A META-ANALYSIS ON DIVERSIFIED CHALLENGES FACED BY SMALL AND MARGINAL FARMERS IN ADOPTING AGRICULTURAL TECHNOLOGY

ABSTRACT

Each year innovation takes place in Agricultural and allied sector and adoption of this agricultural technologies is essential for enhancing the agricultural outputand productivity. For the successful transfer of agricultural innovations Government of India has implemented number of schemes to support farmers in adopting the technology for production. However, various literature have shown that small and marginal farmers, being largest population among the farming community in India, still lag in adopting agricultural technologies successfully. Therefore this study was taken with the aim to analyse the diversified challenges faced in adopting agricultural technologies. Meta-analysiswas used to identify the elementsthat play a keypart in adoption behaviour of small and marginal farmers. The study observed such major factors viz., Psychological based, Economic based, Resource based, Tech-Bridge based, Tech-outreach based, Diversity based and Ambivalence based that hampered decision making behaviour in adopting agricultural technologies among small and marginal farmers.

***Key Words*:** Agricultural Technology, Adoption, Diversified Challenges, Meta-analysis

Introduction :

Buchanan, Robert Angus (2022) defined the concept of 'Technology' as the utilization of scientific knowledge for the purpose of improving human life or for the purpose of transforming human society. Gradually by 20th century the term included

a growing variety of means, procedures, and ideas and in addition to innovations,tools and machines. Today technological advancements is the means and methods of providing goods and services (Loevinsohn*et al.,* 2013) that have led to significant changes in society.

Agriculture sector encompasses a broad range of disciplines, therefore agriculture technology includes all kinds of improved or modified devices and practices that improves agricultural production (Jain *et al.,* 2009). Modifications in farming practices and field managing systeminprevious few decades have been innovative. Every year, there are several new agricultural inventions and, sometimes, ground-breaking innovations occurs and this advancement in technology is considered to be vital to raise output and reduce cost of cultivation. Hence to encourage the adoption of agriculture technology among the growing population of Small and Marginal Farmers (SMF)the Government of India has taken numerous efforts(Agricultural census division, Government of India, Ministry of Agriculture and Farmers Welfare, 1970-2016).

Despite thelarge scale efforts towards SMF population literature showed that farmers avoid adoption (W. Samuelson, R. Zeckhauser, 1988) and relied on outmoded methods of production (Margeret and Samuel, 2015). This may be because the adoption of advanced methods in agriculture has positiverelativeexclusivity that cannot be pooled by theories focused on distinct level actions change (Keerti Prajaapti, Shabyasachi, 2019) and also adoption of technology is highly influenced by availability & affordability of technologies and expectation of farmers profit earning (Foster and Rosenweig, 2010). Several challenges are faced by small and marginal farmers in adopting agricultural technologies and this often lead to slow adoption behaviour among the famers (Bandiera and Raul, 2006; Simtome, 2011).

This triggered the researcher on the need to analyse the major challenges faced by small and marginal farmers in India in adopting agricultural technologies. Researchers also observed that over the years various studies have been conducted on various technologies in the country and in addition adoption & impact of different technologies by the farmers have been studied. However, the aspects of diversified challenges faced by SMF in adopting technologies in agriculture sector was given less importance and poorly acknowledged.

Therefore, this paper tries to review literature on challenges faced by small and marginal farmers of India in adopting agricultural technologyfor 176 years i.e. from 1846 to 2022 and comprehensively evaluate the 21st century challenges. In order to address the challenges encounteredby small and marginal farmers with regard to agricultural technology adoption, meta-analysis was used. It is a statistical analysis that pools the results of numerous scientific studies (Gene V Glass, 1976). The main contribution of this paper is identifying the factors affecting the farmer's technology adoption behaviour and to provide better understanding of diversified challenges faced by small and marginal farmers in technology adoption.

MATERIALS AND METHODS

Literature Search Strategy and Sources

Meta-analysis requires unbiased selection of studies to validate the goal of the researcher (S. John A. *et al.,* 1998). Therefore, our goal was to review all the relevant published articles and technical recordsfrom public database, wherein international database Scopus (https://www.scopus.com) was selected purposively.Considering the study period of 176 years from 1846 to 2022, types and extent of analysis on diversified challenges encountered by the small and marginal

farmers of India in adopting agricultural technology was critically analysed.In addition subjective change in the challenges faced by small and marginal farmers were reviewed for quality of the study.The search was aimed at the publication with the key words ‘Agriculture’, ‘Challenges’ and ‘India’ within the title and abstract with different combination in singular to plural. The search was limited to manuscript in English without restrictions in publication date and the first result was found from 1846. The explorationwas conducted on April 2023, the cut-off date for covering publications was made until the end of 2022.

