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Technology Validation is the Driving Heat of Excellent Innovation Process (Case Study of Tanzania)

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Abstract: ***Validation Cantered Technology Development. The technology validation is expected to be a very important activity in the process of technology development and verification of the quality for the stakeholders expected to benefit from the technology. Tanzania is one of the least developed countries that has put a great effort in establishing the technology development centres. On the extensive visit made in a number of technology development centre related to mechanical engineering, it was observed that the technology validation process is partially undertaken and sometimes completely not understood and hence not fully practiced. The scope of validation process and the need for the same process is not clear. On the other side the design process starts at the need identification, need justification, need interpretation, development of technology design specification and technology/process validation. Certainty of the appropriate technology design development should be the result of comparative analysis of the expected technology development variables and the actual market performance of the technology. There has been a need of studying the deriving variables for technology validation thence mining these variables so that they are made as input to a development of a model for Engineering Design Validation Process. Structured interviews, questionnaires and observations in R&D organisation, staffs, validators and activities studies were used to collect data from sources identified. Literatures on engineering design, use of technology validation and various models for innovation were studied. At the later stage the model was developed and validated. The major finding of the validation process was the transformation of the technology design specification into the complete and thorough validation procedure, the understanding and the development of the design procedure was still a myth in least developed countries. It was noted that the development of technology for market acceptance or diffusion is more than the prototype development. The whole technology validation processes need be to considered for relevant technology development. Validation is the heart of design process (Design for technology life cycle)***

1. Introduction

Most of technology in least developed countries fail to penetrate the market, the reason been not well established and incomplete design cycle consideration (Sanga, 2015). One of the common practices that is used in Tanzania is a reverse validation process that, comes too late for the rectification of the design for market fit. In examining two packaged technologies from the former IPI later changed to TDTC, it was noted that these technologies; the palm oil extractor project sponsored by SIDA-SAREC and mini sugar plant sponsored by SUDECO could not reach the objective due to poor initiation activities of the projects (Chungu et al., 2001). For the lack of understanding of the importance of technology validation process many requirements of the technology design processes are omitted as a result the technology development objectives are not clear and are never achieved.

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 services, 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 appropriate technology validation hence diffusion. Thirteen (13) units produced were limited edition and the project stalled. One of the clear observations is that there were inadequate technology validation processes in appropriate time.

Though Sanga (2016) noted that the initiation process involves the need assessment, preliminary feasibility study, the development of technology project brief or charter, business case and the whole exercise goes with the concept synthesis of the technology to be designed (PMI, 2008, Cooper, 2009) but this alone is not sufficient without the understanding of the requirements for the validation processes. The maim problem in Tanzania has been the lack of society need assessment for appropriate technologies development and validation. To rectify this problem there is a need of developing a system that is going to improve the relationship between national technologies needs and the Research and Development activities undertaken in the country. For this process, to take place the technology validation process consideration is inevitable.

The consideration of design cycle at the stage of technology project validation is still a myth in LDCs. There is a need of studying factors and variable that affect technology innovation acceptance in a life cycle, by development of technology validation plan. For achievement of this objective the following have to be done:

1) To develop List of variables affecting technology validation for innovation in the life cycle.
2) To assess the magnitude of the impact these variables are causing on technology acceptance
3) To develop dynamic model that guide on technology development for effective validation
4) To validate the validation model

2. Literature Review

The problems of technology success presented in the house of common UK (2013) using the "twin valley of technology death" graph as shown in Figure 1. The main issue regarded are failure to commercialise the prototype and failure to commercialise the whole technology developed, known as twin valleys of death. Total technology innovation approach requires the identification of engineering design variables that do affect 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). This literature has a very strong innovation picture that has led to the comparative study between what is happening in our R&D Sector and the twin valleys explanations, however macro and micro variable to be considered to level two chasms are not yet explicit in this time with more emphasis of technology validation.

