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What motivates farmers' adoption, upscaling and continuance with farming and harvesting edible insects in Western Kenya?

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List of Abbreviations

ATT	Attitude
BI	Behavioural Intentions
CONF	Confirmation
FAO	Food and Agriculture Organisation
ICIPE	International Centre of Insect Physiology and Ecology
JOOUST	Jaramogi Oginga Odinga University of Science and Technology
KN	Knowledge
PBC	Perceived Behavioural Control
PEU	Perceived ease of use
PU	Perceived usefulness
PV	Perceived value
RP	Risk perceptions
RT	Risk tolerance
SAT	Satisfaction
SN	Subjective norms
UN	United Nations
UNEP	United Nations Environment Programme

WTC	Willingness to continue

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Abstract

Insect as food and feed is a growing theme in the current dispensation. Recently, there has been a rise in the number of enterprises rearing insects *en masse*, most of which enjoy the advantages of scale efficiency. However, with the growing concerns of rapidly population growth, the unprecedented economic and environmental impacts of traditional sources of protein, and a realization of the importance of promoting circularity in production systems, efforts aimed at increasing public awareness of edible and animal-fed insects have erupted in recent years. As such, farmers have been brought onboard as important actors within insect's value chains. While most of the studies in the field of insects for food and feed have focused more on understanding and arousing consumer interests as well as on appraising emerging start-ups, this study, targeted small-scale farmers. Face-to-face survey questionnaires were administered to 358 farmers from Kakamega and Siaya Counties in Western Kenya with the goal of predicting their intentions to start, upscale and continue with insect farming and harvesting practices. Items therein were formulated from well-known theories of planned behaviour, technology acceptance model and expectation confirmation theory. The study established that more farmers were indeed willing to adopt or upscale current insect farming and harvesting practices and this willingness was predicted more by knowledge, perceived usefulness, attitude, and behavioural intentions. Perceived ease of use, perceived value, confirmation, and satisfaction antecedents were the most important predictors of willingness to continue. The study recommends continuous training and farmers' engagement by policy and technical institutions to develop these predictors.

CHAPTER ONE:

1.0 INTRODUCTION

Nascent studies exploring the topic of entomophagy, the practice of eating insects, have exploded in recent years and their results have ignited significant attention at the global arena. Delays in the appreciation of insects as potent sources of human food, as reported by Van Huis et al. (2013) and subsequent studies, is partly a result of misconceptions by consumers that insects are a nuisance to humans and are considered pests for crops and animals (Blank, 1984). Further, majority of consumer studies have also reported disgust attitude and food neophobia as the major factors derailing insects' consumption globally (Liu et al., 2020; Mancini et al., 2019; Sogari, Amato, et al., 2019; Sogari, Liu, et al., 2019; Sogari, Menozzi, Hartmann, et al., 2019; Sogari, Menozzi, & Mora, 2019; Tan, 2017). Nonetheless, recent, and ongoing studies aimed at exploring market environments of edible insects and related value chains have shown that insects indeed provide healthy foods with low associated externalities, thereby impacting positively on livelihoods through income while conserving the environment.

Results from various exploratory studies and field trials have shown that insects, although with varying differences within and between species, are highly nutritious and healthy sources of human food containing high fat, protein, vitamin, fibre, and mineral content. Furthermore, compared to conventional livestock, insects have reportedly shown higher feed conversion rates and can live in high densities on fewer feedstock (Meyer-Rochow et al., 2021) (van huis, 2010,2013), while at the same time emitting fewer greenhouse gases and ammonia (Oonincx et al., 2015). These properties indeed put them atop in the race for the best contender in the race for sustainable alternative proteins. However, these benefits have not yet coincided with the intended increases in the production and consumption of insects and insect products, and thus the need for concerted efforts by producers.

With surveys showing that about 2 billion people around the world consume 2000 species of insects regularly (Jongema, 2017; Van Huis, 2017), a surge in studies on consumer trends on edible insects has been witnessed since 2013 (Dagevos, 2021). However, these emerging trends and their resultant medial relevance are yet to spur full valorisation of insect farming for human food, majorly because most of these early studies have focused more on the consumer acceptance and mass industrial production, while neglecting the role of farmers who constitute majority of food producers worldwide.

Another development that is shaping the global dynamics in the demand and supply of insects relate to insect´s utility as alternative animal feed sources. Finding new cost-effective animal-derived alternatives has been cited to be key in supporting the ever-growing global human population (Hamid, 2021). The projected figure of 9 billion people by 2050 inevitably imply an increased food demand, particularly in the animal-based protein sector (Van Huis et al., 2013), consequently inflicting pressure on the current livestock, poultry, and fish feed supply. Studies have shown that over the next decade, the increases in income in developing countries is expected to catalyse further increases in meat consumption of close to 1.9% per year (Allegretti et al., 2018). Already, the demand from aquaculture is quite overwhelming, for instance. In 2008, it was reported that about 31.5 million tonnes of farmed fish and crustaceans, being 46.1% of total global aquaculture production, depended on the supply of external nutrient inputs from fresh, dried feed items, farm-made feeds, or commercially manufactured feeds. These include farmed insects. Further, A growth of close to 71 million tonnes of production was projected for the year 2020. Yet, aquaculture alone represents only 4% of global animal feed supply (Tacon et al., 2011). Therefore, insects presents an enormous opportunity for the sector especially if the current requisite average growth rate of 8 to 10 per cent per year up until 2025 is to be maintained (Tacon et al., 2011).

Africa, and more particularly the Sub-Sahara is in dire need of new food sources given the revelations of a recent United Nations (UN) population report, opining that the continent's population is expected to double by 2050 (Nations, 2019). African nations will therefore be forced to double their food production if only to keep pace with this population growth (Lartey, 2013). Nevertheless, this does not imply that the current food supply is sufficient to meet the demands of today's populations. The Food and Agriculture Organization in its latest African Regional Report on Food Security and Nutrition, indeed laments that today, 256 million Africans (239M in the sub-Saharan and 17M in Northern Africa), representing 20% of the continent's population, are undernourished. Further, population pressure in the continent has implied an intensive production system dominating the already fragmented land often characterised by low yields and limited technologies (Knapman et al., 2017). More specifically, for example, the achievement of Sustainable Development Goal number 2 on Zero Hunger is far from being a reality for Kenyans, the casing point for this study, as the country still grapples to quell food insecurity and malnourishment which affects millions of her population every day. At least one in every three Kenyans is food poor, representing 33% of the population (Mbatia, 2021).

These two realities combined, put African countries at a disadvantage, especially in view of supporting the burgeoning population with sufficient and sustainable food. As such, the search for an alternative production system that guarantees food for Africans with the least of human interests is of urgent need. Insects, in this respect, do provide the best option for Africa and significant number of studies have shown that on the account that they require less land, less water, and take up few energy resources, insect farming and production systems provide more sustainable pathways for the continent. However, only a handful of initiatives have been forged in response to this call.

It is recorded that close to 470 edible insect species are found in Africa (Kelemu et al., 2015) and of these, caterpillars, grasshoppers, beetles, and termites are the most common among African cuisines. Pest insects like fall army worms and locusts have also been reported to form part of human diets in the west, central, southern, and eastern Africa with the Mopane caterpillar featuring as one of the delicacies in Southern African countries like Zimbabwe and South Africa. In Kenya, insect consumption is not novel either. Since time immemorial, this practice has been engulfed within cultures and traditions of many communities and more particularly, those from the Western region, are famously known for this age-long practice. Mayflies, crickets, and grasshoppers have been used for centuries as food, animal feed, medicine, and for witchery. While these have been the options of these communities during times of abundance as occasioned by good climatic conditions and natural plagues like insect infestations, the current chorus vocalized by many proponents of entomophagy and insect-based feeds regards the food security benefit it accrues to most of the populations in this region, who are especially affected by challenges of undernutrition and hidden hunger. This theme has already attracted a significant amount of literature.

Already, studies investigating consumers' acceptance and subsequent experimental trials with farmers have been conducted in various parts of the country, with the Western region attracting most of these inquiries. The media has also been very crucial in disseminating information on insect-based technologies and as such, a huge demand for insect-based products among Kenyan consumers ought to have significantly surged. Inevitably, by the principles of economics, the supply side has been forced to respond to this call by investigating and implementing ways of meeting this increased demand. Industries and enterprises have been pioneers in this regard. However, in order to record the much-needed livelihood and development implications, farmers, who constitute majority of Kenyan population and food producers, need to be brought to the table. Case studies can be borrowed from the "Flying Food", "GREEINSECT and "INSFEED" projects which trained more than 2000 farmers between 2011 and 2016 on technologies that aim to make insect-based foods available throughout the year, at a reasonable price and in different forms (Pambo et al., 2016).

The result of these promotional efforts has been an emergence and multiplication of both insect-based enterprises and farmers involvement in insect farming and harvesting practices. However, it is unclear whether farmers' decisions to establish insect farms or indulge in harvesting techniques is profit-motivated or is seen a form of livelihood strategy or whether there are other hidden motivations driving their involvement in these practices. To unearth the real motive of farmers in adopting insect farming practices, this study targets the behavioural characteristics of farmers through the lenses of established theories of perceived behavioural control and technology acceptance model in modelling farmers' decisions to adopt insect farming and harvesting practices and then uses the expectation confirmation theory to model their decision to continue with these practices. Finally, to understand the adoption trajectory, the study seeks to investigate sustainability of insect farming beyond field trials and whether indeed farmers can initiate on their own, and sustain the practice of insect farming, by focusing on the challenges faced by farmers who choose to adopt insect farming practices, both ex-ante and post-ante.

Problem Statement

Insects are considered the fastest growing alternative protein sources in the world, especially in the European, North American, and Australian regions (Payne et al., 2019). In Africa however, the rate of adoption of insect farming technologies is still exceptionally low and activities related to the practice are still mostly limited to wild harvesting (Madau et al., 2020). While European and North American perspective on the adoption of insect as food and feed relates to insects being considered environmentally friendly and safer alternatives, in Africa and Asia, the concern is on the potential of insects to contribute to food and nutritional security, in addition to guaranteeing some level of household income (Ayieko et al., 2016; Diaz et al., 2021). These should inevitably inspire confidence both in practice and scholarship and indeed studies along these tangents have been exhausted, yet they have not ignited significant actions, both in policy and practice, on the appreciation of insects as one of the agricultural products (mini livestock) to be included in farm production systems.

Again, literature from the demand side have been conclusive, with a general positive attitude from the consumers towards insects being reported, in comparison to European and North American studies. Afterall, novel studies are already exploring technological innovations aimed at transforming insects into products acceptable and familiar to consumers, with the possibility of triggering further demands for insect-based food and feed products (Van Huis, 2020). Despite these, there still exist limited indications in literature on whether farmers can sustain production capacities needed to satisfy these demands in comparison to industrial enterprises. As such, insect value-chains as viewed from the farmers' perspectives would be of importance, with numerous studies emphasising farmers' critical role in supporting insect supply.

Meanwhile, to the best of my knowledge, studies from the producers side especially farmers are very scarce and this could explain low adoption rate of insect farming experienced in Africa since most of the primary food production in the continent are done by the farmers. In fact, farmers have been left out in most studies that evaluate insects' potential as food and feed within the continent. While this current study asserts that farmers play an especially significant role and that they are the ones with whom the decision to adopt insect farming rests, it is not yet established within the African continent as to which factors will motivate them towards adoption and most importantly, continuation with insect farming practices.

These realities are indeed omnipresent in Kenya, and more particularly in the Western region which forms the focus of this study. The region is ranked among the poorest with exceptionally low life expectancy, which has been compounded over years by prevalence of HIV-AIDS, Malaria among other maladies. It is also ranked among the regions most ravaged by nutrient deficiency with many cases of stunt children, in addition to annual highs in the rate of infant mortalities. Insects as new alternative protein sources have been fronted as having the potential to address most of these challenges with particular focus on alleviating nutritional and food insecurity. It is however unclear as to what incentives would drive farmers in this region into adopting these practices. The most promoted insect species for farming in the region are the cricket and black soldier fly (BSF) based on their high feed conversion and sufficient levels of nutrients fit for human and animal consumption. Other species that traditionally form part of culinary practices of the region's populace have also been promoted and specifically encouraged to be domesticated or reared in semi-domestic environments as part of livelihood options for farmers. Nevertheless, it is the farmers, as alluded to in the earlier, with whom the ultimate choice of farming insects rests thereby making them available to various consumers including insect mongers, other livestock farmers and animal feed producing companies as well as food processing companies.

It is estimated that there are close to 1000 black soldier fly larvae and cricket farms spread across East Africa (Tanga et al., 2021). Despite this growing numbers, the economic health and status of these farms is still subject to scientific scrutiny, and this begs the question as to whether indeed extant studies are ripe enough to present insect farms in Kenya as truly profitable and attractive ventures. Existing figures like the those presented in (Oloo et al., 2021) as well as willingness-to-pay studies by authors like (Chia et al., 2020) and (Halloran et al., 2020) do not supply full economic evaluation of these farms by omitting the cost element, something that the current study predicts to be among others, an influential factor in farmers' decisions and ability to adopt and sustain such new innovations.

Despite these, attempts by several authors to profile socioeconomic characteristics of these farms have indeed been made. For instance, Oloo et al. (2021) provide a review of what characterises cricket farmers in the Lake Victoria Region by illustrating their sociodemographic, economic and cultural characteristics. While their qualitative approach is something to behold, their study nevertheless does not predict whether these characteristics truly inspire behavioural instincts on the part of farmers to such an extent that they would be willing continue or quit their newly learned techniques in insect farming. These sentiments are in fact reflected by Olum et al. (2020) in their review where they highlight that most adoption studies tend to focus more on reporting socio-demographic characteristics as key factors in farmers' adoption decision pattern. However, a more expansive criteria is of urgency if we were to utterly understand farmers' decision patterns when choosing to adopt and sustain new practices. New study by Tanga et al. (2021) that maps insect ventures in East Africa only segments these farmers by gender, yet other factors like training experience, off-farm employment, and consumer sovereignty as well as individual characteristics like education level also play a role in adoption practices (Diaz et al., 2021). This study builds on these gaps and seeks to quantitatively evaluate in addition to socioeconomic, the behavioural and technological variables that influence farmers' motives to sustain insect farming techniques based on a modified theoretical framework. Beyond showing these factors, we also look to model how these factors interact with each other to trigger farmers' decisions and adoption behaviours by assessing the moderation and mediation effects.

This region, which includes former western and Nyanza provinces, is selected because of its rich history in entomophagy and the existing use of insects by farmers as animal feed based on favourable and existing animal husbandry practices. This is in addition to prior treatment of farmers in this region to insect farming technologies through JOOST and ICIPE, which are two key research institutions working to promote insect farming technologies in the region.

The study recognises the contributions made by these institutes and assumes based on recent literature that trained farmers have indeed adopted the practice of farming cricket and black soldier fly larvae as initially introduced to them by JOOUST and ICIPE, respectively. To model farmers' behaviours, the current study includes and extends beyond these treatment farmers and includes other farmers within the region. We look to understand whether initial treatments were successful in enabling small-scale farmers to set up sustainable and profitable insect holdings and as such, we perform a post-ante analysis of treatment effects. Key questions to be answered through this include whether farmers were willing to continue with the insect farming practices and what factors motivated their decisions.

It is nonetheless difficult to find in literature, the connection between farmers motives in their role of providing insects for food and feed and their ultimate decisions to adopt insect farming practice. This study therefore assumes that such triggers can either be of economic, psychologic, or social origin as grounded on behavioural and technology adoption theories. It is also certain that these relationships are too complex, needing a thorough enquiry.

To understand the overall impacts of introduction of these new farming practices in the region, we also study the extent of adoption by looking at general farmers who had no prior encounter with these two institutions. We expect the emergence of farmers who later got the skills through various means and started insect farms, and for them, we specifically evaluate their sources of inspiration to start and continue with these farm enterprises. We also explore the association between these farmers and those who earlier received training in a bid to analyse the extent of diffusion of insect farming technologies based on the diffusion of innovation theory (Rogers, 1963). For those who are yet to adopt the practice, we assess their willingness to adopt insect farming techniques. Ultimately, and considering the above approach, the study clusters insect farming adoption into three; the convinced adopters, the open-minded supporters and the reserved interested (von Veltheim and Heise, 2021).

Objectives and Research Questions

This study aims to determine the level of insect farming and harvesting practices acceptance in Kenya's western region. In particular, the study aims to comprehend the driving forces behind farmers' decisions to increase the scope of their insect operations as well as their willingness to include the practice of farming insects into their current farm operations. Again, it also seeks to assess the extent to which farmers are involved in wild harvesting of established edible insect species. While it will be interesting to explore whether farmers would be willing to substitute their normal operations with these novel practices, such an assessment is beyond the scope of this study and the existence of such association will only be reported in summary of our review of secondary information. Instead, our focus is on the existence of these farm operations in the study area and respective association of this existence or lack thereof to latent variables. We also aim to understand whether early adoption by pioneer farmers in this region has had substantial effect such that an adoption curve can be drawn. Along this tangent, we aim to characterise and distinguish among the early adopters, late adopters, and the non-adopters/ resistors. By relying on an established library of adoption literature and a modified joint theory of TAM, TPB and DIM, we aim to answer the following questions.

a) What factors determine farmers' willingness to adopt, upscale or continue with insect farming techniques?

b) Are there significant synergies among these factors in mediating or moderating main determinants of farmers’ decisions to adopt, upscale or eventually continue with insect farming techniques?

c) Are there significant variations in the adoption, upscaling, and continuation paths with respect to insect farming and harvesting techniques among different groups of farmers?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

By carefully reviewing the existing literature on the use of insects for food and feed and related acceptability, it is easy to understand why farmers would feel the need to start, upscale, and even continue with adoption practices regarding insect farming and harvesting. This chapter synthesizes the pertinent literature to increase theoretical understanding of insect farming and harvesting for food and feed and to identify any knowledge gaps. To connect knowledge of key concepts, a research model, and hypotheses, the chapter begins by summarizing and evaluating the body of prior research on insect farming and harvesting techniques.

Insects as food

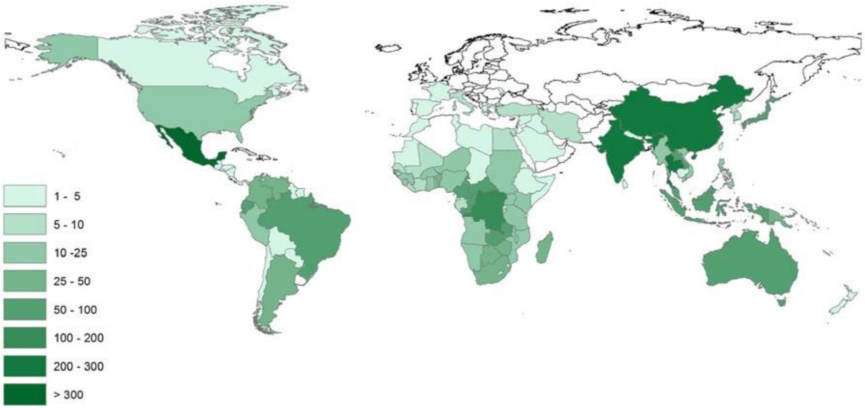
The case for use of insect as food has a very long history, probably dating back to the neolithic era where authors like (McGrew, 2014) and (Sanz et al., 2014) aver that there is sufficient archaeological evidence indicating that primates, including humans in their various evolutionary forms, crafted specific tools for gathering edible insects from their hideouts. Although such archaeological standpoint has many examples of ancient "anthropoentomophagy" (Sanz et al., 2014) to borrow, a look at 2 millennia ago is enough to discover that societies from Aristotle to Medieval Europe ingested insects (Seckman, 2021).

Modern-day scholars do converge in agreeing with these assertions. Early and ongoing inquiries on alternative and sustainable food sources have widely acknowledged the role of insects in yielding excellent sources of protein. Currently, with more than two thousand insect species identified as being edible (Ramos-Elorduy, Pino Moreno, & H., 2012; Ramos-Elorduy & Viejo Montesinos, 2007), entomophagy has exponentially elevated a series of insects up the gastronomic tables.

