# The Role of Smart Agriculture for Sustainable Rural Development: Case study of Basti Mithu, Multan

Author

MUHAMMAD DANIYAL NOON

Regn Number

00000203690

Supervisor

Dr. Abdul Waheed

DEPARTMENT OF URBAN AND REGIONAL PLANNING, NIT

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

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Author

MUHAMMAD DANIYAL NOON

Regn Number

00000203690

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Thesis Supervisor:

Dr. Abdul Waheed

Thesis Supervisor's Signature: ___________________________________

DEPARTMENT OF URBAN AND REGIONAL PLANNING

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

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# ABSTRACT

Rural spaces have been neglected for a long time and consequently, they are in decline. The rural populations are migrating towards cities causing unnecessary pressures on the services of the urban cores. Smart village is a comprehensive strategy to improve all the aspects of village life and hence protecting the rural as well as releasing pressure on urban areas while also promoting agriculture. Five main dimensions for Smart village were found; Smart Agriculture, Sustainable energy, Inclusive Development, Knowledge-Based Economy, and ICT. For the purpose of finding the barriers to the implementation of the Smart Agriculture in Pakistan, a questionnaire was designed and data were collected from the selected villages of Multan. Factor analysis was performed to combine the numerous barriers into fewer concentrated and more meaningful groups. One of the main barriers found was the lack of funding and interest by the public institutions to improve the rural areas and the lack of infrastructure to support villages. An acceptability index was made through the composite index method to find out the acceptability of Smart Agriculture among the locals. A moderate level of acceptability was derived from the composite index with a low standard deviation concluding the uniform opinion among the locals. Finally, a smart village framework was devised for policy interventions and structural reformation of rural areas in Pakistan.

**Keywords:** *Village, Smart, Rural areas, Pakistan, Barriers, Sustainable, Acceptability, Agriculture*

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Sustainable Development is the ability of the governing bodies to perform development in such a way that it does not diminish the capability of the future generations to meet their needs. It is therefore essential to have integrated processes of development, incorporating every stakeholder to come up with creative ideas, that will support sustainable solutions for the future. This undoubtedly requires to have an all-encompassing approach and thus sustainable rural development is an important part of the process. Smart Village, a new and more focused concept has the ability to provide sustainable rural development through ICT (not always), innovation and the use of new and advanced technologies where it can be applied to improve the quality of life in the rural areas.

There has been a surprising lack of interest in the rural agenda in the past decade or so. The issues pertaining to the rural space are diverse and complicated. The limited research and lack of data on rural areas contribute to the ambiguous situation of the complex issues. The subject is further complicated by non-uniform definition of what constitutes a rural area and as reported by Thomas Dax, in his impactful journal article “Defining Rural areas”, there is no one definition for a rural area and the common (mis) perception is that rural areas are non-urban areas. The lack of uniformity in the concept of rural areas as explained have greater policy implications as the issues are seen as mainly “rural issues or non-urban issues” requiring distinct solutions which in reality would require holistic methodologies involving all the interdependent regional entities(Dax, 1996). This above-mentioned uncertainty, among other issues such as duplication of roles in institutions related to rural development or uncertainty in departments over funding, make it difficult to implement practical solutions and provide a better system of governance in the rural areas. In short, rural areas have governance issues as the policies and instruments for delivery do not support the actual on ground situation of the rural areas. The term governance is used to describe the relationship between the state and its people(Goodwin, 1998) and while governance issues are being discussed in context of urban metropolitans, it is certain that the mis-governance of rural areas will hinder most or all of the SDGs (Sustainable Development Goals) provided by United Nations in 2015. 3.4 billion people (or 40% of total population) live in rural areas as reported by United Nations in 2018(Affairs, 2018). For example, to achieve SDG goal no 1 to end poverty there must be an agenda incorporating both urban and rural areas as it is impossible to eradicate poverty while neglecting 40% of the human population, SDG goal no 2 zero hunger requires the same. Most of the SDGs require holistic frameworks that not only address urban populations but focus on rural populations as well. “Smart Village” is a concept that can address these problems by providing the framework for Sustainable Rural development.

Globally about 70% of the poor reside in villages, therefore if a strategy for poverty eradication has to be successfully implemented, there must be a visible focus on rural areas. Secondly, the nutritional requirements of the population, more specifically in developing countries, come from the rural areas, therefore the practices adopted by the farmers are of utmost importance to the government and good willed policy makers. The need of the century is to provide massive consumption for the billions while reducing the stress on the natural environment as much as possible, preferably through modern and sustainable agricultural techniques. As discussion in Smart Villages and its dimensions will continue later, we will see that to motivate farmers specially poor farmers there is a need for an in-depth incentivized framework for agriculture that provides not only short term benefits such as higher crop yields but long term incentives as well such as education for the farmers children or pension schemes focusing deliberately on farmers adopting good agricultural practices(Hazell & Lutz, 1998). Sustainable Agriculture is the hallmark of Smart villages in developing countries and it is the dire need for the future.

There are multiple strategies to tackle the problems and make rural areas more sustainable. One such strategy, most often thought as an exclusive urban solution, is a smart community concept. This strategy is explicitly related to SDG goal no 11 of sustainable cities and communities *as this approach allows us to give smart solutions for sustainability in both rural and urban areas*. The strategy also incorporates many other SDG goals including but not limited to good health and well-being, responsible consumption and production and Climate action. As we will continue into further sections of the research, we will realize that Smart village is not a “one idea fits all” type solution but rather a more practical response to real life issues that can be solved with smarter solutions preferably (but not always) with ICT (Information Communication and Technology) and has the potential to improve the quality of life of its rural citizens. Like every new concept there are many ambiguities and no such universal definition exists. Some researchers such as Holmes and Zavratnik have done extensive research on Smart village concepts around the world and several successful smart initiatives have been dissected in order to reveal their potential strengths and weaknesses. (Holmes et al., 2015)

In this research, a comparative analysis of smart village will be done where definitions, dimensions and well-established pillars will be assessed in order to conceptualize the term “smart village”. Furthermore, the possible shortcomings that exists in current research scenario of smart villages will also be reviewed. The aim of this study is to suggest a smart village framework suitable for Pakistan. Major obstacles are also highlighted that includes policy hurdles and institutional weaknesses in rural development, cultural hindrances and funding issues related to the rural areas in Pakistan.

## 1.2 Main Objective of the Study

The primary objective of this study is to assess the role of Smart Agriculture in Sustainable Rural Development in Pakistan. The study area selected for survey was Basti Mithu, Multan.

## 1.3 Sub Objectives

1. To conceptualize the concept of a Smart Village from the lens of Sustainable Development Goals and Sustainable Rural Development
2. To explore the constraints/barriers towards implementation of a Smart Village
3. To find the acceptability of the Smart Village concept by the local rural population
4. To propose a Smart Village framework for villages in Pakistan

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Sustainable Development

“Sustainable Development” is the current buzzword in every aspect of social, economic and political sphere of our lives. It is presented in business meetings as to ensure their products are “sustainable” to the environment, or in high level government councils where they propose policies on decreasing the carbon emissions to achieve “sustainable” growth. It is the term when used appropriately means a lot of work on every dimension of our life and therefore requires deeply integrated policies and strong institutional support to implement these policies on ground(Fu et al., 2019).

