DEVELOPMENT OF A DIFFUSION MODEL FOR AGRO-TECHNOLOGIES INNOVATION FOR RESEARCH AND DEVELOPMENT ORGANISATIONS IN TANZANIA

BY

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ABSTRACT

Research and development (R&D) organisations in Tanzania use old systematic design models that focus on the mere agro-technologies prototypes development, instead of innovation of agro-technology for diffusion. A serious gap exists in the incorporation of the agro-technologies diffusion factors in design models in R&D organisations in Tanzania. The twin valley of technology death describes the technology development failures based on business vision disregard. Technology prototypes or services are developed, though are not linked to business setup, and that they don't get ripe to earn money through commercial sales. This study identified that there is no customised model for agro-technology diffusion in research and development organisations in Tanzania. Structured questionnaires, interview with R&D organisation staffs and stakeholders and observation of activities in these R&D organisations were used to collect data from sources identified. Literatures on engineering design, technology development for diffusion and various models for innovation were studied. The factors that were linked with agro-technology were identified and their related variables and hence the model was developed, that proved to be useful in guiding technology developers in ensuring the good final diffusion of technologies to above 95% significant level. Regression analysis and system dynamic model development and analysis were used to organise identified factors into agro-technology innovation diffusion model. The model was calibrated and validated using data collected from various R&D organisations in Tanzania between the year 2011and 2013. Factors that were included in the model are: relevance of needs identification, need identification, interpretation of variable into design specification, agro-technology validation process, agro-technology information generation and proper agro-technology packaging and agro-technology development stages importance. These factors were found to affect agro-technology diffusion at a rate between 10 and 65%. It was noted that the development of technology for diffusion is more than the prototype development. By using the model with its user interface provides guidance to agro-technology developers that the control of innovation diffusion is above 95% confidence interval. However further work to improve the model especially on time adjustment and other socioeconomic factors like human resource requirement, fixed capital and R&D organisation rationalisation in Tanzania that has to be done.

DECLARATION

I, **Fredrick Michael Sanga**, do hereby declare to the Senate of the Sokoine University of Agriculture. Morogoro, Tanzania. That this is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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DEDICATION

To the almighty God, to my late mother Mary Sanga, to my wife Juliana Sanga and my farther Michael Sanga.

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LIST OF ABBREVIATIONS AND SYMBOLS

AKIS	Agricultural Knowledge and Innovation Systems
AT	Agro-technology
ATDF	Agro-technologies Diffusion Factors
BRELA	Business Registrations and Licensing Agency
CA	Customer Attribute
CAMARTEC	Centre for Agricultural Mechanisation and Rural Technology
CBI	Content Based Instruction
CCT	Cambridge Chemical Technologies
CDFC	Conceptual Design For Capacity
CE	Concurrent Engineering
CIS	Commonwealth of Independent States
CMA	Centre for Management in Agriculture
CoET	College of Engineering and Technology
CRDB	Cooperative Rural Development Bank
CSR	Corporate Social Responsibility
CTS	Critical to Satisfaction
DAMDV	Define Analyse Measure Design Verify
DFSS	Design For Six Sigma
DIT	Dar es Salaam Institute of Technology
DSS	Decision Support System
DST	Decision Support Tool
DV	Design Validation
EDT	Expected Design Trend
EU	European Union
EUROSTAT	European Statistics

FMEA	Failure Mode and Effect Analysis
FR	Function Requirement
GTZ	Gesellschaft für Technische Zusammenarbeit
GUI	Graphic User Inter-phase
IDS	Identified Design Specification
IDV	Interpretation Design Variables
INTERPI	Interpretation Index
ISO	International Standard Organization
ITSBIC	Institute of Technology Sligo Ballinode Ireland cumpas
LDC	Least Developed Countries
MVIWATA	Mtandao wa Vikundi vya Wakulima Tanzania
MAFC	Ministry of Agriculture, Food Security and Cooperatives
NBC	National Bank of Commerce
NEEDI	Need identification
Needi	need identification
NEEDR	Need relevance
Needr	need relevance
NIIR	National Institute of Industrial Research
NMB	National Microfinance Bank
NPD	New Product Development
NPL	New Product Launching
OECD	Organisation for Economic Co-operation and Development
PIR	Post Implementation Review
PMI	Project Management Institute
QFD	Quality Function Deployment
REPOA	Research on Poverty Alleviation

RNR	Rate of Need Reflection
S&T	Science and Technology
SACCOS	Savings and Credit Cooperative Societies
SCAR	Standing Committee on Agricultural Research
SD	System Dynamics
SHS	Stakeholders' Satisfaction
SI	Stage Index
SIDO	Small Industries Organization Development
STDIN	Stages Index
STI	Science Technology and Innovation
SUA	Sokoine University of Agriculture
TAI	Technology Achievement Index
TATC	Tanzania Automotive Technology Centre
TDI	Technology Diffusion Index
TDTC	Technology Development and Transfer Centre
TEMDO	Tanzania Engineering and Manufacturing Design Organisation
TIB	Tanzania Investment Bank
TIC	Tanzania Investment Centre
TIG	Technology Information Generation
TINFA	Technology Information Availability
TIRDO	Tanzania Industrial Research and development Organization
TPAVA	Technology Package Availability
TPC	Technology Package Completeness
TQM	Total Quality Management
TRA	Tanzania Revenue Authority
TRIZ	Theory of Inventive Problem Solving

TU	Technology Un-appropriateness
TV	Technology Validation
TVAL	Technology Validation
tval	Technology Validation
UDSM	University of Dar es Salaam
UK	United Kingdom
United Kingdom	United Nations
URT	United Republic of Tanzania
VETA	Vocational Education and Training Authority

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Diffusion of agro-technologies innovation is among the main drivers of economic development of countries that are heavily depending on agriculture activities. However, according to Koshuma (2005) and URT (2010b), while developed nation have achieved 100% innovation targets in Agro-technologies diffusion, sub Saharan countries are below 2% of the needed technology diffusion rate. For example, while 80% of Tanzanians depend on agriculture, only 1% of agro-products are processed compared to 20-70% in medium level countries (Mukani, 2003). The poor performance in value addition to agro-product is attributed to poor diffusion of agro-technologies innovation (URT, 2012b; EU-SCAR, 2012). According to Arnold and Guy (2000), research and development (R&D) organisations has historically focused on the agro-technologies innovation-creation process, without investing on diffusion of the innovations.

For many years, through R&D organisations, Tanzania has been undertaking significant scientific researches in agro-technology development. However, most of the research results have not been translated into tangible products, processes and services for development purposes (URT, 2010b; Koshuma, 2005). The Technology Achievement Index (TAI), used to measure how well a country is creating and diffusing technology, ranks Tanzania at 70 out of 72 Least Developed Countries (LDC) (Banji and Gehl, 2007). This shows how poor diffusion of innovations is in Tanzania.

Most of Agro-technologies developed, adapted or adopted in Tanzania do not diffuse into the market. Few examples are; Sorghum Processing Technology imported from Botswana (Cecil, 1992; Gordon *et al.*, 2002; Schmidt, 1988; Rooney, 2003), Rural Road Compacting Machine developed by CoET (Dugushilu *et al.*, 2010), tractor developed by CARMATEC, Cassava Processing Machines developed in Morogoro (Adebayo, 2004) and the recently developed TATC power tiller.

An innovation diffusion model for agro-technology can be defined as a representation of empirical objects, phenomena, and physical processes in a logical and objective way, used by a network of organizations, enterprises, and individuals that focuses on bringing new products, processes, and forms of organization into agricultural economic use (Rajalahti *et al.*, 2008; Edquist, 2001; OECD, 2008; Jörg, 2007; Hurst, 1999; Simona *et al.*, 2007; Tassey, 1992; Brodén, 2005; Mmasi, 2007; OECD, 1997).

Most design models that do exist are prototype development models. It is unfortunate that these models lack forward and backward integration of technology development factors that affect agro-technologies innovation diffusion. Dym's, Pahl and Beitz's and Shigley's are example of models that are used in Tanzania; however these models are for prototype development. As a result a prototype like two wheel tractor developed by Tanzania Automobile Technology Centre (TATC) has been developed, but has never diffused.

Other models that exists like stage gate (Cooper, 2009; 2010) which is not understood in Tanzania and its main objective is to cut the technology development cost, by narrowing the numbers of technology developed in R&D, rather than pushing technology diffusion, this model has been used in Japan and resulted in reduction of R&D costs by 30%. Models like triple helix (Farinha and Ferreira, 2012) and concurrent engineering (Hall, 1991) have been useful in developed world due to advanced technology infrastructure existing. In recent years there has been a move from study of model from static to dynamic approaches to harness the reality of model performance (Wunderlich and Größler, 2012); however this has not been done looking at Agro-technologies innovation diffusion in R&D organisations. In Tanzania, the existing models need to be worked upon, taking into account local factor that affect agro-technologies diffusion in the technology development processes.

Poor agro-technologies development processes are evident in Tanzania due to lack of appropriate model used to develop the same Agro-technologies Factors that affect agro-technology diffusion need to be identified. The focal point is the use of these local factors in the technology development. The model should guide technology developers to come up with the diffusing technology.

1.2 Statement of Problem

Innovation Diffusion is a driving force for economic development, with about 50% growth contribution in the 21st century (URT, 2010b; Jörg, 2007; NIIR, 2004; Peilei, 2008; Shah, 2004). However, the classical systematic design processes used for agro-technology development in Research and development (R&D) organisations have the main objective of prototype development rather than technology innovation diffusion.

R&D organisations have been under tremendous pressure on the global competition and studies are performed to find best innovation diffusion model, which can be adopted, for the improvement of agro-technologies diffusion in Least Developed Countries (LDC).
Currently, most design models that are associated with R&D activities, in engineering education focus on aspects of “good” technical design. However, to meet the competitive environment, factors of innovation diffusion must also be identified and incorporated (Özaltın, 2012; Matthews and Bucolo, 2011).

The study on innovation diffusion that was presented in the house of common used the "valley of death" to describe the technology development failures based on the failure to link engineering factors and business set up vision, however, most of effort has been put in studies that are related to social economic factors that influence Agro-technologies diffusion, while very little is done in examining engineering, development process for technology and development variable that affects Agro-technologies diffusion. Total agro-technologies innovation approach requires the identification of engineering design variables that do affect Agro-technologies diffusion in the two valleys of technology deaths (UK, 2013).

Singh (2010) findings in the study done in India shows that the stakeholder needs to have sufficient resources to develop the prototype into business case with sufficient cash output, through sales to customers that would allow it to be self sufficient and grow.

System dynamic (SD) approach in studying technology development has proved to be very useful as compared to static approaches (Grobbelaar and Buys, 2005). SD approach emphasizes on studies of internal feedback loop process and deals with the causal relations between the dynamic behavioural analysis and multi-variables (Kim and Choi, 2009). Various researchers have conducted studies of innovation, using the SD approach (Grobbelaar, 2006). However there is nothing that has been done in studying the innovation diffusion variables that are engineering related in SD models.

1.3 Justification of the Study

1.3.1 Research relation to the priority of the LDC and Tanzania

R&D organisations in Tanzania use systematic design model, (Budynas, 2006; Hurst, 1999) that focuses on the mere Agro-technologies prototypes development aspects including functionality, stress/strain analysis, tolerances, ergonomics, aesthetics, technical drawing development and prototypes manufacturing, instead of innovation of agro-technology for diffusion (OECD, 2005). A serious gap exists in the incorporation of the Agro-technologies Diffusion Factors (ATDF) in design models in R&D organisations in Tanzania. A model for agro-technology diffusion is needed by R&D organisation; this is the justification of studying the ATDF during agro-technology development cycle. The technology development needs the input of variable from technology initiation stage to the market configuration stage of technology output, which is total ATDF study.

1.3.2 Knowledge gap identified

After conducting this study in Tanzania scientific engineering model will be understood, improved and used to develop the diffusion model of agro-technology in Tanzania. The diffusion model will trigger the use of various tools and techniques during the technology development and predicts the possible outcome as the technology development is in progress. Graphic User Interface (GUI) shall simplify the use of the model. The development of model having a high capability of guiding the development of agro-technology and predicting possible level of technology diffusion using system dynamic nature of ATDF interaction (Haefner, 1996; Grobbelaar, 2006; Vensim, 2003) shall fill in the technology innovation diffusion scientific knowledge gap, engineering being the focal point rather than considering mere social science factor (Kim and Wilemon, 2002; De Marco *et al.*, 2012; Beaudry, 2007; Najjar, 2013).

This research intends to develop an agro-technologies model for innovation diffusion in Tanzania which will contribute to improvement of synthesis and analysis, with technology needs as driver of Agro-technologies design process hence agro-technology diffusion and economic improvement.

1.4 Objectives

1.4.1 Main objective

The main objective of the study is to develop a model that will enhance the diffusion of innovations of agro-technology developed by the R&D organisations in Tanzania.

1.4.2 Specific objectives

The specific objectives of this study are:

(i) To study the historical background of agro-technologies development in R&D in Tanzania.

(ii) To study factors influencing the diffusion of agro-technologies development in R&D organisations in Tanzania (ATDF).

(iii) To develop a model for diffusion of agro-technologies innovations in Tanzania.

(iv) To test and validate the agro-technologies diffusion model.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Agro-technologies

Agro-technology is the technology of agriculture, as the methods or machinery needed for efficient production (House-Dictionary, 2014). Agro-technology means all the machineries and methods supporting agriculture sector. According to Merriam-webster (2013) dictionary; agro-technology covers the science, art, or practice of cultivating soil, producing crops, raising livestock and in varying degrees preparation and marketing of the resulting products. In other words agro-technology innovation diffusion covers the whole value chain addition from the fields to industries that make the final products to the consumers. The scope of agro-technology scope is broad and, it includes land crops production, aquaculture, apiculture, horticulture, forestry and animal husbandry, with all the forward, backward and sideways, integration of value chain processes. Agro-technology has a very broad end processes and products that are from food, textile and many other industrial products like furniture and the like.

In his study, Singh (2010) realised that agro-technology is an important factor that contributes to the agriculture development in India. In organised annual survey of agro-technology industries conducted in India by Singh (2010), it was found that (tractors and harvesters) contributed 0.6% of all factories by numbers, 0.26% of fixed capital in India and 0.43% of employment in India. India was ranking 8th in the world in terms of tractors population, although generally the agro-mechanisation is still low. In 2003 the density of tractors was 12 tractors per 1 000 hectares of gross occupied area, as compared to world average of 50 (Singh, 2010).

Another important finding was the increase in sales of tractors in 2003. This was mainly attributed to the loan scheme that was government guaranteed after proper cost benefit analysis, the reason being that few farmers could afford to buy these tractors without loan schemes. About 80% to 90% of tractors sold were due to bank credit, and the government has developed standard feasibility studies and special tax relief schemes. Similar system is lacking in the LDCs like (Tanzania). The establishment of agro-technology diffusion model and policy are still underway (Singh, 2010).

2.2 An overview on innovation

On one side there is innovation and on the other side there is invention. According to van Cruysen and Hollanders (2009) design is defined as a structured process that transforms creative ideas into concrete products, services and systems, and as such links creativity to innovation as shown in Fig. 1. The figure shows link of innovating with R&D, design, culture, business, creativity and productivity.

From Fig. 1, it is evident that innovation has to be very systematic so that there is a link between scientific invention and innovation. Unsystematic design results into poor innovation process. The same applies to R&D organizations in Tanzania, and hence the agro-technology innovation processes need to be thoroughly studied and improved for effective innovation diffusion.

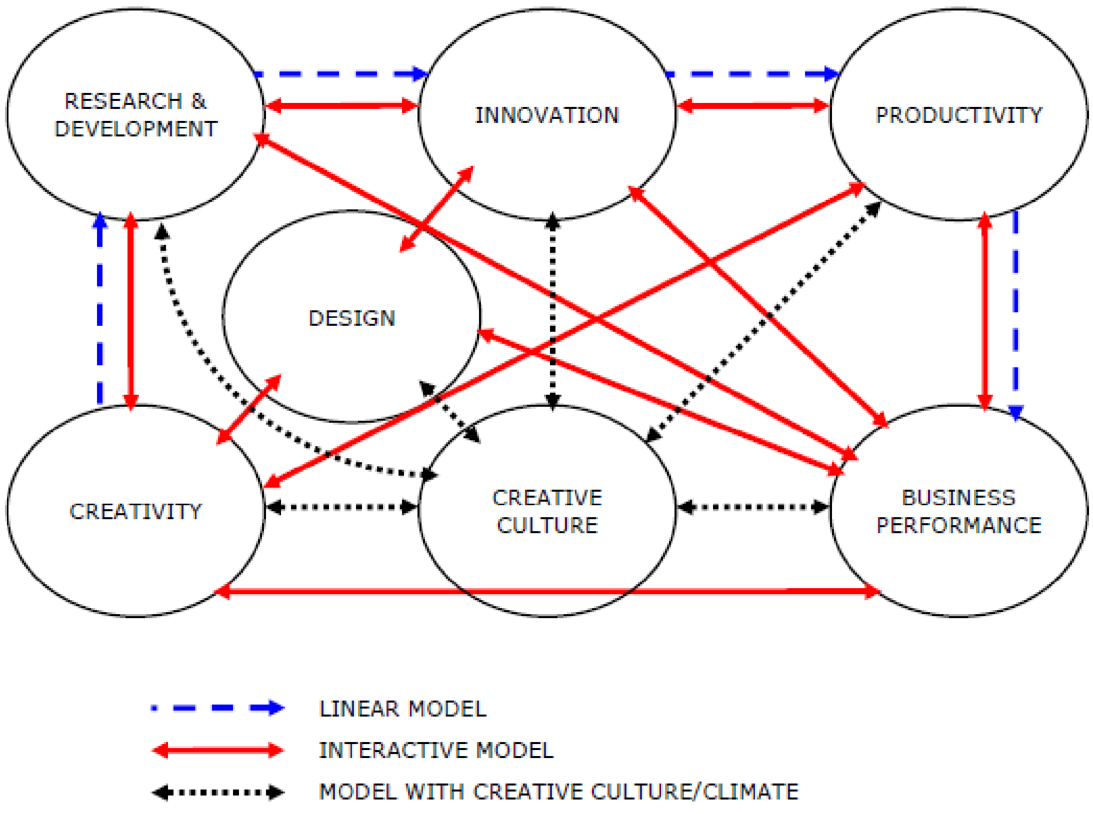


Figure 1: Linking creativity, design and innovation.

Source: van Cruysen (2009)

The four types of innovations are: product innovations, process innovations, organisational innovations and marketing innovations (OECD and Eurostat, 2005). Innovation is the process by which social actors create value from knowledge (Daane *et al.*, 2009; Learnthat, 2004). It may refer to incremental, emergent, or radical and revolutionary changes in thinking, products, processes, or organizations (Katie, 2010). Banji and Gehl (2007) defined the innovation as a deliberate and purposive set of actions involving a set of actors taken in order to foster knowledge creation, adoption and distribution through interactive learning among firms, public and private organizations that support innovation processes.

Very little is documented on engineering R&D efforts in Tanzania that leads to innovation process that is, linking the new product development, stake holders' participation and their interaction. With the current used engineering design models, technology development and its diffusion is a trial and error process that has an objective of prototypes development rather than agro-technology innovation diffusion.

2.3 The Concept of Twin Valley of Death Against Innovation Diffusion

The study on innovation diffusion that was presented in the house of common UK (2013) using the "twin valley of death" graph as shown in Fig. 2. It describes the technology development failures based on business vision disregard. Sometimes technology prototypes or services are developed, though are not linked to business setup, and that they don't get ripe to earn money through commercial sales. The development of sustainable innovation becomes more feasible with the reduction of the impacts of technologies' twin valleys of death. Total agro-technology innovation approach requires the identification of engineering design variables that do affect agro-technology diffusion in the two valleys of technology deaths. That is from the product concept, products development, manufacturing and trading (Tidd, 2006; URT, 2010a; Mnenwa and Maliti, 2009). The first valley called failure to industrialise research, is a failure to transform applied research into industrial infrastructure. The second valley is called the failure to commercialise industrialised innovation, this is a failure to turn the innovation into business opportunities. Technology development models that do not recognise the two valleys of technology death very little chance of making a positive impact on technologies innovation diffusion as it is prove in Tanzania.

The incorporation of elements of innovation diffusion in design is an approach that can be studied and used to eliminate technology valleys of death as shown in Fig. 2 and hence increases the chances of technology diffusion. According to Özaltın (2012), innovation does not only depend on creative idea generation, but also relies on thoughtful engineering design and the product realization process. This entails the need for proper coupling of innovation variables from pure science to social entrepreneurship for effective technology innovation diffusion.

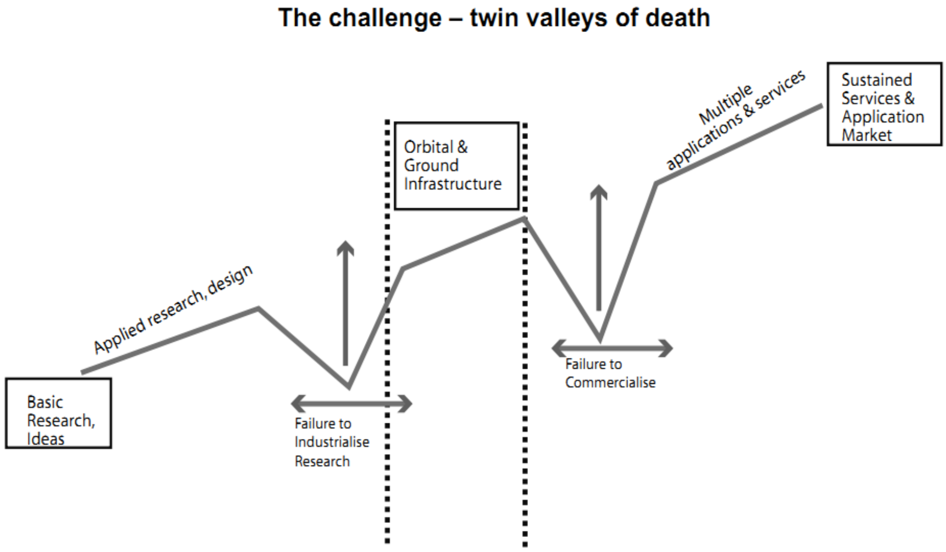


Figure 2: Twin valley of death.

Source: (UK, 2013) EV 108

2.4 The history of R&D Activities in Tanzania

During the 19th Century, there were no known organised scientific research activities in the country. The history of science and technology development in Tanzania however dates back to the colonial era in 1905 when the Germans established the first Central Veterinary Laboratory at Mpwapwa in Dodoma. The research centres grew in numbers all over the country until 1919 when the British took over Tanganyika from the German. The British reorganized the running of the R&D organisations by establishing the East African High Commission in 1948 (Mukama and Yongolo, 2005). Areas of concentration were: malaria in Tanganyika; forestry and veterinary in Kenya; trypanasomiasis, virology and fresh water fisheries in Uganda, and marine fisheries in Zanzibar.

With attainment of independence in the early 1960s, the three member states (Tanzania, Kenya and Uganda) sought to maintain the colonial legacy for health, food and livestock development without a spelt out science and technology policy. Arusha declaration in 1967 restructured the shape of organisations in Tanzania into socialism and self reliance. This was the time that there was a forced link of R&D organisation that had a superficial effect on technology diffusion. In October 10^{th} 19 1968, National Assembly passed the act No 51 which called for establishment of Tanzania National Scientific Council (TNSC), which was inaugurated 1972 to coordinate R&D activities in Tanzania. The TNSC was mainly merged with East Africa Community structure. The collapse of the same community in 1977 forced Tanzania to the passing amend Tanzania National Scientific Council Act 17 of 1977, which refined coordination of R&D organisation in Tanzania.

This era was highly affected by the war between Uganda and Tanzania in 1977 to 78 and the structural adjustment programme led by World Bank and IMF which began in 1986. The support of public organisation to the manufacturing sector was cut off and the flow of low cost manufactured goods from abroad gave a devastating blow to the manufacturing sector as a result of the trade liberalization. This led to the collapse of socialist economy in 1980s to 90s, where the open market economy policy was adopted and interrupted the link between state owned manufacturing organisations and R&D organisations (Mizuno and Mhede, 2012).

It was only after entering the year 2000’s that the link between states owned manufacturing organisations and R&D organisations recovered from the previous level of structural adjustment. Since then, the growth of the sector was observed and especially from the middle of the year 2000’s the growth has been accelerated despite of a number of constraints such as frequent power failure and poor infrastructure (Mizuno and Mhede, 2012).

Three issues of interest are observed in the history of technology development: the effect of lack of well defined policy, the forcefully political transformation and the market structure turbulence (Szirmai and Lapperre, 2004). However the routes taken by various nations indicate that these things can be studied and solution be found if the technology development model is well defined. It has been difficult even to finalise the STI policy in Tanzania because there is no sufficient efforts in developing the model for agro-technology diffusion for R&D organisations.

2.5 Innovation Diffusion Models

2.5.1 Static Design Innovation models

The existing systematic design models such as Dym's (Fig. 3), Pahl & Beitz's, Ohsuga, Shigley's and many other engineering design models put much emphasis on procedures and steps that brings out the prototype of product realization but not product diffusion realization (Özaltın, 2012). Major components of most of these models are shown in Fig. 3.

Fig. 3 shows the final output of the model is a product; it is definite that, processes like technology incubation for a complete business setup are excluded in the technology design, development and transfer; as a result the chances for technology diffusion are reduced. For example, defining the market and its growth potential, determination of production cost, identification of target customer and market can be considered as parts of the engineering design process.

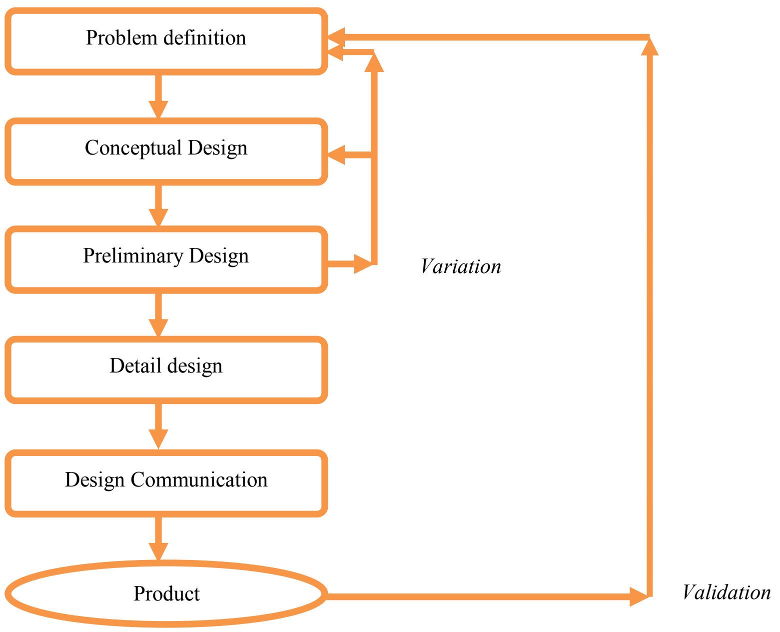


Figure 3: Dym's Design Process.

Source: Dym (1994)

The management aspects are also crucial since the projects are conducted by teams (van Cruysen and Hollanders, 2009; Hobday, 2005; Pierre and Julie, 2008; Hall and Childs, 2009). The fact has been clear that the prototype development alone cannot justify the diffusion of technology.

Instead of stopping at the product level, the design process for innovation diffusion need to be expanded to include participation of all stakeholders' variables from the beginning to the end, as summarised in Fig. 4. It includes business setup that incorporates incubation service provision (ITSBIC, 2008). This has been found to be the strength of innovation sustainability in Nordic countries on the Corporate Social Responsibility (CSR). Businesses integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis are important for innovation diffusion (Als, 2010; UK, 2011).

2.5.2 System dynamics and innovation diffusion

As proved by Grobbelaar (2006), System Dynamics (SD) is used due to nature of the complexity of the innovation process for diffusion. Dynamic and systematic thinking emphasized on an internal feedback loop process and deals with the causal relations between the dynamic behavioural analysis and multi-variables (Kim and Choi, 2009). Various researchers have conducted studies of innovation, using the system dynamic approach. However there is nothing that has been done in studying the innovation diffusion variables that are engineering related in system dynamics.

System dynamics originated in 1960 when Jay Forester created a methodology for analysing a complex system to aid and improve decision making and policy formation (Forester, 1961) cited by (Haefner, 1996; Grobbelaar, 2006). The system dynamic model has proved to be a very useful tool in modelling product diffusion (Vensim, 2003). Though the focus of most of authors has been mainly on broad perspective of innovation and other areas such as technology innovation as related to products supply chains (Kim and Wilemon, 2002; De Marco *et al.*, 2012; Beaudry, 2007; Najjar, 2013), less attention is given to the engineering design factors that affect the technology diffusion.

As an example, Fig. 5 illustrates the use of stock and flow diagram in customer closeness alone, instead of consideration of the whole stakeholders’ configurations as the main cause of technology diffusion effectiveness. Stakeholders variables associated with technology development processes need to be included this can be achieved by using the dynamic frame work to enhance the power of the dynamic diffusion model.

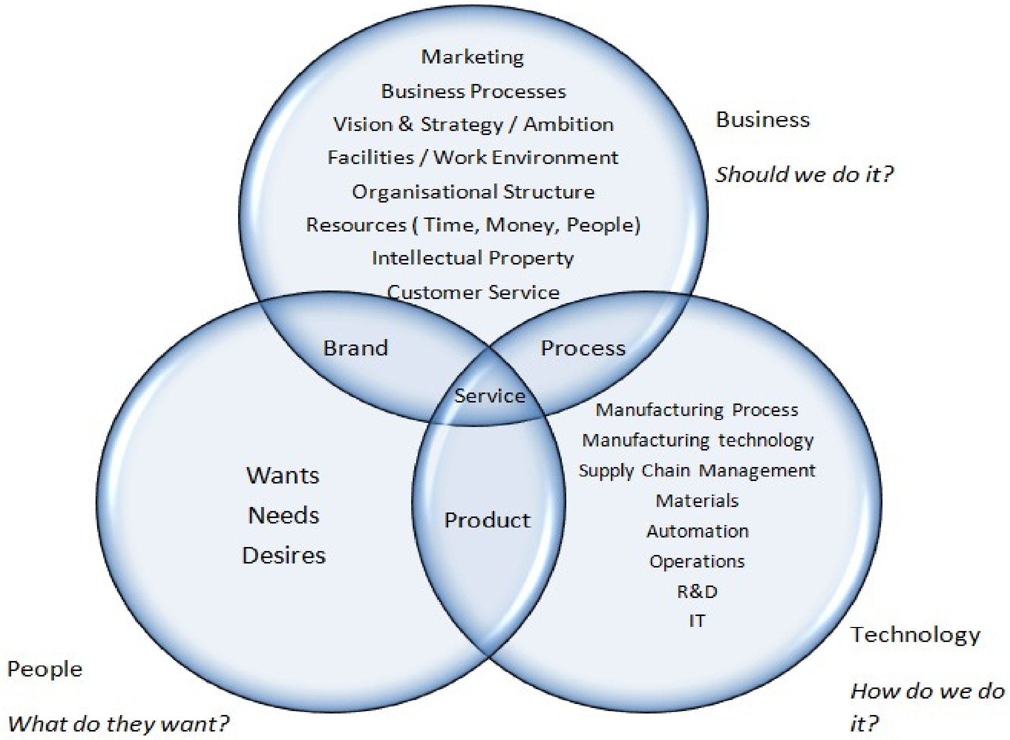


Figure 4: Design for innovation.

Source: (ITSBIC, 2008)

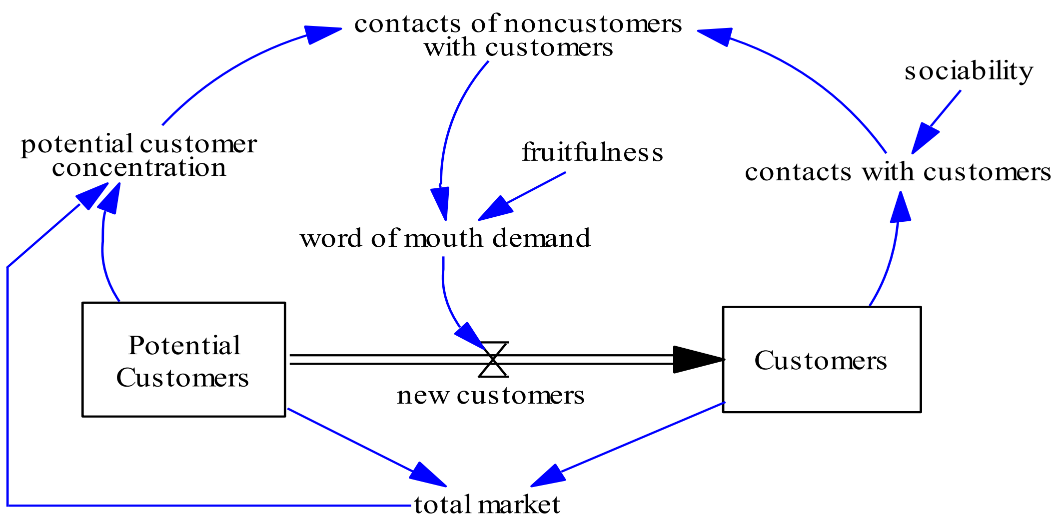


Figure 5: System dynamic model example.

Source: (Vensim, 2003)

2.6 System Dynamic Approach

According to García and Miguel (2012) "System Dynamics (SD) is a method that challenges on how to move from generalizations (abstractness) about accelerating learning and system thinking to tools and processes that help to understand the complexity, design better operating policies, and guide change in systems (concrete) from the smallest business to the planet as a world". Due to the interaction nature of factors that affects R&D activities there is a need of considering innovation process as dynamic rather than static (Grobbelaar, 2006; Grobbelaar and Buys, 2005). In other words system makes mathematical model more realistic in real life (Iyer, 1999). Most of design model lacks this system dynamic approach and assume static behaviour. While System Dynamics is considered suitable to model and analyse innovation processes (Milling, 2002), there is no thorough review of the model using System Dynamics in the area of technology design and development for diffusion (Wunderlich and Größler, 2012). Most of studies and research are focused on policy issues, overall innovation dynamics at macro level, inter-organisational relation impact and mostly focused on social economic factors as driver of innovation, but there is no compressive study in the system dynamics in engineering design as a focal point. The following steps are a useful guideline when the system dynamics method is used to examine a system (Vensim, 2003).

2.6.1 Issue statement

A problem statement clearly states the purpose of the model, and specifies the problem, difficulty and improvement the system process needs. This statement makes the system process more practical.

2.6.2 Variable Identification

Identifies key quantities that will be needed by the model to address issues at hand and is useful just to write down all of variables that might be important and regression is done on them in order to identify the most significant ones.

2.6.3 Reference modes

Reference modes are empirical patterns over time and they may be in the form of data or graphs for a reasonable time. The high precision is not precedence over the trend behaviour. Rather, reference modes are cartoons that show a particular characteristic of behaviour that is interesting.

2.6.4 Reality Check

Define some Reality Check statements about how things must interrelate. These include a basic understanding of what actors are involved and how they interact, along with the consequences for some variables of significant changes in other variables. This may combine theoretical models and actual practices in the area of study.

2.6.5 Dynamic hypotheses

A dynamic hypothesis is a theory about what structure exists that generates the reference modes. A dynamic hypothesis can be stated verbally but more preferably, as a causal loop diagram (Fig. 6), or as a stock and flow diagram. The dynamic hypotheses you generate can be used to determine what will be kept in models, and what will be excluded. Like all hypotheses, dynamic hypotheses are not always right. Refinement and revision is an important part of developing good models.

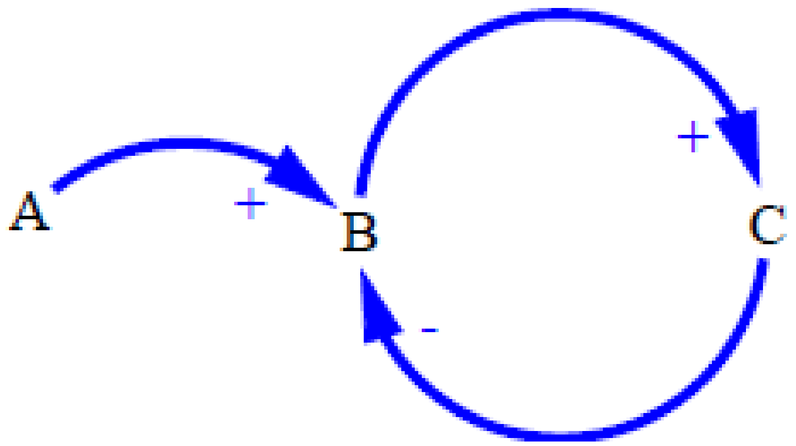


Figure 6: Casual loop.

The causal loop in Fig. 6 enables to visualize the feedback loops of a model. A feedback loop exists when a variable can influence its own value over time. In a positive or amplifying feedback loop, an increase in the variable will lead to a further increase of the variable over time. In a negative or balancing feedback loop, an increase in a variable will lead to a decrease of the variable over time.

2.6.6 Simulation Model

Simulation model is the refinement and closure of a set of dynamic hypotheses to an explicit set of mathematical relationships. Simulation models generate behaviour through simulation. A simulation model provides a laboratory experiment for understanding how different elements of structure determine behaviour.

The process in Fig. 7 is an example of iterative and flexible stock (boxes) and flow (valves) diagram project work accomplished that can be loaded with formulas. As one continues to work with a problem, gains understanding of changes and the new way to think about the things they have done before.

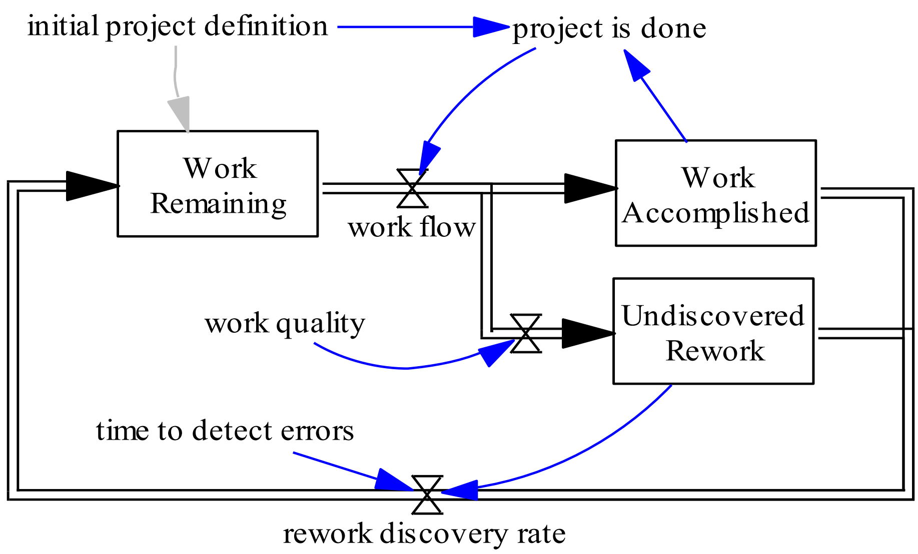


Figure 7: Example of the project progress model.

Source: (Vensim, 2012)

Software like Vensim-Pro or Stella provide explicit support for naming variables, writing Reality Check

2.7 Performance Agriculture in Tanzanian Economy

According to URT (2008a), the GDP per capita increased at an average of 3.3% annually between 1998 and 2007, while the rate has been 1.4% in agriculture. The analysis of long-term economic growth in Fig. 8 shows that Per Capita GDP achieved a rate of 4%, while agriculture sector Per Capita GDP achieved only 2%. A small positive growth rate in agriculture sector shows that its contribution to the economy was growing at a higher rate than the population growth rate though not higher enough to reduce income poverty. This is also picked showing even projected trend of agriculture per capita is close to the actual finding of 4,4% (URTb, 2012). Therefore there is clear indication that agriculture sector's growth was neither optimal nor satisfactory given the great investment opportunities available in the country (Duderstadt, 2008).

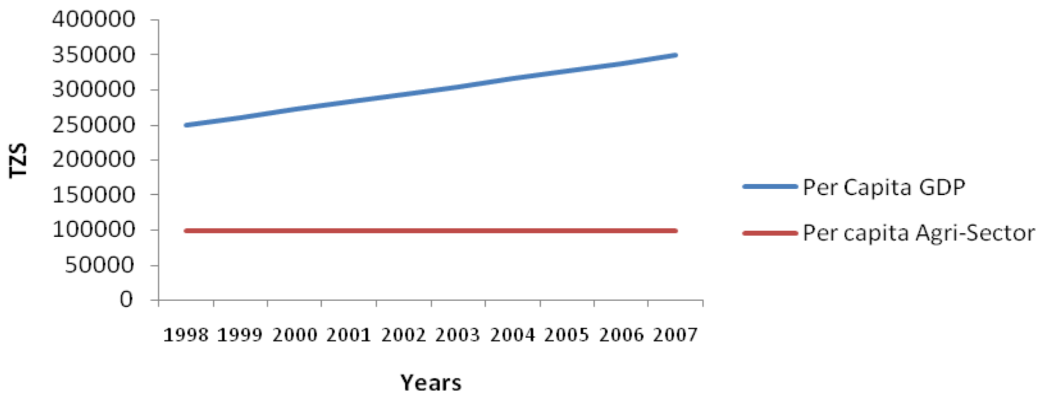


Figure 8: Per capital and agriculture sector (TZS).

Source: (URT, 2008b)

Development in any sector such as agriculture goes with investment. Like many other LDC, Tanzania lags behind in agro-technologies innovation. It spends about 0.2% of GDP on research and development (R&D), far below the average of 1.0% for Sub-Saharan Africa, and many other economic blocks (Mbelle, 2005; ECA, 2005; Sachs, 2005; Léger and Swaminathan, 2007). The need for incorporation of innovation investment in agro-technology R&D activities is inevitable for producing reasonable agriculture and industrial economic growth (URT, 2012a; URT, 2010b; Jörg, 2007; Shah, 2004; NIIR, 2004; Peilei, 2008).

2.8 Technology diffusion

Diffusion of engineering, science and technology is the process through which they spread from source entity to other entities (OECD, 1997). The diffusion process refers to the process of adoption of new products by the consumer marketplace (Learnthat, 2004). According to Arnold and Guy (2000) LDCs governments have historically focused on the innovation-creation process only. This has been justified by arguments about market failure: the inability of market mechanisms to secure long-term, common good improvements in science and technology. However, it has been accepted that it is not the creation of technological leadership in itself that affords a nation its competitive advantage, but the rate and level of diffusion of the technology into economic use. Technology diffusion involves far more than the simple introduction of new machinery into the firm. Diffusion should maximize potential national economic returns. The measure for technology diffusion has been a challenging issue, since some indicators used are not reflecting the social economic contribution to LDC nations. For LDC the amount of sales of technology is related to the use of technology by communities and hence improving their economic performance (World-Bank, 2008; Jaramillo *et al.*, 2001). For measuring the diffusion of Agro-technologies three indicators are used; quantity, value and rate of sales of technologies (Unesco, 2010).

The following are barriers for such innovation to be diffused: poor policies and infrastructure framework (duplication of works); poor knowledge development and inefficient technological systems to translate research into innovations. Others are: limited Entrepreneurial skills; poor technological inputs to both the research programmes and conversion of research results into useful innovations; little diffusion knowledge through networks; poor guidance of research; insufficient market formation (added advantages like tax regime); poor production systems; unlinked innovation network; poor information and technology utilisation and poor resource mobilisation (finance and human); lack of advocacy collision (creative destruction); weak globalisation links; weak actors' roles, activities attitude and practices and poor functions breakdown structure (Banji and Gehl, 2007; Simona *et al.*, 2007; World-Bank, 2006; Dugushilu *et al.*, 2010; Koshuma, 2005). The literature shows weakness in various processes linked to New Products Development (NPD).

2.9 Diffusion and Logistic Growth (''s-shaped curve'') Characteristics

The general trend of technology acceptance has takes a bell curve (Fig. 9) or S Curve (Fig. 10) in their performance in the market improvement over their lifetimes (Ayres, 1994;

Christensen, 1993, 1994; Foster, 1986; Twiss, 1992) cited by (Schilling and Esmundo, 2009). In these curves of technology diffusion, logistic growth depicts a process in which there are initially only few early adopters of an innovation. As the population of adopters increase more information about the technology is shared among existing and potential users and the rate of adoption increases under the influence of reinforcing feedback. At some point along the curve, the increase in new adopters becomes self-sustaining. This has been referred to as the critical mass (Allen, 1988; Flynn, 2002; Markus, 1987; Valente, 1993) cited by (Schilling and Esmundo, 2009). At this point technology becomes a renowned commodity in the market and hence attracting some stakeholders in using, retailing, manufacturing, financing and politicize the product. With various names the Bell Curve and S Curve, have proved to be useful tools in studying products diffusion (Kucharavy and Guio, 2007). However, the exploitation of variable that may shift the gradients and the magnitude of S curve values is still to be exploited since there are a number of technologies that give low market performance, though following the S curve pattern.

A **sigmoid function** is a mathematical function having an "S" shape (**sigmoid curve**). Often, *sigmoid function* refers to the special case of the logistic function shown on the right and defined as follows (Kucharavy and Guio, 2007):

$$S(t) = \frac{K}{1 + e^{-\alpha t - \beta}} \qquad \text{...(1)}$$

Where:

S(t) = cumulative diffusion (Quantity)

‘t = time (months)

κ = is the asymptotic limit of growth

α = growth rate parameter specifies "width" or "steepness" of S-curve

β = parameter specifies the time (tm) when the curve reaches 0.5κ

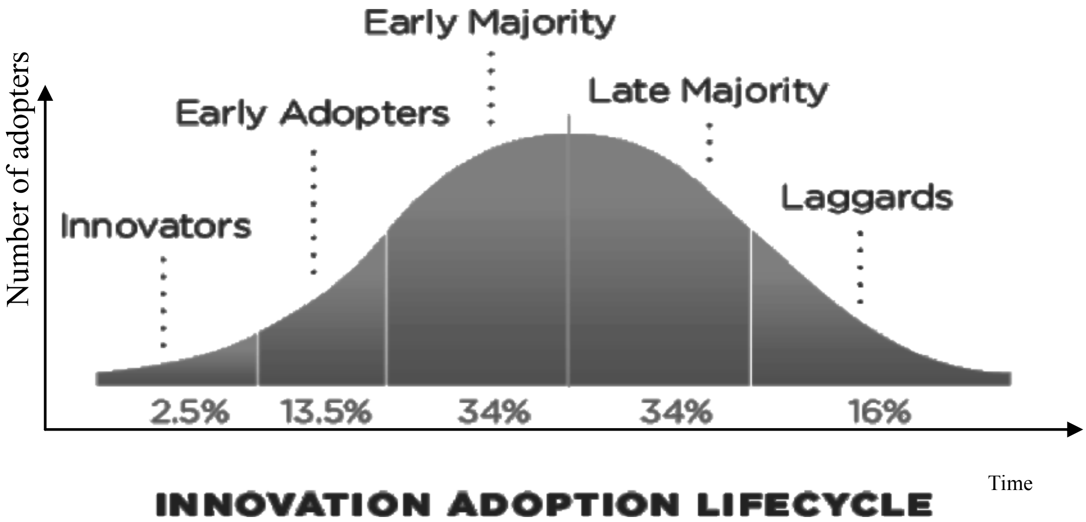


Figure 9: Bell curve of adoption frequency.

Source: Rogers (1983)

It is good to note that with the generation of brands of the same product the S curve can be presented in Fig. 11 as the generation or conversional technology trends.

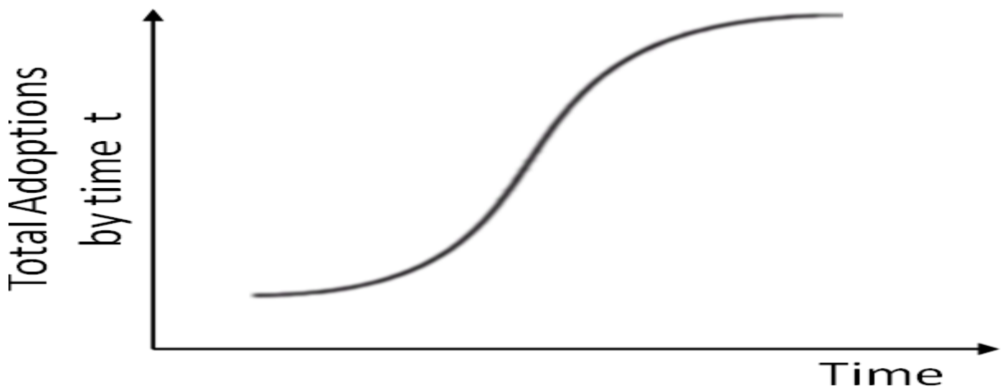


Figure 10: S-curve of cumulative adoptions.

Source: Rogers (1983)

The S curve in Fig. 11 manifests in two types of trends of frequency of diffusion of the products, namely creative destruction and creative accumulation with the characteristics shown in Table 1 (Filippetti *et al.*, 2009). According to Danneels (2004) cited by (EU, 2012), a disruptive technology is a technology that changes the bases of competition by changing the performance metrics along which firms do compete. It is common to have two types of ends of the S curve, either disruptive or incremental as shown in Fig. 11.

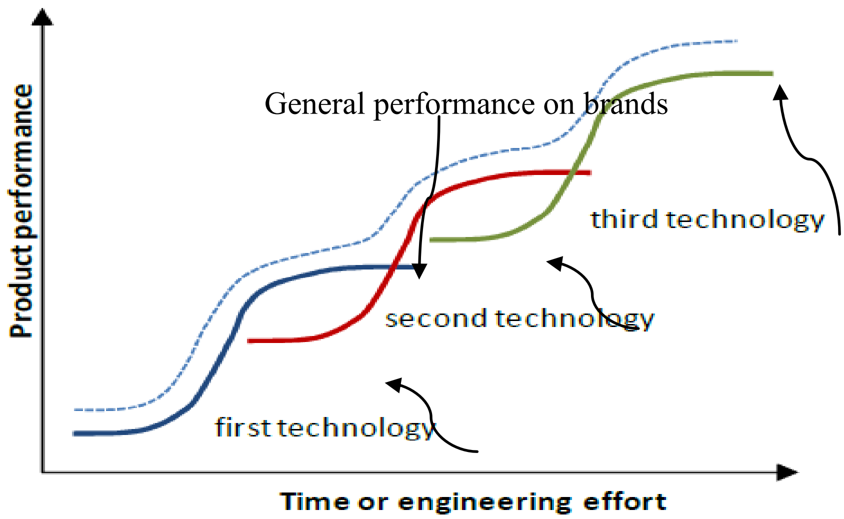


Figure 11: The conversional technology S Curve.

Source: Chritensen (1992; Dym, 1994)

Table 1: Characteristics of different innovation drivers under creative destruction and creative accumulation

Dimensions	Creative destruction	Creative accumulation
Characteristics of the innovating firms	Small firms, new entrants are at the core of the innovation process	Innovations are driven by large, incumbent firms that seek new solutions through formal research
Characteristics of the market structure	Low barriers to entry into markets and low levels of concentration	Barriers to entry are high due to relative importance of appropriation and cumulativeness of knowledge and high costs of innovation
Characteristics of the key technologies	New technologies around which a large number of opportunities arise	Technological advancement based on path dependent technological trajectories
Type of knowledge and innovation	Path-breaking innovations with a greater relevance of applied knowledge.	High relevance of past innovations and accumulated knowledge (formal R&D) leading to a large number of more incremental innovations

Source: Filippetti *et al* (2009)

2.10 Technology Innovation Models

2.10.1 Linear innovation model

The Linear Model of Innovation is an early model of innovation that suggests that technical change happens in a linear fashion from Invention to NPD. It prioritises scientific research as the basis of innovation, and plays down the role of later players in the innovation process; as a result it is no longer effective. It was initiated by Vannevar Bush in 1945 (Benoît, 2009; Jacob and Methew, 2008; Urban and Hippel, 1988; Stewart and Hyysalo, 2008; Raasch *et al.*, 2008). Taufik (2010) and Tidd (2006) shows the evolution of innovation models for linear to system model. This entails technology push era (1960s – 1970s), demand pull era (1970s – 1980s) to innovation system (IS) era (1980s – 2011s). The summary of the progression of innovation process is shown in Table 2.

Table 2: Progress in conceptualizing innovation

Model	Characteristics
First linear models	need pull and
Second linear models	technology push
Third	Interaction between different elements and feedback loops between them – the coupling model
Fourth	The parallel lines model, integration within the firm, upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances
Fifth	Systems integration and extensive networking, flexible and customized response, continuous innovation

Source: Tidd (2006)

However, by referring to the twin valley of technology death in Fig. 2 two main areas of weakness are observed in the technology development processes for most of LDCs, which are industrialisation and commercialisation of technologies. This study will contribute to improvement of design for innovation process and hence innovation diffusion by adopting the lower part of models in Table 2.

2.10.2 Stage gate model

A stage-gate system (SGS), (Fig. 12), is both a conceptual and an operational model for moving a new product from idea to launching stage. A process is sub divided into a number of stages or workstations. Between each stage, there is a quality control checkpoint or gate. The outputs are the decisions at the gate, typically a Go/Kill/Hold/Recycle decision and the approval (Cooper, 2009; 2010).

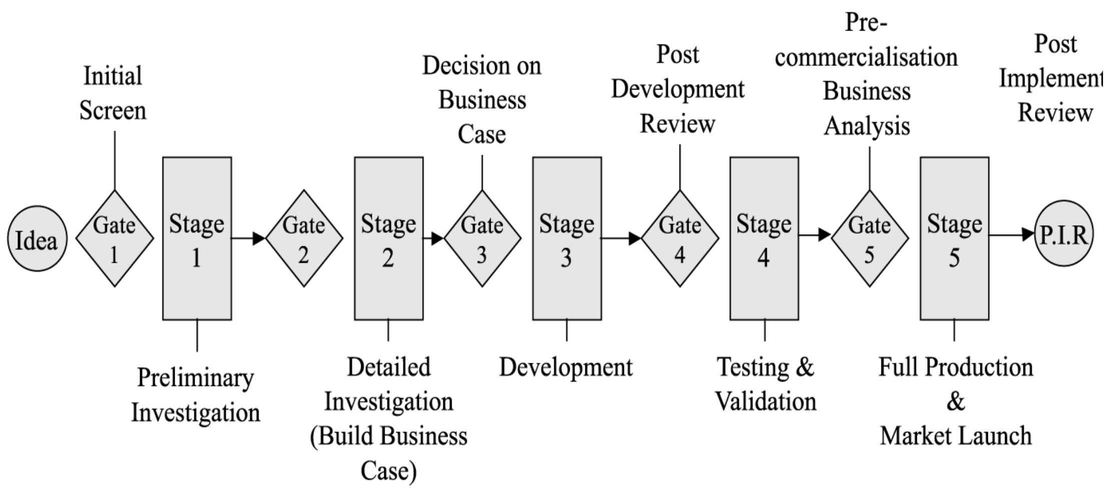


Figure 12: Stage gate model.

Source: Cooper (2010)

According to Cooper (2009; 2010), the great majority of firms (76%) have too many projects and an overloaded development pipeline. This model reduces the number of projects and hence the duration to completion is reduced by 30%. Japanese companies, like Toyota, have been experiencing this advantage (Verma *et al.*, 1995). However the model put more emphasis in optimization of technology screening process with indirect help to the engineering profession in improving individual, technology innovation diffusion. Some of the concept in this model will form input into the development of optimal design model for Tanzania innovation processes.

2.10.3 Triple helix model

A triple helix regime model (Fig. 13) typically begins when a university, industry, and government enter into a reciprocal relationship with each other in which each attempts to enhance the performance of the other. Benefits realised in triple helix is creation of industrial park and incubation of industries, all these leads to enhancement of technology diffusion (Etzkowitz, 2008; Malerba, 2005; Qing-dong, 2010).

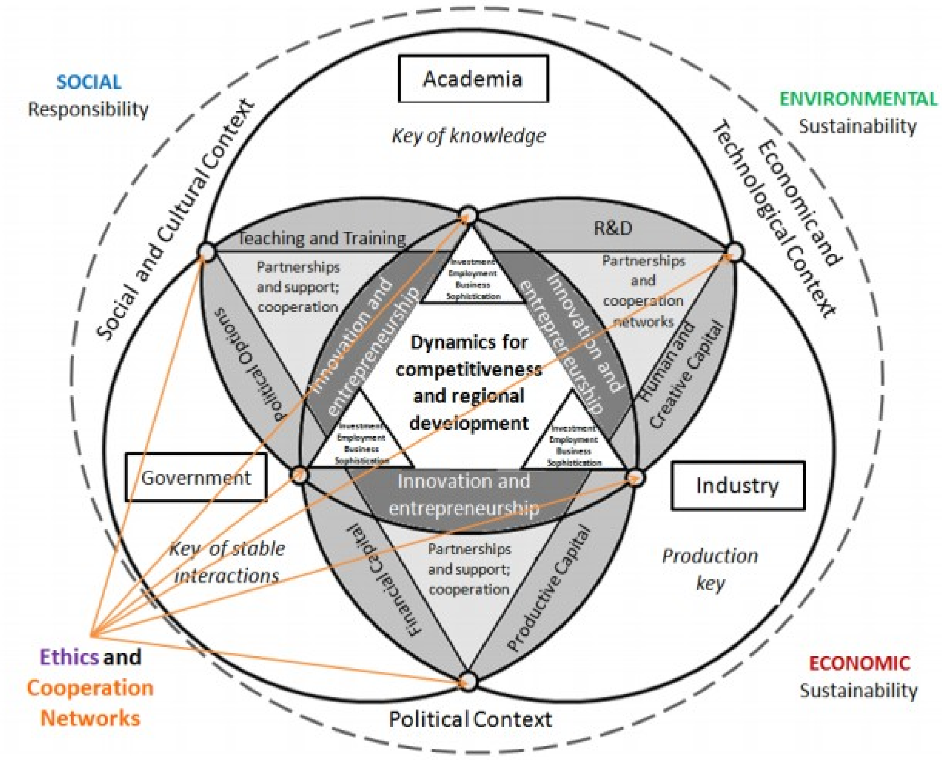


Figure 13: Triple helix triangulation model.

Source: Farinha and Ferreira (2012)

Farinha and Ferreira (2012) in Fig. 13 show the need of examining the "Triple Helix" model in more detailed way, as it is great contribution to the fact that NPD need to be re-examined beyond the prototype development, important facts to be examined are shown. Though the model is more into social econometrics than helping a designer to achieve the diffusion objectives through super interaction therefore in this study more effort was put on interpreting the good concept of triple helix model into design model for agro-technology innovation diffusion.

2.10.4 Innovation system models

An Innovation System (IS) can be defined as a network of organizations, enterprises, and individuals that focuses on bringing new products, processes, and forms of organization into economic use (Rajalahti *et al.*, 2008; Edquist, 2001). National Innovation System (NIS) is an organisational innovation programme focused on wealth creation in the nation (Qing-dong, 2010). Industrial innovation system (Fig. 14) refers to the network posed by the development, production and sales of products in specific sectors (Lord. *et al.*, 2005). Cluster innovation system is the system of narrow regional innovation with industrial cooperation in NPD (Edquist, 2001; Mwamila and Temu, 2005). Collaborative innovation system as shown in Fig. 13 and 14 emphasises on team work in NPD (Balamuralikrishna *et al.*, 2000; Fagerström *et al.*, 2002; Punt, 2009; Wengel *et al.*, 2003). Innovation systems approach can help policymakers, researchers, research managers, donors, entrepreneurs, and others identify and analyse new ways of encouraging innovation (Olufemi, 2005). The innovation system has made the economy of Japan, Indonesia and Taiwan to have great success in reducing the raw materials import by more than 10% annually, reduce transaction costs, improving the quality and quantity of technology sale and hence causing the economic growth rate of 10% yearly (Rianto *et al.*, 2009). The innovation system approach in Tanzania is sporadic in nature and not sustainable. The engineering design model for agro-technology diffusion will trigger the review of innovation systems in Tanzania by exploring existing innovation system models.

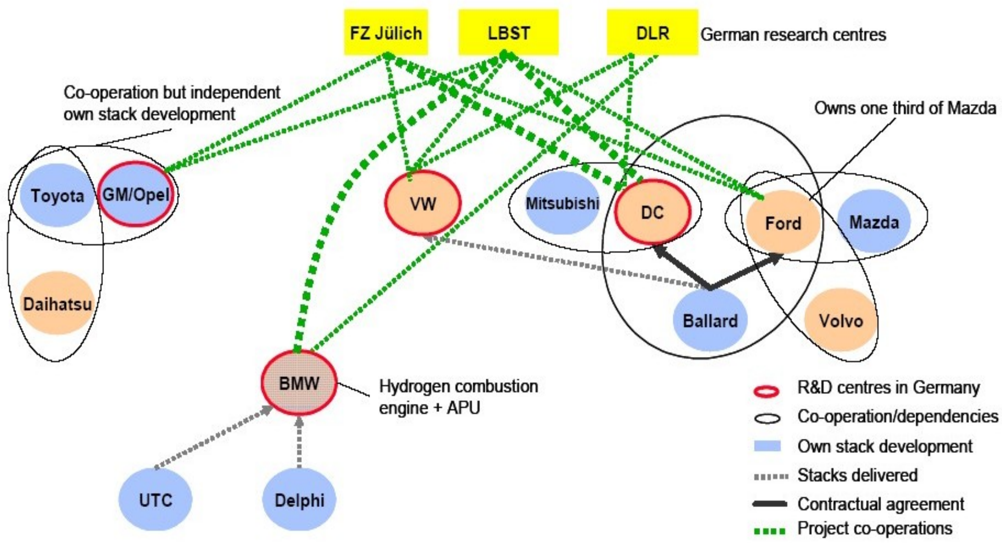


Figure 14: Fuel cells clusters.

Source: Wengel *et al* (2003)

2.11 Engineering approaches in new products development

There are various tools and techniques that are in use in engineering NPD such as; six sigma which ensures compliance of customers requirement (Chase *et al.*, 2004). Others are; the Define Analyse Measure Design Verify (DAMDV) and design for six sigma (DFSS) (El-Haik, 2005), Total Quality Management (TQM) which, integrates continuous quality improvement of products and processes. Zero defects, quality management system (ISO 9000) and Failure Mode and Effect Analysis (FMEA), which emphasises on the quality consideration in NPD. Quality Function Deployment (QFD) is a method used to transform user demands into design quality. TRIZ is the Russian acronym for the "Theory of Inventive Problem Solving and is based on logic and data and not intuition. It provides repeatability, predictability, and reliability (Katie, 2010). Concurrent Engineering (CE) (Fig. 15) is a simultaneous development of the product design and process design (Hall, 1991; Ziemke and Spann, 1991) it takes care of the manufacturing line development over and above the technology development. The approaches for NPD are not systematically incorporated into the innovation models in R&D organisations in Tanzania and render existing models functionless. In this study the NPD tools are included in the developed model to enhance innovation diffusion.

2.12 Models for Engineering Machinery Design

In both design models (Figure ***16***Fig. 16 and 17), the conceptualisation, synthesis, and design production are given higher priority. However, the variables that are affecting the technology diffusion are not explicit. In this study the efforts are put to study these models variables and matching them with the innovation diffusion barriers and hence come up with more appropriate design model for technologies diffusion.

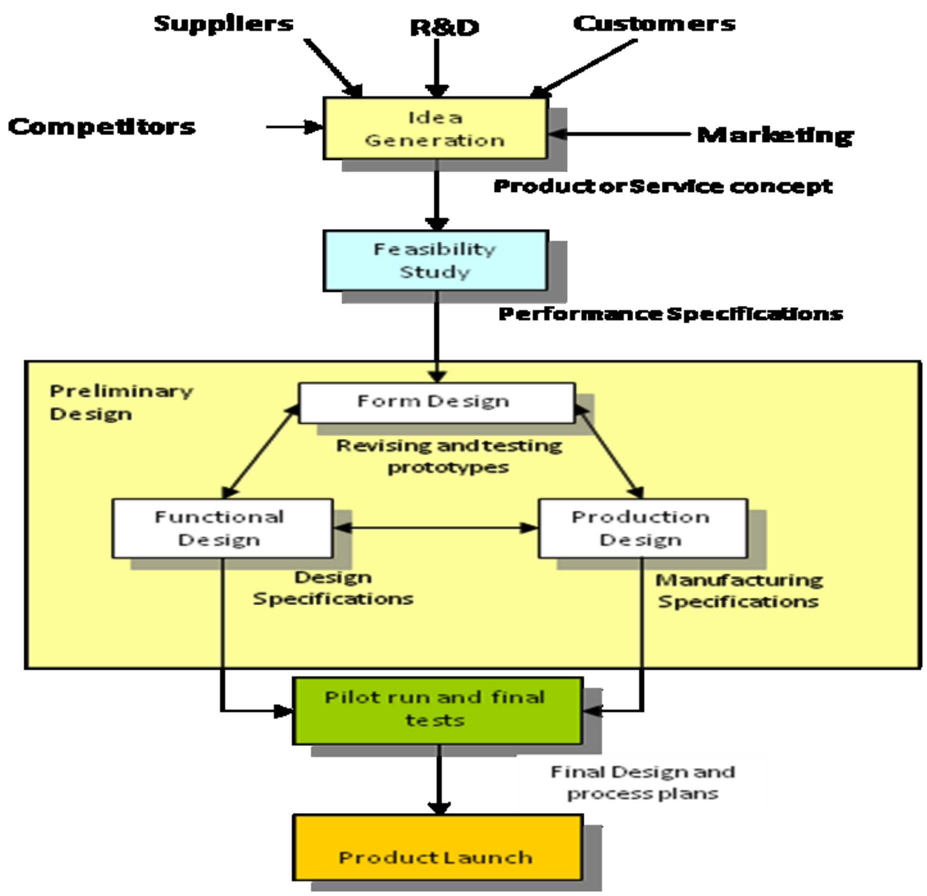


Figure 15: Concurrent engineering.

Source: Hall (1991)

Most of design model that do exist are prototype development models, it is unfortunate that these models lacks forward and backward integration of technology development factors that affect their diffusion, as shown in Fig. 16 . Dym's, Pahl and Beitz's and Shigley's models shown in Fig. 17 are example of models that are used in Tanzania; however these models are for prototype development only. As a result a prototype like two wheel tractor developed by TATC is completed but has never diffused.

Currently, most design models that are associated with R&D activities, in engineering education focus on aspects of "good" technical design. However, to meet the competitive environment, factors of innovation diffusion must also be identified and incorporated (Matthews and Bucolo, 2011; Özaltın, 2012).

2.13 Project Approaches in Engineering Design

According to Project Management Institute (PMI) (2008), a project is a temporary endeavour to create a unique product, service or result. The temporary nature of the project indicates definite beginning and end. The end is reached when the project objective has been achieved, or the project is terminated because the objective cannot be met or when the need for the project does no longer exist. Most of agro-technology developments processes are project in nature but project approach is not well considered in NPD. Sanga and Mganilwa (2012) recommended steps shown in Fig. 18 in which project management processes (PMI, 2008; Sorli and Stokic, 2009) and design model are concurrently considered. In this way the project management processes are harnessed into the developed model.

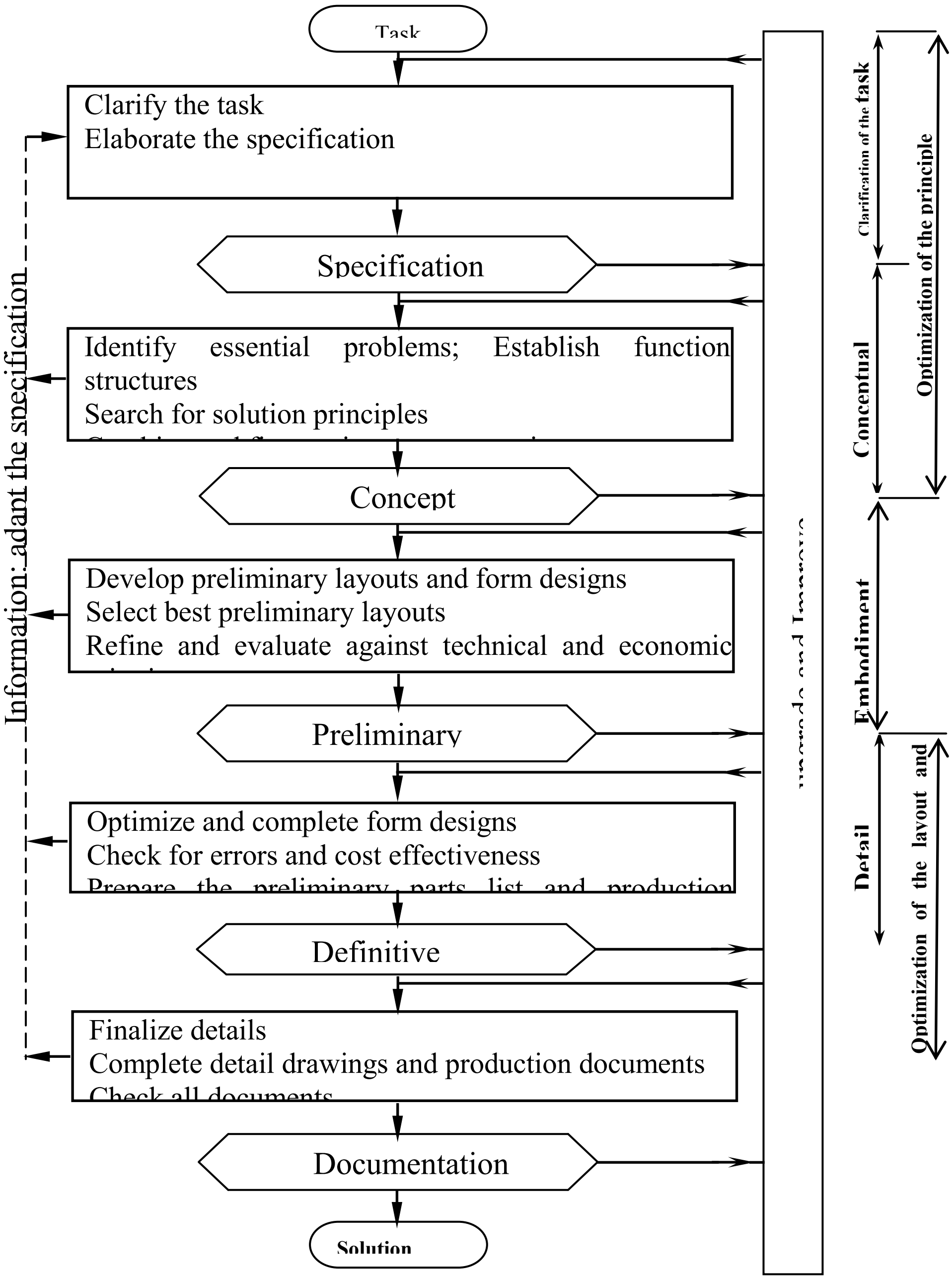


Figure 16: Steps of the design process.

Source: Pahl *et al* (2007)

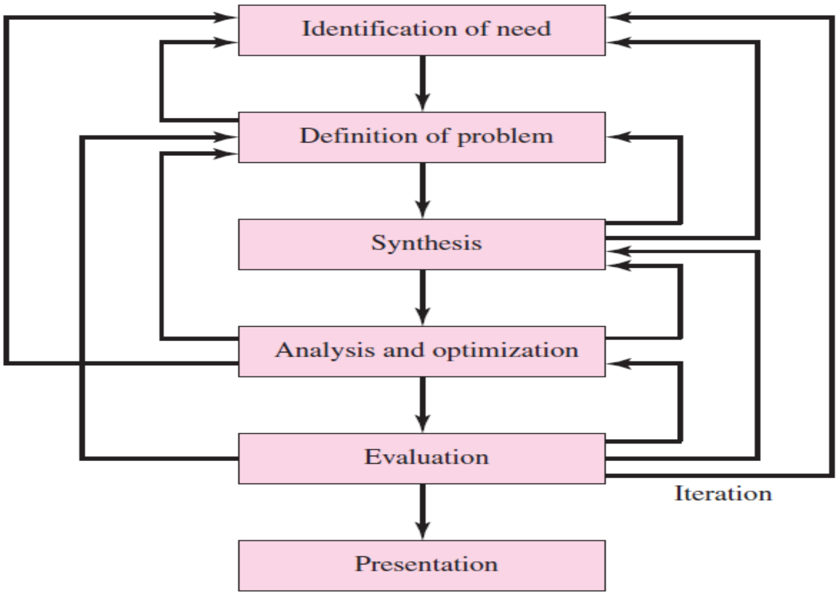


Figure 17: Shigley's design model.

