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Impact of Stake Holders in Technology Design Life Cycle in Tanzania

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Abstract: ***Technology design lifecycle has anumber of aspects embedded on it, in this paper the stakeholder's participation in technology development has been made a focal point aspect for effective technology acceptance in the market. There has been great effort in Tanzania for the development technology but with incomplete life cycle.Factor that are affecting the life cycle and the market acceptance pattern are not well understood.Stage gate model for technology development seem to show a sign that this failure can have a link with the stake holders' participation. There has been a need of studying the relationship between stake holders' participation in technology development and technology life cycle perfection. Structured interviews, questionnaires and observations in R&D organisation, staffs and stakeholders and activities were used to collect data from sources identified. Literatures on engineering design, technology development life cycle and various models for innovation were studied.At the later stage, the model was developed and tested. Factors that were included in the model was the participation of stake holder in processes such as need identification, technology validation process, these factors were found to affect market acceptance. It was noted that the developers of technology are not just the technologist but the whole team of stake holders for that particular technology. The stakeholders' participation is vital for effectivetechnology development.***

Keywords: Innovation diffusion, Technology life cycle stakeholders

1. Introduction

The extent of understanding the product design life cycle has been a relative term and somehow subconsciously regarded in many R& D organisations in Tanzania and other Least Developed countries. On the other hand, the process of product development had been rigidly driven by the end user expectations instead of stakeholders' expectations. Most of technology developing organisation have been characterised with failure to transfer technologies after prototype development (Dugushilu et al., 2010, URT, 2012, EU-SCAR, 2012, Koshuma, 2005).

Mganilwa and Sanga(2012) shows that there are number of phases that technology development need to go through for it to be successful, namely initiation, conceptualisation, design development, prototype validation and transfer facilitation. In his study on technology diffusion Sanga (2016)realised that most of researchorganisation in Tanzania do not use thestakeholder analysis knowledge in their product development. The whole concept of Public Private Partnership (PPP)(Mwamila and Temu, 2005), the formation of industrial parks and clusters and technical business environment is not simple as many of scholars would like to conclude.

There has been a main problem in involving stake holders in the process of technology development in the whole concept of technology use, spill over effect and industrial and business orbital infrastructure development(Ford et al., 2007, UK, 2013). On the other hand, the key player in technology development are thought to be engineers while others are left out(Etzkowitz, 2008). However, to the researcher, stake holders' analysis is standing to be the driver of many technology design and innovation models.

The Main Objective of this research is to develop a model that will guide the technology developer in analysing and including acceptable numbers of stake holder in the technology design life cycle for sustainable technology diffusion

1) To identifyeffect of the composition of stake holders in the technology development cycle
2) To develop the model that accommodates stake holders in technology development
3) To validate the model on technology diffusion effect

2. Literature Review

In consideration of the word stake holder in this research it implicating goes beyond the individual entity as discussed by Thomas (1995) and other scholars.However, the project management gurus are among the first people to refine the definition of stake holder in the project to business perspective.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). According to (Whitley and UK, 1997) the definition of stake holders need to be more improved so as to include the factor of inter-organisational links in the value addition processes.

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.Instead of stopping at the prototype development level, the design process for innovation diffusion need to be expanded to include participation of all stakeholders' variables in the whole design cycle. It includes business setup that incorporates incubation service provision (ITSBIC, 2008).

The growing activities related to stakeholder (Figure 0-1) analysis reflects the need of how the characteristics of stakeholders' individuals, groups and organizations

influence decision-making processes. Stakeholder analysis can be used to generate knowledge about the relevant actors so as to understand their behaviour, intentions, interrelations, agendas, interests, and the influence or resources they have brought or could bring – to bear on decision-making processesespecially in R&D organisations (Brugha and Varvasovszky, 2000, Elias et al., 2002, Sanga and Mganilwa, 2012).