Agenda 2030 was proposed on the United Nations sustainable development summit in New York. It was formally signed by all the member nations on 25$^{th}$ September, 2015. It streamlined the previous Agenda 21 and put forth 17 goals with timebound targets. Agenda 2030 is famous for putting the concept of 5 P’s (Peace, Prosperity, People, Planet, Partnership), where these 5 terms are essentially required for achieving the 17 proposed goals. These goals are important for all nations and their people in order to have a sustainable growth pattern. This ensures protection of the natural environment as well as the social and economic benefits that are necessary for providing good quality of life to the citizens of this planet. Some goals include SDG1 End poverty in all its forms everywhere, SDG2 End hunger and achieve food security, SDG7 Ensure access to affordable, reliable and sustainable energy for all. The essence of the SDGs is to guide everyone into leading a conscious life, growing while protecting the natural environment and taking care of the limited resources available on the planet as well as ensuring the well-being of the future generations(Sachs et al., 2019).

## 2.2 Relation between Sustainable Development and Rural Development

2/3$^{rd}$ of the total population in the subcontinent reside in rural areas(Muhammad et al., 2017), which means that to achieve SDG1 of ending poverty requires actions in rural areas or SDG2 of ending hunger or SDG11 of making cities and "human settlements" sustainable all require a deliberate focus on rural areas. Without the due attention most of the SDGs will not progress farther especially in the developing nations where rural population is still a major chunk of the total population. Most of the SDGs proposed in Agenda 2030 will have to consider rural spaces as well, the debate on Sustainable Development cannot be concluded without giving Rural Development a key role in all our actions and policies.

## 2.3 Importance of Rural Development

The World Bank's report, *state of water supply, sanitation and poverty in Pakistan and its impact on child stunting,* released in 2018 has calculated the rural poverty at 36%, while urban poverty stands at 18%. Another revelation from the report is also desolate, although the overall poverty levels have gone down since 2000-2001 but the gap between rural poverty and urban poverty has stagnated. About the literacy rates, report findings show female literacy rate in rural areas at 28% which is less than half of the urban female literacy rate(Mansuri et al., 2018). These poverty and gender gap statistics on rural areas is a cause of concern and therefore the need for better rural development is called for.

In the 2001 paper by Simon Maxwell, "Rethinking Rural Development", Simon correlates the trends of rural-urban migrations and ask if the migrations will continue through 2020 as projected by the data at the time. And will the villages become sanctuaries for the very young and the old, while the productive youth migrate to urban centers in search of wages and employment opportunities. This question has remained relevant throughout, with much of the research is being done on rural-urban migrations and the effect on cities resources while less so on the impact of rural economies because of rural to urban migrations(Ashley & Maxwell, 2001). In this regard, the rural areas have been neglected as the issues pertaining to lack of labor force, employment opportunities, decreasing trend of enterprises etc. have continued throughout to 2020 (present).

Lack of basic services, hubs of poverty, lack of growth opportunities, shortage of skilled/ semi-skilled laborers etc. needs a new and rethinking of rural development policies. These issues show the rural development done in the past is not working, therefore it is time to change the way we think about rural areas and how we govern them.

### 2.3.1 General Approach to Rural Development

Rural Development policies has been stagnant in the past few decades. Primarily, the policies towards rural development have been directed towards agricultural productivity while a great neglect is been shown in issues pertaining to circular rural economy, community participation, basic services, de-ruralization and lack of basic utilities. The Green revolution in the 1960's made the mass agricultural production possible, therefore the approaches towards rural development have been normally persistent towards improvement of agriculture and more recently "Sustainable Agriculture" term has been coined by various International agencies as being of utmost importance towards nation development and betterment of rural areas. Investment in agriculture has many benefits, i.e., increased labor, enhanced food production, coping with stresses in malnutrition. These benefits alone are enough for many nations to focus solely on rural farm economy but recent trends of rural to urban migrations, shortages of labor, climate induced migrations and shifting weather patterns show that there is required an integrative policy towards rural development that needs to cater to the issues currently developing. The major policy change is required to focus on the rural non-farm economy (RNFE), it is essential that the migration outflows be weakened to improve the overall well-being of rural areas. Investment in agriculture is no more the only solution towards rural development (Ashley & Maxwell, 2001; Ellis & Biggs, 2001; Šimková, 2007).

## 2.4 Defining Smart Village

As mentioned earlier the term "smart village" is relatively new and therefore there is a wide gap in research. The most common working definition as reported by European Network for Rural Development (ENRD) is "rural areas having practical solutions to problems given by the locals themselves and actions taken by community-led programs to improve the quality of life of its residents". ENRD also recognizes the differences between each community and the importance of contextual solutions rather than actions that can bring benefit to some communities but not others(Visvizi et al., 2019a). Rural areas that will build on their existing strengths and emerge from their weaknesses with better support of the community can be considered in becoming smart villages.

Rather enforcing ICT and Digitization in rural areas what is needed are local solutions based on local issues and with consultation of local stakeholders. The solutions that are made by discussion with the local population will be sustainable in the long term. Rural areas improving upon their existing quality of life and with improvements in services such as energy, access to finance and credit system, sustainable agriculture and inclusive development can be called smart villages. It is realized that the smart village concept preludes ICT and Digitization to improve upon their problems but that should not be the case, the ICT part must come after potential issues are identified and the solutions can be given with (or without) ICT. ICT is one of major pillars of Smart villages but enforcing ICT on local populations who are unable to use them will not be practical. Local training programs including the local acceptability surveys should be done to improve the skill level of the rural residents and incentives specified which will motivate the population especially youth to use the digital services for their improvement(Holmes & Thomas, 2015).

Many argue that smart strategy should not be applied on single distinct areas but should be part of the regional strategy. The argument given is based on grounds that all areas are interdependent on each other and for the improvement of one village requires improvement on the villages and cities it directly and indirectly benefits from. Another major component that many prefer necessary is the "smart specialization" strategy. This utilizes the rural areas existing potential strengths and improves them upon using innovative solutions. It is also proclaimed that this strategy is more useful for rural areas rather than urban areas which have diversity of business's, markets, services and governance levels and so cannot specialize in one area. Rural areas are more uniform and thus specialization can be made more effective in villages. Undoubtedly this strategy requires a good business environment, hardworking employees, innovation, R&D and inclusivity to be successful(Naldi et al., 2015).

Different stakeholders will have different solutions, each actor can base its opinion in self-interest rather in the community's interest. Therefore, it is important to regularly update policies and strategies to streamline the smart programs according to the community's needs.

The overall concept of Smart village can be complicated especially when compared to the relatively more refined smart city concept, we have to realize the differences and similarities between these two apparently similar terms. The urban cores are highly developed with a huge potential for utilization of digital and ICT services, on the contrary rural areas are sparsely populated and basic infrastructure may or may not be available to implement ICT. Thus, we cannot assume ICT will be integrated smoothly into the rural space but gradual improvements to the basic facilities can make sure the rural areas become smart-er (Visvizi & Lytras, 2018).

There may be a notion that improving technological developments in the villages will make them smart but it is important to consider the gaps in technological improvements and that it might not be the only strategy. Technology must be integrated coherently with the smart objectives of the village. Technology alone cannot be a strategy for improving villages but a more extensive program that should preferably include better technologies for the benefit of the village must be applied. In short traditional and new networks must be strengthened with the help of innovative technological solutions to benefit the residents and enterprises of the village(Budziewicz-Guzlecka, 2019).