Source: Budynas (2006)

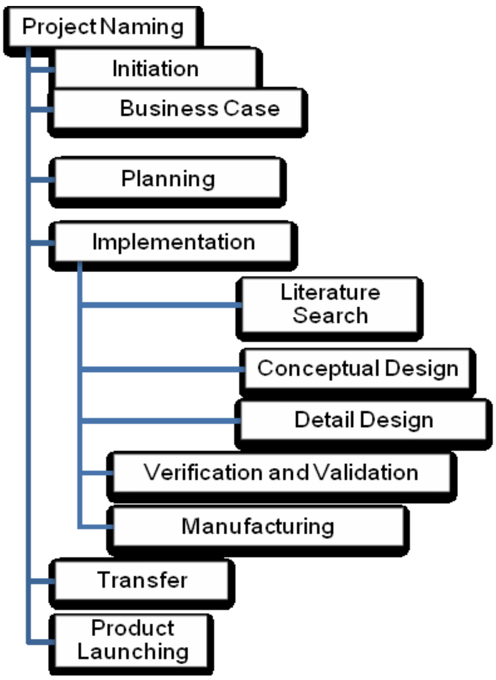


Figure 18: Innovation & Project Processes combined.

Source: Dym, Sanga and Mganilwa (2012; 1994)

2.13.1 Customisation of innovation models

The nature of R&D organisations and innovation systems in developing countries differs substantially from those in developed countries due to completely different nature of industries, size, economic power, and community activities (Szogs *et al.*, 2010). However systems like triple-helix or concurrent engineering do serve well in the developed countries. These models cannot just fit in the LDC, unless some customisation to match local environments is done (Ulrich, 2010). There is a need of development of a design model that leads to engineering agro-technologies diffusion in Tanzania by studying the existing models in the world; however customisation of diffusion variables for the innovated agro-technologies in LDC is unavoidable.

2.13.2 Technology title and problem behind

Technology title is the first item in the project development and that a wrong title will bring about a wrong project (Adedeji, 2009). The title present the problem, objective and scope but most of technological project write-ups do miss some important aspects especially those affecting the diffusion factors, hence the title should lead to clear technology design problem (Nigel, 2000; Hurst, 1999).

2.13.3 Technology initiation

Initiation is a stage that identifies and justifies the need for the technological project. In innovation this is where the need for innovation is identified as a result of dissatisfaction of the community in performing certain function (Hugh *et al.*, 2007). The output of the need assessment should be the technology project charter (Heldman, 2005) and together with project write up this document is necessary to give the approval of valid innovation project.

Technology project charter is a professional document, developed involving various stake holders, like donors, financiers, consultants, professional and technical associations. The document is used for justification, and measurement of project objective. This document shows all the projects requirement and description, risks involved, milestone schedule and budget summary (Heldman, 2005; PMI, 2008). Guideline of micro diffusion variables is included in Appendix 3. Although there may be some differences in the information required in the project charter the listed items are normally required (Inc, 2013). For a useful technology need assessment, the project charter is a good guide to have the effective assessment for project implementation.

2.13.4 Technology business case

A business case captures the reasoning for initiating a project or task. It is often presented in a well-structured written document, but may also sometimes come in the form of a short verbal argument or presentation. The logic of the business case is that, whenever resources such as money or effort are consumed, they should be in support of a specific business need (Gambles, 2009). Innovation of Engineering Technology without thorough development of the business case is bound to failure. Business case links Engineering efforts to society, and leads to acceptance of technology by the community (Hugh *et al.*, 2007). It is a tool that allows the stakeholders to make rational decisions for successful technology diffusion. The use of business case in agro technologies design is still a grey area and it is the area that was studied in this work.

Common items in the business case overlap with some items in the project charter, though business case is more robust to ensure that the project captures all the business expectation of the project (Canada, 2009). Guidelines for development of business case are provided in Appendix 30.

A good business case is likely to promote technology transfer and diffusion, since rapidly changing global business environments, suggests that technology venturing is becoming an important paradigm in world economies. A critical component of technology venturing is technology transfer or the commercialization of technology/knowledge/ideas as products and/or services (Sunga *et al.*, 2002). The main issue is to link the design exercise with the business analysis for the expected innovation. By doing so engineers are enabled to develop and take care of the business aspect of the innovation throughout the technology development stages.

2.13.5 Technology development planning

Technology development plans start with development of the project charter, business case development and hence implementation planning. It is a continuous process that needs frequent reviews (Heldman, 2005). Technical, technological and other parameters at this stage are interpreted in the project plan. Stakeholders analysis, finance requirement, technical requirement, environmental requirement should make part of the plan. All forms of linkages with the stake-holder should be part of the plan (Adedeji, 2009).

A good R&D innovation plan needs to be comprehensive to meet all items in Appendix 3. The interaction with the stake holders should be given a reasonable priority; one way in which one can achieve this, is to include stake holders in stages and gate keeping or team members in the technology development stages as suggested by Cooper (2010).

2.13.6 Concept development of technology

It is normally the initial phase of the project implementation stage. According to El-Haik (2005) the conceptualisation stage affects 80% of the quality in the whole NPD process. Conceptualisation is mainly the synthetic work of development for the technology functions that are highly influenced by expertise and creativity capability (Hurst, 1999) and the information availability using data from literature which includes number of data books and now days the ICT, that includes supplier's catalogues (Qing-dong, 2010). Since most of the design specifications are ill defined, various functions breakdown loops, and combination are needed for evaluation to optimal design. It is at this stage that most of the qualities of the end product are established by eliminating conceptual and operational vulnerability (El-Haik, 2005). In most cases this stage is avoided by designers of new products and hence having weak technology design specifications (Nigel, 2000). When this stage does not exploit the stakeholder's needs or wants, by using proper conceptualisation tool and techniques, then the technology diffusion stands a little chance of success.

2.13.7 Quality in reseach and conceptulisation

El-Haik (2005) found out that, systematic research in engineering design began in Germany during the 1850s. Recent contributions in the field of engineering design include axiomatic design, product design and development (El-Haik, 2005), the mechanical design process (Ullman, 2009), Pugh's total design, and TRIZ (2005). However there has been a problem of linking what the customers need with the design and hence design methods miss the quality aspect. Then comes the Axiomatic design process as shown in Fig. 19.

Where: CA is Customer Attribute; FR is Function Requirement and CDFC is Conceptual Design For Capability. The main aim of axiomatic design is to have a systematic way of converting customer requirement into quality and reliable product for customers. Quality Function Deployment (QFD) is best viewed as a design tool that relates a list of wants and needs of customers to product technical functional requirements.

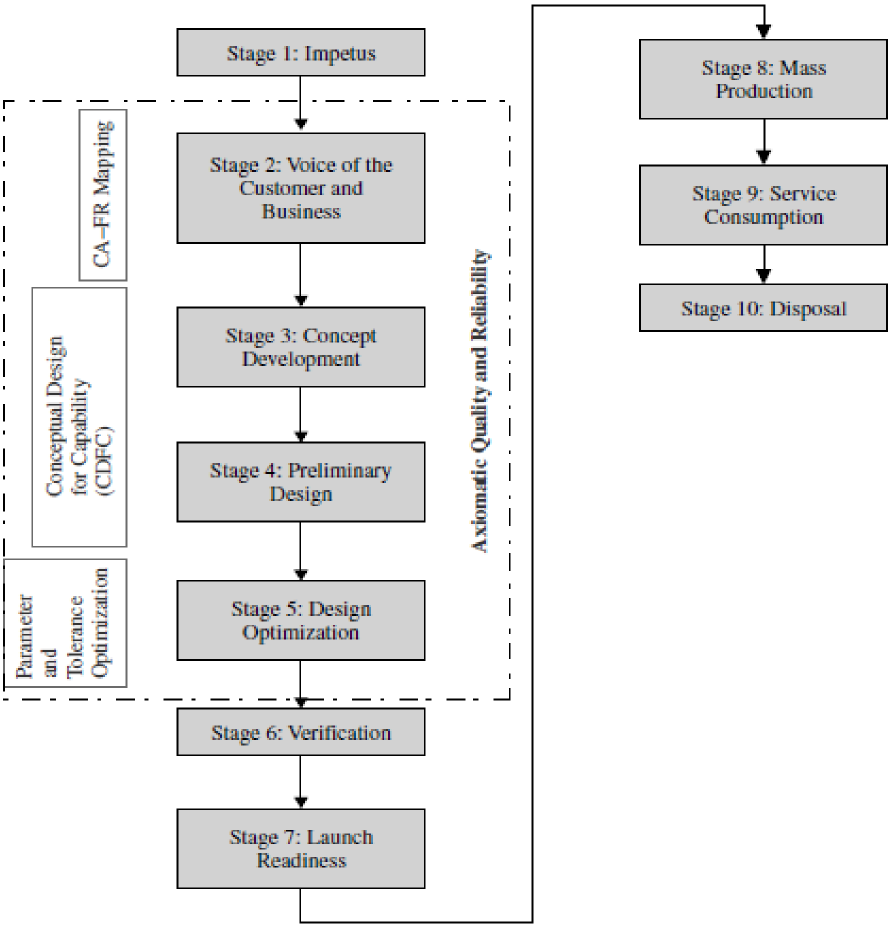


Figure 19: Axiomatic design.

Source: El-Haik (2005)

In the QFD methodology the customer defines the product using his/her own expressions, which usually do not carry any actionable engineering terminology. The voice of the customer can be discounted into a list of needs used later as input to a relationship diagram as shown in Fig. 20 and 21, which is called QFDs “house of quality” (HOQ). Full QFD activity expands over four stages. Yang and El-Haik (2003) discussed the role of QFD within the broad perspective of design for six-sigma (DFSS).

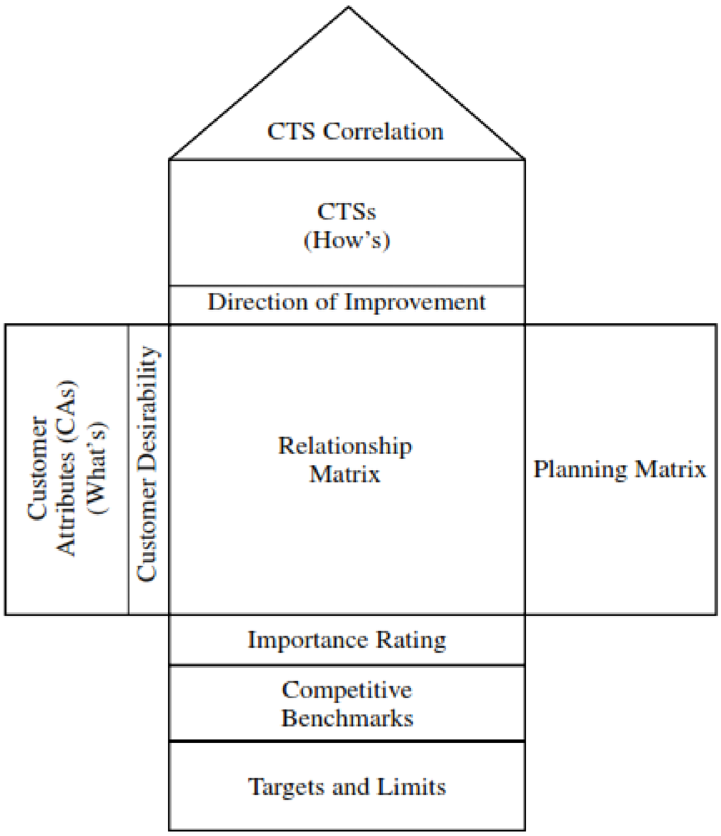


Figure 20: Quality function deployment house of quality.

Source: El-Haik (2005)

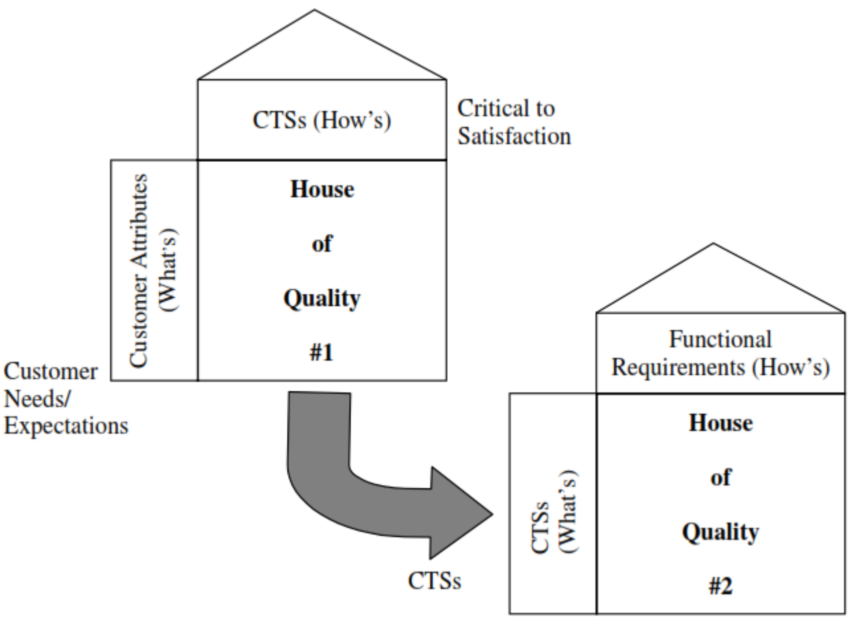


Figure 21: Axiomatic design for CA-to-FR mapping.

Source: El Haik (2005)

Although the QFD brings about the optimal design for diffusion has been proved very useful for developed countries, there is still a lot to be done in the LDCs including Tanzania to ensure that the power of QFD is fully harnessed.

2.13.8 Engineering analysis and detail design

With the advance of computer modelling tools, all the engineering analysis, development of details, and drawings has been simplified and hence the speed of conceptualisation, analysis, and product of drawing development has been increased (Saxena and Birendra, 2005; Jun *et al.*, 2011; Ruiz and Gabi, 2010). Parametric soft-wares like solid-works; pro-engineering, solid edge, uni-graphic and others are available and have proved to be user friendly in terms of design accuracy, communication and short product development cycle (Hernandez, 2006). The extent to which these kinds of software are used in Tanzania is good indicators on the level of engineering design processes advancement.

Detail design development is an output of the concept development. Before embarking into the detail design a number of analysis has to be performed (Hurst, 1999); functions analysis e.g. tolerance against cost, performance and assembling, motion analysis (Chase and Greenwood, 1988), structure analysis (Budynas−Nisbett, 2006), cost and economy and environment, manufacturability and application (Venkata, 2011). All the analysis is driven by the requirement of the project charter and business case context.

Because of the multidisciplinary nature of the mechanisms (discrete products), the design analysis may be focused on one or more of the following areas (Khan and Raouf, 2006) analysis for: strength, bending, torsion, buckling, contact loading, combined loading, cyclic loading, cyclic loading at elevated temperature, resonance, thermal effects, effects of gravity, effects of the magnetic field, effects of static and dynamic fluid, effects of liquids of various pH, exposure to radiation of various intensity, exposure to electroweak forces and analysis for exposure to various air or gaseous environments. The outputs are prototyping and testing documentations (engineering drawings, manufacturing drawings, manufacturing plan, operation plan, maintenance plan and verification plan).

2.13.9 Technology prototype development

The development of prototype is done so that the detail design is verified and modified. On the first stage the fittings, motion and functions are studied, when these are successful then the functional (both technical and technological) verification is done in comparison to the expected performance parameters. It is important that the stakeholders are involved for their input. All necessary modifications are done before the prototype is forwarded for thorough validation process (Carlopio, 2010). The other advantage of the prototype manufacturing is the testing of manufacturing process, need of which has decreased with the advancement of three dimension modelling tools (Jun *et al.*, 2011). Preliminary plans of manufacturing infrastructure, lines, plan and resources are necessary consideration at this stage. The prototype, operation line, validation parameters and draft transfer package, are normally the output of this stage.

2.13.10 Technology verification and validation

According to Hoyle (2001), ISO 9000 verification is a confirmation process, through the provision of objective evidence that specified innovation requirements have been fulfilled. There are two types of verification:

(i) Those verification activities performed during design and on the component to verify conformance to specification.

(ii) Those verification activities performed on the completed design to verify performance against design inputs.

When designing a system there should be design requirements for each subsystem, each item of equipment and each unit and so down to component and raw material level. Each of these design requirements represents acceptance criteria for verifying the design output of each stage. Verification may take the form of a document review, laboratory tests, alternative calculations, similarity analyses or tests and demonstrations on representative samples and prototypes etc. In all these cases the purpose is to prove that the design is right such that it meets the requirements.

Validation on the other hand serves to confirm if the design is right and meet the requirements for a specific application. The reference to planned arrangements again means that verification plans should be adhered to the ISO 9001:2000 standard requires design and development validation to "*be performed in accordance with planned arrangements to confirm that resulting product is capable of fulfilling the requirements for the specified application or intended use that where known*". Validation in engineering innovation is intended to insure what is listed in validation plan (Appendix 30), (Avner, 2010; Hoyle, 2001). All the technology requirement from the project charter have to be interpreted throughout the engineering technology innovation cycle (Avner, 2010). However the validation process may be used to assess the forward integrating of the technology developed by including the assessment of transfer package, prototype and manufacturing line and operation line. Validation parameters and draft transfer package are subjected to validation infrastructure, in a planned manner with sufficient resources to get the approved technology.

At least these are required when the validation process is performed; the technology validation master plan, the technology application, purpose and the scope of the method, performance parameters and acceptance criteria, experiments, equipment and their expected performance, materials and their quantity/quality. The validation has to be conducted based on the acceptance of the stake-holders. Performance parameters may be adjusted as necessary (Hoyle, 2001). The operation procedure for validation has to be clear and it has to include frequency of events. Finally the validation report is compiled (CISR, 2010). Validation data forms an important input in the improvement of the technology both before and after transfer, hence systematic validation situation in R&D organisations in Tanzania are studied, and important variable from validation process are included in the model developed.

2.13.11 Technology transfer

Technology transfer is the process of successfully bringing technology from a source to the targeted user. The transfer package differ depending on the nature and the intention of technology used (Cambridge Chemical Technologies, 2012). The transfer package includes, but not limited to, the following: engineering drawings, manufacturing process sheets, bill of material, technology profile, jigs, fixtures, templates, dies, operation manual, installation manual, maintenance manual, certified training, finance sources (Koshuma, 2005). In LDC this package need to be further studied to examine the effect of inclusion of manufacturing and business framework.

2.13.12 Product launch and commercialisation

Various approaches have been adopted for product launch and commercialisation. Technology incubation is one of the processes that is used (Chijoriga, 2003; Katalambula and Kimambo, 2006). The other strategy is the formation of clusters that are well designed to balance completion and the opening of spill over effects (Shaoa *et al.*, 2008; Felzenszt and Gimmon, 2009), promotion and advertisement using ICT facilities, TVs, radios, newspapers and similar means (Sean, 2008). Another strategy is the cooperation product development regarding the product value chain (Yung-Jie *et al.*, 2007). Although the product launch comes at the end of technology development, it has important variable inputs in technology design. This is an area that needs to be incorporated in the existing design models. The main idea here is to diminish twin valleys of death at the early stage of technology development.

2.14 Model Calibration and Validation

According to Boote (1996) as cited by (Igbadun, 2006) model calibration is a process of adjusting a set of model parameters to make the model work for particular experimental set up or results that match the observed data. In general, this is done by adjusting model parameters. Model calibration is often regarded to be necessary for complex simulation models in order to create a homorphic ("structurally equivalent") abstraction of (a special aspect of) reality (Hofmann, 2005). In order for the parameters of the model to be developed, regression method can be used and later on adjusted to reflect the actual expected output results from the model.

2.14.1 Regression method

Regression analysis enables the establishment of the relationship between dependent variables and independent variables of the study. Multiple regressions are used to examine the effect of outcome while accounting for more than one factor that could influence the outcome.

Regression models describe the relationship between a set of predictor variables $(\boldsymbol{X_i})$ and one or more responses $(\boldsymbol{Y_i})$. For the linear model:

$$Y_1 = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_k X_k + \varepsilon \qquad (5)$$

Where:

$Y_1 =$ Diffusion rate,

$\alpha =$ Constant coefficient,

$\beta_1 ... \beta_k =$ Parameters of the equation,

$X_1 ... X_k =$ are variables affecting the diffusion of technology extracted from Appendix 32.

$\varepsilon =$ error

Where the β_i are coefficients to be estimated from the data. Each element β_i is a partial regression coefficient reflecting the change in the dependent variable per unit change in the i^{th} independent variable assuming all other independent variables are held constant (Levine and Stephan, 2010; Rawlings *et al.*, 1998; Snee, 1977).

Regression analysis has received wide use in data analysis and the development of empirical models. After a regression model which gives an adequate fit to the data has been found, one proceeds to use the model for prediction, or control, or to learn about the mechanism which generated the data. Before a model is used, some checks of its validity should be made (Snee, 1977). In the whole analysis the linear relation between independent and dependent variables has been assumed. The need of checking for the normality of the independent variable is thoroughly examined.

2.14.2 Validity of the model

Model verification and validation (V&V) are essential parts of the model development process if models are to be accepted and used to support decision making. Validation ensures that the model meets its intended requirements in terms of the methods employed and the results obtained. The ultimate goal of model validation is to make the model useful in the sense that the model addresses the right problem, provides accurate information about the system being modelled (Macal, 2005).

Methods to determine the validity of regression models include comparison of model predictions and coefficients with practical existing data. The collection of new data to check model predictions is important. The most common methods are the comparison of model prediction results with theoretical model calculations, and data splitting or cross-validation in which a portion of the data is used to estimate the model coefficients and the remainder of the data is used to measure the prediction accuracy of the model (Xin and Xiao, 2009; Snee, 1977; Levine and Stephan, 2010). A half-half split appears to be the most popular method but it should be systematic with proper reasoning 'or purposeful sampling" depending on the nature of the data (Snee, 1977; Kothari, 2004).

An examination of the model coefficients and associated Variance Inflation Factors (VIF) also provides clues concerning the validity of the model; it measures the collective effect of the correlations among the x variables on the variances of the estimated coefficients. As a general rule, a VIF larger than 5 or 10 is an indication that the associated coefficient is likely to be poorly estimated because of the correlations among the x's. The ratio of the regression sum of squares to the total sum of squares, represented by the symbol R^2 measures the proportion of variation in Y that is explained by the independent variable X in the regression model. The ratio can be expressed as follows:

$$R^2 = \frac{SSR}{SST} \qquad (6)$$

Where:

SSR = *Regression Sum of Square*

SST = *Total Sum of Square*

This is very important measure for the validity of the regression model as well as F-test and T-test (Levine and Stephan, 2010). T-test displays a t value of each coefficient estimated. The null hypothesis for each test is that the value of the coefficient is 0 (SPSS, 2008).

2.15 Development of a agro-technologies Design Guiding Tool for Tanzania

Decision support system (DSS) is a computer based system that supports decision making process in achieving tasks objectives (Laskey, 2006; Druzdzel and Flynn, 2002). The system involves the interaction between human and computer, using data and models to solve structured and unstructured problems. The solution effect supersedes the efficiency of decision process.

Decision support tools (DST) are interactive software tools used by decision-makers to help answer questions, solve problems, and support or refute conclusions (Agency, 2005; Perimenis *et al.*, 2011). In computer systems, a framework is often a layered structure indicating what kind of programmes can or should be built and how they would interrelate. In this case, the access software and the Vensim calibrated model are used to develop the decision support tool.

2.16 Agro-technology R&D Organisation Surveyed in Tanzania

(i) Commission for Science and Technology (COSTECH): COSTECH is a parastatal organization with the responsibility of co-ordinating and promoting research and technology development activities in the country. It is the chief advisor to the Government on all matters pertaining to science and technology and their application to the socio-economic development of the country (COSTECH, 2013). It was established by Act of Parliament No. 7 of 1986 as a successor to the Tanzania National Scientific Research Council. COSTECH became operational in 1988. Its main duties are:

(a) To advice the Government on all matters relating to S&T including but not limited to the formulation of S&T policy, priority setting for R&D, allocation and utilization of resources.

(b) To promote, coordinate, monitor and evaluate scientific research and technology development and technology transfer activities in the country.

(c) To facilitate national, regional and international cooperation in scientific research and technology development and transfer.

(d) To acquire, store, and disseminate scientific and technological information and popularize S&T.

(ii) The Tanzania Engineering and Manufacturing Design Organization (TEMDO): Is an applied Engineering Research and development institution established through Parliament Act No 23 of 1980 which became operational in July 1982. TEMDO operates under the Ministry of Industry, Trade and Marketing. The core function of TEMDO are (TEMDO, 2013):

(a) To design and develop machine and technology,

(b) To transfer technologies to manufacturing SMEs,

(c) To do consulting services to industries and

(d) To training engineers and technician in industries.

(iii) Small Industries Development Organisation (SIDO), was established with a mission to promote the development of small scale industries in Tanzania (SIDO, 2013). Recently however, in response to growing demand from clients, donors and Government, SIDO progressively engaged itself in supporting micro businesses particularly in the informal sector.

(a) Hence, SIDO's new mission is to develop, create, promote and sustain, indigenous entrepreneurial base in the small scale industries and micro businesses.

(b) The main function of SIDO are;

(c) To promote the development of small industries as well as to plan and coordinate their activities,

(d) to provide technical assistance, management and consultancy services to small industry enterprises in Tanzania and

(e) to provide and promote training facilities for persons engaged in or employed or to be employed in small industries and to assist and coordinate activities of other institutions engaged in such training (SIDO, 2013).

Recently SIDO has established six (6) Technology Development Centre (TDC) in the country. These are the only SIDOs setups that were studied since others had no R&D characteristics.

(iv) Tanzania Industrial Research and Development Organization (TIRDO), is a multi-disciplinary research and development organization established by an Act of Parliament No. 5 of 1979 and it became operational on 1st April, 1979. Its mandate is:

(a) To assist the industrial sector of Tanzania by providing technical expertise and support services to upgrade their technology base.

(b) As well, carrying out applied research, for the development of suitable technologies, and value addition to indigenous resources through industrial processing (TIRDO, 2013).

(v) Technology Development and Transfer Centre (TDTC), is one of the constituents of the College of Engineering and Technology (CoET) that was formed on December 15, 2001 through Government Notice 455 of December 7, 2001 as a result of merging the former Institute of Production and Innovation (IPI) and the then Faculty of Engineering (FoE) both of the University of Dar es Salaam. The main aim of TDTC is:

(a) to coordinate the use of college expertise to the provision of technology for national socio-economic development and transfer,

(b) technology incubation,

(c) technology brokerage and

(d) contracted research (TDTC, 2013).

(vi) Centre for Agricultural Mechanisation and Rural Technology (CAMARTEC), was established by Act of Parliament No. 19 of 1981. CAMARTEC's mission is to develop and disseminate improve technologies suitable for agricultural and rural development. The activities are aimed at boosting agricultural production and improving the quality of life and alleviation of rural poverty. The main functions are (CAMARTEC, 1981);

(a) To carry out and promote the applied research designated

(b) To facilitate the designing, adoption and development of machinery and equipment suitable for use in agricultural and rural development.

(c) To develop and manufacture approved prototypes, components and cultural techniques and technologies and evaluate their suitability for adoption and alternative use in rural agricultural production.

(d) To perform tests on all types of machinery and equipment intended for use in agricultural and rural development in Tanzania and to publish results of each test.

(vii) Tanzania Automotive Technology Centre (TATC) was established in 1985 by a presidential decree, as a Research and development Government Institution under the Ministry of Defence and National Service. The Centre is wholly owned by the Government of the United Republic of Tanzania. Its functions are:

(a) To adapt existing engineering technology to alleviate some of the existing problems in transport, agricultural machinery and industry (implementation or pursuit of this function results into adapted or reverse engineered technologies),

(b) To design and develop for production, vehicles, plant and machinery suited to the needs of Tanzania,

(c) To conduct research in materials for use in field of mechanical engineering (material research, metal plastics and rubber, composites.),

(d) To provide consultancy services in the fields of electro-mechanical engineering (industrial consultancy services),

(e) To act as a high technology training Centre,

(f) To conduct quality assurance of land equipment and machinery purchased by the Government and to undertake any special engineering tasks as directed by the Government (TATC, 2005).

(viii) Vocational Education and Training Authority (VETA) Act was enacted by the Parliament in 1994 to guide the vocational education and training (VET) system in Tanzania. The Act established the (VETA) as an autonomous government agency charged with an overall responsibility of coordinating, regulating, financing, providing and promoting vocational education and training. The main vision of VETA is:

(a) To build an excellent VET system that is capable of supporting national social economic development in a global context.

(b) The mission is to ensure provision of quality VET that meets labour market needs, through effective regulation, coordination, financing, and promotion, in collaboration with stakeholders (URT, 2013).

Though the R&D organisation are many, with defined missions and vision, it is not clearly shown how these organisation are interrelated and how do they develop their technologies as related to new agro-technology development model.

Generally on literature reviewed, most of models that were sited had a partial approaches as indicated in the respective sections, however it is noted that most of models were social economic and some were for engineering design with the assumption that the prototype development was sufficient for ensuring technology innovating diffusion shall be achieve. The models call for further development of areas that ensured agro-technologies diffusion in Tanzania.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Primary Data

Primary data were sourced from the R&D organisations as well as other organisations. The information collected focused on: list of technology, technology development processes, manufacturer list, draft variable considered, design processes used, stakeholders involved and their inputs and the effect of these factors to transfer of technology. A total of 116 technologies that were developed by R&D organisations were enlisted.

The main sources of data were R&D institutions in the country, which mainly deal with agro-technology development. The R&D organizations which were the main source of data were as shown in Table 3:

3.1.1 Data from R&D organisations

The first information collected from R&D organisations was the technology inventory that included their values, year of manufacture and the amount of direct or indirect sells. The study was conducted to determine link between R&D organisations and the development of technology. The information obtained was tabulated in the first section of the questionnaire in Appendix 5. The information collected in the first stage were; name of the organisation, number of employees, type of ownership, approximate capital, the main objective, types of products and technical staff composition. Other information was: problems experienced in manufacturing and sales, stakeholders involved in manufacturing and dissemination and the input strength and weakness from designers. Information on involvements of manufacturers in innovation processes was also collected.

Table 3: List of Agro-technology R&D Institution

No	Organisation	Ministry	Location
	TDTC	Ministry of Education and Vocational Training	Dar es Salaam
	TEMDO	Ministry of Industry, Trade and Marketing	Arusha
	TIRDO	Ministry of Industry, Trade and Marketing	Dar es Salaam
	TATC	Ministry of Defence And National Service	Pwani
	CAMARTEC	Ministry of Industry, Trade and Marketing	Arusha
	Uyole Reseach Centre	The Ministry of Agriculture, Food Security and Cooperatives	Mbeya
	SIDO TDC Mbeya	Ministry of Industry, Trade and Marketing	Mbeya
	SIDO TDC Arusha	Ministry of Industry, Trade and Marketing	Arusha
	SIDO TDC Kigoma	Ministry of Industry, Trade and Marketing	Kilimanjaro
	SIDO TDC Iringa	Ministry of Industry, Trade and Marketing	Iringa
	SIDO TDC Lindi	Ministry of Industry, Trade and Marketing	Lindi
	SIDO TDC Kilimanjaro	Ministry of Industry, Trade and Marketing	Kilimanjaro

Since the sample on agro-technology R&D organisations was small, all the identified R&D organisations were included in the study as recommended by Kothari (2004).

3.1.2 Data from other stakeholders

Apart from the data that was collected from the R&D organisation named above, supplementary information was also gathered from the following manufacturing organisations, SEAZ, TEMSO Engineering, Kapalata Engineering, Star Natural Product, Mzinga Corporation, Intermech and Nandra Engineering, and financial organisations TIC, TIB, NMB, NBC, Standard Chartered Bank, CRDB and TRA.

Other areas of data collection were: government agencies such as Ministry of Agriculture, Food Security and Cooperatives, Ministry of Communication, Science and Technology, District agricultural and livestock development offices and BRELA. Societal Groups, Cooperatives, technology users and technology distributors as consumers of technology were consulted.

3.1.1 Primary and Secondary Data

Secondary data were sourced from libraries of the above mentioned organisations. The potential materials for secondary data were from text books, research reports, published journals, annual reports, policies, proceedings and manuals.

Figure 22: Location of deferent R&D organisations in Tanzania.

3.2 Research Design

The methodology used in this research is described in the following section with morphological charts in Appendix 1.

3.2.1 Questionnaires administration

The structured questionnaire and interview were administered to R&D organisations and stakeholders, (Appendix 5), to study the design processes, dependent and independent variables are identified by the cause effect analysis (Appendix 2). As recommended by Kothari (2004) for ranking the findings in research the nominal scale was used, this made it easier to have qualitative analysis where necessary. Concept development, specification of the concept dimension, selection of indicators and formation of index were performed to develop measurement tools. Scaling was used to measure the performance of variables in Fig. 23. Scaling describes the procedures of assigning numbers to various degrees of opinion, attitude and other concepts option as follows:

(i) Making a judgement about some characteristic of an item and then placing it directly on a scale that has been defined in terms of that characteristic.

(ii) Constructing questionnaires in such a way that the score of item's responses assigns a place on a scale.

The second method was mainly used. A scale is a continuum, consisting of the highest point and the lowest point along with several intermediate points between these two extreme points. Scales were rated as shown on the questionnaire and more explicitly in the SPSS 16 software data base.

Likert-type scales with great care to ensure the scaling space giving a closer picture of facts was used as shown in Fig. 23

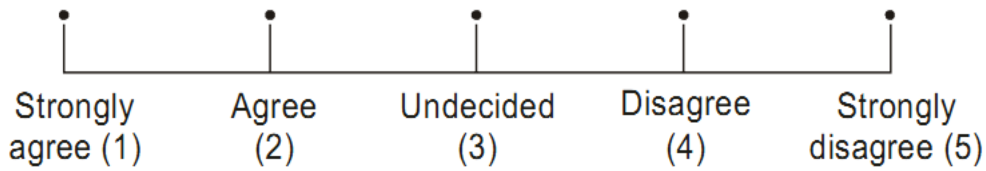


Figure 23: Example of Likert-type scale.

Source: Kothari (2004)

3.3 Assessment of Agro-technology Development in R&D in Tanzania

The study was mostly done by comprehensive interview with key informants and some literature content analysis. Little information was also extracted from the administered questionnaires (Appendix 5). Data studied were overall research history of Tanzania and its relation to political, policy and market dynamism. Other study was done to understand internal capacity of the organisation, technology spectrum for the employment composition and overall technology diffusion trend over the different historical scenarios.

3.4 Identification of Factors for Agro-technology Development Diffusion

Figure 24 in this research is based on the fact that the Agro-technologies design process for technology innovation diffusion is not an isolated series of factors; that it should be linked to social economic activities for the benefit of the country economic growth and improve livelihood of Tanzanians.

The Agro-technologies development process should be of reasonable engineering process that has necessary stakeholder inputs (variables) to increase technology diffusion into society. A stakeholder in an organisation is any group or individual who can affect or is affected by the achievement of the organisation's objectives (Freeman, 1984) cited by Sharp *et al.*(1999).

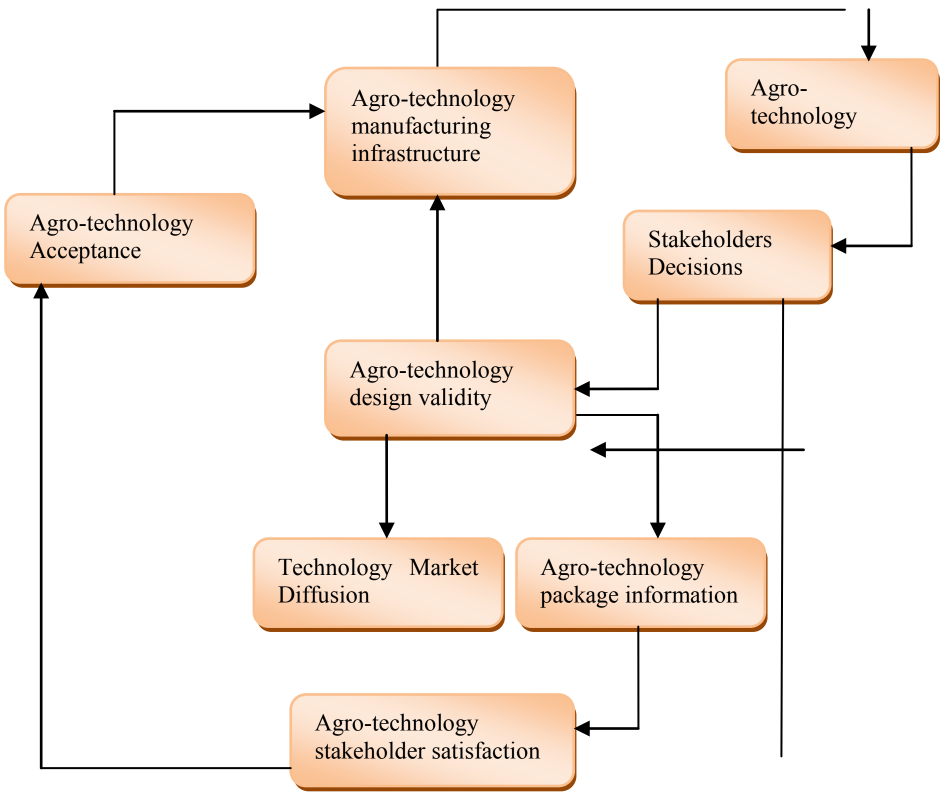


Figure 24: Conceptual frame-work for technology diffusion.

In brief, the main tools that are exploited for enhancement are: innovation design models, Agro-technologies diffusion trends, R&D organisation processes and links, the impact of project management approach, entrepreneurship and the static versus the dynamic behaviour of design model.

Technologies were identified through section one of questionnaires in Appendix 5, one hundred and sixteen (116) engineering agro-technologies from R&D organisations in Tanzania, were identified as itemised in Appendix 8. The criteria for identification of agro-technologies was shown in section 2.1 (Houghton, 2011). The qualifying technologies are ranked using matrix that determine the sales value and quantity of technology both cumulative and per year and sixty (60) technologies were randomly selected using Random Integer Set Generator that is Timestamp: 2012-03-26 14:10:39 UTC. The sample was arranged in diffusion rate and it was split into two equal groups (Kothari, 2004; Snee, 1977). The first group was used for calibration of the model, while the second group was used for validation.

The second important study done was to identify the factors that affect the innovation diffusion process shown based on Fig. 19 (Page 38). A guide of stages included in this study, which are: Initiation, conceptualisation, engineering analysis, prototype development, prototype verification, technology validation and technology transfer were used. By including the information requirement and stakeholder importance, cause effect analysis was used to expand the context of factors. The cause effect analysis (Fig. 25 in Appendix 2) was used to break down stages into variables especially those affects the agro-technology innovation diffusion. At this level the Agro-technology diffusion and stages involved and their inter-relation are shown.

α_i stands for the contributing weight of each stage and, stepwise regression analysis was used to determine each αs. Before the regression analysis was done, each stage was further broken down to determine the component to be studied as shown in Fig. 26 (Appendix 2).

Identification of significant factors for agro-technologies diffusion was firstly done by multiple regression method using SPSS 16 computer software. Diffusion rate is the dependent variable. The governing equation is:

$$Y_1 = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_k X_k + \varepsilon \quad (1)$$

Where:

$Y_1 =$ Diffusion rate,

$\alpha =$ Constant coefficient,

$\beta_1 ... \beta_k =$ Parameters of the equation,

$X_1 ... X_k =$ Are variables that affect agro-technology diffusion.

$\alpha =$ error

The variable (factors) with robust parameter β were used to develop empirical diffusion model (Snee, 1977).

Three dependent variables were used to measure the agro-technology diffusion into society. Cumulative quantity of agro-technologies sold, cumulative value of technology sold in Tanzanian shillings (TZS) and the annual rate of sales of technology in TZS/year.
Linear regression estimates the coefficients of the linear equation, involving one or more independent variables, which best predict the value of the dependent variable. For each variable: number of valid cases, mean, and standard deviation are processed. In SPSS ver 16, for each model: regression coefficients, correlation matrix, part and partial correlations, multiple R, R^2, adjusted R^2, change in R^2, standard error of the estimate, analysis-of-variance table, predicted values, residuals were worked out. Also, 95%-confidence intervals for each regression coefficient, variance-covariance matrix, variance inflation factor, tolerance, Durbin-Watson test and case wise diagnostics were determined. Scatter plots, partial plots, histograms, and normal probability plots were also prepared.

The first stage regressions analysis was done by grouping variables that had close nature and establishing coefficients of groups (macro variables). These coefficients were used in determining weights of groups of variables. The diffusion weighing layout developed in Fig. 25 shows the grouping of variables and their calibration weights α_1 to α_9; The coefficients analysed in the regression analysis are used to develop the stock and flow diagrams as explained in section 2.6, variables are grouped on the basis of the combination of project design models and innovation models as shown in Fig. 18.

.

The interpretation of the project method of NPD in the chart form is displayed in Appendix 4, though shown in a compressed form, yet it is useful in developing the agro technology diffusion parameters layout shown in Fig. 25. The top part of the boxes shows stake holder for each stage, the lower right part of boxes show the stage main activity and the lower left of boxes shows the process output.

Where:

α_1 = weight for initiation stage variables

α_2 = weight of conceptualisation stage

α_3 = weight of engineering analysis stage

α_4 = weight of prototyping stage

α_5 = weight of validation stage

α_6 = weight of transfer stage

α_7 = weight of documentation

α_8 = weight of stages existence

α_9 = weight of validation stake holder participation

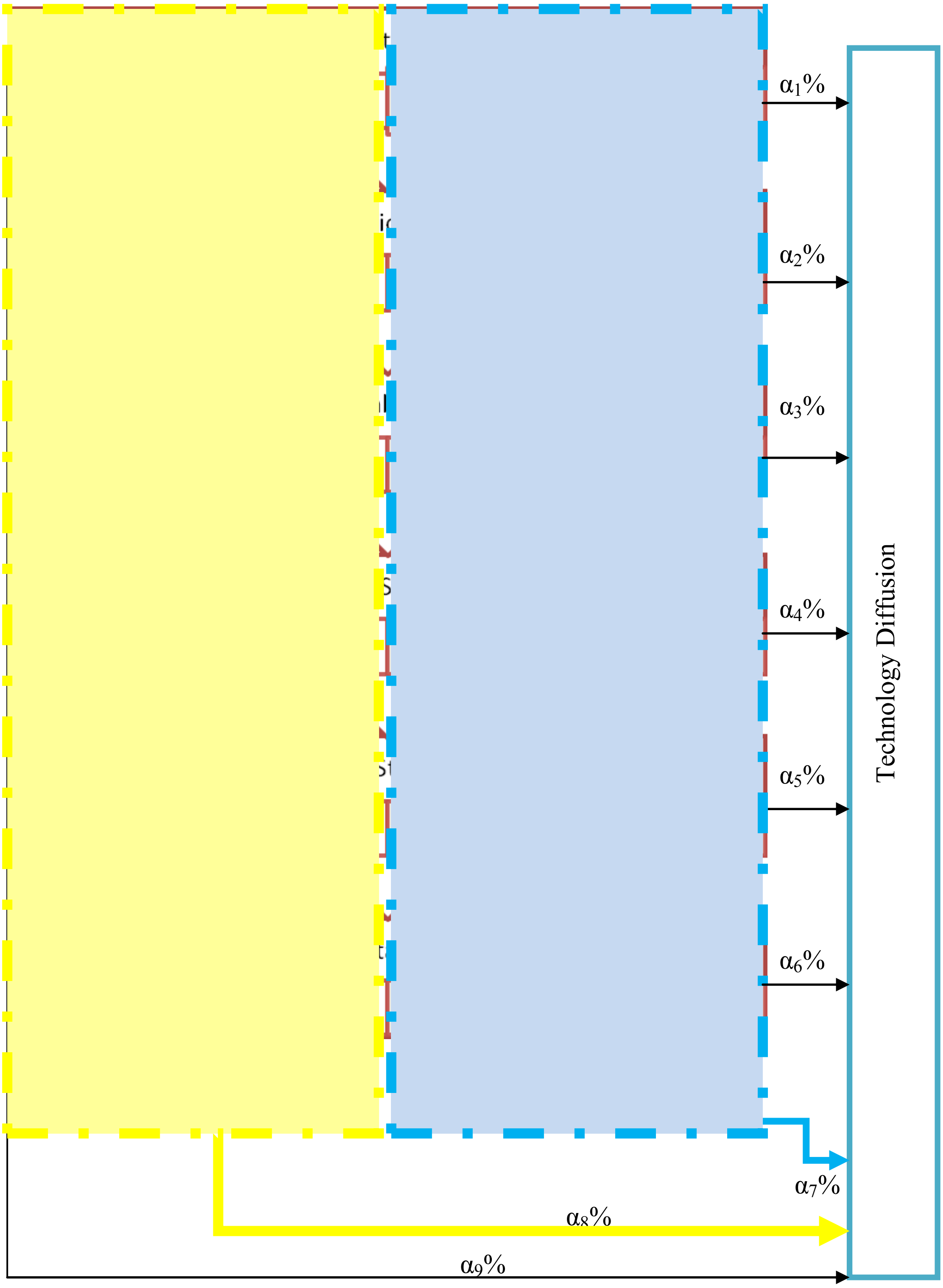


Figure 25: Factors weight layout.

The weights are obtained from the average value of t significance coefficients in each group of classified data. All variables with t value less than 0.05 are picked:

Null hypothesis in this case is $H_0 : \alpha = \alpha_i = 0$ (2)

Alternative hypothesis is $H_a : \alpha = \alpha_i \neq 0$ (3)

Level of significance is 5%

The second multiple regressions analysis is used on individual coded variables, called micro variables. For example, in initiation stage, need establishment to customer request variables for a batch one of first thirty (30) agro-technologies were loaded in the SPSS ver 16 software data base. Stepwise option was used (Stepwise selection). If there were independent variables already in the equation, the variable with the largest probability of F was removed if the value was larger than accepted value. The equation was recomputed without the variable and the process was repeated until no more independent variables could be removed.

Null hypothesis in this case was $H_0 : \beta = \beta_i = 0$ (4)

Alternative hypothesis was $H_a : \beta = \beta_i \neq 0$ (5)

Level of significance was 5%

Equation 5 shows the dependent and independent variable.

3.4.1 Development of model for diffusion of agro-technology innovations

System dynamic method was used to convert static model into dynamic, so that the trend of the effects of design variables can be studied over time:

Variable identification methodology was using Ishikawa cause effect analysis. The variables are filtered and only the important ones were taken into system dynamic model.

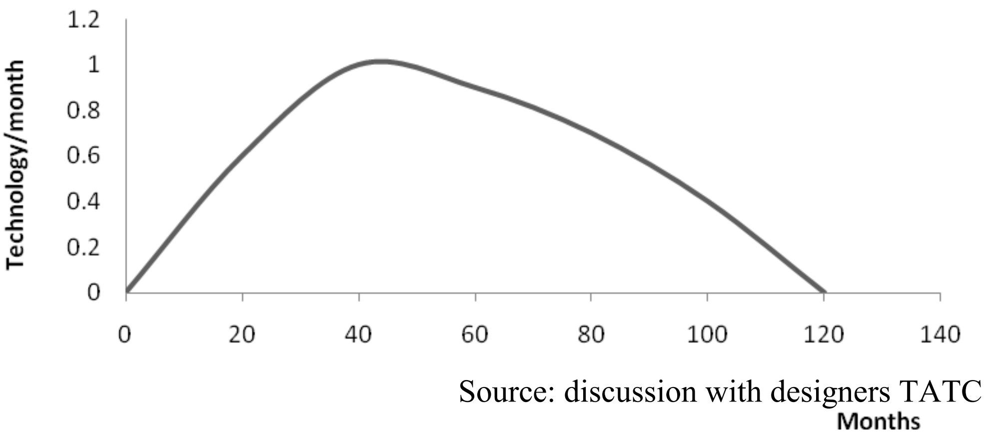
(a) Reference modes

A reference mode is empirical trend over time without much concern on the precision but rather a characteristic. In this research three reference modes were used:

Expected design trend Y_a

$$Y_a = 0.000284 \times time^2 + 0.0315 \times time \tag{6}$$

The assumption is that technology design process takes half the sales life time of the technology. This includes the improvement done to the technology to the market exhaustion. Reference mode was developed using the excel spread sheet and using the scatter plot to get the approximate equation 11, of 94.4% R^2, the equation trend in Fig. 26 is used as a module in the diffusion model.

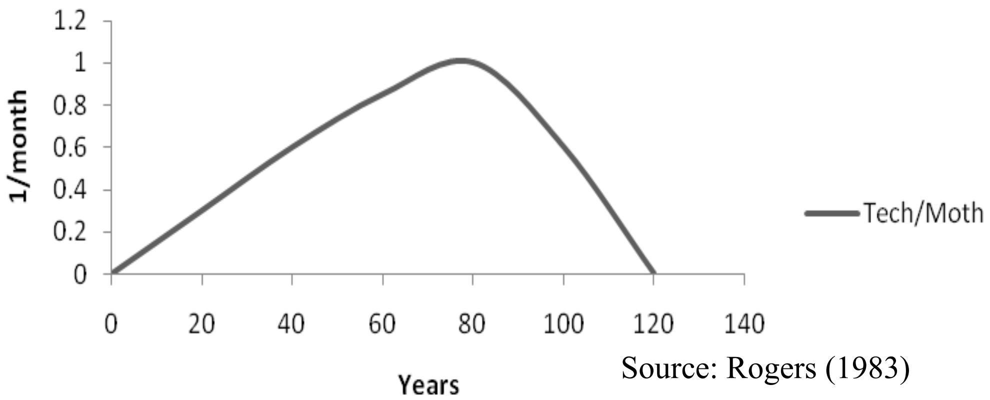


Source: discussion with designers TATC, 2012

Figure 26: Expected design trend.

The second mode used is expected market trend Y_b. (Fig. 27)

$$Y_b = -4 \times 10^{-6} \times time^3 - 0.0005 \times time^2 - 0.0032 \times time \tag{7}$$



Source: Rogers (1983)

Figure 27: Expected market trend.

Other mode close in relation to the second mode is the expected cumulative sales $Y_{c.}$ The theory comes from the sigmoid function referred in section 2.9. For the purpose of this study the sales life span is assumed to be 120 months, that is 10 years, normally this is the average brand life span of medium size machines (response of Interview by experienced engineers), however the model can be modified to accommodate different life spans. The factor of 0.1 is used to spread the S curve (Fig. 28) throughout the sales time.

$$Y_c = \frac{1}{1+e^{[(-0.1 \times time)+(0.1 \times 60)]}} \qquad (8)$$

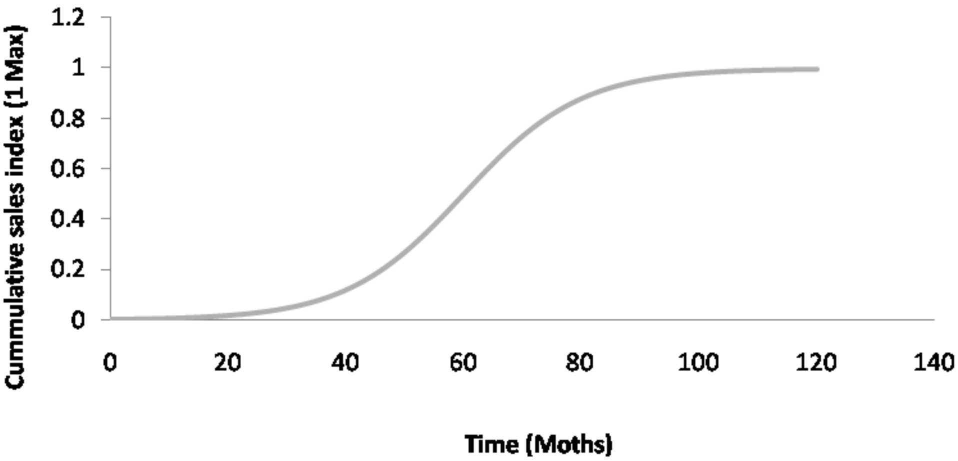


Figure 28: Expected cumulative sales.

Source: Rogers (1983)

(b) Reality check and dynamic hypothesis

This is a process of defining some reality check statements about how things must interrelate (Vensim, 2003) and is shown in Table 4 and Fig. 29. A dynamic hypothesis is a theory about what structure exists that generates the reference modes. A dynamics hypothesis can be stated verbally but more preferably, as a causal loop diagram, or as a stock and flow diagram.

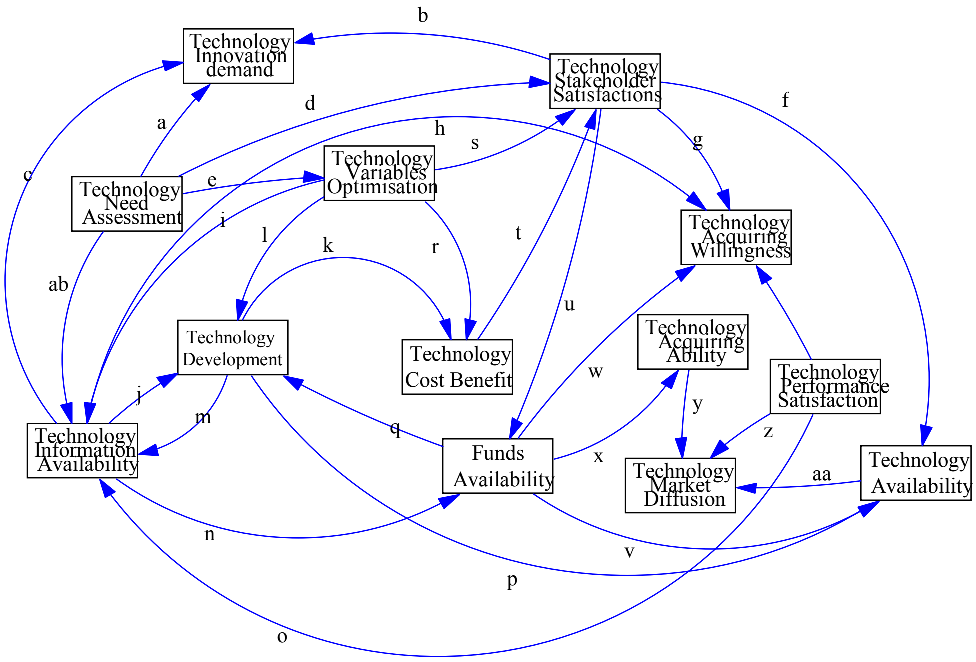


Figure 29: Agro-technology diffusion causality diagram.

(c) Simulation Model

Simulation model is the refinement and closure of a set of dynamic hypotheses to an explicit set of mathematical relationships. Simulation models generate behaviour through simulation. A simulation model provides a laboratory in which experiment to understand how different elements of structure determine technology diffusion behaviour.

The causality loops shown in Fig. 29 with the combination of factors and their related variables were done and illustrated in Table 5. Main factors, modules and dependent variables were linked in stock and flow diagram shown in Fig. 30 using the Vensim software.

Equations 14 to 49 were loaded into the developed model to be tested. Actual variables and coefficients were loaded after the analysis of the values. The model starts with the need identification for the technologies that take care of the relevance needs, there after the need are interpreted into design variable.

Table 4: Reality check

Loop	Implication	Common variables
a	Identification/creation of demand	Technical specification Technological specification Business scope
b	Identification/creation/optimisation of demand	Matching stakeholder expectation, i.e. technical technological financial and social economic
c	Enhance adoption efficiency, expand demand (Business case)	Enhancing awareness of stake holders
d	Matching market needs/increase satisfaction	Validation of need assessment
e	Conversion of problems to engineering variable	Preliminary development of technology design specification (TDS)
f	Enhancing manufacturing business and business set up possibilities	Business set up support to: developers, manufacturer and end users.
g	Expand adopters scope and support	Healthy environment for adopters
h	Technology adoption through information	Technology availability awareness
i	Detailed technology information	Optimal variables for technology design
j	Development for market requirement	Optimal Technology development
k	Appropriate technology (complete package)	Business oriented technology
l	Optimal technology required (Project Charter)	Completeness of technology requirement
m	Development Technical and technological information	Technology information documentation
n	Convince funders, proper project and business plan	Extract for business proposal
o	Information of satisfaction factor	Success stories information
p	Complete sustainable package (Manufacturing, technology, operation)	Technology itself, Manufacturing infrastructure and operation launching
q	Packaged fund (technology develop to incubation)	Funds for development Funds for manufacturing Fund for diffusion
r	Creation of project viability	Bankability Business possibility
s	Comply to users expectations	Stakeholder satisfaction
t	Financial viability	Profit assurance
u	Government, Macro and Micro-financiers and donors satisfaction	Financiers' satisfaction
v	Development and manufacturing	Mainly manufacturer incubation
w	A trigger	For LDC this is the main mean of acquiring technology
x	Technology prices Vs Per capital	Purchasing power
y	Promote procurement (Make it possible)	Enhance chances of technology diffusion
z	Confidence on technology business set up	Enhance chances of technology diffusion
aa	Technology supply	Enhance chances of technology diffusion
ab	Innovation with society as a driver	Social economic advantages

On the other hand the technology validation process ensures the matching of needs and expected technology behaviour, which affects the design validity. Stakeholders' dynamism emphasises on the stakeholders' participation in each stage of technology development, this gives rise to stakeholders' satisfaction. Market diffusion dynamism is affected by the demand existence and the market saturation. Technology information availability, stakeholders' technology acceptance and proper packaging of technology lead to higher possibilities of technology diffusion. All these arguments were tested by looking at the sensitivity of mentioned factors shown in Table 5.

Expected cumulative sales is variable that is loaded manually and can give the prediction of the sales value in TZS or quantity depending on the values variable picked in the technology development cycle. The capability of the model in predicting diffusion level is tested as shown in section 3.5, which includes the model calibration discussed in section 2.14.

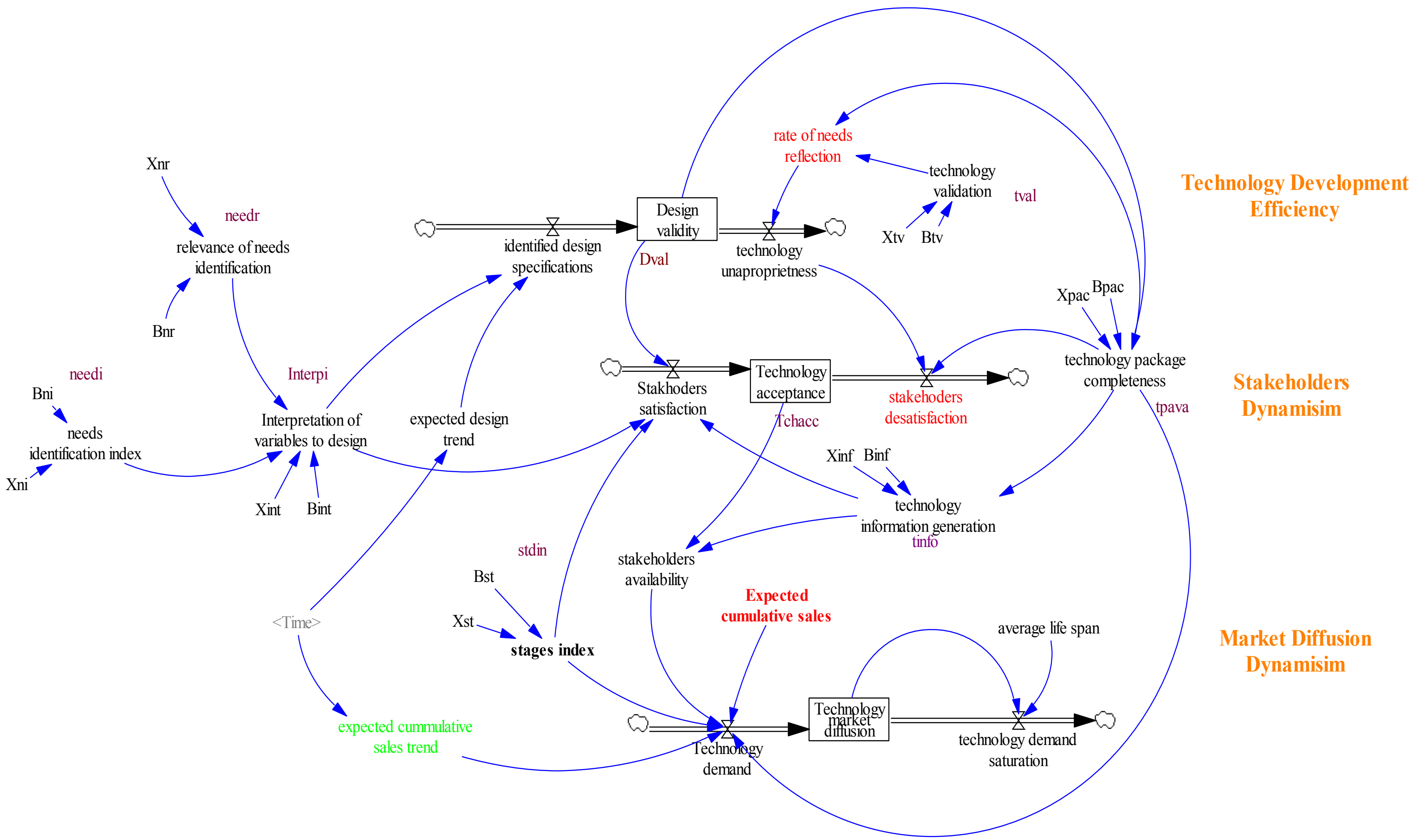


Figure 30: Dynamic simulation model.

Table 5: Description of factors variables and coefficients

Abbreviation factors	The Factor and Dependent variables Meaning	Variable	Coefficient	Link to cause effect loop
needr	relevance of needs identification	Xnr	Bnr	a, q, x, ab
needi	need identification index	Xni	Bni	j, k
interpi	Interpretation of variables to design	Xint	Bint	a, b, e, i, k, m, n, q, x, ab
stdin	stages index	Xst	Bst	g, ab
tval	technology validation	Xtv	Btv	c, d,
tpava	technology package completeness	Xpac	Bpac	g, k, r, v, aa,
tinfo	technology information generation	Xinf	Binf	c, h, i, o
dval	Design validity	Dependent variable		a, j, k, y, aa, ab
tchacc	Technology acceptance	Dependent variable		r, q, p, o, s, z, t,u, v, ab
tmdif	Technology market diffusion	Dependent variable		all

(d) Vensim diffusion formulas development

average life span	=	200	Units: Month	(14)
Binf[Tech]	=	Binf	Units: Dmnl [5.46506e-044,?]	(15)
Bint[Tech]	=	Bint	Units: Dmnl [5.46506e-044,?]	(16)
Bni[Tech]	=	Bni	Units: Dmnl [5.46506e-044,?]	(17)
Bnr[Tech]	=	Bnr	Units: Dmnl [5.46506e-044,?]	(18)
Bpac[Tech]	=	Bpac	Units: Dmnl [5.46506e-044,?]	(19)
Bst[Tech]	=	Bst	Units: Dmnl [5.46506e-044,?]	(20)
Btv[Tech]	=	Btv	Units: Dmnl [5.46506e-044,?]	(21)
design validity[Tech]	=	INTEG ((identified design specifications[Tech] - technology unapproprietness [Tech]),	Units: Tech	(22)
expected cumulative sales trend[Tech]	=	-4e-006*Time^3 + 0.0005*Time^2 - 0.0032*Time	Units: 1/Month	(23)
expected cumulative sales[Tech]	=	1	Units: Tech	(24)
expected design trend[Tech]	=	-0.000248*Time^2 + 0.0315*Time	Units: Tech/Month	(25)
identified design specifications[Tech]	=	expected design trend[Tech]*Interpretation of variables to design[Tech]	Units: Tech/Month	(26)

Interpretation of variables to design[Tech]	=	(Sum Xint*Bint/ Sum Xint*Bint)*((Wnr*(need identification index[Tech]+Wni*relevance of needs identification[Tech]))/(Wnr + Wni)	Units: Dmnl	(27)
need identification index[Tech]	=	Sum (Xni[Tech]*Bni[Tech])/sum max (Xni[Tech]*Bni[Tech])	Units: Dmn	(28)
rate of need reflection[Tech]	=	(Btv*technology validation[Tech]+Bpac*technology package completeness[Tech])/ (Btv+Bpac)	Units: Dmnl	(29)
relevance of needs identification[Tech]	=	Sum(Bnr*Xnr[Tech]/Bnr	Units: 1/Month	(30)
stages index[Tech]	=	Sum Xst[Tech]+Bst[Tech])/Sum Max (Xst*Bst)	Units: Dmnl	(31)
stakeholders dissatisfaction[Tech]	=	(1-technology package completeness[Tech])*technology unaproprietness[Tech]	Units: Tech/Month	(32)
stakeholders availability[Tech]	=	(Technology acceptance[Tech]*technology information generation[Tech])/0.4	Units: Tech	(33)
Stakeholders satisfaction[Tech]	=	(Design validity[Tech]+Interpretation of variables to design[Tech]+stages index [Tech]+technology information generation[Tech]) Units: Tech/Month		(34)
Technology acceptance[Tech]	=	INTEG ((Stakeholders satisfaction[Tech]-stakeholders dissatisfaction[Tech]), 0)	Units: Tech	(35)
Technology demand[Tech]	=	(Expected cumulative sales[Tech]*(expected cumulative sales trend[Tech])*((stages index[Tech]+technology package completeness[Tech]*stakeholders availability[Tech]	Units: Tech/Month	(36)
technology demand saturation[Tech]	=	(Technology market diffusion[Tech])/average life span	Units: Tech/Month	(37)

technology information generation[Tech]	=	technology package completeness[Tech]*Xinf[Tech] *Binf[Tech]	Units: Tech	(38)
Technology market diffusion[Tech]	=	INTEG ((Technology demand[Tech]-technology demand saturation[Tech]), 0)	Units: Tech	(39)
technology package completeness[Tech]	=	Design validity[Tech]*Sum ((Xpac[Tech]* Bpac[Tech] /Sum (Max Xpac*Bpac))	Units: Tech	(40)
technology unapproprietness[Tech]	=	1-rate of need reflection[Tech] Units:	Tech/Month	(41)
technology validation[Tech]	=	*Sum Xtv[Tech]*Btv[Tech])/Sum max (Xtv[Tech]*Btv[Tech]))*	Units Tech/Month	(42)
Xinf[Tech]	=	GET XLS CONSTANTS('Toven.xlsx','tinfa','F2*')	Units: Dmnl	(43)
Xint[Tech]	=	GET XLS CONSTANTS('Toven.xlsx','interpi','I2*')	Units: Dmnl	(44)
Xni[Tech]	=	GET XLS CONSTANTS('Toven.xlsx','needi','C2*')	Units: Dmnl	(45)
Xnr[Tech]	=	GET XLS CONSTANTS('Toven.xlsx','needr','B2*')	Units: Dmnl	(46)
Xpac[Tech]	=	GET XLS CONSTANTS('Toven.xlsx','tpava','B2*')	Units: Dmnl	(47)
Xst[Tech]	=	GET XLS CONSTANTS('Toven.xlsx','stdin','B2*')	Units: Dmnl	(48)
Xtv[Tech]	=	GET XLS CONSTANTS('Toven.xlsx','tval','G2*')	Units: Dmnl	(49)

(e) Graphic user inter-phase

Since the model is intended to be used by designers in developing or assessing developed agro-technologies, skeleton graphic user inter-phase is developed as a tool to facilitate the use of the model. The combination of Vensim ver. 6.0, Access ver. 2007 and Excel ver. 2007 computer software were used to develop the innovation tool in the form of designers' window to guide design processes and enable checking if the final innovated product could be diffused. The stock and flow data are used to develop source codes.

3.5 Model Verification and Validation

The second group sample as explained in section 3.2 b and shown in Appendix 33 is used to validate the model. Variable related to technology development such as manufacturing machinery availability, manufacturing human resources consideration, manufacturing capital, project charter development, business case existence and incubation are among the variables that were picked from technology development cycle. Technology development variable such as human resources, financial resources, machinery, software and tools for analysis and drawings or modelling, utilisation of PDS in design, utilisation of PDS in validation, planning of validation and validation output, financial analysis of technology and financial support. Stakeholders' input consideration and the cooperative design processes are translated into variables for testing the tool.

The developed model was loaded with variables from the agro-technology sample two (2) to test if it is functioning to the expected prediction and is also user friendly. Sample one (1) was used to develop the model. On running the model, the output from the model predicts whether the technology will diffuse or not and predict the chances of diffusion.
Statistical analysis was used on the model output and the results obtained from the data on diffusion rate are found in sample 2. The tool prediction was compared with actual finding in sample 1 and the internal consistency reliability of the model was measured by Pearson correlation statistics. SPSS software was used to speed up the analysis.

3.5.1 Computing and interpreting the Durbin–Watson statistics

If it is the residual associated with the observation at time t, then the test statistic is

$$d = \frac{\sum_{t=2}^{T}(e_2 - e_{(t-1)})^2}{\sum_{t=1}^{T} e_t^2} \tag{9}$$

where T is the number of observations. Since d is approximately equal to 2(1 − r), where r is the sample autocorrelation of the residuals, and d = 2 indicates no autocorrelation. The value of d always lies between 0 and 4. If the Durbin–Watson statistic is substantially less than 2, there is evidence of positive serial correlation. As a rough rule of thumb, if Durbin–Watson is less than 1.0, there may be cause for alarm. Small values of d indicate successive error terms are, on the average, close in value to one another, or positively correlated. If d > 2 successive error terms are, on the average, much difference in value to one another, i.e., negatively correlated. In regression, this can imply an underestimation of the level of statistical significance.

CHAPTER FOUR

4 RESULTS AND DISCUSSIONS

4.1 Agro-Technology Development and Diffusion by R&D Organisation in Tanzania

4.1.1 Diffusion comparison in different organisations

As suggested by general findings, performance of R&D organisations in technology diffusion differs by technology types, sizes and originating organisation however, development processes were started at different times and these times were not having similar market policies.

Fig. 31 shows that in the 1980s there was a higher diffusion rate (7 million TZS and 5 thousands technologies), as at that time Tanzania was practising socialism and there were many cooperatives and parastatal organisations linked to R&D organisations. In 1990 the diffusion dropped tremendously to less than 1milion TZS and 400 technologies. This was due to the abandonment of socialist policy and confusion that grouped R&D organisations with other parastatal organisations, that they had no government support. In the year 2000 to 2010 the government realised the need for reviving the support on R&D organisation, however the effort is not yet well linked to the free market economy and the diffusions rate. Two million TZS and 1 000 technologies did not reach the diffusion rate of the 1980s levels. In the free market economy, which is well explained with the concept of twin valley of death forms the input of the model developed.

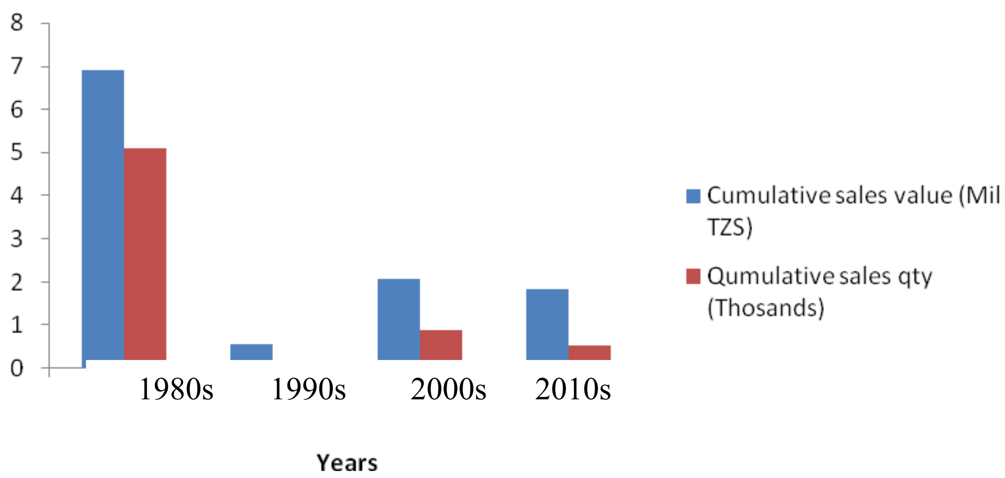


Figure 31: Sales trend over years.

Milling technology diffusion rate in Table 6 and Fig. 32 has shown that the variables like capacity, price and location have great influence on the amount of sale.

