commitment to soil fertility management and food security since the late

1980s. Implementation of on-farm trials and innovation specific extension services have been pathways for promoting consistent utilisation of maize-legume innovations. The Ministry of Agriculture has implemented on-farm trials under Maize Productivity Task Force (MPTF) between 1988 and 1998 and Agriculture Sector Wide Approach-Support Project (ASWAP-SP) between 2008 and 2015. These trials were strategically located in areas of production potential for both maize and legumes and were supported by international agricultural research organisations including CIMMYT and ICRISAT. The trials complemented national programs on food security support to smallholder farmers: Starter Pack Scheme; between 1995 and 1999; Targeted Inputs Programs; between 2000 and 2004 (Chinsinga, 2004, 2011), and; Farm Inputs Subsidies Programme (FISP) between 2005 and 2015 (Arndt, Pauw, & Thurlow, 2016; Lunduka et al., 2013). These programs directly supported a selection of resource poor farmers with farm inputs commonly maize and legume seeds (pigeon peas, groundnuts and soybeans) as well as inorganic fertilisers.

The promotion of maize-legume intensified systems in Malawi has always involved well-established extension modalities such as on-farm demonstrations; on-farm trials; field days, and; farmer trainings. These extension modalities provide farmers with social spaces for acquiring information on agricultural innovations. These spaces are also vehicles for organising farmers into groups to demand agricultural services Farmer participation in the modalities is both voluntary and by nomination by community members if a leading role is suggested. If farmers are elected into leading roles they become contact points (lead farmers) for the organisations promoting agricultural innovations. Apart from receiving free farm inputs they also receive branding materials including bicycles (Wellard et al., 2013).

3. Materials and methods

3.1 Study area and data

This study is part of a larger investigation of low utilisation of maize-legume intensified systems in Malawi. The larger study ascertains how the decision for size of maize area under diversification with legumes is affected by; (i) attitudes towards legume diversification; (ii) perceptions of norms influencing farmers' decisions as well as compliance with organisations promoting legume diversification, and; (iii) farm-level socio-economic constraints (Kamanga et al., 2016). The present study focuses on how institutions in promotion of maize-legume intensified systems through these extension modalities; on-farm trials, use of lead farmers motivation to participate in and facilitation of legume marketing affect farmers' utilisation of these systems. Data was collected from north and central Malawi in Mzimba and Salima districts respectively Figure 1), between February and May 2015.

Figure 1. Study area

Study sites were purposefully sampled in consultation with agricultural extension development officers (AEDOs) on the basis that in addition to ASWAP-SP trials activities, there had been specialised agricultural projects promoting maize-legume intensified systems. The projects were legumes best-bet in Mzimba and Sustainable intensification of Maize and Legumes in Eastern and Southern Africa (SIMLESA) in Salima. Land limitations restrict many smallholder farmers to only maize-legume intercrops (Thierfelder et al., 2012). We selected study districts, with average landholding sizes of at least 1 ha, where some crop rotations may not deprive farmers of their area for maize production (Snapp et al., 2010).

Table 2 presents data collection approach, number of farmers interviewed according to village, Extension Planning Area and district. Agriculture staff were interviewed at district level only. There were eight farmer focus group discussions (FDG-F) with a total of 106 participants and two agriculture staff focus group discussions (FGD-S) with a total of seven participants. There were also six interviews with lead farmers (KII-LF).

Table 2. Selection of sites for data collection

District/*EPA*	Codes for Focus Group Discussions with farmers level (FGD-F)	Name of villages & number of farmers in FGDs by sex: (Male/Female)	Codes for key informant interviews for lead farmers (KII-LF)	Type of interview with Agriculture staff at district level (Number participating)
Mzimba				FGD-S (3); KII-S (1)
Bwengu	FGD-F1	Timothy Ngwira (4/9)	KII-F1	
	FDG-F2	George Jere (4/10)		
Zombwe	FDG-F3	Robert Mseteka (6/6)	KII-LF2	
	FDG-F4	Thakopole Longwe (5/9)		
Salima				FGD-S (4); KII-S (1)
Tembwe	FDG-F5	Tembwe (6/6)	KII-LF3	
	FDG-F6	Katsukunya (7/6)	KII-LF4	
Chinguluwe-Chitala	FDG-F7	Scheme 1 (5/10)	KII-L5	
	FDG-F8	Cheyiweni (5/8)	KII-LF6	

At least half of study farmers had participated in government supported maize-legume intensification on-farm trials under the ASWAP-SP since 2008 by hosting the trials. The other study participants were selected on the basis of having adopted maize-legume intensification technologies from participation in the ASWAP-SP trials or other food and soil fertility projects in their communities ran by legumes best bet or SIMLESA projects. Farmers' and agricultural extension officers' raw remarks are only identified by alpha numeric codes both in FGDs and KIIs.

Prior to farmer FGDs, the research team organised group meetings in the eight sampled villages to brief farmers on the study purpose. From these meetings some farmers volunteered themselves to take part in the FGDs while others were nominated by other farmers at times with suggestions from agricultural officers who accompanied the research team. Written consent to participate in the study was obtained individually. The research team encouraged women to participate in order to get views from both male and female farmers. The farmer FDGs were planned for 12 farmers but this number exceeded in most of the FGDs as shown in Table 2. The FGDs were all conducted by the lead investigator in a popular local language in each district. In addition to field notes all interviews were audio-recorded for later transcription. The average length of the interviews was 42 minutes and ranged between 23 and 56 minutes. Discussion questions are listed in the appendix.

3.2 Data analysis

The study employed a content analytical approach using NVivo 11 to filter responses towards three areas concerning promotion of maize-legume intensified systems among smallholder farmers of: on-farm trials; use of lead farmer, and; facilitation of legume marketing. The results are reported from both FGDs and KIIs from farmers with additional input from FGDs with agriculture extension staff.

4. Results and discussion

4.1 Institutions within on-farm trials for maize-legume intensified systems

Farm trials and on-farm demonstrations were important modalities for sharing knowledge on legume diversification. These were jointly coordinated with lead farmers and AEDOs at farmer level, hence supporting group extension approaches. Ideally, these approaches are important for reaching more farmers and also avoiding favouritism towards clientele such as progressive farmers, male farmers, and other influential members of the farming communities (Mudege et al., 2015).

Farm trials for legume diversification were used for two purposes: (i) to make farmers aware of new maize-legume innovations (ii) to bring new legumes that enhanced soil fertility to different areas. Participation of farmers in these trials was for new knowledge in these. Otherwise they had knowledge about beneficial soil attributes from legumes passed from generation to generation e.g., "…we have seen some soybean demonstrations recently in our area… otherwise we have always grown cowpeas, mainly intercropped with cotton, but now they are encouraging us to intercrop with maize..." - FGD-F 5, and "…this type of planting is not entirely new. For many years we have done it in different ways but what may appear new these days is the type of crops that we use"-FGD-F8. Nevertheless, legumes like pigeon peas had never been locally grown prior to these on-farm trials particularly in Mzimba. For example, "…we have known most of these legumes … but pigeon pea came with these projects" -FGD-F2.

Pigeon pea had been used in intercrop with soybean or groundnuts in Mzimba district in a novel legume diversification technology called 'doubled-up legume rotation'. This is where two legumes, one short and one long term are intercropped in two successive seasons then rotated with maize in the third season (Kerr et al., 2007; Smith et al., 2016).

Generally, farmers hosting on-farm trials expected free or subsidised farm inputs, e.g., ASWAP-SP trials for FISP inputs. This expectation of incentives likely came from tactics used by AEDOs seeking to persuade farmers to take good care of, or volunteer to conduct, trials: "...it is not always easy to persuade farmers to take good care of the trials particularly concerning legumes like pigeon peas or soybean…so we sometimes promise them FISP inputs coupons…" – FGD-S1. Pigeon pea and soybean were not grown widely because they are not widely consumed in the homes. They are mostly sold to industrial food processors hence face uncertain market as there are a few large buyers in Malawi. Similar findings have been reported in previous studies in Malawi (Kamanga, Kanyama-Phiri, Waddington, Almekinders, & Giller, 2014) and in Zimbabwe (Giller et al., 2011) for pigeon peas and soybean respectively.

In addition to farm inputs, farmers hosting trials expected to receive other incentives including protective wear, bicycles, notebooks and farmer tours to other areas with on-farm trials. Such an approach may motivate farmers to consistently manage on-farm trials, but could divert their focus from knowledge on the innovations to these incentives. It does not acknowledge the inherent value of maize-legume intensified systems. Potentially, farmers may limit utilisation of new knowledge to the trial only to continue to be a demonstrator to access the incentives. The new institutions propagated by the extension workers in the conduct of farm trials lead to farmers' dedication to trial management. However, they can divert their learning from the trials through abandonment if no incentives are received.