Villages are being depopulated, loosing essential services and the quality of life is decreasing. Rural youth are continually migrating to cities perceiving better livelihood opportunities and higher wages. The heritage and unique cultures of villages are disappearing and agricultural is stunted. The major objective for a successful smart village strategy must be therefore to first and foremost improve the image of the village life, which can be done partly by using the term "smart village". Provision of basic services and diverse livelihood opportunities will create an incentive for the youth to either stay or migrate back from major urban centers. Decreasing the digital divide between villages and cities will also play a major role by providing a virtual space for rural dwellers for work and leisure. Digitization can further be employed in improving market access and introducing e-services. A successful implementation of smart strategy will however require an intensive policy framework and an undivided attention towards smart rural development. A constant supply of funds will also be necessary without any delays and complications. A "one-stop shop" is also advised where the residents or the concerned villagers can ask for help in smart projects, this one-stop shop will guide them according to their projects and a smooth implementation can be done without worrying about bureaucratic hurdles and complicated paperwork. We need to make villages attractive for the residents so they can be proud of their place of residence. This will allow the local persons in investing further on improvement of their villages and also will be more involved in any smart strategy introduced by the governments.(Visvizi et al., 2019b; Wolski & Wójcik, 2019).

We have now understood the complexities and uncertainties around the smart village concept. The need of smart villages may be challenged for its blurriness but as we have learned that smart village is not just a fad, it is a wholesome concept that covers all aspects of rural life. For example, a smart village will "improve the lifestyle of its residents by ensuring energy as a catalyst for development, ensuring inclusive development with reduced inequalities, sustainable agriculture with environment conservation, attractive opportunities for youth to come back to their rural homes, digital services such as e-commerce, e-markets, e-banks, mobile banking facilities and empowerment of excluded segments of the rural society." The benefits of Smart Villages are numerous provided we apply the concept generously and give the rural residents a voice to take over their developments. We will later see when studying case studies of developing countries that the smart village concept can be as simple as providing sustainable electricity to off-grid villages and improving their agricultural practices, because that is the need of that "particular" village and this would be considered a "smart growth strategy".

### 2.4.1 Benefits of Smart Village

Rural areas are facing numerous problems including depopulation of rural areas, stagnant lifestyles, limited employment opportunities among others (Katara, 2016). Smart village aims to provide a sustainable environment through community-led development(Veronika Zavratnik et al., 2018). It seeks to empower those who will directly benefit from the smart village. Sustainable energy solutions and climate-smart agriculture will provide access to better wages and opportunities for the local people. Furthermore, basic services such as water supply and sanitation, electricity, health facilities will be prioritized in a smart village. It is important to note here that although the smart village initiatives are bold and idealistic, the strengths and limitations each village has will define what kind of goals the project achieves(Naldi et al., 2015).

### 2.4.2 Dimensions of Smart Village

After extensive Literature review on the Smart village, the five major dimensions most mentioned by authors in the field were found. Below are most commonly defined Dimensions with empirical evidences for smart village listed in no specific order.

*Table 1 Dimensions from literature review*

| Dimensions | Empirical Evidence |
|---|---|
| **Smart Agriculture** | (Aggarwal et al., 2018; Campbell et al., 2014; De-Pablos-Heredero et al., 2018; Fennell et al., 2018; Jagustovic et al., 2019; Srivatsa, 2015) |
| **Sustainable Energy** | (Heap et al., 2017; Ho et al., 2014; Holmes & Thomas, 2015; Nasiakou et al., 2016; van Gevelt et al., 2018) |
| **ICT** | (Fennell et al., 2018; Holmes & Thomas, 2015; van Gevelt et al., 2018; Viswanadham & Vedula, 2010; V. Zavratnik et al., 2018) |
| **Knowledge-Based economy** | (Heap et al., 2017; Holmes & Thomas, 2015; Ranade et al., 2015; van Gevelt et al., 2018; V. Zavratnik et al., 2018) |
| **Inclusive Development** | (Heap et al., 2017; Jagustovic et al., 2019; Ranade et al., 2015; Srivatsa, 2015) |

## 2.5 Smart Villages for Sustainable Rural Development

Smart Villages has been considered a viable strategy by various scholars(Fennell et al., 2018; Heap et al., 2017; Holmes et al., 2015; Holmes & Thomas, 2015; Tiwari et al.; Wolski & Wójcik, 2019) for Sustainable Rural Development. The dimensions mentioned earlier certainly improves the aspect of a village to become sustainable. For example. Sustainable Energy is evidently a catalyst for several Sustainable Development Goals such as Education for all, improved water and sanitation services, decreasing digital divide in rural areas. The concept of smart village can be used to achieve sustainable rural development through various instruments like community-led development, smart agricultural technologies, digital creative entrepreneur solutions, inclusivity in development among others.

Smart villages allow for its inhabitants to use new and existing technologies in order to improve the well-being of its populations and it also helps in reducing the outflow migrations thus decreasing the service delivery load in the urban centers. The use of technology is encouraged as to incentivize the youth to stay in the villages by giving them access to internet for education, health and businesses. This incentives will motivate the youth to remain in their villages and further improve rural economies through their active participation in the development of the villages(V. Zavratnik et al., 2018). The ideal case would be to use community participation in developing villages on grounds of smart village concept thus moving towards sustainable rural development.

## 2.6 Case studies of Smart Villages

There are numerous examples of smart village implementation around the globe. There are differences between those implementations especially between developed and developing world. Following sections highlight the successful initiatives of smart villages in both the developed and developing countries in order to explain the variation in smart villages.

### 2.6.1 Smart Villages in Developed Countries

Each village has a unique identity with different cultures and social systems. This unique identity has to be kept in mind while following any smart village idea. For example, in Wisconsin, USA the goals that are required come from the fact that basic infrastructure and common services such as utilities, banks, market access etc. are easily available.

The smart goals therefore reflect this information and are as follows:

1. To create new housing opportunities for locals,
2. Make communities walking friendly,
3. Promote a sense of belonging for the residents,
4. Conservation of environment protection zones,
5. Making new and enhancing on-going developmental projects,
6. Improving transportation

The above goals are context based and follow the course of action as per need of the region.

The European Union on the other hand is focusing on making rural areas smarter by investing in “Knowledge-Based Economies” through digital and innovative projects. The priorities are to engage community members in using digital applications for variety of services including e-government, e-marketing, e-education among others. The European focus is of overcoming the digital divide between urban and rural residents and therefore connecting communities digitally for mutual benefit. Markets can be directly connected through ICT to consumers, cutting out the middle man and improving the direct relationship between consumers and producers. Knowledge based economies foster innovation and connect people through common goal of community improvement. This European model focus is based on the needs and existing infrastructure of the region (V. Zavratnik et al., 2018). *It is also important to understand the mutual interactions of villages on cities and vice-versa. These interactions must be in a balance to avoid tilting the rural youth population into urban areas. This is an important factor while considering any smart village model as stated by Srivatsa in his research on Indian smart villages(Srivatsa, 2015).*

Recently in 2016 Cork Declaration 2.0 was proposed under the label of "Better life in rural areas". The declaration discussed various emerging issues in rural areas of Ireland including rural exodus and youth drain. It encouraged investment in rural areas to improve the life of rural residents and decrease rural to urban migrations. It also recommended to increase the sense of place of these rural areas to make them more attractive to live. This Declaration had several smart goals including digital transformation of rural areas and increased ICT connections(Declaration, 2016).

Another Declaration named as Bled Declaration (Bled, Slovenia) was much more recently passed in 2019. It realized the potential of digital economies in rural areas, if invested can bring great change in overall quality of life of rural residents as well as provide much more livelihood opportunities. This will undoubtedly give the youth a good reason to come back to their rural households after finishing studies in urban centers. This will tackle the ongoing issue of depopulating villages in Europe. Some of the ideas for digitalization included precision farming, e-commerce, e-learning and e-health. The declaration called upon all Smart villages, using the platform "Smart Villages Network" to share their experiences in order to learn the best practices and improve upon mistakes(Declaration, 2018).