Table 6: Milling machines diffusion characteristics

Technology	Capacity	Units	Year Developed	Qty	Value	Manufacturer	sales per year (TSh Mil)
Maize Mill	550	kg/hrs	2007	52	2 300 000.00	TDC Arusha	23.9
Spices Milling Machine	90	kgs/hr	2008	11	1 400 000.00	TDC Arusha	3.9
Maize Milling Machine	700	kgs/hr	2004	300	2 500 000.00	TDC Kilimanjaro	93.8
Maize Mill	550	kgs/hr	2003	82	2 500 000.00	TDC MBEYA	22.8
Grain mill	2 000	kg/hr	2010	2	5 000 000.00	TDTC	5.0
3 Roller hammer	1 000	kg/hr	2002	25	1 990 000.00	TDTC	5.0
Maize mill	1 000	kg/hr	1988	26	2 570 000.00	TDTC	2.8
Maize mill	500	kg/hr	1987	25	2 100 000.00	TDTC	2.1
2 Roller hammer	500	kg/hr	1990	22	1 560 000.00	TDTC	1.6
Maize mill	250	kg/hr	1988	4	1 680 000.00	TDTC	0.3

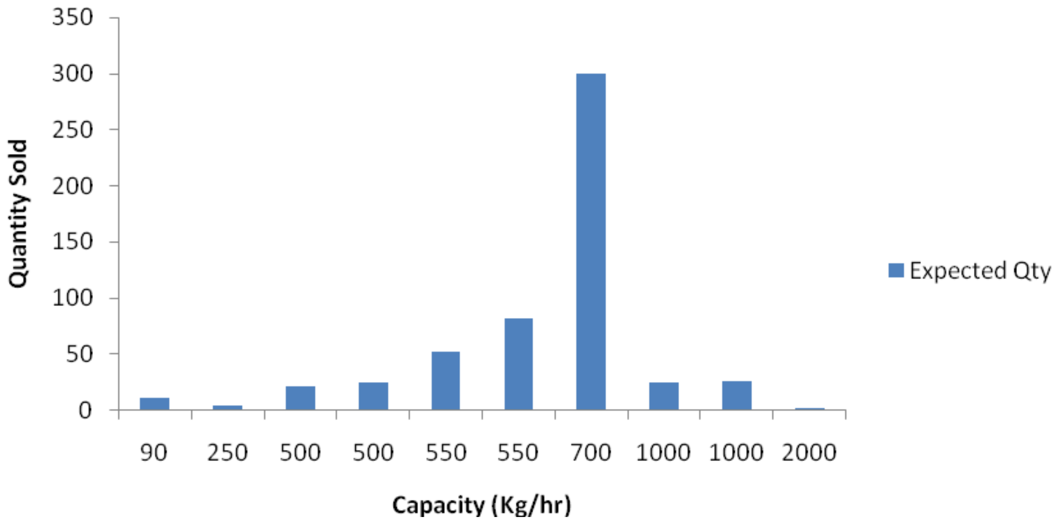


Figure 32: Milling machine market trend.

Maize mills with capacity of 250 kg/ hr developed at TDTC 1980s could not find market while that of 500 to 1 000 kg/hr developed in 1090s had a higher market share. The same trend is shown by SIDO TDCs, the 700 kg/hr milling machine real hit the market in 2007s, followed by 5.5 kg/hr 134 units. The grain milling of 2 000 kg/hr was a special order. From these preliminary findings in Table 6 and Fig. 32, it can be deduced that variation in design variable affects the diffusion rate. But bad finding was that the R& D organisation transformed themselves into manufacturing firms instead of developing and transferring technologies as stipulated in their establishment missions.

In examining two packaged technologies from the former IPI later changed to TDTC as shown in Table 7, it was noted that there were two technologies; the palm oil extractor project sponsored by SIDA-SAREC and mini sugar plant sponsored by SUDECO.

Table 7: TDTC palm oil plant and mini sugar plant

Technology	Capacity	Units	Year Developed	Qty	Value (TSh Mil)	Manufa-cturer	Sales per year (TSh Mil)
Palm Fruit Sterilizing Tank	300	kg/batch	1987	2	0.72	TDTC	0.06
Palm Fruit digester	500	Ltr/hr	1987	5	1.80	TDTC	0.36
Palm Fruit Clarifier	500	Ltr/hr	1987	4	2.28	TDTC	0.36
Palm fruit thresher	700	kg/hr	1987	2	2.76	TDTC	0.22
Sugar cane crusher	2 000	kg/hr	1990	13	33.00	TDTC	19.50
Evaporating furnace	2 000	kg/hr	1990	13	5.79	TDTC	3.42
Crystalliser bank	2 000	kg/hr	1990	13	12.93	TDTC	7.64
Centrifuge	2 000	kg/hr	1990	13	2.70	TDTC	1.59
Settling tank (Sugar processing)	2 000	kg/hr	1990	13	1.41	TDTC	0.83

For sugar mini plant it was found that, there have been operational and logistical problems for the existing plants, such as lack of agricultural extension service, poor management, inadequate infrastructural support, and low sugar productivity. The failure in achieving the expected linkages between the plant owners and sugarcane out growers was caused by the plants owners' inward looking behaviour and failure of the plant owners to manage relationships with the sugarcane out growers (Chungu *et al.*, 2001). The project aim was to be spread all over the country, but there were no sufficient design factors consideration to enable diffusion. Thirteen (13) units produced were limited edition and the project stopped. One of the observations that were very clear was lack of agro-technology development model and science, technology and innovation policy.

The same scenario was found in many other organisations and the associated technologies.

Table 8: SIDO TDC Performance

Technology	Capacity	Units	Year Developed	Qty	Value	Manufacturer	Annual sales
Maize Mill	550	kg/hrs	2007	52	2 300 000.00	SIDO Arusha	23 920 000
Maize Milling Machine	700	kgs/hr	2004	300	2 500 000.00	SIDO Kilimanjaro	93 750 000
Maize Huller	400	kgs/hr	2004	300	2 500 000.00	SIDO Kilimanjaro	93 750 000
Candle Moulding machine (Manual)			2005	300	350 000.00	SIDO Kilimanjaro	15 000 000
Energy Serving Stove			2006	80	700 000.00	SIDO Kilimanjaro	9 333 333
Maize Mill	550	kgs/hr	2003	82	2 500 000.00	SIDO MBEYA	22 777 778
Maize huller	450	kgs/hr	2003	73	2 500 000.00	SIDO MBEYA	20 277 778
Maize Sheller	1 000	kgs/hr	2003	50	2 800 000.00	SIDO MBEYA	15 555 556
Animal Feed Milling	240	kgs/hr	2005	64	1 250 000.00	SIDO MBEYA	11 428 571

Although mission statement differs from one organisation to the other, the nature and type of technology are similar. However, there were differences on the number of variety (quantity) of technology produced. Some R&D organisations have narrow brands while others have wide range of products. TDTC has the highest range (43) of product followed by TEMDO (19) and other organisation as shown in the Fig. 33.

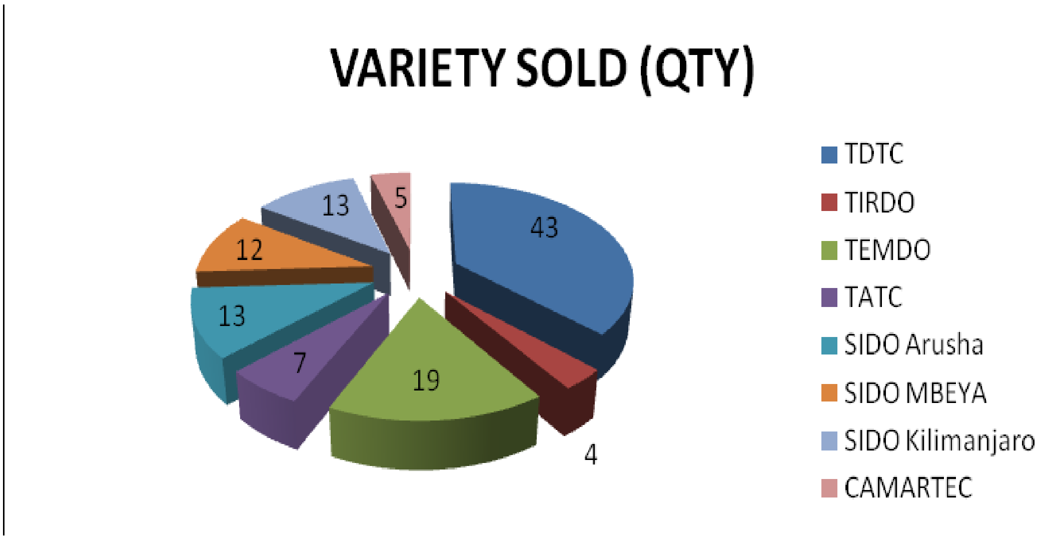


Figure 33: Variety of agro-technology developed in quantity.

On cumulative values of technologies developed and sold by these eight sampled R&D organisations, the results in Fig. 34 shows that CAMARTEC has an outstanding performance on the cumulative sales (1 684 mil TZS), although the spectrum of products it produced was narrow (5). This aspect of narrowing the scope is explained in the stage gate model that may increase innovation efficiency by 40%. In this model stages existence are taken as important factors in agro-technologies diffusion.

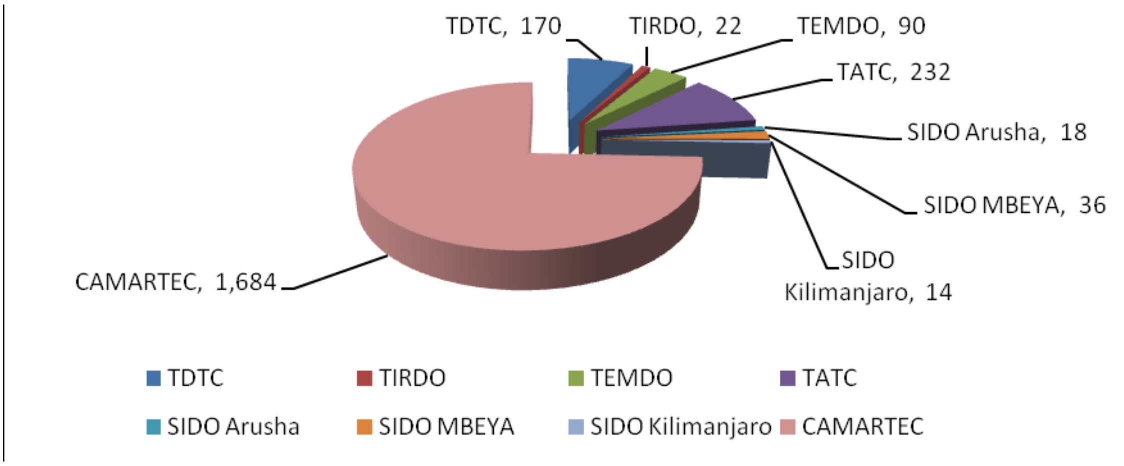


Figure 34: Cumulative value of agro-technology developed and sold by selected 8 R&D organisations (million TZS).

On the other side, average sales per year in value had similar performance for all eight R&D organisations as shown in Fig. 35. TATC sales of 261million TZS per year is mainly due to the high value of technologies they make and the support from the Ministry of Defence and National Service. CAMARTEC has a long history of selling the same type of products (Biogas plant and Coal stoves; 1080) as shown in Fig. 36, looking at the S curve structure the market is going to saturation. TDTC and TEMDO are declaring failure to transfer their technologies and having small mass production capacity (about 100 million TZS). TIRDO has almost abandoned the agro-technology development process (33 million TZS). SIDO TDCs seems to be good competitor and coming up with good sales rate (428 million TZS) but in the development side, very little has been done, whereby most of technologies are copied. These organisations are almost doing the same kind of work with no rationalisation to have a continuous innovation process.

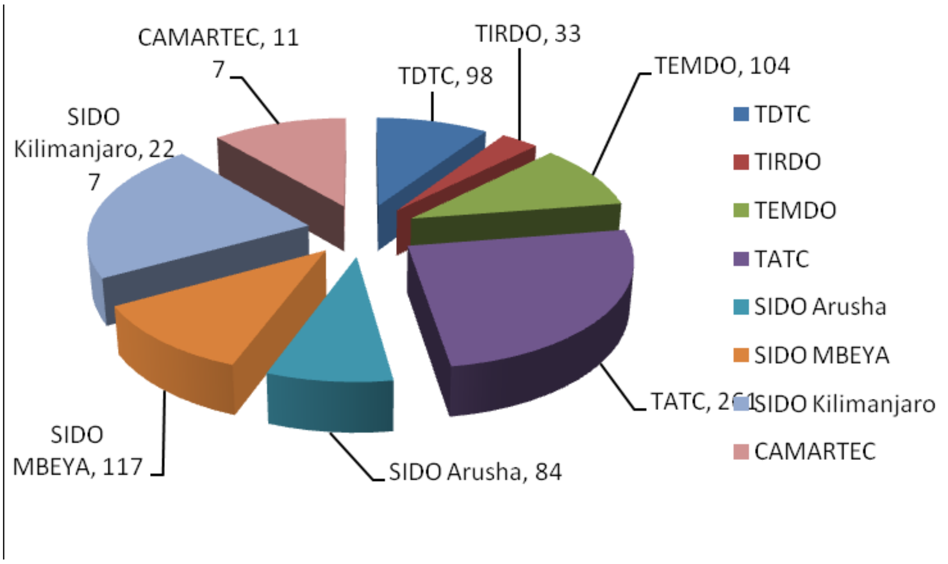


Figure 35: Diffusion rate in sales per year (Million TZS.)

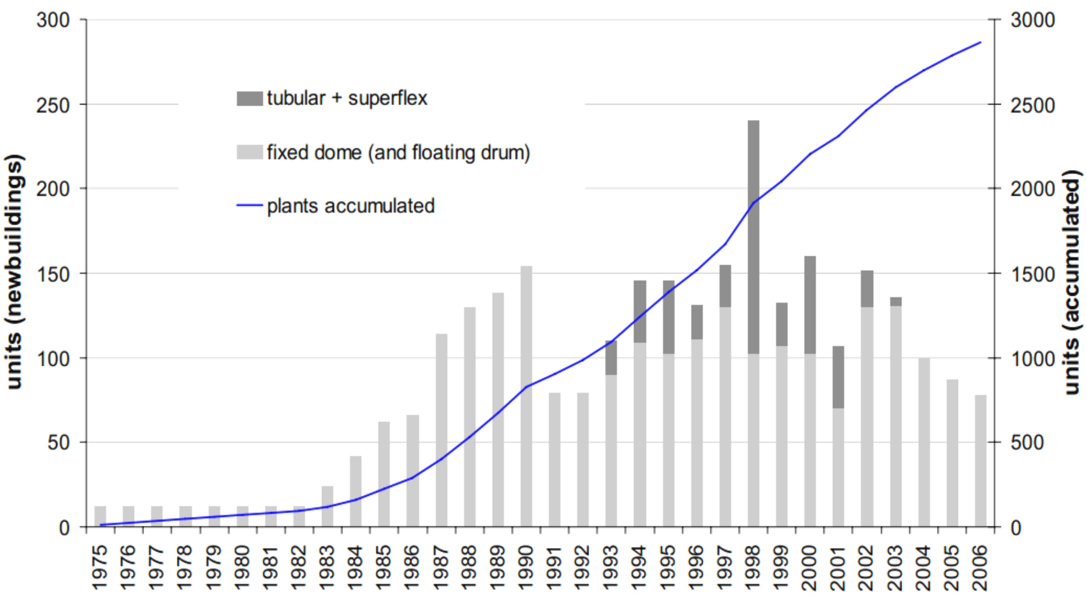


Figure 36: Overall biogas plants sales trend in Tanzania.

Source: (GTZ, 2007)

On fixed resources that are machineries for developing technology, all organisations are ranging between 0.8 to 1 billion Tsh this is mainly because all studied organisations are parastatals. On human resources there is resemblance between TEMDO, CAMARTEC, TIRDO and TDTC (~100), on the other hand SIDO TDCs are having less workers (~20) (Fig. 37).

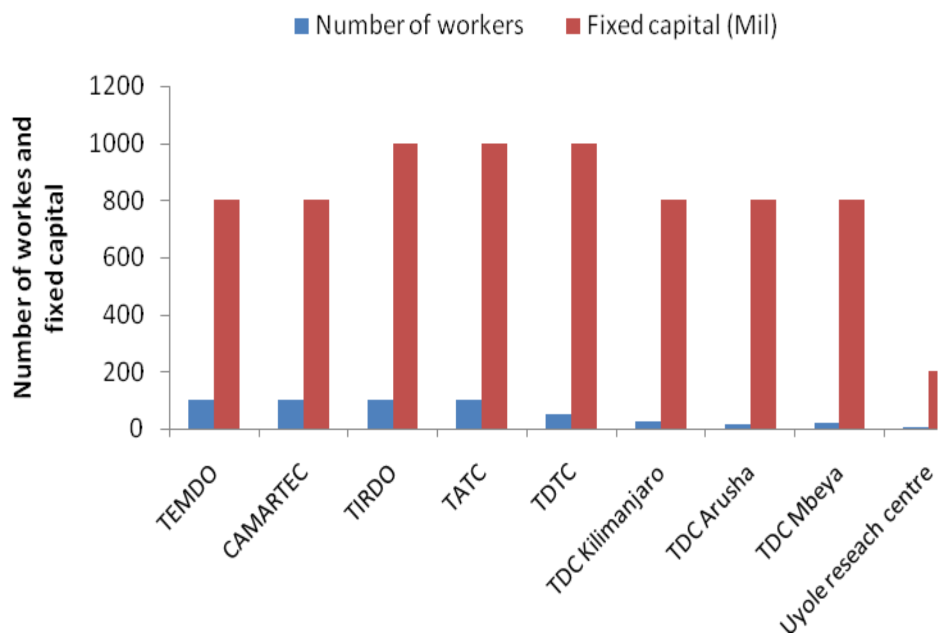


Figure 37: Human resources and fixes capital.

There is a big inconsistency of the ratio of workers in R&D organisations in Tanzania (Fig. 38). Resources for agro-technology needs studies for diffusion are of no priority in terms of staffs' recruitment. Although this is outside the scope of this study, the re-examining the staff's composition in R&D organisation in Tanzania is inevitable. For instance by observation, TATC has engaged itself highly on big scale production of spare parts for TAZARA and other customers order, like NIDA storage boxes that need big number of artisans, reason being production for organisation survival. So the staffs' academic ratio is not linked to R&D activities. It is apparent that SIDO (TDCs) are not yet focused on R&D

activity but rather copying and producing. Most of these organisations have one engineer who has to manage both technology manufacturing and technology development.

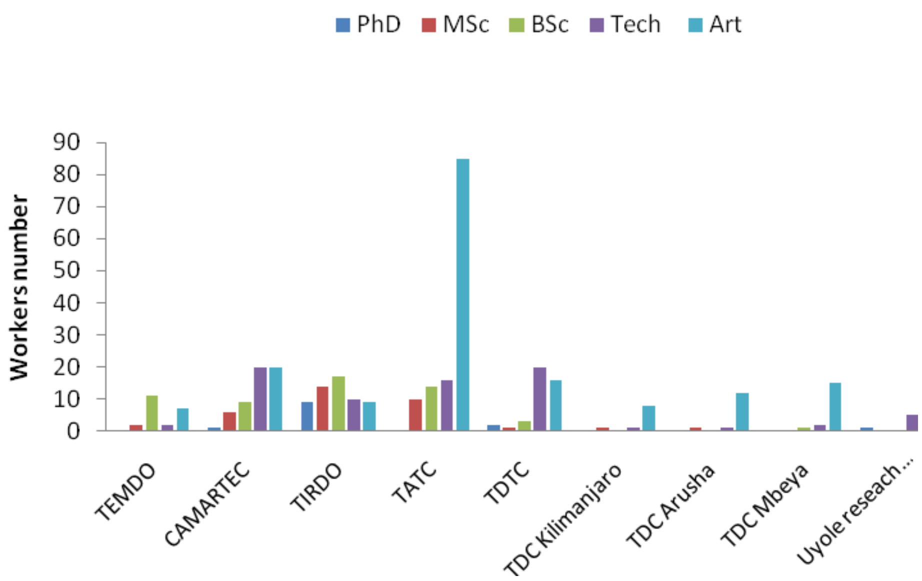


Figure 38: Workers ratios in R&D organisations in Tanzania.

4.2 Factors Influencing the Diffusion of Agro-technology in R&D Organisations in Tanzania

4.2.1 Identification of factor for diffusion of agro-technology in R&D organisations in Tanzania

Major factors influencing the agro-technology in Tanzania are identified and later used in the model but they are driven by the following macro variables:

(a) Initiation stage variables identification

The identification, studying and generation of the dependent and independent variables that could be used to study variables coefficients need to be done. Variables were identified by the cause effect analysis using Vensim software Ver. 6. The dependent macro variables were identified.

Before the performance of the cause effect analysis, the following facts were scrutinised for data collected in batch one. Various projected option were used to build the cause effect tree. Assumption was that any variable having value above one (1) is worthy to be investigated, since that is the indication that it influence agro-technology diffusion. Table 9 to Table 33 present available data.

It was found in Table. 9, that the customers were the main source of need identification (mean 2.47). Manufacturer and need assessment approaches were of given a low priority on need identification; this is also depicted in Appendix ***34***.

Table 9: Problem that gave rise to a need for the technology development

	Customer request	Manufacturer request	National need assessment	Company initiatives
N	30	30	30	30
Mean	2.47	1.17	1.17	1.77
Std. Deviation	0.86	0.46	0.53	0.68
Skewness	0.41	2.93	3.16	0.32

There was almost no use of project charter on approval of the project, poor findings (mean less than 1.07) Table. 10 show poor understanding of project management principles.

Table 10: Project approval methods

	Customer order	Project charter	Committee	Engineers opinion
N	30	30	30	30
Mean	2.13	1.07	1.60	1.60
Std. Deviation	0.82	0.37	0.56	0.77
Skewness	0.14	5.48	0.20	1.34

The main source of technology capacity is customer (Table. 11), in one way is good; however, thorough study is needed on the viability of the project before converting it to technology for innovation diffusion. There was no evidence of business case for these kinds of projects.

Table 11: Establishment of capacity of the project

	Customer Proposal	Manufacturer proposal	Our organization	Business plan
N	30	30	30	30
Mean	2.13	1.17	1.80	1.20
Std. Deviation	0.86	0.46	0.92	0.48
Skewness	0.43	2.93	1.83	2.50

Determination of technology price was mainly coming from design process (Table. 12), these variable needs to be optimised even for a single customer, but is more important if the technology need to be adopted for diffusion. There was no evidence for this.

Table 12: Setting up of technology price

	Design process	Manufacturer	Customer recommendation	Busines s case
N	30	30	30	30
Mean	2.23	1.60	1.17	1.23
Std. Deviation	0.50	0.72	0.38	0.50
Skewness	0.42	0.79	1.88	2.15

There has been a wrong perception that the technology stakeholder is the end user only, but for technology diffusion, there is a need of involving other stakeholders like manufacturer, brokers, donors and financiers right at the beginning (Table. 13).

Table 13: Stakeholders participation in the verification of the technology need

	With user	With manufacturers	With Brokers	With donors	Other financier
N	30	30	30	30	30
Mean	2.53	1.27	1.03	1.40	1.17
Std. Deviation	1.04	0.52	0.18	0.77	0.46
Skewness	-0.29	1.87	5.48	2.06	2.93

Options found were transformed to cause effect tree, with coded variables, where 111 stand for 1.1.1. Thus, (a) above derive 1,1.i, (b) 1.2.i, (c) 1.3.i, d1.4.i, (d) 1.4.i, and (e) 1.5.i. The initiation stage is regarded as a very important feeder to the whole agro-technology development process. Objective number one is to identify diffusion variables as shown in Fig. 39.

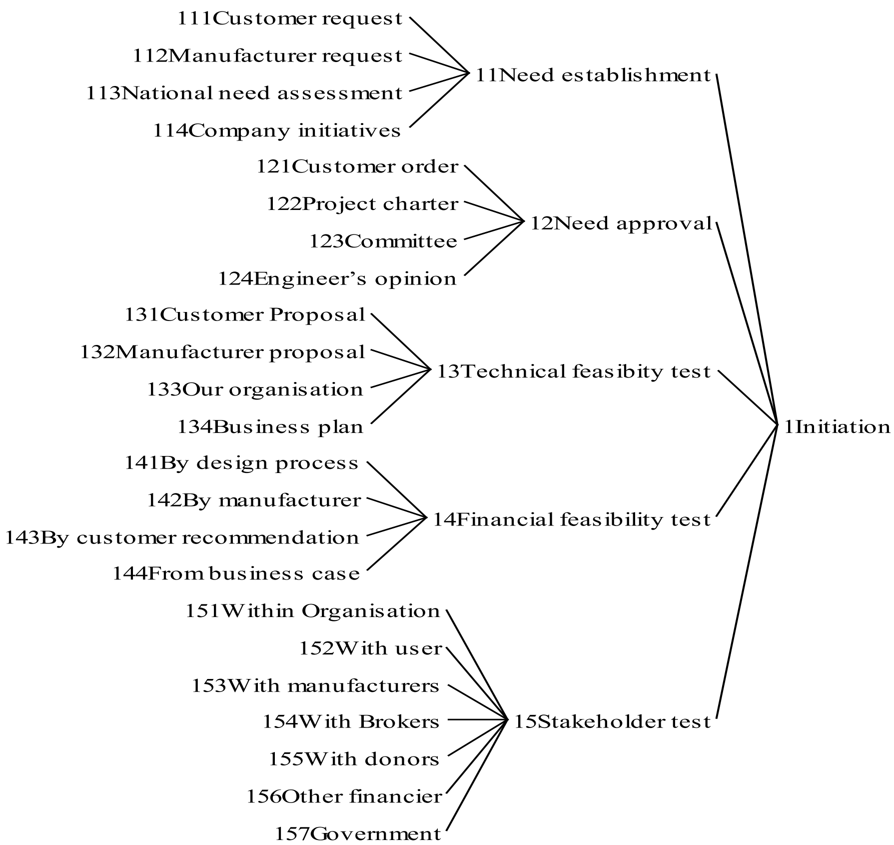


Figure 39: Initiation cause effect diagram.

(b) Concept development tools variables identification

The concept development stage was very critical, since this is a stage where the stakeholder's values of technology to be developed are transformed into engineering function required for the technology that is acceptable by the society, and hence increasing the probability of diffusion of the technology. As quoted in 2.13.6 this stage can affect the success of the project by 80% (Cooper, 2010). In developing variable to be studied the following variables were scrutinised, to develop the cause effect tree in Fig. 40:

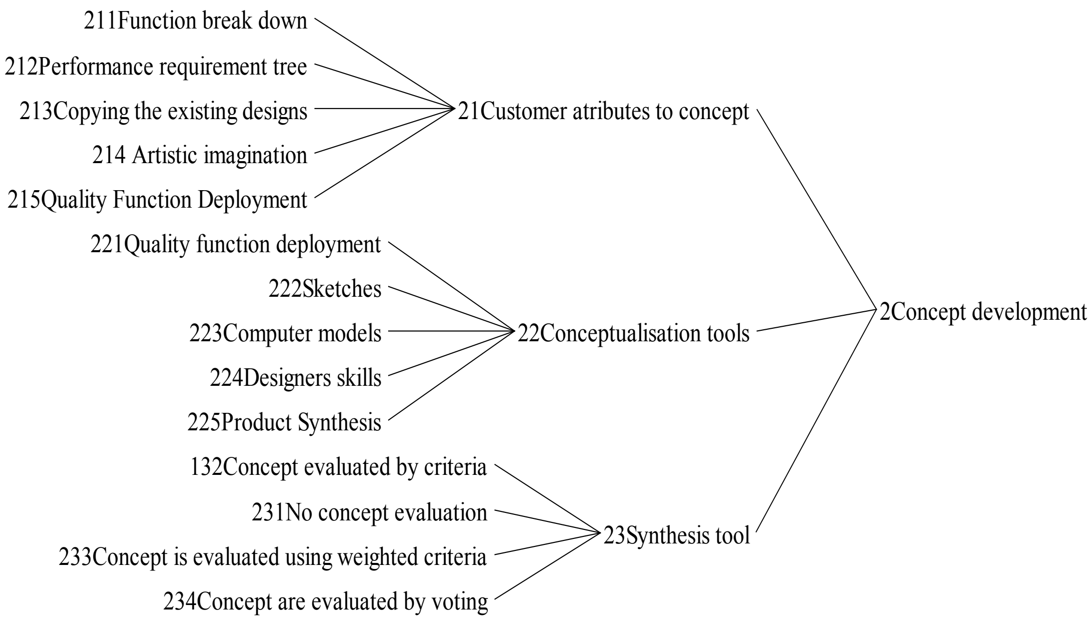


Figure 40: Conceptualisation cause effect diagram.

Function breakdown and copying of existing designs are the main methods used to get engineering specification. Personal imagination is another method. Scientifically developed tools like QFD are not used. The maximum score here is 2.2 out of 4; this is basically a low scientific performance (Table 14).

Table 14: Agro-technology performance for stakeholder's requirement conversion into engineering specification

		Function	Performance	Copying	Imagination	QFD
N	Valid	30	30	30	30	30
Mean		2.20	1.37	2.5	1.967	1.03
Std. Deviation		0.85	0.67	0.73	0.72	0.18
Skewness		-0.41	1.64	-0.57	0.05	5.48

Only sketched with the mean score of (3) and personal skills (2.3) are the main method used to develop engineering concepts, the rest scientific methods are not used. This is not a good picture in the development of engineering concepts (Table 15).

Table 15: Tools used to develop engineering concepts

	QFD	Sketches	Modelling	Skills	Synthesis
N	30	30	30	30	30
Mean	1.03	3.00	1.67	2.27	1.53
Std. Deviation	0.18	0.64	0.80	0.69	0.63
Skewness	5.48	0.00	0.70	-0.41	0.76

Generally the concept development process is very poor with the highest mean score of 2. This is the indication that copying of existing design is a common practice. But even copying needs some customisation and optimisation (Table 16).

Table 16: Optimisation of the concepts developed

		None	Criteria	Weighed Criteria	Voting
N	Valid	30	30	30	30
Mean		1.30	1.97	1.87	1.03
Std. Deviation		0.84	0.10	1.01	0.18
Skewness		2.77	0.51	0.72	5.48

(c) Identification of agro-technology variables for engineering analysis

Design establishes and defines solutions to pertinent structures for problems not solved before, or new solutions to problems which have previously been solved in a different way.

For these to be achieved, configuration, parametric and industrial design analysis are to be accomplished (Dieter and Schmidt, 2009). Although in section 2.13.8, Khan and Raouf (2006) listed many variables that can be examined, in this study few are selected and expounded in Fig. 41 as follows:

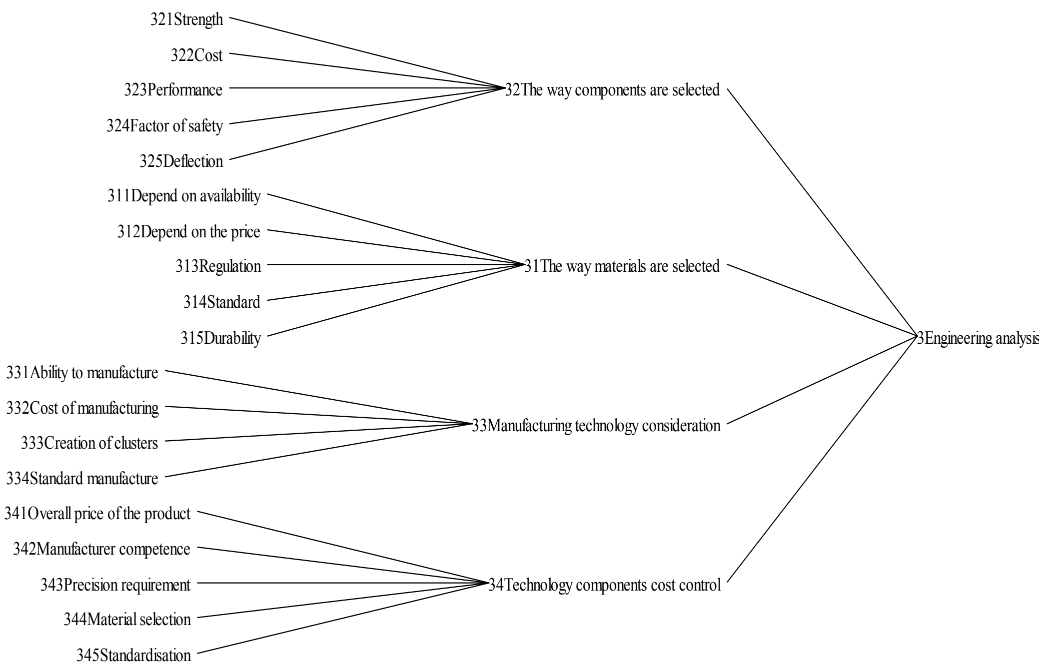


Figure 41: Design cause effect diagram.

Material selection is done with average engineering understand, that is mostly looking at availability with the mean score of 2.80, though more efforts has to be put to have the mean score above three. Generally the score is low as shown in Table17.

Table 17: Material selection analysis

	Availability	Price	Regulation	Standard	Durability
N	30	30	30	30	30
Mean	2.80	2.67	2.40	2.53	2.60
Std. Deviation	0.55	0.48	0.67	0.57	0.56
Skewness	-0.11	-0.74	0.03	-0.73	-1.04

.

Component selection is done with average engineering understand, though more efforts has to be put to have the mean score above three (3). Criteria for analysis are generally low as shown in Table 18 this is likely to give poor engineering analysis.

Table 18: Components development analysis

	Strength	Cost	Performance	Factor of safety	Deflection
N	30	30	30	30	30
Mean	2.57	2.70	2.50	2.60	2.13
Std. Deviation	0.50	0.47	0.68	0.56	0.51
Skewness	-0.28	-0.92	-1.05	-1.04	0.27

Manufacturing consideration is taking care of the cost, ability and standard, but the lack of link with manufacturing and the buy/make decision is not given priority hence the formation of cluster. The men score are below 3 as shown in Table 19. This is not a good practice when analysing manufacturability of a technology.

Table 19: Manufacturability analysis

	Ability	Cost	Clusters	Standard
N	30	30	30	30
Mean	2.83	2.80	1.10	2.40
Std. Deviation	0.53	0.48	0.31	0.62
Skewness	-0.19	-0.55	2.81	0.41

Cost analysis factors consideration is below mean of three (3) as shown in Table 20. This shown poor control of the overall price of technology developed. It was observed through interview by entrepreneur that the similar technology produced locally had a higher price compared to imported ones, however they acknowledged the robustness of the locally produced.

Table 20: Technology cost analysis

	Price	Competence	Precision	Material	Standard
N	30	30	30	30	30
Mean	2.50	2.43	2.53	2.47	2.50
Std. Deviation	0.73	0.63	0.57	0.63	0.57
Skewness	0.00	-0.64	-0.73	0.13	-0.59

(d) Drawing development variables identification

From section 2.13.8 it was deduced that detail design development is an output of the concept development and, before embarking into the detail design a number of analysis have to be performed (Hurst, 1999). According to NASA (1994) Engineering drawings are defined as those drawings that communicate requirements for the manufacture of the end-product items, their assembly, and their installation. Although there has been a move in developing nations from the used of drawing board to computer aided design and manufacturing. In this study the conversional practice is still studied. Main areas studied are as follows:

The general principles of producing sufficient sketched for combining the concept was not evident during the study, rather the copying of existing design was evident. There is a great work to be done at this stage to remind engineers of the common training that is offered at higher institutions as shown in Table 21. All the mean score are below 2.

Table 21: Design draft development

	None	Drawing boards	2D software	3D software
N	30	30	30	30
Mean	1.10	1.67	1.80	1.07
Std. Deviation	0.31	0.84	0.81	0.37
Skewness	2.81	1.09	0.82	5.48

Though few organisations like TEMDO, TATC and CAMARTED were having effort in design development, there has been a drop in development proper technical drawings for manufacturing. The move from normal drawing board to electronic board like AutoCAD, without training and proper infrastructure of storage of drawing has brought a worse practice (Observation made at TATC and TIRDO). During research training that was conducted at TATC brought a great change in the utilisation of Solid-Work software for designing as shown in Table 22.

Table 22: Engineering design finalisation

	None	Drawing boards	2D software	3D software
N	30	30	30	30
Mean	1.03	1.63	1.87	1.07
Std. Deviation	0.18	0.85	0.82	0.37
Skewness	5.48	1.17	0.66	5.48

In most of SIDO-TDC organisation there were no technical drawings, in TATC, TIRDO sub standard drawing were observed, in TDTC only the drawings during the IPI era were evident as shown in Table 23. Further analysis was done and the study variables are shown in Fig. 42.

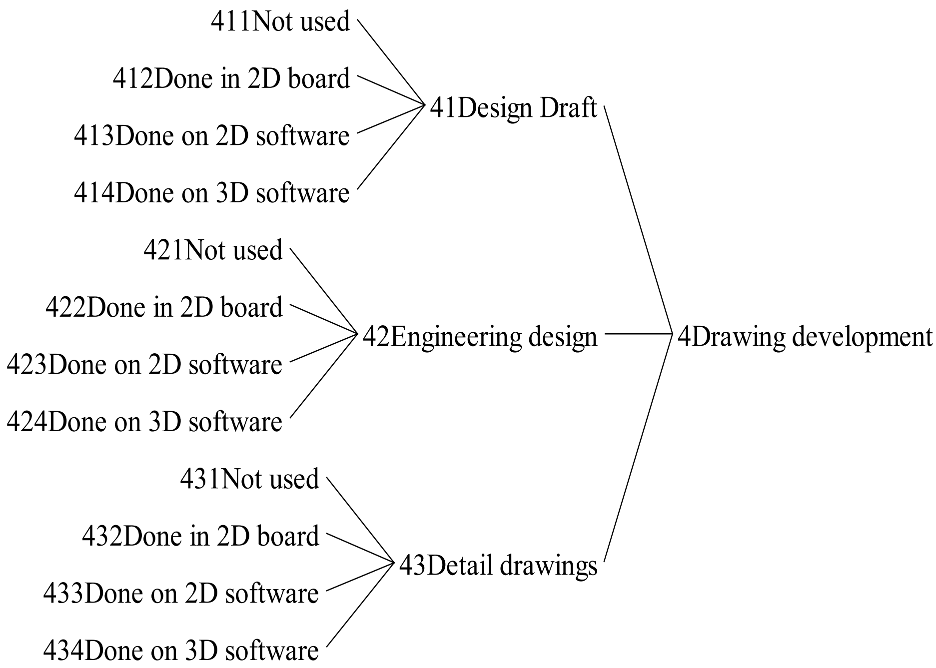


Figure 42: Drawing cause effect diagram.

Table 23: Detail drawing development methods

	None	Drawing boards	2D software	3D software
N	30	30	30	
Mean	1.03	1.63	1.87	1.07
Std. Deviation	0.18	0.85	0.82	0.37
Skewness	5.48	1.17	0.66	5.50

(e) Prototype development variables identification

In section 2.13.9 it was deduced that, the development of prototype is done so that the detail design could be verified and modified. On the first stage, the fittings, motion and functions are studied, when these are successful then functional (both technical and technological) verification is done to compare the expected performance parameters. In this study two main areas were considered: the prototype development control (system and methods used to develop the prototype to the expected specification) and the systems and tools developed to ensure the technology diffusion both in the manufacturing and operation stages. The two aspects used to develop the prototype are further broken down into variables as shown in Fig. 43.

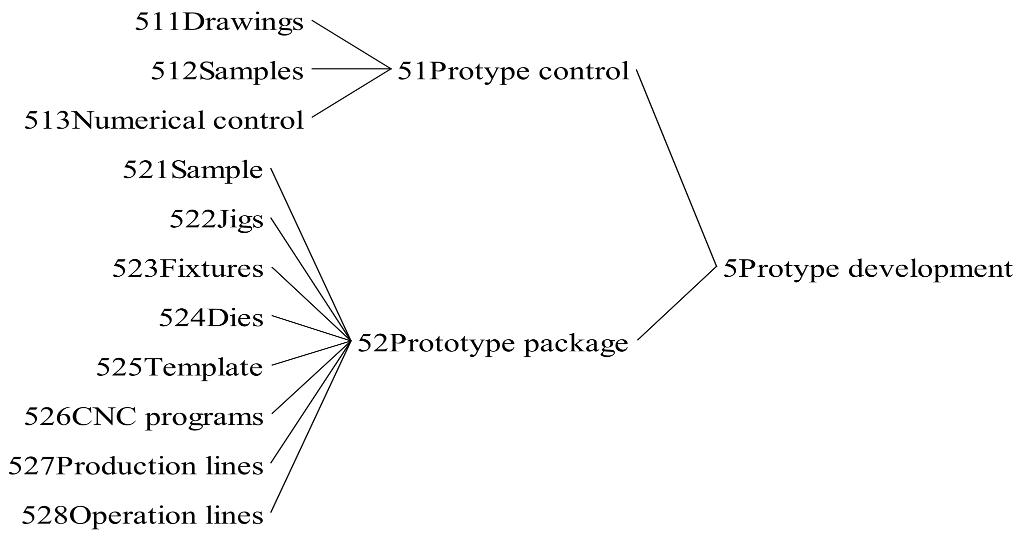


Figure 43: Prototyping cause effect diagram.

Sketches from sample and drawings are the major control of prototype development, sometimes samples are used directly in copying the dimension for manufacturing. The assembling the product is not in good quality since in most organisation visited. Assembly drawings were not evident as shown in Table 24.

Table 24: Prototype production control

	Drawings	Sample	Numerical control
N	30	30	30
Mean	2.27	1.77	1.00
Std. Deviation	0.78	0.50	0.00
Skewness	0.85	-0.42	

The major components in technology transfer were a sample of prototype. Means of manufacturing was not a major issue since manufactures were hardly involved in the development process as shown in Table 25. Jigs fixtures, dies, template and production have mean score close to 1, which implies items linked to manufacturing are give very low priority.

Table 25: Prototype packaging

	Sample	Jigs	Fixture	Dies	Templates	CNC Program	Production line	Operation lines
N	30	30	30	30	30	30	30	30
Mean	2.93	1.30	1.23	1.10	1.50	1.00	1.40	1.87
Std. Deviation	0.37	0.70	0.50	0.40	0.73	0.00	0.56	0.94
Skewness	-0.92	2.70	2.15	4.28	1.13		1.04	0.28

(f) Identification of technology validation variables

The ISO 9001:2000 standard requires design and development validation to “be performed in accordance with planned arrangements to ensure that the resulting product is capable of fulfilling the requirements for the specified application or intended use where known”. Validation in engineering innovation is intended to insure items listed in section 2.13.10. The following items are broken down to main areas required to be studied as shown in Fig. 44.

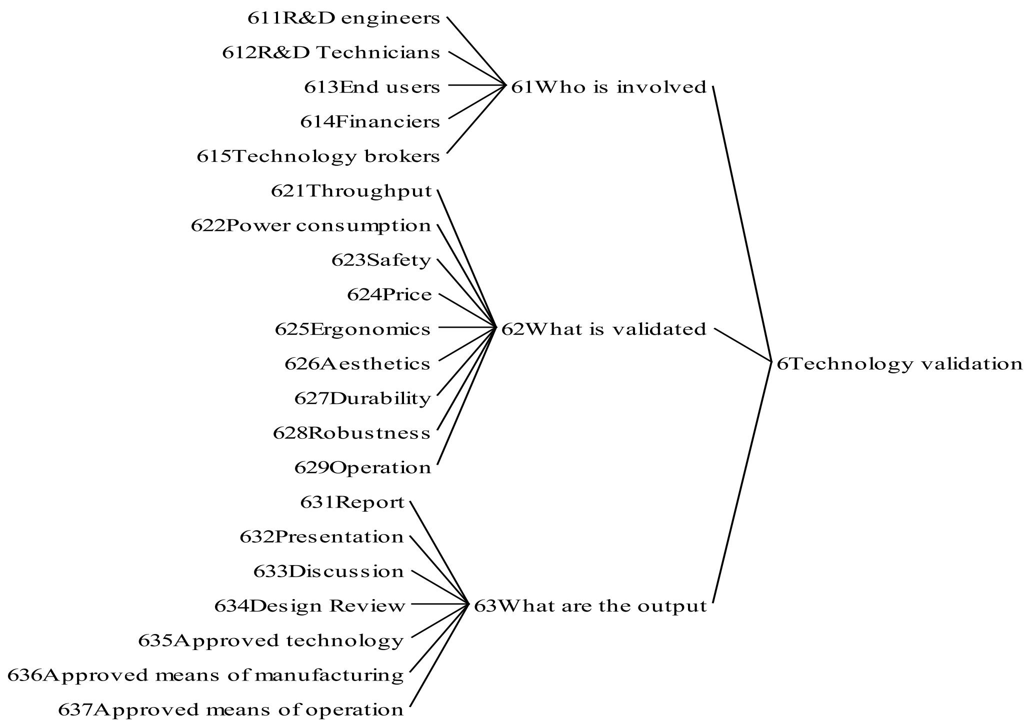


Figure 44: Validation cause effect diagram.

Engineers, Technicians and users were above average (Mean of 2.5) in participation in validation processes; however other stakeholder participation (financiers and brokers) was poor, misunderstanding of the validation process as a mere prototype trial run was noted (Table 26). This was one of the sources of failure of diffusion in the end, since most of these technologies needed broad participation of stakeholders in validation stage. This was a result of poor understanding of the validation process.

Table 26: Validation stakeholders

	Engineers	Technicians	Users	Financier	Brokers
N	30	30	30	30	30
Mean	2.93	2.90	2.27	1.27	1.00
Std. Deviation	0.52	0.88	0.87	0.74	0.00
Skewness	-0.11	-0.12	-0.23	2.81	

Observing the mean value of variable study findings, capacity, safety, robustness and operation are given partial observation (mean above 2). The rest of variables were not of priority (Table 27). In observation the validation process itself is very shallow and was not even systematic. There is a need of very serious attention for guiding model and training.

Table 27: Technology validation context

	Capacity	Power	Safety	Price	Ergonomics	Aesthetics	Duration	Robust	Operation
N	30	30	30	30	30	30	30	30	30
Mean	2.47	1.87	2.40	1.80	1.97	1.17	1.93	2.33	2.37
Std. Deviation	0.82	0.68	0.62	0.55	0.41	0.38	0.69	0.55	1.47
Skewness	0.11	0.17	-0.52	-0.11	-0.26	1.88	0.76	0.05	1.18

Generally there is no culture of having systematic output of validation process, the review process is poor and the approval of result is not systematic. In the end technologies are rejected because they are pushed without optimisation processes. Good examples are Nyumbu tracks, former IPI (TDTC) Sugar processing plants and the like. As shown in Table 28 almost all the mean value of validation output have the value close to 1, this is s poor output.

Table 28: Validation outputs

	Report	Presentation	discussion	Design review	Technology approval	Manufacture Approval	Operation approval
N	30	30	30	30	30	30	30
Mean	1.07	1.13	2.23	1.73	1.90	1.60	2.13
Std. Deviation	0.25	0.43	0.50	0.78	0.76	0.50	0.97
Skewness	3.66	3.49	0.42	1.44	0.68	-0.43	0.44

(g) Technology transfer variables identification

Technology transfer is the process of successfully bringing technology from a source to the targeted user. The transfer package differs depending on the nature and the intention of technology use (Cambridge Chemical Technologies, 2012). The items included in the technology transfer are those discussed in the section 2.13.11. Technology transfer is more of package as shown in the analysis in Fig. 45.

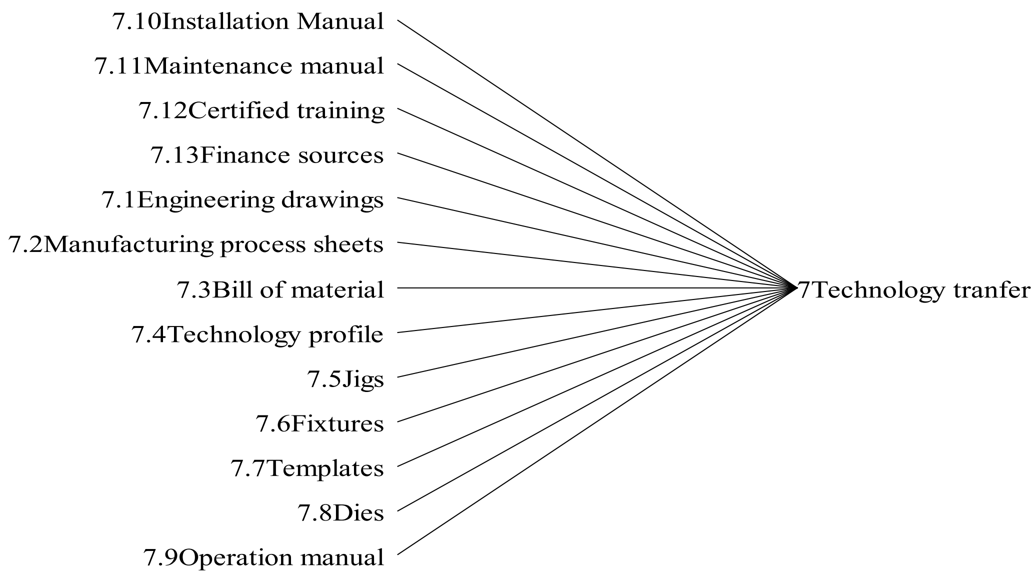


Figure 45: Technology transfer package.

With the exception of the engineering drawing it is clear that the technology transfer package is very poor as shown in Table 29 and 30, that is all the mean values approaching the value of one (1). The poor package induces the difficulty in setting up the business and hence diffusion of technology.

Table 29: Transfer package Table a

	Drawings	Process sheet	Bill of materials	Tech profile	Jigs	Fixtures
N	30	30	30	30	30	30
Mean	2.30	1.33	1.67	1.33	1.10	1.07
Std. Deviation	0.92	0.48	0.71	0.55	0.31	0.25
Skewness	-0.08	0.74	0.59	1.41	2.81	3.66

Table 30: Transfer package Table b

	Templates	**Dies**	**Op Manual**	**Inst Manual**	**Maintenance Manual**	**Training certificate**	**Finance Source**
N	30	30	30	30	30	30	30
Mean	1.07	1.07	1.33	1.00	1.17	1.33	1.17
Std. Deviation	0.25	0.25	0.55	0.00	0.65	0.55	0.46
Skewness	3.66	3.66	1.41		3.91	1.41	2.93

(h) Identification variables for documentation for technology diffusion

Information and communication technologies (ICT) are now an integral part of our environment and are among the most important drivers for innovation in many sectors (Little, 2011). In LDCs, many research organisations are still using hard system of information storage and dissemination. As mentioned in the literature there is a number of important documents for effective technology transfer. For this study the documentations in Fig. 46 are studied.

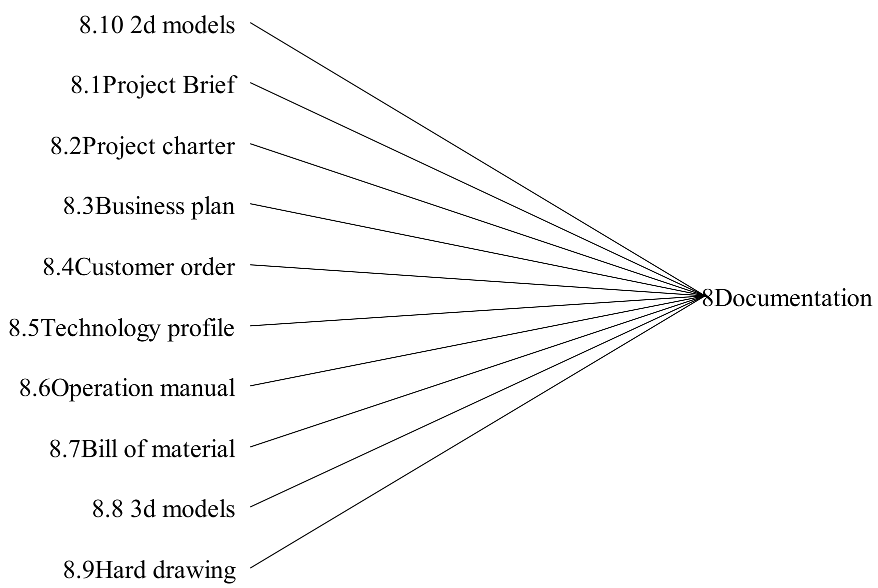


Figure 46: Information cause effect diagram.

It was very clear that the need assessment survey, preliminary document like project charter or brief and engineering modelling were not practices in most of R&D organisations as shown in Table 31. On the other hand drawings and operation manual were given a better but below average (2.5) priority as shown in Table 32. In general the preparation and handling of information was found to be poor, that is average close to one (1).

Table 31: Technology information (a)

	Project charter	Project Brief	Business case	Feasibility study	Need assessment	Operation manual	Bill of material
N	30	30	30	30	30	30	30
Mean	1.07	1.63	1.23	1.57	1.17	1.33	1.67
Std. Deviation	0.37	0.67	0.50	0.57	0.53	0.55	0.71
Skewness	5.48	0.59	2.15	0.33	3.16	1.41	0.59

Table 32: Technology information (b)

	Done on 3D software 3	Done in 2D board 1	Drawings	Customer order	Technology profile	Operation
N	30	30	30	30	30	30
Mean	1.07	1.67	2.27	2.13	1.33	2.17
Std. Deviation	0.37	0.84	0.78	0.82	0.55	1.21
Skewness	5.48	1.09	0.85	0.14	1.41	0.54

It was very clear that the need assessment survey, preliminary document like project charter or brief and engineering modelling were not practices in most of R&D organisations. On the other hand drawings and operation manual were given a better but below average (2.5) priority. In general the preparation and handling of information was found to be poor.

(i) Stages effect variables identification

Stages improve the efficiency of technology development (Cooper, 2010; Cooper and Edgett, 2008). Main stages in innovation projects are broken down in Fig. 47 so as to study their impacts in technology development.

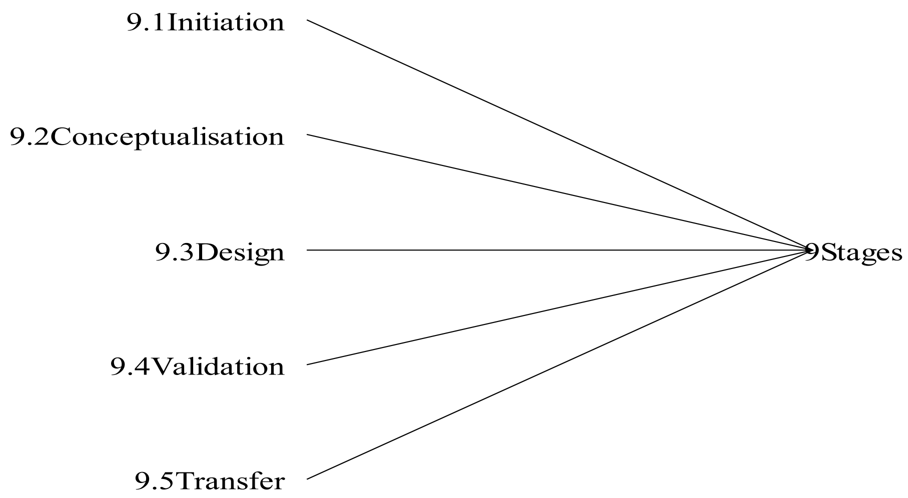


Figure 47: Stages cause effect diagram.

As shown in Table 33. initiation processes and transfer were found to be very poor processes in R&D organisation with score close to one (1), while prototyping was thought to be sufficient process with the mind that prototyping is just a development of technology prototypes. The symptoms of twin valleys of technology deaths in Tanzania are vividly seen in here.

Table 33: Stages existence effect of technology diffusion

	Initiation	Conceptualisation	Prototyping	Validation	Transfer
N	30	30	30	30	30
Mean	1.57	2.03	2.50	1.97	1.17
Std. Deviation	0.57	0.32	0.51	0.41	0.38
Skewness	0.33	0.79	0.00	-0.26	1.88

A total of one hundred and twenty nine (129) variables identified by cause effect analysis as a requirement of specific objective number one and are summarised in Appendix 3 as independent variables.

The diffusion indices used to study the diffusion rate is quantity of technology manufactured that is from R&D organisation, cumulative amount of sales from the time of development and average sales per year. Table 41 in Appendix 9 displays the preliminary findings of agro-technology and their dependent diffusion variables. The cumulative quantity and cumulative sales values were not good indicators of agro-technology diffusion since there was a big variation of time among agro technologies studied. The sales rate expressed in quantity (Qty) per time or value per time were examined in Fig. 48.

Fig. 48 shows that the value diffusion rate has a trend over time. However the quantity rate is already included in the value rate. The value rate index was picked as the most optimal indicator of diffusion rate, though on the calibration of the model all the three dependent variables were studied. The index used to study the diffusion rate is quantity of technology manufactured that is from R&D organisation, cumulative amount of sales from the time of development and average sales per year sown in Appendix 9, (Table 41), display the preliminary finding of diffusion. In Fig. 48, the maize milling having index of one (1) is the best performing studied technology and the soap greater is the worst one, using the value sale rate index. Very few technologies are above the 0.95 this shows the overall poor performance of technology diffusion in Tanzania.

4.1.2 Determination of factors coefficients for agro-technologies diffusion with respect to innovation processes used by R&D organisation in Tanzania

In addressing the magnitude of factors effect on technology diffusion, data shown in Appendix 33 were captured and processed to get variables with high significance. Through questionnaires, variables rates for different agro-technologies were identified and multi-linear regression was used to calibrate the co-efficiencies of these variables. The first stage was to study the trend of three dependent variables that could explain diffusion impact.

These are agro-technologies cumulative quantity developed, the cumulative sales of the same technologies and sales per year of these agro-technologies.

The normality variation along the line of regression, the Q-Q plot under normal distribution using Van der Waerden's was applied to test for normality of these dependent variables (SPSS, 2008) and these are displayed in Fig. 49, 51 and 53 (Levine and Stephan, 2010). Three dependent variables named above were transformed into natural logarithm and they showed good normality with a mean of 14.82, least standard deviation of 1.62 and the least skewness of 0.140. All the three variables meet regression analysis requirement, however the sales per year with a good normal graph appeared to be the best dependent variable for regression analysis as shown in Fig. 50, 52 and 54. The summary of the skew test is shown in Table 34.

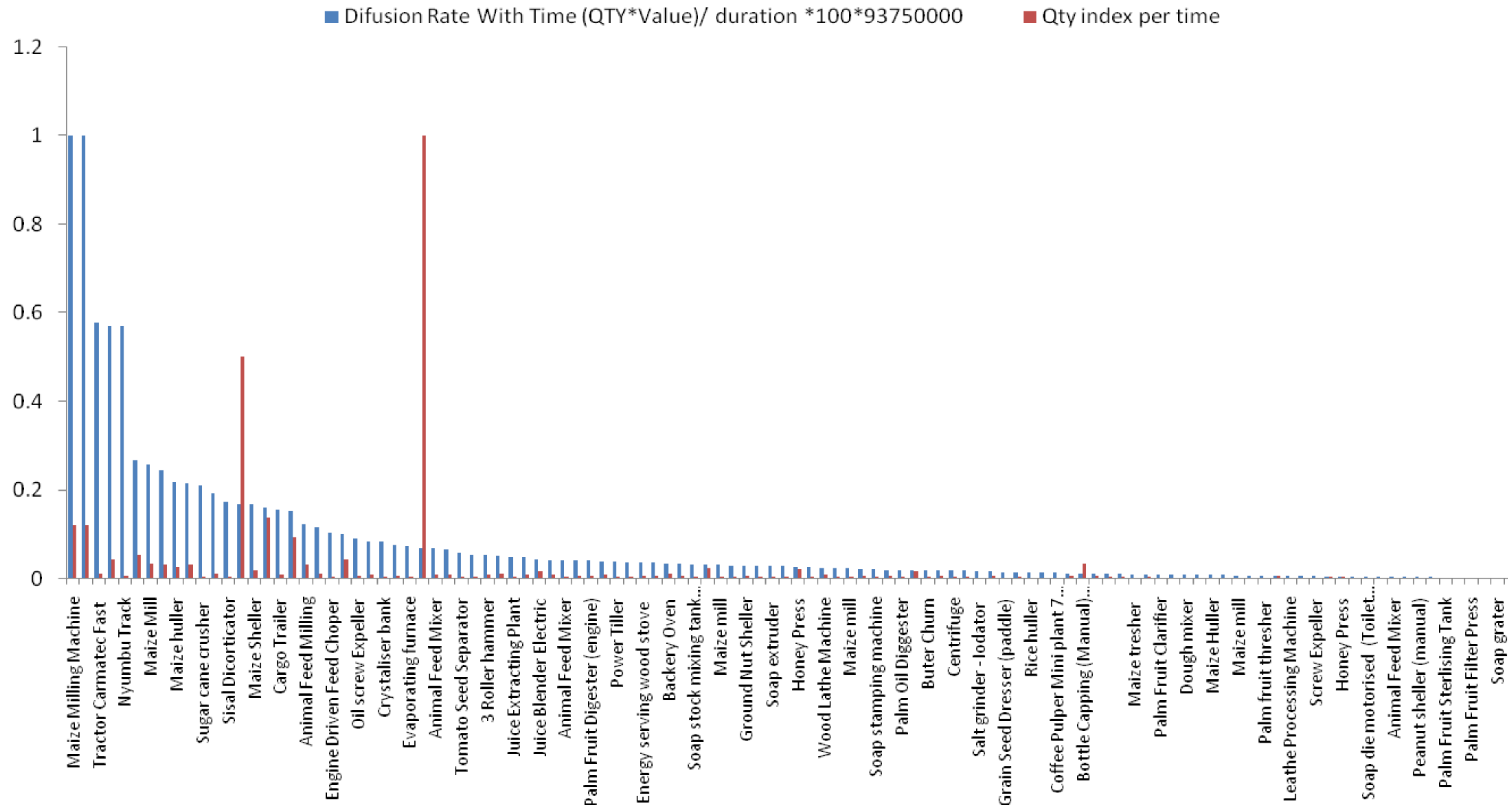


Figure 48: Comparative display of quantity versus value of sales per time.

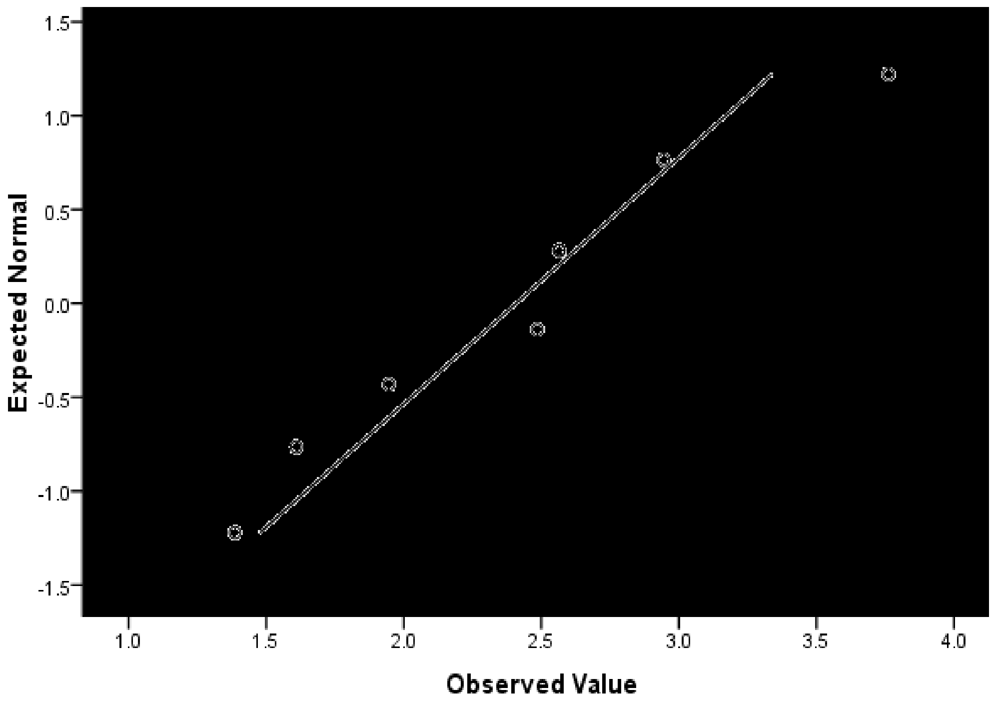


Figure 49: Q-Q Plot for cumulative quantity.

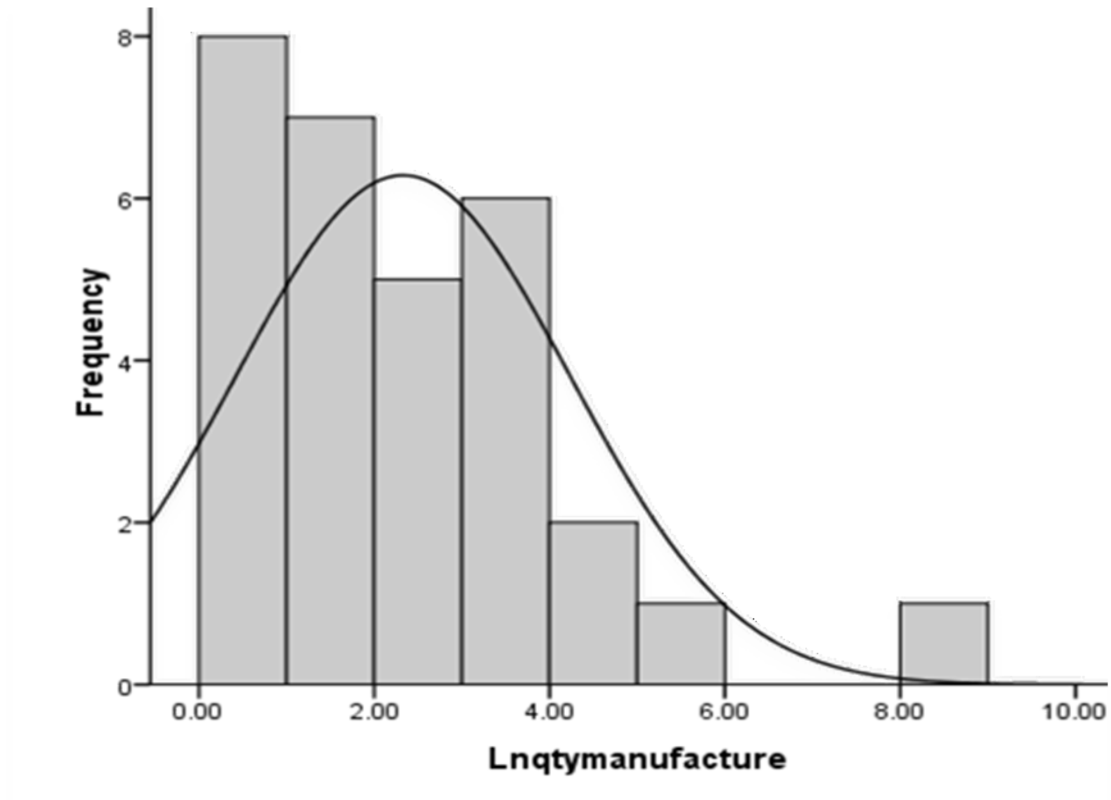


Figure 50: Normality of quantity.

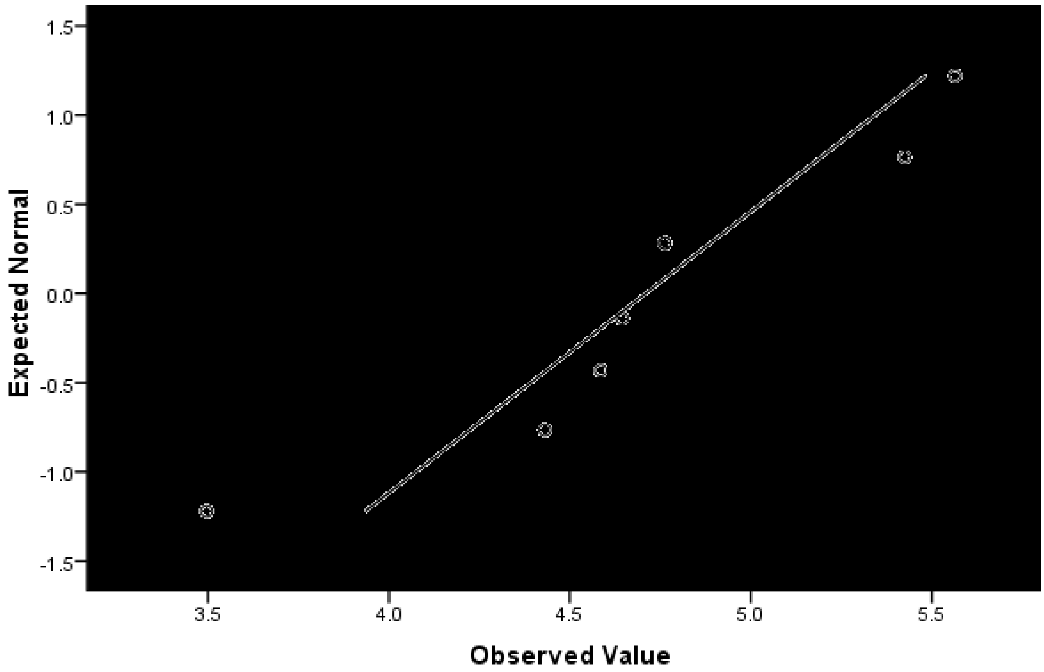


Figure 51: Q-Q plot for sales per year.

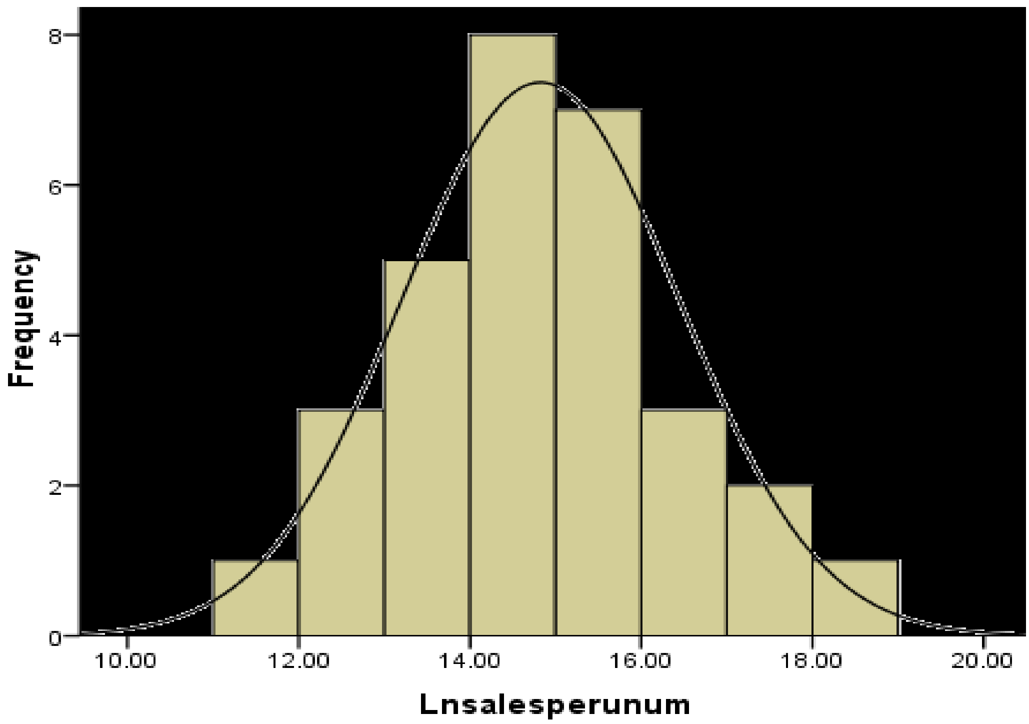


Figure 52: Normality of sales per year.

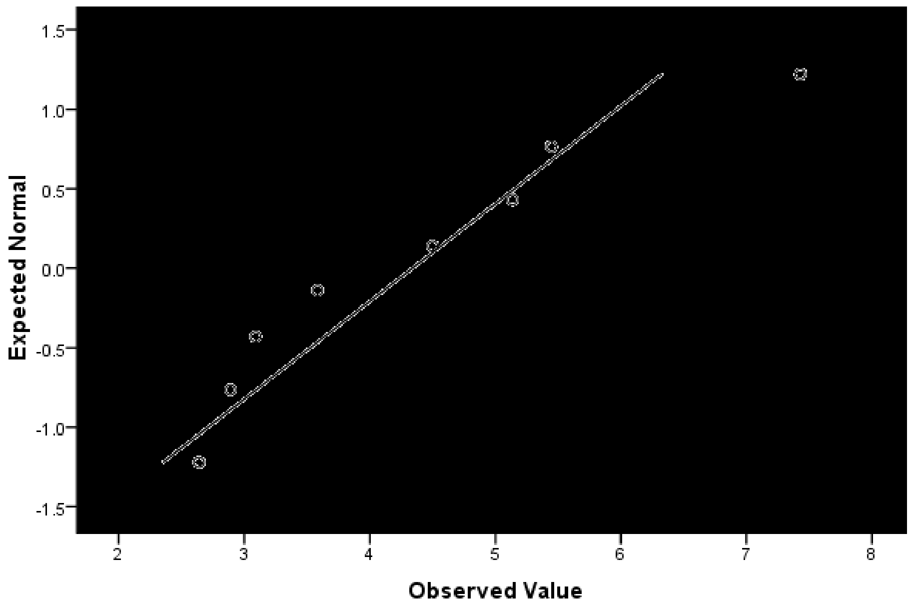


Figure 53: Q-Q plot for cumulative sales.