Inclusion and Exclusion for Study Selection

In addition to text selection in English language and regarding the date of publication, publications in closed access were excluded. The repeated bibliography denoting to the same documents were eliminated that stated the same results in different publications (e.g., an article from a journal published as book chapter and journal article referring the same challenges faced in agricultural technology adoption). Furthermore, specific criteria was used for inclusion i.e. specifically focusing on challenges faced by SMF of India in adopting agricultural technology.In addition, it also included all the sectors of agriculture regardless of specific technology adoption to study the general challenges encountered by SMFs. This inclusion was correlated to answer the research survey related question.

This approach ensured that the qualitative data required in meta-analysis was generated through systematic review based on available manuscripts and provided sufficient conceptual data for quantitative analysis in full text.

Selection for Data Extraction and Synthesis

In total of the 39 articles reporting on, at least one of the challenges encountered bySMF in implementing any technology in agriculture sector that met the criteria selection was included. The literature search process initially included 421,752 results with search word ‘Agriculture’ in online database (Scopus) and was reduced to 47853 with inclusion of the word ‘Indian Agriculture’. Furthermore, selection process was conducted phase wise as shown in Table 1 and Table 2. As a result, a total of 39 manuscripts were included for research survey consisting of full length text in English, in the context of diversified challenges faced by SMF in adopting agricultural technology in India.

Data Extraction and Variable Categorization

The full text of 39 manuscripts were selected and examined in order to develop the variable framework. A total of 17 variables were identified that had major impact on technology adoption among the SMF of India. An overview of the identified variables is explained in Table no. 3 and variables were further categorized into seven major factors or groups (Table 4) based on types of constraints faced by the small landholders in Indian farming condition. Table 6 describes the concepts of identified factors.

RESULTS AND DISCUSSION

Research Findings from Meta-analysis

Analysis of literature showed that farmers (smallholders) faced challenges at different levels in adopting agricultural technology. Defining challenges faced by small and marginal farmers in adopting agricultural technology is a complicated task as it varies from type of technology one needs to adopt to compatibility of the technology with the farmers situation which may be based on size of land owned,

affordability of the technology, psychological phase of an individual farmers and so on. Therefore the researchers in this paper collected, classified and defined the diversified constraints faced by the SMF and factorized the identified variables as Psychological Constraints, Economic Constraints, Resource Constraints, Tech-Bridge Constraints, Tech-outreach Constraints, Diversity Constraints and Ambivalence Constraints (Table 5).

Psychological Constraints

Traditionally psychology of a farmer in analysis of agricultural technology adoption is built or endowed based on their information seeking behaviour, risk taking ability, experience with uncertainty and available infrastructure within their habitat (Feder et al., 1985; Singh & Kohli, 1997; Rogers, 2003 and Uaiene, 2011).Various studies revealed that farmers with higher experience had better knowledge and full information to evaluate the new technology (Chilot*et al.,* 1996; Dev, 2012; Sawmiya, 2021) and chance of technology adoption in agriculture is increased. Whereas having lobbying power owned by an individual or among a group of farmershad high correlation with agricultural technology adoption because cultural factors mostly are seen from gender point of view (FAO, 2011) and adoption decision is influenced by the male head of the household. Although various variables identified from the literaturehad influence on adoption behaviour among the SMFs, researcher felt that Psychology of farmers had major impact in decision making for their own profit making with agricultural technology adoption.

Economic Constraints

Majority of the researchers discussed in literature on land size constraints encountered by the small land holders intechnology adoption behaviour (Kasenge, 1998; Ahmed, 2004; Mignouna*et al.,* 2011) that stated positive relation exists

between the land holding size and adoption of agricultural technology. Large landholding farmers were likely to implement new technology as they could have the funds for the technology and offer a part of their land for technology trial (Uaiene*et al.,* 2009).Several studies have also exposed that availability and affordability of agricultural technology were driving force among the farmers in adopting agricultural technology successfully.However the key elements of technology adoption in agriculture among the small holders is the net addition obtained by the farmer from adoption (Foster and Rosenzweig, 2010).