Example of Túristvándi', a village in Hungary gives us key insights in to context-based smart solutions. The village is modeled on being self-sufficient with exploring touristic potential in several areas including restoration of the ancient water mill. The practices for agriculture had been mainly traditional, now the model has improved upon these practices by introducing improved agricultural techniques. The model is suitable for this village and can be considered as a smart move for the future of Turistvandi(V. Zavratnik et al., 2018).

Another great example of smart villages is the Smart Basilicata project in Italy. The region is characterized by low population density with high unemployment and limited livelihood opportunities. The approach was to introduce community-based projects with the help of the local population and ensure long-term attendance in all of these projects by the local people to make it sustainable for the future. The improvement of social capital within projects of community participation will help achieve smart rural areas which are ready for the future. The project focused on the region Basilicata to make it more sustainable with five major pillars for smart growth in rural areas which includes: natural resources, energy, mobility, culture and tourism, smart participation(Salvia et al., 2016).

In conclusion, the developed countries are improving their rural economies by making them smarter with the help of education, innovation, community development and research as outlined in Europe policy document 2020 (Naldi et al., 2015).

### 2.6.2 Smart Villages in Developing Countries

The biggest and the most ambitious Smart village project in developing countries is being run by IEEE, which aims to promote off-grid villages by introducing sustainable energy businesses in remoter villages of the developing countries. Energy is the foremost need of the villages living in far off regions with little to no access to information, services and utilities. The countries chosen are therefore from Africa, India and Haiti. Around 50,000 people and 34 villages are being served through the program and the funding is purely based on fundraising, especially by big donor agencies in the developed world. The program has effectively implemented and is continuously monitoring 34 energy-smart villages. One of the major products of the program apart from energy-smart villages is the Sun Blazer-II project that is a mobile solar based energy system which enables students from energy-smart villages to share and spread best experiences from their villages for the common goal of improving the rural life. The program by IEEE is based on the notion that "Energy is the catalyst for development" and therefore by providing energy to off-grid villages through various mobile technologies, which is cheaper than extending the grid, it would benefit the rural areas and make them smart-er in the future. Energy is certainly the forefront for the basic utilities including sanitation, clean water and services like vocational training and e-education. Therefore, the project focuses on bringing energy to the remotest areas of the planet in order to provide benefits that stems far from electricity consumption only. It further hopes to increase community-led development projects that will benefit the whole community through shared information(Anderson et al., 2017).

CIGAR research program started in 2011, its main focus is on Climate change, Agriculture and food security. The program has various collaborators and stakeholders whom sole focus is introducing climate-smart villages specifically in the developing world. The countries chosen are the most climate vulnerable ones including African countries. Already 30 climate-smart villages are implemented effectively around the developing world and thus the project can be deemed successful. The program deals with variety of solutions for rural areas especially agricultural practices that are sustainable and have lesser carbon footprint. The future agenda of the program deals with sustainable villages that are "climate-smart" and therefore ready to deal with the climate related challenges of the future. It deals with local solutions which are devised by inclusive consultation of the local people. The important part of the plan is to train the local people rather making them dependent on external teachers for solutions and practices. By training the local rural population the program achieves greater sustainability in the long run. One of the practical outputs by the program is the Weather prediction modules developed solely for the farmers of the village. The weather predictions are fairly accurate giving real time information to the farmers and guiding them when to sow and when to harvest. Overall the program has two key objectives: 1) To make climate-smart villages through improved agricultural technologies and 2) To train local populations through community improvement programs which will benefit the locals in the longer run(V. Zavratnik et al., 2018).

### 2.6.3 Smart Village and Pakistan

There has been extremely limited research on smart villages in Pakistan. The on ground work has also been disappointing with many villages in decay. The few articles published have focused on Smart agriculture(Imran et al., 2018; Shahzad & Abdulai, 2020). There has been no clear dissection of the smart village concept in regards to the local culture and norms of Pakistan*. In this study, the aim is to reduce the research gap and become an impetus for local solutions to smart villages in Pakistan.

# CHAPTER 3

## METHODOLOGY

### 3.1 Conceptual Framework

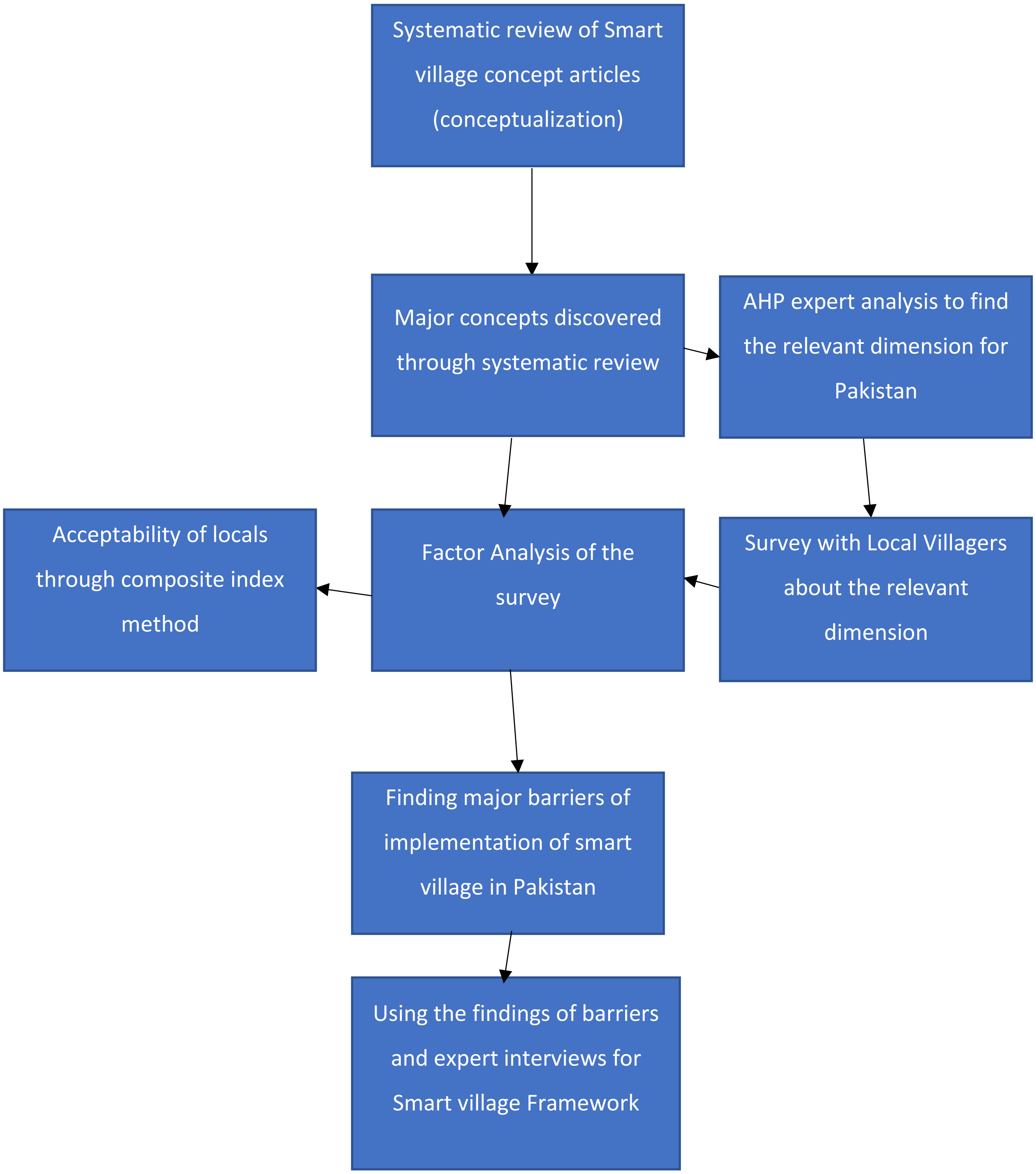


*Figure 1 Conceptual Framework*

## 3.2 Conceptualizing Smart Village: A Systematic review

This study is a systematic review of research articles related to “Smart village concept”. Research articles from 2010 to 2019 were extracted using the international database of Science Direct. Keywords that were used for searching the relevant articles were **smart**, **village**, and **concept**. In order to select the relevant articles, reviewed titles and abstracts of selected articles. Articles were selected on the basis of title, abstract and accessibility of paper. PRISMA Flow Chart was developed to show the selection criteria of the articles. Total 129 articles were retrieved. Of these 129 articles, 66 were rejected on the basis of title and abstract while 2 were excluded due to accessibility issue. Hence, 61 articles were selected for systematic review. Articles were analyzed to perform definitional analysis for smart villages. A table was formulated merging definitions and thematic areas. NVivo was used to determine accuracy of the analysis.