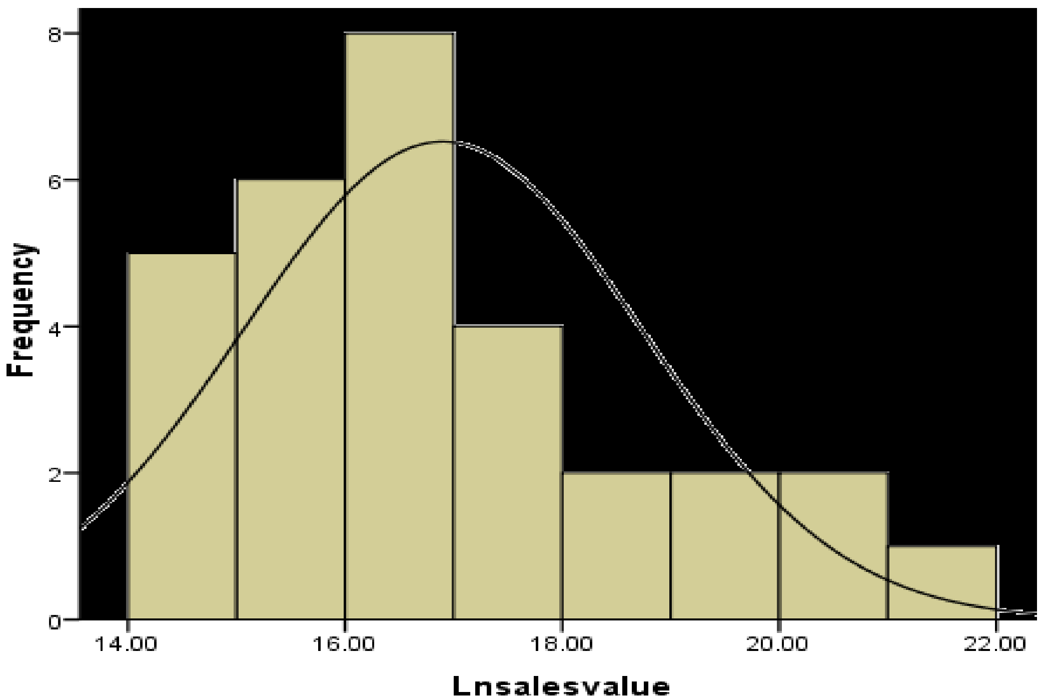


Figure 54: Normality of cumulative sales.

Table 34: Skew test summary

		Statistics		
		Lnqtymanufacture	Lnsalesvalue	Lnsalesperunum
N	Valid	30	30	30
	Missing	0	0	0
Mean		2.3281	16.8978	14.8233
Median		1.9356	16.8600	14.8292
Std. Deviation		1.90402	1.83497	1.62453
Skewness		1.206	.643	.140
Std. Error of Skewness		.427	.427	.427
Percentiles	25	.6931	15.4420	13.7699
	50	1.9356	16.8600	14.8292
	75	3.2645	17.8912	15.7118

Variables were grouped in nine main cases, as shown in section Fig. 134 in Appendix 2 and analysed using SPSS16 software. The first stage of analysis was to establish independent variables that cause significant changes in agro-technologies diffusion. Two major factors were used to pick effective variables that are variables with higher prediction powers in technology diffusion; these are the model prediction power using R^2 above five and Durbing-Watson indicator as described in section 3.5.1.

(a) Initiation stage coefficient determination

Although the prediction power of all the three models are of higher confidence but some variables show low significances as they appear in Appendix 10, with their prediction values being above 0.05. None in (LnQty), customer proposal in (LnValue) and none in (LnSales per Year). The remaining variable show good technology diffusion prediction as shown in the following equations.

$$Y_1 = 0.631 + 2.628X_1 + 1.049X_2 + 0.637X_3 + 2.31X_4 - 1.635X_5 - 1.725X_6 - 0.979X_7 + 0.711 \quad (1)$$

For this analysis the standardised equation is as follows:

$$Y_{1std} = 0.732X_1 + 0.474X_2 + 0.257X_3 + 0.560X_4 - 0313X_5 - 0.343X_6 - 0.249X_7 \quad (2)$$

(R^2 = 0.894) for the model is reasonable. There was generally little understanding of the project charter context and uses in R&D organisations with higher sales quantity. Customer recommendation at the project approval stage was uniformly not a consideration and in most of technologies business plan was not a key activity and lastly the prediction of quantity diffused is not significant with customer proposal(Cooper, 1988):

$$Y_2 = 9.993 + 2.253X_1 + 0.357X_2 + 0.724X_3 + 1.379X_4 + 0.689X_8 \quad (3)$$

For this analysis the standardised equation is as follows:

$$Y_{2std} = 0.625X_1 + 0.167X_2 + 0.304X_3 + 0.222X_4 + 0.307X_8 \quad (4)$$

Although the model has high significance of prediction (R^2 = 0.816), the significance of the customer proposal on technology capacity variable is above 0.05 and hence it is a bad predictor.

$$Y_3 = 9.071 + 1.454X_2 + 0.719X_4 + 1.698X_5 + 0.735 \quad (5)$$

For this analysis the standardised equation is as follows:

$$Y_{3std} = 0.770X_2 + 0.204X_4 + 0.382X_5 \quad (6)$$

Where:

X1 = National need assessment

X2 = Customer Proposal

X3 = With donors

X4 = Manufacturer proposal

X5 = Project Charter

X6 = Customer recommendation

X7 = Business Plan

X8 = Customer order

As shown in Fig.55 Need assessment (1.4), customer proposal (1.4), manufacturer proposal (1.0), donors as financiers (0.56), customer order (0.31) and manufacturer proposal (0.99) variable with positive high significant. Data from R&D did not show higher significance on project charter (0.07) and business plan (-0.3) as part of the new product development requirements for diffusion due to lower understanding of project management theories. On customer recommendation the result showed a negative result, this is mainly attributed to on poor conversion of customer's proposal into projects. The study on innovation diffusion that was presented in the house of common UK (2013) used the "valley of death" the findings show the same weakness that in the twin valley of death, that is the deficiencies of existence of good project charter and business case. But the need assessment has also a very high significance in diffusion.

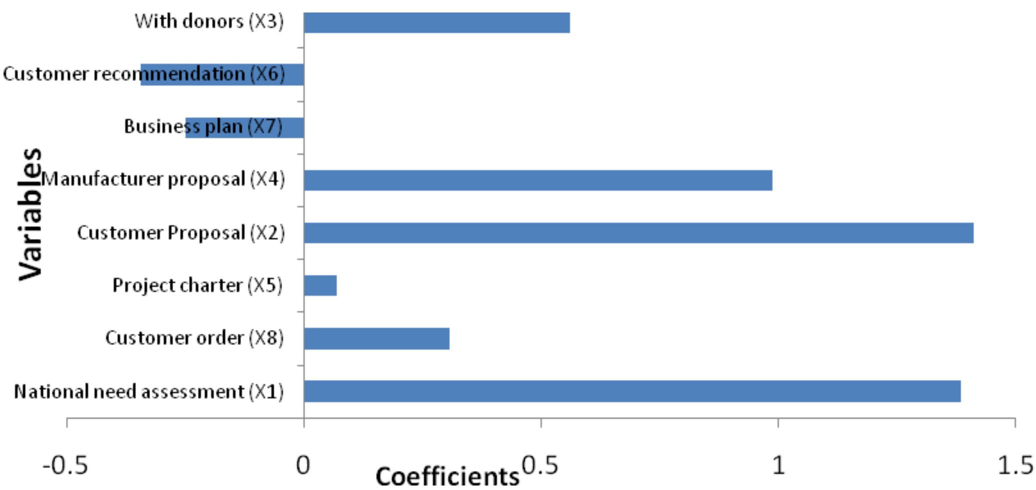


Figure 55: Sum of initiation coefficients.

(b) Conceptualization stage

Figure 56 shows very crude way of technology function analysis was used in R&D organisations; Fig. 57 shows another method of ensuring the technology performance variables is not understood. This method is also given a poor consideration in technology development in Tanzania and Fig. 58 shows poor understanding and use of QFD. It was found that the conversion of the design problem into viable design concept is poorly done. Fig. 59 shows that, the artistic imagination is applied. In engineering, this is very important but cannot produce relevant product without combining it with other systematic conceptualisation methods. Referring to Appendix 11, finding on the use of computer models in design was not significant; there was lack of software and skills.

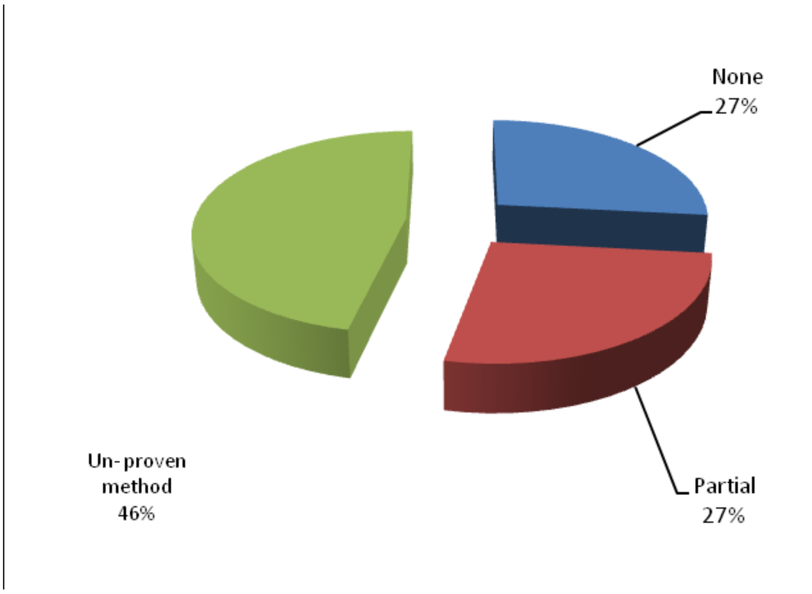


Figure 56: Function break down.

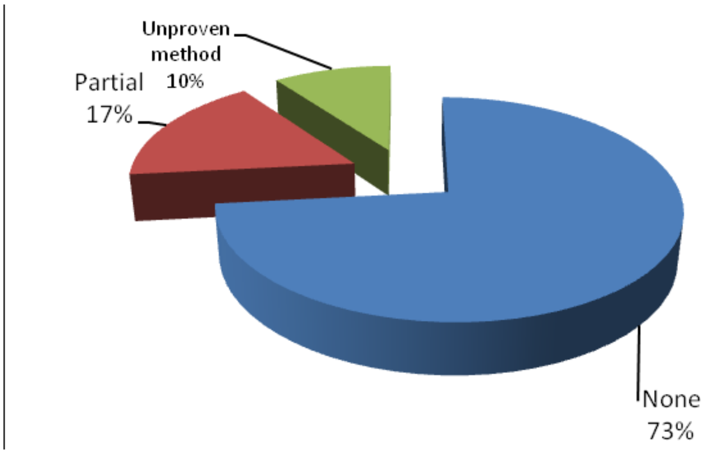


Figure 57: Performance tree approach.

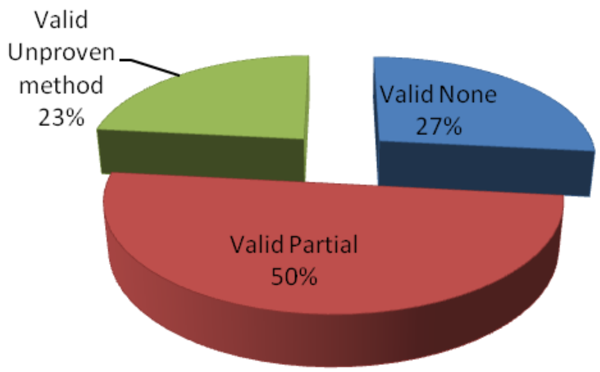


Figure 58: Quality function deployment method.

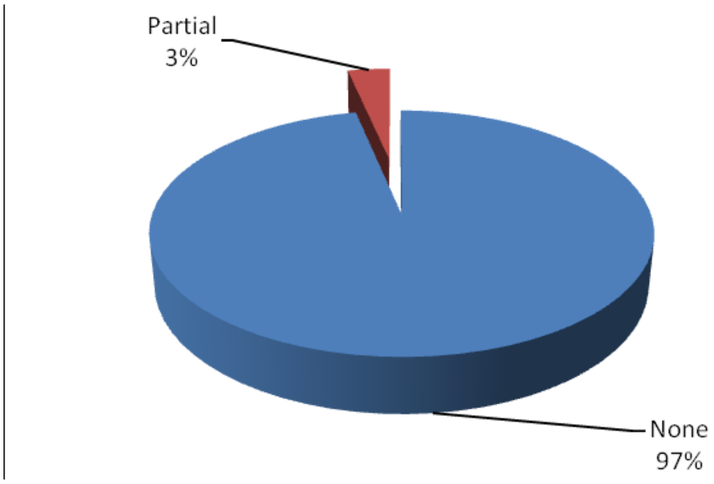


Figure 59: Artistic imagination.

Most of R&D organisations were not using these tools as a result the negative coefficient does not have strong argument, which causes negative effect on technology diffusion (Fig. 60). Generally the use of other engineering tools was of lower level throughout the R&D organisations interviewed, hence the optimisation of design concept was observed to be unprofessional. The following activities are emphasised in this level: objectives tree, function analysis, performance specification, quality function deployment, morphological chart, weighted objectives and value engineering (El-Haik, 2005; Nigel, 2000). All of these were given minimum priority.

Most of the R&D organisations with exception of TDTC, TEMDO and TATC had one engineer or technician to run the R&D processes. The regression model with R^2 was above 6, and the significance of F-chance below 0.05 and Dubing-Watson of 1.8 as reasonable correlation measure (Levine and Stephan, 2010; SPSS, 2008) , section 3.5.1. For the cumulative sales regression equation is as follows:

$$Y_2 = 12.89 + 1.089X_9 + 0.667X_{10} + 1.219X_{11} - 0.714X_{12} + 1.2162 \qquad (7)$$

The equation with standardised coefficients appears as follows:

$$Y_{2std} = 0.409X_9 + 0.304X_{10} + 0.418X_{11} - 0.312X_{12} \qquad (8)$$

Where: *X9* = Designer skills

X10 = Undefined evaluation

X11 = Product synthesis

X12 = Computer model

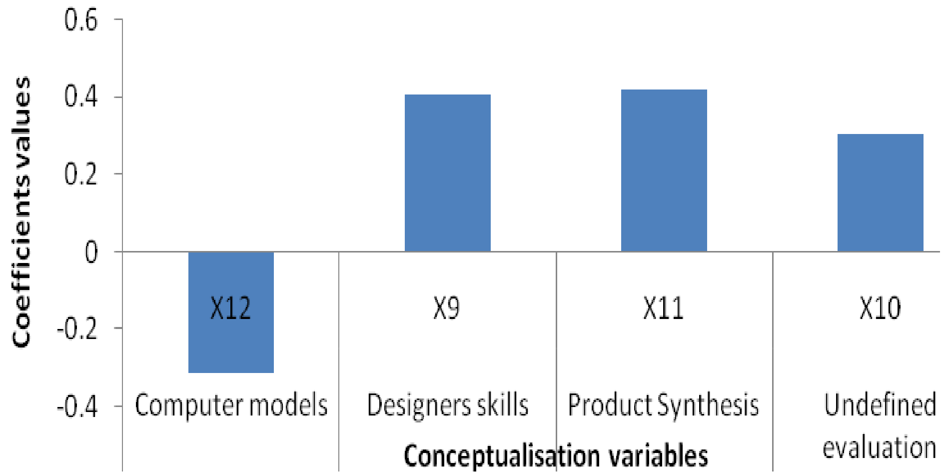


Figure 60: Sum of conceptualisation coefficients.

(c) Drawing stage coefficient determination

Referring to Appendix 12; only one of the three models shows robust estimation of liner regression, since Durbin-Watson test for Ln cumulative sales is 2; other models have Durbin-Watson test less than one.

In the dependent variable Ln Quantity Manufacture technology performance variable shows a moderate prediction since significance of F-changes is above 0.05 (Levine and Stephan, 2010; SPSS, 2008). In the variable of factor of safety coefficient is negative, however, R^2 of 6 the following equation is derived.

$$Y_2 = -2.111 + 1.605X_{56} + 1.704X_{51} + 1.32 \qquad (9)$$

The standardised equation is as follows:

$$Y_{2std} = 0.743X_{56} + 0.404X_{51} \qquad (10)$$

Where:

X_{56} = Detailing in 2 D board

X_{51} = Design draft done in 3 D system

The drawing process was not well organised in most of R&D organisation and regression analysis showed poor coefficients values. Though computerised drawings were used but training in computerised drawings development was poor and insufficient. Few R&D organisations (TATC, CAMARTEC, TDTC and TIRDO) show the limited use of technical drawing in development of their prototypes, the others used sketches; this practice was mainly used by SIDO TDC. These findings disqualify the fundamental principle of existence of engineering drawings, that is the basic object of engineering drawing is to communicate product design and manufacturing information in a reliable and unambiguous manner (Griffiths, 2003). A strong gate needs to be introduced in this stage of technology development (Cooper, 2010).

(d) Design analysis stage coefficient determination

Referring to Appendix 13; all three model shows robust estimation of liner regression, although Durbin-Watson test for Ln Sales per Unum is less than one; that is a sign of having a consistent error in variables prediction.

In the dependent variable Ln Quantity Manufacture technology performance variable shows a bad prediction since significance of F change is above 0.05. In the variable of factor of safety, is negative, but, lack of seriousness to adherence to standards in designing practices, causes bad prediction, the regression equations are shown in the following equations:

$$Y_1 = -5.901 + 0.936X_{13} + 1.710X_{14} - 1.136X_{15} + 0.018X_{16} + 1.650X_{17} + 1.09414 \tag{11}$$

The equation can be standardised as follows:

$$Y_{1std} = 0.271X_{13} + 0.453X_{14} - 0.336X_{15} + 0.403X_{16} + 0.634X_{17} \tag{12}$$

In Ln Cumulative sales values, (material selection independent variable) does not give a good prediction. Since most of technologies are copied the response to questionnaire was not consistent due to the less interest in taking care of this variable.

$$Y_2 = 3.819 + 0.344X_{13} + 1.990X_{14} + 1.036X_{17} + 1.559X_{18} + 1.05697 \tag{13}$$

The equation can be standardised as follows:

$$Y_{2std} = 0.103X_{13} + 0.547X_{14} + 0.413X_{17} + 0.415X_{18} \tag{4}$$

Durability was not an issue given a priority in design, and overall price of the product could not be well predicted. This applies to the cost of manufacturing since the transfer activities have been abandoned in the design process.

$$Y_3 = 8.49 + 1.254X_{13} + 0.537X_{17} - 1.033X_{19} + 0.82X_{20} + 0.0X_{21} + 0.897 \tag{15}$$

The equation can be standardised as follows:

$$Y_{3std} = 0.425X_{13} + 0.242X_{17} - 0.358X_{19} + 0.245X_{20} + 0.0X_{21} \tag{16}$$

Where:

X_{13} = Depend on availability of materials

X_{14} = Strength

X_{15} = Factor of safety

X_{16} = Technology performance

X_{17} = Overall price of the technology

X_{18} = Ability to manufacture

X_{19} = Durability

X_{20} = Cost of Manufacturing

Fig. 61 shows summary of the equation findings, material availability (0.8), strength (1.0) overall price (1.2) of the products and internal ability of manufacturing (0.5), these are good level of coefficients. The durability and factor of safety consideration are showing negative, general findings on these two variables show decline of profession practice in engineering design. In spite of the weakness in the existing design model this is the area where these models can be applicable to improve technology design (Özaltın, 2012; Pahl *et al.*, 2007).

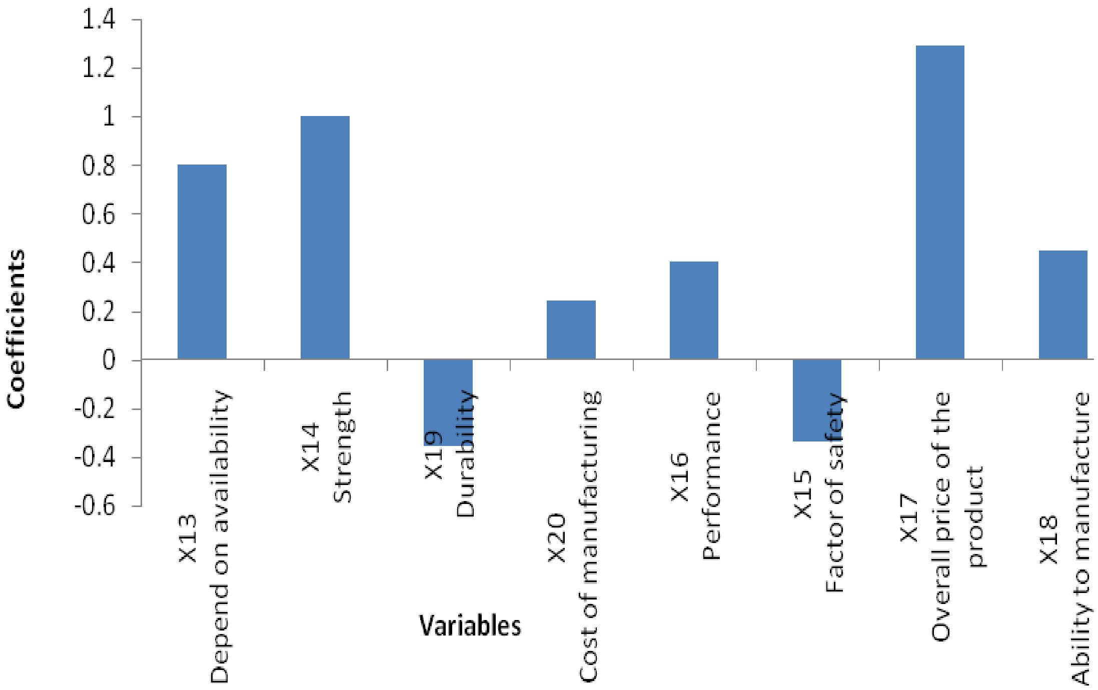


Figure 61: Sum of design coefficients.

Though these coefficients are for the model calibration, but variables like durability and factor of safety trend are very good indicators that our R&D organisations are not doing professional development works in agro-technology development. It is at this stage that most of the qualities of the end product are established by eliminating conceptual and operational vulnerability (El-Haik, 2005). In most cases this stage is avoided by designers of new products and hence having weak technology design specifications (Nigel, 2000). The mechanical design process described by Ullman (Ullman, 2009), Pugh's total design, and TRIZ (El-Haik, 2005) and the like, are existing. However there has been a problem of linking what the customers need with the design and hence design methods miss the quality aspect.

(e) Prototyping stage coefficient determination

Referring to Appendix 14, all the three models, that is the Ln cumulative quantity, Ln Cumulative sales and Ln Sales per year have low F-change significance, Durbing-Watson above 1 (Levine and Stephan, 2010; SPSS, 2008) . Thus they are good predicting regression models. The prediction has shown that engineering drawings, samples, jigs, prototype itself and fixtures consideration and processing do affect technology diffusion. The technology sample variable did not show a good prediction, in the cumulative quantity produces since it has significance above 0.05.

$$Y_1 = -5.469 + 0.842X_{22} - 0.138X_{23} + 1.459X_{24} + 1.444X_{25} + 0.957 \qquad (17)$$

With the standardised coefficient the equation is as follows:

$$Y_{1std} = 0.347X_{22} - 0.036X_{23} + 0.538X_{24} + 0.277X_{25} \qquad (88)$$

$$Y_2 = 7.940 + 1.156X_{22} + 1.421X_{25} + 1.761X_{26} + 1.108 \qquad (19)$$

With the standardised coefficient the equation is as follows:

$$Y_{2std} = 0.490X_{22} + 0.280X_{25} + 0.480X_{26} \tag{20}$$

$$Y_3 = 9{,}184 + 0.816X_{22} + 0.981X_{23} + 1.66X_{26} + 1.07486 \tag{21}$$

With the standardised coefficient the equation is as follows:

$$Y_{3std} = 0.394X_{22} + 0.304X_{23} + 0.517_{26} \tag{22}$$

Where: X_{22} = Drawings

X_{23} = samples

X_{24} = Jigs

X_{25} = Prototype

X_{26} = Fixture

As shown in Fig. 62, R&D Organisations are putting limited efforts in the use of drawing (1.2) which is mainly sketches for internal use in the same R&D organisations, samples (0.2) that are occasionally developed to complement technical drawings, there was no evidence of use of sample for testing the manufacturing line, prototype (0.5) that are just for testing the functioning of technology without a link to technology business requirement, jigs (0.5) and fixture (1.0) were mainly for internal use in manufacturing, the package that shows very little effort in development of the manufacturing infrastructure and the business set up; however the preliminary processes that are supposed to feed into this stage are not good enough. So this in itself could not be a guarantee of technology diffusion. Apart from prototype development, this stage give the insight of the expected transfer package; jigs and fixtures that show the need for consideration of manufacturing infrastructure, while sample shows the need of existence of validation of the manufacturing system and the business case. The triple helix (Etzkowitz, 2008; Malerba, 2005; Qing-dong, 2010), concurrent engineering (Hall, 1991; Ziemke and Spann, 1991) and twin valley of technology death (UK, 2013) model has a good input in the stage, that is R&D organisations were supposed to develop transfer package instead of prototype and small scale tools for manufacturing internally. According to RAND (2003) three main observation were emphasised:

(i) Technology transfer should be viewed broadly to include national investment, legislation, and commercialization

(ii) Industry partnerships with other research institutions is vital

(iii) Coordinating among many organizations, some with widely varying missions, is a significant challenge, it needs a strong policy.

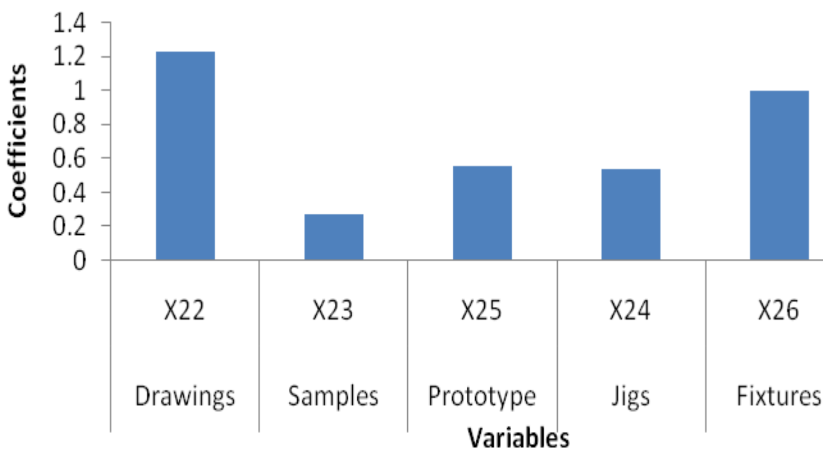


Figure 62: Sum of prototyping coefficients

(f) Validation stage with stake holders coefficient determination

Validation is a stage where technology is tested against stake-holders requirement (Avner, 2010; Hoyle, 2001), mostly with their involvement. Referring to Appendix 15 all three models, that is the Ln cumulative quantity, Ln Cumulative sales and Ln Sales per year have low F-change significance, Durbing-Watson above 1, thus they are good predicting regression models (Levine and Stephan, 2010; SPSS, 2008). The prediction has shown that end user participation, durability, consideration, engineer participation and R&D Technician participation affect technology diffusion. The sample variable financier participation did not show a good prediction, in the cumulative quantity produced since it has significance above 0.05. The main thing in this stage is the stakeholder's participation in the validation process and their influence into technology diffusion as discussed by Singh (2010). That brought great successes in the diffusion of tractors and harvesters in India.

$$Y_1 = -2{,}475 + 0.906X_{27} + 0.548X_{28} + 1.063X_{29} + 1.0813 \quad (23)$$

With the standardised coefficient the equation is as follows:

$$Y_{1std} = 0.413X_{27} + 0.213X_{28} + 0.386X_{29} \quad (24)$$

$$Y_2 = 9.719 + 0.801X_{27} + 0.855X_{29} + 1.265X_{30} + 0.946 \quad (25)$$

With the standardised coefficient the equation is as follows:

$$Y_{2std} = 0.376X_{27} + 0.322X_{29} + 0.359X_{30} \quad (26)$$

$$Y_3 = 7.883 + 0.507X_{27} + 1.25X_{30} + 0.733X_{31} + 0.617 \quad (27)$$

With the standardised coefficient the equation is as follows:

$$Y_{3std} = 0.271X_{27} + 0.401X_{30} + 0.399X_{31} \quad (28)$$

Where: X_{27} = End user participation

X_{28} = Financier participation

X_{29} = Durability consideration

X_{30} = R&D engineer participation

X_{31} = R&D Technician participation.

As shown in Fig. 63 the general understanding of the validation process was not good, unsystematic and incomplete validation process led to shallow participation of stake holders, that is engineers 0.8, technician 0.4, end users1.0 (mostly those ordering technologies) and financier 0.2, stake holders like manufacturers, vendors and government was not seen (Farinha and Ferreira, 2012). However the importance of external and internal technology developers of scrutinising the design variable against the expected agro-technology market diffusion is picked as an important process. The participation of stake holders shows the existence of the quality gate that is known as design review (Cooper, 2010; Hoyle, 2001).

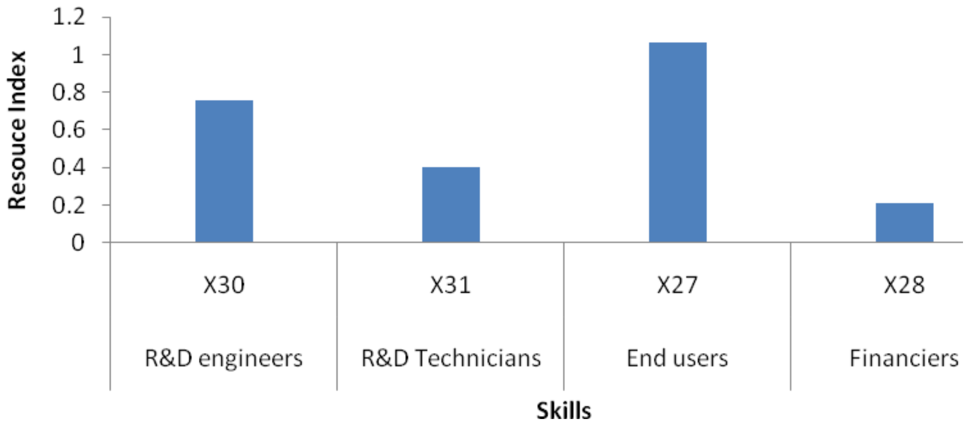


Figure 63: Sum of stake holders' participation in validation process coefficients.

(g) Validation stage and the coefficients of engineering variables

Table 54 and 55 in Appendix 16, show that, although the general GroupWise regression analysis emphasize on the stake holders participation, there are variables like technology durability, through-put and robustness are well predicted in all the three models, i.e. the Ln cumulative quantity, Ln Cumulative sales and Ln Sales per year. However the aesthetics has been an ignored issue in various stages of technology development and is not well predicted.

$$Y_1 = -1.169 + 1.993X_{29} + 1.271X_{51} - 1.776X_{52} + 1.11 \qquad (29)$$

With the standardised coefficient the equation is as follows:

$$Y_{1std} = 0.386X_{29} + 0.547X_{51} - 0.386X_{52} \qquad (30)$$

$$Y_2 = 11.638 + 1.343X_{29} + 1.08X_{51} + 1.05 \qquad (31)$$

With the standardised coefficient the equation is as follows:

$$Y_{2std} = 0.506X_{29} + 0.482X_{51} \qquad (32)$$

$$Y_3 = 9.172 + 0.607X_{29} + 1.118X_{51} + 0.738X_{53} + 0.76 \qquad (33)$$

With the standardised coefficient the equation is as follows:

$$Y_{3std} = 0.258X_{29} + 0.564X_{51} + 0.248X_{53} \qquad (34)$$

Where: X_{29} = Durability consideration

X_{51} = Throughput

X_{52} = Ergonomics

X_{53} = Robustness

Experiments done during the validation are referred to as validation contents. The spectrum of validation content is affecting the scope of validation process as shown in section 2.13.10 (Avner, 2010; Hoyle, 2001), hence the assurance of crossing the twin valleys of technology death referred to in section 2.3 (UK, 2013). R&D organisations in Tanzania have shown a little understanding of the technology validation process that has caused poor agro-technology diffusion factors observation. As shown in Fig. 64 only two variables are having higher coefficients that are technology capacity known as throughput (1.6), the durability (1.0) and technology robustness (0.25). Ergonomics shows a negative value (0.4); this has been a problem in technology like animal feed mixer and some other technologies. Knowledge in ergonomics and aesthetics need to be improved. As shown in Appendix 30, ISO 9001: 2000 standard has very useful general recommendation of a guideline for technology validation by which more detailed variables have to be established for a specific technology during the validation process and appear in the validation process output (Avner, 2010; Hoyle, 2001).

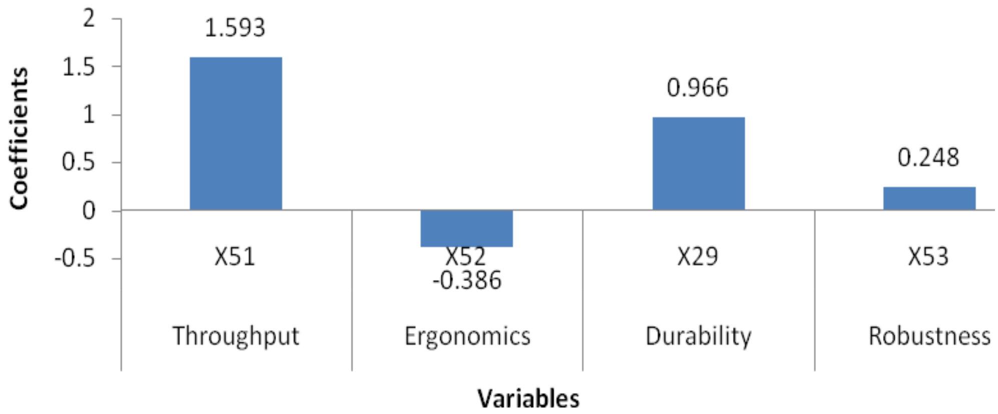


Figure 64: Sum of validation contents coefficients.

(h) Validation output sub model coefficient determination

Referring to Appendix 17; the approved technology and the approved means of operation have shown reasonable significance in the sub group regression model for technology diffusion.

$$Y_1 = -1.29 + 1.91X_{54} + 1.26 \quad (35)$$

With the standardised coefficient the equation is as follows:

$$Y_{1std} = 0.759X_{54} \quad (36)$$

$$Y_2 = 13.74 + 1.66X_{54} + 1.36 \quad (37)$$

With the standardised coefficient the equation is as follows:

$$Y_{2std} = 0.686X_{54} \quad (38)$$

$$Y_3 = 11.65 + 0.76X_{54} + 0.81X_{55} + 1.05 \quad (39)$$

With the standardised coefficient the equation is as follows:

$$Y_{3std} = 0.355X_{54} + 0.485X_{55} \quad (40)$$

Where:

X_{54} = Approved technology

X_{55} = Approved means of operation

As shown in Fig. 65 approved technology has coefficient of 1.8 and approved means of operation has a coefficient of 0.5. Documented report of validation together with all the existing soft and hard items of technology, has to pass throughout the stake holders scrutiny using the model similar to stage gate by Cooper (2009), the gate keeper should be satisfied with the validation report with guide shown by variables stipulated in the project charter and the business case (CISR, 2010; Hoyle, 2001). These provide a link to the optimal design variables specified at the initiation stage to proper packaging of agro-technology for diffusion (Cambridge Chemical Technologies, 2012). As the regression analysis has shown a positive report from the validation process ensures high rate technology diffusion.

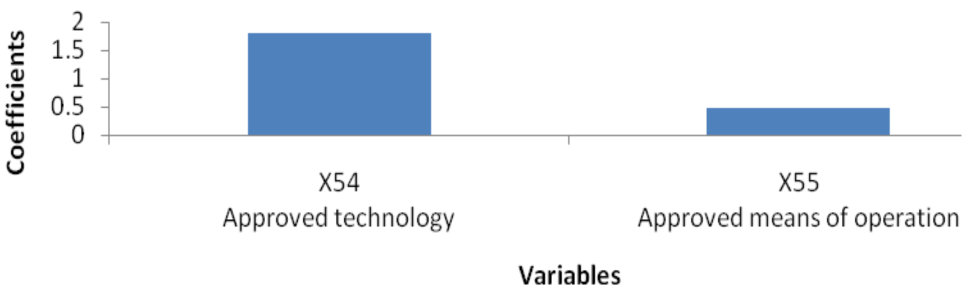


Figure 65: Sum of technology validation output coefficients.

(i) Technology transfer stage coefficient determination

As depicted in Appendix 18, all three models, that is the Ln cumulative quantity, Ln Cumulative sales and Ln Sales per year have low F-change significance, Durbing-Watson above 1, are good predicting regression models. The prediction has shown that operation manual, bill of material, engineering drawings, finance sources and fixtures affect technology diffusion. This finding is in line with what was discussed by Koshuma (2005).

The following are equations:

$$Y_1 = -4.408 + 1.793X_{32} + 1.11X_{33} + 0.459X_{34} + 1.233X_{35} + 1.061 \qquad (11)$$

With the standardised coefficient the equation is as follows:

$$Y_{1std} = 0.515X_{32} + 0.414X_{33} + 0.221X_{34} = 0.299X_{35} \qquad (42)$$

$$Y_2 = 11.284 + 1.296X_{33} + 1.212X_{35} + 1.912X_{36} + 1.22 \qquad (43)$$

With the standardised coefficient the equation is as follows:

$$Y_{2std} = 0.502X_{33} + 0.305X_{35} + 0.264X_{36} \qquad (44)$$

$$Y_3 = 10.980 + 1.226X_{33} + 1.544X_{35} + 1.175 \qquad (55)$$

With the standardised coefficient the equation is as follows:

$$Y_{3std} = 0.537X_{33} + 0.438X_{35} \qquad (46)$$

Where: X_{32} = Operation manual

X_{33} = Bill of material

X_{34} = Engineering drawings

X_{35} = Finance sources

X_{36} = Fixtures

Generally all the eleven variables shown in section 4.1.2 (g) expected to be incorporated in the transfer package show a very poor consideration, occasionally engineering drawing and technology samples were mentioned in three R&D organisations for one technology each

(TATC cashew nut processing plant, Tractor driven maize sheller by TDC SIDO and TDTC sugar processing plant). All three technologies didn't show any significant quantity manufactured.

As shown in Fig. 66, sample generally is not considered as important item in the transfer package. Engineering drawing and the bill of materials are considered to be main control on technology mass production. Fixtures are standing for the manufacturing infrastructure. Operation manual stands for other manual that makes the technology friendly to the users, and finally the interaction with financial institution and donors give birth to the finance sources for manufacturer and end users, since most of these technologies can be bought through loans (Singh, 2010).

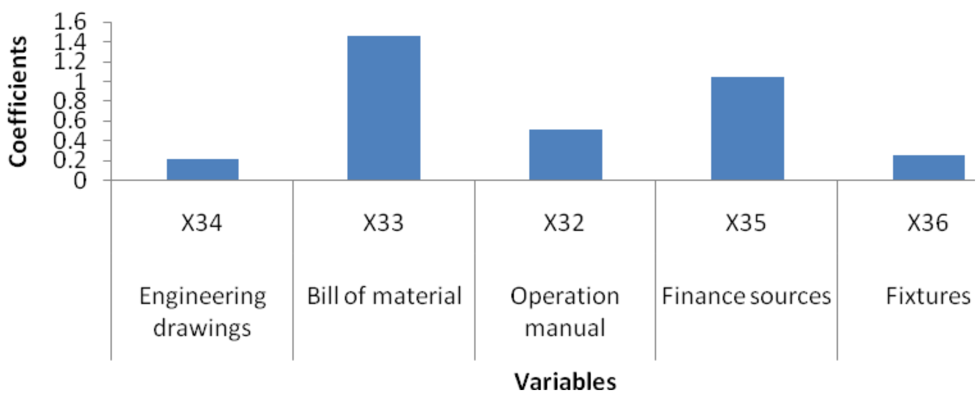


Figure 66: Sum of technology transfer coefficients.

(j) Documents in various stages coefficient determination

As illustrated in Appendix 19, two of three models, that is the Ln cumulative quantity, and Ln Sales per year have low F change significance, Durbing-Watson above 1, thus they are good predicting regression models. However the Ln Cumulative sales have higher significance for F-change of 0.272, which indicates the linearity problem. The prediction has shown operation manual, project brief, bill of material, done on 3D software 3, done in

2D board 1, drawings, bill of material, customer order, technology profile, operation manual and business case affect technology diffusion. Though technology profile and operation manual shows negative coefficients, they are not common practice in R&D organisation. While this technology may seem to be readily available for commercial use, there are many barriers that prevent its easy movement from the R&D organisations to the private sector. Among those barriers are a lack of awareness of the R&D, a misunderstanding of its potential applications to commercial use, a means to access technology information, and the capital to fund the commercialization process (USA, 1993). Technology information availability and protection are vital for agro-technology diffusion. The following are equations for information variables:

$$Y_1 = -4.546 + 1.14X_{37} + 0.867X_{38} + 0.974X_{39} + 1.291X_{40} + 0.800 \qquad (47)$$

With the standardised coefficient the equation is as follows:

$$Y_{1std} = 0.327X_{37} + 0.305X_{38} + 0.364X_{39} + 0.248X_{40} \qquad (48)$$

$$\begin{aligned} Y_3 &= 8.983 - 0.891X_{37} + 0.725X_{38} + 1.332X_{39} + \\ &0.832X_{42} + 1.046X_{44} - 0.996X_{45} + 0.676X_{47} + 0.617 \end{aligned} \qquad (49)$$

With the standardised coefficient the equation is as follows:

$$\begin{aligned} Y_{3std} &= -0.311X_{37} + 0.209X_{38} + 0.238X_{39} + \\ &0.198X_{42} + 0.189X_{44} - 0.288X_{45} + 0.307X_{47} \end{aligned} \qquad (50)$$

Where: X_{37} = Operation manual

X_{38} = Project Brief

X_{39} = Bill of material

X_{40} = Done on 3D software 3

X_{41} = Done in 2D board 1

X_{42} = Drawings

X_{43} = Bill of material

X_{44} = Customer order

X_{45} = Technology profile

X_{46} = Operation manual

X_{47} = Business case the information availability is obtained in hard and soft documentation. As shown in Fig. 66 the average coefficients for information variables show positive contribution to agro-technology diffusion. This is what was argued in the very early stages of discussion on innovation diffusion (Rogers, 1983). All the document existence necessitates some scientific processes of technology development as prerequisite and the form a control of the whole process of agro technology development. Project brief or chatter shows how the project was approved from the need point of view (0.5); the business case gives the set up of expected business (0.3), operation (0.6) together with maintenance and installation manuals stipulates technology management requirements. Bill of material (0.6) give the list and the price of technology, while drawing (0,2, 0.3 and 0.7) provides the layout of technology, manufacturing and business package. The customer order (0.6), but if it needs to be transformed into technology for diffusion it has to go back to project charter and business case. The technology profile (0.3) should communicate all the benefits of the technology.

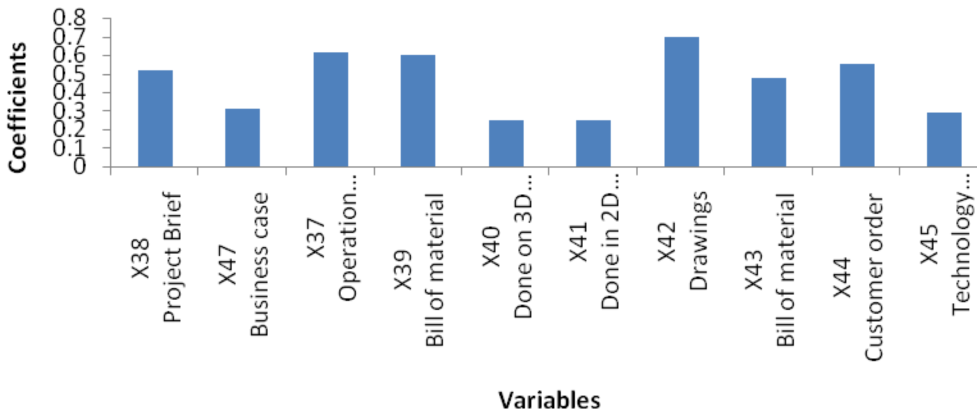


Figure 67: Sum of technology information availability coefficients.

(k) Stages in agro-technology diffusion coefficient determination

The three models in Appendix 20, show that the Ln cumulative quantity, the Ln Cumulative sales and Ln Sales per year have low F-change significance, Durbing-Watson above 1, although lower R^2 of (0.44), thus they are good predicting regression models. The prediction has shown that, transfer stage, validation stage and prototyping do affect technology diffusion. These are represented in the following regression equation:

$$Y_1 = -4.231 + 2.636X_{48} + 1.771X_{49} + 1.479 \quad (51)$$

With the standardised coefficient the equation is as follows:

$$Y_1 = 0.525X_{48} + 0.385X_{49} \quad (52)$$

$$Y_2 = 9.95 + 1.92X_{49} + 1.269X_{50} + 1.428 \quad (53)$$

With the standardised coefficient the equation is as follows:

$$Y_{2std} = 0.433X_{49} + 0.352X_{50} \quad (54)$$

$$Y_3 = 7.448 + 1.7571X_{49} + 1.571X_{50} + 1.036 \quad (55)$$

With the standardised coefficient the equation is as follows:

$$Y_3 = 0.446X_{49} + 0.492X_{50} \quad (56)$$

Where:

X_{48} = Transfer

X_{49} = Validation

X_{50} = Prototyping

As shown in Fig. 68 three variables have shown high significance in the need to have stages in the process of technology development to ensure their diffusion. Validation is shown as very important for technology diffusion (1.3), followed by prototyping (0.8) and the transfer (0.5). Other stages are not shown here, however development of the prototype without design is questionable and so the conceptualisation to initiation are included in the prototyping process (Sanga and Mganilwa, 2012; Cooper, 1992; Cooper, 1988; Cooper, 2010; Cooper, 2009).

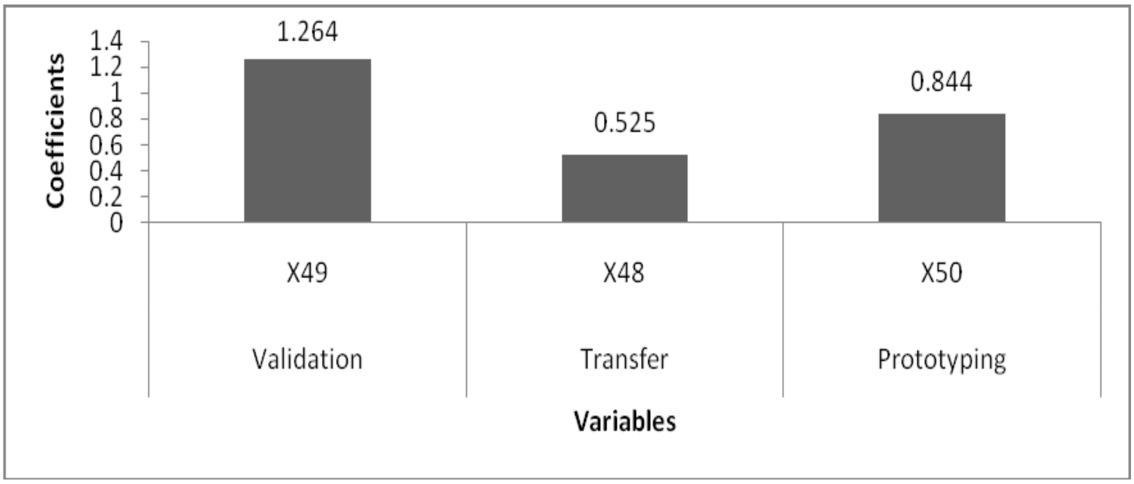


Figure 68: Sum of stages importance in technology development coefficients.

In this section the parameters that lead to high diffusion rate of agro-technologies in Tanzania R&D organisations have been determined (Appendix 20). Standardised coefficients related to these variables are used in calibration of system dynamic model (Fig.

71) and used to finalise insertion of formulas in the model in the following sections (Levine and Stephan, 2010).

On the way to preparation of the model variables were grouped into major factor depending on how they affect technology diffusion:

(a) Relevance of needs identification (needr), which is driven by x2, x3, x5 and x7.(van Cruysen and Hollanders, 2009)
(b) Need identification (needi) that has are driven by variable x1, x4 and x8 (Cooper, 1988)
(c) Interpretation of variable (interpi) into design specification which is driven by x9, x10, x11, x12, x13, x14, x15, x16, x17, x18, x22, x23, x24, x25 and x26 (UK, 2013; UK, 2011; Ulrich and Eppinger, 2004; Verma *et al.*, 1995)
(d) Agro-technology validation process (tval) which is driven by x27, x28, x29, x30, x31, x52, x53, x54 and x55 (Arnold and Guy, 2000; Hoyle, 2001; Husig and Kohn, 2003; Lord. *et al.*, 2005).
(e) Agro-technology information generation (tinfa) which is driven by x37, x38, x39, x40, x41, x42, x43, x44 and x45 (Rogers, 1983)
(f) Proper Agro-technology packaging (tpava) which is driven by x32, x33, x34, x35 and x36. (Cambridge Chemical Technologies, 2012; Singh, 2010)
(g) Agro-technology development stages importance (stdin) which is driven by x48, x49, and x50 (Cooper, 2010; Cooper, 2009; Sanga and Mganilwa, 2012)

4.2 Dynamic model for diffusion of agro-technology innovations in Tanzania

4.2.1 Model calibration

This is the calibration at the macro variable level. As explained in section 2.14 after regression the following main variables weights were established as shown in Table 35:

These are sums of the coefficients, in each group, obtained from the three independent variables i.e. quantity, cumulative value and sales rate.

Table 35: Sum of coefficients established

Variables		Stage Weights	Out of 1	
weight for initiation stage variables	α_1	4.126	0.133	13%
weight of conceptualisation stage	α_2	0.819	0.026	3%
weight of engineering analysis stage	α_3	3.493	0.112	11%
weight of prototyping stage	α_4	3.591	0.116	12%
weight of validation Process	α_5	5.966	0.190	19%
weight of transfer stage	α_6	3.495	0.112	11%
weight of documentation	α_7	4.548	0.146	15%
weight of stages existence	α_8	2.633	0.085	8%
weight of validation stake holder (participation of stake holder)	α_9	2.435	0.078	8%

Null hypothesis in this case is *H_0.*

$$H_0 : \alpha = \alpha_i = 0 \qquad (57)$$

Alternative hypothesis is H_a

$$H_a : \alpha = \alpha_i \neq 0 \qquad (58)$$

Level of significance is 5%

Values of the weights are loaded into the Fig. 69. This model is used to feed in the data and formula into the technology development layout in Fig. 69.

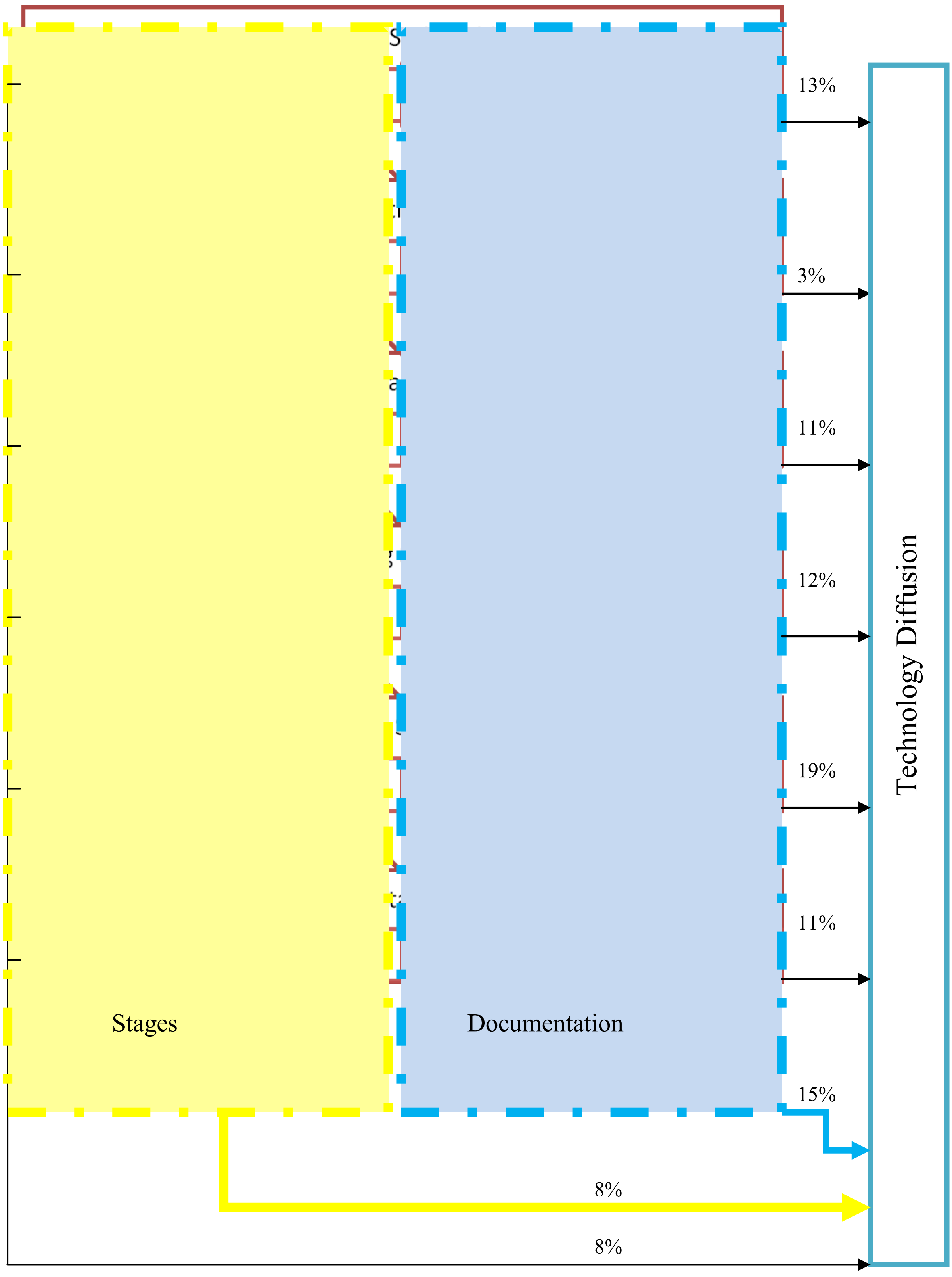


Figure 69: Diffusion model calibration framework with weights.

4.2.2 Execution of the dynamic model

As described in the section 2.6 above the dynamic model framework for technology diffusion was developed. The equations were developed to describe macro-variable in the dynamic model in Vensim software 2007 as described in section 3.4.1 including equation and 4.1.2(k) including factors and variables. Data are input in the designer user interface in access form, developed in the access software 2007, which is arranged in a probing guide questions to check, as data goes directly to the access form shown in Fig. 70, the Vensim model shown in Fig. 71 is used to run performance analysis and predict the diffusion outputs. The output is also accompanied by the recommendation to the designer.

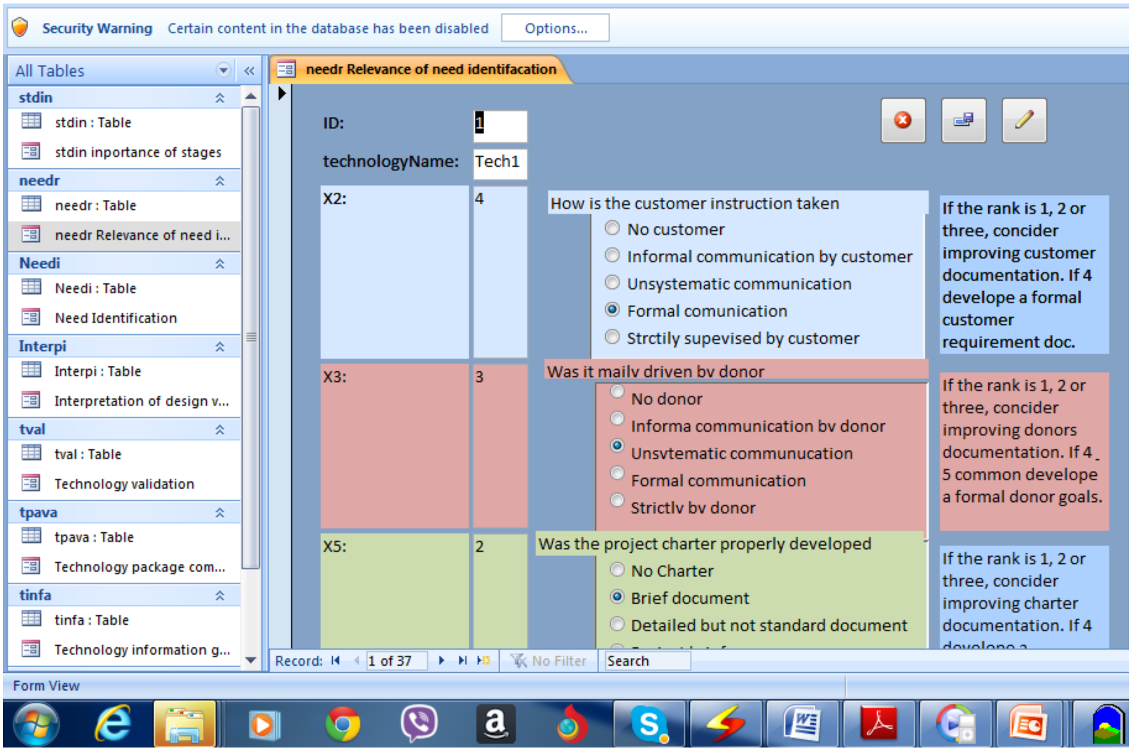


Figure 70: Designer user interface example.

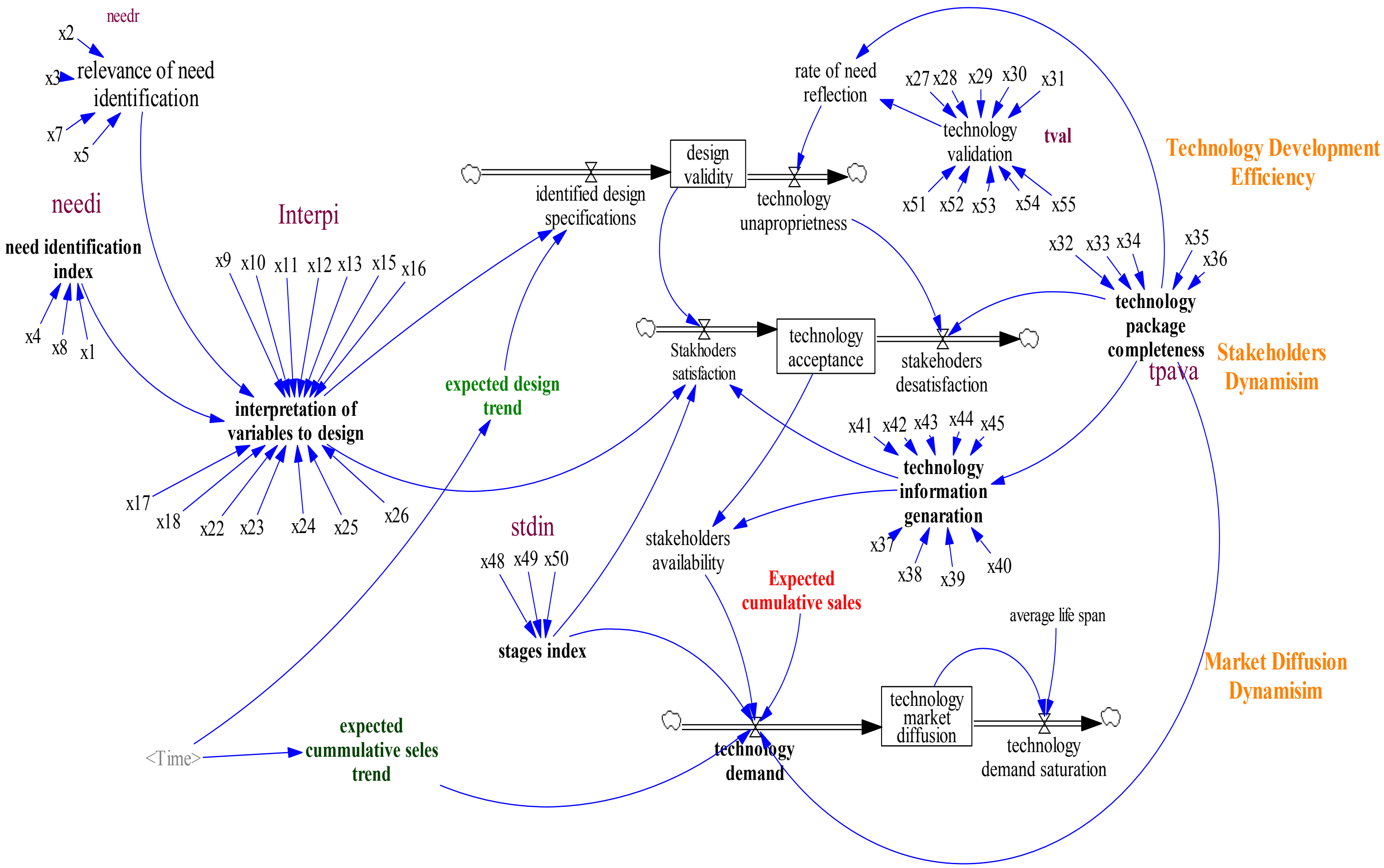


Figure 71: Diffusion dynamic model.

4.3 Testing and Validating the agro-technology Diffusion Model

1.1.1 General verification of the model

Various tests were done on the model for preliminary calibration. On running the model with all variables changed from 1 to 5, as displayed in Fig. 70 good finding were observed as shown in Fig. 72. However validation was needed to prove this.

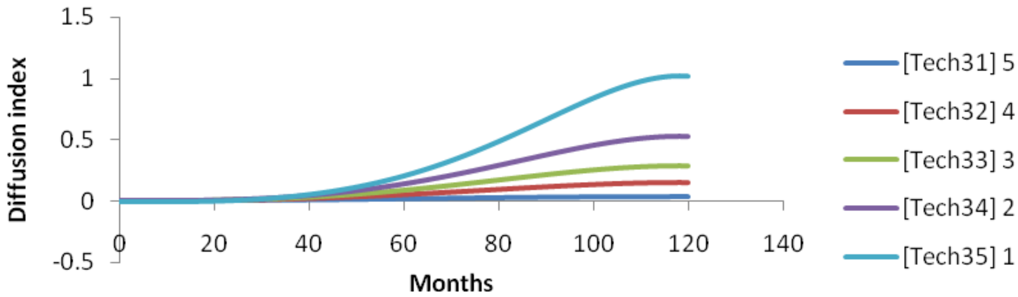


Figure 72 Technology market diffusion index.

Figure 72 shows that the variable average of 4 (80%) to 5 (100%) are giving the diffusion rate of 50% to 100%. This simply gives the picture of the technology diffusion rate expectation for the model. Technology number six was picked because was the highest performing technology given the maximum diffusion index value of one in the preliminary calibration.

Other macro variables that affected by the changes of micro variables are:

Design validity display in Fig. 73, shows that average of mark 4 and 5 gives 50% and 100% of having reliable design respectively. For proper information availability the average mark should be about 4.5 to get 50% assurance that is sufficient for technology diffusion (Fig. 74).

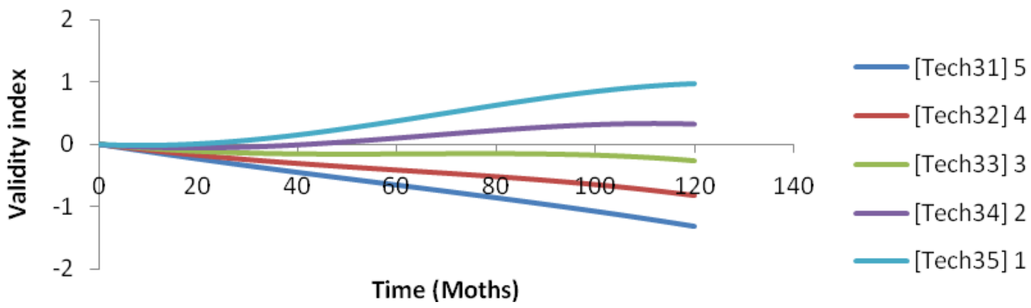


Figure 73: Design validity index

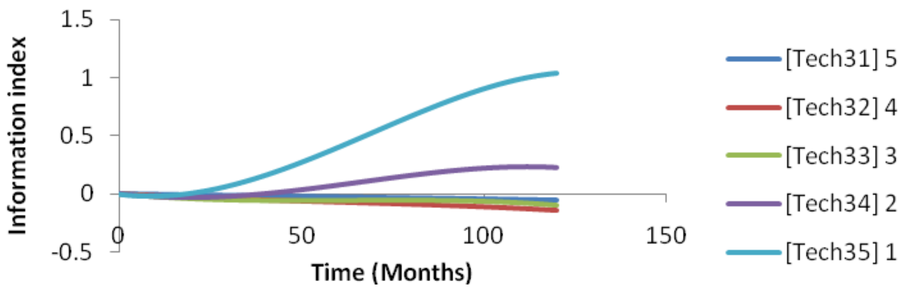


Figure 74: Technology information generation index.

Others are technology acceptance index that put the average score of 3 as a splitting point, as the mark goes above 3, technology is likely to accepted by stakeholders as shown in Fig. 75 and finally technology package completeness shown in Fig. 76 which demands average score above 4 to be 50% assured that the package is good for business environment.

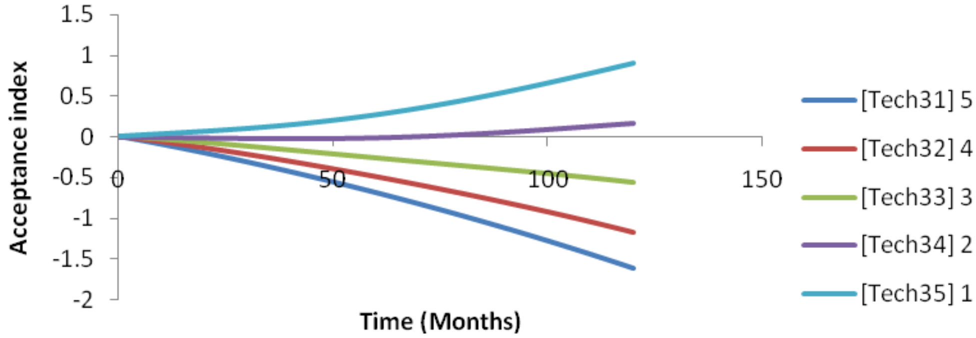


Figure 75 Technology acceptance index.

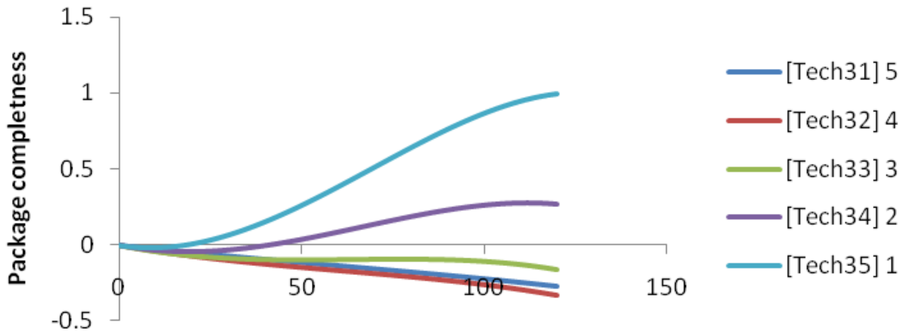


Figure 76: Technology package completeness.

4.3.1 Relevance of need identification

Relevance of need identification (needr) is macro variables driven by the need for development of the project charter and business plan as described in sections 2.13.3 and 2.13.4. This facilitates the transformation of customer attributes into function requirement (engineering variables) for the engineering technology development as displayed in Fig. 20 and Fig. 21 of literature review.

$$needr = \frac{(\beta_2 \times x_2[Tech] + \beta_3 \times x_3[Tech] + \beta_5 \times x_5[Tech] + \beta_7 \times x_7[Tech])}{(\beta_2 \times 5) + (\beta_3 \times 5) + (\beta_5 \times 5) + (\beta_7 \times 5)} \tag{59}$$

Since values of β_i are known and are constant and for the denominator the maximum value of x is 5, these values loaded into equation number 110:

$$needr = \frac{(1.4 \times x_2[Tech] + 0.56 \times x_3[Tech] + 0.1 \times x_5[Tech] - 0.5 \times x_7[Tech])}{(1.4 \times 5) + (0.56 \times 5) + (0.1 \times 5) + (0.5 \times 5)} \qquad (60)$$

Where:

β_2 = Coefficient of customer proposal on the capacity of the technology

β_3 = Coefficient of the participation of the donor in the review at initiation stage

β_5 = Coefficient of having comprehensive project charter

β_7 = Coefficient of having comprehensive business plan

x_i = Are the values of variables corresponding to $\beta_{i.}$, the maximum value is fixed at 5.

[Tech] on [T] is a way to call subscripts from data base, in this case the database in Microsoft office excel 2007. Figure 77 shows the list of group of thirty technologies.

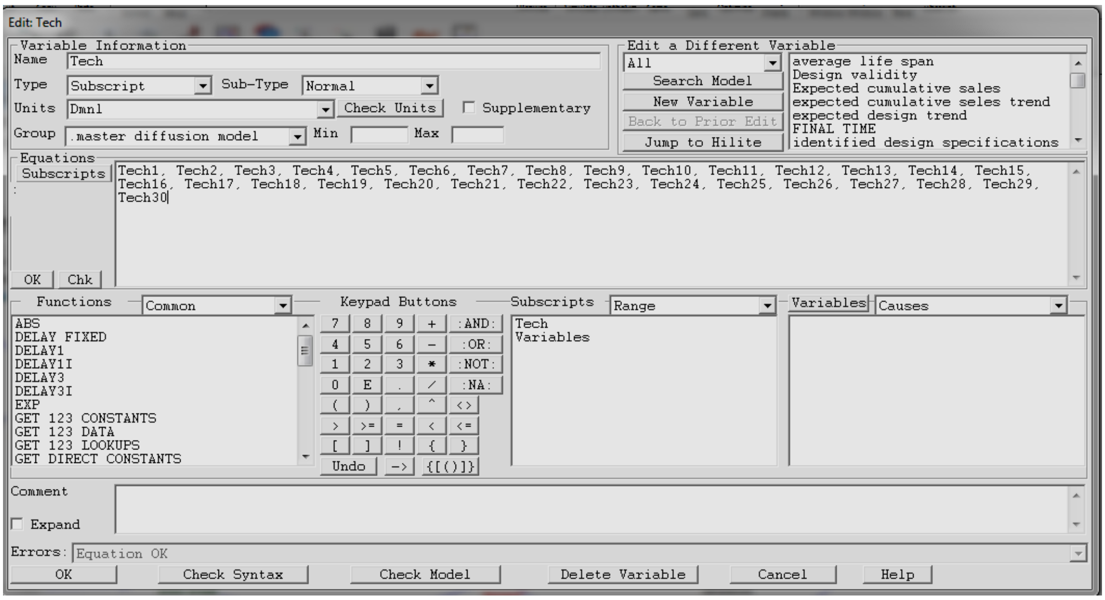


Figure 77: Technology subscript definition.