The FAO reports that today, people from 130 countries and 3071 different ethnic groups regularly eat insects. Nearly 5.4 billion of the planet's 7.8 billion people live in underdeveloped nations, and an estimated 2 billion of these people regularly consume insects, making entomophagy practices still a source of nutrient-rich food for modern humans (Costa-Neto & Dunkel, 2016).

The figure below demonstrates the number insects that are presently consumed globally (fig 2.1). With the bulk of its countries eating at least 100 different varieties, it is evident that Asia has the largest consumption. Comparatively, nations in North America, Europe, and the Commonwealth of Independent States consume fewer species. This supports the notion of the vast contemporary divide between Eastern and Western cultures regarding insect consumption.

Figure 1: Record of existing edible insects by country



Source: Based on data compiled by Jongema, (2015)

Insects such as crickets and locusts are now being consumed either as snacks or as a dietary whole meal routine in various forms. They can be boiled, dried, toasted, or fried and this practice has been deep-rooted among the people living in many parts of Asia, Africa, and Latin America (Melgar-Lalanne et al., 2019). This elevation has been compounded by observations made in many experimental studies that explore insects' nutritional and functional components, and these inquiries have indeed shed a great deal of light on the presence of valuable nutrients, micronutrients and energy elements in many insect species (Baigts-Allende et al., 2021). Thus, insects have been described in literature as possessing exceptionally high protein content, a perfect set of amino acids, omega 3 and 6, calcium, zinc, iron, and vitamins. Again, a considerable number of studies have established that their consumption is believed to have medicinal effects as some have been confirmed to alleviate inflammatory bowel diseases and strengthen immune system (Hunts et al., 2020)

Insects as animal feed and animal feed ingredient

The role of insects in promoting sustainable animal husbandry cannot go unnoticed. Insects are promoted globally as ingredients for animal feeds, with epistemological evidence linking beneficial aspects to aquaculture (Barroso et al., 2014; Magalhães et al., 2017; Makkar et al., 2014), poultry (Adli, 2021; Menozzi et al., 2021; Sogari et al., 2022), swine (Veldkamp & Vernooij, 2021) ,and ornamental and pet animals (AHMED et al., 2022; Hu, 2020; Van Huis, 2015). The existence of set industrial standards for the use of insect meal like pre-pupae *Hermetia illucens* (black soldier fly) in fish feeds among others have been reported in many studies, especially from Western nations. Furthermore, a congregation of European studies have also thoroughly established the basis for use of mealworms in a variety of domesticated animals (Basto et al., 2019; Duhra et al., 2021a, 2021b; Henry et al., 2018; Jeong et al., 2017; Miller & Redfern, 1988; Panini et al., 2017; Rios et al., 2021; Selaledi et al., 2021; Selaledi et al., 2020; Valipour et al., 2019; Yang, 2022; Yuan et al., 2022).

Overall, two important themes can be drawn from all these studies. On one camp, it is vivid that researchers seek to appraise insect-based feeds based on their nutritional and functional benefits as accrued to animals. On the other, we can see those with economic justifications, protesting costly animal feeds and this group presents insects as the cost-effective alternatives. Nonetheless, these set of viewpoints do converge at justifying the superiority of insects both in terms of their nutrient composition and net economic benefits for livestock farmers to the extent that they push for replacing traditional animal feeds with insect meals. For example, a report by the European Commission applauds the increase in insect meal production in the European Union and predicts that this production will be largely balanced by the anticipated loss in the EU's area under soybean and other oilseed crops (major ingredients in animal feeds). The analysis predicts that grain prices may consequently drop by 5% and soybean prices may drop by up to 11% (EC, 2020).

In practice, this replacement has not yet been actualized in accordance with the anticipated rate yet aquaculture has offered significant number of casing points. (Henry et al., 2015) laments that although fishmeal and black soldier fly are thought to have nutritional values that are similar, there hasn't been much success in replacing fishmeal with black soldier fly in aquafeeds. Their analysis predicts a maximum dietary fishmeal replacement level of 6 to 25%, depending on the fish species. Other studies have observed highest levels in rainbow trout, Oncorhynchus mykiss (Sealey et al., 2011). While a considerable number of studies, in response, have opted for supplementation rather than replacement, counter effects on growth performance have been noted on channel catfish, Ictalurus punctatus, rainbow trout, and turbot, Psetta maxima (Kroeckel et al., 2012; Newton et al., 2004; St-Hilaire et al., 2007).(Magalhães et al., 2017)

Consumer Acceptance of insect-based food and feed products

That today's consumers are a choicy lot is an obvious reality reported in all consumer studies. As humans, we are often conscious of what we eat. We have the advantage as omnivores of being flexible and adaptable to different diets. However, the shortcoming of this as explained in many studies, is a heightened risk of taking in toxic ingredients hence justifying people's resolve to seeking diversified and new foods as well as applying scrutiny before tasting novel foods (Haidt et al., 1997; Pliner & Hobden, 1992; Szendrő et al., 2020). The same principle is applied in human choices on feedstuffs they give their livestock.

Indeed, the preliminary stages of promoting insects' utility as food and feed were predominated with negative responses on the side of consumers. With the lack of cultural history in entomophagy and the negative thoughts of insects being painted as pests and pathogens delaying early developments, consumers' habits like product consciousness reflected in their tendencies to search for clues on how the food they consume is produced or to read labels in shelves to validate their purchase choices have persisted up to date and these behaviours have indeed triggered media attention.

In response, a flurry of promotional studies now dominate literature on insect as food and feed (Bazoche & Poret, 2021), most of which have identified that psychological constraints, like food neophobia (being cautious with new foods, especially those containing animal products), and socio-cultural barriers like taboos and lack of trust in the practice (Bazoche & Poret, 2021), tend to explain people's aversion towards insects as food and feed.

A food related emotion called "core disgust" has been defined in literature to further appraise the notion of food neophobia. This emotional response as explained by various authors (Hamerman, 2016; Ruby et al., 2015), has transitioned from enabling humans understand what to consume in the world around them to what to do in a society with cultural, social and moral norms. Typically, insects live and fly in big swarms, are harmful, and spread disease and dirt (Looy et al., 2014), and these are some of the "core disgust" triggers. Again, many insects live in garbage, such as worms and cockroaches and these realities in tandem with educational, cultural and social norms that tend to weave out "food taboo" do explain why many people, particularly from western countries qualify the idea of eating insects and animals fed on insects with disgust (Bazoche & Poret, 2016).

Studies have thus emphasized the need for public education. In fact, results from a survey conducted by PROteINSECT, show that consumers need more information on the potential use of insects as a protein source. However, the results suggest that people are more accepting of the idea of insects in food (PROteINSECT, 2015, 2016). But there is a clear desire for more information on this topic to be made available hence the need for continued public engagement to increase awareness (Bazoche & Poret, 2021; Fitches & Smith, 2018), something that is lacking in most literature that focus on developing world. Insect products can be consumed more widely by highlighting their sustainability, improving their flavour, and finding ways to hide them in commonplace products, among other tactics (Veldkamp et al., 2022).

While Westerners tend to be squeamish about insects and thus struggle to consider insects as one of their food sources , in most parts of Africa and Asia, the obverse is true. Yen (2015) describes the Asia Pacific region as having had a long history in the use of insects both as human food and as animal feed. In China where there are still 26 ethnic groups that are keeping the custom of eating insects in the multi-national area, it is documented that insects have been consumed since 3,200 years ago (Yi et al., 2010). The method adopted in continuing this practice includes wild harvesting of insects as food, insect farming, and the use of insects in small village level animal production systems involving fish or poultry. Nevertheless, barriers to widespread acceptance by consumers still exist in the form of the lack of baseline information on what is eaten, how diverse cultures use or used them, the reluctance to eat insects due to increasing Western influence and the globalisation of fast foods, health and safety issues, and legislative requirements.

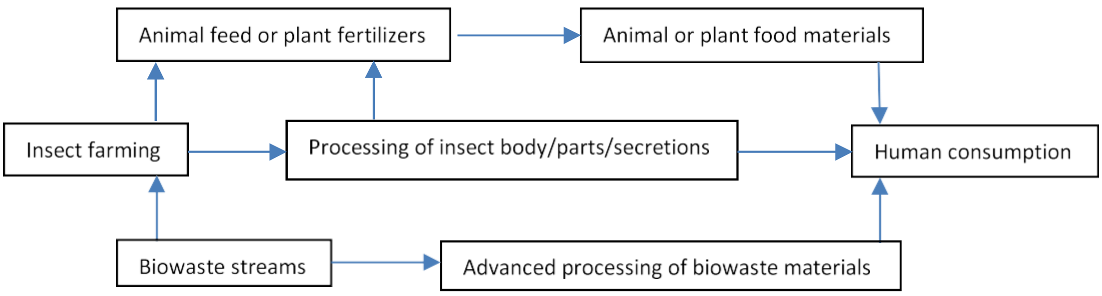
Markets and value chains for insects as food and feed

Market information for edible insects is both broad and specific in current literature. Mass rearing by large enterprises and their related value chains have been reported by scholars using specific start-ups as case studies (e.g. (Derrien & Boccuni, 2018; Thévenot et al., 2018)). Generally, insects for food and feed are a niche market in the EU with whole insects and processed products like cricket flour finding their ways in shelves of many market outlets (Drew & Pieterse, 2015; Halloran et al., 2017). Evidence from developing world is very scanty, with most literature

For small to medium scale farms, existing literature have cited local community markets, direct selling, wholesale supermarkets, minimarts, and the use of traders and other intermediaries as typical strategies used by farmers and harvesters to reach out to consumers (Halloran et al., 2017; Hanboonsong et al., 2013). More specifically, authors like Hanboonsong et al. (2013) are optimistic that there is still a significant domestic market for edible insects, and numerous distribution routes and business models, including transboundary trade among countries.

Value addition in edible insect industry is an ongoing development in most literature. However, it has been reported that cooking, frying, and freezing are the most basic ways that small-scale farmers can improve the quality and hence economic benefits from their enterprises. Large-scale companies have exploited opportunities in advanced processing where molecular and functional structures of insects have been explored for instance, extraction of specific proteins from insects. Sun-Waterhouse et al. (2016) summarises these value chains as shown below.

Figure 2: Insect for food and feed value chains



Source: (Sun-Waterhouse et al., 2016)

Environment benefits

Environmental benefits associated with insects are related to the notion of resource recovery, life cycle assessment, efficiency, and sustainability. These are themes that are widely discussed in circular economy literature and commentators therein are mainly concerned with ensuring that material products and inputs needed in economic systems are used up until their maximum economic lifespans have been exhausted. For those whose utilities may not have been fully optimized, it is argued in this school that these products ought to be brought back to their consumptive circle until a period when their maximum utility is reached.

Researchers who widely praise insets for their catalytical role in such a cyclic and recovery process, do argue that insects are poikilotherm and when produced in mass, have the capability of fully valorising organic wastes by feeding on them, thereby ensuring fewer wastes reach landfills, among other destinations. With growth in the consumption of animal products, this is set to increase and, as such, practical solutions are needed to facilitate significant reductions of this high-volume low value waste stream. For instance, with medium confidence, the United Nations Environment Programme (UNEP) in its recent Food Waste Report estimates that Kenya produces 5,217,367 tonnes of food wastes every year (UNEP, 2021) with the capital, Nairobi, creating around 1,900 tons of organic waste every day. Globally, about one-third of the total food produced is wasted (Sultana et al., 2021). This is suggested to be a huge opportunity for food scraps to be fed to insect larvae then dried and sold as animal feed (Ngila, 2021).

There is sufficient evidence in literature supporting organic waste reduction through insect rearing. It has been shown that dipteran larvae can reduce the volume of organic waste by up to 60% in just 10 days (Sheppard et al., 1994). The leftover material, also known as frass (which is composed of a mixture of excreta from living and dead insects and insect parts), can then be used to make compost, fertilizer, soil-improving materials, and as a substrate to produce biogas.

Such conceptualization of beneficial aspects of insects is more popular among researchers from the western world particularly due to scale-efficiency exhibited by the cases they investigate (Veldkamp et al., 2022). Nevertheless, their studies have shown empirically that reliance on insects as agents of waste valorisation is indeed common in the current dispensation, where governments and firms are espousing environmental protection, preservation, and awareness. Accordingly, insects inevitably are considered one of the best alternative food sources that demand less from the natural environment.

Other benefits to the environment include reduction of resource use and related externalities, especially in the form of emissions. A considerable number of studies have attempted to compare various animals used for meat production. These studies have found that insects cause significantly less emissions (only about 1% of emissions caused by ruminants) and require a lot less water (Daub & Gerhard, 2021; Oonincx et al., 2010; Van Huis et al., 2013).

The nexus between Food and Nutritional Security, and insect-based diets

According to the 1996 World Food Summit definition, “food security exists when all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life” (Rao, 1997). To do this, it is necessary to evaluate several distinct but related processes, including food availability, which refers to the provision of food in sufficient quantities for consumption, food access, which denotes that households should have the financial and physical resources required to obtain these foods, in addition to avoiding barriers related to custom and tradition, and food utilisation, which denotes the establishment of the capacity and resources required to use and store food in order to feed people. (Fanzo, 2012; Rao, 1997; Thomas, 2006).

Currently, there exists disparities in the statistics on global food security situation. Not all people have the physical and economic access or the ability to meet specific dietary needs as measured respectively by the number of people who go hungry and those who while can access food, are still undernourished. It is projected by FAO that 720 to 811 million people faced hunger in 2020 globally. The same report further establishes that over a half of malnourished people are found in Asia (418 million) and more than one-third in Africa (282 million). With the new projections, it is evident that unless key actions, particularly those targeting inequality in access, are taken towards accelerating the ongoing progress, it will be difficult to eradicate hunger by 2030. Already, the COVID-19 has exacerbated the discouraging pre-pandemic trends (FAO et al., 2021).

While a substantial reduction in hunger is projected for Asia by 2030 (from 418 million in 2020 to 300 million people), a significant increase is forecasted for Africa (from more than 280 to 300 million people), placing it by 2030, on par with Asia as the regions with the highest number of undernourished people. Globally, progress is being made for some forms of malnutrition, but the achievement of the targets set for any of the nutrition indicators by 2030 is something yet to be witnessed. The current rate of progress on child stunting, exclusive breastfeeding, and low birthweight is insufficient, and progress on child overweight, child wasting, anaemia in women of reproductive age, and adult obesity is either stalled or the situation is worsening (FAO et al., 2021).

Taking a closer look at Africa, majority of the estimated 800 million people who live in Sub Sahara (SSA) consist of the youngest cohort, characterised by a low life expectancy (below 50 years in many countries) and extremely high rates of maternal and child mortality. Income disparity is highly prevalent with increasing gaps between the richest and the poorest over the last decades delimiting which percentile is to be food secure and which one to be hungry. Again, as alluded to in the above paragraphs, the continent is reported to host some of the most nutritionally insecure people in the entire world and this has over the years been compounded by the prevalence of substandard infrastructure, limited resources, strife, HIV, and poor access to quality health care. Against the background of unprecedented population growth and the ramifications of climate change, the prospects of food security scenario in Africa are still vague. Amidst all the uncertainties, it is clear nonetheless how some trends are taking shape (Field et al., 2014; Giller, 2020). The prevalence of undernutrition in Africa rose from 17.6% of the population in 2014 to 19.1% in 2019, more than double the world average and the highest of all regions of the world (FAO et al., 2020).

It is a serious challenge accessing high-quality and nutritious food for many households in SSA. Most diets mainly consist of cereals or root staple crops with extremely limited animal protein, micronutrient-rich vegetables and fruits and quality diverse food basket. Because of either higher price, local unavailability, unequal distribution within household or even not being prioritised atop of competing demands on already meagre household income, these superior sources of micronutrients have failed to reach the tables of most African households. Therefore, meeting nutritional targets as highlighted in the SDGs necessitates that all households can always get adequate proteins, vitamins, carbohydrates, and minerals. Asides from the intake of food and related functional forms, such components as health and environmental factors including proper sanitation form part of the food security equation.

Improving nutrition and food security through sustainable agriculture is one of the targets of SDG 2. Evidently, an increase in food production as well as promotion of major advances in access to affordable and nutritious food, and education and behavioural change regarding diets would be desirable. Insect proteins have been praised in literature for their potential to reduce the level of malnutrition particularly in the most critical regions of the world where environmental stochasticity limit livelihood opportunities (Dickie et al., 2019).

Wild harvesting

According to Van Huis (2003), insects can be collected in many ways based on their behaviour, as influenced by environmental elements including temperature, their resting locations and responses to light. Glue derived from saps and latex of specific trees have been reported to be used in Indonesia, South Africa, Cameroon, and Central African Republic to collect dragonfly, cicadas, crickets, edible beetles and grasshoppers (Raheem et al., 2019; Van Huis, 2003). Capturing devices such as bow and arrow, traps made of clothes and other materials have also been used by communities from Asia and Africa to harvest crawling bugs, while for some like grasshoppers, the hand has always been the most efficient tool. Termites exhibit different hallmarks but overall, techniques for capturing them has always depended on the species. There are those that are captured using light-traps, others are known to be scooped from their hideouts though digging holes adjacent to their mounds.

Most importantly, the question of who is mandated to harvest insect necessitates a scrutiny of literature on gender roles. Basically, the answer to this as pointed out by (Van Huis, 2003), is that the importance of the catch determines whether it is collected by women, men, or children, or the entire community. When there is a large catch, as occasioned by events like plgues, the men or the entire community will also gather insects but typically it is the women's job to capture insects.

One of the major reported challenges of wild harvesting is excessive and uncontrolled insect harvesting practices (Sun-Waterhouse et al., 2016). Economic models for determining the maximum sustainable yield, which is key in efficient allocation, to the best of my knowledge, are either scarce or non-existent. It is also argued that establishing the safety of insect harvested is difficult and health concerns e.g., adverse/allergic reactions or poisoning, have attracted attention of proponents of established farming systems for edible insects. Furthermore, uncertainty in the supply of edible insects have been reported to result from natural factors (rainfall, climate change or even natural disasters), unpredictable human activities (urbanisation, overcollection, careless hazards like fires during gathering), or even direct competition between humans and wildlife for edible insects (Ghazoul, 2006). This is in addition to the logic that most species of edible insects are only present briefly (Figueirêdo et al., 2015; Yen et al., 2013).

Insect rearing

Most of the one million identified species of insects have never been reared, either because no one has tried or because attempts have failed. However, lessons have been borrowed from mass rearing systems in sericulture and apiculture (Maciel-Vergara & Ros, 2017). Ample food and housing must be provided, as well as entomological expertise and information for successful rearing operations (Eilenberg & van Loon, 2018).

In general, there are two different methods for producing edible insects: industrial rearing and insect farming. Industrial rearing, mostly dominating western-world literature, occurs under carefully monitored circumstances and according to established norms. Insect farming systems, which are more prevalent in the tropics, do not strictly manage production conditions (such as temperature), and rules and standards are less strict or do not exist in addition to the fact that technological investment is smaller, and automatization is nearly non-existent (van Huis (Van Huis et al., 2013).

Rearing techniques and structural requirements often defer depending on which insect is being reared. Insect farming, however, typically comprises of two main independent units: one for maintaining the breeding colonies in captivity and another for raising larvae from eggs (Halloran et al., 2018). An additional raising area is required if the farm specializes in mature insects, as is the case with cricket farms (Dossey et al., 2016). Advanced systems frequently have a section for processing insects and enhancing the resulting products. Furthermore, production by-products like frass and residual substrate can be used to make fertilizers, promoting circularity and sustainability in more specialized facilities (Cadinu et al., 2020).