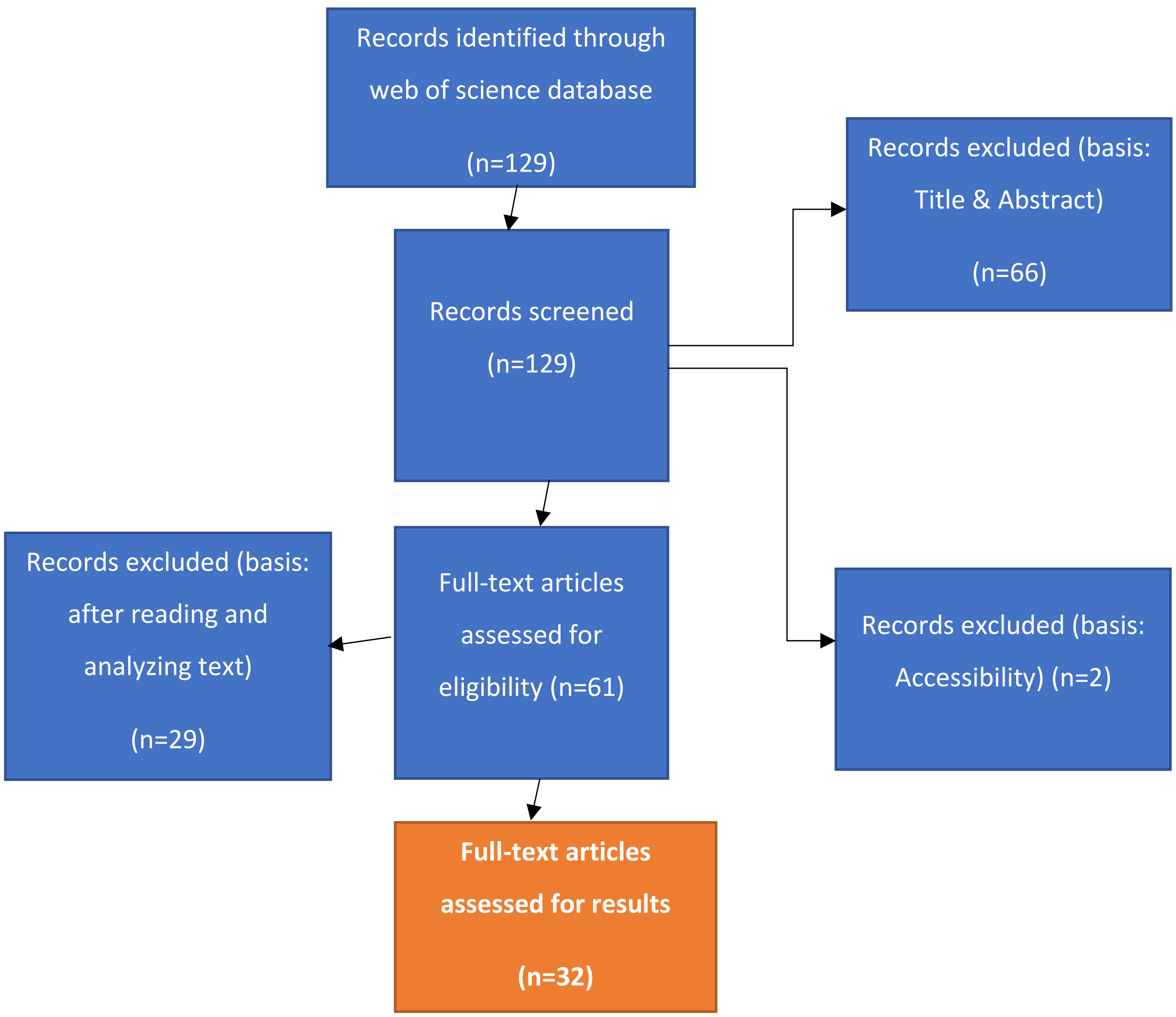


*Figure 2 Systematic review flowchart*

## 3.3 Expert Survey for AHP analysis

The Analytic Hierarchy Process (AHP) is a method for selecting the criteria of experts through pairwise comparisons. This method was developed by Thomas L. Saaty 40 years ago. AHP gives a framework which is rational and alternative options are given to experts to choose from. This allows the surveyor to calculate the favorability or inclinations towards one subject by the experts. In this study, 30 expert surveys were conducted in University of Agriculture, Faisalabad. Experts ranged from Professors to Lecturer's and Researchers in Rural Sociology and Agriculture Departments. In order to determine the most relevant dimensions with respect to Pakistan, AHP was performed. The questionnaire was based on the following matrix where experts compared the importance of criteria, two at a time, through pair-wise comparisons. Dimensions were then ranked according to the priority given by the professionals and consistency ratio was calculated for each survey matrix. All surveys had a CI less than 10% which showed that all questionnaires were consistent. The example below shows how the AHP survey was performed and individually matrices were made and then solved for results.