Using FISP inputs to persuade farmers to adopt legume diversification technologies legumes from the on-farm trials undermines the criteria for selecting FISP inputs recipients. This is because farmers conducting on-farm trials are selected based on their potential of producing enough food for themselves. This is a sharp contrast to selection of FISP inputs beneficiaries who by rule should be selected on basis of having enough land and labour but still considered food insecure within their community (Dorward et al., 2008).

Receiving FISP inputs for hosting on-farm trials encouraged farmer cooperation on trial management as expected by extension workers e.g., "…I encourage other farmers to respect agreements with organisations because we know they are helping us improve our farming (using improved maize-legume integration" (KII-LF 5). This reflects farmers' commitment to institutions in the promotion of maize-legume intensified systems through on-farm trials.

Nevertheless, our findings suggest that using FISP inputs as incentives for management of on-farm trials for maize-legume intensified systems potentially limits the expansion of the trial practices to the rest of farmers' area as farmers maintain the trial's visibility. While the promise of FISP inputs attracts farmers' dedication to trial management. But learning from CA projects such incentives have a potential to divert learning from the trials through abandonment if no FISP inputs are received (Brown et al., 2017b; Ward et al., 2016).

In summary, farmers' cooperation with agricultural extension officers on management of on-farm trials led to emergence of new informal institutions within the established institutions of implementing the trials. However, these new informal institutions create short cuts in administration of a service and may deprive deserving farmers of benefits (farm inputs). This analysis has shown that these new informal institutions have both positive and negative influence on farmers' adoption decisions of maize-legume intensified systems.

Table 3 summarises farmers' motivations for participating in on-farm trials. Apart from acquiring information and knowledge on legume diversification farmers attained various other benefits ranging from social to material.

Table 3. Farmers' FDGs quotes on purpose of participating in on-farm trials

Purpose of participating in on-farm trials	Quote (source of quote)
Participation	'We look forward to participating in projects farm trials' (FDG-F1)
Acquire new knowledge/learning	'Most of us here have a small plot for practicing what we learn at the demonstration plot. This is the way to learn' (FDG-F2)
	'We have a chance to learn something new even though most of us have knowledge about these things' (FDG-F5)
Solving livelihood challenges	'These days a farmer must be active,…otherwise one will not eat' (FDG-F3)
Expecting other rewards	'We get discouraged sometimes when we do not receive fertilizers' (FDG-F4)
	'We are very much eager to improve the soils for our crops…when we take part in agricultural extension activities such as ASWAP demonstrations… we know that we will receive FISP coupons' (FDG-F8)
New knowledge (from visitors)	'The good thing is that when we are visited by farmers from other places, we learn their way of farming' (FDG-F6)

3.2 Institutions within working environment of lead farmers on legume diversification

Table 4 shows that lead farmers expressed different opinions on the medium of information exchange for maize-legume intensified systems. They were respected for their roles. This can be because they were also contact points for various agricultural services in their villages (Masangano & Mthinda, 2012) in addition to legume diverisification.

Table 4. Perceptions of lead farmers' role in promotion of maize-legume intensified systems

Relevance to farmer adoption decisions	Quote	Id
Demonstrable agronomic characteristics legume diversification	'We emphasize on the importance of intercrops and rotations. Rotations are important to prevent pest attack when we switch the crops and also the maize can make use of the nutrients left behind by a legume.'	KII-LF1
Feasibility of technology	'When we have intercropped legumes and maize and also applied fertilisers, both crops do well… so this is what we show our fellow farmers'	KII-LF2
The importance of engaging lead farmers on promotion of maize-legume intensified systems	"Many farmers know these things, but I do not know why they find it difficult to practice. So, I and other lead farmers have developed a plan for reaching out to them. With the bicycle that I received from the government I am able to meet every farmer on their farm."	KII-LF3
	'We lead farmers have the duty to help our friends (farmers) better use agricultural technologies, therefore, we must have a sample for verification of what we do'	KII-LF5

Despite the enthusiasm of lead farmers to reach out to other farmers, some farmers still lacked the right information about management practices of maize-legume intensified systems. Furthermore, even in villages located near main roads where one could assume ease of access by lead farmers and extension workers, farmers still lacked the right information. For example,

> "It is difficult to intercrop when we plant 1-1(one maize seed per station, spaced at 25 cm). Otherwise if you want to do intercropping with legumes like ground nuts *(Arachis hypogaea)* it means you should plant the maize at wider spacing in order to provide space for the ground nuts. So most of us just do rotations" (FDG-F4).

There were similar indications of wrong or inadequate information about basic agronomy in maize-legume intensified systems in other villages. This may indicate infrequent contact by an extension worker or casual approach to maize-legume integration where officers assume that farmers have adequate knowledge owing to long history of utilisation (of maize and legumes).

Such officer - farmer relationship corroborates literature in promotion of agricultural technologies (Seyoum, Battese, & Fleming, 1998).

Apart from receiving no or inadequate information about legume diversification the study found that there was disapproval of the lead farmer where their selection was done without the knowledge of the wider community. For example,

> "First of all, most of us did not know that we had a lead farmer because he was selected behind our back. So we just see people (from the agriculture office) visit him… Some of the women here do not know him too" (FGD-F2).

This disapproval arose from shortcuts in selection of lead farmers by extension workers. The study found that some extension workers only consulted a village chief and other senior village members on who to be a lead farmer. This mode of nomination was breaking established rules are lead farmers were supposed to be nominated at an open forum in their community (Wellard et al., 2013). This twisting of institutions regarding selection of lead farmers negatively affect agricultural activities (Khaila, Tchuwa, Franzel, & Simpson, 2015) as other farmers show resentment (Brown et al., 2017a). This gives insights into factors affecting farmers' participation in information fora on maize-legume intensified systems.

4.3. Institutions within legume marketing following maize-legume intensification projects

Legumes were sold at farm gate; physical markets; as well as through bulking centres for supply to a specific buyer. The bulking centres were reported in Zombwe EPA in Mzimba district only. With assistance from the legumes best bet project farmers sold soybean in bulk to a hospital in their locality. Following this market opportunity farmers with relatively larger cropping areas increased land allocation to soybeans. This change in cropping patterns is consistent with earlier studies that farmers prioritise cash and food incomes at every opportunity to diversify legumes (Pircher et al., 2013). While the project had linked farmers to sell their soybean to the local hospital, agents who represented the hospital charge a fee (illegal commission) to buy the soybean and ended up sourcing from different farmers. This malpractice disappointed many maize-legume diversification 'registered' farmers (adopters). This had the potential to negatively impact on their crop selection including the soybeans in later seasons.

Worth noting, farmers whom use orientation for legumes was home consumption were concerned less about legume marketing (e.g. 'For most of us, we do not produce a lot of legumes, which one would worry about marketing. We simply consume everything in the home and keep a little for the rainy season' (FGD-F1). Yet other farmers were discontented with failure to market food crops (e.g. 'The problem is that the government has not made much effort to ensure that farmers can make good cash (income) even from food crops...there are good marketing arrangements for tobacco only.' (FGD-F2). This was a comparison between traditional cash crops (tobacco) and traditional food crops, whereby tobacco marketing was sold from farmer clubs at competitive prices. This is evident in the various ways farmers marketed their legumes as reported in this study.

Most farmers expressed dissatisfaction with instability of soybean price and lack of formal institutions in the marketing chain considering that the government promoted this crop for cash and soil fertility among smallholder farmers. Soybean marketing is important as many farm households in Malawi grow this crop as a cash crop and do not do any processing beyond packaging the grains (Mumba et al., 2017). Failure to sell or to sell at satisfactory prices has constrained farmers from consistently growing legumes like soybean as observed in Zimbabwe (Giller et al., 2011). Our findings corroborate this. In light of price fluctuations and out of dire need for cash, farmers sold legume grains reluctantly, for example,

> "Even though we may not get good prices for our legumes and other crops but we still can sell most of our food crops because our villages are closer to the town centre…and we sell straight to the big buyers like Agricultural Development and Marketing Corporation and Export Trading" (FDG-F5).

While better legume prices would attract farmers to integrate more legumes in their maize cropping systems (Giller et al., 2009), farmer accounts from this study suggest that certain markets are a key. This may be debatable as where a market opportunity arises farmers only increase sole cropping of legumes (Kamanga et al., 2017b; Pircher et al., 2013). Therefore, use orientation for legumes plays a central role on whether farmers interact the legumes with maize consistently (Kamanga et al., 2017b). Other researchers proposed promotion of maize-legume intensification using legumes with local marketability to ensure farmers can sell their grains quickly (Snapp et al., 2002).

Nevertheless, this would limit utilisation of other legumes that are superior in biological nitrogen fixation but lack local marketability. Our conclusion from this discussion is that continuous awareness on the nutrient mining effect of maize mono crop is necessary to encourage farmers improve the fertility of their soils through legume diversification. This would stimulate inherent value of soil fertility among the smallholder farmers. Finally, the distortions in institutions within on-farm trials and extension service delivery on maize-legume intensified systems are a deterrent to farmers' positive adoption decisions.