For rearing, multileveled shelves of rearing boxes occupying the entire space for maximum production, stackable boxes or boxes set on moving pallets have been shown to be used (Dossey et al., 2016). The so-called farrow-to-wean areas, where adults breed and females lay their eggs, are necessary because it is in these areas that the larvae are routinely moved to the fattening region after hatching. A subset of the newly born larvae is kept in the farrow-to-wean area to be grown up to the adult stage to repopulate the breeding population. Within the breeding area, adults are kept in cages with access to food and water.

For non-flying insects, dividers are often retrofitted for maximum space use while for flying insects, closed cages are often recommended (Halloran et al., 2018). Sites for oviposition ought to be reduced to specific areas inside breeding cages for easier egg collection (Dossey et al., 2016). To prevent the insect meal's quality from declining and the potential threat this poses to the health of the animals they feed, farmers must set aside a space for storing and processing feed in accordance with established hygiene requirements (Committee, 2015).

Insect growth should be optimized depending on the species and stage of development under the ideal rearing conditions, which are defined by temperature and humidity suitability. According to several sources, typical ranges for temperature and humidity are 20–35 °C and 55%–75%, respectively [69,71]. It is advised that air must be cycled to prevent the buildup of CO2 and pathogens. The importance of these climate control techniques is highlighted by the fact that temperature changes of 2 to 3 °C have an impact on insect development, which impacts the expected results of insect rearing (Dossey et al., 2016).

Insect production requires a lot of labor; for example, adults must be fed, the dead and frass must be removed, oviposition must be monitored, eggs must be moved to rearing regions, and at the farrow-to-wean section, young adults must be released into the colony. A good proportion of substrates and water is needed for the fattening section, and larvae that have grown to the desired size are removed and processed (Dossey et al., 2016).

To manufacture insects, a variety of technologies can be used, including sun, freeze, microwave, smoke, and oven drying [112]. Other strategies, such as lowering lipid or chitin concentrations or obtaining derived products like oil and protein powders and pellets, are frequently employed to guarantee a better macronutrient ratio in the finished insect feed. As a result, risk management is made more effective (Committee, 2015).

The main challenge of rearing insects at high densities is proliferation of pathogens which, depending on various conditions, cause disease outbreaks (Eilenberg & van Loon, 2018). Carefully planning and controlling farming with optimized nutrition and living circumstances is a prerequisite procedure in current production of edible insects (Figueirêdo et al., 2015; Yen et al., 2013).

From a normative standpoint, consumer acceptance, lack of a multi-disciplinary approach to management, necessary to permit the inclusion of most if not all the factors involved in insect rearing, and a mismatch between processes requiring automation and those that need human labour have hampered the appetite and growth of insect farms worldwide. As a result, most insect farms, particularly the small to medium scale operations have been prone to heuristic trial-and-error procedures.

CHAPTER THREE

3.0 THEORETICAL FRAMEWORK

3.1 Overview

The evolution of theories has contributed to greater understanding of human behaviour especially when faced with complex decisions. Farmers, whose systems are complex, have offered exciting moments for considerable validation of several theories as supported by the necessary exploratory research. In this view, some key theoretical underpinnings in agricultural innovations most of which have stemmed from the classical diffusion of innovation theory (Rogers, 1963; Rogers, 2010) have over time been used to explore, predict and explain behavioural and cognitive antecedents of adoption, upscaling and continuance of innovative ideas and technologies, as opposed to reliance on rational logic.

The divergence from neoclassical economic models that viewed farmers as rational beings capable of making rational economic decisions, is a result of realisation that that pure economic models alone cannot capture the full complexity of farmers' motivation and behaviour (Austin et al., 1998). Such models as theory of reasoned action (TRA), theory of Planned Behaviour (AJZEN, 1980; Fishbein & Ajzen, 1977) and Technological Acceptance Model (TAM) (F. D. Davis, 1985) have for decades guided exploration of farmers' adoption and upscaling intentions, which form the basis of the first model used in this dissertation.

Using TPB, it is herein postulated that a farmer's intention to adopt insect farming innovations is decided based upon three factors – attitude, subjective norm and perceived behavioural control (Rogers, 1963), which are also driven by other higher order variables expounded upon in the next section.

Additionally, other variables key to adoption and upscaling can be borrowed from the information systems theories, most notably, (F. Davis, 1985) Technology Acceptance Model. This model postulates that people (farmers in this context) are more willing to use new technology when they perceive it to be relatively advantageous, less complex and easy to use, and rate high in "trialability" (Conrad et al., 2012). As such, perceived ease of use and perceived usefulness are herein used as antecedents of attitude which predicts behavioural intentions.

In addition to acceptance and upscaling, it is acknowledged herein that continuous use of a given technology or idea is often of paramount significance. This study adopts the Expectations Confirmation Theory, famously used in the Marketing field, to predict farmers' ex-ante and post-ante willingness to continue using insect farming practices. This forms the basis of the second model used in this dissertation. The following sections dissect these theories, outlining salient features of their key constructs while highlighting those constructs of relevance to the current study.

3.2 Theory of Planned Behaviour

In 1980, Theory of Reasoned Action (TRA) was renamed the Theory of Planned Behaviour (TPB). It was crafted to predict a person's intention to engage in a behaviour at a particular time and place. The theory's goal was to explain every action that a person can exercise self-control over. The most important aspect of this model is behavioural intent. Behavioural intents are impacted by attitudes regarding the likelihood that a behaviour will have the desired outcome as well as by a subjective assessment of the risks and advantages of that outcome.

In other words, human behaviour, as the theory postulates, is entirely under volitional control and predicts intention, which in turn is captured by attitude and subjective norm, to explain a given behaviour (Ajzen & Fishbein, 1975). The volitional control assumption in TRA was criticised by Ajzen (1991) who observed that not all human behaviour are completely under volitional control; some relies on external factors. It is upon this background that he proposed the theory of planned behaviour, which added more flavour to TRA.

According to the TPB, ability (behavioural control) and motivation (intention) are both necessary for behavioural achievement. It makes a distinction between three categories of beliefs: control, normative, and behavioural each of which form part of higher order constructs of the main constructs leading to intention. Six constructs make up the TPB, which represents a person's true control over the behaviour and ultimately are considered the weighted functions of behavioural intention.

As per the theory, the degree to which a person views the action of interest favourably or negatively is referred to as their attitude. It involves considering how the action will affect the results (LaMorte, 2019).

Behavioural intention relates to the driving forces behind a particular activity, where the more strongly one intends to engage in the conduct, the more probable it is that one will do so.

Subjective norms are the opinions of whether or not the majority of individuals are in agreement with the action. It has to do with how a person feels about whether peers and other significant individuals believe the conduct should be pursued.

Social norms are the accepted standards of conduct within a community or within a broader cultural setting. A group of people regard social norms as normative or standard.

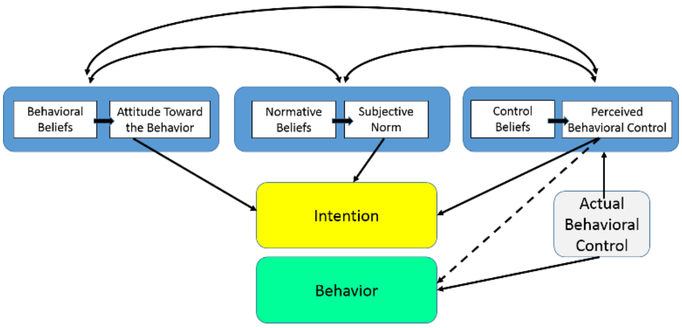
Perceived power is the perception of factors that could help or hinder an activity from being performed. A person's perception of behavioural control over each of those aspects is influenced by perceived power.

The term "perceived behavioural control" describes how someone feels about how easy or difficult it is to carry out the desired activity. Because perceived behavioural control differs between contexts and behaviours, a person's views of behavioural control change depending on the circumstance. The Theory of Reasoned Action gave way to the Theory of Planned Behaviour following the later addition of this theoretical construct. For this study, only the primary constructs; Attitude, Subjective Norms and Perceived Behavioural Control were used, with their respective higher order constructs' items being included in tandem with items of the primary constructs.

This new proposition indeed stimulated reactions from scholars and notably, (Taylor & Todd, 1995) criticised the model's monolithic structure of belief component. Instead of the unidimensional belief they constructed a multidimensional belief component in their proposed framework. Their main thesis was that the cognitive component of the belief structure is grounded in different ideas hence it should not be unified in a single conceptual unit.

Other issues have been pointed out by (LaMorte, 2019). First, he contends that regardless of intention, TPB is predicated on the assumption that the person has access to the resources and opportunities required to successfully engage in the desired behaviour. He also objects to the TPB's failure to take into account other elements that influence behavioural intention and motivation, such as fear, threat, mood, or prior experience. His third issue is that while normative impacts are taken into consideration, economic or environmental factors that might influence a person's intention to engage in a behaviour are still unaccounted for. Finally, he claims that it ignores the notion that behaviour can change over time and instead assumes that behaviour is the outcome of a linear decision-making process.

Figure 3: Original TPB Model



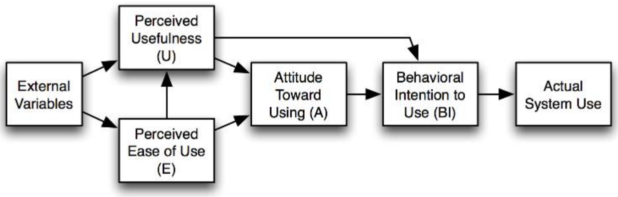
Source: (LaMorte, 2019)

Technology Acceptance Model

Technology Acceptance Model or TAM is another modification of TRA designed primarily to simulate users' acceptance of information systems or technologies (Merchant, 2007). According to the theory, two factors—perceived usefulness (PU) and perceived ease of use (PEU)—determine whether potential users will adopt a computer system (F. Davis, 1985). This model's emphasis on potential users' perceptions is its defining characteristic. In other words, even though a technological product's inventor may think the product is practical and user-friendly, potential users won't accept it until they also have the same opinions.

The theory has been widely used in practical testing of innovation across diverse fields and particularly, their acceptance among intended users, thereby enabling technology designers and implementors to evaluate such proposed innovations prior to deployment (Conrad et al., 2012). Initially, Davis included the Attitude construct as a mediator between PU and PEU and intention. However, both perceived usefulness and perceived ease of use were found to have a direct influence on behaviour intention, thereby obviating the need for the attitude construct (Venkatesh & Davis, 1996).

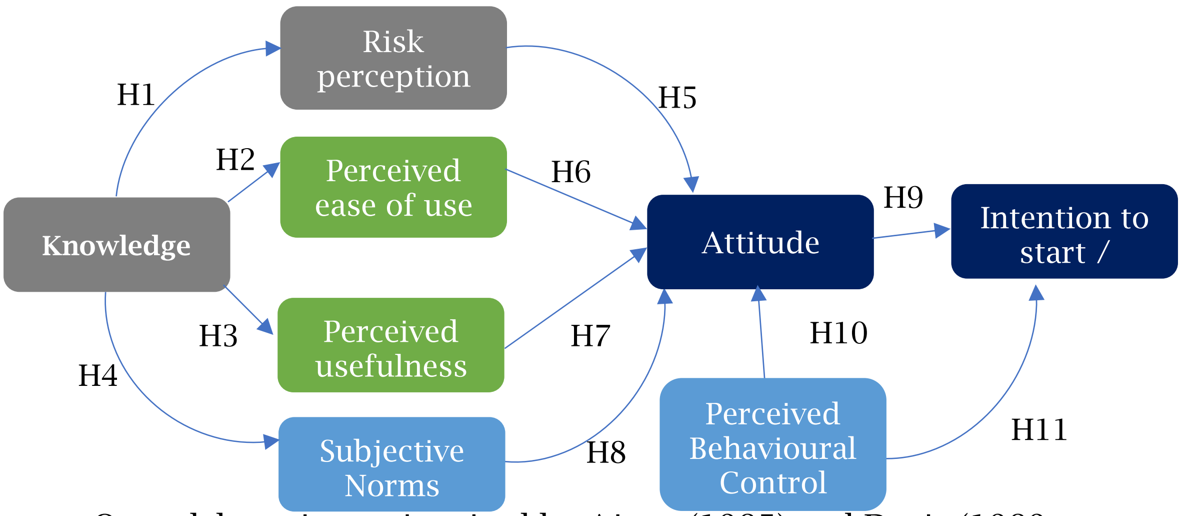
Figure 4: Original TAM Model



Source: Davis(1989)

This dissertation uses all the three main variables in tandem with the constructs accentuated in the preceding section to construct a more modified model which considering limitations mentioned above, includes economic and demographic variables to predict intentions. These are demonstrated in figure 3.3

Figure 5: Conceptual model of Behaviour Intentions



Source: Own elaboration as inspired by Ajzen (1985) and Davis (1989

Hypotheses Statements for BI paths

H1: Farmers that are more aware about issues relating to insect farming and harvesting methods have a better perception of the risks involved in the practices.

H2: It is easier for farmers who are more aware about issues relating to insect farming and harvesting methods to employ the technologies and tools required to embrace the practices.

H3: Farmers who are more aware about issues relating to insect farming and harvesting methods see the practices as being more useful to them.

H4: More knowledgeable farmers are easily swayed by the pro-adoption sentiments from networks and people who are significant to them.

H5: Farmers' attitudes about rearing and harvesting insects are negatively impacted by their perception of the risks associated with the techniques.

H6: Farmers are more likely to adopt and scale up insect farming and harvesting practices if the technologies and tools required for effective operations are simple to use.

H7: Farmers that think insect farming and harvesting techniques are beneficial have a favourable attitude toward the techniques.

H8: A positive approval by networks and people who are important to farmers induces a positive attitude by farmers towards farming and harvesting insects for food and feed

H9: Farmers' intentions to embrace and advance insect farming and harvesting practices are greatly influenced by their positive attitudes toward farming and harvesting insects for food and feed.

H10: Farmers' ability to manage their desire to begin and advance insect farming and harvesting techniques suggests that they have a more favourable attitude on the intended practices.

H11: The ability of farmers to manage their commitment to begin and advance insect farming and harvesting operations strongly suggests their behavioural intentions.

Expectation confirmation Theory

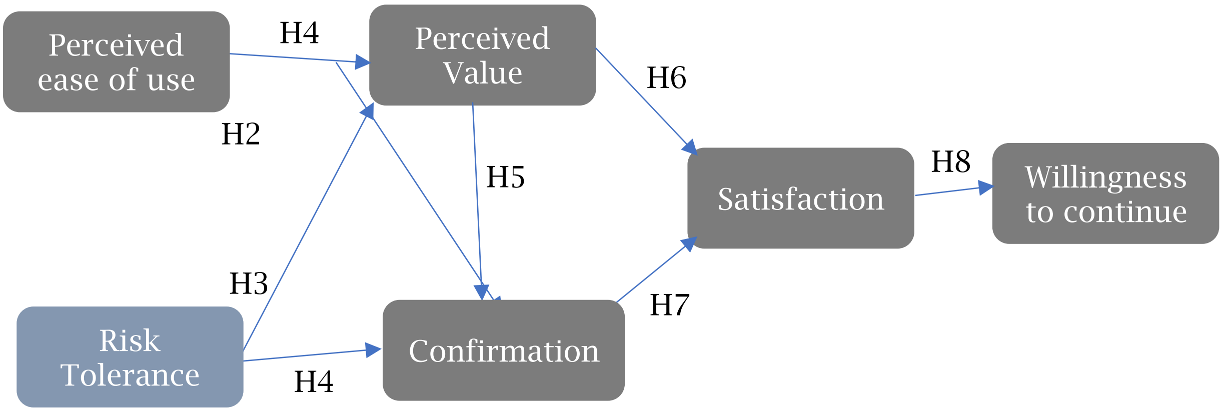
This theory originates from marketing literature although it uses constructs borrowed from behavioural and social sciences. The theory postulates that before making a purchase, buyers are thought to establish expectations about a product's performance characteristics. (Oliver & DeSarbo, 1988).

Initial findings by Oliver (1980a), the author of the theory, suggest that expectation-related effects and perceptions of disconfirmation actually work together. Expectations, as he posits, are specifically believed to establish a framework for comparison when making judgments. A better-than, worse-than heuristic is used by buyers to compare actual performance levels to anticipation levels based on subsequent purchases and usage. In this way, he concludes that results that are worse than expected (a negative disconfirmation) are rated below this base, and results that are better than expected (a positive disconfirmation) are rated above it (Oliver, 1993). Therefore, satisfaction can be viewed as an additive effect of the level of expectation and the consequent disconfirmation. Precisely, a customer's satisfaction with their purchase and their eventually propensity to make additional purchases will depend on whether a product or service met or exceeded their initial expectations (Michalco et al., 2015; Oliver, 1999). As such, if people have unreasonable expectations, they may be disappointed after utilizing the technology, which may cause them to mistrust and reject it

(Lankton et al., 2014; Oliver, 1999).

This dissertation uses this framework to model willingness of farmers to continue with insect farming practices, having opted to adopt. In contrast to Oliver's proposed disconfirmation construct, the study confirmation in addition to Risk Tolerance as external variable and demographic (training) and economic (Farm Business Environment) as moderating variables. The final model is presented in figure 3.4.

Figure 6: Conceptual Model of Willingness to continue



Source: Own elaboration based on it (Oliver, 1993)

Hypotheses Statements for WTC paths

H1: Farmers' positive perceptions of how simple it is to use the equipment and tools needed for insect farming and harvesting operations indicate that they value the practices.

H2: Farmers are more likely to confirm pre-adoption projected results if they can employ the technologies and tools necessary for insect farming and harvesting methods with ease.

H3: Farmers value raising and harvesting insects if they can tolerate pressure in the face of risks.

H4: When adopting insect farming and harvesting practices, farmers' approval of anticipated results is positively correlated with how risk-averse they are.

H5: A favourable assessment of the value of insect farming and harvesting techniques implies confirmation of the anticipated results.

H6: A favourable assessment of the value of insect farming and harvesting methods by farmers denotes satisfaction with the current practices.

H7: Farmers who confirm the predicted results are happy with the methods they have employed in farming and harvesting insects.

H8: The farmers' desire to keep using the same techniques for insect farming and harvesting increases as their satisfaction with the results of those techniques increases.

CHAPTER FOUR

4.0 RESEARCH METHODOLOGY

Overview

This chapter outlines the methods and tools used in this dissertation. The first four sections entail a detailed discussion of the research methodology employed, the research processes designed to achieve the main objective, and the methods used to collect the data. These are followed by an outlook of data analysis approaches (i.e., SEM, partial least squares), and the statistical analysis techniques used to assess reliability and validity of the research models, and the significance of measured items that aid in confirming or rejecting the set hypotheses. In its concluding section, the chapter highlights the stages involved in the development of the research instrument, along with statistical analyses conducted on the demographic and items data.

Research methodology

This dissertation adopts a quantitative research method, an approach that consist of two common research methodologies. These as (Creswell, 2009) outlines, include survey research and experimental research. According to Malhorta & Grover (1998), a survey methodology is popular among researchers whose goals are to develop standardized information that describe variables and examine relationships among those variables. These procedural and analytical approaches indeed coincide with the objectives of this dissertation. A keen attention is dedicated to data collection, data analysis, and testing key relationships between the constructs as modelled in the previous chapter.

Research Processes

The approach used by the researcher in this dissertation was guided by the appraisal of research problem upon reviewing pertinent literature on adoption and continuation intention studies. This review confirms that indeed it is urgently necessary to have a deeper understanding of the factors that influence a farmer's decision to start, upscale, and continue with insect farming and harvesting practices.

The measurement scales obtained from previous research were used to build the requisite instrument in this dissertation. To ensure that items really fit within the context of the current research, necessary alterations were done. Data from a preliminary pre-test study conducted before the actual survey were used to assess the validity and reliability of these instruments which enabled enable further development of the instrument.

Farmers were sampled through random and snow-bowl sampling methods to participate in face-to-face survey. PLS, a structural equation modeling (SEM) approach was then used to analyse the test data. Finally, an interpretation and documentation of the findings were made.