4.3.2 The variation of relevance of need identification per technologies

From Vensim simulation model as shown in Fig. 78 solar drier for agro-product received the highest rank of 1.0 TDI, followed by maize milling machine with 0.80 TDI, followed by the biogas plants with 0.78 TDI. On relevance of need, the model seems to give a good view of the market reflection. On the interview conducted to Network of farmers' Group in Tanzania (MVIWATA) at the agriculture trade fair in Morogoro in the year 2012, there was a great concern over the availability of solar drier, especially for fishery industries in Lake Tanganyika. By that time the engineer from TIRDO showed a great demand of the same technology but lacked forward integration of the project. There is a strong argument from other researchers that the assessment of relevance of need plays a crucial effect on the whole processes of technology development (Chungu *et al.*, 2001; Cooper, 1988).

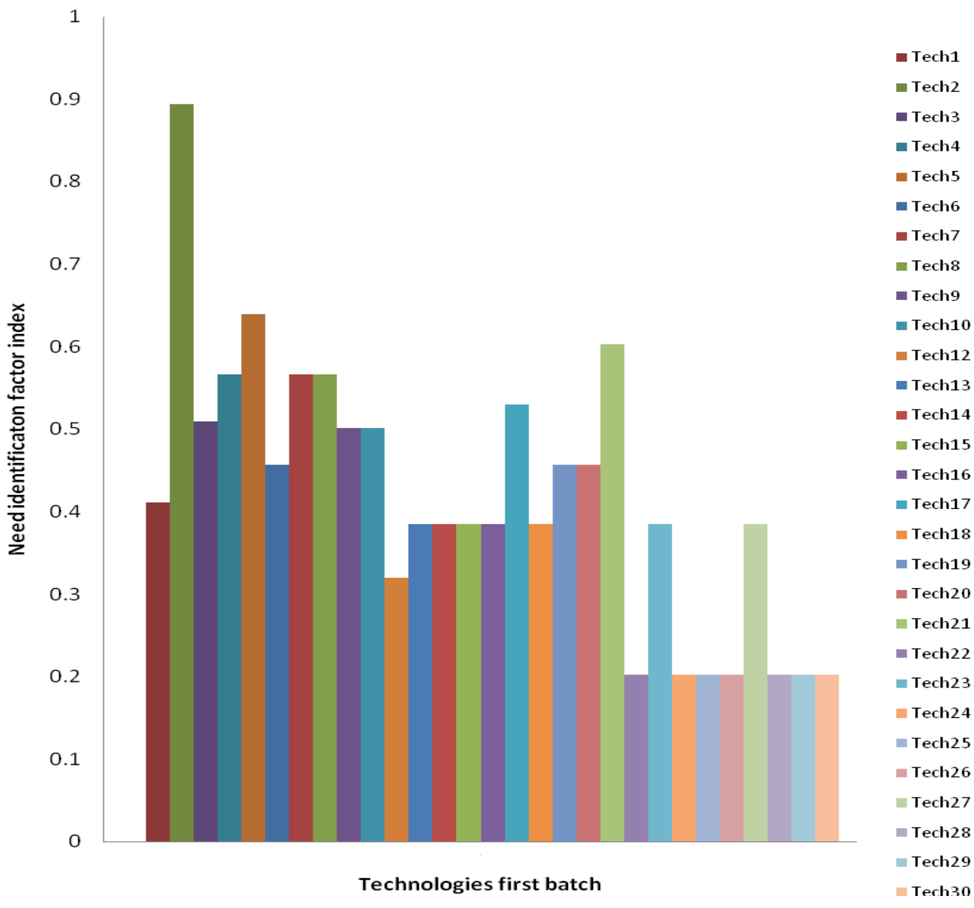


Figure 78: Relevance of need identification variation.

4.3.3 Sensitivity of need relevance in the technology diffusion

Running sensitivity analysis to see the impact of need requirement on the technology market diffusion, technology acceptance and technology validity, X2, X3, X5 and X7 were randomly varied from the 1 to 5 at a step of 1. The maximum variation at 100 confidence bound was ~ 13% (Fig. 79). For normal business undertaking with profit margin of 25% for sales revenue, this is half the amount of the profit and is significant. The proper compilation and analysis of customer proposal on the capacity of the technology, the participation of the donor in the review at initiation stage, comprehensive project charter and comprehensive business plan is of higher significance on technology diffusion rate hence variables on the agro-technology needs relevance are very important for ensuring a good technology diffusion.

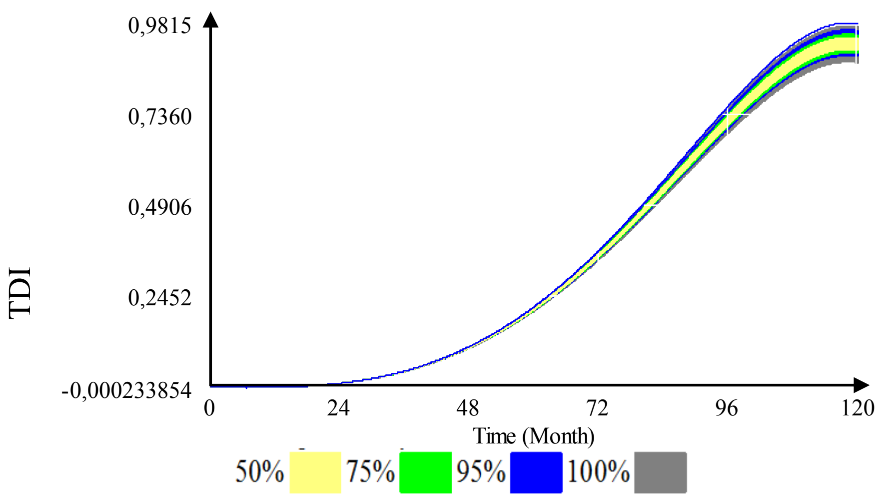


Figure 79: Technology market diffusion Vs Needr confidence bounds.

Relevance of need identification is to level of 25%, that mend the compilation of project charter and business case contexts are necessary processes to have a good engineering design as depicted in Fig. 80.

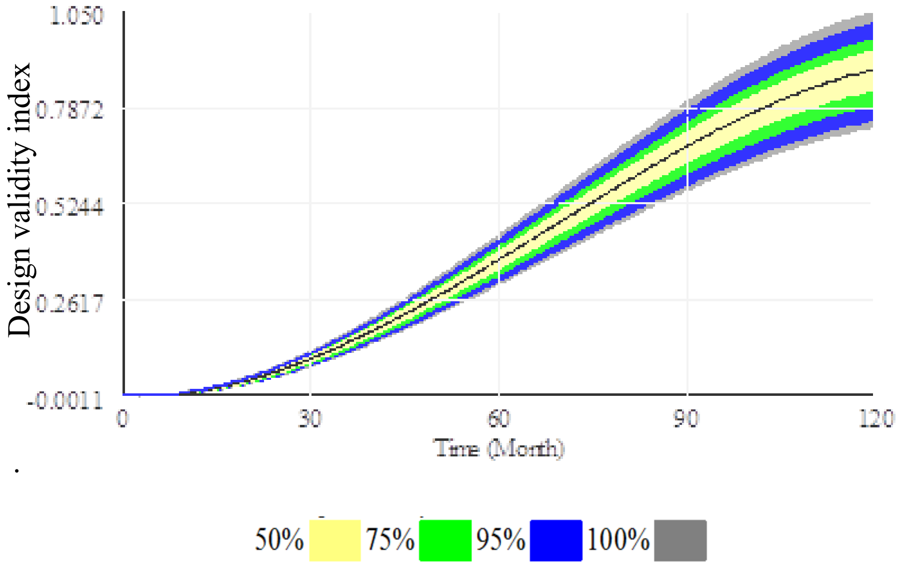


Figure 80: Design validity index.

Good information availability is affected to the range of 25%. Initiation variable have impact on the information reliability to stake holders as depicted in Fig. 81.

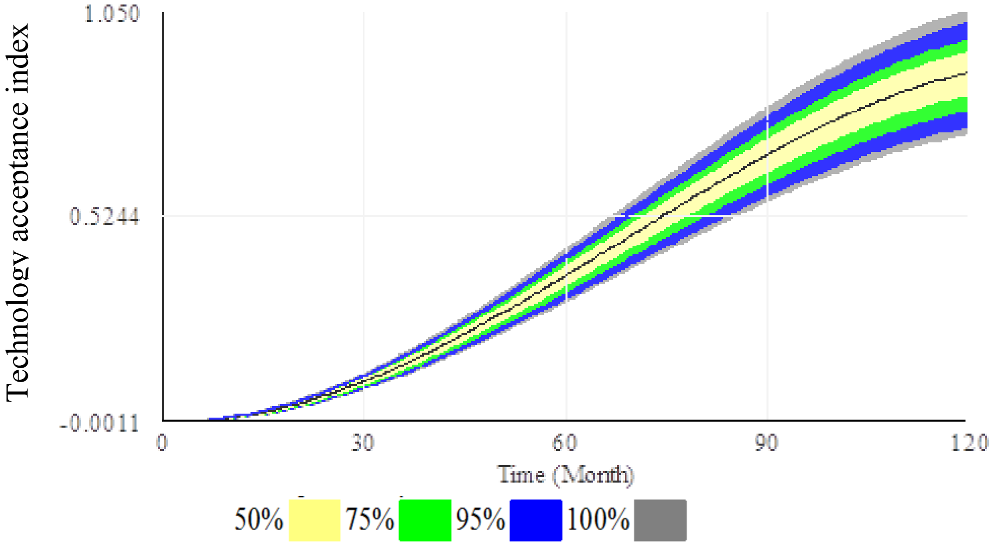


Figure 81: Technology information generation confidence bounds.

Both the technology acceptance as depicted in Fig. 82 and goodness of technology package as shown in Fig. 83, are affected by 17% and 27% respectively. Variable of the need relevance affects main areas of agro-technology development for diffusion.

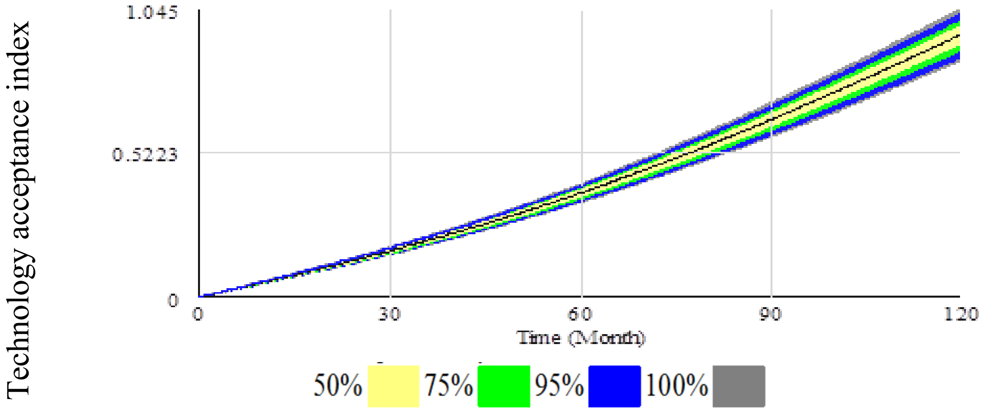


Figure 82: Technology acceptance index.

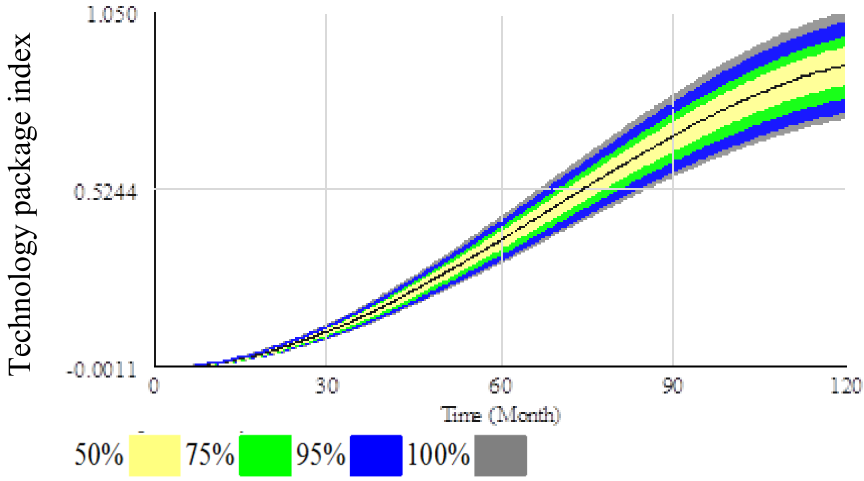


Figure 83: Technology package completeness index.

4.3.4 Need Identification

National technology need assessment was mentioned as an important process in the technology; however it was acknowledged that it is not professionally practiced in Tanzania. Individual R&D organisations conducted partial technology need assessment that was not well documented; this is shown as a very important factor for final technology success (Canada, 2009; Heldman, 2005; Hugh *et al.*, 2007; Sunga *et al.*, 2002). Additional customer and manufacturer input are included in the dynamic model equation for need identification process.

$$needi = \frac{(\beta_1 \times x_1[Tech] + \beta_4 \times x_4[Tech] + \beta_8 \times x_8[Tech]}{(\beta_1 \times 4) + (\beta_4 \times 4) + (\beta_8 \times 4)} \tag{61}$$

$$needi = \frac{(1.4 \times x_1[Tech] + 0.99 \times x_4[Tech] + 0.31 \times x_8[Tech]}{(1.4 \times 4) + (0.99 \times 4) + (0.31 \times 4)} \tag{62}$$

Where:

B_1 = coefficient of national technology need assessment

β_4 = Coefficient of manufactured proposal on the capacity of technology

β_8 = Coefficient of customer order as means of approving the project

As depicted in Fig. 84 need identification index for Nyumbu truck is leading with 0.53, followed by CAMARTEC biogas plant with index of 0.51, SIDO TDC maize huller with index of 0.50, followed by SIDO TDC maize mill with index of 0.46. The only technology that was given special market is Nyumbu truck. Trend shows importance of technology need identification process. What is learnt here is that the need assessment has very low index value due to the fact which was confirmed by the COSTECH and the Ministry of Agriculture, Food Security and Cooperatives that need assessment is not done officially in Tanzania.

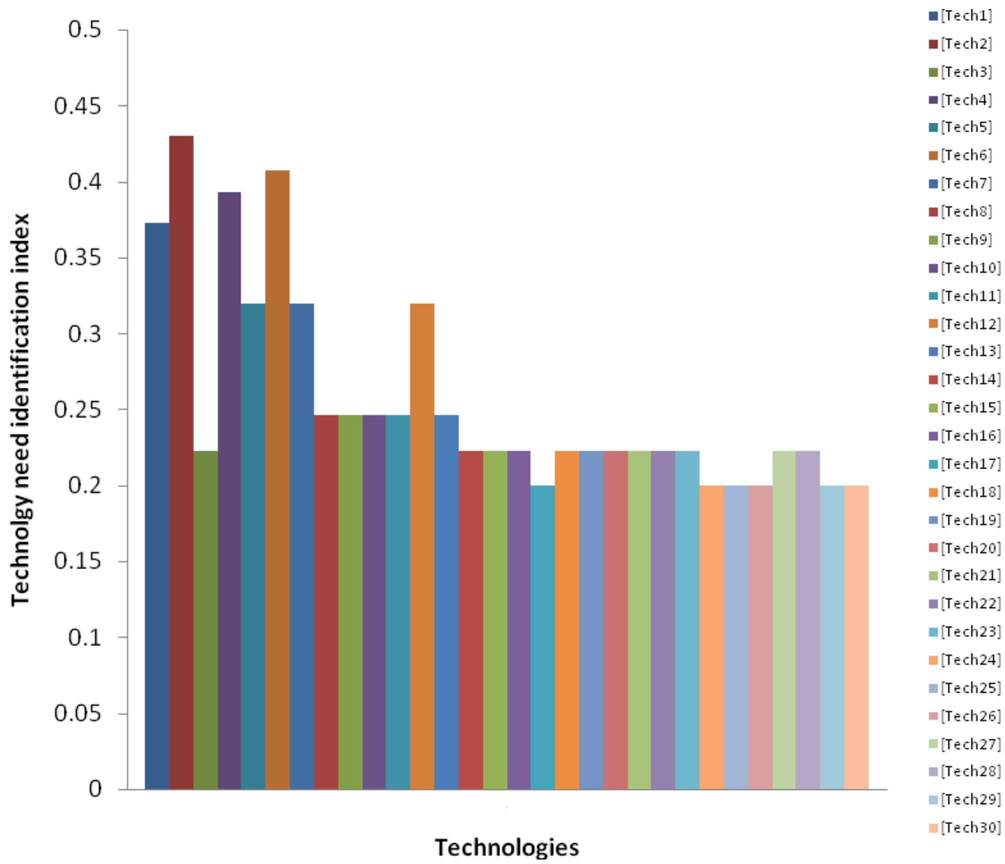


Figure 84: Technologies need identification variables.

4.3.5 The sensitivity of need identification

At 100% confidence bound the variation of national technology need assessment (X1), manufactured proposal on the capacity of technology (X4) and customer order as means of approving the project (X8), between 1 and 5 at the step of 1 gave the variation of technology diffusion index of 10% (Fig. 85), technology design validity index of 20% (Fig. 86), technology information generation of 20% (Fig. 82, technology acceptance of 10% (Fig. 88) and technology packaging sufficiency of 20% (Fig. 89). In summary this shows that the agro-technology need assessment study (survey) and the corresponding reports are important for ensuring optimal technology development for diffusion (Adebayo, 2004; Hugh *et al.*, 2007; Singh, 2010).

The impact of agro-technology need identification to other factors and driven major processes as shown in Fig. 85, 86, 87, 88 and 89.

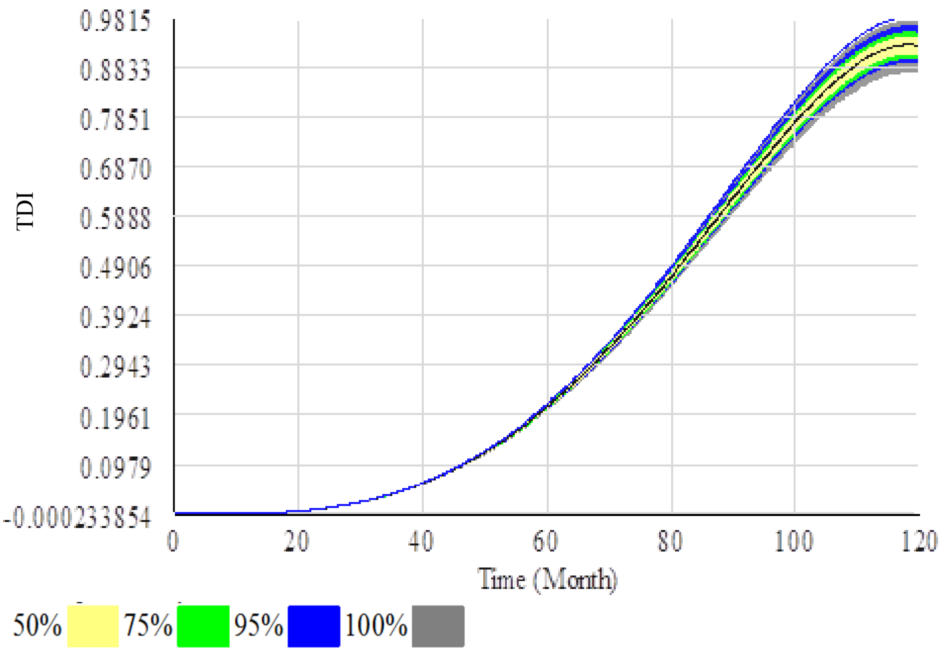


Figure 85: Technology market diffusion Vs Needi confidence bounds.

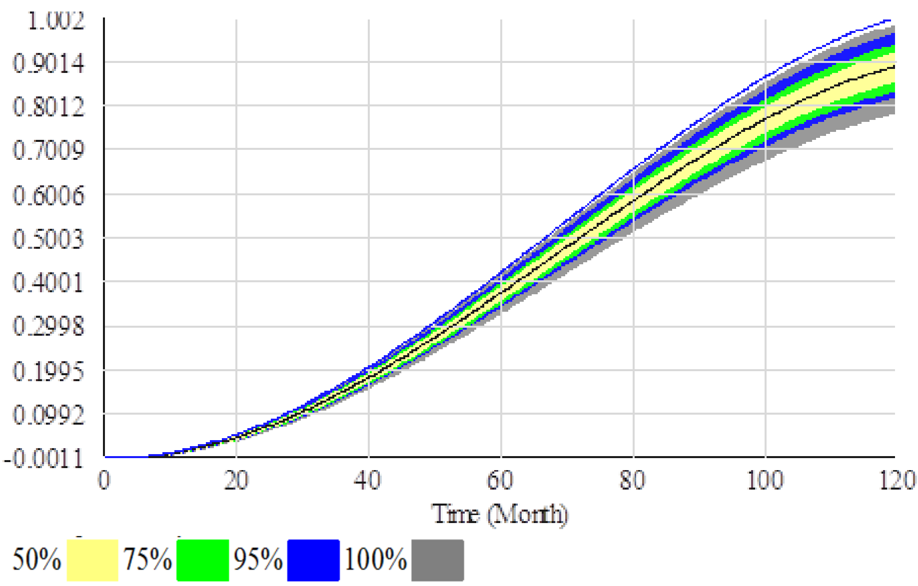


Figure 86: Technology design validity Vs Needi confidence bounds.

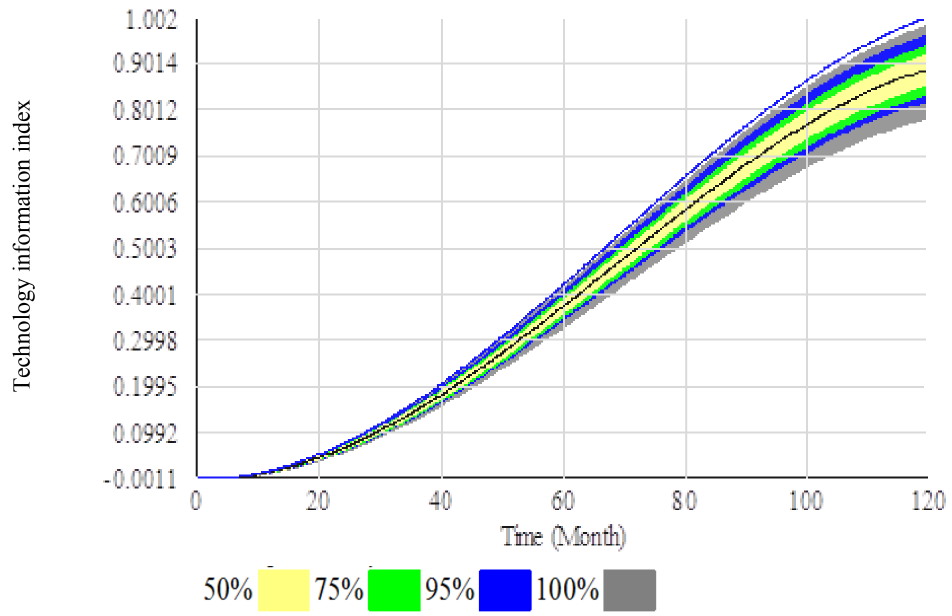


Figure 87: Technology information generations, Needi confidence bounds.

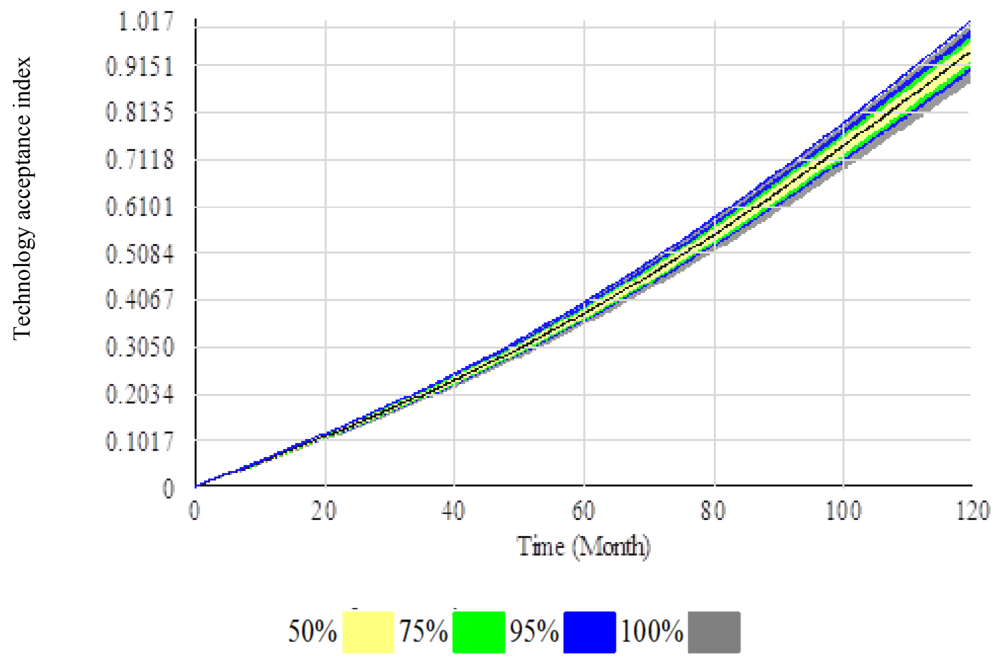


Figure 88: Technology acceptance Vs Needi confidence bounds.

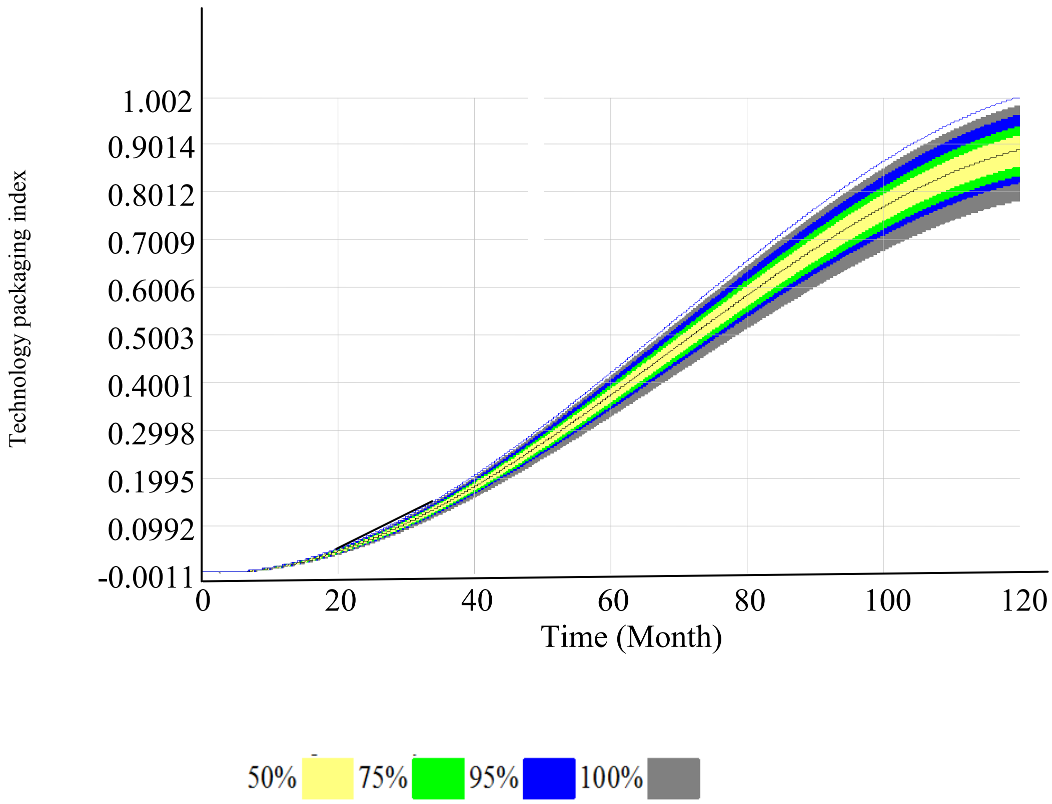


Figure 89: Technology packaging Vs Needi confidence bounds.

4.3.6 Interpretation of design needs into engineering design variables

The main assumption here is proper need identification combined to need relevance makes it possible to get better design variable. CAMARTEC Biogas plant is having a highest index close to 1.0, this is the project that received a good support from GTZ a number of studies and papers were written throughout the implementation of the project (GTZ, 2007). The maize milling technology follows closely with an index of 0.93 and the third technology is TIRDO solar drier that was again donor supported but innovation diffusion was left to individual farmers. The other case is SIDO TDC Coffee pulpier with an index of 0.82 and then Nyumbu truck that has an index 0.80. This also reflected in high rank of design variable availability. The equation for interpi is as follows:

$$\text{int}\,erpi = \left\{ \begin{pmatrix} 13\times\left(needi[T]+needr[t]\right)+ \\ \left(3\times\frac{0.41\times x_9[T]+0.3\times x_{10}[T]+0.42\times x_{11}[T]-0.34\times x_{12}[T]}{0.41\times 4+0.3\times 4+0.42\times 4-0.34\times 4}\right)+ \\ \left(11\times\frac{0.8\times x_{13}[T]-0.34\times x_{15}[T]+0.4\times x_{16}[T]+1.3\times x_{17}[T]+0.45\times x_{18}[T]}{0.8\times 4-0.34\times 4+0.4\times 4+1.3\times 4+0.45\times 4}\right)+ \\ 12\times\frac{1.23\times x_{22}[T]+0.27\times x_{23}[T]+0.59\times x_{24}[T]+0.56\times x_{26}[T]+1\times x_{26}[T]}{1.23\times 4+0.27\times 4+0.59\times 4+0.56\times x_{26}[T]4+1\times 4} \end{pmatrix} \right\} \div \left(13+3+11+12\right) \quad (63)$$

Where T stands for Tech, 13, 3, 11 and 12 are values of α_1, α_2, α_3 and α_4

4.3.7 Technologies sensitivity of interpretation of design needs to variables

At 100% confidence bound the interpretation of needs into design variables are randomly altered with values between 1 and 5 at the step of 1 (Vensim, 2003). The three groups of variable that were combined in Equation 113, using their weight shown in Fig. 69, to form these factors shown Fig. 90 as follow:

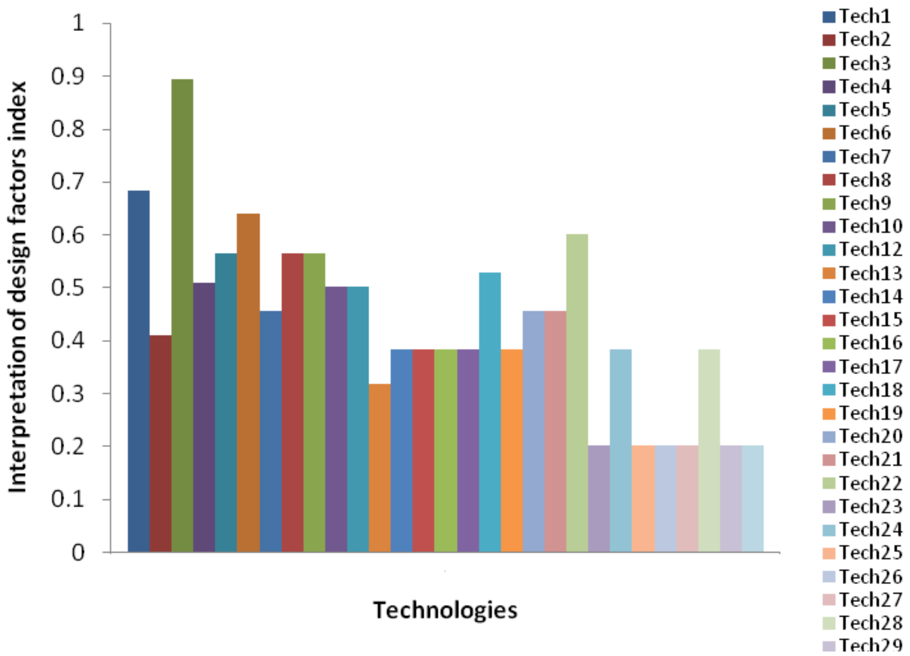


Figure 90: Technologies interpretation of design factors.

(a) Technology conceptualisation with the following variables

Effect of designer skills in conceptualisation (X9), effect of undefined concept evaluation (X10), effect of effective product synthesis (X11) and effect of use of computer modelling in conceptualisation (X12).

(b) Design analysis with the following variables

Availability of materials as main variable (X13), strength of materials (X14), factor of safety (X15), technology performance (X16), overall price of the technology (X17), ability to manufacture (X18), durability (X19) and cost of manufacturing (X20).

(c) Finally in prototyping as a verification of expected variables achievement with the following variables

The use of drawings (X22), the use of sample (X23), development of jigs (X24), verified prototype (X25), development of fixture (X26).

These variation of technology diffusion index of 12% as shown in Fig. 91, technology design validity index of 24% as illustrated in Fig. 92 technology information generation of 22% as depicted in Fig. 93, technology acceptance of 15% as indicated in Fig. 94 and technology packaging sufficiency of 25% as shown in Fig. 95.

In summary this shows that the agro-technology need conversion into optimal design variables is important for ensuring optimal technology development for diffusion this fact is supported by a number of others researchers (Adedeji, 2009; Budynas, 2006; Carlopio, 2010; Chase and Greenwood, 1988; Cooper, 2009; Cooper, 1994; Hurst, 1999; Jun *et al.*, 2011).

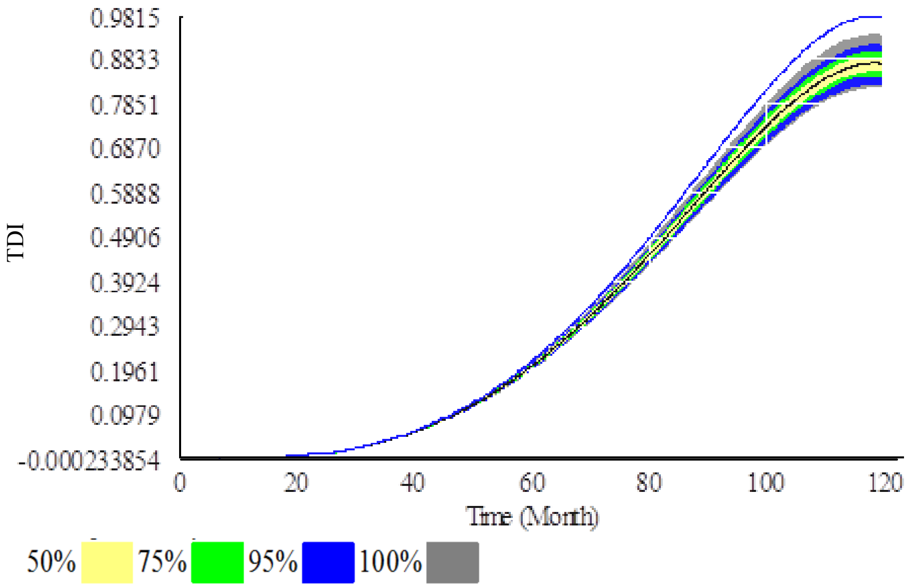


Figure 91: Technology market diffusion Vs interpi confidence bounds.

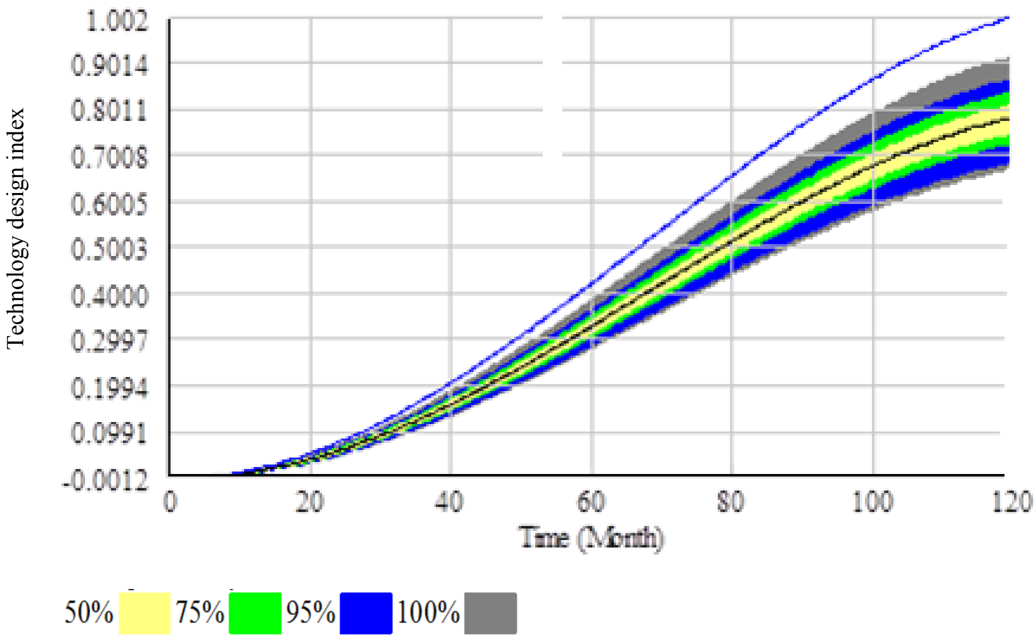


Figure 92: Technology design validity Vs interpi confidence bounds.

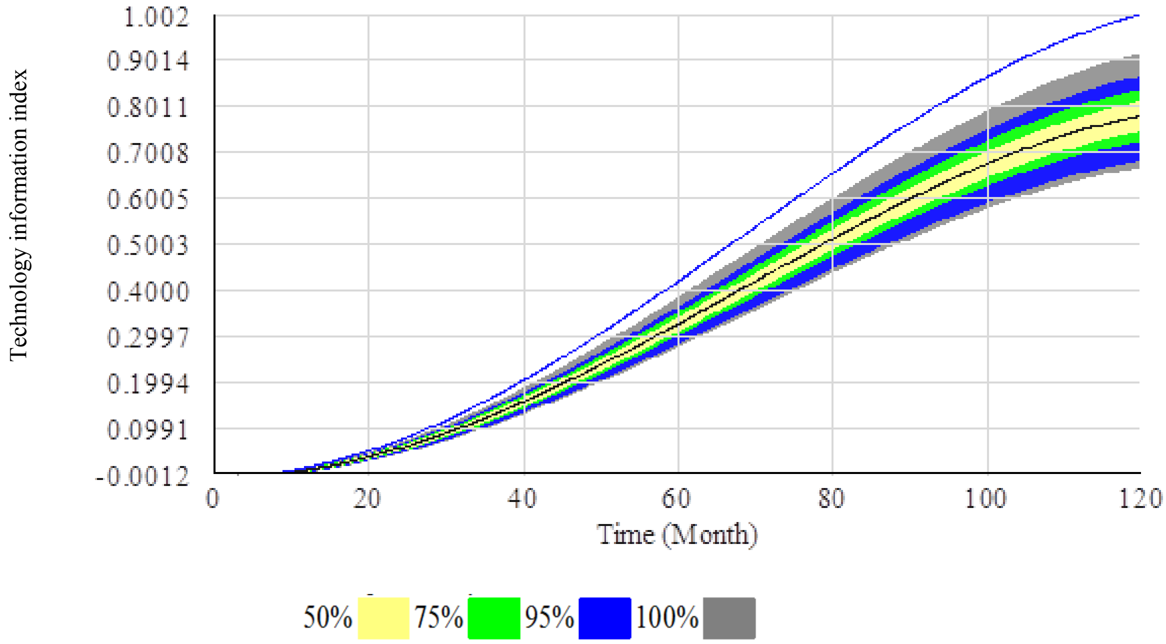


Figure 93: Information generations vs interpi confidence bounds.

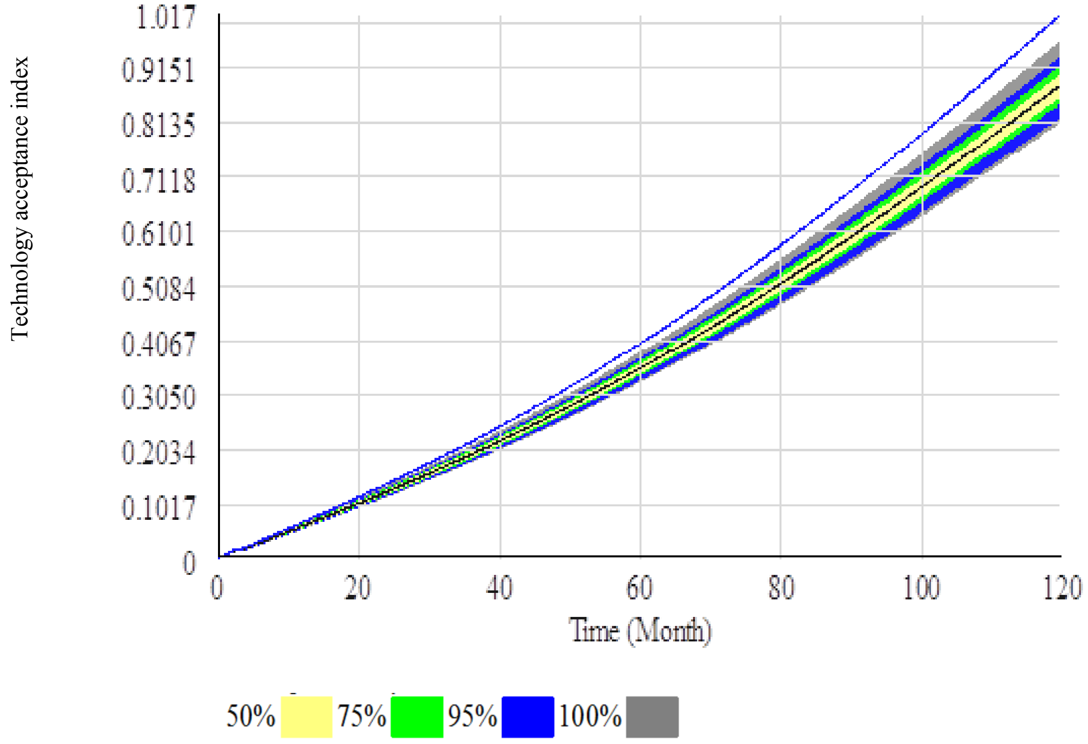


Figure 94: Technology acceptance Vs interpi confidence bounds.

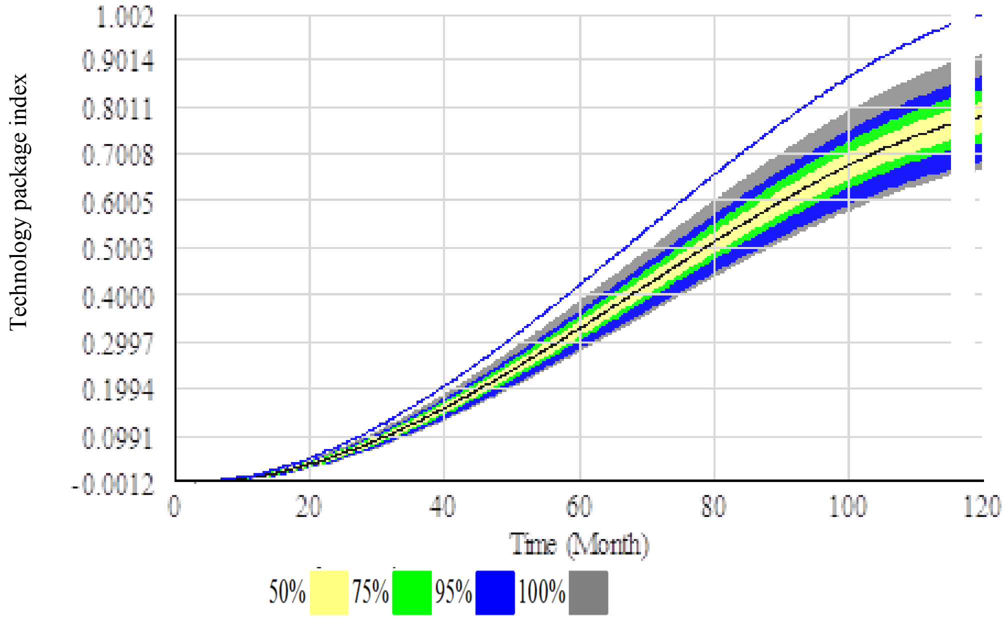


Figure 95: Technology packaging Vs interpi confidence bounds.

4.3.8 Design trend mode

As suggested by Engineers at TATC and SIDO TDC common agro-technology was designed between three to four years to completion (Fig. 96). This fact was loaded into the sigmoid function in section 3.4.1 and the design trend mode was developed and used in the development of the agro-technology diffusion model. Basically the main concept was to maintain the S shape as depicted in Fig. 96 (Rogers, 1983; Vensim, 2003).

$$Y_c = \frac{1}{1+e^{[(-0.2\times time)+(0.2\times 20)]}} \tag{64}$$

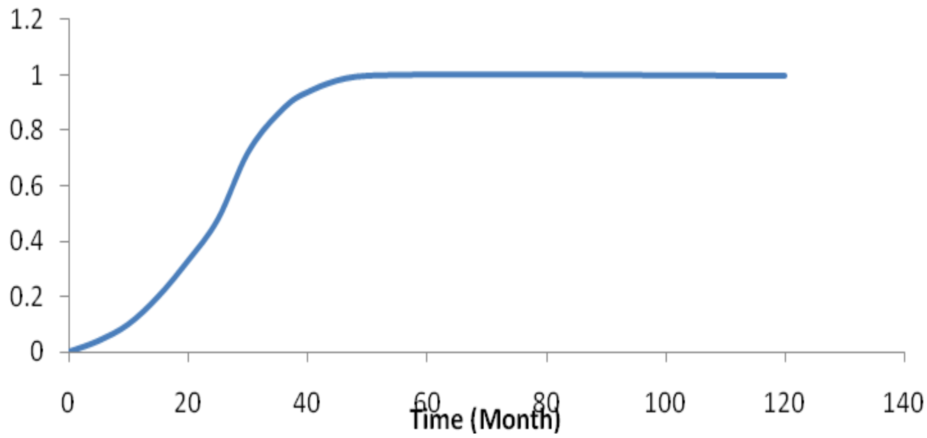


Figure 96: Expected design trend.

(Source: Engineers experience)

4.3.9 Identified design specification

Design specification identification is a process whereby the agro-technology needs or customers (stakeholders') attributes are progressively converted into function requirement that leads to the development of design drawing, prototype and the validation of the prototype. Sometime even after the sales, technology performance is monitored. This process reaches the peak when the technology characteristics are reflecting stakeholder requirements. One theory that describe the process of transforming stakeholders attribute into function requirement of a technology to be developed is axiomatic design (El-Haik, 2005). The formula for expected design trend is as follows:

(Expected design trend[Tech])*Interpretation of variables to design[Tech]

$$IDS = EDT \times \text{int}\, erpi \tag{115}$$

Where:

IDS	=	Identified Design Specification
EDT	=	Expected Design Trend

Interpi = Interpretation of design need into engineering variables.

With the design mode, dynamic model shows the prediction of efficiency of getting design specification in Fig. 97. The trend shows a good link between the proper need identification and good design specification. Since generally technologies with low TDI shows bad perfomance in IDS, technology number 6 which is CAMARTEC biogas plants show the highest index of 1.0, this technology was studied for quite some time and given a strong suport by GTZ (2007). This is followed by the SIDO TDC maize milling machine of 700 kg/hr (Tech 2) with the index 0.93, as compared to other maize mills of different capacity, this has shown outstanding performace in TDI. The third technology is solar drier for agrotechnology (Tech), this has IDE index of 0.93, this technology was donor funded with a reasonable feasibility study and design processes. Famer interview showed a good interest in this technology. IDE is a function of preliminary work in addresing the technology needs against technology validation to give the techology validity index(Dym, 1994; Braun and Herstatt, 2007; Carlopio, 2010; CISR, 2010; El-Haik, 2005).

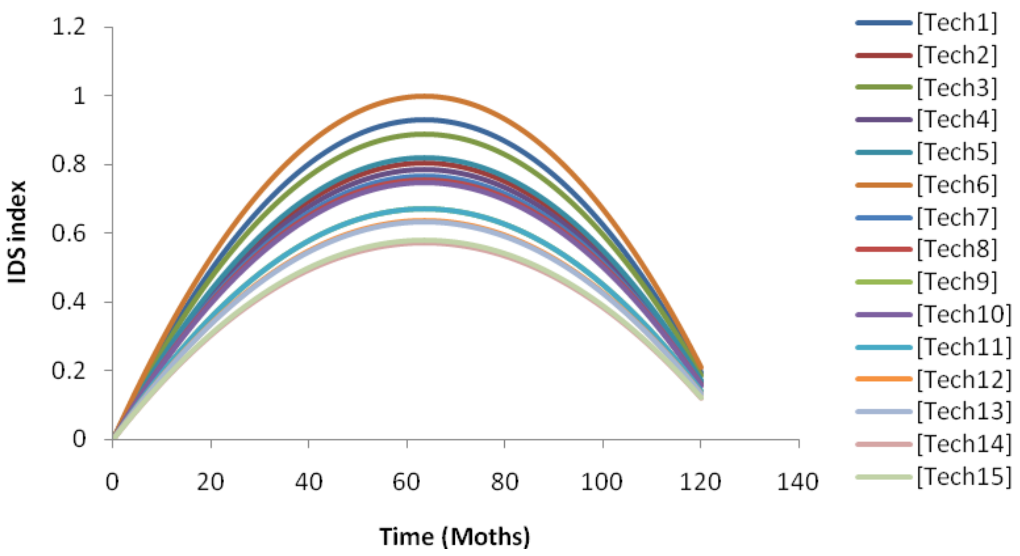


Figure 97: Identified design specification.

4.3.10 Design validity

Design validity is the measure of relation between the customer requirements and the technology design specification, the higher the stakeholders' satisfaction the higher the design validity for agro-technology diffusion. This is where tools like QFD are very useful (Carlopio, 2010; Chungu *et al.*, 2001; Hoyle, 2001; Hurst, 1999). The equation for design validity is as follows:

$$DV = \int_0^{120} \left(IDS[Tech](t) - TU[Tech](t) \right) dt \qquad (65)$$

Where: DV = Design Validity

TU = Technology Un-appropriateness

As shown in Fig. 98, Tech 6, the CARMATEC biogas plant has the maximum design validity of index 0.93, TIRDO Solar drier for agro-products has an index of 0.70, SIDO TDC maize milling machine with an index of 0.68, followed by Tech 1 Nyumbu truck with index of 0.56 and the rest technologies with less than DV index of 0.5. This stage ensures the elimination of technology operation vulnerability and elimination of the twin valleys of death to produce the technology business oriented technology that can easily diffuse into market (El-Haik, 2005; UK, 2013).

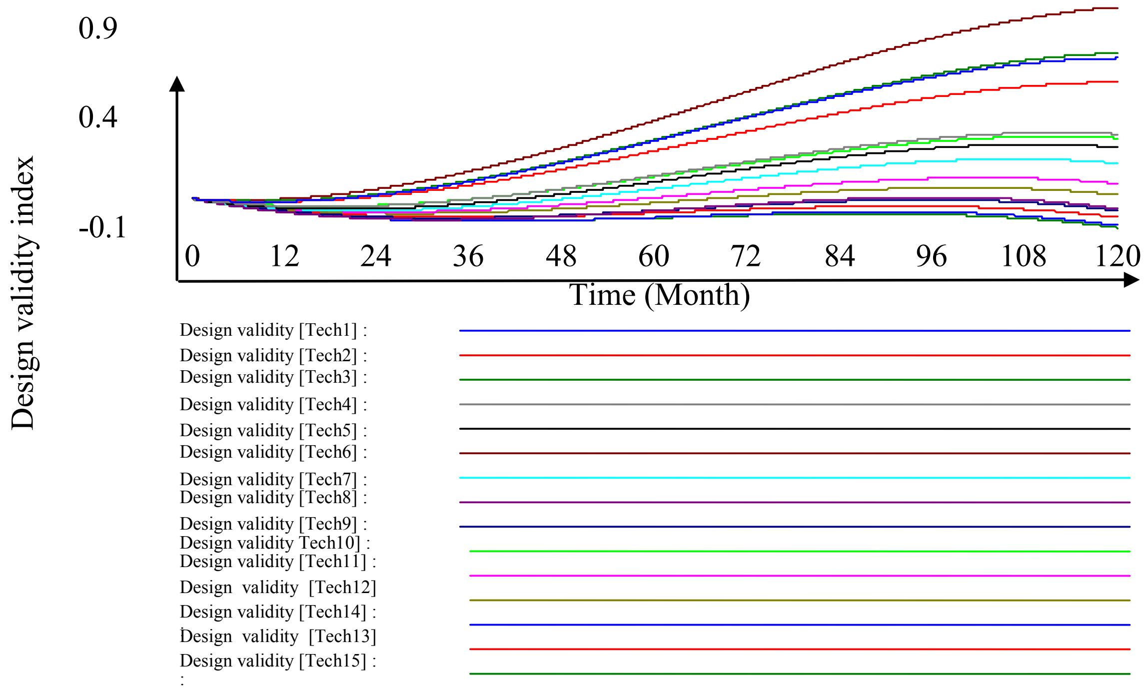


Figure 98: Design validity.

4.3.11 Technology validation

Validation process is the testing of agro-technology against the stakeholders' requirement mostly with their participation. Technology validation in technology diffusion has three parts: contribution of stakeholders' participation, power of engineering variable and the importance of validation output (Avner, 2010; CISR, 2010; Hoyle, 2001). The equation of technology validation index is as follows:

$$TV = \left\{ \begin{array}{l} 8\times\left[\dfrac{1.1\times x_{27}[T]+0.2\times x_{28}[T]+0.76\times x_{30}[T]}{1.1\times 4+0.2\times 4+0.76\times 4}\right]+ \\ 11\times\left[\dfrac{0.97\times x_{29}[T]+1.6\times x_{51}[T]-0.4\times x_{52}[T]}{0.97\times 4+1.6\times 4-0.4\times 4}\right]+ \\ 8\times\left[\dfrac{0.25\times x_{53}[T]+1.8\times x_{54}[T]+0.49\times x_{55}[T]}{0.25\times 4+1.8\times 4+0.49\times 4}\right] \end{array} \right\} \div (8+11+8) \qquad (66)$$

Where TV = Technology validation

The general validation process indices per technology are shown in Fig. 99. The CAMARTEC biogas plant has the highest index of 1.00, followed by TIRDO Solar drier for agro-technology with an index of 0.99. Nyumbu truck is in the third position with an index of 0.98, followed by SIDO TDC maize milling machine (700 kg/hr) with an index of 0.96, the worst technology (Tech30) palm fruit sterilising tank, with an index of 0.32. These results show a decrease of TDI with the decreasing of TV index. The validation process is a factor that contributes to assurance of technology diffusion.

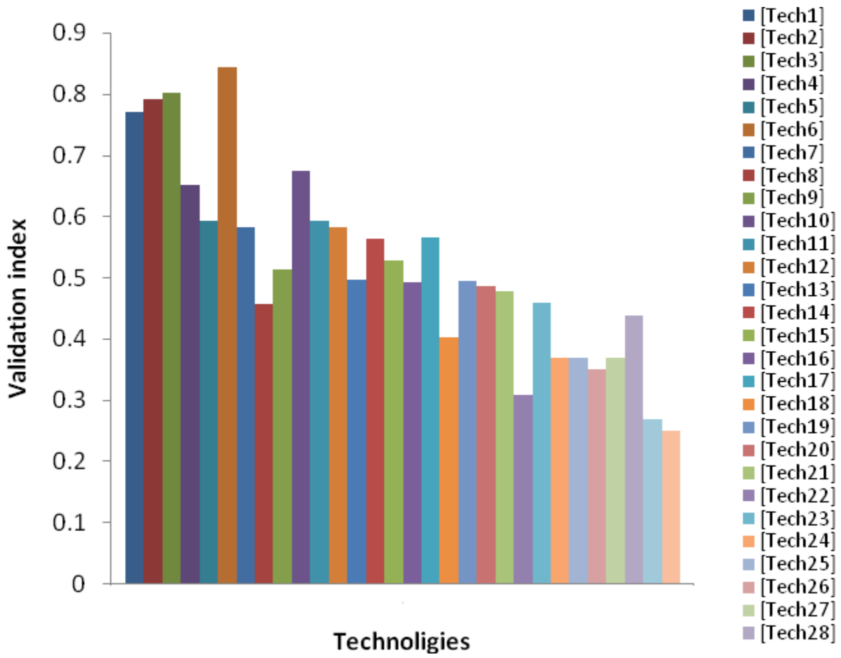


Figure 99: Technology validation index.

4.3.12 Sensitivity analysis of Validation

At 100% confidence bound the variation of interpretation of needs into design variables the following three groups of variables were altered between 1 and 5 at a step of 1:

Validation stage with stake holders variables are: end user participation (X27), financier participation (X28) and R&D engineer participation (X30).

The validation stage and the power of engineering variables are: durability consideration (X29), throughput (X51), ergonomics (X52) and robustness X53.

Validation output variables are: approved technology (X54) and approved means of operation (X55).

These variables gave the variation of TDI of 30% as shown in Fig. 100. Technology design validity index of 62% as depicted in Fig. 101, technology information generation of 61% as shown in Fig. 102 technology acceptance of 65% (Fig. 103) and technology packaging sufficiency of 61% (Fig. 104). In summary this shows that the agro-technology validation into optimal design variables is the most important process for ensuring optimal technology development as described by Avner (2010).

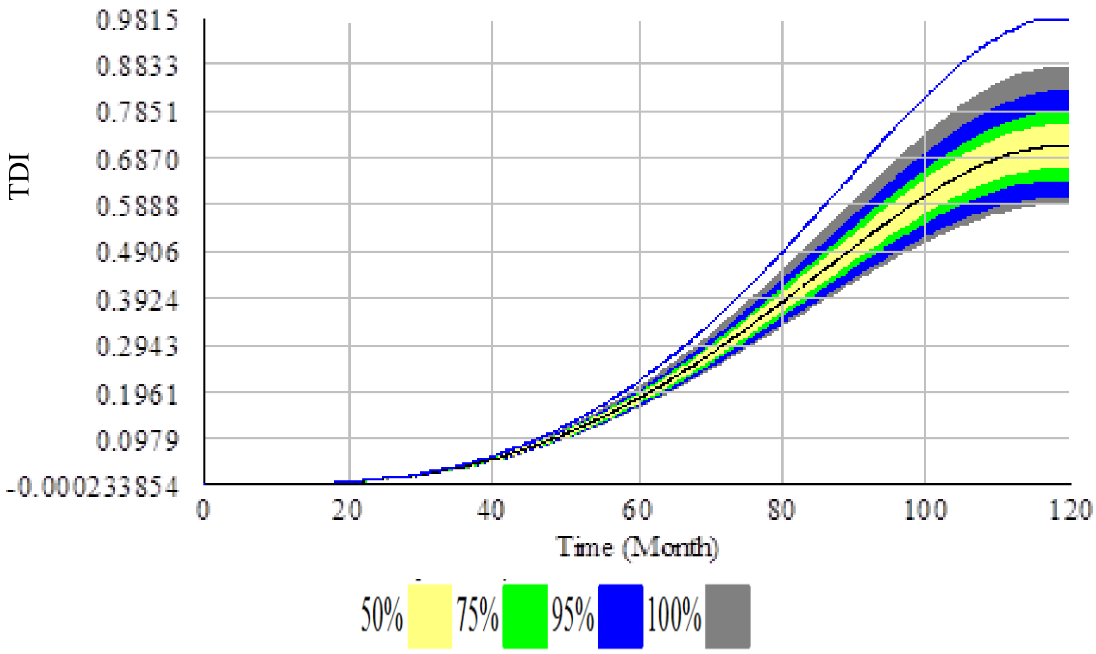


Figure 100: Technology market diffusion Vs tval confidence bounds.

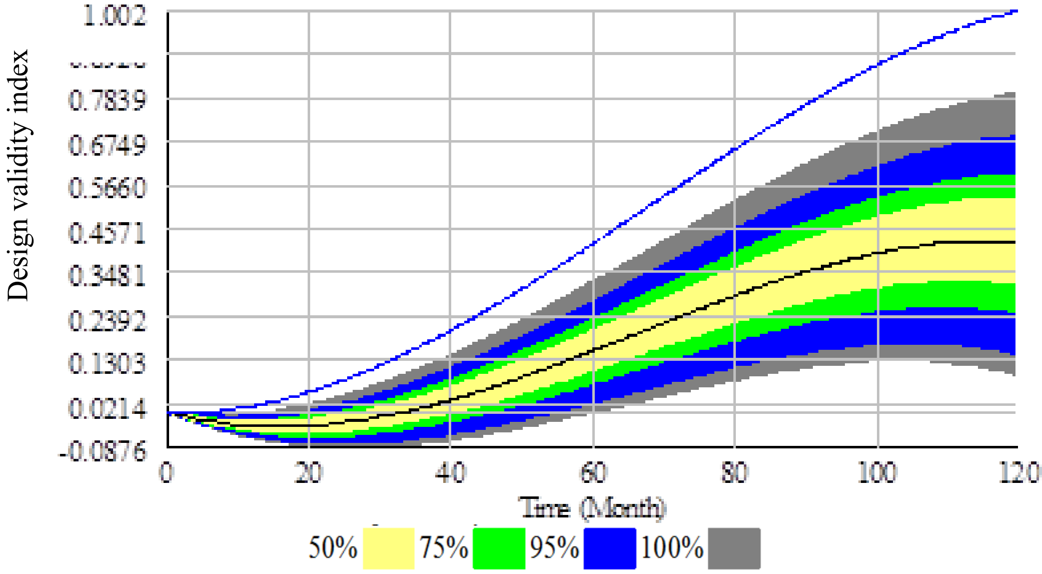


Figure 101: Technology design validity Vs tval confidence bounds.

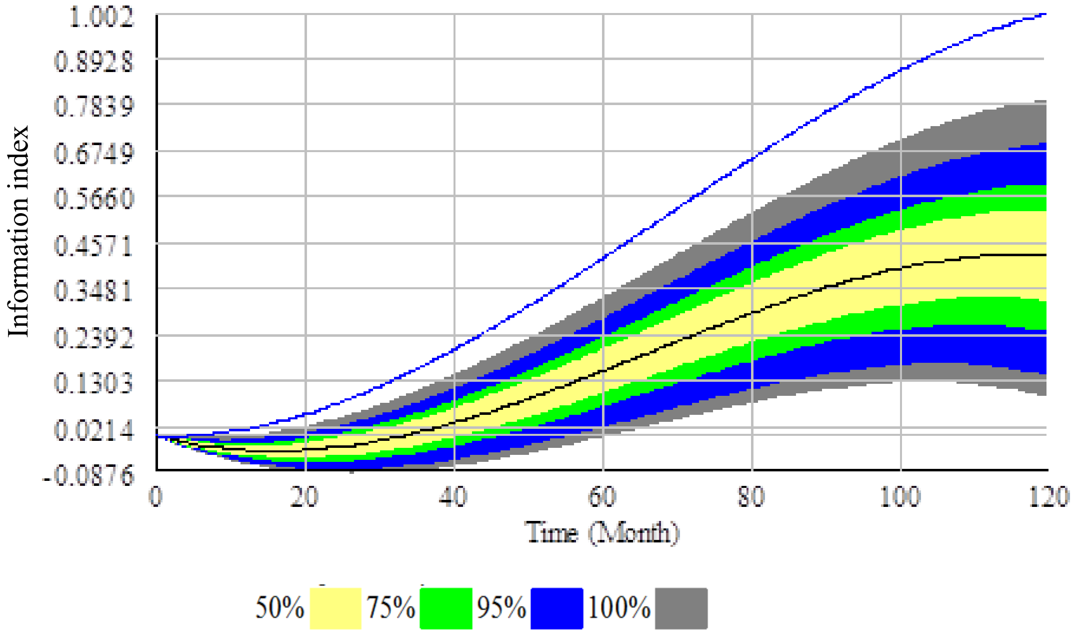


Figure 102: Technology information generation Vs tval confidence bounds.

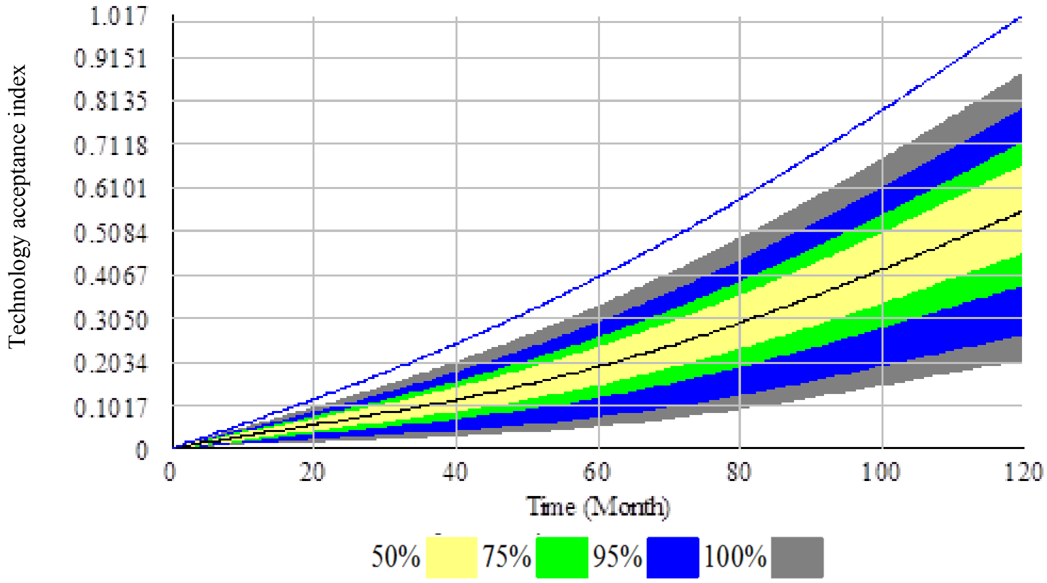


Figure 103: Technology acceptance Vs tval confidence bounds.

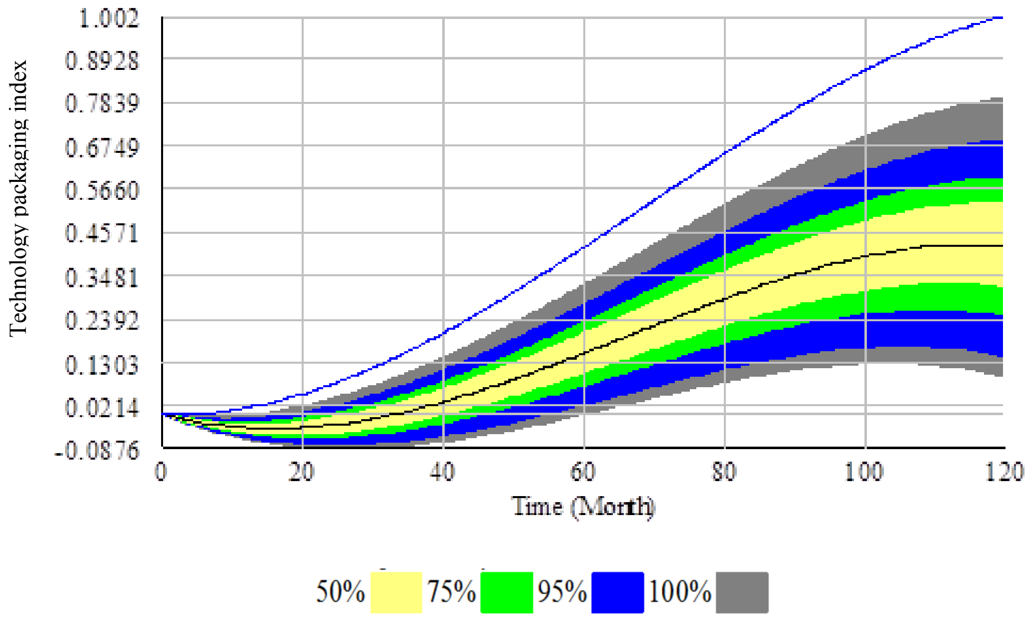


Figure 104: Technology packaging Vs tval confidence bounds.

4.3.13 Rate of need reflection

This is simply measurement of rate the of design compliance to customer requirement. The macro variables are observed: the completeness of design package and the technology validation proceeds. The rate of need reflection is given by:

$$RNR = \frac{37 \times TV[T] + 11 \times TPC[T]}{37 + 11} \qquad (67)$$

Where:

TV	=	technology validation
TPC	=	technology package completeness
RNR	=	Rate of need reflection

4.3.14 Stake-holder satisfaction

The word stakeholder stands for technology user (Fig. 105), technology output users, manufacturer, financier of research and technology procurement, vendors, guarantors and all those affecting technology diffusion. The inputs to this macro-variable are calibrated to have a maximum value of one (1). Thus stakeholders' satisfaction (SHS) is determined as follows:

$$SHS = \frac{DV[T] + IDV[T] + SI[T] + TIG[T]}{0.65 \times 4} \qquad (68)$$

Where:

SHS	=	Stake-holders' satisfaction
DV	=	Design validation
IDV	=	Interpretation of variables to design
SI	=	Stage index
TIG	=	Technology information generation

The general stakeholders' satisfaction indices per technology are depicted in Fig. 105. The CAMARTEC biogas plant was having the highest index of 1.00, followed by Nyumbu truck in the third position with an index of 0.93, followed by TIRDO Solar drier for agro-technology with an index of 0.91. The worst technology was Tech30 palm fruit sterilising tank, with an index of 0.0. These results show a decrease of TDI with the decreasing of TV index. The validation process is a factor that contributes to assurance of technology diffusion. With abnormalities shown in technology no 6, which is caused by the deep support of donor in running the project, the trend of stakeholder satisfaction decrease with TDI. This aspect has been discussed by number of researchers with main emphasis of linking technology development and stakeholders requirement (Etzkowitz, 2008; Ford *et al.*, 2007; GTZ, 2007).

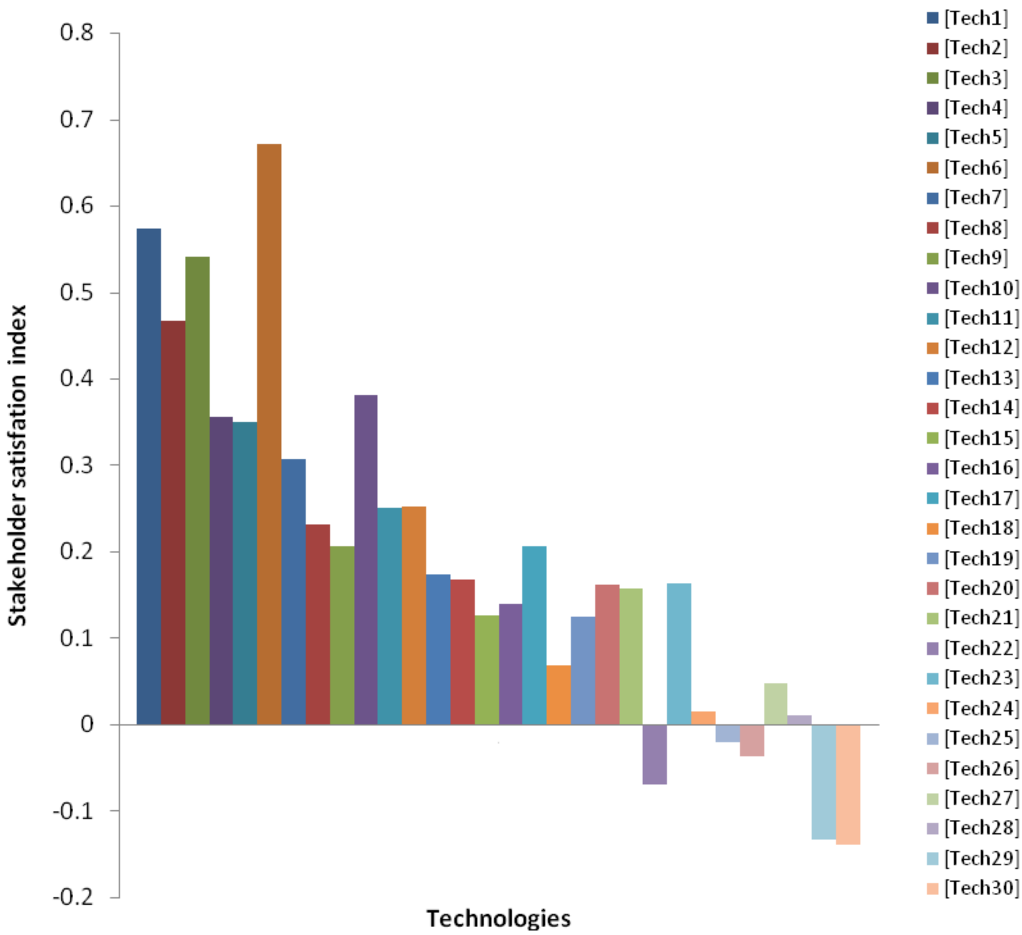


Figure 105: Technologies stake holders' satisfaction.