Our findings have implications for promotion of legume diversification as well as other sustainable intensification practices such as conservation agriculture (CA) among smallholder farmers in the wider sub Saharan Africa as well as south Asian region. These findings are further relevant considering the involvement of agencies external to farmers' communities in the promotion of agricultural technologies.

5. Implications and conclusions

This study was set to analyse the implications of farmers' perceptions of institutions affecting their participation in maize-legume intensified systems through three extension modalities: on-farm trials; use of lead farmers, and; facilitation of legume marketing. The following are study implications on promotion of legume diversification of maize systems.

5.1 On- farm trials

Engaging farmers in trials can influence positive perceptions of an agricultural technology by demonstrating the efficacy of the technology while incorporating their preferences (Alomia-Hinojosa et al., 2018). As an important foundation for promoting adoption of agricultural technologies as well as achieving the technology proponents' objectives, on farm trials have been implemented with supply of farm inputs to farmers for wider integration in their farms (Cheesman et al., 2017). This has been justified where results from adoption are uncertain or take long such as full CA (Ward et al., 2016). Nevertheless, our findings show that incentives beyond farm inputs have a potential to demotivate farmers in utilisation of agricultural technologies. This corroborates earlier studies on the effect of incentives to adoption of CA in Malawi (Wellard et al., 2013).

There is a need to address the farmer discontent arising from on farm trial implementation arrangements. Singling out legume diversification from sustainable agricultural intensification practices, we propose specific recommendations to influence its increased utilisation. Farmer sensitisation on agronomic benefits from diversifying legumes in their maize systems should include justification for provision of farm inputs to farmers hosting on-farm trials to avoid jealous attitude. Our study findings suggest the need for creating awareness on the importance of the apparent privileges, that aid in management of trials and outreach to other farmers as well as spread of technology-specific messages. This is because farmers that host the on-farm trials are part of a wider farming community except only carrying out a facilitator role to agricultural development (Wellard et al., 2013).

5.2 Information exchange under lead farmers

Farmer fora for information exchange have been learning spaces for many farmers that would otherwise lack knowledge about agricultural practices. However, lead farmer as an agent for information about agricultural technologies should be part of a medium existing at the village level facilitated by extension workers. Old group extension methods like the farmer field schools can come be reintroduced in legume technologies too even though farmers have been attached to these legumes for a long time. Lalani et al. (2016) found that farmers who attended farmer field school (FFS) in Mozambique had higher intentions for conservation agriculture (CA). This was both due to social obligations and improved understanding of the ecological benefits of CA practices following attendance to the school. Such forum is a good social capital nurturing ground, which can be exploited by extension workers. In FFS more people turn out to be trainers of other farmers as they all learn key skills of communicating to other farmers (Van den Berg & Jiggins, 2007). This way information is not concentrated with the lead farmer only. The need for well-functioning information exchange fora for farmers is emphasised by a number of scholars (Chowa et al., 2013; Gowing & Palmer, 2008; Masangano & Mthinda, 2012; Ojiem et al., 2006).

5.3 Legume marketing

Market centres serve as information centres too for various agricultural technologies such that physical presence of farmers at the markets enables them access new information (Ojiem et al., 2006). This suggests that restricting farmers from participating in legume markets denies them opportunities for growth of their agricultural enterprises. In this study physical farmer participation at markets was limited due to distance in some study sites hence forcing farmers to sell at the farm gate. Distance to markets is a common factor affecting utilisation of agricultural technologies requiring purchase of inputs (Kassie et al., 2015) as well as sell of agricultural produce or products (Feleke & Zegeye, 2006).

There has been proposals for institutional arrangements to facilitate legume marketing for smallholder farmers to encourage adoption of legume diversification (Ojiem et al., 2006). Furthermore, recent studies from east, west and southern Africa have brought evidence of farmer participation in legume markets after strong institutions are laid out as reported from Uganda, Nigeria and Malawi (Stadler et al., 2017). This study has found that evidence of collection of produce from farmers not be enough proof that the deserving farmers (adopters) are supplying the produce. Marketing opportunities that provide a diversity of buyers would spread out the risks associated with abuse of institutions within smallholder legume marketing such as those revealed in section 4.3.

The promotion of novel technologies in legume diversification of maize systems have sought utilisation of incentives to attract farmers to adopt. This is because these novel technologies are brought to farmers as a package of conservation agriculture (CA). Unlike integrating maize and legumes through intercrops or rotations, full CA has other practices such as mulching, pitting and zero tillage, which may justify expectation of incentives. This is due to what maybe unfamiliar elements in the full CA package.

Because many organisations promote a mix of these maize-legume intensification methods (at times full CA) in Malawi, It has become a norm to kick start a project on sustainable agricultural intensification with what may be seen as free inputs supply including maize and legume seeds and inorganic fertilisers to participating farmers. These inputs supply to farmers dealing in CA may appear to establish a foundation that CA utilisation requires external support of fertilisers and other farm inputs. Therefore, participation in agricultural project activities has a large bearing on access to farm inputs, information services and even marketing of agricultural produce in Malawi.

6. Conclusion

This study has looked at how institutions within extension modalities on legume diversification of maize systems impact on farming decisions.

Farm trials are an important modality for agricultural extension in developing countries. It is customary to support farmers with start-up inputs to encourage dedication to trial management. However, in an effort to get ready or speed up adoption, the bending, or disregard, of rules and norms by extension workers creates antipathy to the agricultural technology promotional programs by the part of the farmer population not directly benefiting from it. Even for farmers hosting trials, there is no guarantee that they will extend the innovation to wider farm area because of focusing on maintenance of a good stand of the trial plot. Through this they are assured of hosting trials every year and receiving incentives for doing so. These incentives may be given in form of free farm inputs from national programs hence at the expense of more deserving farmers.

This study has also shown that the restructuring of extension delivery services to lead farmers has brought new challenges to the extension system, which are reflected in the manner in which farmers receive new agricultural technologies and innovations. Lead farmers are a mouth piece of extension workers and have helped other farmers to manage agricultural technologies but have not always had the right information about these. Furthermore, they have concentrated on farmers within their communities. Most importantly the plurality of agricultural extension service providers has brought apparent competition on type of incentives given to lead farmers. The existence of multiple extension service providers in developing countries has brought various agricultural service delivery approaches to farmers. A common thread in these is free farm inputs and branding materials as well as bicycles given to lead farmers for facilitating diffusion of agricultural technologies and speeding up uptake. These have led to discontent among other farmers when perceived to be excluded from economic benefits from organisations promoting the technologies. Therefore, findings of this study also reflect on farmers' decision drivers on legume diversification when social network obligations or the expectation of farm inputs and branding materials are more prioritised than inherent value of maize-legume intensified systems.

Ways of marketing legumes were part of this study because many studies in southern Africa have highlighted it as one major decision driver for legume diversification of maize systems. This study found that farmers were not satisfied with prices of legumes and they felt neglected by the government when farm gate prices are too low as dictated by agents of big agricultural produce buyers. In other areas this led to establishment of initiatives to facilitate bulking of legumes from smallholder farmers following excess production of some legumes such as soybean. However, the twisting of formal rules regarding which farmers access this facility by projects' agents excluded other farmers from selling their legumes like soybean. This negatively affects farmers' choices of legumes for integration with maize. Marketing of legumes is considered the ultimate decision driver on adoption and continued utilisation of specific legumes, particularly those not widely consumed in the home like soybeans.

From a background of slow adoption of the whole CA package in southern Africa, our study singled out legume diversification in maize systems for its direct bearing on food security and soil fertility. Our findings show that there is a need to monitor the performance of extension modalities through which farmers get knowledge and information about agricultural technologies. This improvement has been proposed in: administration of on-farm trials; functioning of lead farmers in extension service delivery, and; facilitation of legume marketing. It can follow a purpose-made study of farmers utilising a particular technology to identify social issues embedded between the farmers and service providers.

7. Appendix

Discussion questions

Agricultural extension services delivery on maize-legume intensification
How have farmers come to learn of maize-legume intercrops and rotations in your area?
You have grown legumes and maize in different ways for a long time. How different are the new methods of integrating maize and legumes under ASWAP project?
How are lead farmers involved in promotion of maize-legume intercrops/rotations?
What role do village headmen/women take in promotion of maize-legume intercrops/rotations
What is the role of the Agricultural Extension Development Officer (AEDO) in maize-legume intensified systems?

Utilisation of maize-legume intensified systems
Why do you think some farmers apply maize-legume intercrops/rotations only to a part of their maize area?
What fears do you have on the future of maize-legume intensified systems if ASWAP project phased out?
What similarities would you point out on promotion of maize-legume intensified systems between ASWAP project and other soil fertility projects in your area?

Marketing of legumes and maize
How is maize sold in your area
How are legumes sold in your area
What is the role of men/women in marketing of legumes in your area?
Apart from the free supplied legume seeds, which other ways do you acquire legume seed?

Seed supply systems
How do free inputs programmes contribute to utilisation of maize-legume intercrops/rotations?
What is your opinion regarding provision of free legume seed whether by government or nongovernmental organisations to farmers in relation to maize-legume intercrops /rotations?
What fears do you have on the future of maize-legume intensified systems if ASWAP project phased out?