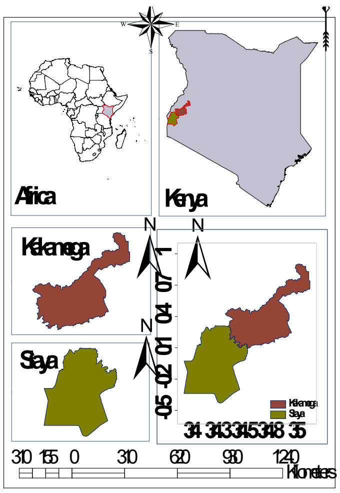
The study area

The research was conducted in Western Kenya, more specifically in Siaya and Kakamega Counties. The two counties boarder each other with Kakamega, sitting geographically atop of Siaya County and stretching towards the north-east direction. Combined, these two counties border Kisumu, Vihiga and Uasin-Gishu Counties to the east, Busia and Bungoma to the West, and Lake Victoria to the south.

Siaya County lies between latitude 0˚ 26' to 0˚ 18' north and longitude 33˚ 58' east and 34˚ 33' west. The county's population is approximately 941,724 with predominantly youthful population (Ouko et al., 2019). Agriculture and fishing are the main economic activities. Crop farming is the major land-based agricultural practice with maize, beans, sorghum sweet potatoes among others finding their ways in the menus of food and cash crops valued within the county. Cattle and poultry are also raised as alternative income and livelihood strategy by residents. In terms of economic opportunities, family agricultural holdings account for 44% of employment in the county. Lake Victoria supports the vibrant fishing industry. Siaya County's Gini index, an important measure for shared prosperity, is 0.405 signifying a balanced wealth distribution.

About 30 km are north of the equator is the county of Kakamega. The predominant economic activities are farming and fishing, and the climate is tropical with frequent periods of heavy rainfall. With a total area of 3,050.3 km2 and a population of 1,812,330, Kakamega County is the third largest County in Kenya. It is primarily a rural area.

Figure 7: Study area



Source: Own elaboration

Data Collection Techniques

The following subsections discuss sampling and data collection on farmers' willingness to adopt, upscale and continue with insect farming and harvesting techniques. To test the hypothesized relationships, both quantitative and demographic data were collected from Western Kenyan farmers.

Sampling

For this dissertation, only farmers hailing from the study area were eligible to take part in the survey. The reason for this being that the main objective of this study is to understand the drivers of adoption, upscaling, and continuation intention among farmers in the Western Region of Kenya. The preferred counties for collecting data were Kakamega and Siaya based on the historical establishment of insect farming and harvesting culture within these two counties. Participants of the study were divided into three based on the intended multi-group analysis that the study aimed to conduct.

The first group included farmers with insect farming experience where the study skewed towards assessing their willingness to upscale their current or stalled adoption activities in addition to assessing their motivation to continue. The second group consisted of farmers whose interest in insect practices relates to wild harvesting. Similar objectives were aimed at this group. The final group consisted of farmers with no experience in any of the insect farming or harvesting techniques and by dissecting factors that would guide their decisions, the study took keen interest on assessing their willingness to start insect farming or harvesting practices.

Inexperienced farmers were randomly sampled while for those with wild-harvesting experience, the researcher employed snow-ball sampling upon randomly selecting farmers from within the study area. Snow-ball sampling was also employed on those with farming experience upon obtaining training participants lists from Jaramogi Oginga Odinga University of Science and Technology and ICIPE.

Face-to-face survey Questionnaires

Following (Converse & Presser, 1986) advice, this dissertation recognises that any survey must be designed to fit within its intended research purpose. The main aim of this study was to identify the most important determinants of farmer's behavioural intentions to start, upscale and continue with insect farming and harvesting practices. As such, the use of survey questionnaire is believed to be key in addressing this objective.

While online surveys have gained popularity in recent years (Evans & Mathur, 2005; Ilieva et al., 2002; Vehovar & Manfreda, 2008), this study adopted a face-to-face survey, based on three major reasons; first, the demographic profile of the intended respondents both in terms of their literacy level and inability of majority to afford mobile phones or other gadgets with internet capability inhibited the use of online survey. Second, as an exploratory study with specific interest in the two counties, it demanded the researcher to ensure that respondents were true residents of these counties and thus a field survey would efficiently verify such an assertion. Thirdly, by exploring two models i.e., behavioural intentions and willingness to continue, the survey inevitably contained considerably many measurement items. This was indeed necessary to fulfil the intended goal of discerning scores for the two models described in the previous chapter. Therefore, to ensure a higher response rate, a face-to-face interview was indeed necessary.

Responses stored using Kobo Collect Toolkit©, based on its ability to capture data in areas where internet accessibility is limited. Enumerated data were then extracted from the toolkit for analysis.

Measures

To create its measurement items, this study adapts previously verified constructs. Reusing already validated instruments when employing survey methodologies has received praise from many studies, most notably Straub (1989). These supporters assert that the primary benefit of this approach is that the measures' reliability and validity testing was already completed by earlier researchers, giving the current researcher confidence in the measurement properties of the existing measures without the need to evaluate the measures (Bryman and Bell, 2007). Again, when a construct is tested and validated using a range of samples in various contexts across time, it is easier to determine its homological validity (Straub et al., 2004). Nevertheless, as a crucial component of the model analysis, the researcher carried out a reliability and validity test.

Data Analysis

Structural Equation Modelling (SEM)

Structural equation modeling (SEM), a class of multivariate statistical analyses, allows for the examination of a set of relationships between one or more independent latent variables (IVs), which may be continuous or discrete, and one or more dependent latent variables (DVs), also which may be continuous or discrete. (Gefen et al., 2000; PM, 2003; Ullman & Bentler, 2003). In SEM, several analyses such as regression analysis, factor analysis, path analysis, canonical correlation analysis, and growth curve modeling are conducted simultaneously.

Due to this property, C. Fornell and F. L. Bookstein (1982) call SEM the "second generation of multivariate analysis" because it combines two simpler analyses: principal component analysis (PCA), which generates numerical proxies for theoretical concepts, and multiple linear regression analysis, which establishes the relationships between those proxies. SEM therefore incorporates methods from econometrics, psychometrics, and general statistics (Bollen & Long, 1993).

Herein, as (JF Hair Jr et al., 2021) put it, the goal of the regression analysis is to test these theories and concepts. However, they further suggest that the technique can also be used to explore whether additional independent variables that prove valuable for extending the concept being evaluated, significantly affects the original mode.

Again, when used properly, SEM outperforms the first generation of analysis approaches by giving researchers the flexibility to evaluate how theory and data interact (Chin, 1998a). However, (Hair Jr, Hult, Ringle, Sarstedt, et al., 2021) guide that five elements have to be given due consideration in settling for SEM usage in research: (1) composite variables, (2) measurement, (3) measurement scales, (4) coding, and (5) data distributions .

Generally, SEM allows researchers to assess the overall fit of a model and to test the structural model all together (Chin, 1998b; Gefen et al., 2000). It evaluates the hypothesized structural linkages among constructs and the linkages that exist between a construct and its respective measures. While relationships among constructs are believed to feed into the substantial theory, the relationships between a collection of individual items and their respective constructs as elaborated by (Henseler, 2020) feed into auxiliary theories.

SEM has been found to give researchers the ability to: (1) model relationships between multiple predictors and criterion variables; (2) create unobservable latent variables; (3) model measurement errors for observed variables; and (4) statistically test a priori theoretical and measurement assumptions against empirical data (Chin, 1998a)Many of the constricting underlying assumptions of maximum likelihood techniques are avoided by the PLS approach, which also guards against inappropriate solution and factor indeterminacy. (C. Fornell & F. Bookstein, 1982; JF Hair Jr et al., 2021).

CB-SEM versus PLS-SEM

The manner that each approach handles the latent variables contained in the model is a key conceptual distinction between PLS-SEM and CB-SEM. The constructs are taken into account by CB-SEM as common factors explaining the covariation between its associated metrics. In order to estimate the model parameters, the scores of these common components are neither known nor required. The constructs of interest are represented by proxies in PLS-SEM, which are weighted composites of indicator variables for a specific construct. As a result, PLSSEM is a composite-based approach to SEM that relaxes CB-strict SEM's presumption that every covariation across sets of indicators is explained by a single factor. (cf. Henseler et al., 2014; Rigdon, 2012, 2014).

The advantages and disadvantages of PLS-SEM have long been subjects of heated debates in many disciplines since the development of PLS-SEM by Herman Wold (Boardman et al., 1981) and covariance-based SEM (CB-SEM) by Karl G. (Jöreskog & Sörbom, 1982). The fact that composite-based PLS-SEM and factor-based CB-SEM were created as complementary, but distinct statistical methods with unique goals and needs, however, is one obvious point of convergence among current researchers (Sarstedt et al., 2014). As such, it is imperative that a researcher comprehends the assumptions in both methods prior to choosing which methods to employ. To guide such determination, researchers may opt for CB-SEM or PLS-SEM by looking at factors like the research objective, types of measurement model specification, the modelling of structural model, data characteristics and model evaluation (Hair et al., 2011). In the modest approach, Hair et al. (2012), point out several rules of thumb that can be used as guides.

CB-SEM is effective when used when the study's main aim to test or confirm a theory. The rationale for this is that testing a theory necessitates the ability of researcher to show how well a theoretical model fits the observed data (Hair et al., 2021a). According to Gefen et al. (2011), the force of CB-SEM is felt more when modelling theories whose objectives are to minimize respective covariance matrices. On the obverse, PLS-SEM is most suitable when research aims at predicting and developing new explanations of a theory. Here, the model focuses on discerning the best prediction of relationships among latent variables and on amplifying covariance between latent variables to increase the model interpretation (Hair et al., 2021b).

Furthermore, while CB-SEM is applicable to inquiries that model only reflective constructs (although past studies have employed formative measures within the structural model), inclusion of formatively measured construct often lead to identification problems (Henseler et al., 2009). Chin (1998b) highlights how employing formative constructs within CB-SEM might lead to a situation where it would be unable to explain the covariance of all indicators. Conversely, a study model that includes both formative and reflective constructs can be analysed using PLS-SEM (Chin, 1998b). As a result, PLS gives researchers the option of using either reflective, formative, or a combination of both reflective and formative constructs.

Finally, CB-SEM requires a normally distributed data and large sample size something that is robustly overlooked in PLS-SEM thanks to its standardization mechanisms, which transform any non-normal data into data that adheres to the central limit theorem ((J. Hair et al., 2013).

Partial Least Square (PLS)

As mentioned in the previous section, PLS-SEM combines application of psychometric and econometric approaches. Partial Least Square (PLS) by nature of its origin (pioneered by Herman Wold, an econometrician in the 1970s) (Boardman et al., 1981; JF Hair Jr et al., 2021) is the engine within PLS-SEM that applies econometric procedures in the algorithmic apportioning of scores for the latent variables. Wold developed the method for use in the analysis of high dimensional data in a low-structure environment and over years, it has undergone various extensions and refurbishments. Nevertheless, PLS basically includes alternating least squares algorithms, which extend principal component and canonical correlation analysis (Henseler et al., 2009).

Usually, the PLS path models tend to simulate two sets of linear equations; the measurement model and the structural model (Henseler et al., 2009). The former is also referred to as the outer model and it specifies the relationships between latent variables, whereas the latter, also known as the inner model, specifies the relationships between an unobserved variable and its related manifest variables (Gorai et al., 2015; J. Hair et al., 2013; Leguina, 2015).

According to (Henseler et al., 2009), within this structure, PLS algorithm is seen as iteration of sequences of regressions that produce weight vectors. The basic algorithm of PLS involves the following three stages:

Table 1: PLS Algorithm components

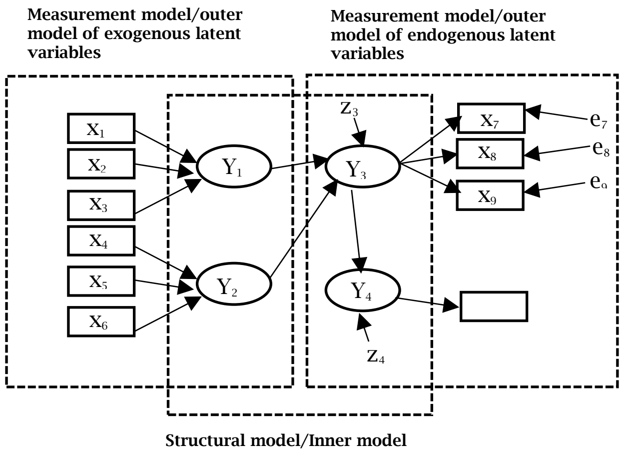
Stage	Main component of the algorithm
Stage one:	Latent variable scores are estimated iteratively using a four-step process that is repeated until convergence is achieved: Outer approximation of the latent variable scores, inner approximation of the latent variable scores, estimation of the inner weights, and estimation of the outer weights are all examples.
Stage two:	Estimation of outer weights/loading and path coefficients.
Stage three:	Estimation of location parameters.

As (Henseler et al., 2009) note, PLS in its use has attracted researchers from a variety of disciplines including among others, strategic management, management information systems, e-business, organizational behaviour, marketing, and consumer behaviour. In their review, the authors observe that the PLS-SEM approach as a more robust estimation of the structural model. PLS-SEM is also viewed as an alternative method when CB-SEM distributional assumptions cannot be met (Hair Jr, Hult, Ringle, Sarstedt, et al., 2021; Mohamed et al., 2017a; Sarstedt et al., 2014). However,

This dissertation, in its analytical approach, applied Partial least square path modeling in discerning important constructs impacting behavioural and continuation intentions. It must be noted here that the study does not aim at confirming at theory. Rather, efforts are geared towards predicting behavioural and continuation intentions. With the merger of TAM and PBC theoretical constructs and introduction of RP and KN into the mix, it is interesting to understand how the causal relationships come into play in predicting intentions in the first model. Again, additional constructs (Risk Tolerance) in the CI model exhibit similar hallmarks. Such large complex models with many latent variables are better assessed using PLS-SEM (JF Hair Jr et al., 2021). The relations examined herein are based on prior theoretical knowledge. PLS-SEM can estimate the correlations between residuals and assess their effects on the model.

Recall that path models are developed based on theory (a set of systematically related hypotheses developed following scientific method that can explain and predict outcomes). Thus, hypotheses are individual conjectures, whereas theories are multiple hypotheses that are logically linked together and can be tested empirically. In PLS-SEM, two types of theory are necessary to develop path models: measurement theory and structural theory. The latter specifies how the constructs are related to each other in the structural model, while measurement theory specifies how each construct is measured (Hair et al., 2021b). These are illustrated in figure 6 below:

Figure 8: Measurement and Structural



Source: Modified from Hair et al. (2021b)

This dissertation follows along these tangents to assess and validate the models by first evaluating the measurement model and then the structural model. Ultimately, model validation enables a researcher to determine whether both the measurement and the structural model meet the quality criteria for empirical research (Urbach & Ahlemann, 2010). This dissertation employs the guidelines depicted in the following sections in assessing both measurement and structural models.

Measurement Model

Three quality criteria must be used to first validate reflectively measured constructs. This should be grounded upon prior studies. They include examining construct's internal consistency, indicator reliability, convergent validity, and discriminant validity (J. Hair et al., 2013).

Internal Consistency

Cronbach's alpha has always been the go-to parameter used by researchers in assessing internal consistency. The criterion follows that constructs with high alpha values denotes the items within the construct have the same range and meaning (Davadas & Lay, 2017). Therefore, this criterion yields an estimate for the reliability based on indicator inter-correlations.

As Tavakol and Dennick (2011) note, improper use of alpha can lead to either a test or scale being wrongly discarded or the test being criticised for not generating trustworthy results. Understanding of the associated concepts of internal consistency, homogeneity or unidimensionality can help to improve the use of alpha, more so the threshold and tolerable values. As such, it would be considered extremely satisfactory when the internal consistency reliability value is at least 0.6 in the early stage, and above 0.8 or 0.9 in more advanced stages of research. Value below 0.6 indicate a lack of reliability (Nunnally and Bernstein, 1994).

Nevertheless, sometimes Cronbach's alpha may underestimate the internal consistency as a reliability measure. Another measure given in PLS-SEM to augment the assessment of internal consistency is composite reliability (Chin, 1998b) where the threshold stands at 0.70. Composite reliability assumes that indicators have different loadings.

Indicator Reliability

To evaluate how a variable or a set of variables is consistent with what it intends to measure, indicators' reliability is determined. This measure has a distinct calculation for each construct. At least indicator loadings of 0.7 is desirable at 0.05 confidence level (Chin, 1998b) but generally as opined in other studies any loadings greater than 0.5 would yield better results (Truong & McColl, 2011). According to Hair et al., (2010), (J. Hair et al., 2013)factor loading estimates should be between 0.5 and 0.7.

Bootstrapping procedure within PLS is a resampling method that checks significance of indicator loading. Only when the indicator's reliability is poor and removal leads in a significant improvement in composite reliability can it be eliminated (Henseler et al., 2009).

Convergent Validity

Convergence validity in leman terms simply measures how well indicators converge in explaining a specific indicator in comparison to all other indicators (Hair et al., 2021b). It is assessed using the value of average variance extracted (AVE) which is arrived at summing the square of all factor loadings of all indicators and then dividing by the number of indicators. The threshold is at least 0.5 (C. Fornell & F. L. Bookstein, 1982).

Discriminant Validity

To differentiate one construct's measures from another, discriminant analysis comes in handy. It measures the degree of difference between overlapping constructs (GOELTOM et al., 2020) and what makes it different from convergent validity is that it tests whether the items unintentionally measure something else besides the intended construct. Fornell-Larcker criterion

(Fornell & Larcker, 1981), cross loading (Chin, 1998b), and heterotrait-monotrait ratio are the three measures of discriminant validity provided by PLS-SEM (Chin, 1998a, 1998b).

The Fornell-Larcker criterion requires that a latent variable share more variance with its indicators more than any other latent variable. It does so by comparing square root of the AVE with the correlation of latent constructs (Munaro et al., 2020). Square root of each construct's AVE should exceed the correlations with other latent constructs (J. Hair et al., 2013).

The component scores of each latent variable are correlated with the scores of all other items to determine cross-loading. It can be assumed that the different constructs' indicators are not interchangeable if each indicator's loading is higher for its designated construct compared to any other constructs (Chin, 1998b).

Structural Model

The structural model should be examined only after the measurement model has been successfully validated (Mohamed et al., 2017b). Validating the structural model enables an accurate assessment of measures that supports or rejects hypotheses modelled by the SEM, based on the test data. Coefficient of determination (R^2) and path coefficients (regression weights) are the key measures requisite for the structural model analysis in PLS-SEM path.

The R^2 measures the relationship of a latent variable's explained variance to its total variance. Chin (1998b) prescribes that a value of R2 around 0.67 is substantial, around 0.333 are average, and of 0.19 and below are weak. On the other hand, the path coefficient value makes predictions about the strength of the association between two latent variables. We can rank the relative statistical significance of various path coefficients based on their weight. Researchers should look at the path coefficients, algebraic sign, magnitude, and significance when determining this type of link. To account for a specific impact within the model and to be significant at the 0.05 level of significance, path coefficients must be more than 0.1. (Huber et al., 2007; Vollhardt, 2007)

Moderation Relationships

When the effect of one variable on another is affected by a third variable, the third variable is termed as a moderator variable (Cohen et al., 2014). Such an effect is sometimes referred to as interaction in literature. A moderator can either be categorical or continuous variable affecting the direction and/or strength of the relationship between dependent and independent variables (Cohen et al., 2014). Researchers can account for variables and subpopulation heterogeneity by analysing interaction effects (Memon et al., 2019)

Multi-group analysis

While SEM models tend to estimate paths for independent-dependent variables relationships, it is important to understand that such relationships are not always homogeneous across the entire test data. The data, by virtue of responses from sampled population, consist of respondents with heterogenous traits. As such, it is always of great interest for the researcher to understand whether significance of measures would arise from the entire test data, or they are just augmented within a specific group in preference to others. In SEM research, such analysis is termed as a multi-group analysis and its goal is to understand whether there exist significant differences in the structural and measurement model assessment results in assessed unique groups.