4.3.15 Technology un-appropriateness

This is a measure of technology un-acceptance by the society as a result of not complying with stakeholders expectations and is governed by:

$$TUA = 1 - RNR[T] \tag{69}$$

$$RNR = \frac{37 \times TV[T] + 11 \times TPC[T]}{37 + 11} \tag{70}$$

Where:

TUA	=	Technology un-appropriateness
RNR	=	Rate of Need Reflection
TV	=	Technology Validation
TPC	=	Technology Package Completeness

4.3.16 Technology package completeness

This is the measure of technology development thoroughness in the R&D design and development processes, that is transfer package, the manufacturing systems, business set up systems, the support from all necessary stakeholder and the user friendliness of technology (Canada, 2009; Carlopio, 2010; Chase *et al.*, 2004; El-Haik, 2005; Cambridge Chemical Technologies, 2012)Technology package completeness, TDC is expressed as:

$$TPC = \frac{DV[T] \times \left(0.52 \times x_{32}[T] + 1.45 \times x_{33}[T] + 0.22 \times x_{34}[T] + 1.0 \times x_{35}[T] + 0.26 \times x_{36}[T]\right)}{\left(0.52 \times 4 + 1.45 \times 4 + 0.22 \times 4 + 1.0 \times 4 + 0.26 \times 4\right)} \tag{71}$$

Where:

TPC	=	Technology Package Completeness
DV	=	Design Validity

As depicted in Fig. 106 Technology No. 6 CAMARTEC biogas plat has the highest index of 0.8, followed by TIRDO solar drier 0.53, followed by SIDO TDC maize milling machine and then Nyumbu truck. As illustrated in the Fig. 106 the packaging is poor for most of technologies and most of technologies have no packaging consideration at all. This area is very critical when the idea of twin valley of technology death is considered, models like concurrent engineering and complete business setup together with the incubation programs, loan schemes and industrial parks formation are important (Als, 2010; Balamuralikrishna *et al.*, 2000; Braun and Herstatt, 2007; Canada, 2009; Etzkowitz, 2008).

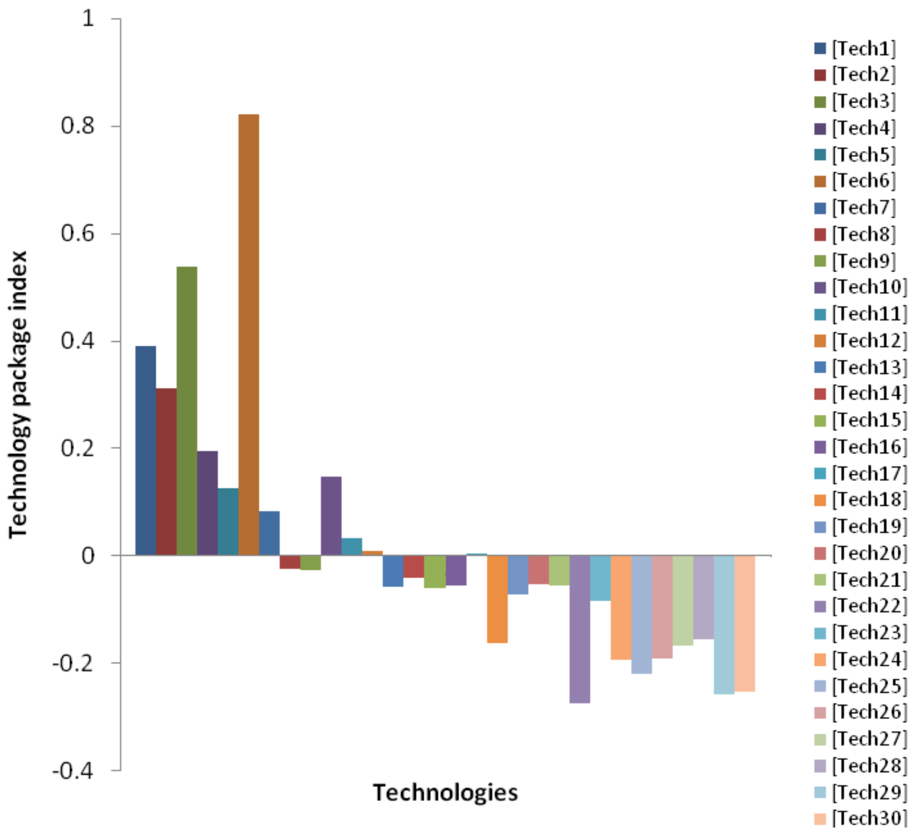


Figure 106: Technologies package completeness.

4.3.17 Sensitivity analysis technology package completeness

At 100% confidence bound variation of the technology packaging altered the following variables: Operation manual, X32; Bill of material, X33; Engineering drawings, X34;

Finance sources, X35; and Fixtures, X36. These variables were altered between 1 and 5 at the step of 1, and gave the variation of technology diffusion index of 25% (Fig. 107), technology design validity index of 10% (Fig. 108), technology information generation of 62% (Fig. 109), technology acceptance of 15% (Fig. 110) and technology packaging sufficiency of 65% (Fig. 111). In summary this shows that the agro-technology packaging is the most important practice for ensuring optimal technology development for diffusion.

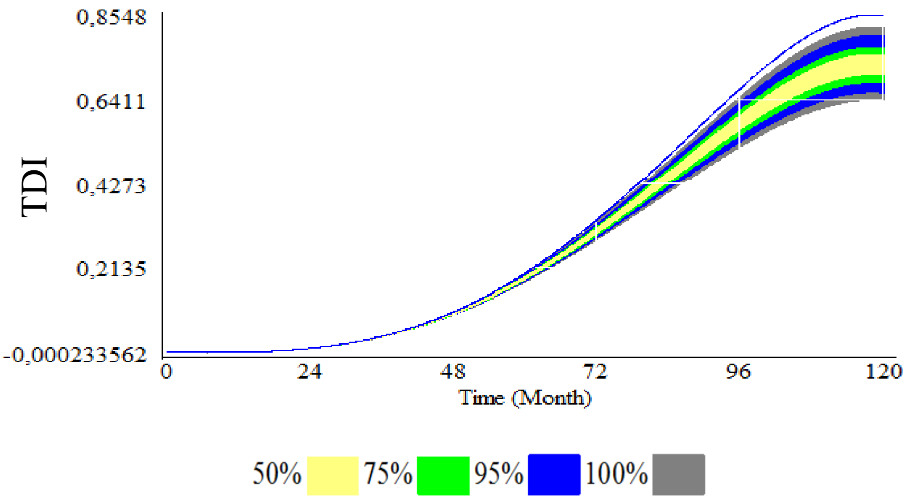


Figure 107: Technology market diffusion Vs TPC confidence bounds.

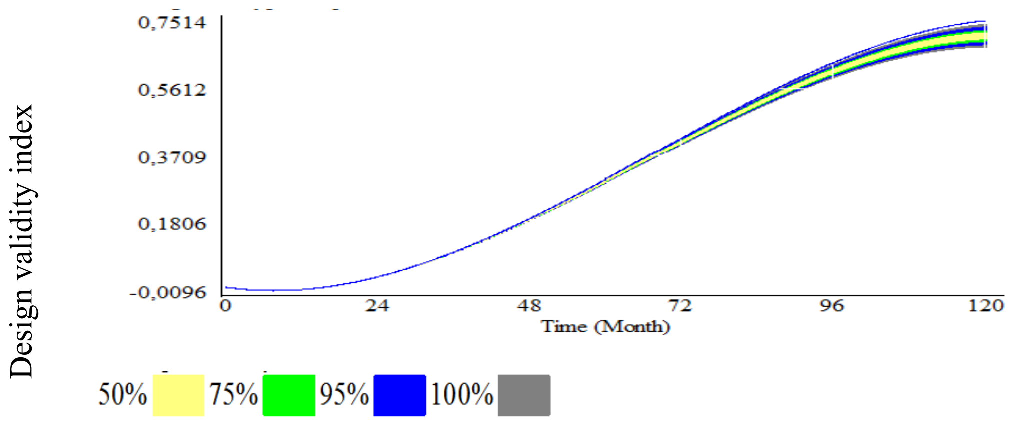


Figure 108: Technology design validity Vs TPC confidence bounds.

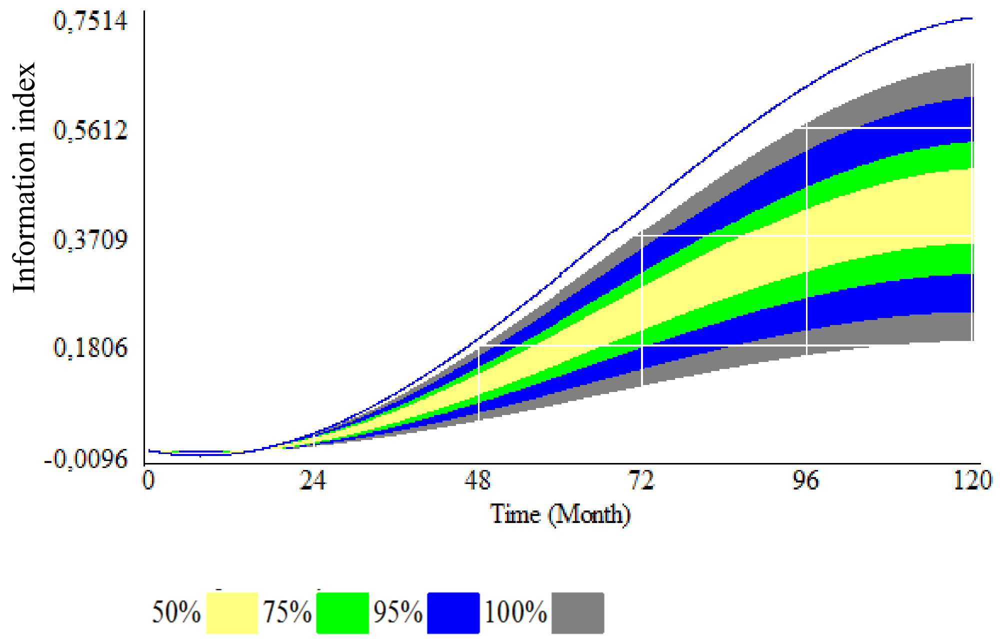


Figure 109: Technology information generation Vs TPC confidence bounds.

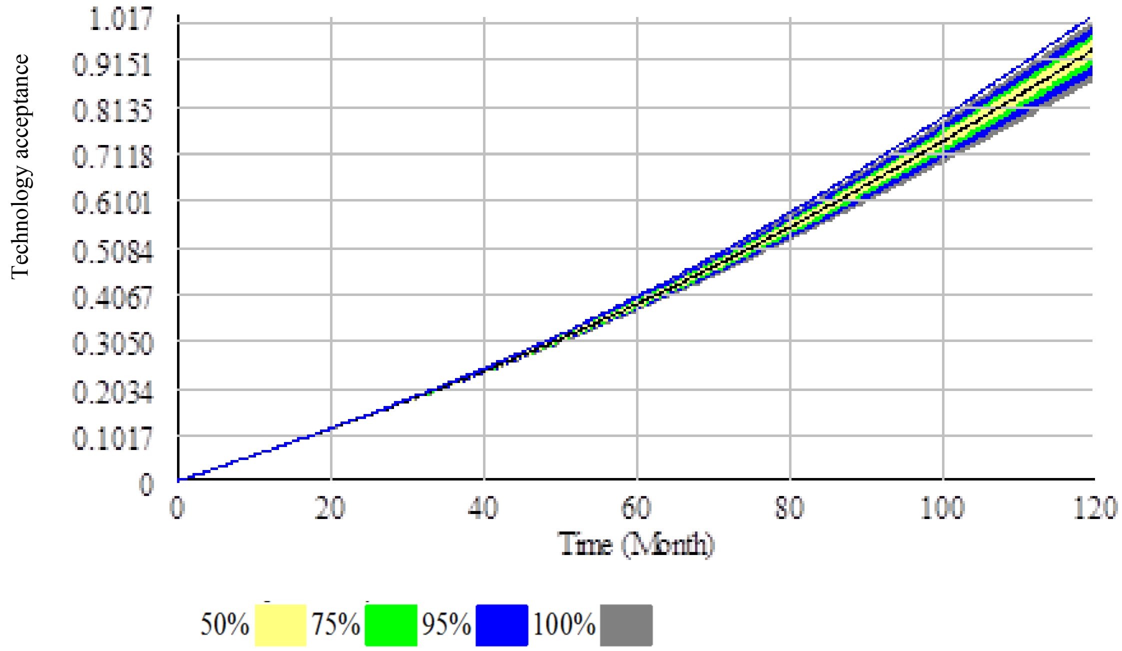


Figure 110: Technology acceptance Vs TPC confidence bounds.

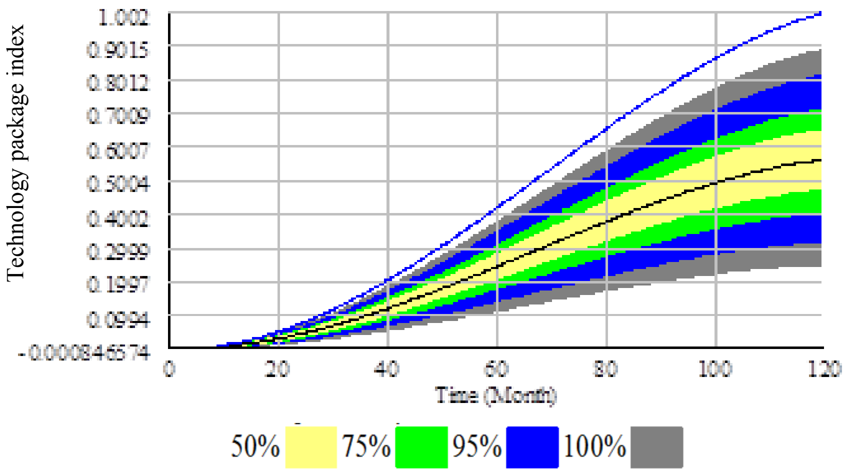


Figure 111: Technology package completeness Vs TPC confidence bounds.

4.3.18 Technology information generation

The only way to have technology information available (tinfa) is the generation of information about the technology itself. This is the measure of how much information is readily available to technology stakeholders. The technology information generation, TIG is determined by:

$$TIG = TPC[T] \times \left\{ \begin{matrix} \left(\begin{matrix} 0.62 \times x_{37}[T] + 0.51 \times x_{38}[T] + 0.60 \times x_{39}[T] + \\ 0.25 \times x_{40}[T] + 0.25 \times x_{41}[T] + 0.70 \times x_{42}[T] + \\ 0.47 \times x_{43}[T] + 0.55 \times x_{44}[T] \end{matrix} \right) \div \\ \left(\begin{matrix} 0.62 \times 4 + 0.51 \times 4 + 0.60 \times 4 + \\ 0.25 \times 4 + 0.25 \times 4 + 0.70 \times 4 + \\ 0.47 \times 4 + 0.55 \times 4 \end{matrix} \right) \end{matrix} \right\} \quad (72)$$

Where: TIG = Technology Information generation

TPC = Technology package Completeness

As illustrated in Fig. 112 Technology No. 6 CAMARTEC biogas plat has the highest index of 0.53, followed by TIRDO solar drier 0.26, followed by SIDO TDC maize milling machine index 0.25 and then Nyumbu truck with the index of 0.19. As shown in the Figure the information generation is very poor for most of the technologies. It can be stated that information contributed negatively to the diffusion process. However the trend shows a relation with information diffusion. As early as 1980s Roger had already seen the impact of information in technology diffusion (Rogers, 1983). Information un-availability is a very strong barrier to many processes that enhances technology diffusion (Simona *et al.*, 2007).

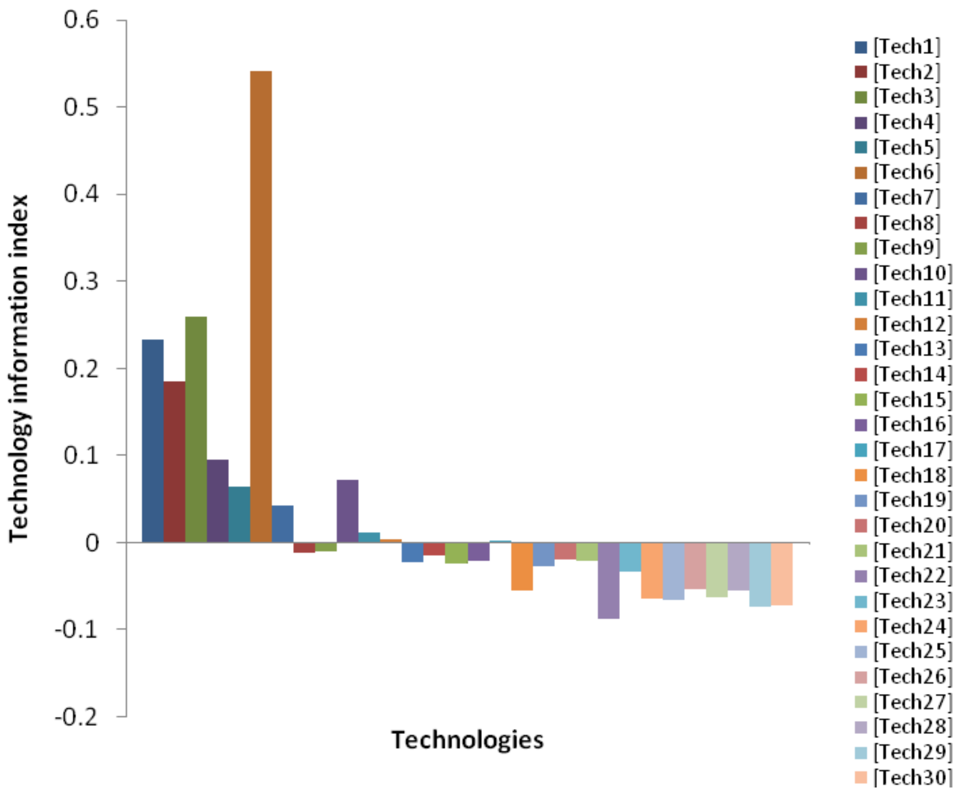


Figure 112: Technologies information generation.

4.3.19 Sensitivity analysis of Technology information generation

At 100% confidence bound the variation of Operation manual (X37), Project Brief (X38),

Bill of material (X39), Done on 3D software 3 (X40), Done in 2D board 1 (X41), Drawings (X_{42}), Bill of material (X_{43}), Customer order (X_{44}) and Technology profile (X_{45}), between 1 and 5 at the step of 1 gave the variation of technology diffusion index of 10% as shown in Fig. 113, technology information generation of 45% as shown in Fig. 114 and technology acceptance of 10% as shown in Fig. 115. In summary this shows that the agro-technology development information importance for ensuring optimal technology development for diffusion (Heldman, 2005; PMI, 2008).

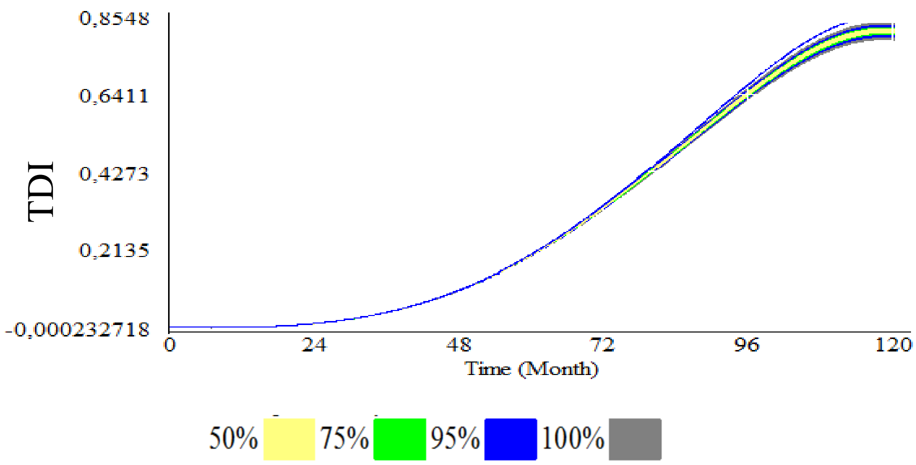


Figure 113: Technology market diffusion Vs TIG confidence bounds.

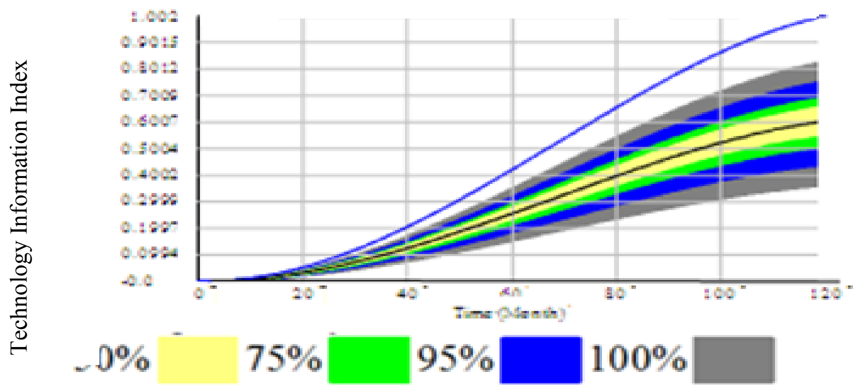


Figure 114: Technology information generation Vs TIG confidence bounds.

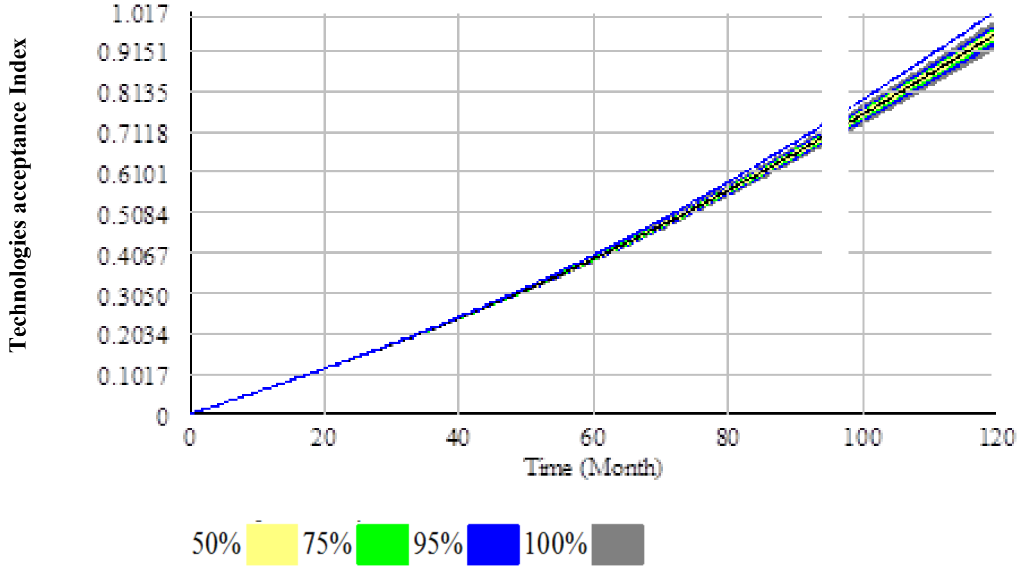


Figure 115: Technology acceptance Vs TIG confidence bounds.

4.3.20 Stakeholders availability

Stakeholders' availability is mainly affected by the readily available information package about the technology and their participation in the technology development processes (ITSBIC, 2008 ; Jacob and Methew, 2008). However the information should reflect the stake holders' expectations and bring about their technology acceptance. The Stakeholders Availability, SHA is given by:

$$SHA = \frac{TA \times TIG}{NF} \qquad (73)$$

Where: NF = Normalising Factor

SHA = Stakeholders availability

TA = Technology acceptance

TIG = Technology Information Generation

As depicted in Fig. 116, CAMARTEC biogas plant is having a highest index of 1.0, followed by TIRDO solar drier for agro-products with an index of 0.37, followed by SIDO

TDC maize milling machine, followed by Nyumbu truck with an index of 0.2 and thereafter, the final technologies with low rate of diffusion show the increased index. This might be attributed with single customer participation, however the projects were not transformed to overall market needs (Cooper, 1988). With exception of biogas plant the trend shows a relation with TDI though the last technology shown abnormal trend as already explained.

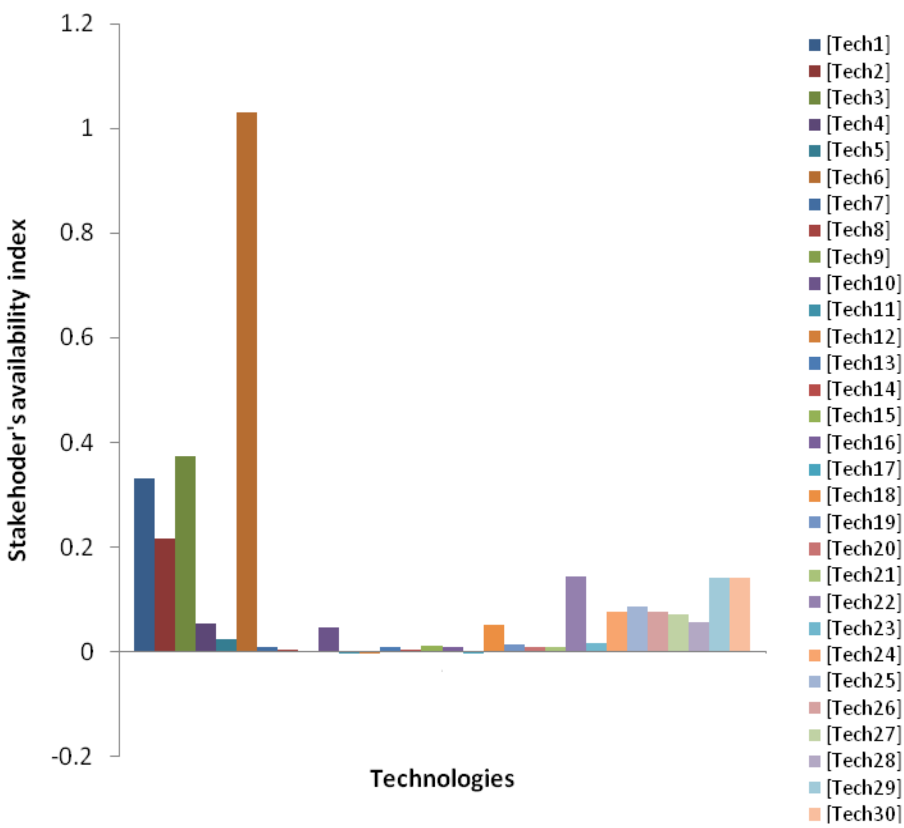


Figure 116: Stakeholders availability.

4.3.21 Technology demand

According to Whelan et al (1996) demand is an economic concept that describes a buyer's desire, willingness and ability to pay a price for a specific quantity of a good or service. Demand refers to how much (quantity) of a product or service is desired by buyers. The main factor considered are cumulative sales, from market research, the gap existing between what is already in the market and what is needed, stages that stakeholders have participated in screening technology, package completeness and stakeholders readiness to facilitate the sales. Technology demand is governed by:

$$TD = ECS[T] \times EMT[T] \times \frac{STDIN + TPC + SA}{3} \quad (74)$$

$$ECS = \frac{1}{1 + e^{-0.5 \times time + 0.5 \times 60}} \quad (75)$$

$$EMT = -4 \times 10^{-6} \times time^3 + 0.0005 \times time^2 - 0.0032 \times time \quad (76)$$

Where:

ECS	=	Expected cumulative sales
EMT	=	Expected market trend
STDIN	=	Stages index
TPC	=	Technology package completeness
SA	=	Stakeholders availability

Figure 117 shows that the highest demand index was found in the CAMARTEC biogas plant (0.96) followed by TIRDO solar drier (0.65), followed by SIDO TDC maize milling machine (0.61) followed by Nyumbu truck (0.50) and the rest of technologies showed the decrease in demand with the decrease in sales index. From the definition of demand by Whelan *et al* (1996), and what was observed by Singh (2010) in India, it is definite that demand affects the technology diffusion and on the other hand demand is affected by expected market trend, stages index, technology package completeness, stakeholders availability. Fig. 118 illustrates the demand trend over time, the peak, at 92 moths, data are extracted from this figure and the results are shown in Fig. 117.

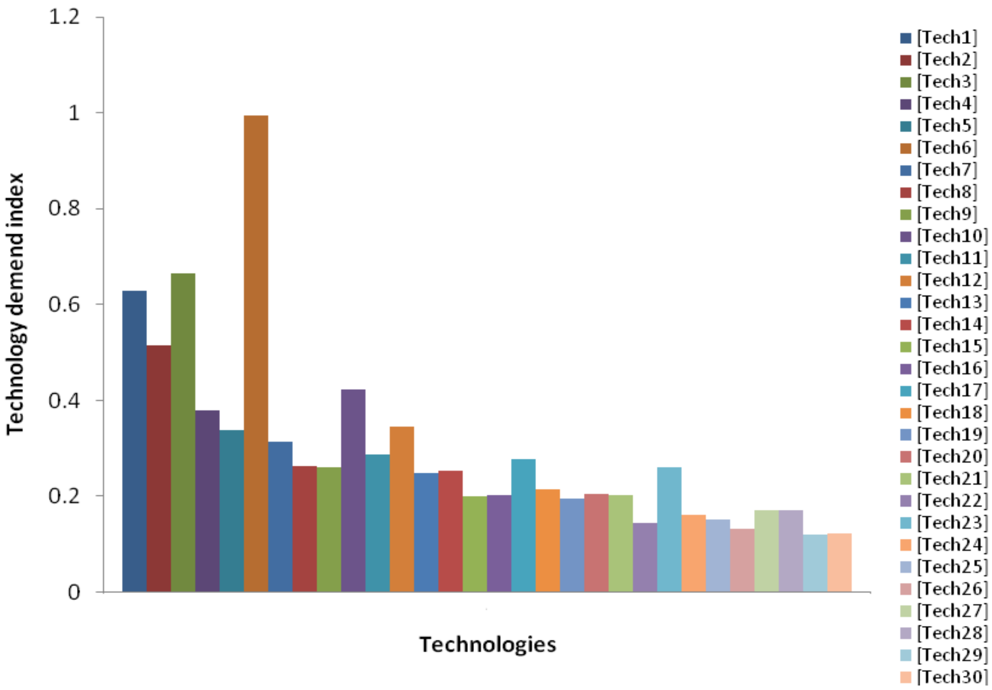


Figure 117: Technology demand index at 92 months.

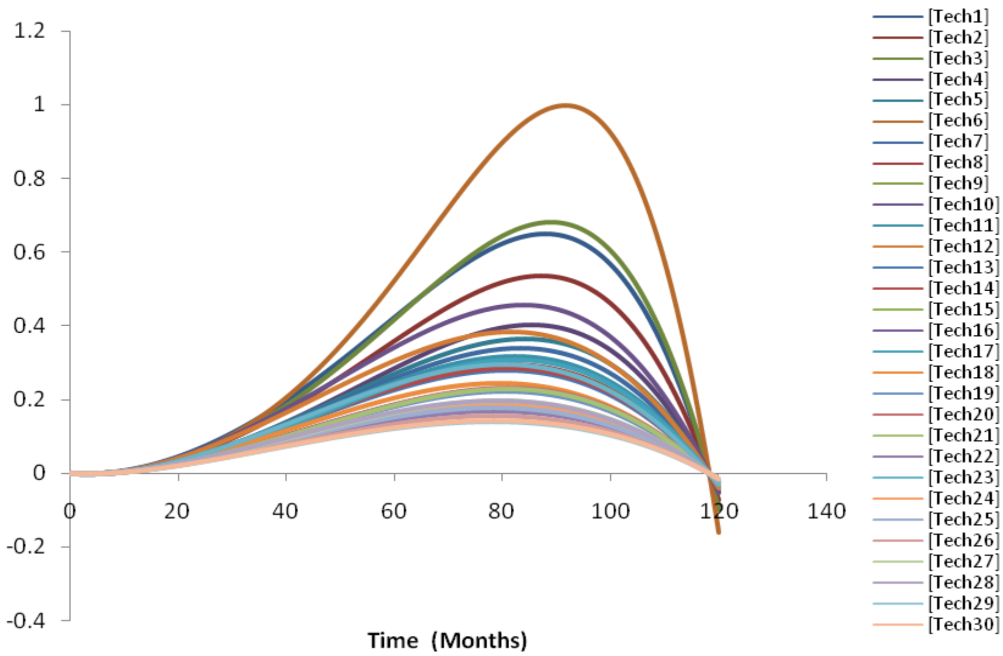


Figure 118: Technology demand trend.

4.3.22 Technology market diffusion

Technology market diffusion is the measure of technology sold into the market and; this may be in monetary value, quantity or rate of either the value or quantity (Learnthat, 2004; OECD, 1997). However the best predictor was identified as sales rate index as discussed in section 4.1.2. Technology Market Diffusion (TMD) is governed by:

$$TMD = TD[T] - TDS[T] \tag{77}$$

$$TMS = \frac{TMD}{TALS} \tag{78}$$

Where:

TD	=	Technology demand
TDS	=	Technology demand saturation
TMS	=	Technology demand saturation
TMD	=	Technology market diffusion
TALS	=	Technology average life span (Months)

As depicted in Fig. 119 CAMARTED biogas plant with an index of 0.99, followed by TIRDO solar drier with index of 0.68, followed by SIDO TDC maize milling machine with index of 0.65, followed by Nyumbu truck of index 0.53 and the trend went on decreasing almost following the technologies number which stands for the decrease in sales rate. Fig. 120 shows the diffusion trend is S curve that is cumulative diffusion. Fig. 119 trend shows that technology diffusion model can give technology diffusing indices of various technologies. This can be used to predict the overall agro-technology innovation diffusion. Further work is done on the validation of the model. This is a proof that twin valley of death can be overcome by using this developed model (UK, 2013).

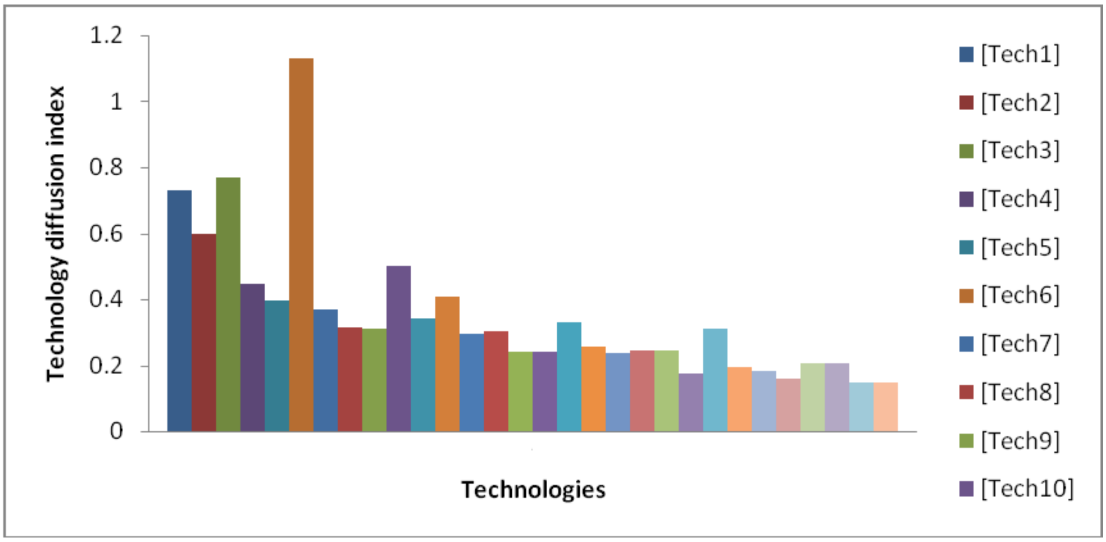


Figure 119: Technology diffusion rate by index.

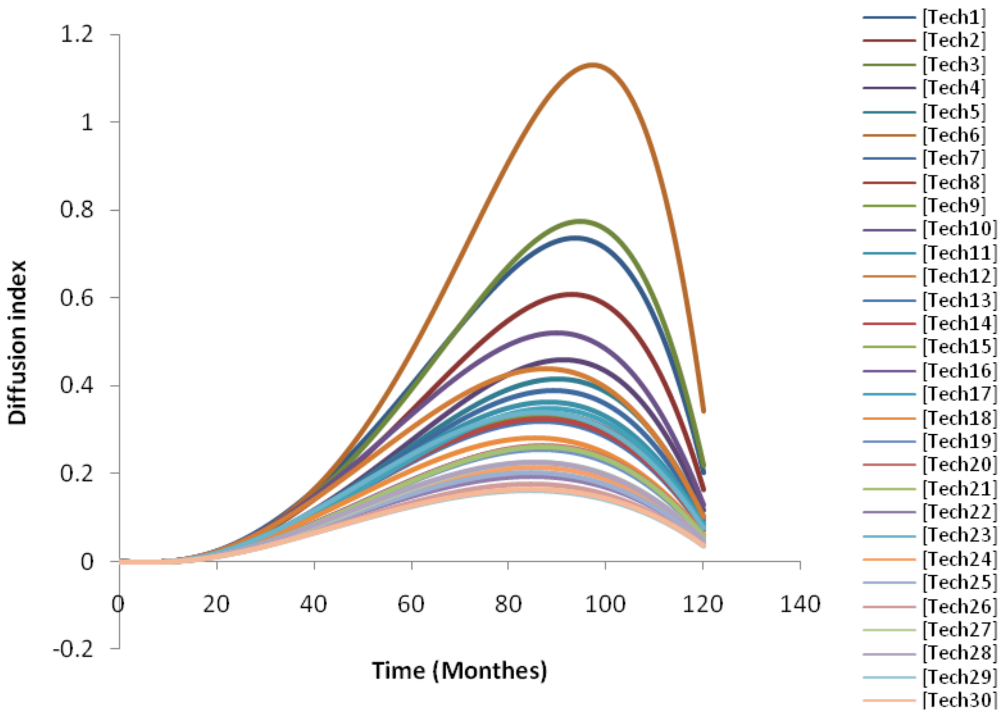


Figure 120: Technology market diffusion.

4.3.23 Stages importance in technology development

Stages are important in many aspects of technology development. According to Cooper (2010) stage-gate technology development process allows for introduction of stages and gates and allocate stakeholder called stage player and gate keeper to participate in the technology development processes and ensuring their requirement are adhered to. Three variables were left after the regression analysis that is transfer (X48), validation (X49) and prototyping (X50), and are shown in Equation 129 and are resulted in the technology stages importance indices as shown in Fig. 122. The formula for stage importance is as follows:

$$stidin = \frac{1.26 \times x_{48}[Tech] + 0.53 \times x_{49}[Tech] + 0.84 \times x_{50}[Tech]}{1.26 \times 4 + 0.53 \times 4 + 0.84 \times 4]} \qquad (79)$$

Where: stdin = stages importance

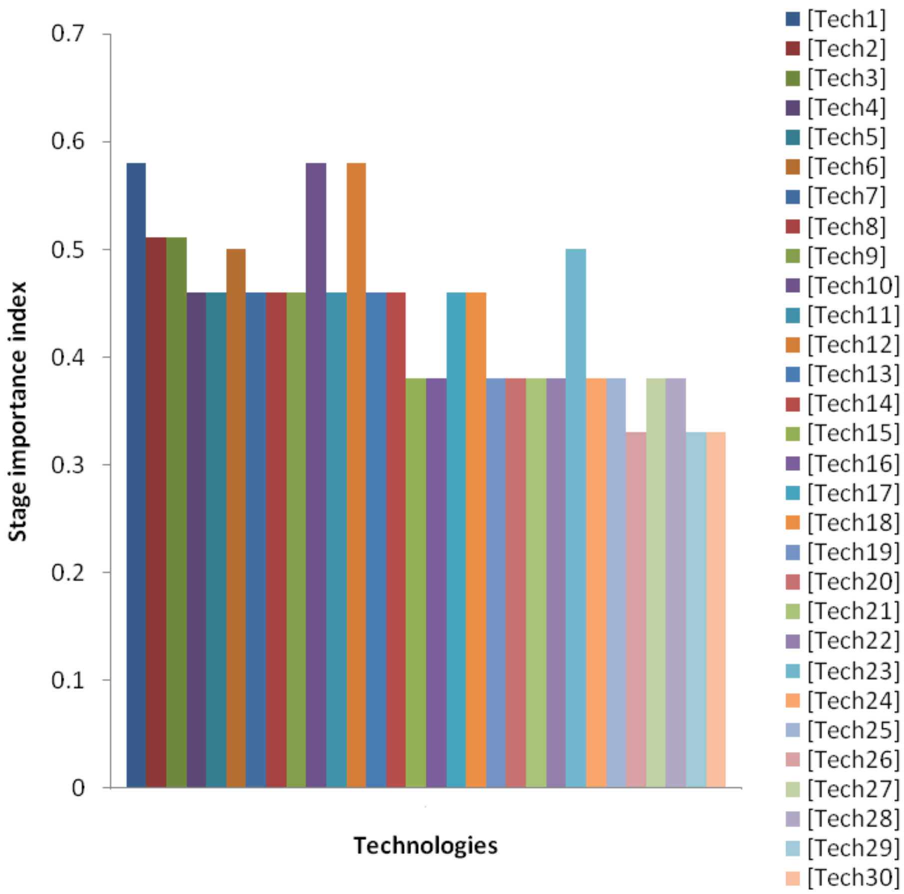


Figure 121: Technologies stages importance index.

4.3.24 Stages sensitivity analysis

At 100% confidence bound the variation of Transfer stage (X48), validation stage X49 and prototyping stages X50, between 1 and 5 at the step of 1 gave the variation of technology diffusion index of 42% (Fig. 122) and technology acceptance of 25% (Fig. 123. This results shows that the agro-technology development stages are very important for ensuring optimal technology development for diffusion (CISR, 2010; Cooper, 2009).

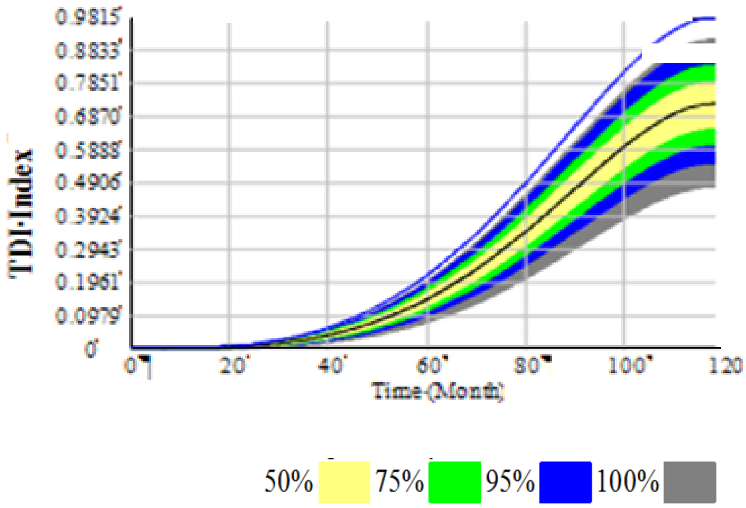


Figure 122: Technology market diffusion Vs stdin confidence bounds.

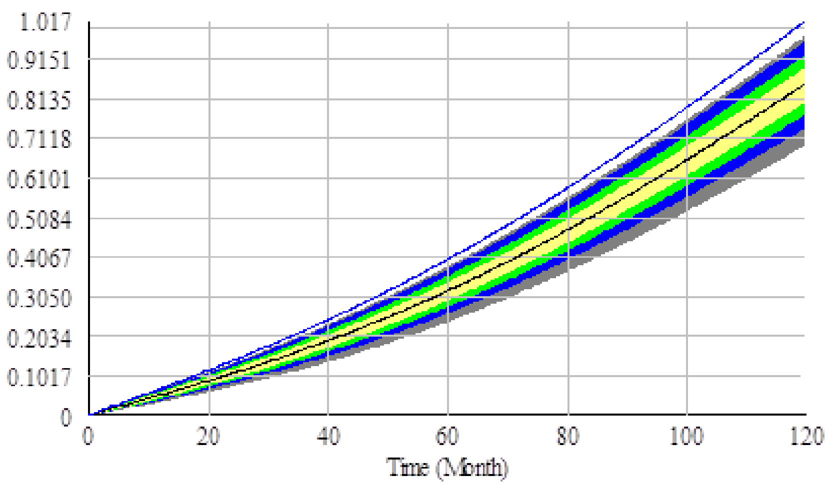


Figure 123: Technology acceptance Vs stdin confidence bounds.

4.3.25 Model Calibration

Model calibration is the process of adjusting model parameters set of a give sample, from a reference system to make the model work for a particular experimental set up or the results that match observed data (Hofmann, 2005; Igbadun, 2006). Inside the model it is calibrated in such a way that the maximum value was indexed as one (1), the process was repeated in iteration till the model was working to the expectation in batch 1. Standardised coefficients obtained in regression analysis in section 4.1.2 were not changed. Equations 14 to 49 were the basis of getting coefficients. The scale was transformed from 1 to 5 instead of 1 to 4 and these made to have good inputs, and out put on scales of 1 to 5 as shown in Fig. 124.

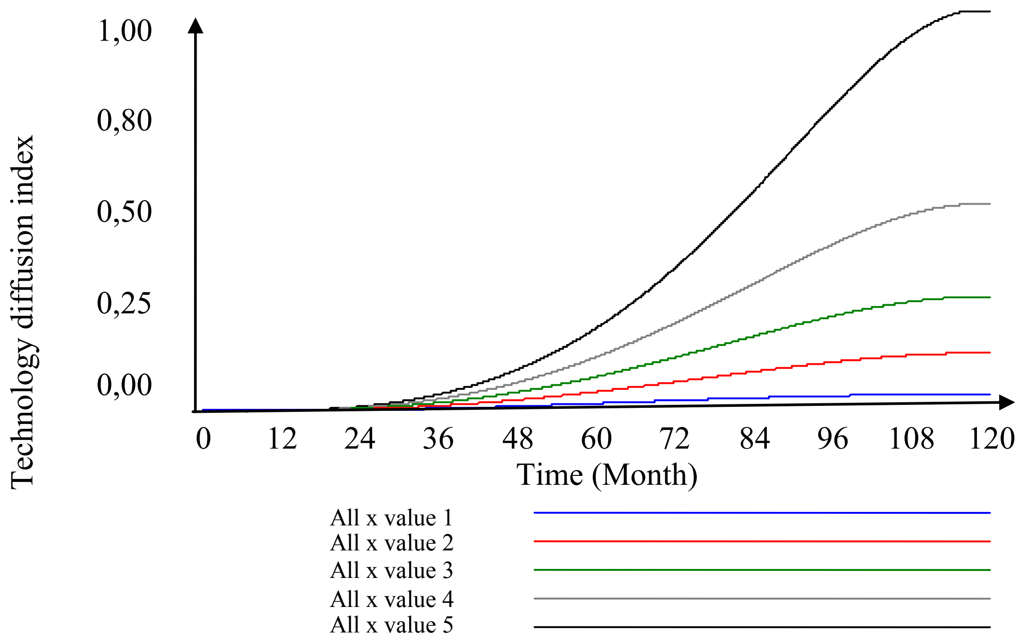


Figure 124: Market technology diffusion test.

The model was tested on various factors and driven variables, on technology market diffusion as shown in Fig. 125, 126 and 127 gave the maximum diffusion index in batch 2 as 0.71, for technology number one (1), that is CAMARTEC tractor and 0.0 for technology number thirty (30). In Fig. 131 the decreasing diffusion trend from technology one to thirty is seen. The test shows the same trend for design validity as depicted in Fig. 128, stakeholders' availability in Fig. 129 and technology package completeness in Fig. 130. These data are used for model validation in Section 4.4.4.

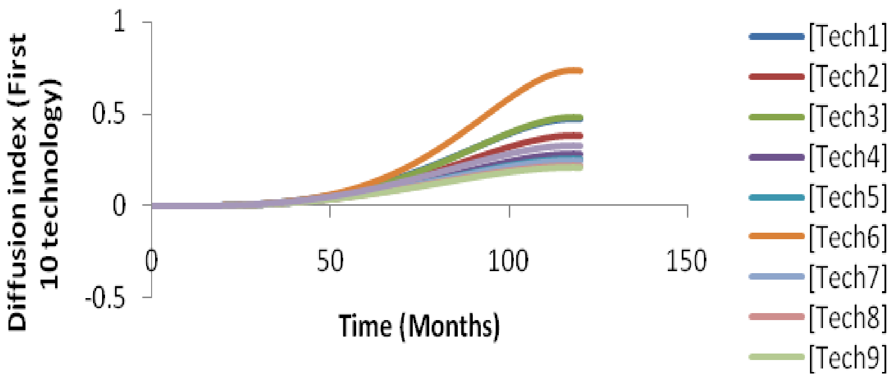


Figure 125: Technology market diffusion of the first 10 technologies.

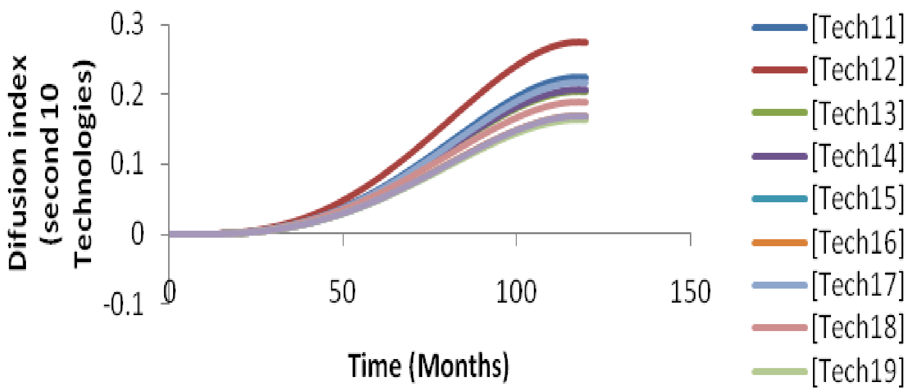


Figure 126: Technology market diffusion of the second 10 technologies.

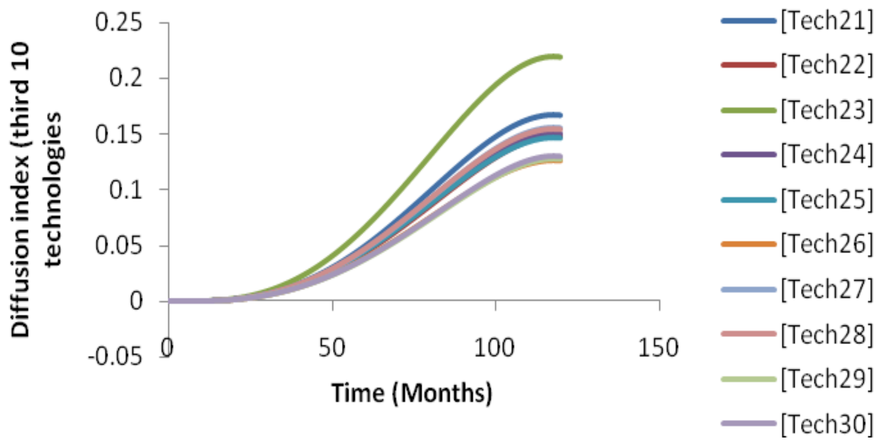


Figure 127: Technology market diffusion of the third 10 technologies.

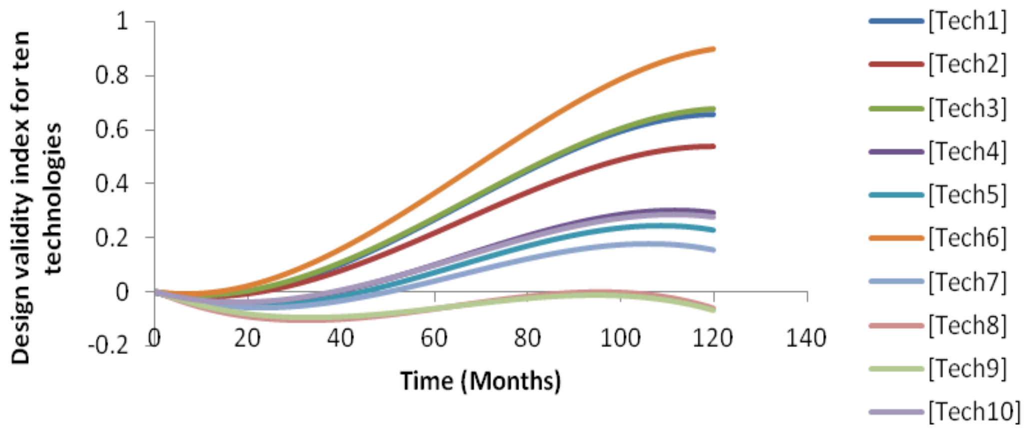


Figure 128: design validity for first technology.

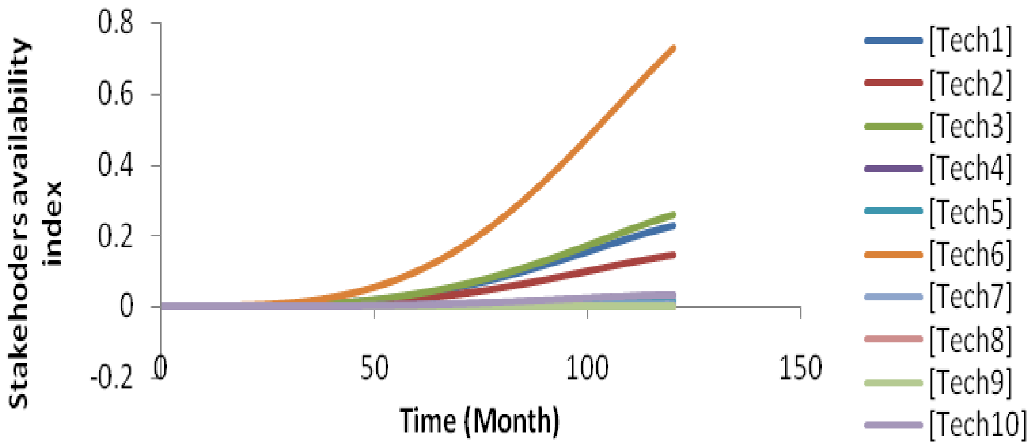


Figure 129: Stakeholders availability.

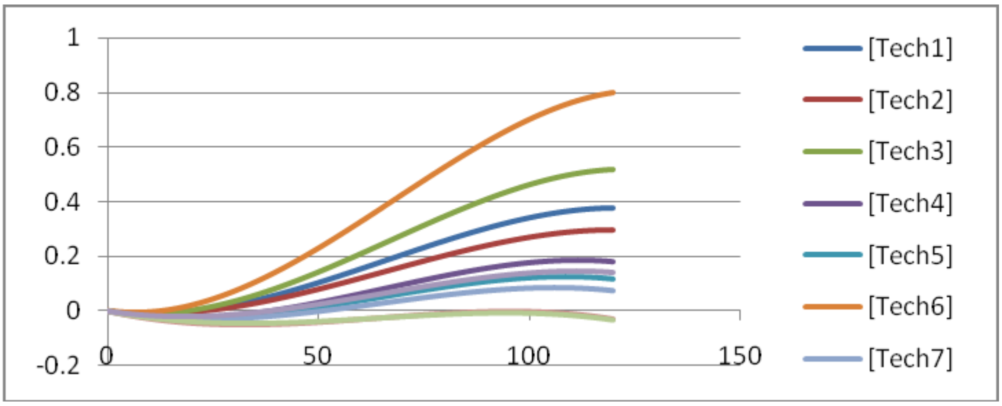


Figure 130: Technology package completeness.

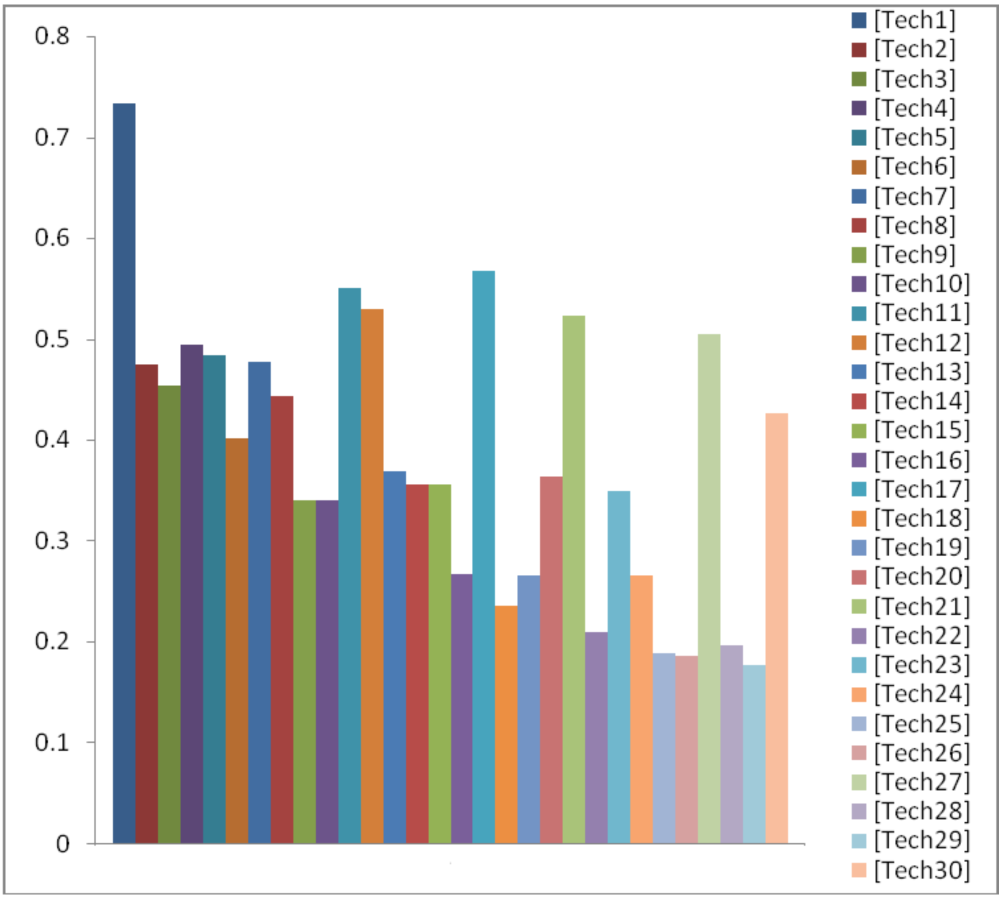


Figure 131: Batch two market diffusion.

4.4.27 Model validation

The model is tested with data from batch one to verify the correlation of the predicted data and the actual data from the field. The model predicted values at 120 months and was compared to index from the field in Table 36. The existence of good relationship between model predicted diffusion index (Fin_ind_2Ven) and the real value found in batch 2, with Pearson correlation coefficient of 0.6 and this is significant at the 0.01 level two tailed, shows a good model prediction of diffusion rate.

Table 36: Comparison of the model prediction index and actual index in batch 1

Descriptive Statistics

	Mean	Std. Deviation	N
Model_at_120	.266689	.1472612	30
Finance_index	.101	.2056	30

Correlations

		Model_at_120	Finance_index
Model_at_120	Pearson Correlation	1	.597**
	Sig. (2-tailed)		.001
	Sum of Squares and Cross-products	.629	.524
	Covariance	.022	.018
	N	30	30
Finance_index	Pearson Correlation	.597**	1
	Sig. (2-tailed)	.001	
	Sum of Squares and Cross-products	.524	1.226
	Covariance	.018	.042
	N	30	30

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

As for diffusion rate prediction consistency, the correlation is good. However, the validation is done using the second batch of data as shown in Appendix 30. On checking the model consistence the Pearson correlation analysis was done between the actual diffusion rate and the predicted diffusion index and factors. Pearson correlation of 0.896 was determined for correlation between predicted diffusion index and actual diffusion index. Correlation is significant at the 0.01 level (1-tailed) as depicted in Table 38. This shows a good overall prediction precision of the model at 99% confidence level. The relationship between model variable has high correlation at the significance level of 0.01, this is sufficient indication of the model internal consistency as previously shown in sensitivity analysis. The lowest correlation level is 95% for need relevance and actual sales index. However this is still acceptable since data availability at the level of need identification stages were problematic.

Table 37: Correlation analysis of batch 2 on predicted and actual factors and index

Fact	Statistic	TDI	Needi	Needr	Interpi	Tval	Tpava	DesVal	Tech Acc	Stdin	Act Index
TDI	Pearson Correlation	1	1.000**	.656**	.810**	.698**	.834**	.783**	.759**	.516**	.896**
	Sig. (1-tailed)		.000	.000	.000	.000	.000	.000	.000	.002	.000
	N	30	30	30	30	30	30	30	30	30	30
Needi	Pearson Correlation	1.000**	1	.656**	.810**	.698**	.834**	.783**	.759**	.516**	.896**
	Sig. (1-tailed)	.000		.000	.000	.000	.000	.000	.000	.002	.000
	N	30	30	30	30	30	30	30	30	30	30
Needr	Pearson Correlation	.656**	.656**	1	.902**	.704**	.721**	.816**	.785**	.586**	.468**
	Sig. (1-tailed)	.000	.000		.000	.000	.000	.000	.000	.000	.005
	N	30	30	30	30	30	30	30	30	30	30
Interpi	Pearson Correlation	.810**	.810**	.902**	1	.864**	.900**	.956**	.932**	.674**	.628**
	Sig. (1-tailed)	.000	.000	.000		.000	.000	.000	.000	.000	.000
	N	30	30	30	30	30	30	30	30	30	30
Tval	Pearson Correlation	.698**	.698**	.704**	.864**	1	.951**	.973**	.982**	.766**	.603**
	Sig. (1-tailed)	.000	.000	.000	.000		.000	.000	.000	.000	.000
	N	30	30	30	30	30	30	30	30	30	30
Tpava	Pearson Correlation	.834**	.834**	.721**	.900**	.951**	1	.967**	.974**	.786**	.738**
	Sig. (1-tailed)	.000	.000	.000	.000	.000		.000	.000	.000	.000
	N	30	30	30	30	30	30	30	30	30	30
DesVal	Pearson Correlation	.783**	.783**	.816**	.956**	.973**	.967**	1	.994**	.754**	.647**
	Sig. (1-tailed)	.000	.000	.000	.000	.000	.000		.000	.000	.000
	N	30	30	30	30	30	30	30	30	30	30
TechAcc	Pearson Correlation	.759**	.759**	.785**	.932**	.982**	.974**	.994**	1	.811**	.627**
	Sig. (1-tailed)	.000	.000	.000	.000	.000	.000	.000		.000	.000
	N	30	30	30	30	30	30	30	30	30	30
Stdin	Pearson Correlation	.516**	.516**	.586**	.674**	.766**	.786**	.754**	.811**	1	.388*
	Sig. (1-tailed)	.002	.002	.000	.000	.000	.000	.000	.000		.017
	N	30	30	30	30	30	30	30	30	30	30
ActIndex	Pearson Correlation	.896**	.896**	.468**	.628**	.603**	.738**	.647**	.627**	.388*	1
	Sig. (1-tailed)	.000	.000	.005	.000	.000	.000	.000	.000	.017	
	N	30	30	30	30	30	30	30	30	30	30

**. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (1-tailed).

The following can be stated about the validity of the model:

(i) The dynamic model for agro-technology diffusion for R&D organisation in Tanzania has been developed, with a good engineering guidance tool that can be used to load the model and hence guide the developers of technologies to succeed in the innovation endeavour. By using this model, agro-technologies developers can evaluate the developed technology or develop technology and predict innovation diffusion above 95% confidence level. The best index to be used for diffusion rate prediction is the sales value rate (money value per time).

(ii) Variables needed to be considered during the agro-technology development in R&D organisation in Tanzania for prosperous diffusion are identified and used to build the model. Macro-variables identified are: Initialisation, conceptualisation, engineering analysis, prototyping, validation and transfer. Others are stages importance and documentation or information importance. Under these Maro-variables, 55 micro-variables were identified as important for technology diffusion.

(iii) Initiation was split into two major macro variables: national need identification for technology, (*needi*) that had 10% effect on the technology diffusion index, 20% on design validity, 20% on technology information relevance, 10% on technology acceptance and 20% on technology packaging efficiency. The common sourced of these variables is the agro-technology national technology need assessment reports. The need relevance (*needr*) is the result of analysis of *needi* against financial, technical, economic and environment analysis, that is reflected in the technology project charter and business case. *Needr* has 13% effect on technology diffusion index, 25% on design validity, 25% on technology information relevance, 17% on agro-technology acceptance and 27% on agro-technology packaging efficiency.

(iv) Technology interpretation of agro-technology needs into design variables (*interpi*). These variables combine the concept development, design analysis and prototype development. *Interpi* has 12% effect on technology diffusion index, 24% on design validity, 22% on agro-technology information relevance, 15% on technology acceptance and 25% on technology packaging efficiency.

(v) Technology design validity has 30% effect on technology diffusion index, 62% on design validity, 61% on agro-technology information relevance, 65% on technology acceptance and 61% on agro-technology packaging efficiency.

(vi) Stakeholders' satisfaction has 25% effect on agro-technology diffusion index, 10% on design validity, 62% on agro-technology information relevance, 15% on technology acceptance and 65% on agro-technology packaging efficiency.

(vii) Agro-technology information generation (*tinfa*) has 10% effect on agro-technology diffusion index, 45% on agro-technology information relevance, 10% on agro-technology acceptance and 25%.

(viii) Technology development stage effect (*stdin*) has 42% effect on agro-technology diffusion index and 25% on agro-technology acceptance.

(ix) By varying value in the expected cumulative sales in the model developed the agro-technology diffusion can be predicted (Technology market diffusion) with precision not less than 95% confidence.

(x) Both the regression and dynamic model have shown a good relation between the engineering design variables for agro-technologies and the rate of diffusion of technologies. The correlation between the actual sales rate and the model predicted index has shown a good model performance. However the prediction accuracy decreased with the decrease in diffusion rate, since technologies with lower diffusion rate had also inconsistent information.

CHAPTER FIVE

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following conclusions have been drawn from the Study:

(i) From the historical background, Tanzania had never practiced a good national policy in agro-technology innovation and hence there has never been a need oriented defined objectives for technology that are developed. Failure to developed technology manufacturing infrastructure and business setup are prominent. Science, Technology and Innovation policy need to be developed.

(ii) Factors that affect agro-technologies innovation diffusion have been identified. These factors are need identification, need interpretation into design variable, technology validation, technology packaging, technology information generation and effective stages in the process of technology development are unavoidable for agro-technology diffusion. These factors have been found to affect design validity, technology market acceptance by stakeholders and the overall agro-technology technology market diffusion. The factors need to be observed very serious if a technology is developed for innovation diffusion.

(iii) Each factor was found to be driven by variables (55 micro-variables) that were picked from regression analysis. The linking of factors and their dynamisms were used to develop the system dynamic model for agro-technology diffusion in Tanzania. This model was found to be useful for guiding technology developer throughout the process of agro-technology development while predicting levels of driven diffusion factors like design validity, technology acceptance and technology market diffusion. With the aid of graphic user inter-phase the model enforces the observation of most factors that affect agro-technology innovation diffusion. That is to say the model ensures the diffusion of agro-technology diffusion.

(iv) Most of scientific models for engineering design were developed when the art and science of innovation diffusion was not a critical issue. But in this era of twenty first century innovation diffusion has become so critical factor that the science built in engineering design has been reviewed and improved to include innovation diffusion. The main scientific contribution is the inclusion of scientific factors and variables that extent the design model beyond mere prototype development to agro technology innovation diffusion.

5.2 Recommendations

(i) From the study of historical back ground of R&D organisation in Tanzania it is evident that Science, Technology and Innovation policy is poor. This has been a problem that has affected this study, since a very poor rationalisation of R&D organisation was observed.

(ii) Most of R&D organisations studied were also the manufacturer of technology and there was reluctance of transferring technologies to other manufacturers. As a result very little information linking R&D organisation and manufacturer and other stake holder was realised. The Science Technology and Innovation policy should be finalised so as to remove the inter-organisational and stakeholders confusion in the technology development environment.

(iii) Most variables identified through literature that were affecting factors that drives the agro-technology innovation diffusion and were removed in the stepwise regression analysis. This was due to poor practices and variable consideration in the R&D organisation under study. The abandonment of professional design development tools and models made this study very difficult. This also was accompanied by poor record keeping with time hence it was difficult to get the time trend of the technology diffusion, instead the S curve was assumed for the development of the model. There should be a purposeful effort to improve the technology development process, like the introduction of quality management system (ISO 9001) in all R&D organisations. Quality management system does enforce the excellent handling of agro-technology innovation variables to achieve the processes desired ends. For the improved organisation the study should be conducted to recalibrate the model as this should be a continuous process.

(iv) The model developed is using three different software to run: that is Vensim, Microsoft Access and Microsoft excel, an improvement is needed to make the model more user friendly. As it is now training is needed for the use of user inter-phase with other soft ware.