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Chapter Seven: General discussion and conclusion

7.1 Introduction

Legume diversification of maize based systems has the potential to improve soil fertility and mitigate the nutrient mining impact of maize in addition to improving access to maize and legume grains for human nutritional needs. Despite three decades of promotion of maize-legume technologies through farmer participatory research and free supply or subsidies of maize and legume seeds in southern Africa, adoption of improved maize-legume integration has been disappointingly minimal. The overall objective of this research was to understand limited utilisation of maize-legume intensified systems among smallholder farmers in Malawi.

The diversity of theories on decision making influenced a mixed methods approach to exploration of the study question through these key related objectives: (i) What is the role of land size and use orientation of legumes in maize-legume intensified systems?; (ii) What is farmers' motivation for intensifying legumes only to a part of their maize area?, and; (iii) What factors affect women farmers' intentions to increase area under improved maize-legume integration?

7.1 .1 Theoretical foundation

Adoption of agricultural technologies can be explained from two main strands of decision making theories; expected utility and socio-cognitive. Most adoption literature assumes that farmers adopt technologies if they are perceived to provide more utility than existing technologies or if utility of the whole farm is expected to increase. In light of this, farmers are assumed to be economically rational. Other adoption literature assumes that farmers adopt agricultural technologies for various reasons including what may seem rational and irrational. Such approaches argue that maximising utility is only a part of what motivates farmers to adopt technologies. Other critical areas of cognition include; habit, attitude, social pressure, obligations and risk perception.

This research was founded on both utility maximising and socio-cognitive theories because firstly, legumes are widely grown in smallholder farming systems in southern Africa. In light of this, uncertainty of their performance is minimal. Secondly, literature has attributed low utilisation of legumes to low prices indicating that contribution to farm income is an important factor to consider in adoption of maize-legume intensifies systems. Hence the relevance of incorporating utility maximising behaviour of farmers in this research. However, the role of biological nitrogen fixation from legumes becomes important too in legume diversification technologies because of the attention given to soil health.

Therefore the research questions identified both perceptions relating to soil fertility and increased farm cash incomes while acknowledging that other decision drivers depart from utility maximisation. For example, following (Ostrom, 2011), farmers' decisions can also be influenced by their perceptions of institutions within agricultural extension modalities on promotion of agricultural technologies. In this research this dimension of influence has been looked into under motivation for minimal legume diversification of maize systems. The research questions are discussed through manuscripts from this research and summarised from section 7.2.1 to 7.2.5.

7.2 Outcomes, discussions and conclusions

Minimal legume diversification of maize systems is largely attributed to utility maximising (UM) behaviour of the farmer centred under risk attitude. Hence following diffusion of innovations theory (Rogers, 1983), this has mostly been explained by characterising farmers into a dichotomy of adopters and non-adopters. However, this approach leaves out other measures of cognitive aspects affecting decision making (Borges et al., 2016). A recent review of agricultural adoption literature found that in situations where no direct economic benefits result from adoption, socio-psychological approaches such as the Theory of Planned Behaviour (TPB) have demonstrated superiority (Borges et al., 2016). This is due to their ability to interact elements of utility maximisation, attitude and social pressure in explaining a behaviour.

7.2.1 Smallholder farmers' decision making on legume diversification

Chapter 2 set the scene for this research by developing a decision framework on legume diversification. This was based on a brief review of frameworks on utilisation of agricultural practices concerning loss of soil fertility, water conservation and loss of soil including cereal-legume rotations as remedial practices to soil degradation. Ervin & Ervin (1982) observed that single discipline approach to explaining farmer decisions did not adequately inform policy. Following this they developed a model that integrated personal, institutional, physical and economic factors to explain farmers' decisions on soil and water conservation practices.

This modeling centred on farmers' perception of the problem of soil erosion and the amount of effort given to soil conservation. This study laid a foundation for farmer behavioural modelling on environmental management practices as it combined cost-benefit and attitude related models. From these foundations and a review of later models this research identified three broad areas influencing farmers' decision making: perception of risk, perception of benefits, and; obligation to agencies promoting agricultural practices or to farmers' social networks. These informed the selection of theories using socio-psychological analytical methods in this research. Based on the Theory of Planned Behaviour and Institutional Analysis and Development Framework, a decision framework was developed explaining motivation for selection of amount of maize area for legume diversification.

Following Bergevoet et al. (2011), a farmer's decision on legume diversification of maize systems was conceptualised to be impacted by perceived goal-related outcomes from the diversification. The goal-related outcomes are influenced by TPB primary intention predictors: perception of agronomic benefits from legume diversification (attitudes); perception of institutions and social norms on legume diversification (subjective norms), and; perceived competence to manage legume diversification (perceived behavioural control). The goal related outcomes were: crop diversifications; increasing farm incomes, and; replenishing soil fertility. These goals are motivation for engaging in legume diversification technologies and they precede the intention. Motivation-intention relationship may take place at the same time. However, because a behavioural intention depicts behaviour Fishbein & Ajzen (2010), the goals are an end in themselves. An SEM was used to validate the framework from a case study of legume diversification technology called doubled-up legume rotation (DLR) in Mzimba district in Malawi. Details of DLR are given in section 7.2.2.

Modeling results in Chapter 2 indicated that the various goals from legume diversification were influenced differently by the TPB intention predictors. Notably, farmers attitudes towards legume diversification significantly influenced all the goals ($p = 0.00$). This indicated that farmers had knowledge of the agronomic benefits from integrating legumes in their maize area. This is partly attributed to the fact that they had grown legumes and maize in for a long time before any projects on soil fertility management. Social norms only influenced the goal of diversifying cropping systems and replenishment of soil fertility. This was attributed to existence of organisations promoting legume diversification whereby some of farmers' decisions arise from moral obligations and social pressure to have belonging and please the people highly regarded respectively. Concurring with literature that farmers increase utilisation of legume technologies when market opportunities arise (Pircher et al., 2013) the analysis showed that perceived behavioural control on legume diversification was only significantly influenced the goal to increase farm incomes ($p = 0.000$). The strength of the framework is the demonstration that goal-related outcomes from utilisation of an agricultural technology are influenced by farmers' attitudes, subjective norms and perceived behavioural control. The framework upholds behavioural modeling by Bergevoet et al. (2004) and May et al. (2011).

The framework can help to explain limited utilisation of agronomic practices among subsistent farmers in developing regions like Africa. In this region there are various organisations aiding farmers to improve their livelihoods through adoption of improved agricultural technologies. Large among these are conservation agriculture to which legume diversification is a part. The framework can be used to identify decision making elements critical to achieving successful adoption. The established linkages between TPB behavioural intention predictors and goals indicate that a behavioural change intervention can be aligned with goal-related outcomes most sought by farmers. Interventions can also be designed to deliberately influence the goal-related outcomes, e.g., those relating to inherent value of soil fertility. Alternatively, researchers can derive interventions to positively influence non-significant TPB behavioural intention predictors. Since the framework is based on the close linkage between motivation and behavioural intention it can also be adapted for pre-agricultural adoption research. This framework laid a foundation for the socio-cognitive theory part of the research question. However, there was a need to introduce a base for quantitatively comparing amount of utilisation of maize-legume intensified systems (Chapter 3). This was done at farm level using a case of doubled-up legume rotations.

7.2.2 Land size does not matter but use orientation for legumes

The aim of Chapter 3 was to investigate whether land size and use orientation for legumes were important factors affecting the probability that farmers increase a legume diversification technology. Land limitations and endemic poverty in southern African smallholder farming systems (Ricker-Gilbert, et al., 2014) make utilisation of improved soil management technologies that directly increase access to food pertinent (Smith et al., 2016). Doubled-up legume rotations (DLR) is novel maize-legume technology involving intercrops of two legumes with complementary phenology for two years before rotating them with maize in the third year (Kerr et al., 2007; Snapp et al., 1998). In Malawi pigeon pea/soybean and pigeon pea/groundnut intercrops are used in DLR. The superiority of DLR to other legume diversification technologies relies on pigeon pea's unique growth habit leading to enhanced soil fertility benefits (Snapp et al., 2010). DLR systems have better fertiliser use efficiency and higher grain yields than maize sole cropping or single legume-cereal intercrops and or rotations (Snapp et al., 2010).

To fulfil the study objective a metric for estimating amount of utilisation of a legume technology at farm level based on DLR was developed in Chapter 3. Consistent with diffusion of innovations theory (Rogers, 1983), DLR utilisation may be partial or full depending on farmer characteristics, biophysical and institutional factors. The research estimated the degree of utilisation of DLR as a ratio of the area under doubled-up legume intercrops (soybean/pigeon pea or groundnut/pigeon pea) to total maize area (DLRPROP). This can be expressed as: ${}^{A_{DLi}}/_{\sum A_{mi}}$ where, A_{DLi} is area in hectares under intercrop of legumes (soybean/pigeon pea or groundnut/pigeon pea), A_{mi} is total area in hectares under maize cultivation for farmer i respectively.