This analysis compares group-specific effects using pre-determined categorical variables believed to affect the relationship between a predictor variable and a criterion variable in terms of direction and/or strength. This kind of interaction is also viewed as a special kind of moderation on the SEM path model as the categorical moderator variable imposes a continuous moderating effect on each observation's group membership (Henseler et al., 2009)

In this dissertation, gender, location, and training are used as categorical moderating variables. In general, the multi-group analysis enables the researcher to check if certain data groups have significant variations in their estimations of group-specific parameters (e.g., outer weights, outer loadings, and path coefficients). PLS offers results from the three methods of multigroup analysis that are based on bootstrapping data from each group. (Sarstedt et al., 2011).

Mediation Relationship

Mediation effect or relationship in path modeling refers to a relationship where a third endogenous latent variable accounts for the effect of the predictor variable on the outcome variable. Graphically, it is expected that a mediator variable comes in between the predictor and the outcome variable to enable mediation. (Baron and Kenny, 1986).

Instrument Development

Items Selection

Table 1 illustrates the descriptive statistics of instruments. To ensure that the reliability and validity of the questionnaire measures meet the requisite quality criteria, authors like Straub (1989) advice that it is important that previously validated items are adapted from early literature. This dissertation heeds to this advice, capitalizing on the advantage that the reliability and validity testing of the adopted measures are already known (Bryman and Bell, 2007).

A variety of items were used as measures of eight constructs for the first (Adoption/Upscaling) and seven for the second (Continuation Intention) model. To organize the respondents into groups of current vis a vis prospective adopter, the respondents are asked to identify an answer that best describe their experience with insect farming or harvesting. Depending on the response they chose, a skip logic automatically directed them into items whose wordings were moulded to apply to the selection. This would be used later in permutational multi-group analysis to enable the researcher to identify the most important predictors of willingness to adopt and those of willingness to upscale insect farming and harvesting practices. For instance, for current adapters, item PEU1 would read as '*Running an Insects farm or a harvesting operation **is** clear and understandable"* for farmers who in the previous item responded as having an experience as an insect farmer or as a wild harvester. However, for those with no prior experience in insect farming or harvesting, the same item would read as '*Running an Insects farm or a harvesting operation **will be** clear and understandable".* This distinction was used across all items, and it ensured that the items were homogenous across the different groups for non-biased analysis.

All the items were measured using a five-scale Likert ranging from strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree to strongly agree, weighted as 1 through 5. Appendix 2 provides a list of items for every construct used to measure both models.

Pre-Test

Prior to distributing the questionnaire to sampled respondents, a pre-test was carried out to evaluate the appropriateness of the instrument. The pre-test participants, consisting of farmers hailing from Kakamega, were requested to complete the instrument and comment on ways to further develop and improve it. The feedback was crucial for adjusting the content, flow, comprehension, and completion rate (Lewis et al., 2005).

Questionnaire format and administration

The survey consisted of four main sections. The first section was introductory, providing respondents an opportunity to understand the topic and objective of the study. The section concluded with statement of assurance of confidentiality and anonymity, giving respondents the option of proceeding to the next section. The second section seeks to find out respondent's demographic information such as gender, household size and farm size which are key for performing moderation analysis as well as permutation MGA. It is in the third section where farmers are grouped into experienced farmers and the non-experienced with regards to insect farming and harvesting. A skip logic follows from this categorisation through to the final section where the real measurement items for PLS-SEM path model are tested on the respondents. While the third section focuses on Adoption/upscaling intention (termed herein as behavioural intention), the fourth section is designed with questions seeking to understand farmers ex ante and ex-post willingness to continue with insect farming or harvesting.

Final survey

Data pre-processing and cleansing

On average, the respondents took 24 minutes and 29 seconds to complete the survey. A csv file was extracted from the survey platform. While initial coding was already accounted for by the researcher during survey development based on the capability of Kobo Toolbox in defining labels and xml values for the answers, further coding was done on the merged data for seamless analysis. Data cleansing, formatting, new attribute generation and merging was done in RapidMiner Studio software version 9.10.010. Kobo Toolbox ensures that only valid and complete responses are made available for download. As such, all 358 responses were complete and valid. Since the survey was enumerated on a face-to-face basis, there were no cases of non-conforming responses, such as a respondent answering single item (e.g., strongly agree) for all questions.

Pursuant to this evaluation, all 358 usable cases were first loaded into RapidMiner for pre-processing and resultant dataset imported into SAS JMP software to generate descriptive statistical reports. SPSS was further used to generate exploratory analyses on every variable to check for normality test, response bias and common method bias.

For PLS-SEM analysis purposes, Smart PLS 4.0 M3 was used to analyse the measurement and structural models. For the current analysis, the dissertation opted for transforming the final data into xlxs and then loaded it into Smart PLS 4.0 to generate raw input for the application.

Descriptive Statistics of Respondents

For us to understand the demographic profile of the study respondents, it is important for this dissertation to presents them in a descriptive statistic. Further analysis of this is provided in provided in chapter 5.

Table 2: Respondents' demographic information

Demographics	Frequency	Percentage
Gender		
Male	210	58.7
Female	148	41.3
Age		
18 - 28	28	8.0
29 - 38	110	31.4
39 - 48	96	27.4
49 - 58	57	16.3
59 - 68	39	11.1
69 - 78	15	4.3
79 - 88	5	1.4

Location		
Siaya	221	61.7
Kakamega	137	38.3
Years of farming experience		
0 - 10	101	28.8
10 - 20	130	37.0
20 - 30	71	20.2
30 - 40	29	8.3
40 - 50	16	4.6
50 - 60	4	1.1
Insect farming and harvesting experience		
Prospective	228	63.7
Current	34	9.5
Discontinued	32	8.9
Wild harvesters	64	17.9
Number of Farm labour		
0 - 5	279	77.9
5 - 10	70	19.6
10 - 15	6	1.7
15 - 20	1	0.3
20 - 25	2	0.6
With Off-farm income		
Without off-farm income	142	39.7
With off-farm income	216	60.3

Descriptive Statistics of Instrument

The mean, standard deviation, variance, minimum and maximum value of each indicator were examined using SAS JMP version 25.0. In the Table 3, the descriptive statistics for all indicators are outlined. In the proceeding Chapter, the descriptive statistics of the instrument for the final study are further explored.

Table 3: Descriptive statistics of measurement items

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
ATT1	358	1	5	4.13	1.104	1.218
ATT2	358	1	5	4.19	1.174	1.377
ATT3	358	1	5	4.05	1.134	1.286
ATT4	358	1	5	4.27	1.140	1.299
ATT5	358	1	5	3.86	1.354	1.833
ATT6	358	1	5	3.99	1.326	1.759
BI1	358	1	5	3.78	1.412	1.993
BI2	358	1	5	3.66	1.507	2.270
BI3	358	1	5	4.28	1.180	1.392
BI4	358	1	5	3.47	1.625	2.642
BI5	358	1	5	3.94	1.364	1.859
BI6	358	1	5	3.21	1.633	2.666
BI7	358	1	5	2.97	1.691	2.859
CI1	358	1	5	4.20	1.249	1.560
CI2	358	1	5	4.28	1.167	1.363
CI3	358	1	5	4.33	1.210	1.465
CONF1	358	1	5	4.11	1.160	1.344
CONF2	358	1	5	4.05	1.128	1.272
CONF3	358	1	5	4.10	1.163	1.353
KN1	358	1	5	2.91	1.769	3.129
KN2	358	1	5	2.89	1.714	2.936
KN3	358	1	5	2.65	1.706	2.911
KN4	358	1	5	2.43	1.605	2.576
KN5	358	1	5	3.63	1.359	1.848
PBC1	358	1	5	3.77	1.311	1.718
PBC2	358	1	5	4.55	0.871	0.758
PBC3	358	1	5	4.58	0.842	0.709
PBC4	358	1	5	3.92	1.125	1.265
PBC6	358	1	5	3.54	1.329	1.767
PBC7	358	1	5	3.15	1.522	2.315
PEU1	358	1	5	3.61	1.405	1.975
PEU2	358	1	5	3.73	1.355	1.835
PEU3	358	1	5	3.47	1.549	2.401
PEU4	358	1	5	3.12	1.710	2.924
PEU5	358	1	5	3.09	1.725	2.975
PU1	358	1	5	4.15	1.137	1.292
PU2	358	1	5	4.23	1.138	1.296
PU3	358	1	5	3.68	1.316	1.732
PU4	358	1	5	4.16	1.072	1.148
PU5	358	1	5	3.79	1.280	1.638
PU6	358	1	5	3.72	1.375	1.891

PU7	358	1	5	4.08	1.231	1.514
PU8	358	1	5	3.68	1.409	1.984
PU9	358	1	5	3.71	1.467	2.151
RP1	358	1	5	3.89	1.023	1.048
RP10	358	1	5	3.47	1.421	2.020
RP11	358	1	5	4.06	1.184	1.403
RP12	358	1	5	3.96	1.260	1.586
RP13	358	1	5	4.09	1.230	1.513
RP14	358	1	5	3.01	1.443	2.081
RP2	358	1	5	3.75	1.257	1.581
RP3	358	1	5	3.01	1.340	1.795
RP4	358	1	5	2.95	1.377	1.897
RP5	358	1	5	2.97	1.535	2.357
RP6	358	1	5	2.60	1.461	2.134
RP7	358	1	5	3.80	1.303	1.698
RP8	358	1	5	2.96	1.507	2.270
RP9	358	1	5	3.95	1.327	1.760
SAT1	358	1	5	4.18	1.075	1.156
SAT2	358	1	5	4.18	1.097	1.204
SAT3	358	1	5	4.15	1.163	1.352
SAT4	358	1	5	4.16	1.067	1.139
SN1	358	1	5	3.08	1.549	2.400
SN2	358	1	5	3.29	1.366	1.866
SN3	358	1	5	3.53	1.234	1.522
SN4	358	1	5	3.20	1.585	2.511
SN5	358	1	5	4.02	1.044	1.089
SN6	358	1	5	3.86	1.294	1.674
TOL1	358	1	5	3.63	1.271	1.616
TOL2	358	1	5	3.90	1.182	1.396
TOL3	358	1	5	3.76	1.406	1.976
TOL4	358	1	5	4.49	0.885	0.783
VAL1	358	1	5	4.33	1.017	1.035
VAL2	358	1	5	4.47	0.951	0.905
VAL3	358	1	5	4.15	1.079	1.165
VAL4	358	1	5	3.96	1.218	1.483
Valid N (listwise)	358					

Verifying Data Characteristics

In this section, it is acknowledged that verifying the test data as collected from sample population is an important step prior to actual analysis, ensuring that the data used in the higher-level analyses is valid and complete. This involves verifying data normality, checking for and fixing missing values and determining the possibility of common method bias.

Missing Data

In this dissertation, missing values were not experienced because the researcher set Kobo Toolkit to force respondents to answer all the necessary questions with the skip logic ensuring that they respond to questions that applied to specific categories. It is impossible to include incomplete responses as Kobo Toolbox automatically flags them offs. Hence, all responses in the downloaded csv file were complete and lacked missing data.

Data Normality

One of the most common requirements for hypothesis testing is that the data used must be normally distributed. Two statistical analyses were used to examine data normality: (1) Shapiro-Wilk test; and (2) an assessment of skewness and kurtosis. The results from the Shapiro-Wilk test show that all variables have significant values of 0.001, indicating the data are not normal (non-normal). To augment this result, skewness and kurtosis values were examined, and the result confirmed that the data distribution was non-normal, where 80.4598% of the data presented skewness and kurtosis above the recommended threshold (-3 to +3). The fact that we reject the data normality distribution assumption permits the researcher to proceed with the use of PLS-SEM.

Common Method Bias

This dissertation used the Harman's one factor test, which has been used in earlier studies to assess the possibility of common method bias (Leimeister et al., 2006) to look at the results of the unrotated factor solutions and determine the number of factors accounting for the variance in the variables. When one factor emerges from the factor analysis or when one general factor explains the bulk of the covariance in the independent and criterion variables, it can be concluded that the items are subject to common method bias.

Control Variables

It's crucial to evaluate how control variables affect the dependent variables in order to eliminate confounding effects (other possible effects that are unrelated to the hypothesized relationships) (Hashim & Tan, 2015). Age, training, business focus, and the capacity to meet household nutritional needs were chosen as control variables for this dissertation. These control variables are used in a post-hoc analysis along with other latent variables as independent variables to assess path coefficients and value significance. It is found that even with the inclusion of control variables, both significant and non-significant pathways continue to have the same status and direction in both BI and WTC models, signifying lack of possible confounding effects see table 4 below.

Table 4: Control variables path coefficient

BI Model with Control variables

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
ATT -> BI	0.753	0.7517	0.0538	13.9881	0.0000*
KN -> PEU	0.7178	0.7193	0.0437	16.4246	0.0000*
KN -> PU	0.4676	0.466	0.0346	13.4977	0.0000*
KN -> RP	0.1225	0.1222	0.0367	3.3386	0.0008*
KN -> SN	0.4986	0.4995	0.0431	11.5778	0.0000*
PBC -> ATT	0.3182	0.3227	0.0678	4.6917	0.0000*
PBC -> BI	0.2655	0.269	0.0719	3.6937	0.0002*
PEU -> ATT	0.0792	0.0818	0.0515	1.5375	0.1242
PU -> ATT	0.5452	0.5395	0.075	7.2668	0.0000*
RP -> ATT	-0.0937	-0.0906	0.0472	1.9836	0.0474*
SN -> ATT	0.0829	0.0798	0.0496	1.672	0.0946

BI model Without Control

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
ATT -> BI	0.7794	0.7794	0.0509	15.3258	0.0000*
KN -> PEU	0.6875	0.6877	0.0333	20.6735	0.0000*
KN -> PU	0.4318	0.4314	0.0256	16.8946	0.0000*
KN -> RP	0.0766	0.0765	0.0304	2.5247	0.0116*
KN -> SN	0.5064	0.5066	0.0308	16.4303	0.0000*
PBC -> ATT	0.3123	0.3157	0.0654	4.778	0.0000*
PBC -> BI	0.2565	0.2574	0.071	3.6148	0.0003*
PEU -> ATT	0.0864	0.0883	0.0499	1.7307	0.0836
PU -> ATT	0.5495	0.5449	0.0738	7.4486	0.0000*
RP -> ATT	-0.0986	-0.0952	0.0471	2.0951	0.0362*
SN -> ATT	0.0851	0.0835	0.0483	1.7621	0.0781

WTC model With Control

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
CONF -> SAT	0.4852	0.4896	0.0686	7.0778	0.0000*
PEU -> CONF	0.0413	0.0422	0.0408	1.0103	0.3128
PEU -> VAL	0.3596	0.3572	0.0407	8.8451	0.0000*
SAT -> WTC	0.9145	0.9102	0.0418	21.8745	0.0000*
TOL -> CONF	0.1663	0.1686	0.0578	2.8768	0.0042*
TOL -> VAL	0.1467	0.1512	0.0705	2.0794	0.0381*
VAL -> CONF	0.7915	0.7843	0.057	13.8857	0.0000*
VAL -> SAT	0.3829	0.3785	0.0635	6.0329	0.0000*

WTC model Without Control

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
CONF -> SAT	0.4896	0.493	0.0709	6.9036	0.0000*
PEU -> CONF	0.0296	0.0295	0.039	0.7573	0.4493
PEU -> VAL	0.3682	0.3662	0.0364	10.1283	0.0000*
SAT -> WTC	0.9081	0.904	0.0397	22.8525	0.0000*
TOL -> CONF	0.1618	0.1642	0.0527	3.0707	0.0023*
TOL -> VAL	0.1544	0.1586	0.0694	2.2234	0.0266*
VAL -> CONF	0.7847	0.7782	0.0563	13.9421	0.0000*
VAL -> SAT	0.3946	0.3898	0.0631	6.2528	0.0000*

Control Variables	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
			BI Model		
Age <- ATT	0.0011	0.0011	0.0031	0.3422	0.7322
Age <- BI	0.0085	0.0086	0.0028	3.0006	0.0027*
Age <- PEU	0.0006	0.0006	0.0042	0.1528	0.8785
Age <- PU	-0.0035	-0.0034	0.0031	1.1157	0.2646
Age <- RP	0.0002	0.0001	0.0033	0.0654	0.9479
Age <- SN	-0.0032	-0.0032	0.0038	0.8514	0.3946
BF <- ATT	0.0113	0.0102	0.0339	0.3323	0.7397
BF <- BI	0.0732	0.0724	0.042	1.744	0.0812
BF <- PEU	-0.0949	-0.0923	0.0562	1.6895	0.0912
BF <- PU	-0.0116	-0.0113	0.0406	0.2869	0.7742
BF <- RP	-0.059	-0.0596	0.0397	1.4848	0.1377
BF <- SN	-0.1046	-0.1015	0.0556	1.8817	0.0599
M_Nutrition <- ATT	-0.0324	-0.0328	0.0386	0.8386	0.4017
M_Nutrition <- BI	-0.0612	-0.0624	0.0454	1.348	0.1777
M_Nutrition <- PEU	-0.0528	-0.0536	0.0593	0.8912	0.3729
M_Nutrition <- PU	-0.0172	-0.0205	0.0521	0.3297	0.7417
M_Nutrition <- RP	0.093	0.0925	0.0568	1.6376	0.1016
M_Nutrition <- SN	0.0086	0.0057	0.0739	0.116	0.9077
Training <- ATT	0.0268	0.0295	0.076	0.3522	0.7247
Training <- BI	0.088	0.0882	0.094	0.9366	0.3490
Training <- PEU	-0.2131	-0.22	0.1743	1.2227	0.2215
Training <- PU	-0.263	-0.2594	0.1221	2.1536	0.0313*
Training <- RP	-0.1963	-0.1961	0.1504	1.3052	0.1919
Training <- SN	0.1636	0.1598	0.1621	1.0093	0.3129
			WTC Model		
Age <- CONF	-0.0031	-0.0034	0.0029	1.0991	0.2722
Age <- SAT	-0.0043	-0.0045	0.0023	1.8426	0.0660
Age <- VAL	0.0047	0.0047	0.0038	1.2447	0.2138

Age <- WTC	0	-0.0001	0.0026	0.0076	0.9939
BF <- CONF	-0.0537	-0.0527	0.0378	1.4223	0.1556
BF <- SAT	0.0165	0.0154	0.0364	0.4542	0.6499
BF <- VAL	0.0239	0.0222	0.044	0.5434	0.5871
BF <- WTC	0.082	0.082	0.0395	2.0726	0.0387*
M_Nutrition <- CONF	0.0603	0.0626	0.0471	1.2785	0.2017
M_Nutrition <- SAT	0.0122	0.0139	0.0531	0.2288	0.8191
M_Nutrition <- VAL	-0.0087	-0.0103	0.0437	0.1989	0.8424
M_Nutrition <- WTC	-0.0142	-0.0129	0.0422	0.336	0.7370
Training <- CONF	-0.0366	-0.0418	0.0896	0.4083	0.6832
Training <- SAT	0.2786	0.272	0.1046	2.6639	0.0080*
Training <- VAL	0.0583	0.0582	0.1032	0.5643	0.5728
Training <- WTC	-0.1375	-0.1344	0.0733	1.8756	0.0613

Note: * p <0.05

CHAPTER FIVE

5.0 DATA ANALYSIS AND RESULTS

5.1 Overview

The outcomes of analytical methods are presented in this chapter, utilizing the resources covered in Chapter 4. The chapter's organization follows the PLS reporting style guided by earlier studies (Chin, 2010) and inspired by (Hair Jr, Hult, Ringle, & Sarstedt, 2021). In the first parts, validity and reliability tests are used to evaluate the measurement models, and then the structural model is validated. Mediation and moderation assessments are carried out to look at the dynamics and relationships among factors. Specifically, this dissertation assesses the mediating influence of attitude and satisfaction on behaviour intention and continuance intention. This chapter also includes a summary of the preliminary study's findings.