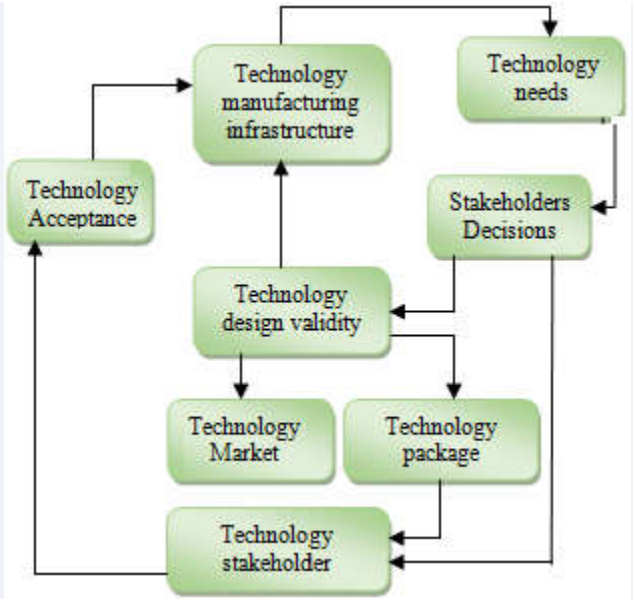


Figure 0-1: Conceptual frame-work for technology diffusion (Sanga, 2015a)

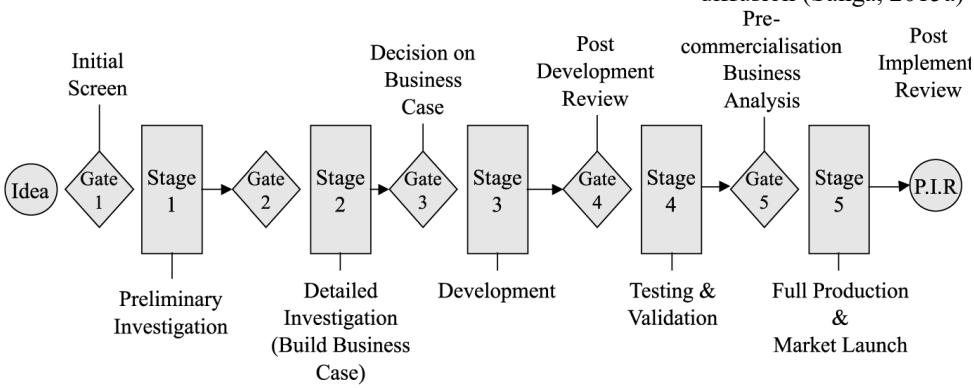


Figure 0-2: Conceptual frame-work for technology diffusion

Stage gate model introduces by Cooper (2010) in Figure 0-3pave a way to include stakeholders in the technology development processes, however in the stage the analysis was not give a deep discussion on the identification of stakeholders.However, understanding of the stages involved in the design cycle is a very important kick to the start of identification of stakeholders involved. The model shows that there is a need of considering the item listed in each stage blocks and identify stake holders.

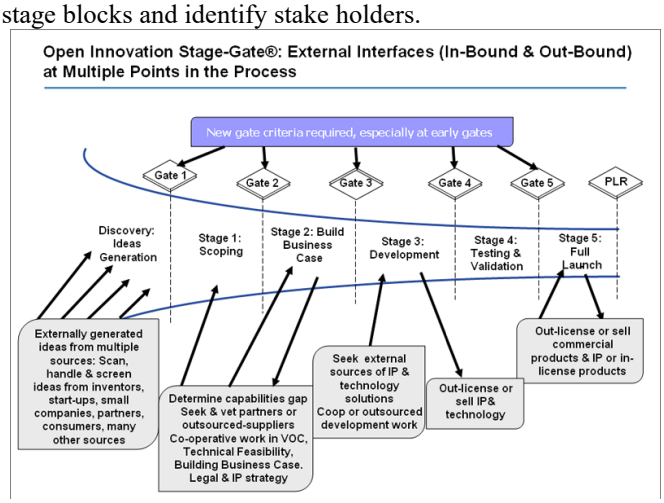


Figure 0-3: Cooper Stage Gate Model, Source: (Cooper R. G, 2016)

Triple helix model

A triple helix regime model (Figure 0-4) typically begins when a university, industry, and government enter into a reciprocal relationship with each other in which each attempt 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 through the participation of critical stake holders (Etzkowitz, 2008, Malerba, 2005, Qing-dong, 2010).