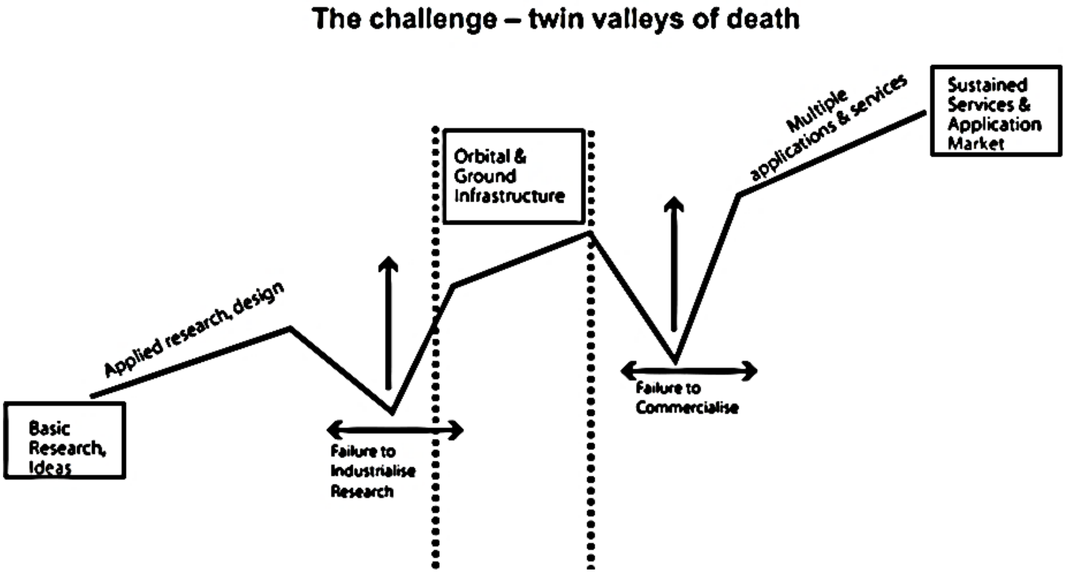

Figure 2-1: Twin Valley of Technology Death Source: **(UK, 2013)** EV 108

As cited by Sanga (2016) 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 technology development in Research and development (R&D) organisations have the main objective of prototype development rather than technology innovation diffusion (Budynas, 2006, Hurst, 1999). The scope of technology design ends at technology development and disregarding other aspects of technology reflecting its objective of development (Özaltın, 2012, Matthews and Bucolo, 2011).

The existing systematic design models such as Dym's , 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 instead of product diffusion realization (Özaltın, 2012, van Cruysen and Hollanders, 2009, Hobday, 2005, Pierre and Julie, 2008, Hall and Childs, 2009) Dym (1994). Most of Engineers and technologists may still be locked in boxes of these model, which have inherent problems when it comes to issues of technology validations.

2.1 Why Validation

According to USA (2011) the Process Validation is defined as the collection and evaluation of data, from the process design stage throughout production, which establishes scientific evidence that a process is capable of consistently delivering quality products.

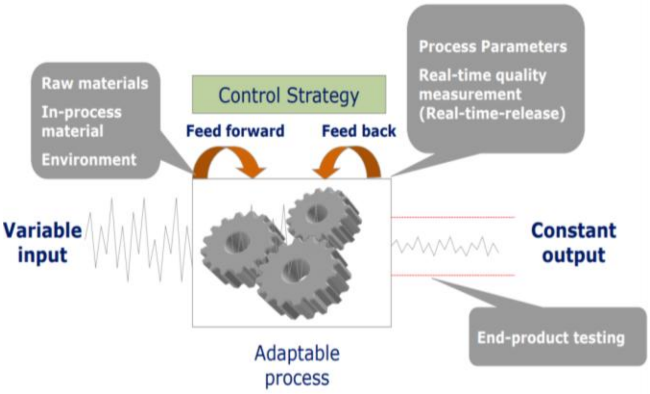

Figure 2-2: Design Process Control, Source: (USA, 2011)

Important questions to be considered where a new technology is developed (USA, 2011);

a) Where are we today?
b) What type of information is gathered during the design phase?
c) How does this information help to ensure that product is produced consistently every time?
d) How well do you know your process / product?
e) What’s in the Technology Transfer Package?

There are clear signs that the proper understanding and implementation of validation centred technology development can perfect the scope development process. The need for collection of all necessary data/variables as input to the technology development and the way of ascertaining that these data are achieved in the end product are the essence of the validation process

Validation begins with a validation master plan that defines the steps in each process. Traditionally, these steps can be categorized into 5 separate qualification categories, which include (RS, 2015):

Design Qualification (DQ): The first step is to demonstrate whether the proposed design of the machine can cope with the functional requirements of the end user. A proposed design must satisfy the DQ before construction and procurement of parts.
Installation Qualification (IQ): The technology, with all its components and documentation, is placed correctly and checked for performance according to the requirements.
Operational Qualification (OQ): All the major parts of the technology are tested to ensure they all perform correctly and are in sync with the entire system.
Performance Qualification (PQ): The technology is monitored over a period of time to check if it consistently delivers results within the required parameters.
Component Qualification (CQ): Auxiliary components and parts that are sourced from a third-party manufacturer are periodically subjected to random tests for quality and performance to ensure they are manufactured to the right specifications and won’t hamper the performance of the technology.

Sometimes the validation is scaled down and before technology is transferred to the market, it must be validated empirically by simulating future practical use of the technology. Technology prototypes are first investigated in simplified contexts, and these simulations are scaled up to conditions of practice step by step as more becomes known about the technology (Wieringa, 2014).