5.2 Sample

The research targeted 400 participants. 358 cases were valid for analysis after factoring out two incomplete responses and the one invalid case based on the respondent not coming from the study area. The minimum age of the respondents was 19 while the maximum was 82 with a mean value of 43.414. Male respondents composed of 58.7% while 148 respondents were female. 137 were in Siaya while 221 hailed from Kakamega County, with a total of 73 respondents reporting to have received some training in insect farming and harvesting techniques. The farmers surveyed were typically small-scale farmers holding an average of 1.217 acres of land on which related land-based activities supported an average of six family members. Majority of the respondents (60.3352%) participated in off-farm income earning activities, with crop farming as their main farm activity. More than half of the participants had attained basic education, thereby confirming that close to 96.65% were literate.

Measurement Model Assessment

In its analytical approach, Smart PLS 4.0 M3 (Ringle et al., 2015) was used in this study to evaluate the measurement and structural model. This statistical software evaluates the measurement model's psychometric characteristics and projects the structural model's parameters.

As mentioned in Chapter 4, the internal consistency reliability, indicator reliability, convergent validity, and discriminant validity are all assessed to first determine the measurement model's validity and reliability. The findings of every analysis performed to judge the accuracy and dependability of the measurement model are presented in the sections that follow.

Internal Consistency Reliability

As noted by (Hatcher & O'Rourke, 2013), Cronbach's alpha, a conventional measure of internal consistency, gives an estimation of the reliability based on the correlations between the manifest indicator variables (Hair Jr, Hult, Ringle, & Sarstedt, 2021). However, a conceivable number of researchers have found that PLS-SEM ranks the indicators in order of individual reliability and that Cronbach's alpha tends to underestimate the internal consistency dependability due to its sensitivity to the scale's item count. Therefore, it could be utilized as a more cautious internal consistency reliability measure. Values above 0.7 are considered excellent measures, while still, those between 0.6 and 0.7 are acceptable only in exploratory research like this. In this dissertation, the initial alpha values for the BI model ranged between 0.7624 and 0.9359 while for WTC, the ranges were 0.5772-0.9489. New Chronbach's Alpha values extracted at the end of measurement model assessment are shown in Table 2 where Risk Tolerance (RT) construct in the WTC model ultimately had acceptable value of 0.6072. All other constructs for both models had values greater than 0.6 upon modification.

It is recommended that composite reliability (CR) be used as a complementary measure of internal consistency reliability. Similar thresholds are used to validate CR. Thus, when CR of each reflectively measured construct is more than the cut-off value of 0.7, a measurement model is considered to have sufficient internal consistency reliability. For this dissertation, the initial CR of each reflectively measured construct varied from 0.1034 to 0.9357 for BI model and 0.7436 to 0.9671 for WTC model, as shown in Table 3. Items with lower CR values were analysed to see if they were below the acceptable 0.4. inevitably, Risk Perception (RP) indicators had to be analysed and systematically removed from the BI model upon performing other reliability and validity assessments.

According to (Hair Jr, Hult, Ringle, & Sarstedt, 2021), true reliability typically falls between Cronbach's alpha (representing the lower bound) and the composite reliability (representing the upper bound) when analysing and evaluating the measures' internal consistency reliability.

Indicator Reliability

By looking at the item loadings, the measurement model's indicator reliability may be evaluated. When the loading estimates for each item are greater than or equal to 0.5–0.708, a measurement model is said to have a sufficient indicator reliability (Hair et al., 2010). According to the analysis, measurement model item for both BI and WTC models had varied. For BI, PBC2 and PBC3 (removed), and all the RP indicators had lower loadings. RP, had negative loadings and as recommended, these were the first to be removed from the model to assess the impact of removal on other indicators. Ultimately, only RP 5,6,8 and 14 were admissible for analysis in the next stage of measurement model analysis. The initial loadings are shown for each item in Table 3.

Convergent Validity

In SEM-PLS, the average variance extracted (AVE) value of a measurement model is frequently used to determine the convergent validity of the model. When constructs have an average variance extracted (AVE) value close to 0.5 or greater, convergent validity is considered appropriate. The AVEs for all constructs in Table 5 range from 0.4267 to 0.5836 following the previous step, thereby indicating that the resultant measurement model had a sufficient level of convergent validity.

Table 5: Reliability assessment

	Cronbach's alpha	rho_A	Composite reliability	Average variance extracted (AVE)
BI Model				
ATT	0.9321	0.9351	0.9317	0.7326
BI	0.9287	0.9313	0.9291	0.7245
KN	0.9198	0.9260	0.9214	0.7025
PBC	0.8062	0.8128	0.8070	0.5836
PEU	0.9338	0.9367	0.9344	0.8263
PU	0.8856	0.8856	0.8852	0.6586
RP	0.6974	0.6930	0.6899	0.4267
SN	0.8829	0.8858	0.8835	0.7169
WTC Model				
CONF	0.9121	0.9206	0.9142	0.7812
PEU	0.921	0.9255	0.9197	0.6979
SAT	0.9562	0.9562	0.9562	0.8451
TOL	0.5682	0.5732	0.5702	0.5996
VAL	0.8832	0.8852	0.8833	0.6548
WTC	0.9489	0.9492	0.949	0.8612

Discriminant Validity

The degree to which a construct actually differs from other constructs according to empirical standards is known as discriminant validity. Three measures are used in this study to assess the models' discriminant validity: (1) Fornell and Larcker's (1981) criterion, (2) cross loadings; and (3) Heterotrait-Monotrait Ratio of Correlations (HTMT). A measurement model is believed to have adequate discriminant validity when: (1) The relationships between the measure and all other measures are outweighed by the square root of the AVE.; (2) the outer loading of an indicator on the linked construct is bigger than any of its cross-loadings (i.e., correlation) on other constructs; and (3) a lower and hence more conservative threshold value of 0.85 of ratio of between-trait correlation to within-trait correlation (HTMT) is arrived at (Henseler et al., 2015)

Fornell and Larcker's (1981) criterion compares the correlation of latent constructs with the square root of the average variance extracted (AVE) (Hair et al., 2014). The variance of a latent construct should be better explained by it than the variance of other latent constructs. As a result, the correlations with other latent constructs should be smaller than the square root of each construct's AVE (Hair et al., 2014).

All square roots of AVE in the BI model in this dissertation were greater than the off-diagonal elements in their respective row and column except the ATT and RP constructs. The non-bolded numbers in Table 13 represent the inter-correlation value across constructions, while the bolded elements in Table 13 represent the square roots of the AVE. To solve the issues with the identified constructs, subsequent cross-loading analysis was necessary.

Cross loading assessment involves examining indicators and comparing them to all construct correlations. Inevitably, the factor loading of indicators on the assigned construct must be higher than all loading on other constructs. The preliminary output of cross loadings, produced by the SmartPLS algorithm function showed that BI6, BI7 and PBC7 were outliers in this respect and together with the construct where the difference between loading on assigned construct and loading on other constructs was less than 0.1, had to be removed to ensure better cross loadings and Farnel and Larker criterion. The ultimate result was that all the remaining constructs loaded more on their assigned constructs. While RP constructs loaded well on RP, it still did not meet Farnel and Larker criterion since its correlation with SN was higher than the square root of its AVE. As such, the researcher had no other option than to remove the construct from the model.

When compared to the (geometric) mean of the average correlations of indicators measuring the same construct, HTMT is the mean of all correlations of indicators across constructs measuring various constructs (i.e., the monotrait-heterotrait correlations (Henseler et al., 2015). From the analysis, all the constructs resulting from preceding analysis had ratios less than 0.85, signifying good convergent validity.

Overall, the final measurement model's reliability and validity tests presented in Table 6 and 6 successfully confirm that the items used to measure the constructs in this dissertation are reliable and suitable for use in estimating the parameters of the structural model.

Table 6: Final BI Model discriminant validity assessment

HTMT	ATT	BI	KN	PBC	PEU	PU	RP	SN
ATT								
BI	**0.8476**							
KN	0.6635	**0.6611**						
PBC	0.8026	0.7543	**0.6429**					
PEU	0.6855	0.6824	0.7904	**0.7272**				
PU	0.7987	0.7734	0.7979	0.7526	**0.81**			
RP	0.4747	0.4728	0.6942	0.4407	0.6434	**0.6523**		
SN	0.6167	0.5898	0.7441	0.6564	0.7776	0.6929	**0.65**	

Fornel and Lacker criterion	ATT	BI	KN	PBC	PEU	PU	RP	SN
ATT	**0.8559**							
BI	0.8491	**0.8512**						
KN	0.6628	0.663	**0.8381**					
PBC	0.8054	0.7555	0.6336	**0.7639**				
PEU	0.6892	0.6844	0.7917	0.7201	**0.909**			
PU	0.8015	0.7777	0.7962	0.75	0.8103	**0.8115**		
RP	0.4896	0.4887	0.7008	0.4459	0.654	0.6621	**0.6532**	
SN	0.6196	0.5936	0.7405	0.6506	0.7774	0.6946	0.6538	**0.8467**

Cross-Loadings

	ATT	BI	KN	PBC	PEU	PU	RP	SN
ATT1	**0.8614**	0.7424	0.5858	0.6677	0.5856	0.6901	0.4273	0.5474
ATT2	**0.7656**	0.6661	0.456	0.606	0.4614	0.6104	0.3166	0.421
ATT3	**0.8730**	0.7102	0.5449	0.7622	0.6289	0.7016	0.4282	0.5698
ATT5	**0.9416**	0.8036	0.6641	0.7347	0.6855	0.7624	0.496	0.5723
ATT6	**0.8283**	0.7053	0.5712	0.6686	0.57	0.6566	0.4132	0.5303
BI1	0.7707	**0.9071**	0.6716	0.6836	0.6383	0.7178	0.4946	0.5763
BI2	0.7295	**0.8588**	0.6579	0.6477	0.6341	0.7401	0.4646	0.5234
BI3	0.6661	**0.7714**	0.3744	0.5439	0.437	0.486	0.2174	0.351
BI4	0.7319	**0.8769**	0.6323	0.7073	0.7045	0.7668	0.5012	0.5982
BI5	0.7118	**0.8356**	0.4598	0.6234	0.4799	0.5782	0.3777	0.4582
KN1	0.551	0.5852	**0.8988**	0.544	0.7345	0.7051	0.6656	0.6244
KN2	0.6032	0.5795	**0.8724**	0.5668	0.6904	0.7012	0.5958	0.6507
KN3	0.5658	0.5515	**0.8762**	0.5281	0.6979	0.673	0.6448	0.6476
KN4	0.5089	0.5367	**0.8207**	0.4913	0.6425	0.6486	0.5988	0.6037
KN5	0.5548	0.5269	**0.7086**	0.5309	0.5355	0.6054	0.405	0.5771
PBC1	0.6818	0.631	0.4614	**0.8412**	0.5342	0.5848	0.2834	0.4512
PBC4	0.5866	0.5444	0.4338	**0.7247**	0.4923	0.5158	0.2578	0.4641
PBC6	0.5716	0.5522	0.5654	**0.7196**	0.6316	0.6214	0.4938	0.5879
PEU3	0.6525	0.6518	0.6519	0.6896	**0.8769**	0.7224	0.5295	0.6543
PEU4	0.5822	0.5974	0.7239	0.6424	**0.8842**	0.7329	0.6095	0.7145
PEU5	0.645	0.6194	0.7793	0.6356	**0.9633**	0.7548	0.6414	0.7488
PU3	0.6196	0.6119	0.6945	0.5488	0.6892	**0.8221**	0.5695	0.6249
PU5	0.6588	0.6313	0.6171	0.6365	0.6141	**0.7988**	0.4875	0.5169
PU6	0.6455	0.6227	0.6193	0.5953	0.622	**0.7917**	0.5209	0.5043
PU9	0.6782	0.6583	0.6523	0.6541	0.7025	**0.8328**	0.5694	0.6051
RP14	0.4518	0.4582	0.4183	0.4284	0.5039	0.5055	**0.7044**	0.4178
RP5	0.2298	0.1812	0.5083	0.2198	0.4033	0.37	**0.6408**	0.4308
RP6	0.264	0.3056	0.453	0.2098	0.3662	0.4163	**0.6109**	0.4363
SN2	0.5576	0.5195	0.6597	0.6183	0.7089	0.6321	0.6013	**0.8947**
SN3	0.5281	0.5324	0.6159	0.5187	0.611	0.5694	0.5066	**0.8403**
SN4	0.4857	0.4541	0.6039	0.5111	0.6531	0.5605	0.5511	**0.8025**

Table 7: Final WTC Model discriminant validity assessment

HTMT						
	CONF	PEU	SAT	TOL	VAL	WTC
CONF						
PEU	**0.4858**					
SAT	0.811	**0.4568**				
TOL	0.3951	0.4448	**0.4571**			
VAL	0.8111	0.6181	0.7846	**0.4381**		
WTC	0.8518	0.3978	0.8552	0.4126	**0.7281**	

Fornell and Lacker criterion	CONF	PEU	SAT	TOL	VAL	WTC
CONF	**0.8839**					
PEU	0.4909	**0.8354**				
SAT	0.8105	0.4591	**0.9193**			
TOL	0.3961	0.4381	0.4581	**0.6321**		
VAL	0.8103	0.6207	0.7856	0.4369	**0.8092**	
WTC	0.8493	0.3997	0.8553	0.4109	0.7294	**0.928**

Cross-Loadings						
	CI	CONF	PEU	SAT	TOL	VAL
CI1	**0.9224**	0.7844	0.3769	0.7889	0.3511	0.6701
CI2	**0.9174**	0.7846	0.3602	0.7846	0.3835	0.6691
CI3	**0.9440**	0.7955	0.3755	0.8074	0.4006	0.6914
CONF1	0.7673	**0.9403**	0.4883	0.7647	0.4014	0.7541
CONF2	0.7867	**0.9151**	0.4455	0.7402	0.3551	0.7445
CONF3	0.6962	**0.7887**	0.3598	0.6380	0.2928	0.6448
PEU1	0.3279	0.3477	**0.7046**	0.3378	0.4176	0.4359
PEU2	0.4215	0.4971	**0.9340**	0.4416	0.3451	0.5479
PEU3	0.3379	0.4213	**0.8607**	0.3935	0.3412	0.5352
PEU4	0.2752	0.3785	**0.8170**	0.3549	0.2147	0.5256
PEU5	0.3012	0.3933	**0.8442**	0.3825	0.2492	0.5413
SAT1	0.7797	0.7447	0.4216	**0.9109**	0.3788	0.7052
SAT2	0.7951	0.7558	0.3963	**0.9321**	0.4172	0.7367
SAT3	0.7979	0.7216	0.4290	**0.9210**	0.4053	0.7349
SAT4	0.7721	0.7584	0.4418	**0.9129**	0.3630	0.7116
TOL1	0.2569	0.2375	0.2893	0.2548	**0.6235**	0.2577
TOL2	0.2630	0.2627	0.2669	0.3214	**0.7002**	0.2936
VAL1	0.6912	0.6941	0.4815	0.7322	0.3326	**0.8675**
VAL2	0.5925	0.6129	0.3904	0.6624	0.3517	**0.7664**
VAL3	0.5536	0.6719	0.5161	0.5837	0.2863	**0.7941**
VAL4	0.5180	0.6416	0.6194	0.5603	0.3098	**0.8054**

Goodness of model fit

The acceptable fit criteria established by Hair et al. (2014) state that the SRMR for SEM model must be less than 0.08. However, in PLS-SEM, the structural model is generally evaluated using heuristic standards that are determined by the model's predicting ability, as opposed to evaluating goodness-of-fit. These conditions preclude measuring the overall goodness of the model fit in the context of the CB-SEM. Instead, the model's predictive accuracy is evaluated (Sarstedt, Ringle, Henseler, & Hair, 2014).

Structural Model Assessment

The significance of the path coefficients (Step 2), the level of the R^2 values (Step 3), the f^2 impact size (Step 4), the predictive relevance Q^2 (Step 5) and the q^2 effect size are the main criteria for evaluating the structural model in PLS-SEM (Step 6). These are discussed in sections that follow. The study model's postulated mediation and moderation linkages are also evaluated in this dissertation using PROCESS analysis and Bootstrapping capabilities of SmartPLS.

Collinearity Assessment

It is necessary to determine whether each set of predictor variables exhibits crucial levels of collinearity. In this dissertation, as generally accepted standards, the essential levels of collinearity in the predictor constructs is tolerance values below 0.20 (VIF value above 5). To address collinearity issues, one should think about removing constructs, combining predictors into a single construct, or developing higher-order constructs if the tolerance or VIF recommendations indicate a crucial degree of collinearity. All the VIF values of all the constructs used for structural model in this dissertation were below 5, hence no multicollinearity issues were observed among the constructs.

Coefficient of Determination (R^2)

The coefficient of determination (R^2) value indicates how much variance in a dependent variable is explained by all independent factors. This is the percentage of data variability that the measurement model can account for or the sum of the impacts of the exogenous latent variable(s) on the endogenous latent variable. The R^2 is a measurement of in-sample predictive power since it represents the squared correlation of actual and anticipated (M. Sarstedt et al., 2014), hence, a larger R^2 value increases the predictive ability of the structural model. (Hair et al., 2012); and (J. F. Hair et al., 2013) suggested in scholarly research that focus on marketing issues, R^2 values of O.75, 0.50 , or 0.25 for endogenous latent variables, can be respectively described as substantial, moderate or weak.

In this dissertation, the R^2 values are calculated in SmartPLS using the consistent algorithm function while the t-statistics and related p-values are generated using the bias corrected and accelerated bootstrapping function, which creates 5000 samples from original 358 cases.

The structural model's findings (shown in Figure 5.1) indicate that, overall, perceived behavioural control and attitude jointly account for 73.51 percent of the variance in behavioural intentions. The variance in the RP, PEU, PU, and SN is explained by knowledge in proportions of 49.11 percent, 62.68 percent, 63.39 percent, and 54.83 percent, respectively. The combined effects of the RP, PEU, PU, SN, and PBC account for 73.96 percent of variations in attitude. Figure 4's findings for the WTC model show that PEU and TOL jointly account for 41.9 percent of the variance in VAL while, along with Val, they account for 65.94 percent of the variance in confirmation. Additionally, perceived value and confirmation together account for 70.53 percent of the variation in satisfaction. In the end, satisfaction accounts for 73.15 percent of the variation in willingness to continue. The two structural models evidently meet the R^2 requirement and has a sufficient level of predictive power (Chin, 1998).

Figure 9: BI coefficient of determination

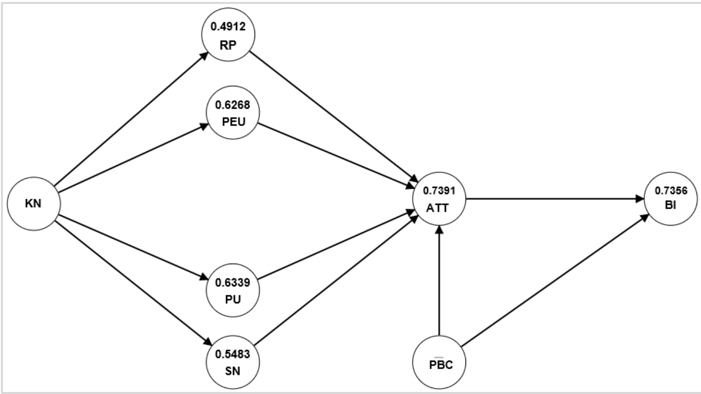
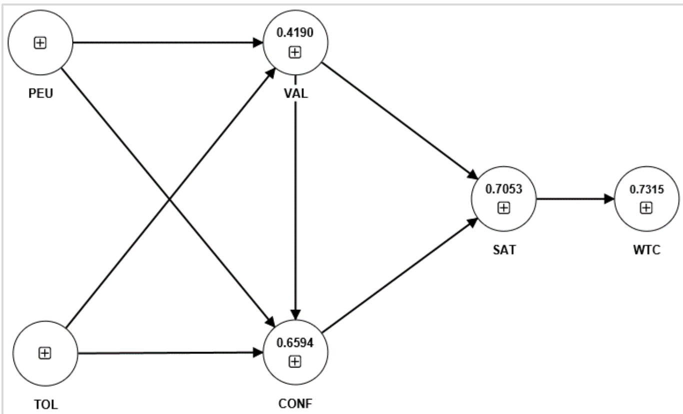


Figure 10: WTC coefficient of determination



Path Coefficients

In SEM, each path connects two latent variables that correspond to hypothesized relationships among the constructs. Path coefficients help the researcher to assess the strength of relationships between the dependent and independent variables and allow them to be confirmed or refuted for each hypothesis.