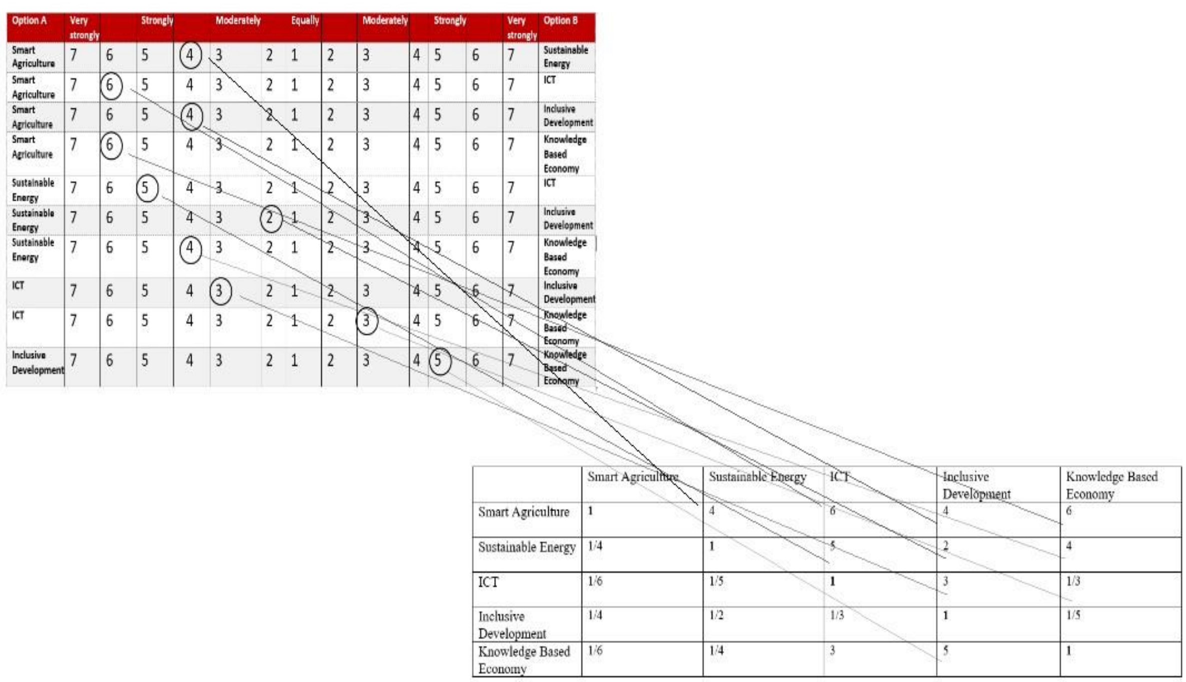


*Figure 3 AHP matrix example*

## 3.4 Study Area

Multan is one of the larger districts in South Punjab and lies between 30.11' N to 71.28' E (Latitude and Longitude). It covers an area of 3721 $km^2$ and has a population of 4,746,166(Statistics, 2017) . Multan district is known for its fertile lands and extensive canal system that provides sufficient water for the 759,766 Acres of cultivated land (Anwar et al., 2009). Due to its high temperatures and favorable conditions, mangoes are also cultivated in large amounts along with wheat, cotton and sugarcane. Multan district is administratively divided into four tehsils (local name for sub-districts) namely; Multan city, Multan Saddar, Shujabad and Jalalpur-pirwala (Faridi & Bashir, 2010). In this research Shujabad tehsil was short listed in order to conduct the survey, and further Union Council "Basti Mithu" was chosen as the study population, due to limited resources and budget. Basti Mithu is a village with population of 21,827 (Statistics, 2017). It is located 40 kilometers from Multan City and has a reasonable road connectivity facilitating farm to market access.

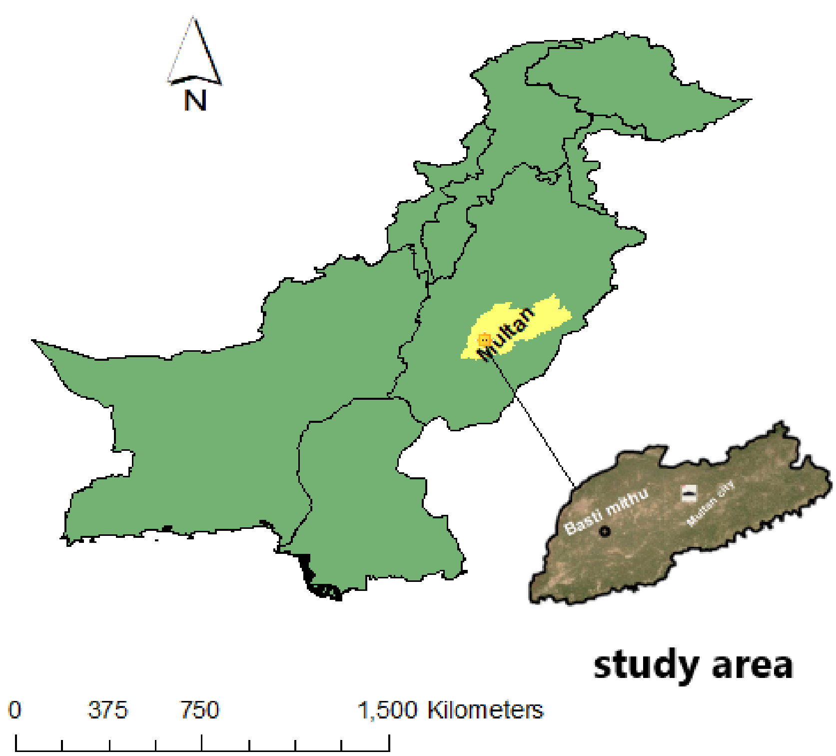


*Figure 4 Study area map*

## 3.5 Questionnaire Design

Indicators and questions were selected after extensive study of literature and global government bodies recommendations for Smart Village study. Based on the questions, two main objectives were achieved namely; Barriers towards implementation of Smart Village in Pakistan and Acceptability of the local population towards Smart Village practices. The survey was designed in such a way to encourage maximum participation. Most of the questions were basic and the language used was simple as to be adequately understood by the population. Some questions were open-ended and some were based on a Likert scale where 1 indicates high acceptability and 5 low acceptability by the locals.

## 3.6 Indicator Table

*Table 2 Indicator table with empirical evidences*

| | Questions asked | Empirical Evidence |
|---|---|---|
| | **Socio-Economic** | |
| S1 | Age | (Kellens et al., 2011; Miceli et al., 2008; Qasim et al., 2015) |
| S2 | Genderg | (Grothmann & Reusswig, 2006; Qasim et al., 2015) |
| S3 | Marital Status | (Grothmann & Reusswig, 2006; Miceli et al., 2008; Qasim et al., 2015) |
| S4 | Gender of head of household | (Grothmann & Reusswig, 2006; Qasim et al., 2015) |
| S5 | Head education level | (Grothmann & Reusswig, 2006; Miceli et al., 2008; Qasim et al., 2015) |
| S6 | Household size | (Grothmann & Reusswig, 2006; Kellens et al., 2011; Qasim et al., 2015) |
| S7 | No of females in your house | (Grothmann & Reusswig, 2006; Qasim et al., 2015) |

| | | |
|---|---|---|
| S8 | No of educated family members | (Grothmann & Reusswig, 2006; Miceli et al., 2008; Qasim et al., 2015) |
| S9 | Length of residency (in years) | (Grothmann & Reusswig, 2006; Qasim et al., 2015) |
| S10 | Monthly income | (Grothmann & Reusswig, 2006; Qasim et al., 2015) |
| S11 | Monthly savings | (Grothmann & Reusswig, 2006; Qasim et al., 2015) |
| | **Barriers to implementation of a smart village** | |
| B1 | Where do you spend the most of your income on your agricultural land? | (Wollenberg et al., 2011) |
| B2 | Have you taken insurance? | (Quinney et al., 2016; Wollenberg et al., 2011) |
| B3 | Have you borrowed loan in past few years? | (Ayaz et al., 2019; Wollenberg et al., 2011) |
| B4 | Source of livelihood other than agriculture? | (Wollenberg et al., 2011) |
| B5 | Do you own any agricultural land? | (Wollenberg et al., 2011) |
| B6 | Are you directly involved in sowing your land? | (Wollenberg et al., 2011) |
| B7 | What type of farming do you use on your land? | (Wollenberg et al., 2011) |
| B8 | What type of crops do you sow? | (Ayaz et al., 2019) |
| B9 | Which crop has the most significant contribution to your income? | (Ayaz et al., 2019) |
| B10 | In which season, you perform agricultural activities? | (Ayaz et al., 2019) |
| B11 | Do you think the education/training provided in your area can help improve agriculture? | (Ayaz et al., 2019) |
| B12 | Have you used any latest agricultural techniques? | (Ayaz et al., 2019) |
| B13 | Do you know any workshop or mechanic who can deal in repairing the latest machinery? | (Ayaz et al., 2019) |
| B14 | Electricity supply | (PICCOLO & RAUNIG; Reytar et al., 2014) |