The success in comparison between the validated results and the variables that were detected during the need assessment to prototype, manufacturing, processing and business setup are the key issues (

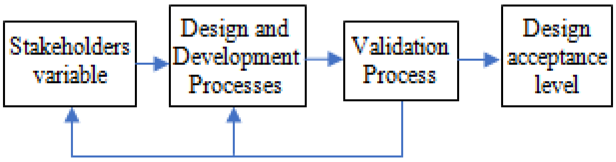

Figure 2-3)

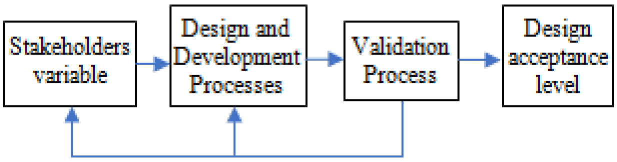

Figure 2-3: Validation Driven Technology Development

The other aspect of design is consideration of quality in the manufacturing process, It is emphasised that the design process should consider technology manufacturing processes, including (IBO, 2018);

2.1.1 Quality control (QC)

Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory in development stage. The QC system is designed to: (i) Provide routine and robust checks to ensure data integrity, correctness, and completeness; (ii) Identify and address neglegences; (iii) Document and archive inventory material and record all QC activities. QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for prolusion calculations, measurements, estimating uncertainties, archiving information and reporting. Higher tier QC activities include technical reviews of source categories, activity and emission factor data, and methods (Mangino, 2000)

a) Tolerances are defined at the design stage of the technology. Parts not within tolerance need to be reworked or scrapped.

b) Continuous monitoring ensures that the technology perform to the pre-determined technology specifications.
c) Ensures that process inputs, such as temperature, pressure, speed, etc., are monitored an adjusted.
d) Quality control at the source eliminates waste from defects as workers are responsible for the quality of the work they do.
e) Able to get the same results over time

2.1.2 Quality assurance (QA)

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, should be performed upon a finalised inventory following the implementation of QC procedures. Reviews verify that data quality objectives were met, ensure that the inventory represents the best possible estimates of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme (Mangino, 2000).
a) This covers all activities from design to documentation.
b) It also includes the regulation of the quality of raw materials, assemblies, products and components, services related to production, and management and inspection processes.
c) It is the maintenance of the entire system from design to purchasing to packaging that meets quality requirements.

2.1.3 Statistical process control (SPC)

Statistical Process Control is an analytical decision-making tool which allows you to see when a process is working correctly and when it is not. Variation is present in any process, deciding when the variation is natural and when it needs correction is the key to quality control (Hart. and Hart., 2007).
a) This is a quality control tool that uses statistical methods to ensure that a process operates at its most efficient.
b) This is achieved through measuring aspects of a component to ensure that it meets the required standard throughout its production in order to eliminate waste.

Technology as a key dimension of service quality has generally been overlooked. When embedded in organisation culture, technology creates a competitive advantage sustainable over time because it is not easily imitated. The value of developing operational definitions of service quality dimensions is explored. Technology is investigated not only as input-processing-output but as the application of knowledge to work (Kingman-Brundage, 1991)

2.2 Anthropometrics

Design is human centred and, therefore, designers need to ensure that the products they design are the right size for the user and therefore comfortable to use. Designers have access to data and drawings, which state measurements of human beings of all ages and sizes. Designers need to consider how users will interact with the product or service. Use and misuse is an important consideration (Openshaw et al., 2006).

2.3 Properties of Materials

The rapid pace of scientific discovery and new technologies has had a major impact on material science, giving designers many more materials from which to choose for their products. These new materials have given scope for “smart” new products or enhanced classic designs. Choosing the right material is a complex and difficult task with physical, aesthetic, mechanical and appropriate properties to consider. Environmental, moral and ethical issues surrounding choice of materials for use in any product, service or system also need to be considered. Stiffness, Hardness**,** Coefficient of Thermal Expansion, thermal conductivity, Shear strength, tensile strength Compressive strength yield strength surface roughness and melting point are very important factors to be observed in selection of materials for designs (Coughlin, 2016)

2.4 Psychological Factors

Human beings vary psychologically in complex ways. Any attempt by designers to classify people into groups merely results in a statement of broad principles that may or may not be relevant to the individual. Design permeates every aspect of human experience and data pertaining to what cannot be seen such as touch, taste, and smell are often expressions of opinion rather than checkable fact (USA, 2018).

The analysis of the human information processing system requires a designer to critically analyse a range of causes and effects to identify where a potential breakdown could occur and the effect it may have.

2.5 Physiological Factors

Designers study physical characteristics to optimize the user’s safety, health, comfort and performance. It is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human wellbeing and overall system performance. Understanding complex biomechanics and designing products to enable full functionality of body parts can return independence and personal and social well- being to an individual (Karwowski, 2005).

Types of physiological factor data available to designers:
a) For example, bodily tolerances such as fatigue and comfort.
b) Muscle strength in different body positions
c) Endurance in different body positions
d) Visual acuity
e) Tolerance to extremes of temperature
f) Frequency range of human hearing,
g) Size
h) Eye/hand coordination

2.6 Sustainable Development

Designers utilize design approaches that support sustainable development across a variety of contexts. A holistic and systematic approach is needed at all stages of design development to satisfy all stakeholders. In order to develop sustainable products, designers must balance aesthetic, cost, social, cultural, energy, material, health and usability considerations.

Triple bottom line sustainability does not only focus on the profitability of an organization or product, but also the environmental and social benefit it can bring.

Organizations that embrace triple bottom line sustainability can make significant positive effects to the lives of others and the environment by changing the impact of their business activities (Designorete, 2014, Ruthtrumpold, 2018).

2.7 Sustainable Consumption

Sustainable innovation and design is not necessarily about new technologies, but about rethinking how to meet the need for growth while at the same time reducing negative environmental and social impacts (Garrette et al., 2009). It is not only the role of designers to create markets for sustainable products. Consumers need to change their habits and express a want and need for these products.