Path coefficients, which are computed in ordinary least squares regression, can be thought of as standardized beta coefficients. Along with t-statistics, the bootstrapping technique is used to determine whether the path coefficients are significant.

The path coefficients, t-statistics, and significance level for each hypothesized link in the BI and WTC models are displayed in Table 8. The following section discusses the findings and their significance.

Table 8: Path coefficients

	Path coefficient	T statistics (|O/STDEV|)	two-tailed confidence interval 2.50%	97.50%	P values
BI model path coefficients					
ATT -> BI	0.6849	7.296	0.4937	0.8655	0.0000
KN -> PEU	0.7917	25.3102	0.7278	0.8508	0.0000
KN -> PU	0.7962	30.4581	0.745	0.846	0.0000
KN -> RP	0.7008	12.2061	0.588	0.8126	0.0000
KN -> SN	0.7405	20.2541	0.6654	0.8083	0.0000
PBC -> ATT	0.4642	4.8353	0.2846	0.6654	0.0000
PBC -> BI	0.2039	2.0462	0.0094	0.4009	0.0408
PEU -> ATT	-0.0485	0.5077	-0.2573	0.1234	0.6117
PU -> ATT	0.4889	4.4848	0.2704	0.6921	0.0000
RP -> ATT	-0.0342	0.4922	-0.1727	0.1015	0.6226
SN -> ATT	0.038	0.4638	-0.1197	0.2006	0.6428
WTC model path coefficients					
CONF -> SAT	0.5067	5.042	0.2933	0.6934	0.0000
PEU -> CONF	-0.0357	0.5195	-0.1746	0.0939	0.6034
PEU -> VAL	0.5313	9.1689	0.4156	0.6413	0.0000
SAT -> WTC	0.8553	28.2379	0.7893	0.907	0.0000
TOL -> CONF	0.0594	0.9155	-0.0641	0.1932	0.3600
TOL -> VAL	0.2042	2.4043	0.04	0.3734	0.0162
VAL -> CONF	0.8065	12.5919	0.6776	0.9294	0.0000
VAL -> SAT	0.375	4.0935	0.2004	0.5655	0.0000

Note: * p <0.05

Hypotheses Testing

Path coefficients between linked latent variables are hereby evaluated to test the suggested hypotheses and relations in the structural model. The strength of structural model's path coefficients can be understood in comparison with one another. When one path coefficient is larger than the other one linking the same endogenous variable, its influence on the endogenous latent variable is stronger. With a significant level of 0.05 or a t-distribution value greater than 1.96, eight of the offered hypotheses in the BI model and six in the WTC model are supported in this study, with the projected direction of influence and path coefficient value (*ß*) ranging from 0.17 to 0.50 being adhered to. (see table 9).

It is evident from that KN positively impacts RP (*ß* =0.7008; *p* <.001), PEU (*ß* =0.7917; *p* <.001), PU (*ß* =0.7962; *p* <.001), and SN (*ß* =0.7000; *p* <.001), thereby supporting H1, H2, H3 and H4 respectively. In similar fashion, PU and SN positively affects ATT (*ß* =0.4889; *p* <.001 and *ß* =0.0380; *p* <.001 respectively) confirming H7 and H8. In contrast, RP and PEU negatively impacts ATT (*ß* =-0.0342; *p* <.001 and *ß* =-0.0485; *p* <.001 respectively, failing to support proposed H5 and H6. Further, attitude is positively related to behavioural intention (*ß* =0.6849; *p* <.001), hence supporting H9. PBC has a positive relationship with both ATT (*ß* =0.4642; *p* <.001) and BI (*ß* =0.2039; *p* <.001), supporting H10 and H11.

For WTP model, PEU positively impacts PV (*ß* =0.5313; *p* <.001) but negatively impacts CONF (*ß* =-0.0357; *p* <.001). Hence, H1 is supported while H2 is not. The impact of TOL on VAL (*ß* =0.2042; *p* <.001) is both positive and supported, while on CONF (*ß* =0.0594; *p* <.001) is not supported. Both H5 and H6 are supported since the path coefficients of VAL influence on SAT (*ß* =0.3750; *p* <.001) and Conf (*ß* =0.8065; *p* <.001) are positive and significant. Finally, is positively and significantly linked to WTC (*ß* =0.8553; *p* <.001) hence H8 is supported.

Table 9: Hypotheses test

	Hypothesis Statement for BI composites	**Result**
H1	Farmers that are more aware about issues relating to insect farming and harvesting methods have a better perception of the risks involved in the practices.	Supported
H2	It is easier for farmers who are more aware about issues relating to insect farming and harvesting methods to employ the technologies and tools required to embrace the practices.	Supported
H3	Farmers who are more aware about issues relating to insect farming and harvesting methods see the practices as being more useful to them.	Supported
H4	More knowledgeable farmers are easily swayed by the pro-adoption sentiments from networks and people who are significant to them.	Supported
H5	Farmers' attitudes about rearing and harvesting insects are negatively impacted by their perception of the risks associated with the techniques.	Not supported
H6	Farmers are more likely to adopt and scale up insect farming and harvesting practices if the technologies and tools required for effective operations are simple to use.	Not supported
H7	Farmers that think insect farming and harvesting techniques are beneficial have a favourable attitude toward the techniques.	Supported
H8	A positive approval by networks and people who are important to farmers induces a positive attitude by farmers towards farming and harvesting insects for food and feed	Not supported
H9	Farmers' intentions to embrace and advance insect farming and harvesting practices are greatly influenced by their positive attitudes toward farming and harvesting insects for food and feed.	Supported

H10	Farmers' ability to manage their desire to begin and advance insect farming and harvesting techniques suggests that they have a more favourable attitude on the intended practices.	Supported
H11	The ability of farmers to manage their commitment to begin and advance insect farming and harvesting operations strongly suggests their behavioural intentions.	Supported

Table 10: Hypotheses test for WTC model

	Hypothesis Statement for WTC composites	**Result**
H1	Farmers' positive perceptions of how simple it is to use the equipment and tools needed for insect farming and harvesting operations indicate that they value the practices.	Supported
H2	Farmers are more likely to confirm pre-adoption projected results if they can employ the technologies and tools necessary for insect farming and harvesting methods with ease.	Not supported
H3	Farmers value raising and harvesting insects if they can tolerate pressure in the face of risks.	Supported
H4	When adopting insect farming and harvesting practices, farmers' approval of anticipated results is positively correlated with how risk-averse they are.	Not supported
H5	A favourable assessment of the value of insect farming and harvesting techniques implies confirmation of the anticipated results.	Supported
H6	A favourable assessment of the value of insect farming and harvesting methods by farmers denotes satisfaction with the current practices.	Supported
H7	Farmers who confirm the predicted results are happy with the methods they have employed in farming and harvesting insects.	Supported
H8	The farmers' desire to keep using the same techniques for insect farming and harvesting increases as their satisfaction with the results of those techniques increases.	Supported

Mediation Analysis

Simple mediation

A significant component of evaluating a structural model, according to Henseler et al. (2009), is identifying the direct and indirect links between exogenous and endogenous latent variables. Researchers can compare the direct effect of an exogenous construct to the mediator's indirect effect on the target endogenous construct using SmartPLS. This dissertation makes use of the bootstrapping technique, a tool that comes standard with SmartPLS, whereas earlier studies have evaluated the significance of mediating effects using the Sobel (1982) test.

A simple mediation analysis is conducted on the impact of PBC on BI through ATT. Specific indirect effect (multiplication of direct effect of PBC -> ATT by that of ATT -> BI) is established to be positive and significant. Thus, the "real" relationship between the PBC and BI is shown by the positive indirect effect via the mediator variable. Since the direct effect of PBC on BI is also found to be significant, it is concluded in this analysis that Attitude is a complementary mediator of PBC's effect on BI (Hair Jr, Hult, Ringle, & Sarstedt, 2021).

Multi-group analysis

Multi-group analysis (MGA) was conducted using four variables: gender, location, adoption experience, and training. The results of each permutational MGA bootstrapping, comparing two distinct groups in each test, are shown in tables 9.

The variances explained in BI for both male and female were not significantly different from each other. However, RP was weightier among men (69.73%) than women (27.63%) as explained by KN. Path coefficients analysis confirms that only KN -> RP path was significant.

Again, equal variance is assumed among farmers from Kakamega and Siaya regarding their behavioural intentions, yet more specifically from path analyses, more farmers from Kakamega than Siaya significantly perceive insect farming and harvesting practices to be more useful, easy to start or upscale, riskier, and mostly influenced by opinions from important people. KN -> PU, KN -> RP, KN -> SN, PBC -> ATT and PBC -> BI are thus significancy different in these two groups.

To understand willingness to adopt and intention to upscale, the dissertation permutated farmers without adoption experience against those with experience and bootstrapping results indicate that attitude explains 70.77% of variance in adoption (BI) for prospective farmers while it only explains 65.05% of variance in upscaling (BI) amongst experienced farmers. According to the results the differences in these Behavioural intentions are nevertheless not significant. However, a closer look at path coefficients reveals significant differences along KN -> PU, KN -> RP, KN -> SN, and SN -> ATT paths, signifying that more prospective farmers believe that they perceive insect farming and harvesting practices to be more useful as their knowledge increase. Moreover, with improved knowledge their perception of risks in the practice also increases compared to adopters. On the contrary, more adopters than non-adopters think that they easily subdue to pro-upscaling sentiments by important people as they gain more knowledge in the practice. Again, more adopters believe that their attitude towards insect farming and harvesting improves as important people in their lives approve their decision to upscale.

Finally, the influence of training on farmer's willingness to adopt or upscale insect farming and harvesting techniques was tested where the trained farmers were pitted against the untrained. From the MGA results presented in table 9, more trained farmers expressed higher variances in BI (68.74%) than untrained (63.31%). However, the other dependent variables showed the opposite. The untrained farmers significantly perceived more risks, found it easier to use insect farming and harvesting technologies, and were more swayed by opinions from their important social networks, compared to the trained farmers. These are enumerated in table below.

Table 11: Multigroup Analyses

	Original (Female)	Original (Male)	Original difference	2.50%	97.50%	Permutation p values
ATT -> BI	0.6588	0.6757	-0.017	-0.3717	0.3768	0.9342
KN -> PEU	0.7743	0.8051	-0.0308	-0.1283	0.1192	0.6378
KN -> PU	0.8256	0.7725	0.0531	-0.106	0.1033	0.3212
KN -> RP	0.5257	0.8351	-0.3094	-0.2354	0.236	0.0098*
KN -> SN	0.774	0.7107	0.0634	-0.1494	0.1452	0.4096
PBC -> ATT	0.5273	0.4269	0.1004	-0.3822	0.3965	0.6136
PBC -> BI	0.2625	0.2021	0.0605	-0.407	0.3843	0.7732
PEU -> ATT	-0.1074	0.0054	-0.1129	-0.4051	0.3761	0.5688
PU -> ATT	0.5306	0.4101	0.1204	-0.4583	0.4256	0.5794
RP -> ATT	-0.07	0.0106	-0.0807	-0.2791	0.2732	0.5634
SN -> ATT	-0.0008	0.0651	-0.066	-0.3347	0.3386	0.6952

	Original (Siaya)	Original (Kakamega)	Original difference	2.50%	97.50%	Permutation p values
ATT -> BI	0.8139	0.5225	0.2914	-0.3926	0.3842	0.144
KN -> PEU	0.3903	0.866	-0.4757	-0.1278	0.1201	0.0000*
KN -> PU	0.6531	0.7944	-0.1414	-0.107	0.1025	0.0068
KN -> RP	0.2432	0.9164	-0.6733	-0.2352	0.2337	0.0000*
KN -> SN	0.3898	0.7963	-0.4065	-0.1508	0.143	0.0000*
PBC -> ATT	0.1589	0.6982	-0.5393	-0.3873	0.4065	0.0066*
PBC -> BI	0.0431	0.3842	-0.3411	-0.4125	0.4177	0.1056
PEU -> ATT	0.0582	-0.1068	0.165	-0.4351	0.373	0.4180
PU -> ATT	0.6154	0.18	0.4354	-0.4657	0.4562	0.0624
RP -> ATT	0.0005	0.1787	-0.1783	-0.2949	0.2879	0.2120
SN -> ATT	0.2576	-0.0498	0.3075	-0.3391	0.3446	0.0738

	Original (WithExperience)	Original (WithoutExperience)	Original difference	2.50%	97.50%	Permutation p values
ATT -> BI	0.5487	0.6948	-0.1461	-0.4027	0.3954	0.4646
KN -> PEU	0.7224	0.828	-0.1057	-0.1315	0.1248	0.1046
KN -> PU	0.6183	0.8733	-0.255	-0.1085	0.1053	0.000*
KN -> RP	0.6056	0.8504	-0.2448	-0.2377	0.2411	0.045*
KN -> SN	0.8363	0.6618	0.1745	-0.1547	0.1465	0.0208
PBC -> ATT	0.2162	0.4577	-0.2414	-0.3977	0.4395	0.2510
PBC -> BI	0.3382	0.1765	0.1617	-0.4244	0.4211	0.4514
PEU -> ATT	-0.0871	-0.0129	-0.0742	-0.4507	0.3768	0.7178
PU -> ATT	0.3414	0.6505	-0.309	-0.4907	0.4598	0.1910
RP -> ATT	-0.0607	-0.168	0.1073	-0.3153	0.3096	0.4674
SN -> ATT	0.4984	-0.0397	0.5381	-0.3479	0.3576	0.003*

	Original (NotTrained)	Original (Trained)	Original difference	2.50%	97.50%	Permutation p values

CONF -> SAT	0.5994	- 0.1612	0.7606	-0.2994	0.3682	0.0000*
PEU -> CONF	0.061	0.1029	-0.0418	-0.2559	0.2676	0.7464
PEU -> VAL	0.5498	0.2539	0.2959	-0.1823	0.2088	0.0036*
SAT -> WTC	0.8167	0.7682	0.0486	-0.1237	0.1926	0.5196
TOL -> CONF	0.0571	- 0.0135	0.0705	-0.216	0.1954	0.5068
TOL -> VAL	0.1111	0.4355	-0.3244	-0.2826	0.2574	0.0168*
VAL -> CONF	0.6681	0.7932	-0.1251	-0.2287	0.2727	0.3248
VAL -> SAT	0.3	0.6557	-0.3558	-0.3093	0.2801	0.0168*

Note: * *p* <0.05

Moderation Relationship

Moderation may (and should) be viewed as a way to account for data heterogeneity (Hair Jr, Hult, Ringle, & Sarstedt, 2021). Figure 11 and 12 is shown to further aid in the comprehension of the moderator and specifically analyses the impact of training on the correlations between ATT and BI and PBC and BI. Interestingly, there is a stronger relationship between attitude and BI among trained farmers. However, training weakens the link between behavioural intention and perceived behavioural control.

Figure 11: Stronger correlation between ATT and BI moderated by training

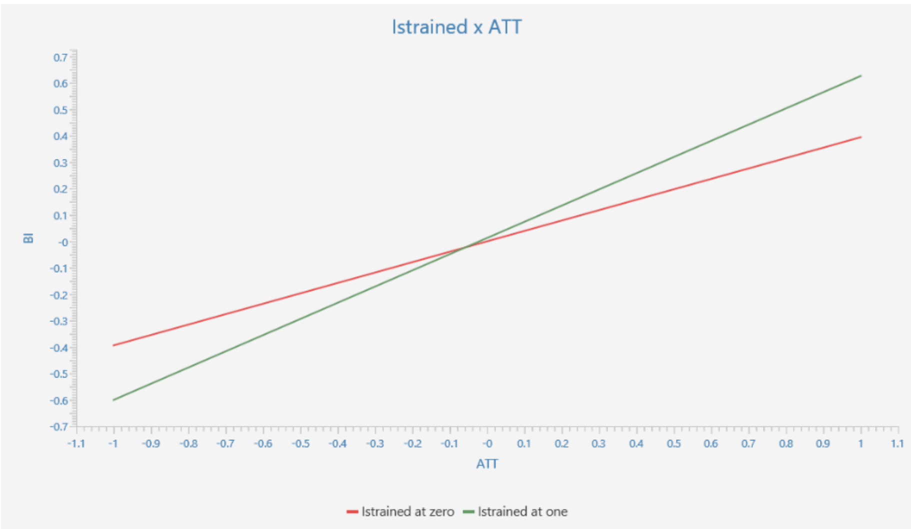


Figure 12: Weaker correlation between PBC and BI moderated by training

Chapter 5 Summary

The three primary aims of the study are examined in this chapter by testing key statistical parameters. Using PLS-SEM path analysis, the study focuses on prediction-oriented multiple regression (pls), where the main outcome variables (behavioural intentions and willingness to continue) are fitted on chained predictor variables. Attitude and Satisfaction are used respectively as direct and mediating contributors to each of these outcome variables.

SmartPLS is used to evaluate the significance and influence of hypothesized linkages. First, construct reliability and validity, as well as discriminant validity tests, guarantee that appropriate quality criteria are adhered to such that only valid and reliable measurement items are utilized in evaluation of correlations and resultant weights among the components in subsequent analysis. The hypotheses proposed in this dissertation are then tested by evaluating the structural model using well loaded indicator data.

Upon dropping indicators with questionable loadings, all constructs had composite reliability scores greater than 0.6, signifying internal consistency. This ensured that retained item loadings used were significant at the level of 0.001 and fell within the prescribed cut-off range, and hence reliable for the final structural model analysis. Additionally, the measurement model showed acceptable convergent and discriminant validity, with final AVE values falling within the suggested range. All retained manifest variables also correlated more with their corresponding latent variables, and the square roots of AVE of each construct were greater than their intercorrelation, affirming conformity with the Fornel and locker criterion. Finally, and most importantly, the HTMT ratio were all below 0.85 as guided by emerging literature, approving the proposed measurement items fitness for path analysis.

Subsequently, the structural model's validation yielded positive results, with an overall R^2 range of modest to considerable. Once more, the significance criterion of 0.05 was reached for eight of the presented hypotheses in the BI model and six in the WTC model and thus were supported.

In evaluating significant interaction effects among the constructs, mediation and moderation analyses are herein conducted. The dissertation bypasses traditional Sobel's test and Hayes' maroProcess and instead opts for inbuild non-parametric bootstrapping procedure to determine the significance of indirect effect brought about by the mediator and compares this with that of the direct effect. Both simple and serial mediation are found to be significant. Also, in examining the moderating effect of training on the effect of exogenous variables (ATT and PBC) on BI, it is established in this dissertation that the relationship between ATT and BI is stronger among trained farmers. However, the influence of PBC on BI is weakened by training.

This study also explored whether there are any discernible and significant disparities among pre-defined data groups (gender, location, adoption experience, and training) concerning their willingness to adopt, upscale and continue with insect farming and harvesting practice. Adoption experience significantly divided the respondents into those who were willing to adopt and those willing to upscale based on their scores on BI.

CHAPTER SIX

CONCLUSION

Overview

This chapter discusses results presented in chapter 5, as well as theoretical and managerial implications emanating from the findings of this dissertation.