Since DLRPROP is a proportion, zero-one inflated beta regression was used to estimate a maximum likelihood function that a farmer would increase proportion of maize area under DLR. For purposes of this estimation increasing utilisation signified allocating more maize area to DLR technology. Independent variables in this estimation included farmers' perceptions of agricultural technology (Adesina & Baidu-Forson, 1995; Adesina & Zinnah, 1993) and those from utilisation of sustainable agricultural practices in developing countries as reviewed by Knowler and Bradshaw (2007).

Specific variables relating to soil fertility were used: perception of superiority of DLR to existing legume technologies; (Smith et al., 2016); use orientation for legumes because legume market opportunities affect adoption decisions (Pircher et al., 2013); perception of the level of fertility of farmers' maize area (Mponela et al., 2016); past utilisation of green manures following linkages between past and current behaviour (Bergevoet et al., 2004). Other variables were included: gender of the farmer; family labour; experience in using DLR; Number of times of agricultural extension contact on DLR; land size; access to seed, and; land rights.

The estimation results indicated a positive relationship between perceived superiority of DLR to other legume technologies with increasing DLR utilisation. In addition: previous utilisation of other green manure technologies; perception that part of farmers' maize area was less fertile, and; ability to access legume seed without external support were positively significant. However, farmers with more land and those whose use orientation of DLR legumes was market were less likely to increase utilisation. In addition women farmers were less likely to increase DLR utilisation.

Because women farmers and generally farmers with less land were less likely to increase utilisation of DLR, the research was directed to investigating perceived competence to increase DLR among women farmers (Chapter 4).

7.2.3 Women farmers have perceived competence to increase doubled-up legume rotations

The aim of Chapter 4 was to investigate perceived competence to increase DLR among women farmers due to (i) the importance of maize and legumes in Malawian diets and the role of women in food production in Malawi following wide consumption of maize and legumes, and; (ii) the finding in Chapter 3 that women farmers held relatively smaller land holdings (below 1.5 ha).

In sub Saharan Africa women farmers face a challenging task to feed their households without external support from food projects and government programmes (Doss, 2001; Fisher & Kandiwa, 2014). This has a negative impact on their access to new agricultural technologies (Doss, 2001; Knowler & Bradshaw, 2007). In light of this, the promotion of improved maize-legume integration is most relevant to help resource poor farmers boost their access to food while rebuilding their soils (Kerr et al., 2007; Rusinamhodzi et al., 2012). The low cost nature of technologies under this practice easily adapt to conditions of nutrient constrained smallholder farmers (Snapp et al., 1998), large of whom are women (Doss, 2001; Fisher & Kandiwa, 2014). DLR is an example of a technology proven to provide more food grains than other legume diversification technologies in Malawi (Smith et al., 2016).

The minimal resource endowments associated with women farmers revealed in Chapter 3 influenced a specialised investigation on which factors can influence them to increase area under DLR with application of the TPB. The women farmers were heads of their households and were purposefully identified to fulfil the study objective as contextual and household factors affecting agricultural adoption impact more on women than male farmers. Within this discourse however, maize and legumes are staples in Malawi (Ngwira et al., 2014) and women play a key role in food production and processing (Kerr et al., 2007). Therefore, it could not be deduced easily if women farmers would have perceived competence to increase DLR.

Following the TPB it was hypothesised that a strong intention to increase the DLR utilisation would be derived following: a favourable evaluation of the attributes of DLR (attitudes); compliance with social pressure on utilisation of DLR (subjective norms), and; perceived competence to manage changes in in cropland following expansion of area under DLR (perceived behavioural control). A comparison of the strength of correlation between direct and indirect measures of attitudes, subjective norms and perceived behavioural control was done.

The findings from this chapter showed that women farmers had positive attitudes towards DLR utilisation. They also acknowledged people whom they held in high regard in as far as DLR utilisation was concerned. Furthermore, they perceived competence to manage the demands from DLR expansion. Overall, correlating direct measures of attitudes, subjective norms and perceived behavioural control with intention showed that only direct subjective norm was not significant. On the other hand, correlating indirect measures of attitudes, subjective norms and perceived behavioural control with intention showed that all measures were significant. One cause of the lack of significance between direct measure of subjective norm was attributed to the natural feeling of not wanting to show low self-esteem when questions appear to suggest so (Garforth et al., 2004). This was deduced from the difference in questions between those depicting descriptive and injunctive norms respectively. The descriptive norms carried active statements whilst the injunctive norms carried passive statements.

The findings mean that the status of women farmers as heads of their households is a strength for enhancing perceived behavioural control relating to DLR utilisation because they can make their own decisions. This may further be strengthened by the characterisation of legumes as ‘women crops’ in Malawi (Kerr, 2005). These two factors can be used to enhance attitudes towards maize-legume intensified systems among women farmers generally. These factors are well supported by the confidence in management of maize-legume rotations owing to a long history of existence of legumes in traditional southern African farming systems. Further to this, promotion of maize-legume intensified systems involved farmer trainings and free farm inputs supply. These strengthened subjective norms on the technology and positively contributed to their motivation to continue utilising DLR.

7.2.4 Social pressure dictates farmers' motivation to increase legume diversified cropping systems

From a background of goal-related outcomes from legume diversification of maize systems, inherent value of soil fertility and increased farm incomes were listed in the conceptual framework (Chapter 2) as determinants of decision on land allocation to improved maize-legume integration. The goal-related outcomes represent motivation for utilising an agricultural technology after Bergevoet et al. (2004). Further to this, Chapter 3 showed that farmers with more land and use orientation of legumes towards markets were less likely to increase utilisation of the DLR.

Within the objectives of this research Chapter 5 investigated whether the two goal-related outcomes from legume diversification of maize systems can affect the amount of utilisation of a legume diversification technology (DLR). A probit analysis was used in this task. It was preceded by a decision model adapted from the TPB that tested the validity of the goal-related outcomes from legume diversification. As a model, attitudes, subjective norms and perceived behavioural control were tested against the two goal-related outcomes: soil fertility and diversified cropping systems. This analysis used a structural equation modeling (SEM).

The model integrated farming goals and the intention predictors of the TPB following Bergevoet et al. (2004) and May et al. (2011). =Goal-related outcomes from DLR were hypothesised to mediate the decision to increase utilisation of DLR and the primary intention predictors of the TPB. Fishbein and Ajzen (2010) established that background factors, which in this context include farm household socio-economic factors influence behavioural, normative, and control beliefs leading to formation of attitudes, subjective norms and perceived behavioural control on a behaviour. However, Lowry and Gaskin (2014) demonstrate how these socio-economic factors become moderator variables (on the effect) in a cause-effect relationship. With reference to this research these socio-economic factors were hypothesised to independently influence whether or how utilisation occurs. In light of this, these factors impact on the decision on amount of utilisation when uncertainty on performance of the technology becomes minimal. Otherwise they impact on the behavioural, normative and control beliefs on the technology.

The SEM analysis in Chapter 5 showed that farmers' attitudes towards DLR were significantly related to pursuit of both farm incomes and crop diversification outcomes. The positive attitudes towards DLR is a strength that agricultural extension can focus on in DLR promotion. The positive attitudes were embedded in farmers' knowledge of primary attributes from legumes and maize-legume integration, e.g., 'DLR reduces weed occurrence in maize'. The favourable attitudes towards DLR show that promotion efforts could be directed towards other areas of the technology than awareness on its attributes.

Subjective norms relating to DLR had a positive significant relationship with crop diversification outcome only. This positive relationship shows that farmers were encouraged to continue utilising DLR by people whom they regarded highly including agricultural extension workers, lead farmers and also family members. Therefore, pathways for enhancing awareness on the ecological benefits of legume diversification should extend to family members and farmers nominated in their communities to help in agricultural technology transfer also called lead farmers in Malawi. This corroborates literature that farmers' decisions on technologies are also influenced by other people in their communities (Bergevoet et al., 2004; Borges & Oude Lansink, 2016). As observed by Lalani et al. (2016), multiple sources of social influence contribute to reduction in uncertainty on the performance of an agricultural technology. Sources such as local and personal contacts may also encourage farmer participation in extension modalities such as on-farm trials and agricultural extension meetings.

Through extension modalities farmers received farm inputs and branding materials as well as bicycles. Further details on this are discussed in Chapter 6. It is within the expected norms to provide farm inputs and other materials to smallholder farmers for experimenting with technologies (Collier & Dercon, 2014). Nevertheless, the strength of the subjective norms in this analysis suggest that farmers' participation in on-farm trials was also an obligation to people held in high regard.

Perceived behavioural control significantly only influenced DLR goal-related outcome of raising farm incomes. This shows that farm resource allocation decisions for DLR depended most on farm household socio-economic factors and farmers' attitudes than social pressure (subjective norms). It further corroborates that smallholder farmers prioritise farm incomes than soil benefits in legume utilisation for soil fertility (Giller et al., 2011; Grabowski & Kerr, 2014; Snapp et al., 1998).