The consumption of goods and services that have minimal environmental impact, promote social equity and economically viable, whilst meeting basic human needs worldwide. Sustainable consumption is not about consuming less but consuming differently. Designers need to recognize the importance of consumerism in developed countries and as an ambition in many developing countries. Societies, particularly in developed countries, are throwaway. Consumers need to be encouraged to repair and reuse products rather than throw them away. Sustainable design and sustainable production contribute to sustainable consumption. This can be achieved in a number of ways, for example, not buying more food than needed and reducing waste; changing attitudes to water and energy use, for example, turning taps off when brushing teeth, aerated water in showers, less water per flush of the toilet, grey water (Gaia, 2012).

2.8 Sustainable Design

The first step to sustainable design is to consider a product, service or system in relation to eco-design and analyse its impact using life cycle analysis. The designer then develops these to minimize environmental impacts identified from this analysis. Considering sustainability from the beginning of the process is essential.

Datschefski’s five principles of sustainable design equip the designer with a tool not only to design new products, but also to evaluate an existing product. This can lead to new design opportunities and increase the level at which a product aligns with these principles (Garrette et al., 2009).

2.9 Market Research

Market research often identifies how to improve the product, service or system and increase its chance of success within a particular sector or segment. The price a user is prepared to pay is usually determined through market research. This in turn sets an upper limit of cost to the design and production of a potential product, service or system. Market research has a crucial role in determining the constraints a designer has to work within.

Often designers will work on projects that have new and radically unfamiliar contexts. This will deepen their understanding of market research, equipping them with a range of tools and skills that they can employ in many areas of life and empowering them as lifelong learners.

2.9.1 Purpose of market research

There are many purposes of market research (Gambles, 2009, Hugh et al., 2007).
a) Gathering information in order to be able to generate new ideas for a product
b) Evaluating the market potential of products at various stages of development

c) Developing ideas into products to suit market requirements
d) Identifying suitable promotional strategies
e) Gathering information relating to demographics
f) Gathering information relating to family roles
g) Collecting data relating to economic trends
h) Taking into account technological trends and scientific advances
i) Gathering information about consumers
j) Considering consumers’ reactions to technology and green design and the subsequent impact on design development and market segmentation

There are documents that are developed after marketing research such as project charter and business cases. Technology project charter is a professional document, developed involving various stake holders, like donors, financiers, consultants, professional and technical associations. This document shows all the projects requirement and description, risks involved, milestone schedule and budget summary. 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 technologies design is still a grey area and it is the area that was studied in this work. In this approach with validation model in place it is possible to capture most of the useful variable required to make a successful technology development

2.10 Robust Product Design

Robust means that something is sturdy or able to hold up. This is an important quality to have when it comes to products, because customers want a product they can trust and depend on. They want to purchase products that meet their standards. In order to meet customer expectations, companies often engage in **robust product design** which is the process of trying to reduce variations in finished products. In other words, it is the process of making sure that finished products maintain their consistency even when factors interfere with the production process. Those factors or variations in production are often called noise (Ranjit, 2001).

2.11 Reliability

Assurance or probability that an equipment, machine, or material will have a relatively long continuous useful life, without requiring an inordinate degree of maintenance. The durability of the product is measured by how well it preforms, stands to usage or maintains its quality over time.

I believe that understanding the difference between reliability testing and durability testing is a key to reducing design/development expenses as well as warranty expenses by an order of magnitude. Specifically, these benefits are based on the following facts (Bajaria, 2000):
a) Reliability tests are shorter than durability tests by a considerable amount of time. The best practices described in Table 1 will discover failures sooner.
b) Validation planning efforts are usually much more meaningful than verification planning efforts resulting in a net benefit.
c) Reliability tests often discover problems before they are discovered in the field. Are you conducting durability tests or reliability tests at your company?

2.12 Durability

Durability is the ability to endure expected conditions over time. It is a type of quality and reliability that is associated with long lasting items that don't break with stress. For example, a spacecraft that can endure the stresses of multiple launches and re-entries to be reused over the course of several decades (John, 2016). It is not feasible to study anything related to durability without touching Quality, Reliability, Resilience and Reliability Engineering. Durability has multiple effect in design concertation that is from technical to financial.

2.13 Safety design

Safety design is the practice of designing-out health and safety risks. In industries such as transportation, safety design has been a standard practice for more than 50 years. In other industries, it is a relatively new practice. Safety design begins by identifying potential risks and developing designs that reduce or avoid risk (John, 2016). The following are common safety design techniques. The primary consideration for safety in product design is to assure that the use of the design does not cause injury to humans. Safety and product liability issues, however, can also extend beyond human injury to include property damage and environmental damage from the use of your design. Engineers must also consider the issues of safety in design because of liability arising from the use of an unsafe product. Liability refers to the manufacturer of a machine or product being liable, or financially responsible, for any injury or damage resulting from the use of an unsafe product (Khandani, 2005).