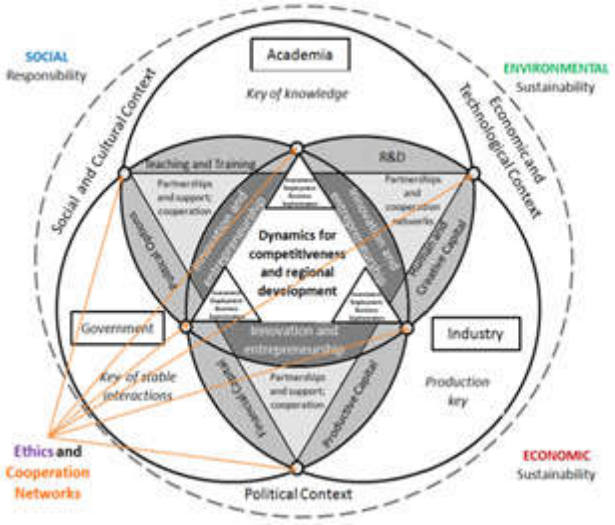
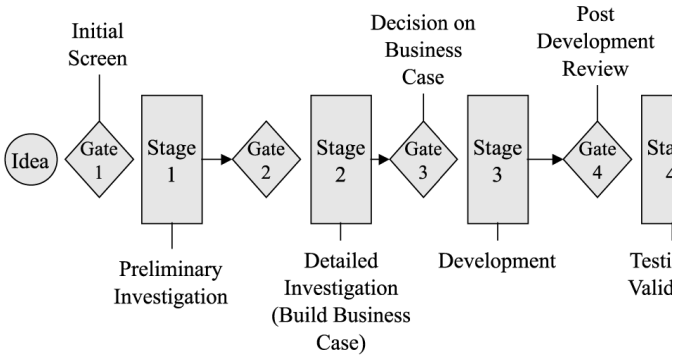


Figure 0-4: Triple helix triangulation model
Source: Farinha and Ferreira(2012)

3. Methodology

3.1 Study Area

The study was mostly conducted in the research and development organisation namely: Tanzania Technology Development Centre (TDTC), Tanzania Automotive Technology Centre (TATC), Tanzania Engineering and Manufacturing Design Organization (TEMDO), Centre For Agricultural Mechanization & Rural Technology(CAMARTEC), Small Industries Development Organization, (SIDO)- Technology Development Centres (TDC), Tanzania Industrial Research and Development Organization (TIRDO), Vocational Educational and Training Authority (VETA),URCFinancial Institutions like Cooperative Rural Development BankCRDB, Tanzania Automotive Technology Centre –(TATC), National Microfinance Bank (NMB), Tanzania Investment Bank, (TIC)Microfinance. Some manufacturing companies also were studies, such as Mzinga Corporation, Intermech Engineering Limited, Siaz(COSTECH, 2013).A total of 116 technologies that were developed by R&D organisations were enlisted.



3.2 Identification of factors affecting the composition of stake holders

The identification of the factors affecting the effective composition of stake holders in the sustainable technology development were accomplished in two stages, the first sage was to identify factors as narrated in the literature review and the interview by the R&D organisations selected staffs. The stage gate model, the Ishikawa fish born Diagrams, and Vensim software (Vensim, 2003, Raasch et al., 2008)enabled the development of factors affecting the composition of stake holders' identification. The second stage was the application of the regression analysis to develop coefficients for the factor'scomposition of stake holders. In all the study, the technologies identified were the driving population of the study.

3.3 Development of model to accommodate participation of stakeholders in technology development

The model was developing by firstly grouping stake holders for each stage and gates in the process of technology development and there after using regression tools to establish their micro coefficients(Rawlings et al., 1998, Snee, 1977, Xin and Xiao, 2009). The macro group analysis was done to establish mathematical relationship between the groups.

3.4 To validate the model on technology diffusion effect

The comparison was done on the prediction of the model of technology diffusion and the actual diffusion for selected technologies the main item under scrutiny was on stake holders' participation in the technology development. The conceptual system dynamic model was developed in Figure 0-5

