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 output and 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-analysis was used to identify the elements that play a key part 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.

Since the agriculture industry spans a wide range of academic fields, agriculture technology refers to any improved or changed tools and methods that increase agricultural output (Jain et al., 2009). Over the past few decades, there have been innovative changes made to farming operations and field management systems. Many new agricultural inventions are made every year, and occasionally, revolutionary discoveries are made as well. This technological improvement is seen to be essential to increasing crop yield and lowering cultivation costs. Thus, the Government of India has made several efforts to promote the adoption of agricultural technology among the expanding population of Small and Marginal Farmers (SMFs) (Ministry of Agriculture and Farmers Welfare, GOI, 2016).

Despite extensive efforts to increase the SMFs population, research revealed that farmers continued to utilize antiquated production techniques and avoided adoption (W. Samuelson, R. Zeckhauser, 1988). (Margeret and Samuel, 2015). This could be due to the fact that the adoption of advanced agricultural techniques has a positive relative exclusivity that cannot be combined with theories focusing on discrete level actions change (Keerti Prajaapti, Shabyasachi, 2019). Additionally, the availability and affordability of technologies as well as farmers' expectations regarding profit margins have a significant impact on the adoption of technology (Foster and Rosenweig, 2010). SMFs have several obstacles while using agricultural technologies, which frequently results in sluggish adoption among the farmers. (Bandiera and Raul, 2006; Simtome, 2011).

This made the researcher realize how important it was to examine the main obstacles small and marginal farmers in India encountered while attempting to adopt new agricultural technologies. Researchers have also noted that a number of research have been carried out on a variety of technologies in the nation throughout the years, including studies on the adoption and effects of various technologies on farmers. However, the variety of difficulties SMFs encountered when implementing new technologies in the agriculture industry received little attention and recognition.

As a result, this study attempts to explore the literature on the difficulties small and marginal farmers in India have had implementing agricultural technology over a span of 176 years, or from 1846 to 2022, and thoroughly assess the difficulties of the twenty-first century. In order to address the challenges encountered by SMFs 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 records from 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 exploration was 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 by SMF 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

A review of the literature revealed that adopting agricultural technology presented many obstacles for small-holder farmers. The difficulties in defining the obstacles small and marginal farmers face in implementing agricultural technology range from the type of technology that needs to be used to its compatibility with the farmer's circumstances, which can include factors like the amount of land owned, the

technology's affordability, the farmer's psychological state, and more. Thus, the investigators in this study gathered, categorized, and clarified the various limitations encountered by the SMF. They then factorized the variables that were found to be Psychological, Economic, Resource, Tech-Bridge, Tech-outreach, Diversity, and Ambivalence constraints (Table 5).

Psychological Constraints

Farmers' psychological makeup has historically been analysed in relation to the adoption of agricultural technology based on factors such as their propensity for information seeking, willingness to take risks, comfort level with uncertainty, and the infrastructure that is readily available to them in their environment (Feder et al., 1985; Singh & Kohli, 1997; Rogers, 2003 and Uaiene, 2011). According to a number of studies (Chilot et al., 1996; Dev, 2012; Sawmiya, 2021), farmers with more experience had greater knowledge and complete information to assess new technology, increasing the likelihood that it would be adopted in agriculture. On the other hand, a strong association was found between the adoption of agricultural technology and lobbying power held by an individual or group of farmers. This is because cultural variables are primarily viewed through a gender lens, and the male head of the family plays a significant role in influencing adoption decisions. While a number of factors found in the literature had an impact on the adoption behavior of SMFs, the researcher believed that farmers' psychology had a significant role in their decision-making when it came to adopting agricultural technologies for their personal financial gain.

Economic Constraints

Majority of the researchers discussed in literature on land size constraints encountered by the small land holders in technology 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

According to Dev (2012), the adoption of agricultural technology is contingent upon farmers having credit availability, as new technology demands a substantial financial outlay for its acquisition in addition to the requirement for complementary inputs. Farmers with formal finance access had a higher likelihood of implementing new technology than farmers without access, according to studies by Million & Getahun (2001) and Beshir et al. (2012). 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 SMFs 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. Following a thorough investigation by the researchers, information and communication technologies (ICTs) and extension services were taken into account under the Tech-Bridge component.

Extension services have traditionally aided the farming community in increasing their revenue and appreciating the value of contemporary agricultural technologies. Farmers who have greater access to extension services adopted agricultural innovations more successfully (Maiangwa *et al.,* 2007 and Akudugu et al., 2012). Bhanwala (2016), however, found that information about new or seasonal agricultural technologies was not distributed in a timely manner to Indian smallholder farmers. Additionally, Christopolus (2010) found that farmers were not sufficiently motivated to adopt new technologies by delayed technological access or a lack of creative extension strategies. This implied to poor extension services provided to the SMFs 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 SMFs 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 SMFs of India.

Tech-outreach Constraints

It was found that SMFs in India have serious issues with technology outreach. The term "tech-outreach" refers to the technical assistance provided to the farming community or other agriculture stakeholders in order to build their capacity and advance the agricultural industry as a whole. This could now encompass artificial intelligence (AI) services like online learning environments. Virtual learning platforms do, however, have a number of benefits, such as the ability to use new technology easily without incurring additional costs or risks. Debarishi Datta (2022) highlighted the limitations that SMF faces due to the absence of AI centres.. There are very few AI centres in the nation, and those that are had extremely little or no access to farmers. Farmers found AI to be a time-consuming procedure and lacked the necessary scientific understanding and Net user friendliness to effectively employ AI. The adoption of new agricultural technology was significantly impacted by a lack of AI centres in the agriculture sector and inadequate training on the revolution in the IT sector.