2.14 Design for Manufacturing

Design for Manufacturing (DFM) and design for assembly (DFA) are the integration of product design and process planning into one common activity. The goal is to design a product that is easily and economically manufactured. The importance of designing for manufacturing is underlined by the fact that about 70% of manufacturing costs of a product (cost of materials, processing, and assembly) are determined by design decisions, with production decisions (such as process planning or machine tool selection) responsible for only 20%.

Reduce the total number of parts, develop a modular design, use of standard components, design parts to be multi-functional, design parts for multi-use, design for ease of fabrication, avoid separate fasteners, minimize assembly directions and Minimize handling (Tien-Chien et al., 1998)

3. 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 114 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 technology development. The R&D organizations which were the main source of data were: TATC, CAMARTEC, TIRDO, Uyole Research Centre, TDTC, SIDO TDC Mbeya, TEMDO,, SIDO TDC Arusha, SIDO TDC Kigoma, SIDO TDC Iringa, SIDO TDC Lindi and SIDO TDC Kilimanjaro

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. Other studies conducted were on: consideration of validation process in technology development, manufacturing and sales, stakeholders involved in technologies life cycle.

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 financial organisations TIC, TIB, NMB, NBC, Standard Chartered Bank, CRDB and TRA. Manufacturing organisations, consulted were: SEAZ, TEMSO Engineering, Kapalata Engineering, Star Natural Product, Mzinga Corporation, Intermech and Nandra Engineering, and 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.

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.
The findings were Brocken down using Ishikawa cause effect analysis into Figure 2-4

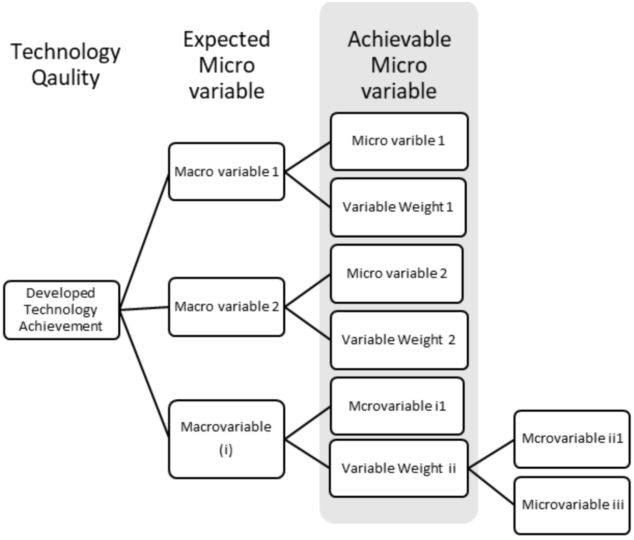

Figure 3-4: Validation Driven Technology Development

Multilinear regression analysis was used to determine the coefficient of each variable listed, there after the system dynamic model (García and Miguel, 2012) was developed using to study the relation between technology initiating variable and the design effectiveness.

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:

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

Where:

$Y_1 =$ Diffusion rate, $\alpha =$ Constant coefficient,

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

$X_1 \ldots X_k =$ are variables affecting the diffusion of technology extracted $\varepsilon =$ error

The regression analysis was done using SPSS ver. 16 and coefficient of variables were established. 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

$$H_0 : \beta = \beta_i = 0 \qquad (2)$$

Alternative hypothesis was

$$H_a : \beta = \beta_i \neq 0 \qquad (3)$$

Level of significance was 5%

3.2 Model validation

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). 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 used, 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).

4. Result and findings

4.1 Regression model Robustness

The P-P plot of results obtained was done in SPSS 16 and all the data showed normality in distribution. Hence data were used in the regression analysis. Multilinear stepwise regression analysis was run to obtain the coefficients of variables used. On running the analysis, the module was achieved with R2 0.916 as shown in Table 4-1. Variables weight W were achieved as shown in

Table 4-2.

Table 4-1: Model Fitness

Model	R	R Right-angled	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.972[a]	.945	.916	.46998	.945	32.750	10	19	.000
a. Predictors: (Constant), W10, W4, W1, W3, W6, W7, W5, W8, W2, W9									
b. Dependent Variable: SalesAnn									

Table 4-2 Standardized Coefficients for Variables

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.466	.304		37.749	.000
	W1	.118	.307	.090	.386	.040
	W2	.719	.335	.452	2.145	.045
	W3	.262	.304	.186	.862	.040
	W4	.196	.237	.099	.824	.042
	W5	.785	.296	.481	2.648	.016
	W6	.035	.436	.025	.080	.043
	W7	.252	.359	.181	.704	.049
	W8	.001	.457	.001	.003	.049
	W9	.525	.571	.383	.918	.037
	W10	.171	.613	.125	.279	.048
a. Dependent Variable: SalesAnual, 95.0% Confidence Interval						