In the probit analysis two groups of farmers were identified: those who had increased area under DLR and those who had not or had reduced. Results showed that only crop diversification outcome from DLR was positively significant ($p = 0.01$). Therefore, the expected goal-related outcome from DLR concerning legume diversified cropping systems has a significant positive influence on DLR utilisation. Inferring from the SEM analysis within the same chapter (5), this resulted from the influence of subjective norms and positive attitudes towards DLR for the purpose of diversifying cropping systems.

Both number of adult workers in the farm household and frequency of contact with extension personnel were positively significant ($p = 0.05$). This indicates that increasing family labour and contact with agricultural extension personnel has a positive contribution towards decision to increase DLR utilisation. Inferring from the SEM results, the extension worker was highly regarded. This also enhanced social capital in driving farmers' participation in various extension modalities.

It was also found that women farmers and farmers with more land were less likely to increase DLR utilisation holding other factors constant at ($p= 0.05$) and ($p = 0.01$) respectively. This may be attributed to resource endowment hence women farmers are more likely to have smaller landholdings (Doss, 2001). These findings corroborated earlier findings in Chapter 3 (Kamanga et al., 2017). One can question whether African smallholder farmers can commit to improvement of soils using grain legumes for the inherent value of soil fertility.

Farmers' attitudes and perceived norms on the pursuit of outcomes from DLR are key drivers of their motivation to increase utilisation of this technology. These findings are relevant for promotion of sustainable agricultural intensification in smallholder farming systems in other developing countries too. Agricultural extension officers should emphasise that what may be considered a high investment cost in soil nutrient stock of maize systems (using DLR), is less than the cost of lost economic opportunities arising due to less attention to soil fertility. Agricultural extension should take advantage of situations where agricultural social capital is robust, to disseminate information on the importance of managing soil fertility using legumes. This should be supported by farmer training in improved ways of incorporating legume residues and leaf litter that maximise gains in soil benefits from legumes (Pircher et al., 2013).

7.2.5 Institutions within on-farm trials, lead farmer extension approach and legume marketing negatively impact farmers' decisions on legume diversification of maize systems

The previous discussion extracted from Chapter 5 revealed that some agricultural extension modalities were instrumental in the promotion of DLR namely: on-farm trials and use of lead farmers or volunteer farmers. Chapter 6 investigated how institutions in three of the commonest extension modalities in Malawi: on-farm trials; use of lead farmers, and; facilitation of legume marketing, can impact farmers' participation in legume diversification.

Institutions were defined as "… enduring regularities of human action in situations structured by rules, norms, and shared strategies, as well as by the physical world" (Crawford & Ostrom, 1995, p.582). They are formed and reshaped following interactions between people or groups to achieve perceived outcomes (Ostrom, 2011). Agricultural services providers provide social spaces such as extension modalities (farmer trainings; farm inputs access; marketing and on-farm trials) through which farmers and service providers interact.

Content analysis showed that a common thread in the three modalities was farmers' expectation of incentives. The use of incentives to encourage adoption and maintain hosts of on-farm trials was also propagated by extension workers as they sought to identify loyal farmers. While provision of incentives beyond farm inputs has become a standard feature in the promotion of agricultural adoption in Africa, it may not sustain wider adoption because these incentives are limited to those who host or participate in on-farm trials. To maintain the high morale and loyalty among farmers, agricultural extension workers diverted some of the farm inputs under national programs (FISP) to incentivise farmers who hosted on-farm trials. This created situations of antipathy and jealousy within communities (Brown et al., 2017a). One conclusion from this is that provision of incentives other than farm inputs does not acknowledge the inherent value of maize-legume intensified systems.

Chapter 6 further found that lead farmers were generally held in high regard and they had high self-esteem. This can be because they were also contact points for various agricultural service providers in their villages. Despite the enthusiasm of lead farmers to reach out to other farmers, some farmers still lacked the right information about management practices of maize-legume intensified systems. One cause of this is a relaxed approach to message dissemination on technologies familiar to farmers such as legume technologies.

Further findings on extension modalities in this chapter show disapproval of lead farmers who were nominated without knowledge of their communities. This happened where extension workers had ran late on deadlines. This mode of nomination broke established rules of nominating lead farmers at an open forum in their community (Wellard et al., 2013). This twisting of institutions regarding selection of lead farmers negatively affects agricultural activities (Khaila et al., 2015) as other farmers show resentment (Brown et al., 2017a). This finding gives insights into factors affecting farmers' participation in information fora on maize-legume intensified systems.

Furthering discussion on institutions in extension modalities Chapter 6 found that organisations that promoted legume diversification did not adequately facilitate sale of legumes like soybeans as agents representing buyers charged illegal commission on sales. This new institution negatively impacted farmers' crop selection in later seasons including commitment to legume diversification. This corroborates other literature that failure to sell legumes like soybean negatively affects legume diversification (Giller et al., 2011). Generally, farmers expressed dissatisfaction with lack of formal institutions in soybean marketing considering that the government encouraged increased soybean production for cash and soil fertility enhancement among smallholder farmers. Out of dire need for cash, some farmers sold legumes reluctantly at low prices at the farm gates. While better legume prices would attract farmers to integrate more legumes in their maize cropping systems (Giller et al., 2009), the current study findings show that certain markets are a key.

7.3 Synthesis of results

This thesis has contributed to understanding farmers' motivation to utilise legume diversification technologies by drawing insights from utility maximisation, social pressure and moral obligations as determinants of behaviour. This section synthesises the results of the thesis presented in Chapters 2 to 6. Firstly, a conceptual framework based on the Theory of Planned Behaviour with insights from Institutional Analysis and Development Framework was developed to contextualise the analytical approaches used in the thesis. A mixed methods approach to the research question was adopted to reflect utility maximisation, social pressure and moral obligations as decision drivers. Through-ought the thesis a legume diversification technology called doubled-up legume rotations was used as a case.

Using three key areas of cognition (utility maximisation, social pressure and moral obligations), Chapter 2 adapted the TPB to a decision framework on legume diversification (DFLD). This tested TPB primary intention predictors (attitudes, subjective norms and perceived behavioural control) against goal-related outcomes from legume diversification: soil fertility; crop diversification, and; increased farm cash incomes. According to (Ajzen, 2005), attitudes, subjective norms and perceived behavioural control are informed by normative, subjective and control beliefs. If there is no relationship between past behaviour and current one or a projected behaviour, then perceived goals from the tasks of a behaviour can influence the three groups of beliefs (Fishbein & Ajzen, 2010). However, where a relationship exists attitudes, subjective norms and perceived behavioural control have influence on the goals (Bergevoet et al., 2004). This thesis took the perspective that current legume diversification technologies had some similarities with previous technologies such as maize-legume intercropping and maize-legume rotations. Farmers utilising DLR were assumed to have minimal uncertainty on the performance of this technology. Consistent with (Marra, et al., 2003) they were able to make informed decisions. Following (Bergevoet et al., 2004; May et al., 2011), the DFLD summarised farmers' motivation for adopting maize-legume intensified systems into goal-related outcomes of: increased maize yields and farm incomes; increased soil fertility, and; crop diversification (as insurance against crop failure).

From the expectation of yield gains and expected gain in soil fertility from utilisation of maize-legume intensified systems Chapter 3 tested the probability of increasing maize area allocated to DLR using zero-one inflated beta regression. The results showed that positive perceptions of the superiority of the DLR to other legume technologies and perception of low soil fertility of part of maize area encouraged farmers to increase land allocation to DLR. Further positive relationships with likelihood of increasing DLR were: previous utilisation of other green manure technologies and ability to access legume seed without external support. However, farmers with relatively more land and those whose use orientation for DLR legumes was market were less likely to increase utilisation. In addition, women farmers were less likely to increase utilisation arguably due to relatively smaller land holding sizes.

The close association between women farmers and land size and how this impacts the utilisation of sustainable agricultural intensification prompted an investigation into the potential of women farmers to increase utilisation of DLR by investigating their intentions as laid out in Chapter 4). It was found that perceived competence in the women farmers was a strong predictor of their intentions to increase DLR utilisation. This was supported by positive attitudes towards legumes generally as women had been gate keepers of household food security and grain legumes and maize are some of the important crops for this in Malawi.

Related to women farmers' intentions to increase DLR was the investigation on which goal-related outcomes from DLR between economic and ecological would motivate farmers to increase utilisation as influenced by attitudes, subjective norms and perceived behavioural control (Chapter 5). It was found that farmers' attitudes towards legume diversification significantly influenced both economic goals of raising farm incomes and ecological goals of crop diversification. On the other hand, subjective norms only influenced ecological goals of crop diversification. Following this, a probit analysis was conducted two years later. The perceived importance of ecological goals significantly influenced increased utilisation of maize-legume intensified systems. This further emphasised the strength of moral obligations and social pressure in influencing agricultural technology utilisation.