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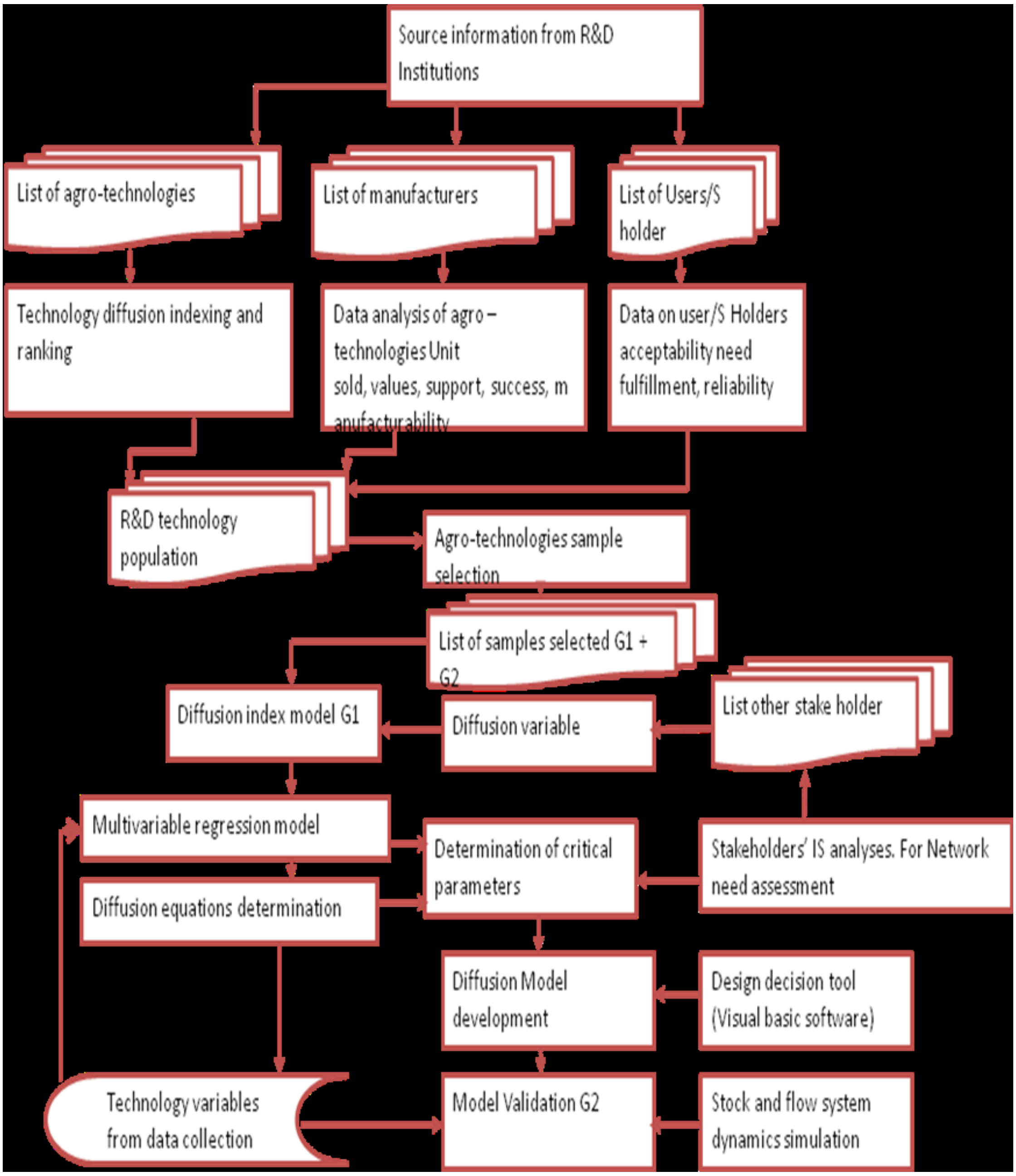
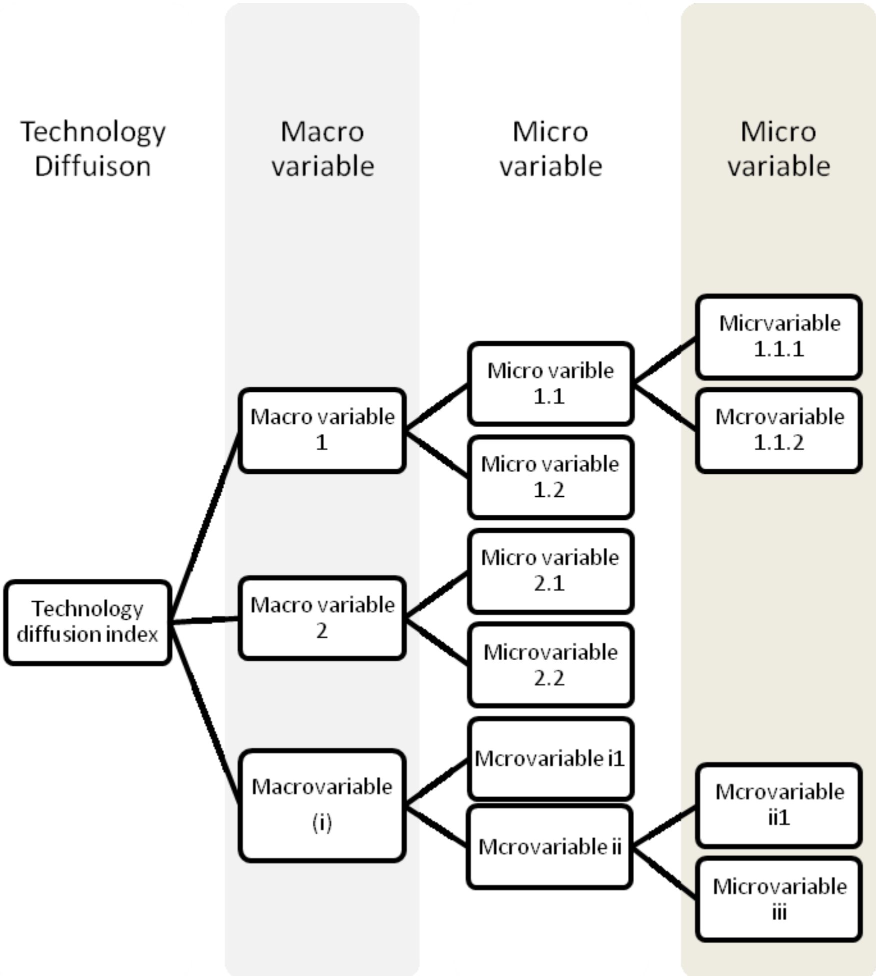
APPENDICES

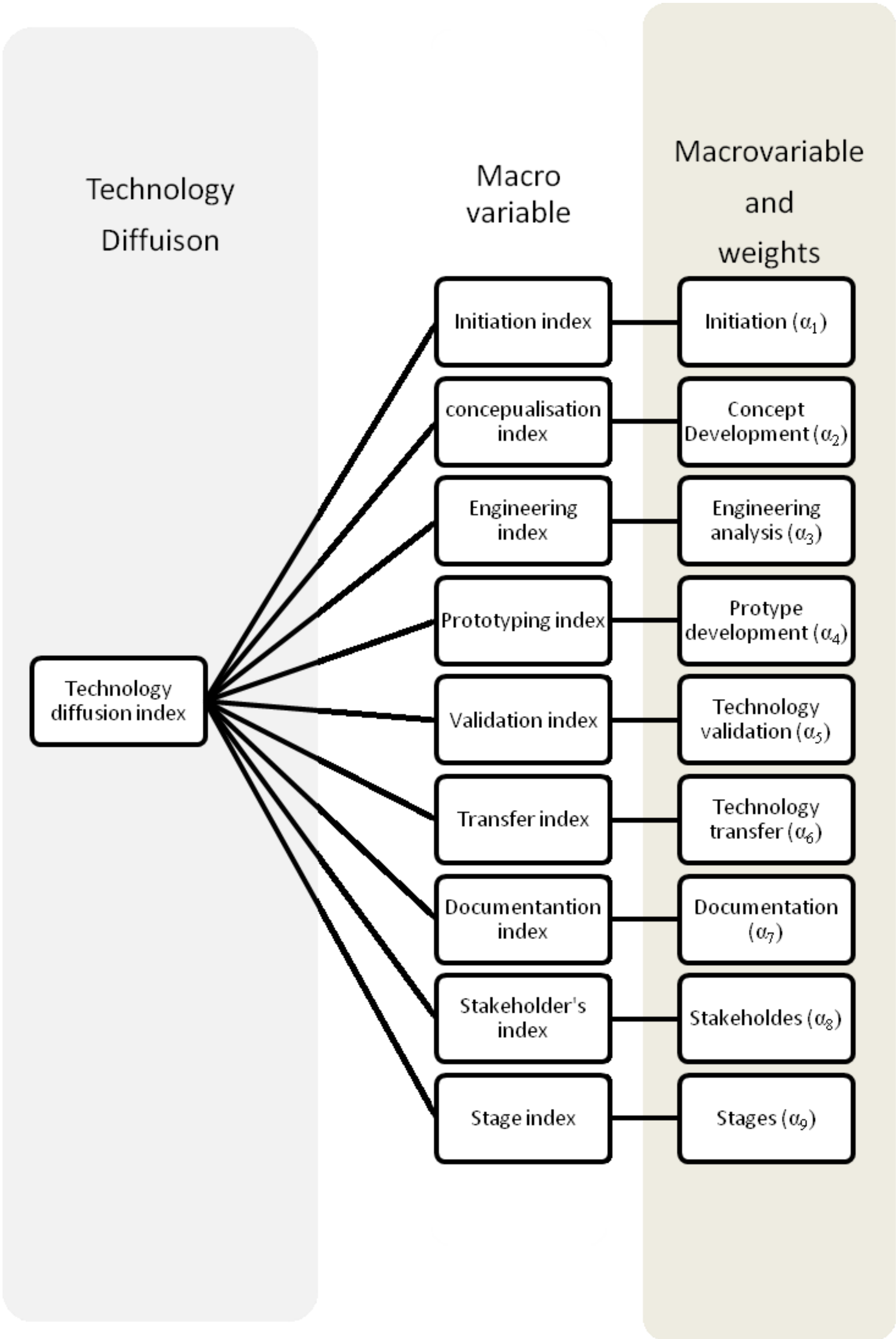
Appendix 1: Morphological Chart (Source Own)



Appendix 2: Cause Effect Framework



Cause Effect Framework



Appendix 3: Micro Diffusion Variables

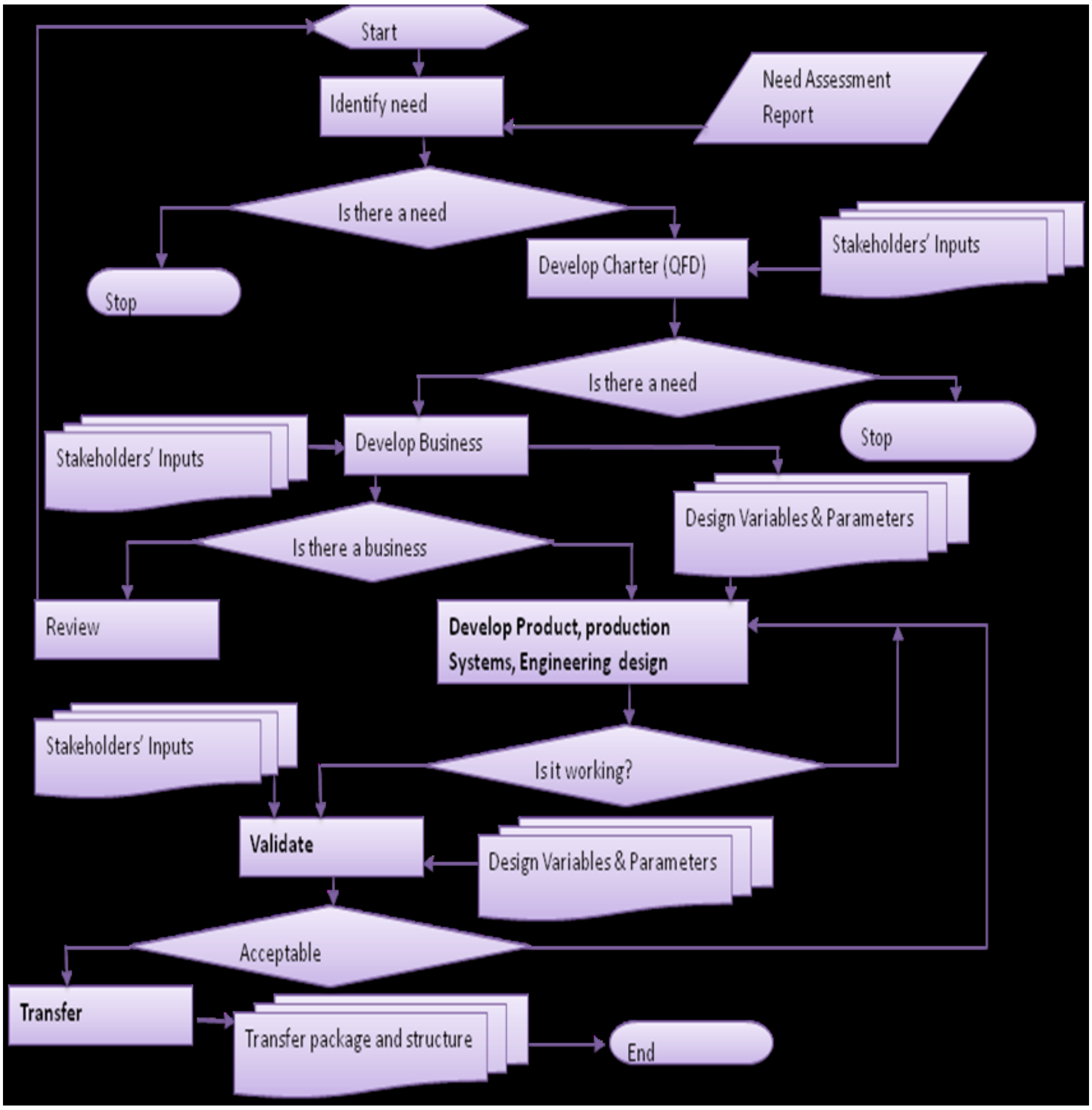
Variable code	Variable name	Explanation
Initiation stage 1.0		
Source of need identification 1.1		
1.1.1	Customer request	Customer thinking there is a need
1.1.2	Manufacturer request	Manufacturer think there is a need
1.1.3	National need assessment	National study to justify the need
1.1.4	Organisation initiatives	R&D organisation think there is a need
Technology approval methods 1.2		
1.2.1	Customer order	Customer order as a contract document
1.2.2	Project charter	Standard document for project approval
1.2.3	Committee	Committee for project approval
1.2.4	Engineer's opinion	Engineer justifies the need of the project
Development of capacity of technology 1.3		
1.3.1	Customer Proposal	Customer determine the size of technology
1.3.2	Manufacturer proposal	Manufacturer determines the size of technology
1.3.3	Our organisation	Capacity determined within the organisation
1.3.4	Business plan	Professional business document use
Establishment of the price limit for the technology 1.4		
1.4.1	By design process	Price come as a result of design
1.4.2	By manufacturer	Price determine by cost of manufacture
1.4.3	By customer recommendation	Customer recommend the price limit
1.4.4	From business case	Professionally done involving stake holders
Review methods of technology initiation 1.5		
1.5.1	Within Organisation	Closed door review
1.5.2	With user	Closed door with expected user
1.5.3	With manufacturers	Closed door with expected manufacturer
1.5.4	With Brokers	Closed door with expected broker
1.5.5	With donors	Closed door with expected donor
1.5.6	Other financier	Closed door with expected financiers
1.5.7	Government	Closed door with expected government
Conceptualisation 2.0		
Product performance clarification 2.1		
2.1.1	Function break down	Use design tool to understand expected functions
2.1.2.	Performance requirement tree	Use design tool to understand expected performance
2.1.3	Copying the existing designs	Reverse or re engineering (adaptation or adoption)
2.1.4	Artistic imagination	Using creativity and experience
2.1.5	Quality Function Deployment	Scientifically convention of customer requirement into design variables
Tool used for concept development 2.2		
2.2.1	Quality function deployment	Scientifically convention of customer requirement into design variables
2.2.2	Sketches	Using sketches in conceptualization
2.2.3	Computer models	Developing computer concept models
2.2.4	Designers skills	Assuming designers have all necessary information
2.2.5	Product Synthesis	Systematic combination of sub concepts

Variable code	Variable name	Explanation
Alternative concepts selection 2.3		
2.3.1	Undefined evaluation	
2.3.2	Concept valuated by criteria	Have defined criteria with equal weights
2.3.3	Concept are evaluated using weighted criteria	Have criteria with assigned weights
2.3.4	Concept are evaluated by voting	Evaluation by opinion of majority
Engineering analysis 3.0		
Selection of material 3.1		
3.1.1	Depend on availability	Availability as a main factor
3.1.2	Depend the price	Price as a main factor
3.1.3	Regulation	Regulation as main factor
3.1.4	Standard	Standards as main factor
3.1.5	Durability	Reliability as the main factor
Sizing of components 3_2		
3.2.1	Strength	Strength analysis as the main factor
3.2.2	Cost	Overall cost of designed technology as a factor
3.2.3	Performance	Performance as the main factor
3.2.4	Factor of safety	Standard factor of safety consideration
3.2.5	Deflection	Deflection analysis as a factor
Engineering design 4.2		
4.2.1	Not used	No evidence of having drawings
4.2.2	Done in 2D board	The use of hard drawings
4.2.3	Done on 2D software	The use 2D soft drawings
4.2.4	Done on 3D software	The use 3D soft drawings
Detail drawings 4.3		
4.3.1	Not used	No evidence of having drawings
4.3.2	Done in 2D board	The use of hard drawings
4.3.3	Done on 2D software	The use 2D soft drawings
4.3.4	Done on 3D software	The use 3D soft drawings
Prototyping 5.0		
Prototype development control 5.1		
5.1.1	Drawings	Using drawings as a control
5.1.2	Samples	Using samples as a control
5.1.3	Numerical control	Direct link to CNC and robots
Prototype package 5.2		
5.1.1	Prototype	Prototype as part of transfer package
5.1.2	Jigs	jigs as part of transfer package
5.1.3	Fixtures	Fixture as part of transfer package
5.1.4	Dies	Dies as part of transfer package
5.1.5	Template	Templates as part of transfer package
5.1.6	CNC programs	CNC Programs as part of transfer package
5.1.7	Production lines	Production line design and machineries as part of transfer package
5.1.8	Operation lines	Operation line design and machineries as part of transfer package
Validation 6.0		
Validation stake holders 6.1		
6.1.1	R&D engineers	Extent of engineers participation in validation
6.1.2	R&D Technicians	Extent of technicians participation in validation
6.1.3	End users	Extent of end users participation in validation
6.1.4	Financiers	Extent of financier participation in

Variable code	Variable name	Explanation
		validation
6.1.5	Technology brokers	Extent of brokers participation in validation
Validation contents 6.2		
6.2.1	Throughput	Performance rate of technology
6.2.2	Power consumption	Energy cost of the technology
6.2.3	Safety	Safety to operator and users
6.2.4	Price	Affordability of the technology
6.2.5	Ergonomics	Comfort of the operators
6.2.6	Aesthetics	Appearance and attractiveness
6.2.7	Durability	Reaching the break even point and beyond
6.2.8	Robustness	Reliable and strong
6.2.9	Operation	Friendly to operators
Validation Process output 6.3		
6.3.1	Report	Availability of validation report
6.3.2	Presentation	Presentation of validation report
6.3.3	Discussion	Discussion of validation report
6.3.4	Design Review	Existence of design review after validation
6.3.5	Approved technology	Existence of technology approval process
6.3.6	Approved means of manufacturing	Existence of technology manufacturing process
6.3.7	Approved means of operation	Existence of the technology operation approval
Transfer 7.0		
Transfer package 7.1		
7.1.1	Engineering drawings	Availability of engineering drawings
7.1.2	Manufacturing process sheets	Availability of manufacturing process sheets
7.1.3	Bill of material	Availability of bill of material
7.1.4	Technology profile	Availability of technology profile
7.1.5	Jigs	Availability of jigs
7.1.6	Fixtures	Availability of fixtures
7.1.7	Templates	Availability of templates
7.1.8	Dies	Availability of dies
7.1.9	Operation manual	Availability of operation manual
7.1.10	Installation Manual	Availability of installation Manual
7.1.11	Maintenance manual	Availability of maintenance manual
7.1.12	Certified training	Availability of certified training
7.1.13	Finance sources	Availability of finance sources
Communication 8.0		
Documentation 8.1		
8.1.1	Project Brief	Project brief existence
8.1.2	Project charter	Project charter existence
8.1.3	Business case	Business case existence
8.1.4	Feasibility study	Feasibility study existence
8.1.5	Need assessment	Need assessment existence
8.1.6	Operation manual	Operation manual existence
8.1.7	Bill of material	Bill of material existence
8.1.8	Done on 3D software 3	Done on 3D software 3 existence
8.1.9	Done in 2D board 1	Done in 2D board 1 existence
8.1.10	Drawings	Drawings existence
8.1.11	Bill of material	Bill of material existence
8.1.12	Customer order	Customer order existence
8.1.13	Technology profile	Technology profile existence
8.1.14	Operation manual	Operation manual existence
Stages.8.2		

Variable code	**Variable name**	**Explanation**
8.2.1	Initiation	Initiation stage thoroughness
8.2.2	Conceptualization	Conceptualization stage thoroughness
8.2.3	Design	Design stage thoroughness
8.2.4	Prototyping	Prototyping stage thoroughness
8.2.5	Validation	Validation stage thoroughness
8.2.6	Transfer	Transfer stage thoroughness

Appendix 4: Project approaches framework in engineering design (source own)



Appendix 5: Questionnaire Research and Development (R&D) Organisations

SECTION-I: PROFILE OF R&D

Name of firm [---------------------------------------]
When was your firm established? [---------------------------------------]
What is the total number of your employees?
More than 100 [ ]
Between 50 and 100 [ ]
Between 25 and 50 [ ]
Less than 25 [ ]
Indicate the type of ownership of your firm
Public/Government [ ]
Sole proprietor [ ]
Incorporated company [ ]
Others (specify) [ ]
What is your capital investment in machinery in Tsh?
Between 0-5 mil [ ]
Between 5-200mil [ ]
Between 200-800 mil [ ]
800 mil and/or above [ ]

What are your main activities?

SN	Activity	Not Done	Some times	Often	Always
	National product need assessment				
	Product Design				
	Prototype Manufacturing				
	Technology Transfer				

What are the types of products you are involved in?

SN	Type of Product	Not Done	Occasionally	Often	Is Main Product
	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Crop processing				

7. Number of your technical manpower
Engineers [Number ----------]
Technicians [Number ----------]
Artisans [Number ----------]

8. What is the education of your technical personnel?
PhD [ ]
Masters [ ]
Bachelors [ ]
Technical certificate [ ]
Trade tests certificate [ ]
Others [ ]

SECTION-II: R&D INNOVATION DIFFUSION RATE

Technology	Year Developed	Amount Manufactured	Value	Remarks on diffusion

SECTION III INNOVATION PROCESS PER TECHNOLOGY

Technology Name: ____________________________________

1. Initiation.

1.1 What made you to develop the technology?

SN	Technology	None	Sometimes	Most Times	Always
1.1.1	Customer request				
1.1.2	Manufacturer request				
1.1.3	National need assessment				
1.1.4	Company initiatives				

1.2 How was the project approved?

1.2.1 Customer order [ ]
1.2.2 Project charter [ ]
1.2.3 Committee [ ]
1.2.4 Engineer's opinion [ ]

1.3 How was the capacity of technology deduced?

1.3.1 Customer proposal [ ]
1.3.2 Manufacturer proposal [ ]
1.3.3 Our organisation [ ]
1.3.4 Business plan [ ]

1.4 How was the price limit for the technology obtained?

1.4.1 By design process [ ]
1.4.2 By manufacturer [ ]
1.4.3 By customer recommendation [ ]
1.4.4 From business case [ ]

1.5. How was the initiation of technology reviews conducted?

SN	Organisation	Not The Case	Some times	Most of the time	Always
1.5.1	Within the organisation				
1.5.2	With user				
1.5.3	With manufacturers				
1.5.4	With Brokers				
1.5.5	With donors				
1.5.6	Other financier				
1.5.7	Government				

2. Concept development

2.1. How are the product performance clarified

SN	Method	Not used	Sometimes	Most of times	Always
2.1.1	Function break down				
2.1.2	Performance requirement tree				
2.1.3	Copying the existing designs				
2.1.4	Artistic imagination				
2.1.5	Quality Function Deployment				

2.2. What tool are used for concept development

SN	Method	Not used	Sometimes	Most of times	Always
2.2.1	Quality function deployment				
2.2.2	Sketches				
2.2.3	Computer models				
2.2.4	Designers skills				
2.2.5	Product Synthesis				

2.3. How are the alternative concepts selected

SN	Method	Not used	Sometimes	Often	Always
2.3.1	No concept evaluation				
2.3.2	Concept evaluated by criteria				
2.3.3	Concept are evaluated using weighted criteria				
2.3.4	Concept are evaluated by voting				

3. Engineering analysis

3.1Selection of material

SN	Method	Not used	Sometimes	Often	Always
3.1.1	Depend on availability				
3.1.2	Depend the price				
3.1.3	Regulation				
3.1.4	Standard				
3.1.5	Durability				

3.2 Sizing of components

SN	Method	Not used	Sometimes	Often	Always
3.2.1	Strength				
3.2.2	Cost				
3.2.3	Performance				
3.2.4	Factor of safety				
3.2.5	Deflection				

3.3 Manufacturing of components (Technology process selection)

SN	Method	Not used	Sometimes	Often	Always
3.3.1	Ability to manufacture				
3.3.2	Cost of manufacturing				
3.3.3	Creation of clusters				
3.3.4	Standard manufacture				

3.4. Price of components (What is the main constraint)

SN	Method	Not used	Sometimes	Often	Always
3.4.1	Overall price of the product				
3.4.2	Manufacturer competence				
3.4.3	Precision requirement				
3.4.4	Material selection				
3.4.5	standardisation				

4. Drawing development (Check the relevant place with √ and if √ show the scale between 1 to 4)
4.1. Design Draft
4.1.1 Not used [ ]
4.1.2 Done in 2D board [ ]
4.1.3 Done on 2D software [ ]
4.1.4 Done on 3D software [ ]

4.2 Engineering design (Check the relevant place with √ and if √ show the scale between 1 to 4)
4.2.1 Not done [ ]
4.2.2 Done in 2D board [ ]
4.2.3 Done on 2D software [ ]
4.2.4 Done on 3D software [ ]

4.3 Detail drawings (Check the relevant place with √ and if √ show the scale between 1 to 4)
4.3.1 Not done [ ]
4.3.2 Done in 2D board [ ]
4.3.3 Done on 2D software [ ]
4.3.4 Done on 3D software [ ]

Prototyping (Check the relevant place with √ and if √ show the scale between 1 to 4)
5.1. What is used to develop prototype
5.1.1 Drawings [ ]
5.1.2 Samples [ ]
5.1.3 Numerical control [ ]
5.1.4 Others [ ]

5.2. Which of the following are developed with the prototype? (Check the relevant place with √, and if √ show the scale between 1 to 4)
5.2.1 Prototype [ ]
5.2.2 Jigs [ ]
5.2.3 Fixtures [ ]
5.2.4 Dies [ ]
5.2.5 Template [ ]
5.2.6 CNC programs [ ]
5.2.7 Production lines [ ]
5.2.8 Operation lines [ ]

6.1 Validation (Check the relevant place with √ and if √ show the scale between 1 to 4)
6.1. Who is involved?
6.1.1 R&D engineers [ ]
6.1.2 R&D Technicians [ ]
6.1.3 End users [ ]
6.1.4 Financiers [ ]
6.1.5 Technology brokers [ ]
6.1.6 Others [ ]

6.2. What is validated? (Check the relevant place with √ and if √ show the scale between 1 to 4)
6.2.1 Throughput [ ]
6.2.2 Power consumption [ ]
6.2.3 Safety [ ]

6.2.4 Price [ ]
6.2.5 Ergonomics [ ]
6.2.6 Aesthetics [ ]
6.2.7 Durability [ ]
6.2.8 Robustness [ ]
6.2.9 Operation [ ]
6.2.10 Others [ ]

6.3. What is the output? (Check the relevant place with √ and if √ show the scale between 1 to 4)
6.3.1 Report [ ]
6.3.2 Presentation [ ]
6.3.3 Discussion [ ]
6.3.4 Design Review [ ]
6.3.5 Approved technology [ ]
6.3.6 Approved means of manufacturing [ ]
6.3.7 Approved means of operation [ ]

7. Transfer (Check the relevant place with √ and if √ show the scale between 1 to 4)

7.1 What is included in the transfer package?
7.1.1 Engineering drawings [ ]
7.1.2 Manufacturing process sheets [ ]
7.1.3 Bill of material [ ]
7.1.4 Technology profile [ ]
7.1.5 Jigs [ ]
7.1.6 Fixtures [ ]
7.1.7 Templates [ ]
7.1.8 Dies [ ]
7.1.9 Operation manual [ ]
7.1.10 Installation Manual [ ]
7.1.11 Maintenance manual [ ]
7.1.12 Certified training [ ]
7.1.13 Finance sources [ ]
8. Communication
8.1 Tools and technique (Check the relevant place with √ and if √ show the scale between 1 to 4)

SN	Level of Tech Development	Power point	3D models	2D drawings	Others
8.1.1	Initiation				
8.1.2	Concept development				
8.1.3	Analysis				
8.1.4	Modelling				
8.1.5	Prototyping				
8.1.6	Verification				
8.1.7	Validation				
8.1.8	Transfer				

9. Participation (Check the relevant place with √ and if √ show the scale between 1 to 4)

SN	Level of Tech Development	Engineers	Economist	Financiers	Users	Manufacturer	Others
9.1.1	Initiation						
9.1.2	Concept development						
9.1.3	Analysis						
9.1.4	Modelling						
9.1.5	Prototyping						
9.1.6	Verification						
9.1.7	Validation						
9.1.8	Transfer						

10. Documentation (Check the relevant place with √ and if √ show the scale between 1 to 4)

10.1 Project Brief [ ]
10.2 Project charter [ ]
10.3 Business case [ ]
10.4 Feasibility study [ ]
10.5 Need assessment [ ]
11 Stages.
11.1 Initiation [ ]
11.2 Conceptualisation [ ]
11.3 Design [ ]
11.4 Prototyping [ ]
11.4 Validation [ ]
11.6 Transfer [ ]

Appendix 6: Questionnaire to Manufacturers

PROFILE OF R&MANUFACTURER

Name of firm [_____________________________]

Age of establishment [_____________________________]

When was your firm established? [_____________________________]

What is the total number of your employees?
More than 100 [ ]
Between 50 and 100 [ ]
Between 25 and 50 [ ]
Less than 25 [ ]

Indicate the type of ownership of your firm
Public/Government [ ]
Sole proprietor [ ]
Incorporated company [ ]
Others (specify) [ ]

What is your capital investment in machinery in Tsh?
Between 0-5 mil [ ]
Between 5-200mil [ ]
Between 200-800 mil [ ]
800 mil and/or above [ ]

What are your main activities? (Check the relevant place with √)

SN	Activity	Not done	Some times	Often	Always
	National product need assessment				
	Product Design				
	Prototype Manufacturing				
	Technology manufacturing				
	Production line development				
	Technology selling				
	Others				

What are the types of products you are involved in? (Check the relevant place with √)

SN	Activity	Not done	Some times	Often	Always
	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Crop processing				
	Others (specify)				

Number of your technical manpower
Engineers [Number ----------]
Technicians [Number ----------]
Artisans [Number ----------]

What is the education of your technical personnel?
PhD [ ]
Masters [ ]
Bachelors [ ]
Technical certificate [ ]
Trade tests certificate [ ]
Others [ ]

MANUFACTURER INNOVATION EFFORTS

The technologies that have been developed/ manufacture

Technology	Year Developed	Quantity Manufactured	Value	Remarks on diffusion

TECHNOLOGY INFORMATION (Manufacturers)
Name technology ________________________________
Designer of technology ________________________________
Price of this technology ________________________________
Number of units sold ________________________________
Main Customers ________________________________

Who are main customers of this technology (Check the relevant place with √)

SN	Buyers	Not	Not Common	Some times	Frequently	Always
	Individual customer					
	Technology sellers					
	Donors					
	Government					

Source of buyer finance (Check the relevant place with √)

SN	Finance source	Not	Not Common	Some times	Frequently	Always
	Micro financing banks					
	Banks					
	Donors					
	Government					
	Pocket					

Is Manufacturability facilitated by the following (Check the relevant place with √)

SN	Facilitation	Not	Not Common	Sometimes	Frequently	Always
	Uses of Templates					
	Use of Jigs and fixture					
	Use of dies					
	CNC Machines					
	Using conventional methods					

What processes are used in manufacturing of technology (Check the relevant place with √)

SN	Processes	Not	Not Common	Sometimes	Frequently	Always
	Metal cutting					
	Metal shaping					
	Metal forming					
	Metal joining					
	Metal casting					
	Metal finishing					

Who facilitates the design of your products? (Check the relevant place with √)

SN	Designers	Not	Not Common	Sometimes	Frequently	Always
	Self					
	SIDO					
	Projects/Programs					
	R&D organisations					
	Universities					

Who facilitates the design of your production line? (Check the relevant place with √)

SN	Designers	Not	Not Common	Sometimes	Frequently	Always
	Self					
	SIDO					
	Projects/Programs					
	R&D organisations					
	Universities					

In this technology what is your experience on the following items (Check the relevant place with √)

SN	Item	None	Poor	Good	Excellent
	Stakeholders design participation				
	Quality of drawings				
	Quality of jigs and fixture				
	Quality of dies				
	Easiness of component manufacturing				
	Material selection				
	Sizing of component				
	Availability of materials				
	Standardisation of components				
	Assembling of components				
	Appropriateness of the through put of technology				

SN	Item	None	Poor	Good	Excellent
	Safety consideration				
	Cost of manufacturing consideration				
	Ergonomics consideration				
	Aesthetics consideration				
	Purchasing finance availability				
	Durability of technology				
	Support from government				
	Support from R&D				
	Support from SIDO				
	Support from universities				
	Support from BRELA				
	Support from banks				
	Support from COSTECH				
	Formation of network (Clusters)				

Section V: Pilot Manufacturing
Who facilitates the validation of prototype? (Check the relevant place with √)

SN	Designers	Not	Not Common	Sometimes	Frequently	Always
	Self					
	SIDO					
	Projects/Programs					
	R&D organisations					
	Universities					
	Extensions MoA					
	COSTECH					

What type of raw materials do you use in developing your prototypes? (Check the relevant place with √)

SN	Materials	Not	Not Common	Sometimes	Frequently	Always
	Mild steel					
	Special steel					
	Copper					
	Cast iron					
	Aluminium					
	Scrap metal					

[C] TECHNOLOGY CHANGES
1. Have you recently improved your products?
Yes [ ]
No [ ]
2. If 'Yes' with whom do you collaborate in improving your products?
Government [ ]
SIDO [ ]
Projects/Programs [ ]
R&D organisations [ ]
Universities [ ]
In-house [ ]

[D] MANUFACTURING

1. Have you recently purchased new/used production machine(s)?
Yes [ ]
No [ ]
2. If No, what other options have you done?
Modified the machines [ ]
Sub-contracted the some activities [ ]
Others (Specify) [ ]
3. What is the main source of fund for purchasing your production machines?
Credit/loan [ ]
Income [ ]
Others (Specify) [ ]
4. Does the change (purchase/modified) of your machines improve your products?
Yes [ ]
No [ ]

Appendix 7: Questionnaire users of the technology

Who is supplying technology? (Check the relevant place with √)

SN	Organisation	No	By chance	Some times	frequently	always
	R&D					
	Manufacturer					
	Brokers					
	Government Ministries					
	Local government					
	COSTECH					
	Banks					
	Universities					
	Donors					

Do you have any formal linkage on technology information development, purchasing or services with the following? (Check the relevant place with √)

SN	Organisation	No	By chance	Some times	frequently	always
	R&D					
	Manufacturer					
	Brokers					
	Government Ministries					
	Local government					
	COSTECH					
	Banks					
	Universities					
	Donors					

For the successes of use of technology? (Check the relevant place with √)

SN	Item	None	Poor	average	good	excellent
	Participation on need identification					
	Participation on describing technology					
	Participation in the design of the technology					
	Determination of the throughput determination					
	Describing the appearance of the technology					
	Determination of the price of the technology					
	Testing and rectifying technology					
	Facilitation of obtaining technology					
	Training on operation of technology					
	Incubation of business					
	Clusters formation					

What is your opinion on the technology (Check the relevant place with √)

SN	Item	Poor	Average	Good	Excellent
	Ergonomics				
	Aesthetics				
	Safety				
	Capacity of the technology				
	Energy requirement				
	Operation				
	Profitability				
	Price				
	Technology Availability				
	Availability of information				
	Credit availability				
	Operation training				
	Maintenance training				
	Business training				
	Durability				
	Maintenance				
	Spare availability				
	Reliability				
	Quality of the output				
	Completeness of the package				

Questionnaire Technology Financiers (Check the relevant place with √)

Name of firm [______________________________]

Age of establishment [______________________________]

When was your firm established? [______________________________]

What is the total number of your employees?

1. More than 100 [ ]
2. Between 50 and 100 [ ]
2. Between 25 and 50 [ ]
3. Less than 25 [ ]

Indicate the type of ownership of your firm

1. Public/Government [ ]
2. Sole proprietor [ ]
3. Incorporated company [ ]
4. Others (specify) [ ]

What is your capital investment in agro-technology development in Tsh?

1. Between 0-5 mil [ ]
2. Between 5-200mil [ ]
3. Between 200-800 mil [ ]
4. 800 mil and/or above [ ]

What are your main support activities in agro-technologies? (Check the relevant place with √)

SN	Activity	Not done	Some times	Often	Always
	National product need assessment				
	Finance product Design				
	Finance prototype Manufacturing				
	Finance technology manufacturing				
	Finance production line development				
	Finance technology selling				
	Others				

What are the types of products you are involved in?

SN	Activity	Not done	Some times	Often	Always
	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Crop processing				
	Others (specify)				

Number of your technical manpower
Engineers [Number ----------]
Technicians [Number ----------]
Artisans [Number ----------]
Industrial economists [Number ----------]

On agro-technology development how do you rank yourself in the following: (Check the relevant place with √)

SN	Item	None	Poor	Average	Good	Excellent
	Participation on need identification					
	Participation on describing technology					
	Participation in the design of the technology					
	Determination of the throughput determination					
	Describing the appearance of the technology					
	Determination of the price of the technology					
	Testing and rectifying technology					
	Facilitation of obtaining technology					
	Training on operation of technology					
	Incubation of business					
	Clusters formation					

If you were to be incorporated in the technology development in Tanzania which of the following areas are deemed as important for availing the finance for procurement of the same technologies: (Check the relevant place with √)

SN	Item	Not Important	May help	help	Very important
	Participation on need identification				
	Participation on describing technology				
	Participation in the design of the technology				
	Determination of the throughput determination				
	Describing the appearance of the technology				
	Determination of the price of the technology				

SN	Item	Not Important	May help	help	Very important
	Testing and rectifying technology				
	Facilitation of obtaining technology				
	Training on operation of technology				
	Incubation of business				
	Clusters formation				

Questionnaire Technology Government Argents
Name of firm [___________________________]
Age of establishment [___________________________]
When was your firm established? [___________________________]
What is the total number of your employees?
1. More than 100 [ ]
2. Between 50 and 100 [ ]
2. Between 25 and 50 [ ]
3. Less than 25 [ ]

Indicate the type of ownership of your firm
1. Public/Government [ ]
2. Sole proprietor [ ]
3. Incorporated company [ ]
4. Others (specify) [ ]

What is your capital investment in workshop machinery in Tsh?
1. Between 0-5 mil [ ]
2. Between 5-200mil [ ]
3. Between 200-800 mil [ ]
4. 800 mil and/or above [ ]

What are your main support activities in agro-technologies? (Check the relevant place with √)

SN	Activity	Not done	Some times	Often	Always
	National product need assessment				
	Finance product Design				
	Finance prototype Manufacturing				
	Finance technology manufacturing				
	Finance production line development				
	Finance technology selling				
	Others				

What are the types of products you are involved in? (Check the relevant place with √)

SN	Activity	Not done	Some times	Often	Always
	Land preparation				
	Planting				
	Weeding				
	Harvesting				
	Crop processing				
	Others (specify)				

Number of your technical manpower
Engineers [Number ----------]
Technicians [Number ----------]
Artisans [Number ----------]
Industrial economists [Number ----------]

On agro-technology development how do you rank yourself in the following: (Check the relevant place with √)

SN	**Item**	**None**	**Poor**	**average**	**good**	**excellent**
	Participation on need identification					
	Participation on describing technology					
	Participation in the design of the technology					
	Determination of the throughput determination					
	Describing the appearance of the technology					
	Determination of the price of the technology					
	Testing and rectifying technology					
	Facilitation of obtaining technology					
	Training on operation of technology					
	Incubation of business					
	Clusters formation					

Appendix 8: Diffusion Rate

SN	Tech	Cap	Units	Year Dev	Qty Man	Unit Value	Manr	Cum Value	Dur	Diffusion Rate
1	Animal Feed Mixer	600	Kg/batch	1987	1	2 300 000.00	TDTC	2 300 000	25	9 2000
2	Animal Feed Mixer	1 200	Kg/batch	1987	20	3 250 000.00	TDTC	65 000 000	25	2 600 000
3	Animal Feed Mixer	1 500	Kg/batch	1987	20	2 640 000.00	TDTC	52 800 000	25	2 112 000
4	Maize mill	250	kg/hr	1988	4	1 680 000.00	TDTC	672 0000	24	280 000
5	Maize mill	500	kg/hr	1987	25	2 100 000.00	TDTC	52 500 000	25	2 100 000
6	Maize mill	1 000	kg/hr	1988	26	2 570 000.00	TDTC	66 820 000	24	2 784 167
7	Grain mill	2 000	kg/hr	2010	2	5,000,000.00	TDTC	10 000 000	2	5 000 000
8	2 Roller hammer	500	kg/hr	1990	22	1 560 000.00	TDTC	34 320 000	22	1 560 000
9	3 Roller hammer	1 000	kg/hr	2002	25	1 990 000.00	TDTC	49 750 000	10	4 975 000
10	Scisor Jack Press for Sunflower	40	kgs/day	1984	800	500 000.00	TDTC	400 000 000	28	1 428 5714
11	Palm Fruit Sterlising Tank	300	kg/batch	1987	2	720 000.00	TDTC	1 440 000	25	57 600
12	Palm Fruit digestor			1987	5	1 800 000.00	TDTC	9 000 000	25	360 000
13	Palm Fruit Clarifier	500	Ltr/hr	1987	4	2 280 000.00	TDTC	9 120 000	25	364 800
14	Palm Fruit Filter Press	300	Ltr/hr	1999	1	1 170 000.00	TDTC	1 170 000	13	90 000
15	Screw Expeller	100	kg/hr	1999	1	5 320 000.00	TDTC	5 320 000	13	409 231
16	Palm fruit thresher	700	kg/hr	1987	2	2 755 000.00	TDTC	5 510 000	25	220 400
17	Palm nut cracker	720	kg/hr	2008	1	2 500 000.00	TDTC	2 500 000	4	625 000
18	Sugar cane crusher	2 000	kg/hr	1990	13	33 000 000.00	TDTC	429 000 000	22	19 500 000
19	Evaporating furnace	2 000	kg/hr	1990	13	5 793 000.00	TDTC	75 309 000	22	3 423 136
20	Crystaliser bank	2 000	kg/hr	1990	13	12 933 000.00	TDTC	168 129 000	22	7 642 227
21	Centrifuge	2 000	kg/hr	1990	13	2 697 000.00	TDTC	35 061 000	22	1 593 682
22	Palm oil expeller			2004	1	4 800 000.00	TDTC	4 800 000	8	600 000
23	Settling tank (Sugar processing)	2 000	kg/hr	1990	13	1 410 000.00	TDTC	18 330 000	22	833 182
24	Maize tresher	1 000	kg/hr	2009	1	2 500 000.00	TDTC	2 500 000	3	833 333
25	Juice blender	20	Ltr/batch	2006	8	1 500 000.00	TDTC	12 000 000	6	2 000 000
26	Peanut butter grinding machine	50	kg/hr	2006	4	1 500 000.00	TDTC	6 000 000	6	1 000 000
27	Soap extruder	200	bars/hr	2004	6	3 500 000.00	TDTC	21 000 000	8	2 625 000
28	Soap stock mixing tank boiling kettle	200	litres	2004	5	4 500 000.00	TDTC	22 500 000	8	2 812 500
29	Soap die motorised (Toilet soap)			2004	1	2 000 000.00	TDTC	2 000 000	8	250 000
30	Sunflower winnower			1989	1	2 000 000.00	TDTC	2 000 000	23	86 957
31	Minibakery oven (500g loaves)	100	pcs/batch	2009	4	2 800 000.00	TDTC	11 200 000	3	3 733 333
32	Energy serving wood stove	25 - 200	litres	2002	13	2 510 000.00	TDTC	32 630 000	10	3 263 000
33	Salt grinder - Iodator	4 000 6 000	kg/hr	1998	1	16 800, 00.00	TDTC	16 800 000	14	1 200 000
34	Peanut sheller (manual)	120	kg/hr	1991	1	2 000 000.00	TDTC	2 000 000	21	95 238
35	Dough mixer	30	kgs/batch	2006	1	4 000 000.00	TDTC	4 000 000	6	666 667
36	Soap stamping machine			2008	3	2 500 000.00	TDTC	7 500 000	4	1 875 000

37	Fruit Solar drier			2006	3	4 741 500.00	TDTC	14 224 500	6	2 370 750
38	Rice huller			2005	1		TDTC	0	7	0
39	Forrage chopper			1689	2	1 800 000.00	TDTC	3 600 000	323	11146
40	Soya milling machine			2007		5 500 000.00	TDTC	0	5	0
41	Soap grater			2007	2		TDTC	0	5	0
42	Briquet fired oven			2009	2	4 000 000.00	TDTC	8 000 000	3	2 666 667
43	Coffee Pulper Mini plant 7 HP	1 000	kg/hr	2007	1	5 500 000.00	TDTC	5 500 000	5	1 100 000
44	Energy Efficient Tobacco Barne	96	kg/5days	2007	10	1 500 000.00	TIRDO	15 000 000	5	3 000 000
45	Solar Drier For Agro-products	50	kg/3hrs	2006	100	1 500 000.00	TIRDO	150 000 000	6	25000000
46	Essential Oil Extracting Plant			1997	1	10 00 ,000.00	TIRDO	10 000 000	15	666667
47	Juice Extracting Plant	30	lir/hrs	2010	1	9 000 000.00	TIRDO	9 000 000	2	4 500 000
48	Nyumbu Track	3	tons	1982	40	40 000 000.00	TATC	1 600 000 000	30	53 333 333
49	Cargo Trailer	5	tons	1987	60	6 000 000.00	TATC	360 000 000	25	14 400 000
50	Fire Fighting Vehicle	7	tons	1993	2	150 000,000.00	TATC	300 000 000	19	15 789 474
51	Cashew Nut Processing Manual Plant			2009	40	4 000 000.00	TATC	160 000 000	3	53 333 333
52	Power Tiller	5	km/hr	2010	1	7 000 000.00	TATC	7 000 000	2	3 500 000
53	Brick Making Machine (Powered)			2006	70	9 000 000.00	TATC	630 000 000	6	105 000 000
54	Sisal Decorticator			2012	1	16 000 000.00	TATC	16 000 000	1	16 000 000
55	Oil screw Expeller	200	kg/hr (ssed)	1983	45	5 500 000.00	TEMDO	247 500 000	29	8 534 483
56	Oil Filter Press	150	ltr/hr	1994	12	1 800 000.00	TEMDO	21 600 000	18	1 200 000
57	Grain Seed Dresser (paddle)	5	kg/batch	1995	6	3 500 000.00	TEMDO	21 000 000	17	1 235 294
58	Maize Huller	1 500	kg/hr	1995	5	2 200 000.00	TEMDO	11 000 000	17	647 059
59	Small Maize Sheller	500	kg/hr	2004	20	1 400 000.00	TEMDO	28 000 000	8	3 500 000
60	Super Maize Sheller (PTO)	2 500	kg/hr	1998	25	1 000 000.00	TEMDO	25 000 000	14	1 785 714
61	Palm Fruit Digester (engine)	30	kg/batch	2005	10	2 600 000.00	TEMDO	26 000 000	7	3 714 286
62	Juice Pasteurizer	55	ltrs/batch	1994	2	1 900 000.00	TEMDO	3 800 000	18	211 111
63	Fruit Pulpier	500	ltrs/hr	2001	8	4 500 000.00	TEMDO	36 000 000	11	3 272 727
64	Tomato Seed Separator	300	kgs/hr	2002	12	4 500 000.00	TEMDO	54 000 000	10	5 400 000
65	Honey Press	12	ltrs/batch	1998	8	500 000.00	TEMDO	4 000 000	14	285 714
66	Honey Sieving	22.5	ltrs/batch	1998	6	300 000.00	TEMDO	1 800 000	14	128 571
67	Stem Wax Extractor	10.8	ltrs/batch	1998	0	600 000.00	TEMDO	0	14	0
68	Palm Oil Clarifier	200	ltrs/hr	2005	10	700 000.00	TEMDO	70 00 000	7	1 000 000
69	Cetrifuge Honey Extractor (Manual)	3	Frames/ batch	1998	5	800 000.00	TEMDO	4 000 000	14	285 714
70	Buter Churn	15	ltrs/hr (Milk)	2004	5	2 600 000.00	TEMDO	13000000	8	1625000
71	Solid Waste Incinerator	100	kg/hr	2002	14	50 000 000.00	TEMDO	700000000	10	70000000
72	Crator Briquete Machine			1993	3	4 500 000.00	TEMDO	13500000	19	710526
73	Leathe Processing Machine			2009	1	1 500 000.00	TEMDO	1500000	3	500000
74	Engine Driven Feed Choper			2007	4	12 000,000.00	CARMATEC	48000000	5	9600000
75	Biogas Plant	30.8	kw	1980	5 000	100 000.00	CARMATEC	500000000	32	15625000
76	Cook Stoves	Vario us		1980	10 000	100 000.00	CARMATEC	1000000000	32	31250000
77	Tomato Seed Separator			2008	8	3 500 000.00	CARMATEC	28000000	4	7 000 000

78	Tractor Carmatec Fast			2010	6	18 000 000	CARMATEC	108000000	2	54 000 000
79	Combination Planner	9	HP	2007	14	3 800,000.00	SIDO Arusha	53200000	5	10 640 000
80	Circular Saw	5.5	HP	2007	13	1 700 000.00	SIDO Arusha	22100000	5	4 420 000
81	Spindle Molder	3	HP	2007	10	1 600 000.00	SIDO Arusha	16000000	5	3 200 000
82	Wood Lathe Machine	4	HP	2007	11	1 000 000.00	SIDO Arusha	11000000	5	2 200 000
83	Bent Saw	5	HP	2007	3	1 600 000.00	SIDO Arusha	4800000	5	960 000
84	Maize Mill	550	kg/hrs	2007	52	2 300 000.00	SIDO Arusha	119600000	5	2 392 0000
85	Maize Huller	500	kg/hrs	2007	48	2 100 000.00	SIDO Arusha	100800000	5	20 160 000
86	Tractor Driven Mize Sheller	3000	kgs/hr	2007	7		SIDO Arusha	0	5	0
87	Sugar Cane Juice Extractor	30	ltrs/hr	2007	16	1 500 000.00	SIDO Arusha	24000000	5	4 800 000
88	Spices Milling Machine	90	kgs/hr	2008	11	1 400 000.00	SIDO Arusha	15400000	4	3 850 000
89	Concrete Block Moulders	Manual		2007	73	300 000.00	SIDO Arusha	21900000	5	43 80 000
90	Honey Press	12	ltrs/Batch	2011	6	400 000.00	SIDO Arusha	2400000	1	2 400 000
91	Honey Sieving Machine	25	lirs	2011	7	400 000.00	SIDO Arusha	2800000	1	2 800 000
92	Maize Mill	550	kgs/hr	2003	82	2 500 000.00	SIDO MBEYA	205000000	9	22 777 778
93	Maize huller	450	kgs/hr	2003	73	2 500 000.00	SIDO MBEYA	182500000	9	20 277 778
94	Maize Sheller	1000	kgs/hr	2003	50	2 800 000.00	SIDO MBEYA	140000000	9	15 555 556
95	Animal Feed Milling	240	kgs/hr	2005	64	1 250 000.00	SIDO MBEYA	80000000	7	11 428 571
96	Animal Feed Mixer	750	kgs/hr	2010	5	2 500 000.00	SIDO MBEYA	12500000	2	6 250 000
97	Animal Feed Mixer	1000	kgs/hr	2010	1	7 500 000.00	SIDO MBEYA	7500000	2	3 750 000
98	Wood Planner	5.5	HP	2003	20	3 500 000.00	SIDO MBEYA	70000000	9	7 777 778
99	Circular Saw	5.5	HP	2003	23	2 400 000.00	SIDO MBEYA	55200000	9	6 133 333
100	Ground Nut Sheller	3	HP	2003	13	1 850 000.00	SIDO MBEYA	24050000	9	2 672 222
101	Wood Turning Lathe	2	HP	2010	3	700 000.00	SIDO MBEYA	2100000	2	1 050 000
102	Cofee Pulper 7 HP	1000	kgs/hr	2008	13	5 500 000.00	SIDO MBEYA	71500000	4	17 875 000
103	Palm Oil Diggester	50	kgs/batch	2003	5	3 200 000.00	SIDO MBEYA	16000000	9	1 777 778
104	Candle Moulding machine (Manual)			2005	300	350 000.00	SIDO Kilimanjaro	105000000	7	15 000 000
105	Winnery Machine (Manual)			2011	1	2 700 000.00	SIDO Kilimanjaro	2700000	1	2 700 000
106	Energy Serving Stove			2006	80	700 000.00	SIDO Kilimanjaro	56000000	6	9 333 333
107	Bottle Capping (Manual) Machine			2011	10	100 000.00	SIDO Kilimanjaro	1 000 000	1	1 000 000
108	Daugh Kneeder	30	kgs/batch	2008	1	2 000 000.00	SIDO Kilimanjaro	2 000 000	4	500 000
109	Juice Blender Electric	4	HP	2006	30	800 000.00	SIDO Kilimanjaro	24 000 000	6	4 000 000
110	Backery Oven			2006	20	900 000.00	SIDO Kilimanjaro	18 000 000	6	3 000 000
111	Cake Oven			2008	8	800 000.00	SIDO Kilimanjaro	6 400 000	4	1 600 000
112	Maize Milling Machine	700	kgs/hr	2004	300	2 500 000.00	SIDO Kilimanjaro	750 000 000	8	93 750 000
113	Maize Huller	400	kgs/hr	2004	300	2 500 000.00	SIDO Kilimanjaro	750 000 000	8	93 750 000
114	Cetrifuge Honey Extractor (Manual)	3	Frames/ batch	2011	1	300 000.00	SIDO Kilimanjaro	300 000	1	300 000
115	Honney Press Manual	12	ltrs/batch	2010	10	350 000.00	SIDO Kilimanjaro	3 500 000	2	1 750 000
116	Ground Nut Sheller Manual	120	kg/hr	2012	2	250 000.00	SIDO Kilimanjaro	500 000	1	500 000

Appendix 9: Summary of the Finding in the Model and Data Collection

	Technology	Model at 120	QTY	Value	rate finance	rate qty	Finance index	Quantity index	Qty Ind	Val Ind	Ave
[Tech1]	Maize Milling Machine	0.53092	300	750 000 000.00	93 750 000.00	37.5	1.00	0.24	0.06	0.47	0.442
[Tech2]	Nyumbu Track	0.43247	40	1 600 000 000.00	53 333 333.33	1.3	0.57	0.01	0.008	1.00	0.396
[Tech3]	Solar Drier For Agro-products	0.54418	100	150 000 000.00	25 000 000.00	16.7	0.27	0.11	0.02	0.09	0.122
[Tech4]	Maize huller	0.31579	73	182 500 000.00	20 277 777.78	8.1	0.22	0.05	0.0146	0.11	0.099
[Tech5]	Coffee Pulper 7 HP	0.28769	13	71 500 000.00	17 875 000.00	3.3	0.19	0.02	0.0026	0.04	0.065
[Tech6]	Biogas Plant	0.82221	5000	500 000 000.00	15 625 000.00	156.3	0.17	1.00	1	0.31	0.620
[Tech7]	Oil screw Expeller	0.27087	45	247 500 000.00	8 534 482.76	1.6	0.09	0.01	0.009	0.15	0.066
[Tech8]	Circular Saw	0.23824	23	55 200 000.00	6 133 333.33	2.6	0.07	0.02	0.0046	0.03	0.030
[Tech9]	Sugar Cane Juice Extractor	0.23745	16	24 000 000.00	4 800 000.00	3.2	0.05	0.02	0.0032	0.02	0.022
[Tech10]	Juice Blender Electric	0.36766	30	24 000 000.00	4 000 000.00	5.0	0.04	0.03	0.006	0.02	0.024
[Tech11]	Animal Feed Mixer	0.25408	1	500 000.00	3 750 000.00	0.5	0.04	0.00	0.0002	0.00	0.012
[Tech12]	Small Maize Sheller	0.31062	20	28 000 000.00	3 500 000.00	2.5	0.04	0.02	0.004	0.02	0.019
[Tech13]	Soap stock mixing tank boiling kettle	0.22999	5	22 500 000.00	2 812 500.00	0.6	0.03	0.00	0.001	0.01	0.012
[Tech14]	Winery Machine (Manual)	0.23307	1	2 700 000.00	2 700 000.00	1.0	0.03	0.01	0.0002	0.00	0.009
[Tech15]	Soap extruder	0.18691	6	21 000 000.00	2 625 000.00	0.8	0.03	0.00	0.0012	0.01	0.012
[Tech16]	Honey Press	0.18921	6	2 400 000.00	2 400 000.00	6.0	0.03	0.04	0.0012	0.00	0.017
[Tech17]	Maize mill	0.24344	25	52 500 000.00	4 772 727.27	2.3	0.05	0.01	0.005	0.03	0.026
[Tech18]	Palm Oil Digester	0.21321	5	16 000 000.00	1 777 777.78	0.6	0.02	0.00	0.001	0.01	0.008
[Tech19]	Butter Churn	0.18492	5	13 000 000.00	1 625 000.00	0.6	0.02	0.00	0.001	0.01	0.008
[Tech20]	2 Roller hammer	0.18904	22	34 320 000.00	3 120 000.00	2.0	0.03	0.01	0.0044	0.02	0.018
[Tech21]	Grain Seed Dresser (paddle)	0.18866	6	21 000000.00	1 235 294.12	0.4	0.01	0.00	0.0012	0.01	0.007
[Tech22]	Rice huller	0.16697	1	8 000 000.00	1 142 857.14	0.1	0.01	0.00	0.0002	0.01	0.005
[Tech23]	Palm Oil Clarifier	0.24692	10	7 000 000.00	1 000 000.00	1.4	0.01	0.01	0.002	0.00	0.007

[Tech24]	Maize thresher	0.16935	1	2 500 000.00	833 333.33	0.3	0.01	0.00	0.0002	0.00	0.003
[Tech25]	Palm Fruit Clarifier	0.16444	4	9 120 000.00	829 090.91	0.4	0.01	0.00	0.0008	0.01	0.004
[Tech26]	Palm fruit thresher	0.14286	2	5 510 000.00	500 909.09	0.2	0.01	0.00	0.0004	0.00	0.003
[Tech27]	Honey Press	0.17525	8	4 000 000.00	285 714.29	0.6	0.00	0.00	0.0016	0.00	0.003
[Tech28]	Juice Pasteurizer	0.17419	2	3 800 000.00	211 111.11	0.1	0.00	0.00	0.0004	0.00	0.001
[Tech29]	Sunflower winnower	0.14393	1	2 000 000.00	181 818.18	0.1	0.00	0.00	0.0002	0.00	0.001
[Tech30]	Palm Fruit Sterilizing Tank	0.14614	2	1 440 000.00	130 909.09	0.2	0.00	0.00	0.0004	0.00	0.001

Dependent Variable: Lnqtymanufacture Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.631	.701		-2.328	.029
	Customer Proposal	1.049	.191	.474	5.499	.000
	National need assessment	2.628	.360	.732	7.300	.000
	Project charter	-1.635	.499	-.313	-3.273	.003
	Manufacturer proposal	2.310	.495	.560	4.670	.000
	With donors	.637	.193	.257	3.294	.003
	Customer recommendation	-1.725	.510	-.343	-3.383	.003
	Business plan	-.979	.409	-.249	-2.396	.026
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	9.993	.700		14.274	.000
	National need assessment	2.253	.317	.652	7.100	.000
	Customer Proposal	.357	.291	.167	1.227	.232
	Manufacturer proposal	.884	.370	.222	2.389	.025
	With donors	.724	.232	.304	3.127	.005
	Customer order	.689	.311	.307	2.214	.037
Dependent Variable: Lnsalesperunum Coefficientsa						
3	(Constant)	9.071	.629		14.423	.000
	Customer Proposal	1.454	.162	.770	8.971	.000
	Project charter	1.698	.375	.382	4.529	.000
	Manufacturer proposal	.719	.303	.204	2.373	.025

Appendix 10: Initiation Regression Analysis Independent Variables

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.946g	.894	.860	.71173	.026	2.738

Lnsalesvalue	.914e	.835	.801	.81835	.037	2.250
Lnsalesperunum	.904c	.816	.795	.73530	.025	1.310

Dependent Variable: Lnqtymanufacture Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.989	.989		-1.719	.097
	Designers skills	.415	.415	.490	3.257	.003
	Undefined evaluation	.343	.343	.327	2.170	.039
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	12.892	.861		14.977	.000
	Designers skills	1.085	.387	.409	2.805	.010
	Undefined evaluation	.667	.288	.304	2.319	.029
	Product Synthesis	1.219	.419	.418	2.909	.008
	Computer models	-.714	.323	-.312	-2.214	.036
Dependent Variable: Lnsalesperunum Coefficientsa						
3	(Constant)	12.674	.842		15.054	.000
	Designers skills	1.576	.365	.671	4.313	.000
	Computer models	-.853	.315	-.421	-2.710	.012

Appendix 11: Conceptualisation Regression Analysis Dependent Variables

Conceptualisation Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.645b	.416	.373	1.50788	.039	2.139
Lnsalesvalue	.788d	.621	.561	1.21620	.036	1.797
Lnsalesperunum	.654b	.428	.386	1.27305	.012	.567

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.111	.949		-2.225	.035
	Done in 2D board 2	1.605	.290	.717	5.526	.000
	Done on 3D software 3	1.704	.676	.327	2.519	.018
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	12.588	1.040		12.098	.000
	Done in 2D board 3	1.604	.335	.743	4.787	.000
	Done on 2D software 2	.906	.348	.404	2.606	.015
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	11.432	.949		12.051	.000
	Done in 2D board 3	1.095	.291	.573	3.769	.001
	Done on 3D software 1	1.502	.676	.338	2.221	.035

Appendix 12: Drawings independent variables coefficients

Drawings Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.745b	.555	.522	1.31680	.018	2.182
Lnsalesvalue	.681b	.464	.424	1.39255	.015	.827
Lnsalesperunum	.623b	.388	.343	1.31700	.035	.742

Appendix 13: Design independent variables coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
1	(Constant)	-5.901	1.692		-3.488	.002
	Depend on availability	.936	.426	.271	2.196	.038
	Strength	1.710	.414	.453	4.131	.000
	Factor of safety	-1.136	.409	-.336	-2.775	.011
	Performance	.018	.403	.007	.045	.964
	Overall price of the product	1.650	.368	.634	4.481	.000
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	3.819	1.762		2.167	.040
	Depend on availability	.344	.461	.103	.747	.462
	Strength	1.990	.409	.547	4.863	.000
	Overall price of the product	1.036	.304	.413	3.408	.002
	Ability to manufacture	1.559	.486	.451	3.204	.004
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	8.490	1.309		6.485	.000
	Depend on availability	1.254	.369	.425	3.403	.002
	Durability	-1.033	.327	-.358	-3.157	.004
	Overall price of the product	.537	.272	.242	1.971	.060
	Cost of manufacturing	.820	.430	.245	1.907	.069

Design Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.852e	.727	.670	1.09414	.000	1.914
Lnsalesvalue	.845d	.714	.668	1.05697	.004	1.635
Lnsalesperunum	.865e	.748	.695	.89661	.017	.722

Appendix 14: Prototyping independent variables

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-5.469	1.544		-3.543	.002
	Drawings	.842	.245	.347	3.438	.002
	Samples	-.138	.488	-.036	-.282	.780
	Jigs	1.459	.309	.538	4.724	.000
	Prototype	1.444	.675	.277	2.140	.042
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	7.940	1.707		4.650	.000
	Drawings	1.156	.275	.494	4.196	.000
	Fixtures	1.761	.410	.484	4.295	.000
	Prototype	1.421	.594	.283	2.391	.024
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	9.184	.943		9.743	.000
	Drawings	.816	.263	.394	3.108	.005
	Samples	.981	.411	.304	2.389	.024
	Fixtures	1.667	.398	.517	4.195	.000

Prototyping Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.885d	.782	.748	.95656	.042	1.808
Lnsalesvalue	.820c	.673	.635	1.10842	.024	1.454
Lnsalesperunum	.779c	.608	.562	1.07486	.000	1.071

Appendix 15: Validation independent general variables

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.475	.667		-3.712	.001
	End users	.906	.273	.413	3.314	.003
	Financiers	.548	.365	.213	1.502	.145
	Durability	1.063	.394	.386	2.697	.012
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	9.719	1.008		9.645	.000
	R&D engineers	1.265	.429	.359	2.949	.007
	End users	.801	.244	.379	3.283	.003
	Durability	.855	.321	.322	2.661	.013
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	7.883	.656		12.009	.000
	R&D Technicians	.733	.258	.399	2.842	.009
	R&D engineers	1.250	.271	.401	4.613	.000
	End users	.507	.246	.271	2.061	.049

Validation Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.843c	.711	.677	1.08129	.012	2.079
Lnsalesvalue	.873c	.762	.734	.94621	.013	1.759
Lnsalesperunum	.933c	.871	.856	.61713	.049	1.580

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.169	.998		-1.171	.252
	Durability	1.993	.370	.724	5.383	.000
	Throughput	1.271	.334	.547	3.811	.001
	Ergonomics	-1.776	.745	-.386	-2.385	.025
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	11.638	.700		16.625	.000
	Durability	1.343	.311	.506	4.314	.000
	Throughput	1.080	.263	.482	4.109	.000
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	9.172	.638		14.372	.000
	Throughput	1.118	.230	.564	4.852	.000
	Durability	.607	.231	.258	2.621	.014
	Robustness	.738	.346	.248	2.132	.043

Appendix 16: Validation independent engineering variables

Validation Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.835c	.697	.662	1.10744	.025	1.896
Lnsalesvalue	.833b	.694	.672	1.05113	.000	1.513
Lnsalesperunum	.896c	.803	.780	.76151	.043	1.063

Appendix 17: Validation Output Independent Engineering Variable

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-1.292	.630		-2.052	.050
	Approved technology	1.905	.308	.759	6.177	.000
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	13.744	.678		20.263	.000
	Approved technology	1.660	.332	.686	4.996	.000
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	11.650	.537		21.699	.000
	Approved means of operation	.810	.289	.485	2.805	.009
	Approved technology	.760	.370	.355	2.052	.050

Validation Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.759a	.577	.562	1.26068	.000	1.576
Lnsalesvalue	.686a	.471	.452	1.35788	.000	1.323
Lnsalesperunum	.781b	.610	.581	1.05203	.050	1.307

Appendix 18: Transfer Package Variables Coefficients

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.408	1.005		-4.387	.000
	Operation manual	1.793	.454	.515	3.951	.001
	Bill of material	1.110	.315	.414	3.525	.002
	Engineering drawings	.459	.239	.221	1.925	.066
	Finance sources	1.233	.438	.299	2.813	.009
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	11.284	1.057		10.677	.000
	Bill of material	1.296	.371	.502	3.498	.002
	Fixtures	1.912	1.057	.264	1.809	.082
	Finance sources	1.212	.501	.305	2.418	.023
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	10.980	.759		14.475	.000
	Bill of material	1.226	.308	.537	3.985	.000
	Finance sources	1.544	.474	.438	3.254	.003

Transfer package Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.856d	.732	.690	1.06087	.009	2.290
Lnsalesvalue	.777c	.604	.558	1.22028	.023	1.591
Lnsalesperunum	.716b	.513	.477	1.17515	.003	1.341

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.546	.683		-6.652	.000
	Operation manual	1.140	.369	.327	3.093	.005
	Project Brief	.867	.267	.305	3.255	.003
	Bill of material	.974	.250	.364	3.902	.001
	Done on 3D software 3	1.291	.473	.248	2.728	.012
	Done in 2D board 1	.562	.236	.249	2.381	.026
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	10.479	.755		13.877	.000
	Drawings	1.168	.232	.500	5.036	.000
	Bill of material	1.222	.261	.474	4.689	.000
	Customer order	.813	.221	.363	3.685	.001

Appendix 19: Documentation Independent Variables

Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	8.983	.522		17.194	.000
	Customer order	1.046	.189	.528	5.526	.000
	Project Brief	.725	.209	.298	3.468	.002
	Bill of material	1.332	.238	.583	5.601	.000
	Drawings	.832	.198	.402	4.206	.000
	Technology profile	-.996	.288	-.335	-3.461	.002
	Operation manual	-.891	.311	-.300	-2.868	.009
	Business case	.676	.307	.210	2.204	.038

Documentation Model Prediction Power

Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.924e	.854	.823	.80050	.026	2.140
Lnsalesvalue	.872e	.760	.732	.94930	.272	2.216
Lnsalesperunum	.944i	.890	.856	.61736	.038	1.715

Appendix 20: Stages Independent Variables

Dependent Variable: Lnqtymanufacture Coefficientsa						
Dependent Variable: LnQtyManufactured Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.231	1.553		-2.724	.011
	Transfer	2.636	.725	.525	3.637	.001
	Validation	1.771	.664	.385	2.667	.013
Dependent Variable: Lnsalesvalue Coefficientsa						
2	(Constant)	9.950	1.550		6.420	.000
	Validation	1.920	.703	.433	2.732	.011
	Prototyping	1.269	.572	.352	2.220	.035
Dependent Variable: Lnsalesperunum Coefficientsa						
5	(Constant)	7.448	1.124		6.624	.000
	Prototyping	1.571	.415	.492	3.788	.001
	Validation	1.753	.510	.446	3.438	.002

Stages Model Prediction Power

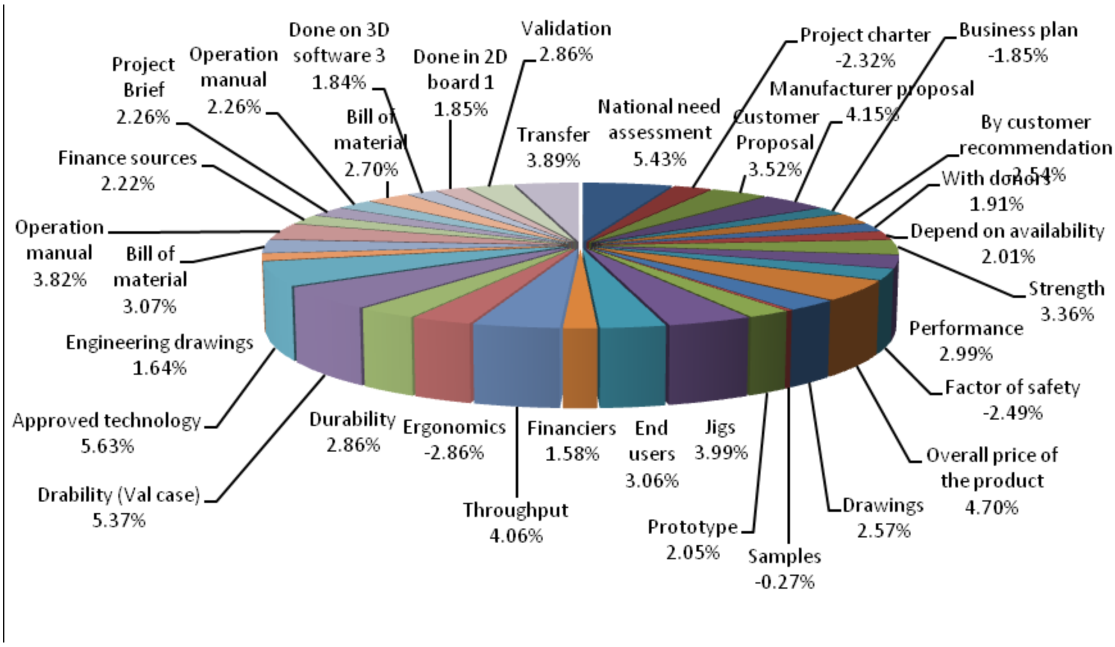
Dependent Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
Lnqtymanufacture	.662b	.438	.397	1.47872	.013	.914
Lnsalesvalue	.660b	.436	.394	1.42839	.035	1.312
Lnsalesperunum	.788b	.621	.593	1.03627	.002	1.130

Appendix 21: Summary of Y1 Coefficients

Stage	Sub stage	Code	Variable name	X1	(ß) Y1	(ß) Y1 Std	t sig	R^2	Udj R^2	d
Initiation	Source of need identification 1.1	1.1.3.	National need assessment	X1	2.628	0.732	0.000	0.894	0.86	2.7
	Technology approval methods 1.2.	1.2.2	Project charter	X5	-1.653	-0.313	0.003	0.894	0.86	2.7
	Development of capacity of technology 1.3.	1.3.1	Customer Proposal	X2	1.049	0.474	0.000	0.894	0.86	2.7
		1.3.2	Manufacturer proposal	X4	2.31	0.56	0.000		0.86	2.7
		1.3.4	Business plan	X7	-0.979	-0.249	0.026	0.894	0.86	2.7
	Establishment of the price limit for the technology 1.4.	1.4.3	By customer recommendation	X6	-1.725	-0.343	0.003	0.894	0.86	2.7
	Review methods of technology initiation 1.5	1.5.5.	With donors	X3	0.637	0.257	0.003	0.894	0.86	2.7
Engineering analysis 3	Selection of material 3_1	3.1.1.	Depend on availability	X13	0.936	0.271	0.038	0.727	0.67	1.914
	Sizing of components 3_2	3.2.1.	Strength	X14	1.71	0.453	0.000	0.727	0.67	1.914
		3.2.3.	Performance	X16	0.018	0.403	0.964	0.727	0.67	1.914
		3.2.4.	Factor of safety	X15	-1.136	-0.336	0.011	0.727	0.67	1.914
	Price of components (What is the main constraint) 3_4	3.4.1.	Overall price of the product	X17	1.65	0.634	0.000	0.727	0.67	1.914
Prototyping 5	Prototype development control 5_1	5.1.1.	Drawings	X22	0.842	0.347	0.002	0.782	0.748	1.808
		5.1.2.	Samples	X23	-0.138	-0.036	0.780	0.782	0.748	1.808
	Prototype package 5_2	5.2.1.	Prototype	X25	1.444	0.277	0.042	0.782	0.748	1.808
		5.2.2.	Jigs	X24	1.459	0.538	0.000	0.782	0.748	1.808