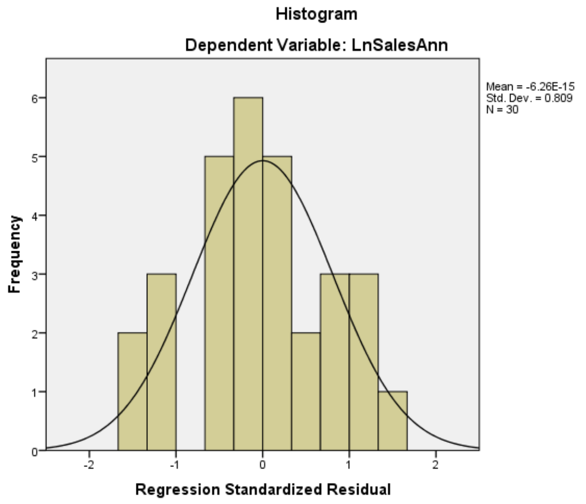

Figure 4-1: Normality of the variable distribution

4.2 System Dynamic module for the validation variables

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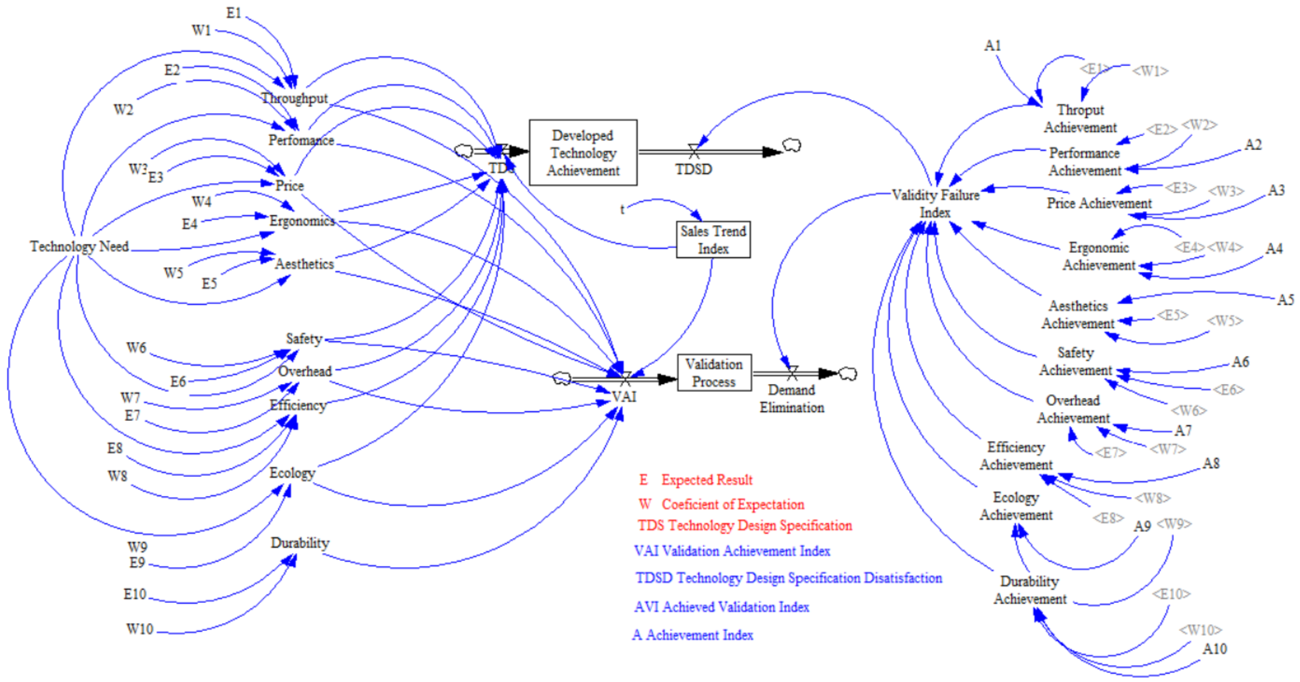

Figure 4-2: System Dynamic Model Developed

4.3 Results on the Validation Trend Against Technology Acceptance

Coefficients obtained in the in the regression model were loaded in the system dynamic model shown in Figure 4-2 the only module used in this system dynamic model was S Curve, as a sales trend index with the maximum value of one (1).

The equation for sales trend was developed using the excel spread sheet:

-4e-006*Time^3 + 0.0005*Time^2 - 0.0032*Time

Time setting for the model was 100 months, that is close the four year that was found to be the average time for development of medium scale technology, mostly agro-processing technology in Tanzania. After the model calibration the following were the findings in the analysis through system dynamic model

4.3.1 The impact of validation on technology acceptance

Technologies developed in Tanzania had little overall acceptance since there were less interaction between the validation and the technology development processes. Technology 1 (Hammer mill had a big acceptance rate since it received a number of input in the development process through many years. Others are Nyumbu Tracks, Solar driers, Maize huller, coffer pulper biogas plants and others. The achievement index in the vacation process was done on the expected result against the actual result and the derived variable weight