Overall research findings

The main objective of this dissertation was to investigate the factors that motivate farmers' intentions to start, upscale and continue with insect farming and harvesting practices. In this study, combined theory of planned behaviour and technology acceptance model were used to model farmers' adoption and upscaling behaviour. In addition, the study also modelled the willingness of farmers to continue with insect farming and harvesting practices. Knowledge was used as antecedent to Risk Perception, Perceived Ease of Use, Perceived Usefulness and Subjective Norms which in turn fed into Attitude. Perceived Behavioural intention also was hypothesised to cause attitude and these two predicted Behavioural intentions. The result indicated that the path along Knowledge, Perceived Usefulness, and Attitude was the best likely to predict Behaviour intentions. However, to understand whether these were the most significant factors, an importance-performance map was derived from SmartPLS.

Evidently, while Perceived Behavioural Control recoded a lower regression weight on Behavioural Intention, its performance in predicting BI was high. As such, in addition to Knowledge, Perceived usefulness, and attitude, it is important to include Perceived Behavioural Control when analysing intentions.

For the second model, Risk Tolerance and Perceived ease were hypothesised to predict both Perceived value and confirmation while both perceived value and confirmation predicted satisfaction. Ultimately, satisfaction was modelled to predict Willingness to continue. The results established that Perceived Ease of Use, Perceived value, Confirmation and Satisfaction offered the perfect combination of factors that would predict farmers willingness to continue with insect farming and harvesting practices. These sentiments were indeed reflected in the Importance-Performance map extracted from SmartPLS.

A multigroup analysis indicated non-significant outcomes for both outcome variables but significant differences were seen in other predictor variable paths. More specifically, Subjective Norms, Risk Perception and Perceived ease of use differed significantly amongst the groups permutated.

Theoretical Implications

A couple of theoretical implications can be drawn from this research. The research enhances the understanding of farmers' behavioural intentions and their motives for continuing with these behaviours. Specifically, it corroborates the idea that psychometric indicators are quite relevant in predicting outcome irrespective of the overall aim on the side of farmers.

Again, this dissertation integrates ideas from commonly used theoretical frameworks in order to strengthen predictability of behaviour. The theory thus magnifies the impact of antecedents used in early frameworks by combining the most important constructs as evidenced by results of longitudinal research and adding other exogenous variables from normative research. Thus, this dissertation broadens the theoretical domain of adoption intentions and willingness to continue with adoption.

Moreover, this dissertation emphasises the role of pioneer studies and resultant theoretical propositions amidst the thirst for newer frameworks. By merging new constructs with ones already appraised in existing studies, it is expected that the current research extends new constructs to be tested. For instance, it will be interesting for future models to use Knowledge and Risk Perception as direct predictors of behavioural intentions.

Finally, the current adoption literature always tends to predict adoption intentions. By assessing farmers willingness to continue with adoptions, it is projected herein that the result would inspire future inquiries into the relevance of innovations and technologies that are introduced to people, by comparing pre-adoption expectations with post adoption satisfaction.

Managerial Implications

The current challenge is to ensure food security for the growing global population. New alternatives as identified in this dissertation do come with challenges which must be avoided. This dissertation acknowledges the importance of farmers in filling in food security and nutrition gaps by adopting and continuing with sustainable alternatives to deleterious production systems. However, it is farmers themselves who have the capability to decide to take up and continue with these new practices. Therefore, as the study establishes, knowledge and training are of paramount importance. It is important that organizations and firms involved in disseminating insect farming and harvesting practices to demonstrate and support farmers in understanding the usefulness and worth of these practices. In so doing, farmers attitude and satisfaction will improve thereby ensuring sustainable of new practices. Most importantly, basic introductory training is not sufficient. Continuous learning, guidance and motivation are key to ensuring that farmers find a competitive edge in insect markets, by boosting their confidence and appetite for more engagement in novel practices.

The dissertation also highlights the importance of preferential treatment of diverse groups of farmers when introducing and pushing for new innovations. Confounding factors such as gender roles must thus be considered if insect farming and harvesting practices are to be promoted.

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Appendix

Appendix 1: Survey questionnaire

For detailed survey, kindly visit https://kf.kobotoolbox.org/accounts/login/?next=%2F%23%2F#/
Login: Username- owuor2527 Password- farmersstudy
Section 1: Demographic Information

I. Farm location: County_____________

II. Your telephone number (to be used for follow-up) __________________________

III. What is your gender?
   - Female
   - Male

IV. In which year were you born? _________________________

V. How many members form your family? _________________

VI. Of these, how many are directly dependent on you for basic survival? ____

VII. How many of them do you directly depend on for basic survival? _________

VIII. What is the highest level of education that you have achieved?
   - None
   - Basic Elementary education (Not completed Primary)
   - Primary education
   - Secondary education
   - Tertiary Education

IX. What is the size of your farm in acres? ______________________

X. For how long (in years) have you been farming? _____________

XI. What is your major farm operation(s) (Select all that apply)?
   - Crop production
   - Fish Farming
   - Pig Farming
   - Poultry Farming
   - Sheep Farming
   - Cattle farming
   - Insect farming
   - Others, please specify _____________

XII. Do you have other sources of income aside from farming? ___
   - Yes
   - No

XIII. How many people (including family members) are directly involved in your farm activities? ________________

XIV. Do you consider your farm a profit-making/business operation?
   - Yes
   - No

XV. How would you gauge the performance of your farm business?
   - Extremely good
   - Somewhat good
   - Neither good nor bad
   - Somewhat bad

- Extremely bad

XVI. How would you rate the ability of your farm to meet your household food and feed need?
  - Extremely satisfactory
  - Somewhat satisfactory
  - Neither satisfactory nor inadequate
  - Somewhat inadequate
  - Extremely inadequate

Section 2: Adoption, upscaling, and Continuation Intention of insect farming.
Kindly indicate how much you agree or disagree with the following statements regarding your knowledge on insects as food and feed ***(henceforth, 1 signifies strongly disagree, 2-Somewhat disagree, 3-Neither agree nor disagree, 4-Somewhat agree and 5-Strongly agree)***

Source	**Knowledge**		**1**	**2**	**3**	**4**	**5**
	KN1	I am not aware that insects can be farmed for food and feed					
	KN2	I have been looking for information regarding the use of Insects as sources of food and animal feed					
	KN3	I am already aware of what it means to be an Insect farmer					
	KN4	I am well conversant with information regarding the requirements for farming Insects.					
	KN5	I am fully aware of the companies and institutions that are involved in Insect farming					

Please choose one option from below that best describes your experience in insect farming.
- I am currently farming insect
- I started farming insects but have abandoned it halfway
- I am currently not farming insects but would like to start
- I am not at all interested in insect farming

Please indicate if you have received any training in insect farming techniques
- Yes
- No

Kindly elaborate on what the training was all about______________________
Kindly indicate how much you agree or disagree with the following statements:

Source	**Risk Tolerance**		**1**	**2**	**3**	**4**	**5**
(Hannus & Sauer, 2021)	RT1	I would prefer certainty over uncertainty when making farm investment decisions					
(Hannus & Sauer, 2021)	RT2	I often avoid risks when deciding for my farm					
(Hannus & Sauer, 2021)	RT3	I am very fond of taking financial risks					

(Hannus & Sauer, 2021)	RT4	I like to play it safe when investing in my farm					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Risk Perceptions**		**1**	**2**	**3**	**4**	**5**
		I think it will be riskier to run and expand insect farm operation because…					
(Slijper et al., 2020)	RP1	I will quite often experience input price fluctuations					
(Slijper et al., 2020)	RP2	I would receive low prices for my insect products in the market					
(Slijper et al., 2020)	RP3	I would exhibit low bargaining power towards my customers					
(Slijper et al., 2020)	RP4	I would exhibit low bargaining power towards my input suppliers					
(Slijper et al., 2020)	RP5	I would have limited access to loans from the banks					
(Slijper et al., 2020)	RP6	I will be receiving late payment from my buyers					
(Slijper et al., 2020)	RP7	I will have very limited skilled labourers					
(Slijper et al., 2020)	RP8	It will be difficult for me to focus on the farm due to illness or other personal circumstances					
(Slijper et al., 2020)	RP9	I am not sure of the future of the insect farm with regards to succession					
(Slijper et al., 2020)	RP10	I will be facing so many strict regulations regarding safety and environmental standards					
(Slijper et al., 2020)	RP11	the public still distrust the idea of eating insects or using them as animal feed source					
(Slijper et al., 2020)	RP12	the society as whole has not accepted the concept of insect as food and feed					
	RP13	There is no proven results or success stories of Insects farms					
	RP14	The design or structure of my farm is in such a way that it can accommodate surges and shortages in the supply of Insects and acquisition of labour and inputs					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Perceived Usefulness**		**1**	**2**	**3**	**4**	**5**
(Slijper et al., 2020)	PU1	Insect farming is an urgent farming practice in the current times					
(Slijper et al., 2020)	PU2	Insect farming has the benefit of protecting and conserving environment					
(Slijper et al.,	PU3	Farming Insects saves time					

2020)							
(Slijper et al., 2020)	PU4	By practicing Insect farming, my income will significantly increase					
(Slijper et al., 2020)	PU5	There is more profit and less cost for farmers who practice Insect farming					
(Slijper et al., 2020)	PU6	Insect farming will have less pressure on my farm resources					
(Slijper et al., 2020)	PU7	My technical capacity will significantly increase by farming Insects					
(Slijper et al., 2020)	PU8	farming Insects is more efficient than other farm operations					
(Slijper et al., 2020)	PU9	It requires few labours to run a successful Insect farm operation					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Perceived ease of use**		**1**	**2**	**3**	**4**	**5**
	EOU1	Running an Insects farm will be clear and understandable					
	EOU2	Insect operations are quite flexible with my needs					
	EOU3	It will be easy to learn how to successfully run an Insects farm operation					
	EOU4	it will be very easy for me to acquire the skills and expertise needed to run Insects farms					
	EOU5	I would find it easy to use the technologies and equipment often used in Insects farms					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Personal Attitude**		**1**	**2**	**3**	**4**	**5**
(Diaz et al., 2021)	ATT1	I like the idea of farming insects					
(Spears & Singh, 2004)	ATT2	I have positive feelings at the thought of farming insect					
(Spears & Singh, 2004)	ATT3	Farming insects is a pleasant experience					
(Spears & Singh, 2004)	ATT4	I feel convinced that farming insect is necessary					
(Borges et al., 2016)	ATT5	I like working with insects for food and feed					
(Borges et al., 2016)	ATT6	I look forward to those aspects of my farm life that require me to work with insects for food and feed					
(Spears & Singh, 2004)	ATT7	unlikeable					
(Borges et	ATT8	unimportant					

al., 2016)							

Kindly indicate how much you agree or disagree with the following statements:

	Perceived Behavioural Control		**1**	**2**	**3**	**4**	**5**
(Smith, 2015)	PBC1	I am confident that I can practice insect farming for food or animal feed in my farm this year					
	PBC2	It will be entirely up to me whether or not I farm insects for food or feed in my farm					
	PBC3	My using farming insects in my farm would demand more planning time.					
	PBC4	If it will require me to bring resources that place unprecedented demands on my time, it will make it more difficult for me to raise insects for food or feed in my farm					
	PBC5	I have the knowledge and ability to farm insects for food and feed.					
	PBC6	If I wanted to, I could easily farm insects for food or feed in my farm					
	PBC7	If I am required to commit more time to developing my skills and revamping my farm to accommodate insect farming, it would make it more difficult for me farm insects for food and feed this year					

Kindly indicate how much you agree or disagree with the following statements:

	Subjective Norms		**1**	**2**	**3**	**4**	**5**
(Smith, 2015)	SN1	Most people who are important to me professionally think I should farm insects.					
(Smith, 2015)	SN2	Customers to whom I sell my farm products would approve my farming of insects for food or feed					
(Smith, 2015)	SN3	My Farmers' group would approve my farming insects for food or feed					
(Smith, 2015)	SN4	Generally speaking, I do what most people who are important to me professionally think I should do.					
(Smith, 2015)	SN5	The food authority that certifies farmers would approve my farming insects for food or feed					

			1	2	3	4	5
(Smith, 2015)	SN6	It is expected of me that I farm insects for food or feed in my farm					

Please indicate how much you agree or disagree with the following statements regarding your intention to adopt the practice of farming insects for food and feed

Source	**Adoption intention**		**1**	**2**	**3**	**4**	**5**
	INT1	I can imagine farming Insects in my farm in the next two years.					
	INT2	I have been thinking of farming Insects in my farm.					
	INT3	Given sufficient resources, I would farm Insects.					
	INT4	In my farm, Insects could be introduced without major changes in my farm operation, even to the levels surpassing the set insect farming standards					
	INT5	Insect farming will certainly be part of my farm operation.					
	INT6	I will be willing to borrow money or breeding stocks from my neighbours and relatives for use in Insect farming					
	INT7	Success or failure of any insect farming operation is not an issue for my farm					

To what extent do you agree that the following will affect decision to continue with Insect farming?

Source	**Farm management and farm business environment**		**1**	**2**	**3**	**4**	**5**
	size	Size of the farm operation					
	champ	Having exclusive knowledge and expertise on insect farming techniques					
	support	farm management support					
	needs	fulfilment of most farm needs					
	turnover	average farm turnover					
	competition	competition from other farmers or traders					
	inputs	Continuous supply of farm inputs ()					
	loyalty	customer loyalty					
	market	market proximity					
	organization	Farmer’s ability and capacity to organize resources					
	consultancy	farmers experience with consultancy and endowment with technical skills					
	developed	farmers participation in trainings, knowledge creation and					

			1	2	3	4	5
		development					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Actual Adoption**		**1**	**2**	**3**	**4**	**5**
	Adopt1	I have allocated a space in my farm specifically for farming insects					
	Adopt2	I have made contacts with substrate and breeding stocks suppliers to make supplies in my farm					
	Adopt3	I have secured customers to whom I will be selling insects					
	Adopt4	My family are providing labour and resources towards developing an insect					
	Adopt5	I sometimes feed my family and livestock with food made of insects that are raised in my farm					

Continuation intention
Kindly indicate how much you agree or disagree with the following statements:

Source	**Perceived Value**		**1**	**2**	**3**	**4**	**5**
(Dodds et al., 1991)	PV1	I believe that the insects that I farm are a value for my money					
	PV2	I consider the insects which raise in my farm to be a good investment					
	PV3	I get what I spend for when I raise insects in my farm					
	PV4	My customers get the worth of the money they spend in purchasing my insect products					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Perceived Enjoyment**		**1**	**2**	**3**	**4**	**5**
(Moon & Kim, 2001)	PE1	Farming insects is a pleasurable experience					
	PE2	I have fun with farming insects					
	PE3	I find farming insects to be interesting					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Satisfaction**		**1**	**2**	**3**	**4**	**5**
(Oliver, 1980b)	SAT1	I am satisfied with my decision to introduce insects in my farm					
	SAT2	My choice to raise insects in my farm was a wise one					
	SAT3	I think I did the right thing by introducing insects in my farm					
	SAT4	I am pleased with the experience of farming insects					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Confirmation**		**1**	**2**	**3**	**4**	**5**
(Bhattacherjee, 2001)	CON1	My experience with farming insect was better than what I expected					
	CON2	The yield and revenue that come from my insect farm is/was/ will be better than I expected					
	CON3	Overall, most of my experience with insect farming were confirmed					

Kindly indicate how much you agree or disagree with the following statements:

Source	**Willingness to continue**		**1**	**2**	**3**	**4**	**5**
(Bhattacherjee, 2001)	CI1	In my farm, I will raise insects on a regular basis					
	CI2	I will be a frequent insect farmer in the future					
	CI3	I will strongly recommend other farmers in my neighbourhood to farm insects					

Appendix2: Preliminary measurement model assessment

Table 12: Initial Measurement assessment

Factor	Indicator	Outer loadings	Cronbach's alpha	rho_A	Composite reliability	Average variance extracted (AVE)
			BI Model			
ATT	ATT1 <- ATT	0.8675	**0.9359**	**0.9396**	**0.9356**	**0.7089**
	ATT2 <- ATT	0.7749				
	ATT3 <- ATT	0.8942				
	ATT4 <- ATT	0.7354				
	ATT5 <- ATT	0.9317				
	ATT6 <- ATT	0.832				
BI	BI1 <- BI	0.9042	**0.9195**	**0.9331**	**0.9217**	**0.6327**
	BI2 <- BI	0.86				
	BI3 <- BI	0.7892				
	BI4 <- BI	0.8763				
	BI5 <- BI	0.8564				
	BI6 <- BI	0.6752				
	BI7 <- BI	0.5399				
KN	KN1 <- KN	0.8841	**0.9198**	**0.9249**	**0.9214**	**0.7021**
	KN2 <- KN	0.8666				
	KN3 <- KN	0.8773				
	KN4 <- KN	0.8267				
	KN5 <- KN	0.7244				
PBC	PBC1 <- PBC	0.8708	**0.7624**	**0.8433**	**0.7323**	**0.3744**
	PBC2 <- PBC	0.074				
	PBC3 <- PBC	0.1923				
	PBC4 <- PBC	0.7445				
	PBC6 <- PBC	0.7508				
	PBC7 <- PBC	0.5722				
PEU	PEU1 <- PEU	0.7662	**0.9210**	**0.9263**	**0.9218**	**0.7035**
	PEU2 <- PEU	0.7651				
	PEU3 <- PEU	0.8587				
	PEU4 <- PEU	0.8577				
	PEU5 <- PEU	0.9337				
PU	PU1 <- PU	0.3143	**0.8852**	**0.9143**	**0.8842**	**0.4822**
	PU2 <- PU	0.2748				
	PU3 <- PU	0.8239				
	PU4 <- PU	0.6942				
	PU5 <- PU	0.8089				
	PU6 <- PU	0.7953				
	PU7 <- PU	0.6225				
	PU8 <- PU	0.79				
	PU9 <- PU	0.8403				
RP	RP1 <- RP	0.3203	**0.8261**	**0.6592**	**0.1034**	**0.1111**

	RP10 <- RP	-0.0389				
	RP11 <- RP	-0.1163				
	RP12 <- RP	-0.1621				
	RP13 <- RP	-0.2886				
	RP14 <- RP	0.5615				
	RP2 <- RP	-0.1038				
	RP3 <- RP	0.15				
	RP4 <- RP	0.247				
	RP5 <- RP	0.5082				
	RP6 <- RP	0.4888				
	RP7 <- RP	-0.3811				
	RP8 <- RP	0.3777				
	RP9 <- RP	-0.3647				
	SN1 <- SN	0.774				
	SN2 <- SN	0.8607				
SN	SN3 <- SN	0.8237	**0.8804**	**0.8949**	**0.8809**	**0.5588**
	SN4 <- SN	0.7738				
	SN5 <- SN	0.4844				
	SN6 <- SN	0.7078				
		WTC Model				
	CI1 <- CI	0.4298				
	CI2 <- CI	0.6933	**0.5925**	**0.6450**	**0.6195**	**0.3603**
CI	CI3 <- CI	0.6446				
	CONF1 <- CONF	0.724				
	CONF2 <- CONF	0.8473	**0.8033**	**0.8117**	**0.8043**	**0.5798**
CONF	CONF3 <- CONF	0.7052				
	PEU1 <- PEU	0.2839				
	PEU2 <- PEU	0.7964				
	PEU3 <- PEU	0.6453	**0.7835**	**0.7880**	**0.7472**	**0.3902**
	PEU4 <- PEU	0.5867				
PEU	PEU5 <- PEU	0.6898				
	SAT1 <- SAT	0.6098				
	SAT2 <- SAT	0.753	**0.7819**	**0.8019**	**0.7856**	**0.4832**
	SAT3 <- SAT	0.8152				
SAT	SAT4 <- SAT	0.5739				
	TOL1 <- TOL	0.8086				
	TOL2 <- TOL	0.1915	**0.4143**	**0.6481**	**0.3646**	**0.2175**
	TOL3 <- TOL	-0.0767				
TOL	TOL4 <- TOL	0.4167				
	VAL1 <- VAL	0.5092				
	VAL2 <- VAL	0.4983	**0.6313**	**0.6544**	**0.6382**	**0.3109**
	VAL3 <- VAL	0.5017				
VAL	VAL4 <- VAL	0.6959				