At the development of the DFLD, subjective norms included perception of institutions in facilitation of legume adoption. This has been explored through three common extension modalities in Malawi: on-farm trials; use of lead farmers, and; facilitation of legume marketing (Chapter 6). It was found that farmers were interested in improved maize-legume integration and were obliged to take part in on farm trials in return for incentives including farm inputs and branding materials. Lead farmers had the self-esteem to reach out to other farmers albeit not always with up to date information. Their high self-esteem was used by agricultural service providers to meet farmers in groups to disseminate agricultural messages.

Agricultural extension workers sought to speed up adoption of some agricultural technologies including improved maize-legume integration particularly involving soybeans. In doing that they selected lead farmers without engaging their communities as required by established institutions. However, this tendency resulted in antipathy and jealousy from other farmers. On facilitation of marketing, most farmers are not organised in groups to sell their agricultural produce to big buyers. The few initiatives introduced by some organisations promoting legume diversification technologies had some loopholes. The research found that in some cases buyers' agents charged farmers illegal fees to buy from them. This created a situation of lack of trust and it subsequently affected farmers' crop enterprise selection in succeeding seasons.

7.4 Policy implications

Maize and legumes are important staples in southern Africa. In Malawi maize-legume innovations have attracted policy interventions in national food security for decades (Dorward & Chirwa, 2011). The Malawi government has demonstrated commitment to fighting poverty and food insecurity through direct support to maize production as well as maize-legume innovations that enhance sustainability of maize environments. This has been demonstrated through national programs on food security such as: Starter Pack Scheme (1995-1999); Targeted Inputs Programs (2000-2004); (Chinsinga, 2004, 2011), and; Farm Inputs Subsidies Programme 2005-2015 between (Arndt et al., 2016; Lunduka et al., 2013). These programs directly supported resource poor farmers with farm inputs commonly maize and legume seeds (pigeon peas, groundnuts and soybeans) and inorganic fertilisers alongside farm trials on the same. Therefore, this thesis brings relevant policy implications to promotion of improved maize-legume integration among smallholder farmers. The research found that smallholder farmers are generally familiar with maize-legume intercrops and rotations and subsequent soil benefits as determined by their positive attitudes towards legume diversification technologies examined in this thesis.

Chapter 2 showed that agricultural extension agents should explore opportunities to cultivate and increase social pressure among farmers adopting legume diversification technologies to influence increased utilisation. The need for this is further emphasised in Chapter 5 where social pressure on utilisation of a legume diversification technology (DLR) was found to positively contribute to decision to increase its area. A lesson from these two chapters is that promotion of maize-legume intensification should also target family members. This can include lobbying with local primary schools where learners cultivate maize and legumes to demonstrate technologies on legume diversification of maize systems. One case in point here is the use of a concept like junior farmer field schools developed by FAO. This concept uses experiential learning to encourage management of agricultural practices as well as to develop life skills (Bonan & Pagani, 2017). Messages on legume diversification technologies should highlight the primary role of these legumes in maize systems, which is the contribution of nitrogen and soil organic matter to the soil.

The metric on amount of legume diversification developed in Chapter 3 indicates the importance of designing messages on legume diversification according to farmer typology based on land sizes. Generally, farmers with relatively less land have no area to expand legume diversification to without significantly trading off area for other crops as they cultivate all their land every season. It can be inferred from Chapter 3 that even with knowledge of the superiority of some legume technologies and the need to increase maize productivity, some farmers still dedicate some part of their small landholdings to crops not contributing directly to productivity of maize e.g., tobacco, finger millet and cassava. This is for cash incomes and insurance against crop failure. Therefore, the role of other crops in farm households can be used to integrate a cost benefit analysis approach to promotion of legume diversification technologies, where farmers can be encouraged to trade off land allocations to earn future benefits to maize through increased legume diversification.

Results in Chapter 3 also showed that a matrix of land size and gender of the farmer streamlines the characterisation of farmers who benefit most from legume diversification technologies. Most women farmers own smaller landholding sizes and due to this, they appear to have the highest dependency on legume diversification technologies. Therefore, ways to promote legume technologies should incorporate the needs of women in their communities. These can be fulfilled by: influencing identification of women to host on-farm trials; engaging other subject matter of importance to household food security in the promotion of legume diversification considering that generally women are at the core of the means of accessing food in their households, and; encouraging women to join farmer groups on legume production. Results in Chapter 4 established that women farmers who are household heads have perceived competence to increase utilisation of legume diversification technologies. This arises from their independence in decision making. With programs directly targeting women farmers more cropping land can be put to legume diversification technologies.

Chapter 5 showed that apart from social pressure contributing positively to increased utilisation of legume diversification technologies, farmers were obliged to abide by the expectation of organisations who promoted these technologies. This was important for their social networks. Another important decision driver arising from interactions with agents of organisations promoting legume diversification technologies was expectation of incentives including farm inputs and branding materials. Here a caution is suggested on use of incentives in promotion of technologies as antipathy and jealousy were reported.

Chapter 6 investigated how institutions in organisations promoting maize-legume intensified systems influence farmers' utilisation decisions. It focused on farmers' participation in on-farm trials, information exchange (lead farmers) and legume marketing. It was found that while many farmers can access these, participation is largely attached to both farm and non-farm inputs incentives for on farm trials and information exchange modalities. Farmers not receiving these incentives feel antipathy over those who host trials. Noting the positive role of these incentives to initiating adoption, there is a need to clarify to farmers the importance of the non-farm inputs (branding materials and bicycles) at the introduction of the technologies in farmers' communities.

The study also revealed that there has also been facilitation of legume marketing for legumes not popularly processed in homes in Malawi such as soybean. However, when buyers' agents change rules to bypass deserving farmers in favour of their own suggests independent monitoring of such facilities to ensure that deserving farmers have access. The research shows that some of the factors holding farmers back from utilising well proven agricultural technologies concern administrative arrangements in the promotion of the technologies. In conclusion, there is a need to improve the functioning of extension modalities on legume diversification technologies to encourage continued utilisation.

7.5 Limitations and future research

This thesis has used two theoretical foundations: the TPB and the UM. The thesis laid its arguments mostly on the TPB and its adaptation to analyse motivation and intentions on maize-legume intensified systems among smallholder farmers in Malawi. It is possible that other areas concerning decision making were not adequately explored. For example, other possible influences of current behaviour such as past behaviour were only explored by a yes/no response. This was adequate for an econometric analysis in Chapter 3. But future research can engage this in a socio-cognitive theoretical adaptation.

The general analysis assumed that farmers made informed decisions about legume diversification technologies owing to a long period of utilisation under different arrangements (maize-legume intercropping; legume-legume intercropping; maize-legume rotations, among others). Studying a case of doubled-up legume rotations, this research considered a minimum of six years adequate for informed decisions. Other work may look into how the theoretical adaptations developed in this work apply to legume diversification technologies that are newly introduced to farmers. An example can be the diffusion of the DLR to other areas where no farmer participatory research took place.

Lessons from the research findings have implications for promotion of other agricultural technologies too such as crop-livestock intensification technologies; zero tillage under CA, and; new varieties of crops. The multiplicity of crop enterprises as revealed in Chapter 3shows that smallholder farmers must fit a technology in a limited space. This maybe one source of conflict between efforts to promote increased utilisation of a proven technology and actual utilisation at farm level.

Future research on adoption of legume diversification technologies can put this into perspective by comparing perceived importance of various crop enterprises in order to find an entry point for demonstrating the overall benefits from legume diversification technologies to the farm and household. For example, DLR utilisation implies that if farmers do not rent land, they can maximise maize cultivation in every third year. This is a change in cropping patterns to farmers who prioritise staples in cropland allocation. Future research can use analytical methods concerning willingness aside from perceived behavioural control and intentions to ascertain readiness. Inferring to this research, such methods would apply to the context of Chapter 4 concerning women farmers' intentions to increase utilisation of DLR.

Lastly, future research may also look at the differences in intentions and willingness towards increasing utilisation of legume diversification technologies between women farmers who are farm wives and women famers who are household heads. Inferring from the findings from Chapter 4, female household heads may express more willingness and higher intentions to increase utilisation of legume diversification technologies due to independence of decision making. On the other hand farm wives may have land area allocated by their husbands to grow legumes and any expansion of legume diversification technologies need to be negotiated for mutually. This has implications on their intentions to diversify more legumes.

7.6 Highlights of research findings

- Smallholder farmers have positive attitudes towards legume diversification technologies
- Land size does not matter on amount of legume diversification technologies that a farmer utilises.
- Use orientation for legumes in a maize-legume intensified system is more important than inherent value of soil fertility.
- Farmers with relatively more land dedicate smaller portion to legume diversification of maize system.
- Women farmers have relatively more maize area under legume diversification due to having smaller cropping land sizes.
- Women farmers who are household heads display a strong perceived competence to increase utilisation of legume diversification technologies due to independence of decision making and direct need for food production for their households.
- Ecological goals from utilisation of legume diversification technologies are more influenced by social pressure and moral obligations even when farmers display a positive attitudes towards that.
- Smallholder farmers balance moral obligations and expectation of incentives from organisations promoting legume diversification technologies.
- There is antipathy towards farmers appearing to benefit more from organisations promoting legume diversification technologies through both farm inputs and non-farm inputs incentives.
- Extension workers have sought to persuade farmers to maintain on-farm trials by supplying them with farm inputs allocated to vulnerable farmers under FISP.
- Lead farmers do not have up to date information about maize-legume intensification.