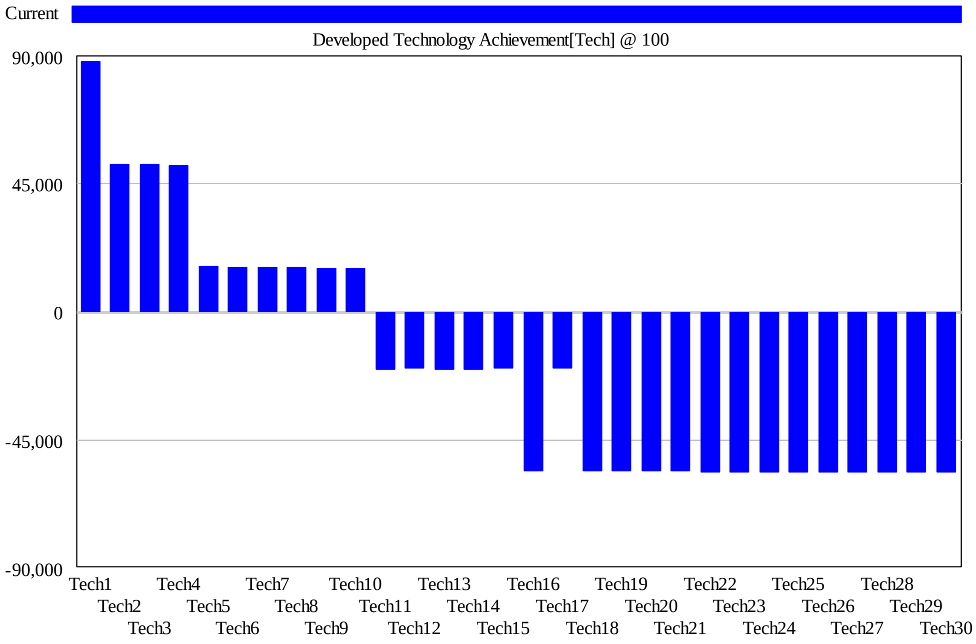

Figure 4-3: Technology Acceptance as Compared to Validation Efforts

4.3.2 Validation process effectiveness against time

Validation process is a function of time and appropriate variable consideration. The combination of time and appropriate variables consideration results on super validated technology hence high quality and acceptance by the society. The negative results in validation are results of poor understanding on the need of following proper validation process in the due course of technology development (Figure 4-4.

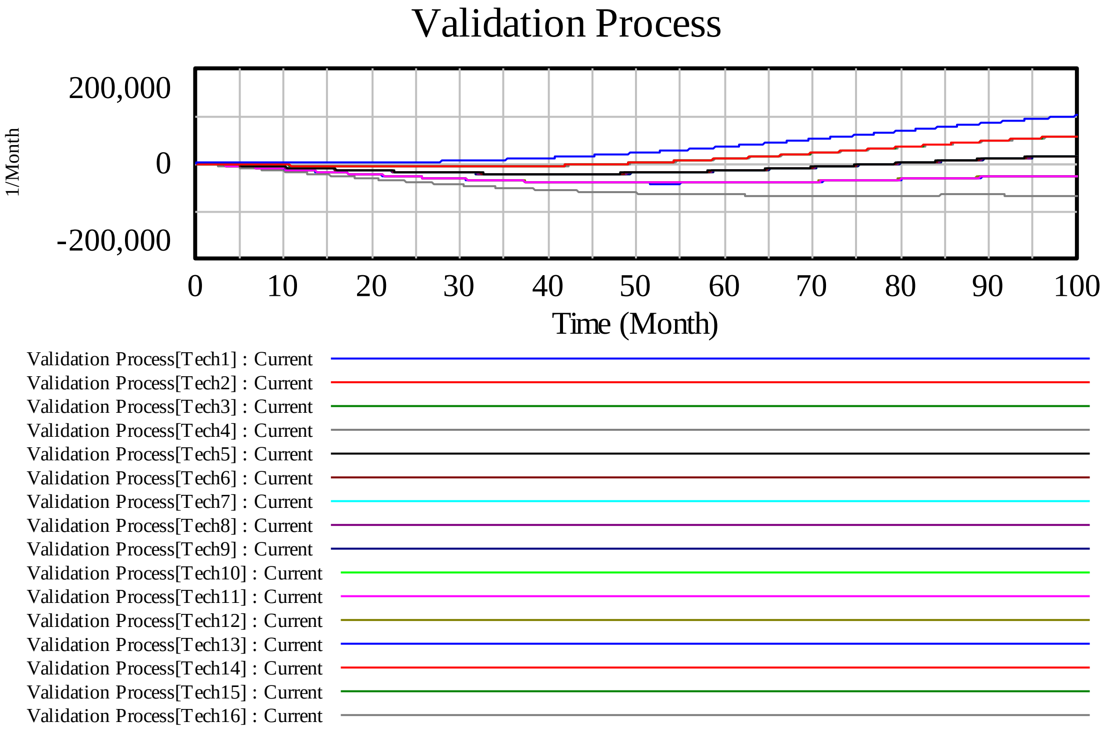

Figure 4-4: Validation Process with time

4.3.3 Level of achievement of validation

There is a need of review the effectiveness of validation by comparing the expected characteristics of technology against the achieve technology performance results. Failure to do this may result negative acceptance of technology by the stakeholders, the less the discrepancy between the expected results and the achieve results assures the quality end technology. Figure 4-5 shown the trend of failure to achieve the expected result in the arrangement of very successful project to poor accepted product.