Figure 0-2

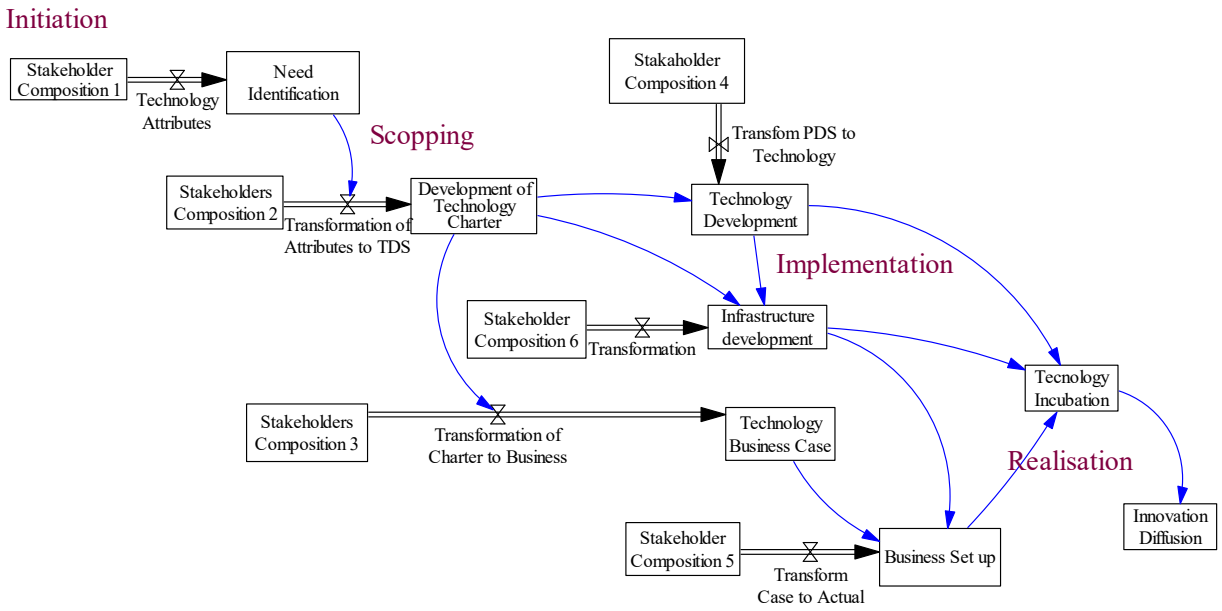


Figure 0-5 Stake Holders Conceptual Model

4. Results and Discussion

4.1 General study on the impact of stakeholders in various stage of technology development

Studies done by Sanga and Mganilwa (2015b) showed that the composition of stake holders in each stage of technology development do differ. On finding the factor that shows the weight distribution along the cycles stages of implementing the project, that is from need identification to the acceptance of the product by into the market,Weighted Least square analysis of stages (Standardized) was used. The main assumption was that stages, stakeholders' effect cannot be the same in types and their input effects to the product market diffusion.The analysis with theR square of 7, the significance level of 0.002 and the identified factors are listed in

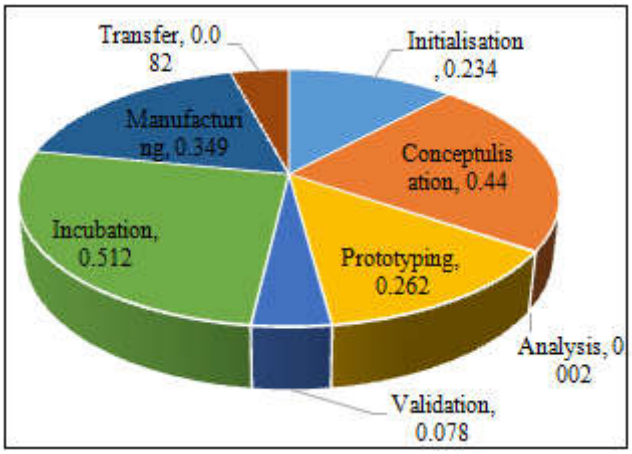


Figure 0-6. Issues that were of great importance here were the incubation process, manufacturing, initial processes, conceptualisation and others as shown were all of high importance. These were considered in the model development.

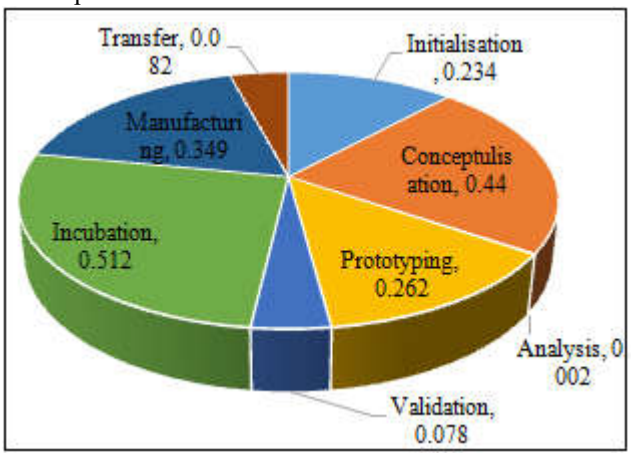


Figure 0-6: Weighted Least square analysis of stages (Standardized)

4.2 Stake Holders Importance in Need Assessment

The stepwise linear regression analysis was done of variables in in

Table 0-1, the model gave the significance value of F chance of 0.002 and the $R^2$of 0.64.