Resource Constraints

As adoption of new technology requires incredible amount of capital to purchase the technology along with complimentary inputs requirement, farmers having credit access become vital for agricultural technology adoption (Dev, 2012). Million & Getahun (2001) and Beshir *et al.,* (2012) studied that farmers with formal credit access possessed higher chance of adopting new technology than the farmers who didn't have access. Adoption of agricultural technology also requires skilled labour to operate and make full use of technology efficiently, however some studies found that skilled and seasonal labour availability had major impact on decision making among the small and marginal farmers in adopting technology (Kanwar, 2000).Fan et al., (2000) revealed another major challenge faced by small and marginal farmers in adopting agricultural technologies was availing of the resource or new technology release by the government because government mostly invested in areas with more productivity and production, whereas it was revealed that government invested less in the areas of under productivity and poor infrastructure areas.

Tech-Bridge Constraints

Tech-Bridge implies to any kind of strategies bridged between the farmers and the information channels used to disseminate agricultural technology. Extension services and Information & Communication Technologies (ICTs) were considered under the factor Tech-Bridge after an in depth analysis among the researchers.

Extension services had always helped farming community in understanding the importance of modern farm technology and to enhance their farm income. Farmers with better access to extension services showed better adoption of agricultural technologies (Maiangwa*et al.,* 2007 andAkudugu et al., 2012). However,Bhanwala (2016) revealed that Indian SMFfaced untimely distribution of inputs and information on new or seasonal agricultural technologies. Christopolus (2010) also studied that untimely availability of technology access and lack of innovative extension approach did not motivate farmers enough for technology adoption. This implied to poor extension services provided to the SMF and in hand it hampered their decision making in agricultural technology adoption.

Whereas mobile usage and internet availability also play crucial role for the farmers for all types of reasons. Some use apps and social media to have better access to farm technology knowledge and keeps tabs on latest agricultural technologies that will be suitable for their farm situation. This facility made SMF keep closer eyes on their needs. However it was observed that although large number of farmers own mobile and have access to agricultural technology information, they felt that the technology mostly didn't align to their need of practice and hence small land holders did not pay much attention to messages forwarded or uploaded (Odame, 2011; Avinash, 2018). Avinash (2018) also cared to explain the science behind their lack of interest in acknowledging the information on new agricultural technology may be due to poor understanding of science communication among the SMF of India.

Tech-outreach Constraints

It was found that SMF in India have serious issues with technology outreach. Tech-outreach explains the technical services extended to the farming community or other stakeholders of agriculture for the purpose of capacity development & for the development of overall agricultural sector. Now this may include the AI (Artificial Intelligence) services such as virtual learning platforms. Although virtual learning platforms holds various advantages from ease of operating new technologies without bearing the cost of damage or risk involved. Debarishi Datta (2022) emphasized on the constraints faced by SMF that there is lack of AI centres. Very few AI centres can be found in the country and that had no or very less access to the farmers. Using of AI also required Net user friendly and proper understanding of science, which farmers were lacking on and farmers also found AI as time consuming process. Lack of training on the IT sectors revolution and lack of AI centres in agriculture sector had major impact in adoption of new agricultural technologies.

Diversity Constraints

Diversity refers to heterogeneous use of farm land. Heterogeneous use of land may be explained by the practice of crop diversification which holds multiple benefits from weed management, nutrient management to increase in the farm income and intended to give better choice in variety for crop production by lessening the risk involved in mono crop failure (C.R Hazra, 2001). HoweverWilk (2002) revealed that SMF faced the issue in adopting suitable agricultural technology while practicing diversified crop cultivation. This leads to difficulty in effective utilization of technology and in addition with high cost of technology purchase made the smallholders in agriculture more indecisive in technology adoption.

Ambivalence Constraints

Technology adoption becomes complicated when an farmers do not have proper information and knowledge of a given agricultural technology. Since adoption of technology is a mental progression that passes through a series of stages generated with knowledge and information i.e. from hearing about the technology to final utilization of technology (F.G *et al.,* 1985). Therefore lack of knowledge and poor information on new agricultural technology often generatesthe state of having mixed feelings among the SMFby creating contradictory ideas on new-improved agricultural technology.This creates indecisivenessin farmers and lowers the rate of technology adoption.Rao (2000) explained how climate variability particularly focusing on monsoon variability in India brought difficulty in decision making to adopt technology. Unable to obtain correct data regarding the monsoon variability and intense drought possibility created dilemma in purchasing high cost technology (Gadgil, 2003; Bhanwala, 2016; Debarishi Datta, 2022).