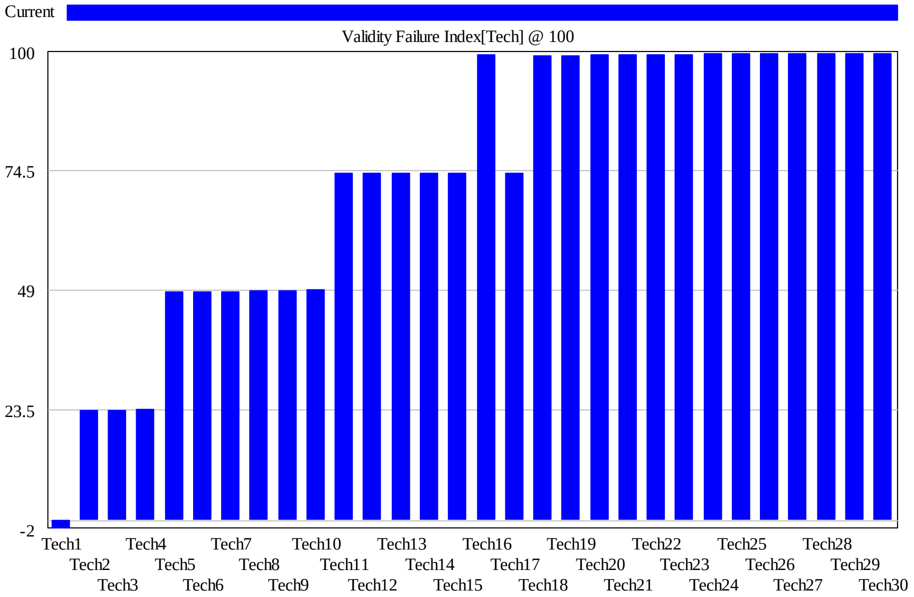

Figure 4-5: Measurement of Failure to Achieve Validity Expectation

GET XLS CONSTANTS('DataVal.xlsx','Achievement','B2*')

4.4 Sensitivity Analysis

The analysis on the through put shows that the technology acceptance is affected to the level of 12%. This can only be realised when the proper validation process on technology development is performed (Figure 4-6).

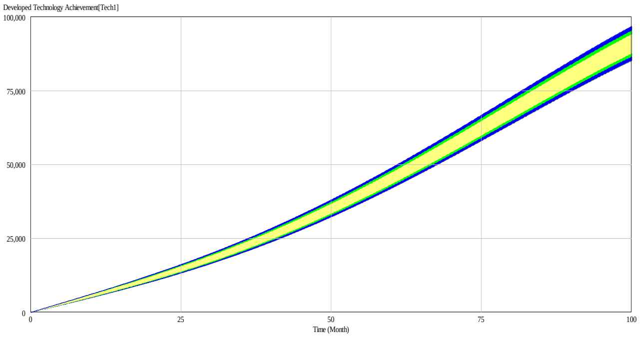

Figure 4-6: The Effect of Through Put Validation of Technology Acceptance

Other variable studied showed the following sensitivity on technology acceptance:

Price achievement, overhead cost control and durability had the sensitivity contribution of 5% each. On the other hand, the throughput, aesthetics and ecology observation contributed to 10% each. Other factors like efficiency and safety contributed to around 1% each. The righter realised that the variable and sensitivity related may differ from one technology to another.

5. Conclusions and Recommendations

5.1 Conclusion

The following conclusions have been drawn from the Study:

(a) The necessary list of technology variable that need to be validated for assurance of technology acceptance in the market (Technology diffusion). About ten (10) macro factors were Identified, namely throughput, performance, physiological or ergonomics, psychological or aesthetics, durability, safety, overhead, efficiency. (robustness, reliability and quality) and ecology. In all the research institution visited, a very partial approach in observation of the mention macro variable were observed. The problem was observed to be caused by the inherent problem in the curriculums used to train the engineers and scientist in the area of technology validation.

(b) Factors that affect technologies innovation acceptance have been identified. The magnitude of individual factors did vary depending on the type of technology, the nature of the market and the major function of technology. The sensitivity analysis showed that the factors are contributing between 12% to 1% on technology acceptance. The cumulative effect is close to 100%.

(c) Variable were analysed and the model that shows the impact of technology validation in technology diffusion was developed. This model was found to be useful for guiding technology developer throughout the process of technology validation while predicting levels of driven diffusion from the early stage of technology development to the development cycle end.

(d) On the validation of the model the finding show that the model can predict the technology acceptance at the accuracy (Confidence Level of 95%)

5.2 Recommendations

- Lack of professionalism in R&D organisation in Tanzania it is evident that Science, Technology and Innovation policy is not yet released and poor rationalisation of R&D organisation was observed.
- Most of R&D organisations studied were also the manufacturer of technology and there was very little knowledge in the field of technology validation. The result the could be more robust it the validation practice was of high level in the research organisation studied.
- Most variables identified through literature were accepted by stepwise regression analysis. Though the general score on the performance of variables was low. There should be a purposeful rationalise technology development process and introduction of quality management system (ISO 9001) in all R&D organisations. Quality management system does enforce the excellent handling of technology innovation variables to achieve the processes desired ends.
- 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.

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