Table 0-1: Stake holders at the Initiation stage

Descriptive Statistics			
	Mean	Std. Deviation	N
Sales (Dependent Indicator)	14.823	1.62494	30
StakeinNeed_User	2.6083	0.78423	30
StakeHolders_Eng	2.0583	0.49863	30
StakeHolde_Socia_Eco	1.4417	0.34543	30
Stakeholder_Financial	1.5	0.32827	30
Government_Gurantess	1.4417	0.34543	30
Trensferer_Influence	1.5083	0.35649	30

$$Y_1 = 0.522x_1 + 0.433x_2 \quad \textbf{Equation 0-1}$$

Where:

x_1 = Government as a main stake holder in need assessment process

x_2= End user environment in the need assessment process

It was noted by the result of analysis the key stake holders in the technology initiation are the government or the urgency that is drivers of need assessment surveys on technology and the identification of the need, definitely this needs thorough interaction with the users environment for further understanding on need assessment read (USA, 2005).

4.3 The Stake Holders participation in processing the PDS

This is idea scanning, handling and screening, capability gap seeks, vet partners and outsourced suppliers, inclusion of the voice of customer, technical feasibility, building business case, legal and IP Strategy. Buy IP or technology solution, technology adoption or adaptation. Sell of technology rights (Cooper, 2010). In this stage the so called Social economic stake holders included, economists, financial, marketing specialist, antirealists and other regulatory bodies, mixed with other experts is very important. Though the system was not well established in most of research organisation there werehaving some trend observed on these stages.

Out of five regressed stakeholders, three were appeared as outstanding. With R^2 0f 0.5 and the hard environment of data collection the author is convinced there is a very great lesson in the relation that is observe in Equation 4-3

$$Y_2 = 0.141x_3 + 0.077x_4 + 0.441x_5$$ **Equation 0-2**

Where x_3 = User input effect
x_4 = Scientist Input Effect
x_5=Social economist input effect

4.4 Analysis Stake Holders

Variable considered werein conducting the design analysis; sales per Unum as dependent variable, user contribution, engineer/scientist contribution, economist effects, financier effect, government effect transferrers and incubators effect. Sample of 30 technologies were studies. With$R^2$is 0.7and significance of 0.001 the relation is developed in equation Equation 4-3.

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Equation 4-3

Where:
x_6 = User stake holder impact
x_7 = Engineer stake holder impact
x_8 = Financier stake holder impact
x_9 = Government stake holder impact
x_{10} = Transfer Incubator stake holder impact

4.5 Prototypedevelopment stake holders

Incubator, user, government, financials, manufacturer and economists were subjected to multilinear regressions against of the average annual sales of thirty technology, with significance of 0.1, and R^2= 4 Using the linear regression the **Equation 0-3**
has been developed

$$y_4 = 0.328x_{11} + 0.346x_{12} + 0.213x_{13} + 0.688x_{14} + 0.104x_{15} + 0.004x_{16}$$

Equation 4-4

Where
x_{11} =Usereffect
x_{12} =Economisteffect
x_{13} =Financialeffect
x_{14} =Manufacturereffect
x_{15} =Governmenteffect
x_{16} =Incubatoreffect

4.6 Validation Process

On the testing of relationship between the technology validation process and the participation of stake holders, the following stake holders were put in the regression model as related technology sales per Unum; users, engineers, economists, Financiers, Manufacturer, with the prediction wit R^2 0.5 with significance 0f 0.001 the equation**Equation 0-4**was developed.

$$y_5 = 0218x_{17} + 0.352x_{18} + 0.401x_{19} + 0.041x_{20} + 0.272x_{21}$$

Equation 4-6

Where:
x_{18}= user
x_{19}=engineer
x_{20}=economist
x_{21}=financier
x_{22}=incubator