Validation 6_1	Validation stake holders 6_1	6.1.3.	End users	X27	0.906	0.413	0.003	0.711	0.677	2.079
		6.1.4.	Financiers	X28	0.548	0.213	0.145	0.711	0.677	2.079
	Validation contents 6_2	6.2.1.	Throughput	X51	1.271	0.547	0.001	0.697	0.662	1.896
		6.2.5.	Ergonomics	X52	-1.776	-0.386	0.025	0.697	0.662	1.896
		6.2.7.	Durability	X29	1.063	0.386	0.012	0.711	0.677	2.079
			Durability (Val case)	X29	1.993	0.724	0.000	0.697	0.662	1.896
	Validation Process output 6_3	6.3.5.	Approved technology	X54	1.91	0.759	0.000	0.577	0.562	1.576
Transfer 7_1	Transfer package	7.1.1.	Engineering drawings	X34	0.459	0.221	0.066	0.732	0.690	2.290
		7.1.3.	Bill of material	X33	1.11	0.414	0.002	0.732	0.690	2.290
		7.1.9	Operation manual	X32	1.793	0.515	0.001	0.732	0.690	2.290
		7.1.13	Finance sources	X35	1.233	0.299	0.009	0.732	0.690	2.290
Document at 8_3	Documentation 8_3	8.3.1.	Project Brief	X38	0.867	0.305	0.003	0.854	0.823	2.140
		8.3.6.	Operation manual	X37	1.14	0.305	0.005	0.854	0.823	2.140
		8.3.7.	Bill of material	X39	0.974	0.364	0.001	0.854	0.823	2.140
		8.3.8.	Done on 3D software 3	X40	1.291	0.248	0.012	0.854	0.823	2.140
		8.3.9.	Done in 2D board 1	X41	0.562	0.249	0.026	0.854	0.823	2.140
Stages.8_4	Stages.8_4	8.4.5.	Validation	X49	1.771	0.385	0.013	0.438	0.397	0.914
		8.4.6.	Transfer	X48	2.636	0.525	0.001	0.438	0.397	0.914

Appendix 22: Y1 Coefficients

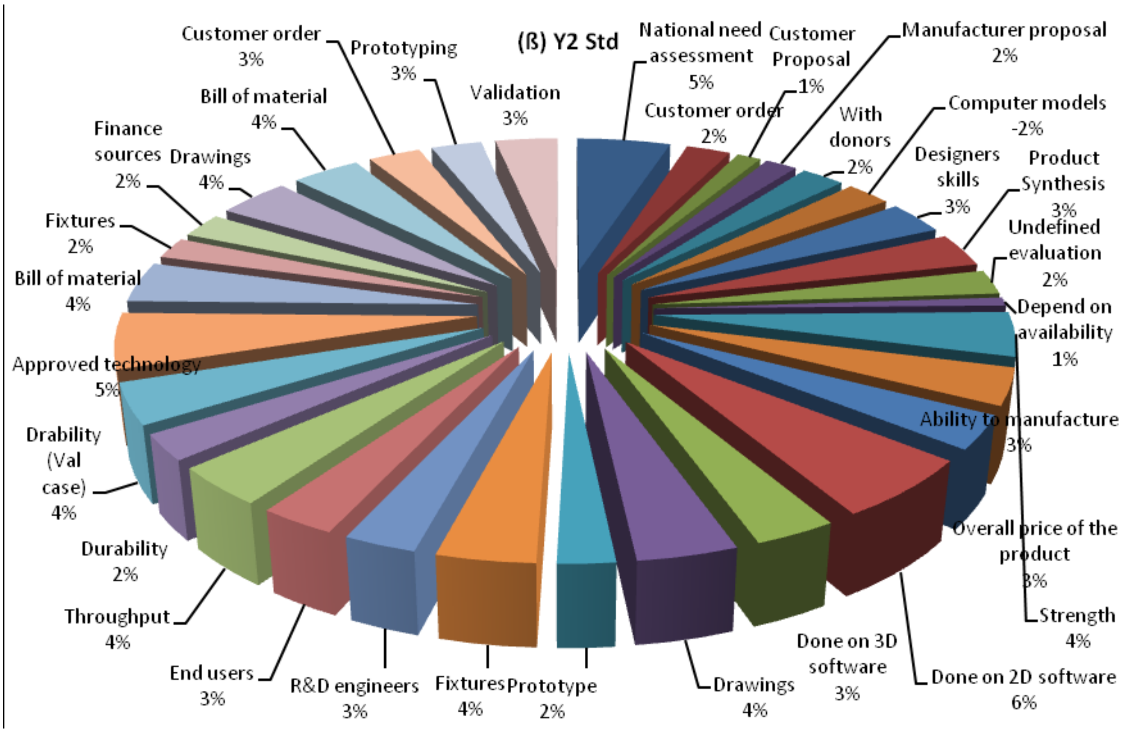


Appendix 23: Summary of Y2 coefficients

Stage	Sub stage	Code	Variable name	Xi	(ß) Y2	(ß) Y2 Std	t sig	R2	Adj R2	d
Initiation stage 1.	Source of need identification 1.1	1.1.3.	National need assessment	X1	2.253	0.652	0.000	0.835	0.801	2.250
	Technology approval methods 1.2.	1.2.1	Customer order	X8	0.689	0.307	0.037	0.835	0.801	2.250
	Development of capacity of technology 1.3.	1.3.1	Customer Proposal	X2	0.357	0.167	0.232	0.835	0.801	2.250
		1.3.2	Manufacturer proposal	X4	1.379	0.222	0.025	0.835	0.801	2.250
	Review methods of technology initiation 1.5	1.5.5.	With donors	X3	0.724	0.304	0.005	0.835	0.801	2.250
Conceptualization 2	Tool used for concept development 2_2	2.2.3.	Computer models	X12	-0.714	-0.312	0.036	0.621	0.561	1.797
		2.2.4	Designers skills	X9	1.089	0.409	0.010	0.621	0.561	1.797
		2.2.5.	Product Synthesis	X11	1.219	0.418	0.008	0.621	0.561	1.797
	Alternative concepts selection 2_3	2.3.1.	Undefined evaluation	X10	0.667	0.304	0.029	0.621	0.561	1.797
Engineering analysis 3	Selection of material Q3_1	3.1.1.	Depend on availability	X13	0.344	0.103	0.462	0.714	0.668	1.635
	Sizing of components 3_2	3.2.1.	Strength	X14	1.990	0.547	0.000	0.714	0.668	1.635
	Manufacturing of components (Technology process selection) 3_3	3.3.1.	Ability to manufacture	X18	1.559	0.451	0.004	0.714	0.668	1.635
	Price of components (What is the main constraint) 3_4	3.4.1.	Overall price of the product	X17	1.036	0.413	0.002	0.714	0.668	1.635
Drawing development 4	Detail drawings 4_3	4.2.3.	Done on 2D software	X56	1.605	0.743	0.000	0.464	0.424	0.827
		4.3.4.	Done on 3D software	X51	1.704	0.404	0.015	0.464	0.424	0.827
Prototyping 5	Prototype development control 5_1	5.1.1.	Drawings	X22	1.156	0.49	0.00	0.67	0.64	1.45
	Prototype package 5_2	5.2.1.	Prototype	X25	1.421	0.28	0.02	0.67	0.64	1.45
		5.2.3.	Fixtures	X26	1.761	0.48	0.00	0.67	0.64	1.45

Validation 6_1	Validation stake holders 6_1	6.1.1.	R&D engineers	X30	1.265	0.359	0.007	0.762	0.734	1.759
		6.1.3.	End users	X27	0.801	0.379	0.003	0.762	0.734	1.759
	Validation contents 6_2	6.2.1.	Throughput	X51	1.08	0.482	0.000	0.694	0.672	1.513
		6.2.7.	Durability	X29	0.855	0.322	0.013	0.762	0.734	1.759
			Durability (Val case)	X29	1.343	0.506	0.000	0.694	0.672	1.513
	Validation Process output 6_3	6.3.5.	Approved technology	X54	1.66	0.686	0.000	0.610	0.581	1.307
Transfer 7_1	Transfer package	7.1.3.	Bill of material	X33	1.296	0.502	0.002	0.604	0.558	1.591
		7.1.6.	Fixtures	X36	1.912	0.264	0.082	0.604	0.558	1.591
		7.1.13	Finance sources	X35	1.212	0.305	0.023	0.604	0.558	1.591
Documentation 8_3	Documentation 8_3	8.3.10	Drawings	X42	1.168	0.500	0.000	0.760	0.732	2.216
		8.3.11	Bill of material	X43	1.222	0.474	0.000	0.760	0.732	2.216
		8.3.12	Customer order	X44	0.813	0.363	0.001	0.760	0.732	2.216
Stages.8_4	Stages.8_4	8.4.4.	Prototyping	X50	1.269	0.352	0.035	0.436	0.394	1.312
		8.4.5.	Validation	X49	1.92	0.433	0.011	0.436	0.394	1.312

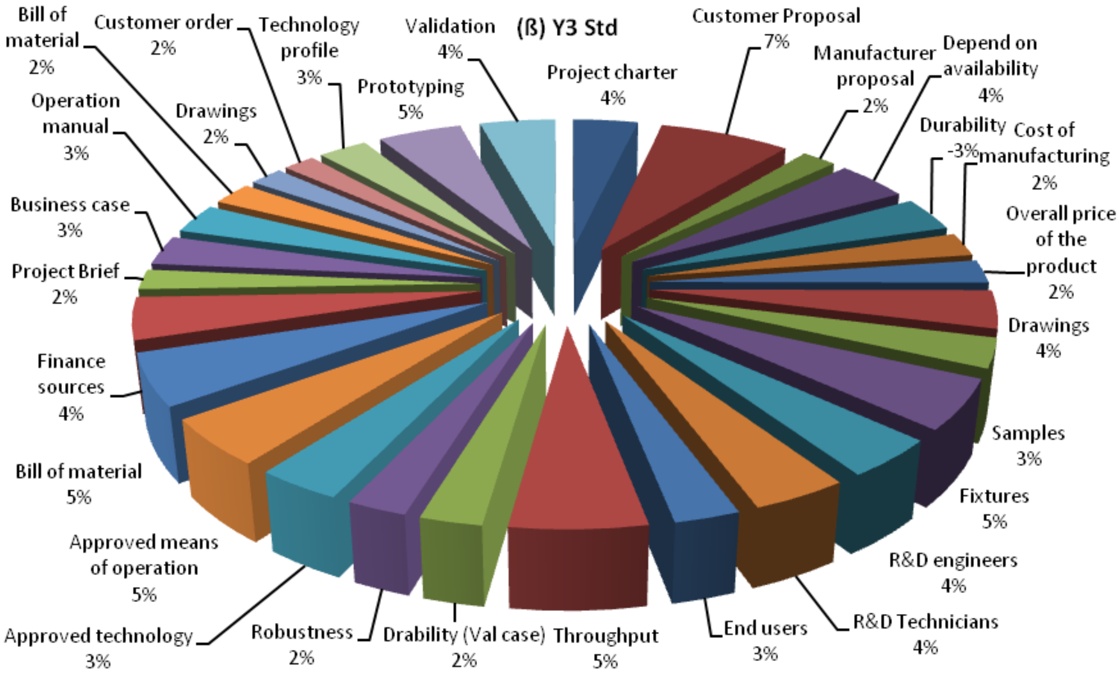
Appendix 24: Y2 Coefficients



Appendix 25: Summary of Y_3 Coefficients

Stage	Sub stages	Code	Variable name	Xi	(ß) Y3	(ß) Y3 Std	t sig	R2	Adj R2	d
Initiation stage 1.	Technology approval methods 1.2.	1.2.2	Project charter	X5	1.698	0.382	0.000	0.816	0.795	1.310
	Development of capacity of technology 1.3.	1.3.1	Customer Proposal	X2	1.454	0.770	0.000	0.816	0.795	1.310
		1.3.2	Manufacturer proposal	X4	0.719	0.204	0.025	0.816	0.795	1.310
Engineering analysis 3	Selection of material Q3_1	3.1.1.	Depend on availability	X13	1.254	0.425	0.002	0.748	0.695	0.722
		3.1.5.	Durability	X19	-1.033	-0.358	0.004	0.748	0.695	0.722
	Manufacturing of components (Technology process selection) 3_3	3.3.2.	Cost of manufacturing	X20	0.82	0.245	0.069	0.748	0.695	0.722
	Price of components (What is the main constraint) 3_4	3.4.1.	Overall price of the product	X17	0.537	0.242	0.06	0.748	0.695	0.722
Prototyping 5	Prototype development control 5_1	5.1.1.	Drawings	X22	0.816	0.394	0.005	0.608	0.562	1.071
		5.1.2.	Samples	X23	0.981	0.304	0.024	0.608	0.562	1.071
	Prototype package 5_2	5.1.3.	Fixtures	X26	1.667	0.517	0.000	0.608	0.562	1.071
Validation 6_1	Validation stake holders 6_1	6.1.1.	R&D engineers	X30	1.25	0.401	0.000	0.871	0.856	1.580
		6.1.2.	R&D Technicians	X31	0.733	0.399	0.009	0.871	0.856	1.580
		6.1.3.	End users	X27	0.507	0.271	0.049	0.871	0.856	1.580
	Validation contents 6_2	6.2.1.	Throughput	X51	1.11	0.564	0.000	0.803	0.780	1.063
			Durability (Val case)	X29	0.607	0.258	0.014	0.803	0.780	1.063
		6.2.8.	Robustness	X53	0.738	0.248	0.043	0.803	0.780	1.063
	Validation Process output 6_3	6.3.5.	Approved technology	X54	0.76	0.355	0.050	0.610	0.581	1.307
		6.3.7.	Approved means of operation	X55	0.81	0.485	0.009	0.610	0.581	1.307
Transfer 7_1	Transfer package	7.1.3.	Bill of material	X33	1.226	0.537	0.000	0.513	0.477	1.341
		7.1.13	Finance sources	X35	1.544	0.438	0.003	0.513	0.477	1.341
Documentation 8_3	Documentation 8_3	8.3.1.	Project Brief	X38	0.725	0.209	0.002	0.890	0.856	1.715
		8.3.3.	Business case	X47	0.676	0.307	0.038	0.890	0.856	1.715
		8.3.6.	Operation manual	X37	-0.891	0.311	0.009	0.890	0.856	1.715
		8.3.7.	Bill of material	X39	1.332	0.238	0.000	0.890	0.856	1.715
		8.3.10	Drawings	X42	0.832	0.198	0.000	0.890	0.856	1.715
		8.3.12	Customer order	X44	1.046	0.189	0.000	0.890	0.856	1.715
		8.3.13	Technology profile	X45	-0.996	0.288	0.002	0.890	0.856	1.715
Stages.8_4	Stages.8_4	8.4.4.	Prototyping	X50	1.571	0.492	0.001	0.621	0.593	1.130
		8.4.5.	Validation	X49	1.753	0.446	0.002	0.621	0.593	1.130

Appendix 26: Y_3 Coefficients



Appendix 27: Summary of Combined Variables Standard Coefficients

Stage	Sub stage	Code	Variable name	Xi	sum of (ß)
Initiation	Source of need identification 1.1	1.1.3.	National need assessment	X1	1.384
	Technology approval methods 1.2.	1.2.1	Customer order	X8	0.307
		1.2.2	Project charter	X5	0.069
	Development of capacity of technology 1.3.	1.3.1	Customer Proposal	X2	1.411
		1.3.2	Manufacturer proposal	X4	0.986
		1.3.4	Business plan	X7	-0.249
	Establishment of the price limit for the technology 1.4.	1.4.3	By customer recommendation	X6	-0.343
	Review methods of technology initiation 1.5	1.5.5.	With donors	X3	0.561
Conceptualization 2	Tool used for concept development 2_2	2.2.3.	Computer models	X12	-0.312
		2.2.4	Designers skills	X9	0.409
		2.2.5.	Product Synthesis	X11	0.418
	Alternative concepts selection 2_3	2.3.1.	Undefined evaluation	X10	0.304
Engineering analysis 3	Review methods of technology initiation 1.5	3.1.1.	Depend on availability	X13	0.799
	Selection of material 3_1	3.2.1.	Strength	X14	1.000
		3.1.5.	Durability	X19	-0.358
		3.3.2.	Cost of manufacturing	X20	0.245
	Sizing of components 3_2	3.2.3.	Performance	X16	0.403
		3.2.4.	Factor of safety	X15	-0.336
		3.4.1.	Overall price of the product	X17	1.289
	Manufacturing of components (Technology process selection) 3_3	3.3.1.	Ability to manufacture	X18	0.451
Prototyping 5	Price of components (constraint) 3_4	5.1.1.	Drawings	X22	1.231
	Prototype development control 5_1	5.1.2.	Samples	X23	0.268
	Prototype package 5_2	5.2.1.	Prototype	X25	0.557
		5.2.2.	Jigs	X24	0.538
		5.2.3.	Fixtures	X26	0.997
Validation 6	Validation stake holders 6_1	6.1.1.	R&D engineers	X30	0.760
		6.1.2.	R&D Technicians	X31	0.399
		6.1.3.	End users	X27	1.063
		6.1.4.	Financiers	X28	0.213
	Validation contents 6_2	6.2.1.	Throughput	X51	1.593
		6.2.5.	Ergonomics	X52	-0.386
		6.2.7.	Durability	X29	0.966
			Durability (Val case)	X29	1.230
	Validation Process output 6_3	6.2.8.	Robustness	X53	0.248
		6.3.5.	Approved technology	X54	1.800
		6.3.7.	Approved means of operation	X55	0.485
Transfer 7	Transfer package	7.1.1.	Engineering drawings	X34	0.221
		7.1.3.	Bill of material	X33	1.453
		7.1.9	Operation manual	X32	0.515
		7.1.13	Finance sources	X35	1.042
		7.1.6.	Fixtures	X36	0.264
Document at 8_3	Documentation 8_3	8.3.1.	Project Brief	X38	0.514
		8.3.3.	Business case	X47	0.307
		8.3.6.	Operation manual	X37	0.616
		8.3.7.	Bill of material	X39	0.602
		8.3.8.	Done on 3D software 3	X40	0.248
		8.3.9.	Done in 2D board 1	X41	0.249
		8.3.10	Drawings	X42	0.698
		8.3.11	Bill of material	X43	0.474
		8.3.12	Customer order	X44	0.552
		8.3.13	Technology profile	X45	0.288
Stages.8_4	Stages.8_4	8.4.5.	Validation	X49	1.264
		8.4.6.	Transfer	X48	0.525
		8.4.4.	Prototyping	X50	0.844

Appendix 28:

Stage	Sub stage	Code	Variable name	X_i	sum of (ß)	sum of (ß) in the stage	sum of (ß) stage ratio
Initiation	Source of need identification 1.1	1.1.3.	National need assessment	X_1	1.384	4.126	0.132771
	Technology approval methods 1.2.	1.2.1	Customer order	X_8	0.307		
		1.2.2	Project charter	X_5	0.069		
	Development of capacity of technology 1.3.	1.3.1	Customer Proposal	X_2	1.411		
		1.3.2	Manufacturer proposal	X_4	0.986		
		1.3.4	Business plan	X_7	-0.249		
	Establishment of the price limit for the technology 1.4.	1.4.3	By customer recommendation	X_6	-0.343		
	Review methods of technology initiation 1.5	1.5.5.	With donors	X_3	0.561		
Conceptualization 2	Tool used for concept development 2_2	2.2.3.	Computer models	X_{12}	-0.312	0.819	0.026355
		2.2.4	Designers skills	X_9	0.409		
		2.2.5.	Product Synthesis	X_{11}	0.418		
	Alternative concepts selection 2_3	2.3.1.	Undefined evaluation	X_{10}	0.304		
Engineering analysis 3	Review methods of technology initiation 1.5	3.1.1.	Depend on availability	X_{13}	0.799	3.493	0.112402
	Selection of material 3_1	3.2.1.	Strength	X_{14}	1.000		
		3.1.5.	Durability	X_{19}	-0.358		
		3.3.2.	Cost of manufacturing	X_{20}	0.245		
	Sizing of components 3_2	3.2.3.	Performance	X_{16}	0.403		
		3.2.4.	Factor of safety	X_{15}	-0.336		
		3.4.1.	Overall price of the product	X_{17}	1.289		
	Manufacturing of components (Technology process selection) 3_3	3.3.1.	Ability to manufacture	X_{18}	0.451		

Prototyping 5	Price of components (What is the main constraint) 3_4	5.1.1.	Drawings	X_{22}	1.231	3.591	0.115555
	Prototype development control 5_1	5.1.2.	Samples	X_{23}	0.268		
	Prototype package 5_2	5.2.1.	Prototype	X_{25}	0.557		
		5.2.2.	Jigs	X_{24}	0.538		
		5.2.3.	Fixtures	X_{26}	0.997		
Validation 6	Validation stake holders 6_1	6.1.1.	R&D engineers	X_{30}	0.760	2.435	0.078356
		6.1.2.	R&D Technicians	X_{31}	0.399		
		6.1.3.	End users	X_{27}	1.063		
		6.1.4.	Financiers	X_{28}	0.213		
	Validation contents 6_2	6.2.1.	Throughput	X_{51}	1.593	3.403	0.109506
		6.2.5.	Ergonomics	X_{52}	-0.386		
		6.2.7.	Durability	X_{29}	0.966		
			Durability (Val case)	X_{29}	1.230		
	Validation Process output 6_3	6.2.8.	Robustness	X_{53}	0.248	2.533	0.08151
		6.3.5.	Approved technology	X_{54}	1.800		
		6.3.7.	Approved means of operation	X_{55}	0.485		
Transfer 7	Transfer package	7.1.1.	Engineering drawings	X_{34}	0.221	3.495	0.112466
		7.1.3.	Bill of material	X_{33}	1.453		
		7.1.9	Operation manual	X_{32}	0.515		
		7.1.13	Finance sources	X_{35}	1.042		
		7.1.6.	Fixtures	X_{36}	0.264		
Document at 8.1	Documentation 8.1	8.1.1.	Project Brief	X_{38}	0.514	4.548	
		8.1.3.	Business case	X_{47}	0.307		0.146351
		8.1.6.	Operation manual	X_{37}	0.616		
		8.1.7.	Bill of material	X_{39}	0.602		
		8.1.8.	Done on 3D software 3	X_{40}	0.248		
		8.1.9.	Done in 2D board 1	X_{41}	0.249		
		8.1.10	Drawings	X_{42}	0.698		
		8.1.11	Bill of material	X_{43}	0.474		
		8.1.12	Customer order	X_{44}	0.552		
		8.1.13	Technology profile	X_{45}	0.288		
Stages.8.2	Stages.8.2	8.2.5.	Validation	X_{49}	1.264	2.633	0.084728
		8.2.6.	Transfer	X_{48}	0.525		
		8.2.4.	Prototyping	X_{50}	0.844		

Appendix 29: Raw data batch one

SN	Technology	Capacity	Units	Year Developed	Qty Manufactured	Value	Manufacturer	Remarks on diffusion Qty * Value	Duration	Diffusion Rate With Time (QTY*Value) / duration	Diffusion Rate With Time (QTY*Value)/ duration *100*93750000 (%)
1	Maize Milling Machine	700	kgs/hr	2004	300	2 500 000	SIDO Kilimanjaro	750 000 000	8	93 750 000	100.00
2	Nyumbu Track	3	tons	1982	40	40 000 000	TATC	1600 000 000	30	53 333 333	56.89
3	Solar Drier For Agro-products	50	kg/3hrs	2006	100	1 500 000	TIRDO	150 000 000	6	25 000 000	26.67
4	Maize huller	450	kgs/hr	2003	73	2 500 000	SIDO MBEYA	182 500 000	9	20 277 778	21.63
5	Coffee Pulpier 7 HP	1000	kgs/hr	2008	13	5 500 000	SIDO MBEYA	71 500 000	4	17 875 000	19.07
6	Biogas Plant	30.8	kw	1980	5 000	100 000	CARMATEC	500 000 000	32	15 625 000	16.67
7	Oil screw Expeller	200	kg/hr (seed)	1983	45	5 500 000	TEMDO	247 500 000	29	8 534 483	9.10
8	Circular Saw	5.5	HP	2003	23	2 400 000	SIDO MBEYA	55 200 000	9	6 133 333	6.54
9	Sugar Cane Juice Extractor	30	ltrs/hr	2007	16	1 500 000	SIDO Arusha	24,000,000	5	4 800 000	5.12
10	Juice Blender Electric	4	HP	2006	30	800 000	SIDO Kilimanjaro	24 000 000	6	4 000 000	4.27
11	Animal Feed Mixer	1000	kgs/hr	2010	1	7 500 000	SIDO MBEYA	7,500,000	2	3 750 000	4.00
12	Small Maize Sheller	500	kg/hr	2004	20	1 400 000	TEMDO	28 000 000	8	3 500 000	3.73
13	Soap stock mixing tank boiling kettle	200	litres	2004	5	4 500 000	TDTC	22,500,000	8	2 812 500	3.00
14	Winery Machine (Manual)			2011	1	2 700 000	SIDO Kilimanjaro	2 700 000	1	2 700 000	2.88
15	Soap extruder	200	bars/hr	2004	6	3 500 000	TDTC	21 000 000	8	2 625 000	2.80
16	Honey Press	12	ltrs/Batch	2011	6	400 000	SIDO Arusha	2 400 000	1	2 400 000	2.56
17	Maize mill	500	kg/hr	2001	25	2 100 000	TDTC	52 500 000	11	4 772 727	5.09
18	Palm Oil Digester	50	kgs/batch	2003	5	3 200 000	SIDO MBEYA	16 000 000	9	1 777 778	1.90
19	Butter Churn	15	ltrs/hr (Milk)	2004	5	2 600 000	TEMDO	13 000 000	8	1 625 000	1.73
20	2 Roller hammer	500	kg/hr	2001	22	1 560 000	TDTC	34 320 000	11	3 120 000	3.33
21	Grain Seed Dresser (paddle)	5	kg/batch	1995	6	3 500 000	TEMDO	21 000 000	17	1 235 294	1.32
22	Rice huller	500	Kg/hr	2005	1	8 000 000	TDTC	8 000 000	7	1 142 857	1.22
23	Palm Oil Clarifier	200	ltrs/hr	2005	10	700 000	TEMDO	7 000 000	7	1 000 000	1.07
24	Maize thresher	1000	kg/hr	2009	1	2 500 000	TDTC	2 500 000	3	833 333	0.89
25	Palm Fruit Clarifier	500	Ltr/hr	2001	4	2 280 000	TDTC	9 120 000	11	829 091	0.88
26	Palm fruit thresher	700	kg/hr	2001	2	2 755 000	TDTC	5 510 000	11	500 909	0.53
27	Honey Press	12	ltrs/batch	1998	8	500 000	TEMDO	4 000 000	14	285 714	0.30
28	Juice Pasteurizer	55	ltrs/batch	1994	2	1 900 000	TEMDO	3 800 000	18	211 111	0.23
29	Sunflower winnower	500	Kg/hr	2001	1	2 000 000	TDTC	2 000 000	11	181 818	0.19
30	Palm Fruit Sterilising Tank	300	kg/batch	2001	2	720 000	TDTC	1 440 000	11	130 909	0.14

Raw data batch two

SN	Technology	Capacity	Units	Year Developed	Qty Manufactured	Value	Manufacturer	Remarks on diffusion Qty * Value	Duration	Diffusion Rate With Time (QTY*Value)/ duration	Diffusion Rate With Time (QTY*Value)/ duration *100*93750000 (%)
1	Tractor Carmatec Fast			2010	6	18 000 000	CARMATEC	108 000 000	2	54 000 000	57.60
2	Cashew Nut Processing Manual Plant			2009	40	4 000 000	TATC	160 000 000	3	53 333 333	56.89
3	Maize Mill	550	kg/hrs	2007	52	2 300 000	SIDO Arusha	119 600 000	5	23 920 000	25.51
4	Sugar cane crusher	2 000	kg/hr	1990	13	33 000 000	TDTC	429 000 000	22	19 500 000	20.80
5	Sisal Decorticator			2012	1	16 000 000	TATC	16 000 000	1	16 000 000	17.07
6	Animal Feed Milling	240	kg/hr	2005	64	1 250 000	SIDO MBEYA	80 000 000	7	11 428 571	12.19
7	Evaporating furnace	2 000	kg/hr	2001	13	5 793 000	TDTC	75 309 000	11	6 846 273	7.30
8	Grain mill	2 000	kg/hr	2010	2	5 000 000	TDTC	10 000 000	2	5 000 000	5.33
9	Circular Saw	5.5	HP	2007	13	1 700 000	SIDO Arusha	22 100 000	5	4 420 000	4.71
10	Spices Milling Machine	90	kg/hr	2008	11	1 400 000	SIDO Arusha	15 400 000	4	3 850 000	4.11
11	Palm Fruit Digester (engine)	30	kg/batch	2005	10	2 600 000	TEMDO	26 000 000	7	3 714 286	3.96
12	Fruit Pulpier	500	ltrs/hr	2001	8	4 500 000	TEMDO	36 000 000	11	3 272 727	3.49
13	Honey Sieving Machine	25	lirs	2011	7	400 000	SIDO Arusha	2 800 000	1	2 800 000	2.99
14	Briquette fired oven	100	Pcs/Batch	2009	2	4 000 000	TDTC	8 000 000	3	2 666 667	2.84
15	Animal Feed Mixer	1 200	Kg/batch	1987	20	3 250 000	TDTC	65 000 000	25	26 00 000	2.77
16	Fruit Solar drier	100	Kg/batch	2006	3	4 741 500	TDTC	14 224 500	6	2 370 750	2.53
17	Super Maize Sheller (PTO)	2500	kg/hr	1998	25	1 000 000	TEMDO	25 000 000	14	1 785 714	1.90
18	Honey Press Manual	12	ltrs/batch	2010	10	350 000	SIDO Kilimanjaro	3 500 000	2	1 750 000	1.87
19	Centrifuge	2000	kg/hr	1990	13	2 697 000	TDTC	35 061 000	22	1 593 682	1.70
20	Tractor Driven Mize Sheller	3000	kg/hr	2007	7	1 000 000	SIDO Arusha	7 000 000	5	1 400 000	1.49
21	Oil Filter Press	150	ltr/hr	1994	12	1 800 000	TEMDO	21 600 000	18	1 200 000	1.28
22	Coffee Pulpier Mini plant 7 HP	1000	kg/hr	2007	1	5 500 000	TDTC	5 500 000	5	1 100 000	1.17
23	Bottle Capping (Manual) Machine	15	Bottles/min	2011	10	100 000	SIDO Kilimanjaro	1 000 000	1	1 000 000	1.07
24	Settling tank (Sugar processing)	2000	kg/hr	1990	13	1 410 000	TDTC	18 330 000	22	833 182	0.89

SN	Technology	Capacity	Units	Year Developed	Qty Manufactured	Value	Manufacturer	Remarks on diffusion Qty * Value	Duration	Diffusion Rate With Time (QTY*Value)/ duration	Diffusion Rate With Time (QTY*Value)/ duration *100*93750000 (%)
25	Palm nut cracker	720	kg/hr	2008	1	2 500 000	TDTC	2 500 000	4	625 000	0.67
26	Screw Expeller	100	kg/hr	2001	1	5 320 000	TDTC	5 320 000	11	483 636	0.52
27	Centrifuge Honey Extractor (Manual)	3	Frames/ batch	1998	5	800 000	TEMDO	4 000 000	14	285 714	0.30
28	Animal Feed Mixer	600	Kg/batch	2001	1	2 300 000	TDTC	2 300 000	11	209 091	0.22
29	Forage chopper			2001	2	1 000 000	TDTC	2 000 000	11	181 818	0.19
30	Honey Sieving	22.5	ltrs/batch	1998	6	300 000	TEMDO	1 800 000	14	128 571	0.14

Appendix 30: Guideline For Developing Project Charter (Inc, 2013)

General information includes at least: project title, project brief description, the name of responsible person and the date of preparation of the charter

Project objective, the main objective and specific objectives, the value the project is adding to the organisation, assessment of the organisation strategic priority and the project. Clearly stating expected results, clearly stating deliverables, benefits expected and the problem addressed by the project.

Assumptions; assumption description that has affected decision making and assumption validation report

Project Scope; Describe the project boundaries/limits and deliverables. Any requirement that seems obvious but not covered by the project should be stated.

Project major milestones and deliverables against time, in table or Gant chart

Impact statement showing system affected by these impacts.

Roles and responsibility of the project team, project sponsor, project manager, customers and other stake holders. Contacts of stake holders and the time frame for implementing their responsibility should be indicated.

Project resources, budgets and constraints

Project risks and tentative mitigations strategies

Success measurements against the expected deliverable performance.

Finally, the project charter should be approved by the stake-holders (The combination of stake holders is determined by the nature of the technology and business environment)

Guideline for developing the business case is as follows (Canada, 2009):

Executive Summary

Introduction

Situational Analysis (Internal Assessment and External Assessment)

Business Proposition

Action Plan (Production Plan, Market Plan, Financial Plan, Human Resources Plan)

Financial Analysis

Evaluation and Measurement

Contingency Plan

Guideline for developing the product realization processes (2001)

Plan the provision of the identified products and services (the project, contract or order planning process).

Design the identified products and services so as to meet customer needs and expectations (the design process).

Procure the materials, components, services needed to accomplish the design and/or generate or deliver the product or service (the procurement process).

Generate the product (the production process).

Supply the product or service (the distribution or service delivery processes).

Install the product on customer premises (the installation process).

Maintain and support the product in service (the product and service support process).

Provide support to customers (the after sales, technical support or customer support process).

Guideline for conducting validation process

Correctness: Does the system perform its tasks as expected?

Completeness: Does the system meet all of the requirements that have been placed on it?

Consistency: Are similar things handled in a similar manner? Is the system consistent with another system that is part of the same family?

Reliability: Does the system perform reasonably well in all cases, even, for instance, in the presence of abnormal conditions?

Usefulness: Does the system provide a useful service?

Usability: is the system convenient to use when carrying out its designated task?

Efficiency: is the system efficient in its use of resources, such as time, memory, network bandwidth, and peripherals?

Standards conformance: Does the system conform to standards, both notational and external standards of interface to the outside world?

Overall cost – effectiveness: Is the system a cost - effective solution to the problem?

Appendix 31: Organisation overview 1

Name of organization	Year	Number of workers	Ownership	Fixed capital (Mil)	Main activity	Types of products
TIRDO	1979	100	public	1 000	Design to transfer	processing
CAMARTEC	1981	100	public	800	Need transfer	Land to processes
TEMDO	1982	100	public	800	Need, training ,Transfer	outgrowing, processing
TATC	1985	100	public	1 000	Need to transfer	land prep and crop processing
TDTC	2001	50	public	1 000	Need to transfer	crop processing
TDC Arusha	2003	17	public	800	Design to transfer	crop processing
TDC Mbeya	2003	22	public	800	Design to transfer	Land to crop processing
TDC Kilimanjaro	2004	25	public	800	Design to transfer	crop processing

Organisation overview 2

Name of organization	**Year**	**Number of workers**	**Ownership**	**Fixed capital (Mil)**	**Main activity**	**Types of products**	**PhD**	**MSc**	**BSc**	**Tec**	**Art**
TIRDO	1979	100	public	1 000	Design to transfer	processing	9	14	17	10	9
CAMARTEC	1981	100	public	800	Need transfer	Land to processes	1	6	9	20	20
TEMDO	1982	100	public	800	Need, training ,Transfer	outgrowing, processing	0	2	11	2	7
TATC	1985	100	public	1 000	Need to transfer	land prep and crop processing	0	10	14	16	85
TDTC	2001	50	public	1 000	Need to transfer	crop processing	2	1	3	20	16
TDC Arusha	2003	17	public	800	Design to transfer	crop processing		1		1	12
TDC Mbeya	2003	22	public	800	Design to transfer	Land to crop processing			1	2	15
TDC Kilimanjaro	2004	25	public	800	Design to transfer	crop processing		1		1	8

Appendix 32: Initiation Batch 1

SN	Technology	Initiation																						
SN	Technology	Need Verification				Approval				Capacity				Price				Review						
SN	Technology	Q1_1_1	Q1_1_2	Q1_1_3	Q1_1_4	Q1_2_1	Q1_2_2	Q1_2_3	Q1_2_4	Q1_3_1	Q1_3_2	Q1_3_3	Q1_3_4	Q1_4_1	Q1_4_2	Q1_4_3	Q1_4_4	Q1_5_1	Q1_5_2	Q1_5_3	Q1_5_4	Q1_5_5	Q1_5_6	Q1_5_7
1	Maize Milling Machine	4	2	2	3	4	1	3	3	4	1	2	2	3	3	1	2	3	3	1	2	1	1	1
2	Nyumbu Track	3	1	3	2	2	3	2	2	2	1	4	1	3	3	1	1	3	2	1	1	1	1	2
3	Solar Drier For Agro-products	2	1	1	2	2	1	2	1	4	1	5	1	3	3	1	1	2	3	1	1	3	1	1
4	Maize huller	3	1	1	2	3	1	1	2	3	3	1	3	3	3	2	3	2	4	2	1	2	2	1
5	Coffee Pulpier 7 HP	2	3	1	2	3	1	2	2	3	2	2	1	2	2	2	2	3	2	2	1	1	1	2
6	Biogas Plant	1	1	3	2	1	1	1	4	3	1	3	1	3	1	1	1	3	2	1	1	2	1	2
7	Oil screw Expeller	3	1	1	3	3	1	2	2	2	2	2	1	2	2	2	2	2	4	1	1	2	1	1
8	Circular Saw	3	1	1	2	3	1	1	2	3	1	1	1	2	2	1	1	2	3	1	1	1	1	1
9	Sugar Cane Juice Extractor	3	1	1	2	3	1	1	2	3	1	1	1	2	2	1	1	2	3	1	1	1	1	1
10	Juice Blender Electric	4	2	1	2	3	1	2	3	3	1	2	2	3	2	1	2	2	4	2	1	1	2	1
11	Animal Feed Mixer	3	1	1	2	3	1	2	2	3	1	2	2	3	1	1	2	1	4	2	1	1	2	1
12	Small Maize Sheller	3	2	1	1	3	1	2	2	2	2	2	2	3	2	1	1	1	3	2	1	1	1	1
13	Soap stock mixing tank boiling kettle	3	1	1	1	3	1	2	1	2	1	1	1	2	1	1	1	1	3	1	1	1	1	1
14	Winery Machine (Manual)	3	1	1	1	2	1	1	2	2	1	1	1	1	1	2	1	2	3	2	1	1	1	1
15	Soap extruder	2	1	1	2	2	1	2	1	2	1	1	1	2	1	1	1	2	3	1	1	1	1	1
16	Honey Press	2	1	1	1	2	1	2	1	2	1	1	1	2	1	1	1	1	3	1	1	1	1	1
17	Maize mill	2	1	1	2	1	1	2	1	2	1	1	1	2	1	1	1	3	2	1	1	3	3	1
18	Palm Oil Digester	2	1	1	1	2	1	1	2	2	1	1	1	2	1	1	1	1	3	1	1	1	1	1
19	Butter Churn	3	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	3	1	1	2	1	1
20	2 Roller hammer	2	1	1	2	2	1	1	1	2	1	2	1	2	1	1	1	3	3	3	1	2	1	1
21	Grain Seed Dresser (paddle)	3	1	1	1	2	1	1	2	2	1	2	1	2	1	2	1	1	1	1	1	4	1	1
22	Rice huller	3	1	1	1	2	1	1	1	1	1	2	1	2	1	1	1	2	1	1	1	1	1	1
23	Palm Oil Clarifier	3	1	1	1	2	1	1	1	2	1	1	1	2	2	1	1	1	4	1	1	1	1	1
24	Maize thresher	1	1	1	2	1	1	2	1	1	1	2	1	2	2	1	1	4	1	1	1	1	1	1
25	Palm Fruit Clarifier	2	1	1	2	1	1	2	1	1	1	2	1	2	1	1	1	3	1	1	1	1	1	1
26	Palm fruit thresher	1	1	1	2	1	1	2	1	1	1	2	1	2	1	1	1	2	1	1	1	1	1	1
27	Honey Press	3	1	1	1	2	1	1	1	2	1	1	1	2	2	1	1	2	3	1	1	1	1	1
28	Juice Pasteurizer	3	1	1	1	2	1	1	1	1	1	2	1	2	2	1	1	3	2	1	1	1	1	1
29	Sunflower winnower	1	1	1	3	1	1	2	1	1	1	2	1	2	1	1	1	3	1	1	1	1	1	1
30	Palm Fruit Sterilising Tank	1	1	1	3	1	1	2	1	1	1	2	1	2	1	1	1	2	1	1	1	1	1	1

Concept and engineering analysis batch 1

SN	Technology	Conceptualization													Eng analysis																				
SN	Technology	Performance				Cons Dev tool					Cons selection				Materials					Sizing					Manufacturing				Pricing					
SN	Technology	Q2_1_1	Q2_1_2	Q2_1_3	Q2_1_4	Q2_1_5	Q2_2_1	Q2_2_2	Q2_2_3	Q2_2_4	Q2_2_5	Q2_3_1	Q2_3_2	Q2_3_3	Q2_3_4	Q3_1_1	Q3_1_2	Q3_1_3	Q3_1_4	Q3_1_5	Q3_2_1	Q3_2_2	Q3_2_3	Q3_2_4	Q3_2_5	Q3_3_1	Q3_3_2	Q3_3_3	Q3_3_4	Q3_4_1	Q3_4_1	Q3_4_2	Q3_4_3	Q3_4_4
1	Maize Milling Machine	3	1	3	1	1	1	3	1	3	2	1	4	1	1	3	3	3	3	3	3	3	3	3	3	3	3	2	3	4	3	2	4	2
2	Nyumbu Track	3	1	2	3	1	1	3	2	3	3	4	3	2	1	4	3	3	2	3	3	2	2	3	1	4	3	1	2	2	2	3	2	3
3	Solar Drier For Agro-products	2	1	1	3	1	1	3	3	3	1	1	3	2	1	3	3	3	3	3	2	2	2	2	2	4	4	1	4	3	3	3	3	3
4	Maize huller	2	1	4	3	1	1	3	1	2	2	2	2	2	1	3	3	2	3	2	3	3	2	3	2	3	3	1	3	3	2	3	3	3
5	Coffee Pulpier 7 HP	3	2	3	3	1	1	4	2	3	2	1	3	1	1	3	2	3	3	2	2	3	3	2	2	3	3	1	2	3	3	2	3	3
6	Biogas Plant	1	1	3	2	1	1	3	1	3	1	4	1	1	1	3	3	1	1	1	3	2	3	1	1	3	3	1	2	4	3	1	1	1
7	Oil screw Expeller	3	2	2	2	1	1	3	3	3	3	1	1	4	1	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
8	Circular Saw	2	2	2	2	1	1	4	1	3	2	1	2	1	2	3	2	3	3	3	3	3	3	3	2	3	3	1	3	3	3	3	3	3
9	Sugar Cane Juice Extractor	3	2	3	2	1	1	4	1	3	1	1	3	1	1	3	3	3	3	3	3	3	3	3	2	2	3	1	2	2	3	2	3	3
10	Juice Blender Electric	3	1	3	1	1	1	4	1	3	1	1	3	2	1	4	3	4	3	3	3	3	3	3	2	3	3	1	3	3	2	3	2	2
11	Animal Feed Mixer	2	1	3	2	1	1	4	1	2	1	3	1	1	1	3	3	2	3	3	2	3	3	3	2	3	3	1	3	3	3	3	3	3
12	Small Maize Sheller	2	1	2	2	1	1	3	1	2	1	1	1	3	1	3	3	2	3	3	2	3	3	3	2	3	3	1	3	3	3	3	2	3
13	Soap stock mixing tank boiling kettle	2	1	2	1	1	1	2	1	2	1	1	1	3	1	3	3	2	2	3	2	3	3	3	2	3	3	1	2	3	2	3	2	2
14	Winery Machine (Manual)	1	1	3	2	1	1	3	1	2	1	1	2	1	1	3	3	3	3	2	2	3	3	2	2	3	3	1	2	2	3	2	2	2
15	Soap extruder	3	1	2	2	1	1	3	2	1	1	1	1	2	1	3	3	2	3	2	3	3	1	2	2	3	3	1	2	2	3	2	2	2
16	Honey Press	1	1	3	2	1	1	3	2	2	1	1	1	1	1	3	3	2	2	2	2	3	3	2	2	3	3	1	2	2	3	2	2	2
17	Maize mill	3	2	2	2	1	1	3	1	2	2	1	1	3	1	3	2	2	2	2	3	3	3	3	2	2	2	1	3	2	2	3	3	3
18	Palm Oil Digester	2	1	3	2	1	1	4	1	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	3	3	1	2	2	2	2	2	2
19	Butter Churn	2	1	2	2	1	1	3	3	3	2	1	1	2	1	2	2	2	2	2	3	3	3	3	2	3	3	1	2	2	2	3	3	3
20	2 Roller hammer	3	3	3	3	2	2	3	1	2	2	1	2	3	1	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
21	Grain Seed Dresser (paddle)	3	3	3	3	1	1	3	3	3	2	1	1	3	1	2	2	2	3	2	3	3	3	3	2	3	3	1	2	2	2	3	2	2
22	Rice huller	1	1	3	2	1	1	3	2	2	2	1	2	1	1	2	2	2	2	2	3	2	2	3	2	2	2	1	2	2	2	3	2	2
23	Palm Oil Clarifier	3	3	2	2	1	1	2	3	3	2	1	1	4	1	3	3	3	3	3	2	3	3	3	2	3	3	1	3	3	3	3	2	3
24	Maize thresher	1	1	3	3	1	1	3	1	1	1	1	4	1	1	3	3	3	3	3	2	3	3	3	3	3	3	1	3	3	3	3	3	3
25	Palm Fruit Clarifier	1	1	3	2	1	1	2	1	1	1	1	3	1	1	3	2	3	2	3	2	3	2	3	3	3	3	1	2	2	1	3	3	3
26	Palm fruit thresher	1	1	3	1	1	1	2	1	1	1	1	2	1	1	3	2	2	2	3	2	2	2	3	3	3	2	1	2	2	1	2	3	3
27	Honey Press	3	1	2	1	1	1	2	3	2	2	1	1	3	1	2	3	1	2	3	2	3	2	2	2	2	2	1	1	3	2	2	2	2
28	Juice Pasteurizer	3	1	1	1	1	1	3	2	2	1	1	1	3	1	2	3	2	3	3	3	2	2	2	2	2	2	1	2	2	2	2	2	2
29	Sunflower winnower	3	1	1	1	1	1	3	2	2	1	1	3	1	1	2	3	2	2	3	3	2	1	2	2	2	2	1	2	1	2	2	2	2
30	Palm Fruit Sterilising Tank	1	1	3	1	1	1	2	2	2	1	1	3	1	1	2	2	2	2	3	3	2	1	2	2	2	2	1	2	1	2	2	2	2

Drawing prototyping and validation batch 1

SN	Technology	Engdwgs							Prototyping										Validation																										
SN	Technology	Drafting	Design			Drawing			Proto cntrl		Protoset								Valistake						Valipara										Valiout										
SN	Technology	Q4_1_1	Q4_1_2	Q4_1_3	Q4_1_4	Q4_2_1	Q4_2_2	Q4_2_3	Q4_2_4	Q4_3_1	Q4_3_2	Q4_3_3	Q4_3_4	Q5_1_1	Q5_1_2	Q5_1_3	Q5_2_1	Q5_2_2	Q5_2_3	Q5_2_4	Q5_2_5	Q5_2_6	Q5_2_7	Q5_2_8	Q6_1_1	Q6_1_2	Q6_1_3	Q6_1_4	Q6_1_5	Q6_2_1	Q6_2_2	Q6_2_3	Q6_2_4	Q6_2_5	Q6_2_6	Q6_2_7	Q6_2_8	Q6_2_9	Q6_3_1	Q6_3_2	Q6_3_3	Q6_3_4	Q6_3_5	Q6_3_6	Q6_3_7
1	Maize Milling Machine	2	2	1	1	1	3	1	1	1	3	1	1	2	2	1	3	3	3	3	3	1	3	3	4	4	3	1	1	4	3	3	2	2	2	2	3	4	1	1	3	2	3	2	4
2	Nyumbu Track	1	1	4	1	1	1	4	1	1	1	4	1	4	2	1	3	1	1	1	1	1	1	1	4	4	3	1	1	4	3	3	3	3	2	3	3	7	1	1	2	4	3	2	4
3	Solar Drier For Agro-products	1	1	3	3	1	1	3	3	1	1	3	3	4	2	1	3	1	1	1	1	1	2	1	4	4	3	3	1	4	3	3	3	3	2	3	3	4	1	2	2	4	3	2	4
4	Maize huller	1	2	2	1	1	2	2	1	1	2	2	1	2	2	1	3	2	2	1	2	1	2	3	3	4	3	2	1	3	2	3	2	2	1	3	3	3	1	3	3	2	2	2	3
5	Coffee Pulpier 7 HP	1	3	2	1	1	3	2	1	1	3	2	1	3	2	1	3	2	2	1	2	1	2	3	3	4	3	1	1	3	2	3	2	2	1	2	3	2	1	1	2	2	2	2	2
6	Biogas Plant	1	4	1	1	1	4	1	1	1	4	1	1	4	3	1	4	4	1	1	1	1	1	1	3	4	4	4	1	3	1	2	2	2	1	4	2	4	1	1	3	2	4	1	3
7	Oil screw Expeller	1	3	1	1	1	3	1	1	1	3	1	1	3	2	1	3	2	2	1	2	1	2	2	3	3	3	1	1	3	2	3	2	2	1	2	3	2	1	1	2	2	2	2	2
8	Circular Saw	1	2	1	1	1	2	1	1	1	2	1	1	3	2	1	3	1	1	1	2	1	2	3	3	3	3	1	1	2	2	2	2	2	1	2	3	2	1	1	2	1	1	2	2
9	Sugar Cane Juice Extractor	1	2	2	1	1	2	2	1	1	2	2	1	2	2	1	3	1	1	1	2	1	2	2	3	3	3	1	1	2	2	2	2	2	1	2	2	2	1	1	2	2	2	2	2
10	Juice Blender Electric	2	2	1	1	1	2	1	1	1	2	1	1	2	2	1	3	2	2	2	3	1	2	3	3	4	3	1	1	3	3	3	2	2	2	2	3	4	1	1	3	2	3	2	3
11	Animal Feed Mixer	2	1	1	1	2	1	1	1	2	1	1	1	1	2	1	3	1	1	1	3	1	2	3	3	4	3	1	1	3	3	3	2	2	2	2	3	4	1	1	3	2	2	2	2
12	Small Maize Sheller	1	2	3	1	1	2	3	1	1	2	3	1	2	2	1	3	1	1	1	3	1	2	3	3	3	3	1	1	3	2	3	2	2	1	2	3	4	1	1	3	2	2	2	2
13	Soap stock mixing tank boiling kettle	1	2	2	1	1	2	3	1	1	2	3	1	2	2	1	3	1	1	1	1	1	2	3	3	3	2	1	1	2	2	3	2	2	1	2	3	4	1	1	2	2	2	1	2
14	Winery Machine (Manual)	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	3	1	1	1	1	1	1	3	3	4	3	1	1	3	1	3	1	2	1	1	2	3	1	1	3	1	2	2	3
15	Soap extruder	1	1	3	1	1	1	3	1	1	1	3	1	3	1	1	3	1	1	1	1	1	1	3	3	3	2	1	1	3	1	3	1	2	1	1	2	3	1	1	2	2	2	2	3
16	Honey Press	1	1	3	1	1	1	3	1	1	1	3	1	3	2	1	3	1	1	1	1	1	1	3	2	3	2	1	1	3	1	3	1	2	1	1	2	2	1	1	2	2	2	2	2
17	Maize mill	1	3	1	1	1	3	1	1	1	3	1	1	2	1	1	3	1	2	1	1	1	1	1	3	3	3	3	1	3	1	2	2	2	1	2	2	2	2	1	1	1	2	1	1
18	Palm Oil Digester	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	3	1	1	1	1	1	1	2	3	3	2	1	1	2	1	3	1	2	1	1	2	2	1	1	3	1	1	2	3
19	Butter Churn	1	1	2	1	1	1	2	1	1	1	2	1	2	2	1	3	1	1	1	2	1	1	1	3	2	2	1	1	2	2	2	2	2	1	2	2	1	1	1	2	2	2	2	3
20	2 Roller hammer	1	3	1	1	1	1	2	1	1	1	2	1	2	1	1	3	1	1	1	1	1	1	1	3	3	2	1	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2
21	Grain Seed Dresser (paddle)	1	1	2	1	1	1	2	1	1	1	2	1	2	2	1	3	1	1	1	1	1	1	1	3	2	2	1	1	2	2	2	2	2	1	2	2	1	1	1	2	2	2	1	2
22	Rice huller	1	1	2	1	1	1	2	1	1	1	2	1	2	1	1	2	1	1	1	1	1	1	1	3	2	1	1	1	1	1	2	1	2	1	2	2	1	1	1	2	1	1	1	1
23	Palm Oil Clarifier	1	1	2	1	1	1	2	1	1	1	2	1	2	2	1	3	1	1	1	1	1	1	1	3	2	2	1	1	2	2	2	2	2	1	2	2	1	1	1	2	2	2	1	1
24	Maize thresher	1	2	1	1	1	2	1	1	1	2	1	1	2	2	1	3	1	1	1	2	1	1	1	3	2	1	1	1	2	2	2	2	2	1	2	2	1	1	1	2	1	1	1	1
25	Palm Fruit Clarifier	1	2	1	1	1	2	1	1	1	2	1	1	2	1	1	3	1	1	1	1	1	1	1	3	2	1	1	1	2	2	2	2	2	1	2	2	1	1	1	2	1	1	1	1
26	Palm fruit thresher	1	1	2	1	1	1	2	1	1	1	2	1	2	1	1	3	1	1	1	1	1	1	1	2	2	1	1	1	2	2	2	1	2	1	2	2	1	1	1	2	1	1	1	1
27	Honey Press	1	1	2	1	1	1	2	1	1	1	2	1	2	2	1	3	1	1	1	1	1	1	1	3	2	1	1	1	2	2	2	2	2	1	2	2	1	1	1	2	1	1	1	1
28	Juice Pasteurizer	1	1	2	1	1	1	2	1	1	1	2	1	2	2	1	3	1	1	1	1	1	1	2	2	2	2	1	1	2	2	2	2	1	1	1	2	1	1	1	2	1	2	2	2
29	Sunflower winnower	1	1	2	1	1	1	2	1	1	1	2	1	2	1	1	2	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1
30	Palm Fruit Sterilizing Tank	1	1	2	1	1	1	2	1	1	1	2	1	2	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1

Technology transfer batch 1

SN	Technology	Transfer																							
SN	Technology	Transfer													Document					Stages					
SN	Technology	Q7_1_1	Q7_1_2	Q7_1_3	Q7_1_4	Q7_1_5	Q7_1_6	Q7_1_7	Q7_1_8	Q7_1_9	Q7_1_10	Q7_1_11	Q7_1_12	Q7_1_13	Q8_3_1	Q8_3_2	Q8_3_3	Q8_3_4	Q8_3_5	Q8_4_1	Q8_4_2	Q8_4_3	Q8_4_4	Q8_4_5	Q8_4_6
1	Maize Milling Machine	1	1	3	2	2	2	2	2	2	1	1	2	2	2	1	1	2	2	2	2	1	3	2	2
2	Nyumbu Track	4	1	3	3	2	2	2	2	1	1	4	1	1	3	1	1	2	2	2	3	3	3	3	1
3	Solar Drier For Agro-products	4	1	1	1	1	1	1	1	1	1	1	3	3	3	1	1	2	1	2	3	3	3	3	1
4	Maize huller	2	1	2	1	1	1	1	1	2	1	1	2	2	2	1	1	2	2	2	2	2	3	2	1
5	Coffee Pulpier 7 HP	1	1	2	1	1	1	1	1	2	1	1	2	1	1	1	1	2	2	1	2	2	3	2	1
6	Biogas Plant	2	1	3	1	1	1	1	1	3	1	3	2	1	3	1	1	3	2	2	2	2	2	2	2
7	Oil screw Expeller	2	2	2	2	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	2	2	3	2	1
8	Circular Saw	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	3	2	1
9	Sugar Cane Juice Extractor	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	2	2	3	2	1
10	Juice Blender Electric	1	1	2	2	1	1	1	1	2	1	1	2	2	2	1	1	2	2	1	2	1	3	2	2
11	Animal Feed Mixer	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	2	1	3	2	1
12	Small Maize Sheller	2	2	2	2	1	1	1	1	2	1	1	1	1	2	1	1	2	1	1	2	2	3	2	2
13	Soap stock mixing tank boiling kettle	3	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	2	2	3	2	1
14	Winery Machine (Manual)	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	3	2	1
15	Soap extruder	2	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	2	2	2	2	2	1
16	Honey Press	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	2	2	2	1
17	Maize mill	3	2	3	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	3	2	3	3	2	1
18	Palm Oil Digester	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	3	2	1
19	Butter Churn	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1
20	2 Roller hammer	3	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	2	2	2	2	1
21	Grain Seed Dresser (paddle)	3	2	2	2	1	1	1	1	1	1	1	2	1	1	1	1	2	1	2	2	2	2	2	1
22	Rice huller	3	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	2	2	2	1
23	Palm Oil Clarifier	3	2	2	2	1	1	1	1	1	1	1	2	1	2	1	1	2	1	2	2	2	2	2	2
24	Maize thresher	3	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	2	2	2	2	1
25	Palm Fruit Clarifier	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1
26	Palm fruit thresher	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1
27	Honey Press	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1
28	Juice Pasteurizer	3	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1
29	Sunflower winnower	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1
30	Palm Fruit Sterilising Tank	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1

Appendix 33: Need Identification Need Requirement And Need Interpretation Variable Batch 2

Technology Name	X1	X4	X8	X2	X3	X5	X7	X10	X11	X12	X13	X15	X16	X17	X18	X22	X23	X24	X25	X26	X9
Tech1	3	3	4	4	3	2	2	2	1	2	3	3	3	3	3	2	2	3	4	3	3
Tech2	3	3	4	3	3	3	3	1	3	2	4	3	3	4	4	4	2	2	4	2	3
Tech3	3	1	3	4	3	1	2	1	1	1	2	2	3	3	3	4	2	2	3	2	3
Tech4	1	3	3	3	2	1	3	2	3	1	4	4	4	3	4	4	2	2	3	2	4
Tech5	2	2	4	4	2	3	1	1	3	2	4	3	3	4	4	4	2	2	4	2	3
Tech6	2	1	1	3	2	1	1	1	1	1	3	3	3	3	3	3	2	3	3	2	3
Tech7	1	2	3	3	2	1	3	2	3	1	4	4	4	3	4	4	2	2	3	2	4
Tech8	1	2	3	3	2	1	3	2	3	1	4	4	3	3	3	4	2	2	3	2	4
Tech9	1	1	3	3	1	1	1	1	1	1	3	3	3	3	2	2	1	1	3	1	2
Tech10	1	1	3	3	1	1	1	1	1	1	3	3	3	3	2	2	1	1	3	1	2
Tech11	1	1	3	3	1	1	1	1	1	3	3	3	3	4	3	4	2	1	4	1	2
Tech12	1	2	3	3	1	2	1	1	1	3	3	3	3	4	3	4	2	1	4	1	2
Tech13	1	1	2	2	1	1	1	1	1	1	3	2	3	3	3	2	2	1	3	1	2
Tech14	2	1	3	4	2	1	1	1	2	3	3	3	3	3	3	3	2	1	3	1	3
Tech15	2	1	3	4	2	1	1	1	2	3	3	3	3	3	3	3	2	1	3	1	3
Tech16	2	1	3	2	1	1	1	1	1	1	3	2	2	2	3	3	1	1	3	1	1
Tech17	1	3	3	3	1	2	2	1	1	3	3	3	3	4	3	4	2	1	4	1	2
Tech18	1	1	1	2	1	1	1	1	1	1	2	1	2	2	2	1	2	1	3	1	2
Tech19	1	1	3	3	1	1	1	1	1	2	4	4	4	3	4	3	1	1	3	1	3
Tech20	1	1	2	2	1	1	1	1	1	1	3	2	3	3	3	2	2	1	3	1	2
Tech21	1	1	3	3	1	1	1	1	1	3	3	3	3	4	3	4	2	1	4	1	2
Tech22	1	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3	1	1	3	1	3
Tech23	1	1	2	2	1	1	1	1	2	2	3	2	3	3	2	2	1	1	3	1	1
Tech24	1	1	3	3	1	1	1	1	1	2	4	4	4	3	4	3	1	1	3	1	3
Tech25	1	1	1	1	1	1	1	1	1	1	3	2	2	2	2	2	1	1	3	1	1
Tech26	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2	2	1	1	3	1	1
Tech27	1	1	3	3	1	1	1	1	1	3	3	3	3	3	3	4	2	1	4	1	2
Tech28	1	1	2	1	1	1	1	1	1	2	2	1	2	2	2	2	1	1	3	1	1
Tech29	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	2	1	1	2	1	1
Tech30	1	1	3	3	1	1	1	1	1	3	3	3	3	3	3	4	2	1	4	1	2

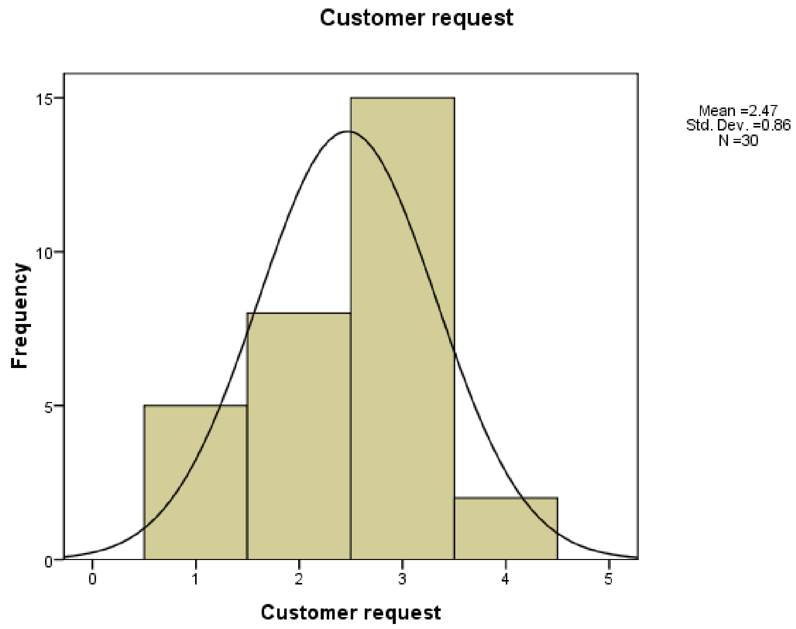
Technology validation and technology availability variables batch 2

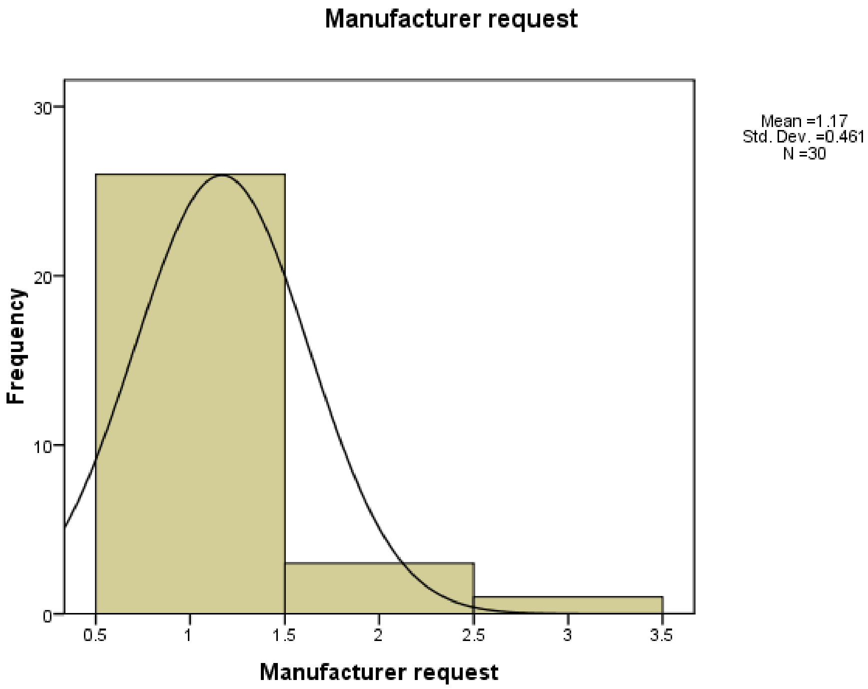
TechnologyName	X27	X28	X29	X30	X31	X51	X52	X53	X54	X55	X32	X33	X34	X35	X36
Tech1	3	3	4	4	4	4	4	4	3	4	3	3	4	2	3
Tech2	3	2	3	4	4	4	3	3	3	4	1	3	4	2	2
Tech3	1	2	3	3	3	4	3	3	3	4	1	1	4	3	1
Tech4	3	3	3	3	3	3	2	3	3	3	3	3	3	1	3
Tech5	3	2	3	4	3	4	3	3	3	4	1	2	4	2	2
Tech6	3	2	3	3	3	3	2	2	3	3	3	3	2	1	1
Tech7	3	3	2	3	3	3	2	3	3	3	3	3	3	1	3
Tech8	2	2	2	3	3	3	2	3	2	3	3	3	3	1	3
Tech9	2	1	1	3	3	2	2	2	2	2	1	1	2	2	1
Tech10	2	1	1	3	3	2	2	2	2	2	1	1	2	2	1
Tech11	3	4	3	3	3	3	3	3	3	3	1	4	4	1	1
Tech12	3	4	3	3	3	3	3	3	3	3	1	4	4	3	1
Tech13	2	1	2	3	3	2	2	3	2	2	1	1	3	1	1
Tech14	3	1	2	3	3	2	2	2	1	2	2	3	3	1	1
Tech15	3	1	2	3	3	2	2	2	1	2	2	3	3	1	1
Tech16	1	1	1	2	3	3	2	2	1	1	1	1	3	1	1
Tech17	3	4	4	3	3	3	3	3	3	3	1	4	4	1	1
Tech18	2	1	1	2	3	2	2	2	1	3	1	2	1	1	1
Tech19	2	1	3	3	3	3	3	3	2	3	1	1	3	1	1
Tech20	2	1	2	2	3	2	2	2	2	2	1	1	3	1	1
Tech21	3	4	3	3	3	3	3	3	3	3	1	4	4	3	1
Tech22	1	1	2	2	2	2	2	2	1	1	1	1	3	1	1
Tech23	2	1	2	2	2	2	2	2	2	1	1	2	3	1	1
Tech24	2	1	3	3	3	3	3	3	2	3	1	1	3	1	1
Tech25	1	1	1	2	2	2	2	2	1	1	1	1	3	1	1
Tech26	1	1	1	2	2	2	1	2	1	1	1	1	3	1	1
Tech27	2	4	3	3	3	2	3	3	3	3	1	3	3	1	1
Tech28	1	1	1	2	2	2	1	2	1	1	1	1	2	1	1
Tech29	1	1	1	2	1	1	1	2	1	1	1	1	2	1	1
Tech30	2	4	3	3	3	2	3	3	3	3	1	3	3	1	1

Technology information availability and stages importance variables

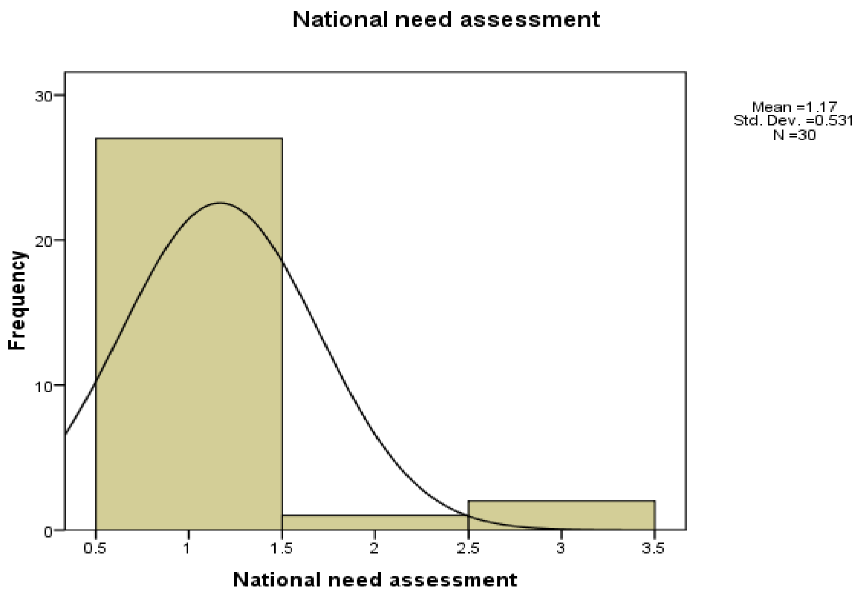
TechnologyName	X37	X38	X39	X40	X41	X42	X43	X44	X45	X48	X49	X50
Tech1	4	3	3	4	4	4	4	3	4	3	3	3
Tech2	4	3	2	4	3	3	3	3	4	1	3	3
Tech3	3	1	2	4	3	3	3	3	4	1	3	3
Tech4	3	3	3	3	2	3	3	3	3	2	2	3
Tech5	3	3	2	4	3	3	3	3	4	1	3	3
Tech6	3	3	2	3	2	3	2	3	3	2	2	2
Tech7	3	3	3	3	2	2	3	3	3	2	2	3
Tech8	3	2	2	3	2	2	3	2	3	2	2	3
Tech9	3	2	1	2	2	1	2	2	2	1	2	3
Tech10	3	2	1	2	2	1	2	2	2	1	2	3
Tech11	3	3	4	3	3	3	3	3	3	2	2	4
Tech12	3	3	4	3	3	3	3	3	3	2	2	4
Tech13	3	2	1	2	2	2	3	2	2	1	2	3
Tech14	3	3	1	2	2	2	2	1	2	2	2	2
Tech15	3	3	1	2	2	2	2	1	2	2	2	2
Tech16	3	1	1	3	2	1	2	1	1	1	2	2
Tech17	3	3	4	3	3	4	3	3	3	2	2	4
Tech18	3	2	1	2	2	1	2	1	3	1	2	2
Tech19	3	2	1	3	3	3	3	2	3	1	1	2
Tech20	3	2	1	2	2	2	2	2	2	1	2	3
Tech21	3	3	4	3	3	3	3	3	3	2	2	4
Tech22	2	1	1	2	2	2	2	1	1	1	1	2
Tech23	2	2	1	2	2	2	2	2	1	2	2	2
Tech24	3	2	1	3	3	3	3	2	3	1	1	2
Tech25	2	1	1	2	2	1	2	1	1	1	1	2
Tech26	2	1	1	2	1	1	2	1	1	1	1	2
Tech27	3	2	4	2	3	3	3	3	3	2	1	4
Tech28	2	1	1	2	1	1	2	1	1	1	1	2
Tech29	1	1	1	1	1	1	2	1	1	1	1	2
Tech30	3	2	4	2	3	3	3	3	3	2	1	3

Appendix 34: Customer Request

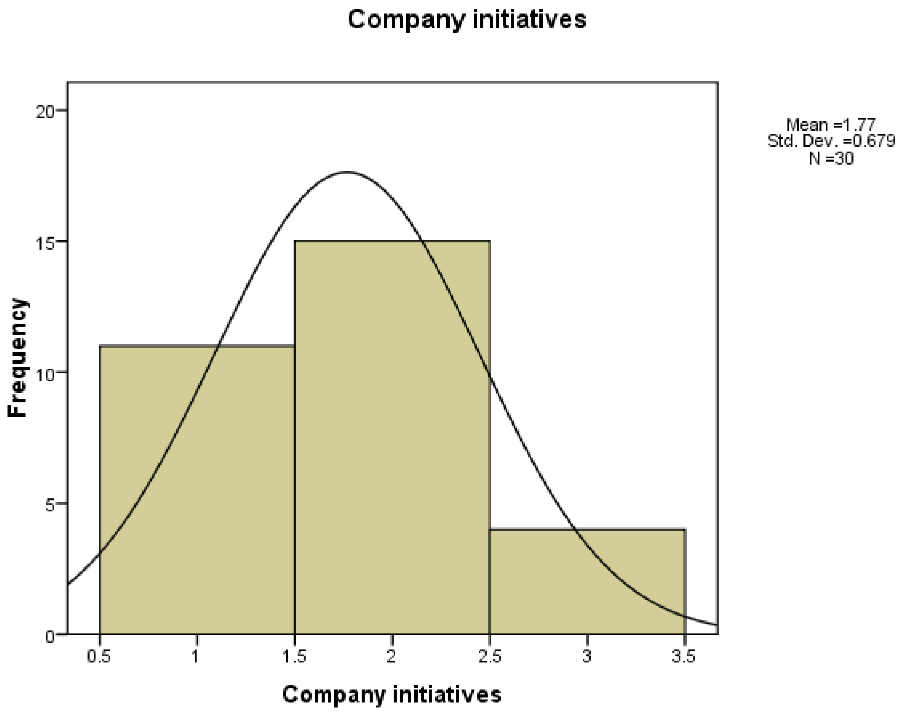




Manufacturer request



National need assessment



Company initiatives

Customer order