| | | |
|---|---|---|
| B15 | Gas supply | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B16 | Clean water supply | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B17 | Sanitation | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B18 | Television access | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B19 | Broadband access | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B20 | Mobile internet access | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B21 | Access to Government portals | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B22 | Road Accessibility | (PICCOLO & RAUNIG; Reytar et al., 2014) |
| B23 | What is the level of food insecurity in your area? | (Arslan et al., 2018; Girvetz et al., 2017; Khatri-Chhetri et al., 2017) |
| B24 | Have you faced any barrier regarding funding from public institutions? | (Khatri-Chhetri et al., 2017) |
| B25 | How much do you think agriculture is being affected by change in weather patterns? | (Girvetz et al., 2017; Khatri-Chhetri et al., 2017; Reytar et al., 2014) |
| B26 | How difficult it is for you to deliver your products to the market? | (Arslan et al., 2018; Girvetz et al., 2017; Khatri-Chhetri et al., 2017; Reytar et al., 2014) |
| B27 | How much do you face difficulties in irrigating your fields? | (Girvetz et al., 2017; Khatri-Chhetri et al., 2017; Reytar et al., 2014) |

| | | |
|---|---|---|
| B28 | What is your level of trust in public institutions? * | (Ayaz et al., 2019) |
| B29 | What is your level of trust in the community? * | (Ayaz et al., 2019) |
| B30 | How much do you rely on traditional agricultural methods? | (Girvetz et al., 2017; Khatri-Chhetri et al., 2017) |
| B31 | How much soil fertility has been decreased in your area? | (Girvetz et al., 2017; Khatri-Chhetri et al., 2017) |
| B32 | How much do you think it would cost to introduce the latest machinery in agriculture? | (Ayaz et al., 2019) |
| B33 | Do you consider rural conflicts as a barrier in improving agricultural production? | (Ayaz et al., 2019) |
| **Acceptability of local population towards implementing smart village** | | |
| A1 | How much information do you have about drip irrigation? * | (Duffy et al., 2017) |
| A2 | How much information do you have about tunnel farming? * | (Duffy et al., 2017) |
| A3 | How much information do you have about solar tube wells? * | (Duffy et al., 2017) |
| A4 | How much information do you have about drone spraying techniques? * | (Duffy et al., 2017) |
| A5 | How much information do you have about High-density farming? * | (Duffy et al., 2017) |
| A6 | At what extent your income level will increase if you introduce new technology in agriculture? * | (Quinney et al., 2016) |
| A7 | How much technology will increase agricultural production? * | (Quinney et al., 2016) |
| A8 | How much do you encourage more female participation in your agricultural work? * | (Duffy et al., 2017; Girvetz et al., 2017; Khatri-Chhetri et al., 2017) |
| A9 | Have you introduced any new agricultural techniques in your area? * | (Quinney et al., 2016) |
| A10 | Will you allow public officials to implement any new agricultural techniques on your land? * | (Quinney et al., 2016) |
| A11 | If public institution introduces any new agricultural smart policies, will you accept them? * | (Quinney et al., 2016) |

| | | |
|---|---|---|
| A12 | How much are you willing in future to seek information about new agricultural technologies? * | (Duffy et al., 2017; Girvetz et al., 2017; Khatri-Chhetri et al., 2017; Quinney et al., 2016) |
| A13 | What is your likelihood of getting crop insurance in future? * | (Duffy et al., 2017; Girvetz et al., 2017; Khatri-Chhetri et al., 2017; Quinney et al., 2016) |

*** Inversed in scale**

## 3.7 Sampling and Data Collection

There are multiple methods used by various scholars to determine the sample size of their respective surveys. Some of them include using predetermined tables with population size and sample size, holding a complete survey for smaller populations, using similar studies sample size

and formulas developed and verified by scholars. For the purpose of this study, Yamane sampling formula was used as it provides the desired level of precision and the sample size accordingly. The equation that was used to determine the sample size is as follows:

$$n = \frac{N}{1+N(e^2)}$$ *Equation 1*

Where 'n' is the target sample size and 'N' denotes the total population of the survey area. 'e' is the precision level.

In this study, random sampling was used in order to reduce biasness. With ± 10% precision level (e) and ± 95% Confidence level, the determined sample size was 100.

## 3.8 Analytical Methods for extraction of barriers

### 3.8.1 Using Descriptive Statistics for Profile of Respondents and Access to Basic Services

Mean and Range was calculated using SPSS for the following indicators: Household Size (S6), Age (S1), Number of educated members in household (S8), Length of residency (S9), Monthly income (S10), Monthly savings (S11), Head Education level (S5) and Ownership of agriculture land (B5).

Mean, Range and Standard deviation was measured using SPSS for the following indicators: Access to Electricity (B14), Access to Gas supply (B15), Access to Clean water supply (B16), Access to Sanitation (B17), Access to Television (B18), Access to Broadband (B19), Access to Mobile data internet (B20) and Access to government portals (B21).

### 3.8.2 Ranking the Barriers on a scale

The survey was designed on a Likert scale where '1' = High acceptance and '5' = Low acceptance. The responses were then orderly ranked according to mean value method.

### 3.8.3 KMO Measures and Bartlett's Test

KMO measures is the test for sample adequacy for performing Principal Component Analysis/ Factor Analysis. The below table shows the value required for sample adequacy for performing PCA/Factor Analysis.

*Table 3 KMO values*

| Sr. No | KMO Value | Acceptability |
|---|---|---|
| **01** | 0.9 – 1.0 | Marvelous |
| **02** | 0.8 – 0.9 | Meritorious |
| **03** | 0.7 – 0.8 | Middling |
| **04** | 0.6 – 0.7 | Mediocre |
| **05** | 0.5 – 0.6 | Miserable |
| **06** | Below 0.5 | Unacceptable |

The second check for proceeding to PCA/ Factor Analysis is Bartlett's test of sphericity. Here we have to see the significance value. If the significance value is below 0.001 then you can perform PCA.

### 3.8.4 Factor analysis for barrier extraction

Factor analysis is performed when you have a large number of indicators and you want to reduce them into conceptually same but fewer groups. This method is commonly used in various fields including medical science and social sciences. The aim of this analysis is to find out those elements that are impactful and thus highlight them for further analysis. In the research Principal Component Analysis (PCA) was used as the method for extracting barriers. PCA is a commonly used method with reliable results and accurate judgements can be made.

### 3.8.5 Anderson-Rubin Test

Anderson-Rubin test is performed post PCA as a check for accuracy of the analysis. In this test the factors that are computed using PCA are saved as variables and the check is to consider mean to be ‘0’ and Standard deviation to be ‘1’ as a successful analysis(Anderson & Rubin, 1949).

## 3.9 Using Composite Index method to evaluate Acceptability of Smart Villages in Pakistan

The composite index method is used by various researchers for its simplicity and accuracy (Abbas & Routray, 2014; Gain et al., 2015; Giupponi et al., 2015). The equation used for calculated the index is as follows:

$$Acceptability\ Index = \frac{A_1 + A_2 + A_3 + \cdots . A_n}{n}.$$

*Equation 2 Composite Index*

Where ‘A’ are the acceptability indicators and ‘n’ denotes total number of indicators used in the equation.

# CHAPTER 4

## RESULTS AND DISCUSSIONS

## 4.1 Smart Village Conceptualization

### 4.1.1 Systematic Review of Selected Articles

After following the methodology for systematic review, the results were compiled. Key concepts were found and then tabulated. Table 4 is the accumulated data from the research articles, with the content extracted directly from the sources the main thematic areas and concepts the authors had focused on were established. This made it able for us to conceptualize the smart village concept in a streamlined and more concentrated manner.