4.7 The effect of participation of the stake holders in the transfer processes

The stake holders evaluated by the stepwise regression analysis included Incubator, Economist, Manufacturer, User, Engineer, Government and Financier. The regression was done against the annual sale of thirty technologies in Tanzania, the R2 0f 0.6 and significance of F chance of 0.001. With the standardized coefficient the Equation 0-5

$$y_7 = 0.202x_{23} + 0.253x_{24} + 0.989x_{25} + 0.217x_{26} + 0.10x_{27} + 0.033x_{28} + 0.246x_{29}$$ **Equation 4-7**

Where:
x_{23} = User
x_{24} = Engineer
x_{25} = Financier
x_{26} = Economist
x_{27} = Manufacturer
x_{28} = Government
x_{29} = Incubator

4.8 The system dynamic mode

The system dynamic model (Figure 0-7) was developed for studying impacts of stakeholders at different stages of technology development cycles. Formula obtained from equation 4-1 to 4-7 were loaded and the calibration was done

using stages weights displayed in

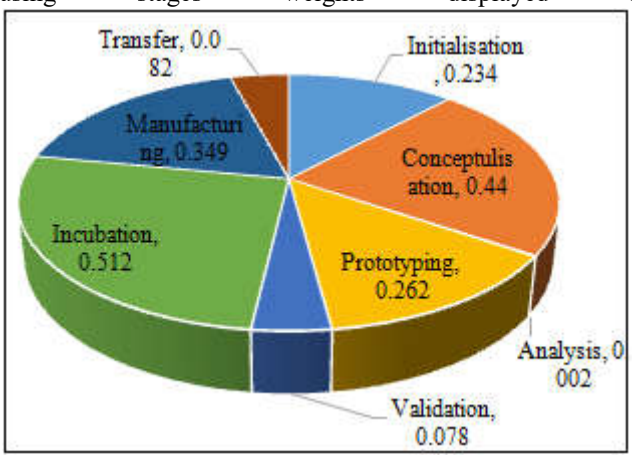

Figure 0-6. The model was run to study the sensitivity of stakeholders' variables in various items considered as important for successful technology development. That is rational technology need development, design analysis, design optimisation, design validation, stakeholder's technology acceptance and technology transfer.

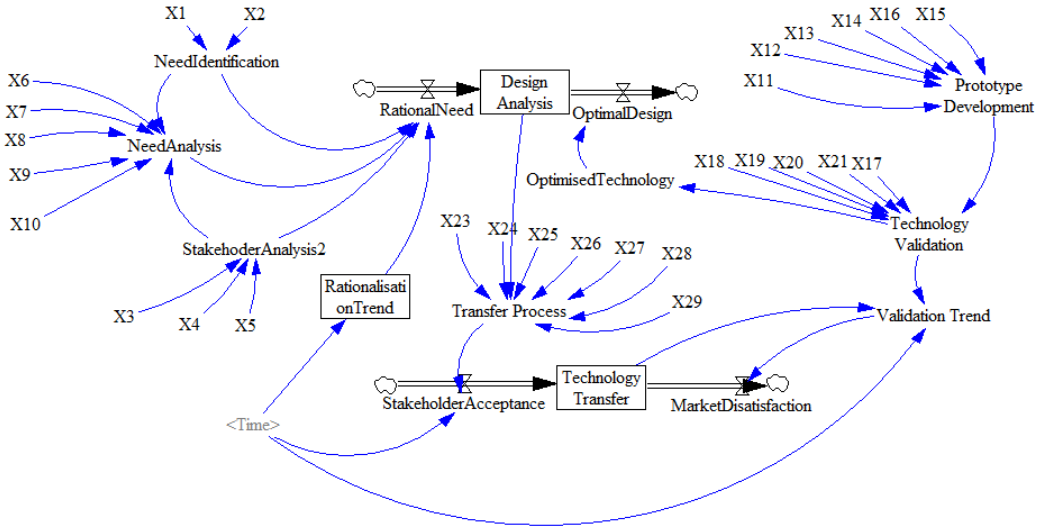

Figure 0-7: Stakeholders System Dynamic Model

4.9 Dynamic model running on key stages

On design process success index the prediction of technology a good design has shown a good trend since technology 1 to ten were highly sold (per Unum), example of the maize mill technology "1" or maize huller technology "4" and the rest followed had a good between stakeholder and technology market acceptance (Fig. 4-3 and Fig. 4-4)