Diversity Constraints

The term "diversity" describes how farmland is used. The practice of crop diversification, which offers several advantages such as weed control, nutrient management to boost farm income, and the goal of providing better crop production options by lowering the risk of monocrop failure, can help to explain heterogeneous land use (C.R. Hazra, 2001). However Wilk (2002) revealed that SMFs 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

Adoption of technology by farmers becomes more difficult when they lack adequate expertise and information about a particular agricultural technique. Since the process of adopting new technology involves a mental evolution through a number of stages created by knowledge and information, such as learning about the technology and using it in the end (F.G *et al.,* 1985). Therefore lack of knowledge and poor information on new agricultural technology often generates the state of having mixed feelings among the SMFs by creating contradictory ideas on new-improved agricultural technology. This creates indecisiveness in 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 SMFs 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 method intended 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 SMFs 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 of Thondamuthur 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 evaluated earlier research that was helpful in identifying the several obstacles that SMFs most frequently faced when using agricultural innovations. The primary survey data collected from the Thondamathur Block of Coimbatore District, Tamil Nadu, revealed that diversity factor had major influence in technology adoption among the SMFs, despite the fact that literature found that farmers' psychological states had the highest impact on decision making for agricultural technology adoption. The study also discovered new variables that farmers are experiencing throughout time, such as Tech-Bridge, Tech-outreach, and Ambivalence factors, which significantly impede the use of agricultural technology in the contemporary day.

Several significant factors impact the SMF's adoption of agricultural technologies. Depending on the farmer's age, educational background, field experience, and cognitive knowledge, these variables may vary depending on the farmer living in a

different place. Agricultural technology adoption is undoubtedly beneficial to farm revenue and is necessary to fulfil the growing demand for improving food security, poverty, rural development, and national economic growth.

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	5,701 articles	867	

		Abstract	were rejected		
		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. A. (2002)	V4	Using land for diversified activities	Survey
5	Fan et. al., (2000)	V5	Government invest less in under productivity and poor infrastructural area	Survey
			Hours spent in farm	

6	Odame (2011) Debarishi (2022)	V6	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	Survey

			by others	
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 access to adopt	Survey

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 any new technology	TC/2
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

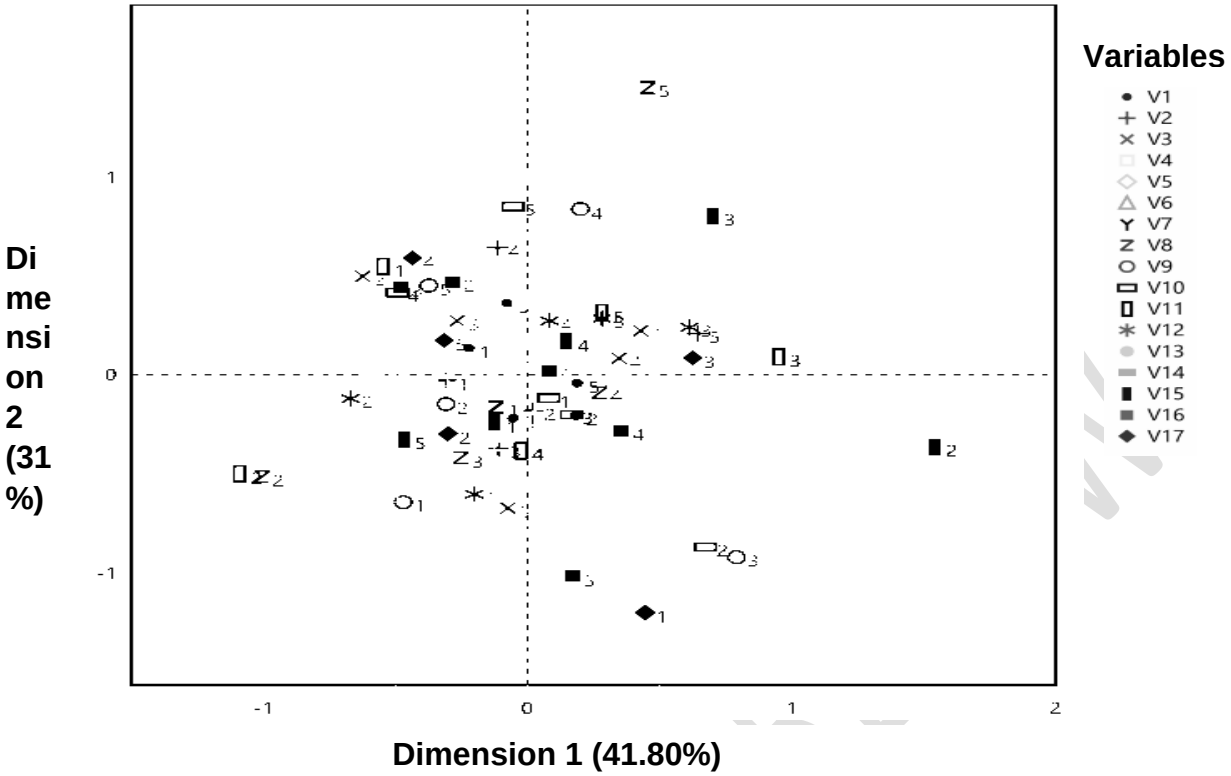
Ambivalence Constraints	Not aware of dealing with natural calamities (climate change)	AC/1
	Monsoon variability and prolonged drought hampers my decision making.	AC/2

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 Constraints	AC	Challenges faced due to cognitive 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)