Research Findings from Primary Data Collection

With the help of identified qualitative variables (Table 6) that defined diversified challenges faced by SMF in adopting agriculture technology, a survey was conducted to have better insights on the prevailing challenges faced. Thondamuthur block of Coimbatore district from Tamil Nadu was purposively selected as the research area. The selected block had 10 villages, out of which 3 villages namely Kalikanayakanpalayam, Narasipuram and Perurchettipalayam were purposively selected. A total of 60 respondents were selected, allotting 20 from each of the selected village through snowball sampling method.

Multiple Correspondence Analysis (MCA) was used to examine the association between qualitative variables. Application of MCA was justified as the dataset of the study. MCA is a multivariate methodintended to determine both inter-relations and

intra-relations of two or more categorical variables by reviewing the closeness and remoteness between the factors (Table 6) and the Plot (Plot 1) below visualizes correlation between diversified challenges (variables) faced by small and marginal farmers and MCA principal dimensions.The plot helps in identifying to what extent the variables correlated with each of the dimension. The distance between the rows and column gives the similarity and dissimilarity among the variables and it can be seen that variables contribute up to 41.80 per cent in dimension 1 and 31 per cent in dimension 2.

Diversity constraints (78%) had major impact on decision making to adopt technology among the SMF of Thondamuthur block of Tamil Nadu. Diversity constraints defines farmers having technology adoption issue to diverse crop cultivation in small piece of land. This confused the farmers to adopt technology for particular crop. This may be because majority of the farmers were cultivating crops (Such as Coconut, Arecanut, Papaya, Banana and Sugarcane) for home consumption and local market supply. However few farmers realized the advantage of adopting a particular technology to its full potential and hence they shifted to cultivating one major crop, provided technology was adopted (Example drip irrigation was commonly adopted among the coconut growers).

Diversity factor was followed by Psychological factor (60%) in agricultural technology adoption behaviour among the farmers. Adoption of agricultural technology leading to additional investment during the adoption of agriculture technology hampered SMF in decision making by 61.66 per cent. This may be supported by the farm income variation among the farmers. 59 per cent of the farmers from selected villages ofThondamuthur agreed on inability to adopt technology because they were not sure of their future farm income generation which would help them in analysing

the present investment pattern. While some respondents disagreed on not adopting technology due to uneconomical land, although 32 per cent of the respondents were marginal farmers and 18 per cent of the respondents were small farmers.

More than half of the respondents (54.99 %) disagreed on statement ‘Extension approach does not motivated them to adopt agricultural technology’. This may be because most of the respondents were in contact with private and public extension agents, specially the coconut growers who had adopted drip irrigation and had credit access with the help of extension agents.

CONCLUSION AND POSSIBILITIES FOR FUTURE RESEARCH

This study has reviewed the past studies that helped in identifying various challenges most commonly faced by SMF in adopting agricultural technologies. Although from literature,psychological state of farmers was found to have highest impact on decision making for agricultural technology adoption, the primary survey data collected from the Thondamathur Block of Coimbatore District of Tamil Nadu revealed that Diversity factor had major influence in technology adoption amongst the SMF. The study also identified new factors evolving with time among the farmers i.e. Tech-Bridge factors, Tech-outreach factors and Ambivalence factors that highly hinder the adoption of agricultural technology in modern times.

Adoption of agricultural technologies among the SMF is influenced by numerous factors as identified. These factors may differ from farmer to farmer living in different areas and based on the farmer’s field experience, cognitive knowledge, educational background and chronological age of the farmer. Adoption of agricultural technology definitely has positive impact on farm income and it is important to meet the increasing demand for enhancing food security, poverty, rural development and economic growth of the country.

Therefore it becomes crucial for researchers to comprehend the conditions and essentials of farmers and other stakeholders of agriculture sector, and provide better insights for policy makers in forecasting and implementing technology related programmes. This can enhance the adoption of agricultural technologies by the farmers.