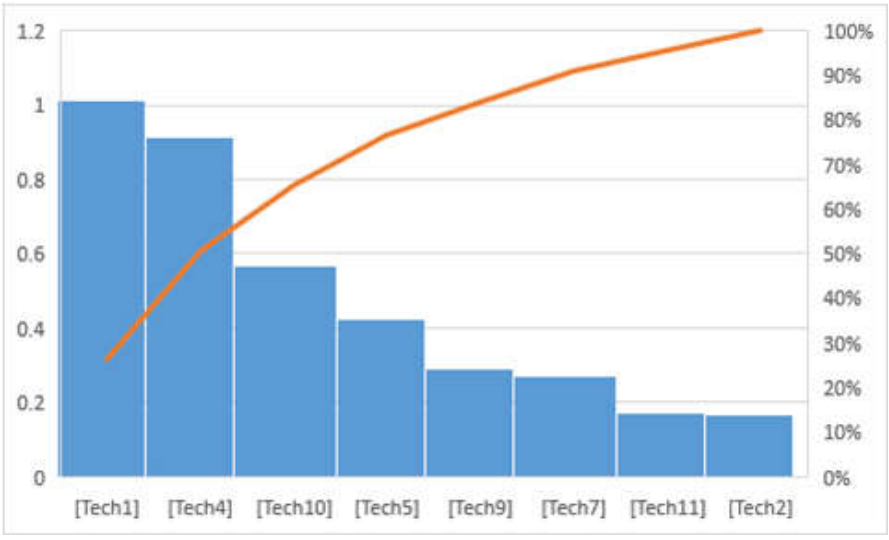

Figure 0-8: Design Process Success Index

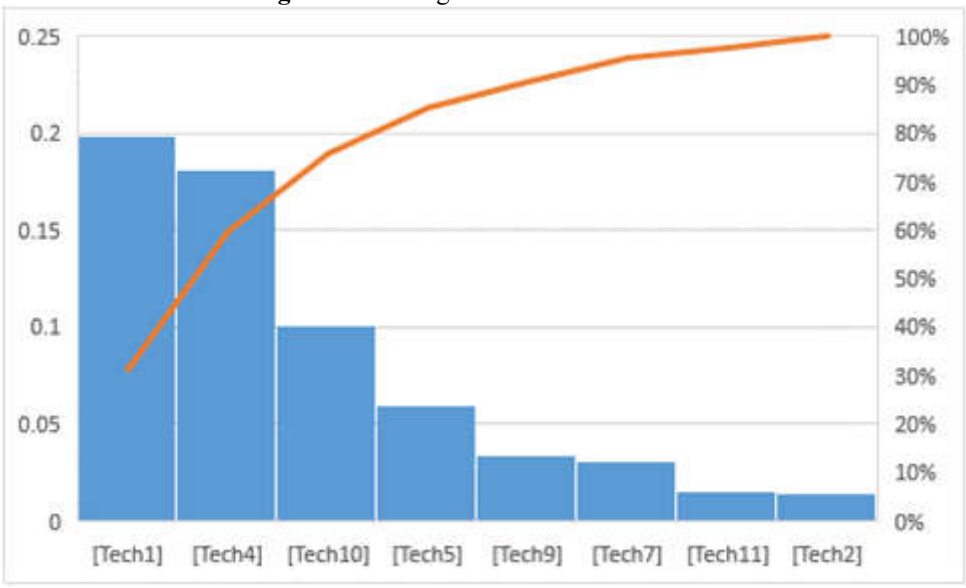

Figure 0-9: General Technology Acceptance

4.10 Dynamic model sensitivity analysis

On running the sensitivity analysis as shown in Figure 0-10, the lack of participation of stake holders in the technology initiation, that is the need identification to need transformation to design specification causes 80% and 100% rejection by the stake holders and vice versa.