7.7 References

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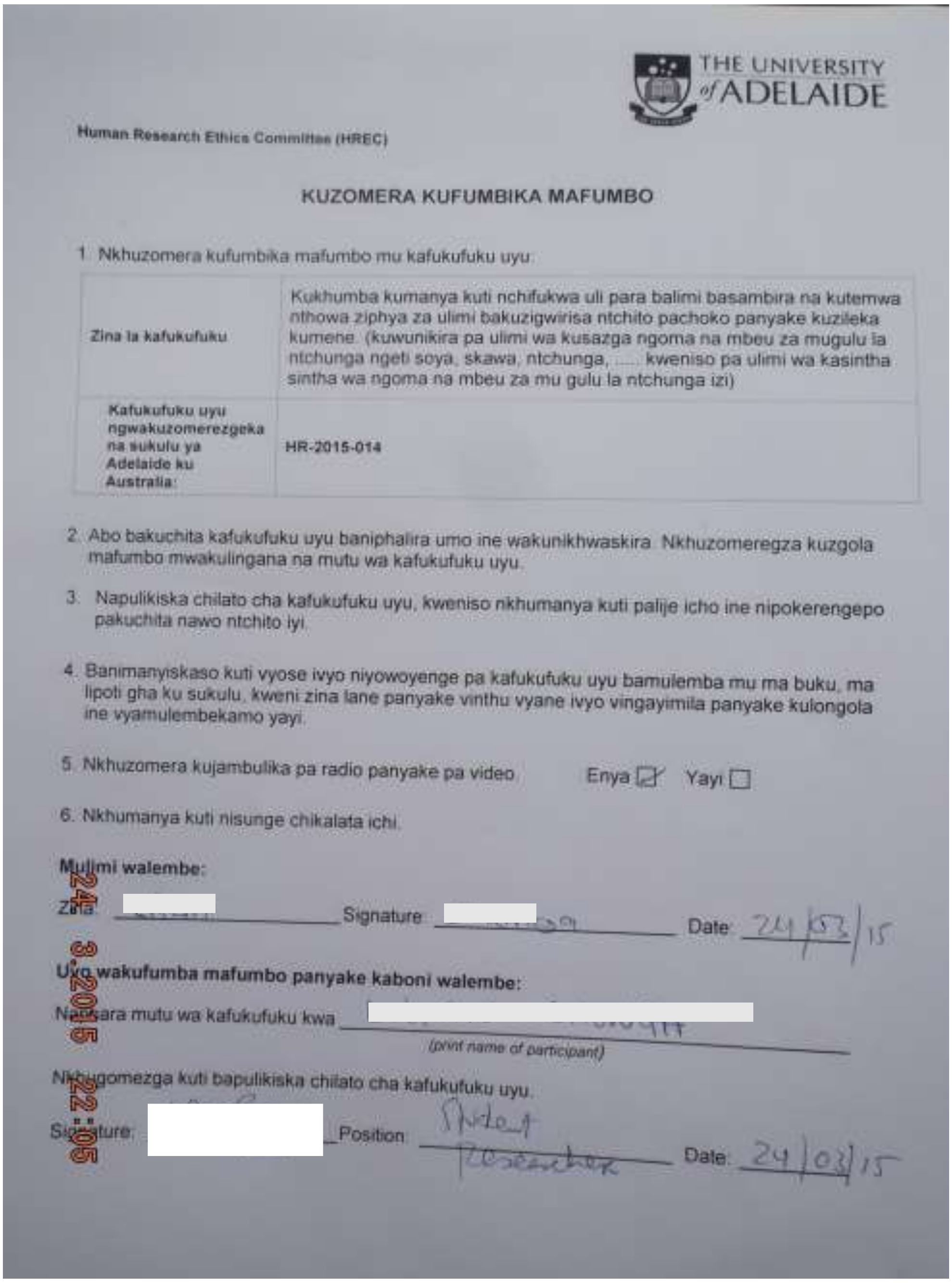
7.8 Appendix

7.8.1 Sample of consent form to take part in the study



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Human Research Ethics Committee (HREC)

KUZOMERA KUFUMBIKA MAFUMBO

1. Nkhuzomera kufumbika mafumbo mu kafukufuku uyu:

Zina la kafukufuku	Kukhumba kumanya kuti nchifukwa uli para balimi basambira na kutemwa nthowa ziphya za ulimi bakuzigwirisa ntchito pachoko panyake kuzileka kumene. (kuwunikira pa ulimi wa kusazga ngoma na mbeu za mugulu la ntchunga ngeti soya, skawa, ntchunga, ... kweniso pa ulimi wa kasintha sintha wa ngoma na mbeu za mu gulu la ntchunga izi)
Kafukufuku uyu ngwakuzomerezgeka na sukulu ya Adelaide ku Australia:	HR-2015-014

2. Abo bakuchita kafukufuku uyu baniphalira umo ine wakunikhwaskira. Nkhuzomeregza kuzgola mafumbo mwakulingana na mutu wa kafukufuku uyu.
3. Napulikiska chilato cha kafukufuku uyu, kweniso nkhumanya kuti palije icho ine nipokerengepo pakuchita nawo ntchito iyi.
4. Banimanyiskaso kuti vyose ivyo niyowoyenge pa kafukufuku uyu bamulemba mu ma buku, ma lipoti gha ku sukulu, kweni zina lane panyake vinthu vyane ivyo vingayimila panyake kulongola ine vyamulembekamo yayi.
5. Nkhuzomera kujambulika pa radio panyake pa video. Enya ☑ Yayi ☐
6. Nkhumanya kuti nisunge chikalata ichi.

Mulimi walembe:

Zina: ________ Signature: ________ Date: 24/03/15

Uyo wakufumba mafumbo panyake kaboni walembe:

Nakara mutu wa kafukufuku kwa ________
(print name of participant)

Nkhugomezga kuti bapulikiska chilato cha kafukufuku uyu.

Signature: ________ Position: Student Researcher Date: 24/03/15

24 3 2015 22:05

7.8.2 General Questionnaire for eliciting responses on legume diversification technologies

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Eliciting the three constructs of attitudes, perceived norms and perceived behavioural control

The following questions are meant to list down your thoughts regarding intercropping/rotating maize and legumes in the next 2 years.

1. Behavioural Outcomes

(a) What do you believe are the advantages of intercropping/rotating maize and legumes in the next 2 years? (Think about a wide range of advantages, e.g. to your garden, to your household, to your livestock, to your body...etc).

(b) What are the various tasks that you undertake in a season to manage an intercrop or a rotation of maize and legumes?

(c) What do you believe are the disadvantages or challenges in intercropping/rotating maize and legumes? (Think about a wide range of disadvantages, e.g. to your garden, to your household, to your body...etc).

(d) Is there anything else you associate with regarding intercropping/rotating maize and legumes?

2. Normative referents

(a) When it comes to intercropping/rotating maize and legumes in the next 2 years, there may be some individuals or groups who would think you should or should not do these activities

(b) Please state any people or groups who would encourage you to intercrop/rotate maize and legumes in the next 2 years.

(c) Please list any groups who would discourage you to intercrop/rotate maize and legumes in the next 2 years.

(d) Please list any people who would discourage you from intercropping/rotating maize and legumes in the next 2 years (Think widely)

(e) Are there any groups who would discourage you from intercropping/rotating maize and legumes in the next 2 years?

(f) Sometimes, when we are not sure of what and how we are implementing activities regarding intercropping/rotation of maize and legumes, we check to see what our other farmers are doing. Please list the individuals or groups who are most likely to do intercropping/rotations of maize and legumes in the next 2 years.

(g) Please list the individuals who are least likely to do intercropping/rotating maize and legumes in the next 2 years.

(h) Is there anything else you associate with regarding other people’s views about intercropping maize and legumes?

3. Control factors

(a) What factors or circumstances would enable you to intercrop/rotate maize and legumes in the next two years? (Think widely....land, labour, marketability, other inputs...etc).

(b) What factors or circumstances would make it difficult or impossible for you to rotate or intercrop maize and legumes in the next two years? (Think widely....land, labour, marketability, other inputs...etc).

(c) Do you intend to grow maize intercropped/rotated with legumes in the next two years?

(d) Are there any other issues that you can think of regarding intercropping/rotating maize and legumes?

7.8.3 Some fieldwork photos

Farmer innovations with soybean

A soybean-tobacco intercrop

A soybean-sweet potato intercrop next to a maize plot