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Table 1: Articles selection

Phase	Criteria	No. of articles displayed	No. of articles rejected	No. of articles selected
Phase-I: Identification	'Agriculture'	421,752	Further criteria applied	421,752
	'Indian Agriculture'	47853	373,899 no's were rejected	47853
Phase-II: Screening	Articles in English	47136	717 no's were rejected	47136
	Articles in Open Access	13796	33,340 no's were rejected	13796
	Articles till the end of 2022	13693	103 no's were rejected	13693

Table 2: Articles excluded in the third phase

Phase	No. of articles displayed	Criteria	No. of articles rejected	No. of articles selected	No. of articles selected
Phase-III: before 1960s	2 out of 13,693	Rejected by Title	-	2	2
		Rejected by Abstract	-	2	
		Rejected by Full Paper	-	2	
Phase-III: After 1960s	213 out of 13,691	Rejected by Title	47 articles were rejected	166	22
		Rejected by Duplication	8 articles were rejected	158	
		Rejected by Abstract	61 articles were rejected	97	

		Rejected by Full Paper	75 articles were rejected	22	
Phase-III: 2000-2022	13,478 Articles	Rejected by Title	6,893 articles were rejected	6,585	15
		Rejected by Duplication	17 articles were rejected	6,568	
		Rejected by Abstract	5,701 articles were rejected	867	
		Rejected by Full Paper	852 articles were rejected	15	
Total number of articles selected					39

Table 3: Overview of articles incorporated in meta-analysis

Sl.no.	Author	Variables Identified		Methodology
1	Sikka, D. R., & Sanjeeva Rao, P. (2000) Gadgil (2003)	V1	Monsoon variability and prolonged drought hampers my decision making.	Survey
2	Kanwar (2000)	V2	Due to lack of seasonal and labour and expensive labour	Survey
3	Kaplan (2008) Odame (2011)	V3	Poor scientific Knowledge	Survey
4	Wilk, J., & Hughes, D.	V4	Using land for diversified activities	Survey

	A. (2002)			
5	Fan et. al., (2000)	V5	Government invest less in under productivity and poor infrastructural area	Survey
6	Odame (2011) Debarishi (2022)	V6	Hours spent in farm increases with technology adoption	Survey
7	NCEUS (2008) M. S. Dev (2012) Debarishi (2022)	V7	Imperfect credit markets leading to optimal decision making	Survey
8	Doss (2005) Ramesh Chand (2022)	V8	Unable to market the produce to recover cost involved	Case study
9	Benyene (2008)	V9	Not sure of future income generation to invest on present technology	Survey
10	Christaplos (2010) Odame (2011)	V10	Extension approach does not motivate me enough to adopt any new technology	Survey

11	World Bank Reort (2001) Odame (2011)	V11	Do not hold any lobbying power in decision making	Survey
12	Odame (2011)	V12	Observed poor performance of technology adopted by others	Survey
13	Doss (2005) Bhanwala (2016)	V13	Not aware of dealing with natural calamities (climate change)	Survey
14	Bhanwala (2016)	V14	Uneconomical land holding	Survey
15	Odame (2011) K. Avinash (2018)	V15	Have access to mobile information but mostly it does not relate to my interest or situation	Survey
16	Debarishi (2022)	V16	Expensive technology adoption adds extra input investment	Survey
17	Debarishi (2022)	V17	Few AI technology stations to learn or	Survey

			access to adopt	

Table 4: Coding of key concepts identified

Groups	Variables	Code
Psychology constraints	Hours spent in farm increases with technology adoption	PC/1
	Observed poor performance of technology adopted by others	PC/2
	Do not hold any lobbying power in decision making	PC/3
	Not sure of future income generation to invest on present technology	PC/4
Economic Constraints	Uneconomical land holding	EC/1
	Expensive technology adoption adds extra input investment	EC/2
	Unable to market the produce to recover cost involved	EC/3
Resource Constraints	Due to imperfect credit markets leading to optimal decision making	RC/1
	Government invest less in under productivity and poor infrastructural area	RC/2
	Due to lack of seasonal and labour and expensive labour	RC/3
Tech-Bridge Constraints	Have access to mobile information but mostly it does not relate to my interest or situation	TC/1
	Extension approach does not motivate me enough to adopt	TC/2

	any new technology	
Tech-outreach Constraints	Poor scientific Knowledge	TO/1
	Few AI technology stations to learn or access to adopt	TO/2
Diversity Constraints	Using land for diversified activities	DC/1
Ambivalence Constraints	Not aware of dealing with natural calamities (climate change)	AC/1
	Monsoon variability and prolonged drought hampers my decision making.	AC/2