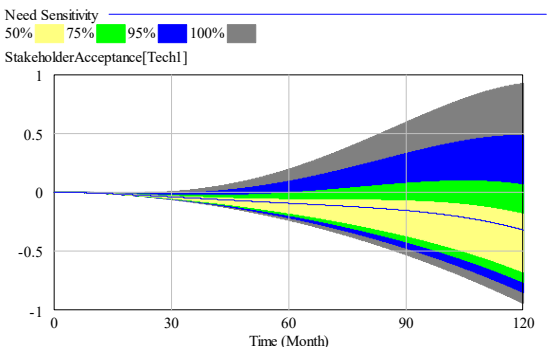

Figure 0-10: Stake holders influence at the initiation stage

On the impact of validation stake holders paticipation, it was noted that make 20% effect of technology transfer process, this means is likely to be more of the work of scientist as long as the input in the need was perfect. 5% of design process

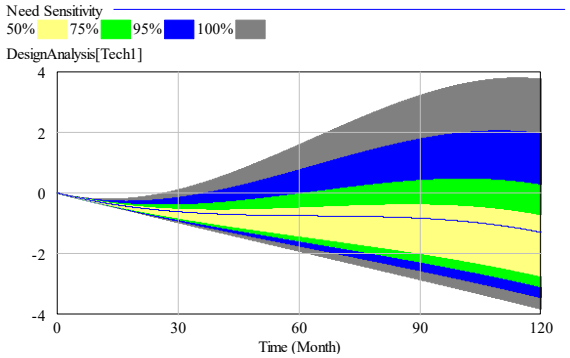

Figure 0-11: Impact of stakeholders at initiation stage in the design analysis

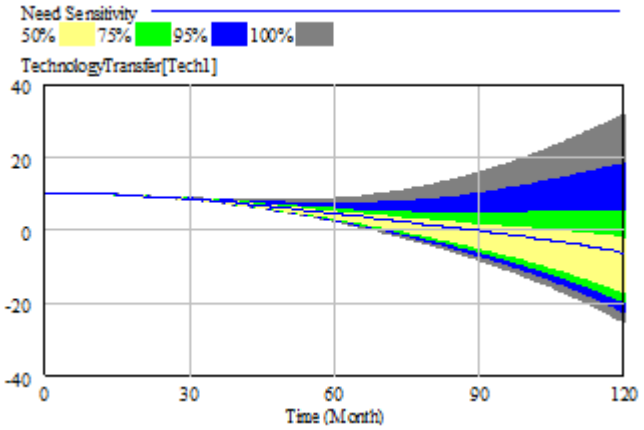

Figure 0-12: Impact of stakeholders at initiation stage in the technology transfer

Sensitivity analysis on prototype development had bad result to the validation process and the technology transfer. It was observed as a tangible device for technology validation and transfer. The effect of participation of stakeholders in this stage was producing the effect of 20% in both the transfer and validation process

4.11 Model validation

The model is tested with data on customer satisfaction correlation of the predicted data and the actual data from the field sales. The model predicted values at 120 months and was compared to index from the field in (Kothari, 2004). The existence of good relationship between model predicted diffusion index (Fin_ind_2Ven) and the real value found in sales of the same technology, with confidence level of 95% and this is significant at the 0.001 level two tailed, shows a good model prediction of diffusion rate(Avner, 2010, Kothari, 2004).

5. Conclusion

Institution like bankers, manufacturers, guarantors and others are taken like stakeholders in the model developed, this shall lead to harmonisation of R&D activities in Tanzania.

Stake holders were identified as follows: Government, Scientist Social, economist Engineer, Financier, Manufacturerand Transfer Incubatoras technology development main stake holder with higher effect on the technology development cycle for market penetration

Model for the effect of stakeholders in different stages are developed and their composition as show in equation 4-1 to 4-7. These mathematical models obtained through the multilinear regression method were loaded into Vensim system dynamic model and run to process data that were used to validate the model. On sensitivity analysis of participation of stakeholders in the technology development cycle, it was noted that the initiation stages, that is need assessment, conversion of stakeholder's attribute to design specification are so detrimental to the development of technology and may cause 100% failure of the technology. In other word the earlier participation of stake holder is important for good end of technology. It was noted the impact of stake holder on technology development reduces as the technology cycle approaches the end with an impact between (20% to 10%)

The model was validated to see its prediction of technologies acceptance by the stake holder and reflection of the sales of the current technology in Tanzania were corelate. It was observed that at the confidence level of 95% and the significance value of 0.001 two tailed. With better practices in technology development processes and more readily available information further studies can be taken to enhance the use of stake holder in the technology development cycles

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