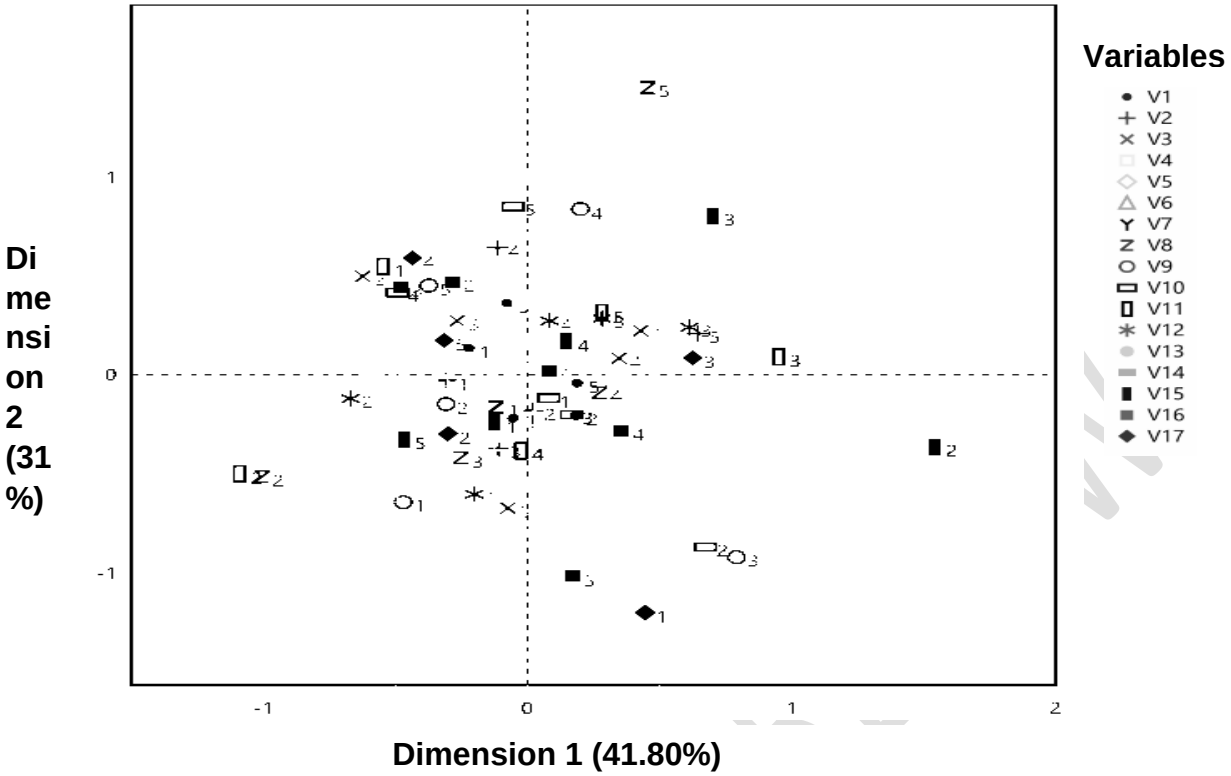
Table 5: Concept categorization

Sl.no.	Group	Code	Group details
1	Psychological constraints	PC	The limitation that is self-imposed in achieving desired behaviour based on cognitive state of an individual
2	Economic Constraints	EC	Financial challenges that limits in adopting agricultural technologies
3	Resource Constraints	RC	The limitation created in obtaining agricultural technology
4	Tech-Bridge Constraints	TC	Challenges faced by farmers in getting proper information about technology through agricultural technology dissemination services
5	Tech-outreach Constraints	TO	Regarded as the limitation of modern technologies
6	Diversity Constraints	DC	Challenges faced by small and marginal farmers due to heterogeneous use of farm land
7	Ambivalence	AC	Challenges faced due to cognitive

	Constraints		dissonance which creates procrastinations and indecisiveness among the farmers in adopting agricultural technology

Table 6: Factors Confidence Overview

Factors	Standard Deviation in Dimension		Correlation
	Dimension 1	**Dimension 2**	**1-2**
Psychological constraints	0.284	0.241	0.050
Economic constraints	0.186	0.283	0.265
Resource constraints	0.412	0.310	0.459
Tech-Bridge constraints	0.575	1.049	0.083
Tech outreach constraints	0.429	1.083	0.681
Diversity constraints	0.662	0.922	0.780
Ambivalence constraints	0.309	0.592	0.748



Picture 1 : Graphical visualization between variables and MCA principle Dimensions

ABBREVIATION

1. Small and Marginal Farmer (SMF)
2. Psychological Constraints (PC)
3. Economic Constraints (EC)
4. Resource Constraints (RC)
5. Tech-Bridge Constraints (TC)
6. Tech-Outreach Constraints (RC)
7. Diversity Constraints (DC)
8. Ambivalence Constraints (AC)