*Table 4 Definitional Analysis*

| Sr. | SOURCE | DEFINITION | THEMATIC AREAS |
|---|---|---|---|
| 1 | (V. Zavratnik et al., 2018) | "Rural areas and communities which build on their existing strengths and assets as well as on developing new opportunities. In Smart Villages, traditional and new networks and services are enhanced by means of digital, telecommunication technologies, innovations and the better use of knowledge for the benefit of inhabitants and business" | ICT, Knowledge Based Economy |
| 2 | (Srivatsa, 2015) | Smart villages will serve as complementary engines of economic growth to smart cities, producing goods and services for local rural markets as well as high-value-added agricultural and rural industry products for both national and international markets giving impetus to the nearby cities to become smarter in real sense. Smart villages will be connected to towns and cities through information and communication technologies (ICT) enabled | ICT, Smart Agriculture |

| | | | |
|---|---|---|---|
| | | by access to global knowledge with a single mouse click. | |
| 3 | (Holmes et al., 2015) | “Smart village,” a rural analog of the “smart city” concept, in which access to sustainable energy, together with modern information and communication technologies, enables holistic development, including cultural changes in the provision of good education and health care; access to clean water, sanitation, and nutrition; and the growth of social and industrial enterprises to boost incomes. | Sustainable Energy, ICT, Inclusive development |
| 4 | (Holmes, 2017) | Building on the catalytic impact of sustainable energy services, in turn enabling the connectivity made possible by modern information and communication technologies, residents of smart villages lead healthy and fulfilling lives, achieve their development potential, earn a decent living, and are connected to the outside world. | Sustainable Energy, ICT, Knowledge Based Economy |
| 5 | (van Gevelt et al., 2018) | Smart Villages Initiative is that the required acceleration must be founded on a more integrated approach to rural energy access in which increased emphasis is placed on the use of renewable energy and modern information communication technologies (ICT) to enable productive enterprises and the provision of key services, and in which more effective partnerships are established between governments, development bodies and the private sector. | Sustainable Energy, ICT, Inclusive development |
| 6 | (Aggarwal et al., 2018) | Climate-smart agriculture (CSA) aims to increase sustainable agricultural production by adapting to and building resilience to climate change. It focuses on food security and national development goals and, where possible, it also aims to reduce or remove GHG emissions. | Smart Agriculture |

| | | | |
|---|---|---|---|
| 7 | (Fennell et al., 2018) | In the case of developing countries, it is crucial that these solutions simultaneously focus on smart village policies where rural communities can access ICT, education, health and energy services to empower youth and young adults with the skills necessary to improve agricultural production opportunities and provide pathways to diversify into other forms of rural employment. | ICT, Inclusive development, Smart Agriculture |
| 8 | (Jagustovic et al., 2019) | The CSV (climate Smart Village) approach is applied with local communities and their partners to test, through participatory methods, technological and institutional options for dealing with climate change risks to agriculture. It generates evidence at local scales of which climate-smart agricultural options work best, where, why, and how, and use this evidence to draw out lessons for policy makers, agricultural development practitioners, and investors from local to global levels. | Smart Agriculture, Inclusive development, ICT |
| 9 | (Ciuffoletti, 2018) | In short, the smart village is a small community, with limited resources, but the solid intent to improve its control on environmental resources, including air, water, energy, roads, parking lots, etc. | Inclusive development |
| 10 | (De-Pablos-Heredero et al., 2018) | Smart farms are accurate farms oriented to increase efficiency and reduce the environmental impacts of animal production practices. Farms must learn to implement technology properly to minimize cost and maximize efficiency. | Smart Agriculture |
| 11 | (Viswanadham & Vedula, 2010) | We define a Smart Village as a bundle of services which are delivered to its residents and businesses in an effective and efficient manner. Dozens of services including construction, farming, electricity, heath care, water, retail, manufacturing and logistics are needed in building a smart village. Computing, communication and information technologies play a major role | ICT |

| | | | |
|---|---|---|---|
| | | in design, delivery and monitoring of the services. | |
| 12 | (Katara, 2016) | A Smart Village comprises a group of services, which are delivered to its businesses and dwellers in an efficient and effective way. Numerous services including health care, education, sanitization, smart agriculture, road infrastructure, disaster management, water supply, construction, electricity, retail manufacturing and logistics are needed in building a smart village. | Inclusive development |
| 13 | (Ranade et al., 2015) | A "Smart Village" will provide long-term social, economic, and environmental welfare activity for village community, which will enable and empower enhanced participation in local governance processes, promote entrepreneurship and build more resilient communities. At the same time, a "Smart Village" will ensure proper sanitation facility, good education, better infrastructure, clean drinking water, health facilities, environment protection, resource use efficiency, waste management, renewable energy etc. | Inclusive development |
| 14 | (Rai et al., 2018) | In general, CRA practices and technologies are low-emission approaches, which aim to improve food security and enhance resilience. CRA practices usually follow several approaches, including cultivating drought-tolerant varieties, diversifying crops, managing the soil and harvesting water. This is considered a transformative approach towards agriculture systems for food security under the changing global environment. | Smart Agriculture |
| 15 | (Kongsager, 2017) | Climate-smart agriculture (CSA) has been proposed as a broad framework of techniques and measures to promote synergies and circumvent trade-offs between adaptation and mitigation in the agricultural sector. CSA includes, for | Smart Agriculture |

| | | | |
|---|---|---|---|
| | | example, practices to improve soil water-holding capacities by adding crop residues and manure to arable soils, which not only affects soil properties and nutrient cycling, but also lowers emissions. | |
| 16 | (Aryal et al., 2018) | Climate-smart agriculture (CSA) employs several agricultural practices that sustainably increase productivity, improve resource-use-efficiency, reduce exposure, sensitivity or vulnerability to climate variability or change, and reduce GHG emissions from agriculture. | Smart Agriculture |
| 17 | (Ho et al., 2014) | "Biomass and Solar Town" harvests the biomass and solar energy within the vicinity of the eco community to provide energy for the localized energy system. The concept can provide technical and environmental benefits, such as a reduction of the energy loss due to the transportation of biomass over short distances, a reduction of the energy loss from transmitting electricity over the transmission line, and a reduction of greenhouse gas (GHG) emissions. | Sustainable Energy |
| 18 | (Chirinda et al., 2017) | The CSA approach is defined as agriculture that (a) sustainably increases agricultural productivity and incomes; (b) improves adaptation and builds farmer resilience to climate change; and (c) reduces and/or removes greenhouses gases (GHG) emissions where possible. | Smart Agriculture |
| 19 | (Nasiakou et al., 2016) | Smart grid is a fully automated power delivery network that monitors and controls every customer and node, ensuring a two-way flow of electricity and information between the power plant and the appliance, and all points in between. Its distributed intelligence, coupled with broadband communications and automated control systems, enables real-time market | Sustainable Energy |

| | | | |
|---|---|---|---|
| | | transactions and seamless interfaces among people, buildings, industrial plants, generation facilities, and the electric network. | |
| 20 | (Westermann et al., 2018) | The concept of climate smart agriculture (CSA) offers a suite of approaches for transforming and reorienting agricultural systems to support food security in the face of climate change, by focusing on the potential synergies and trade-offs between agricultural productivity and food security, adaptive capacity, and mitigation benefits | Smart Agriculture |
| 21 | (Simelton et al., 2015) | 'Climate-smart agriculture' solutions are intended increase "resilience" to climatic impacts improve livelihoods and food security, as well as addressing adaptation and mitigation objectives (FAO 2013). One example of climate smart practice is agroforestry, whereby the deliberate addition of trees on farms is expected to sequester carbon while providing protection to adjacent crops, such as shading, wind-break and binding erosive soils. | Smart Agriculture |
| 22 | (Heap, 2015) | Smart villages will be connected to towns and cities through information and communication technologies (ICT) enabled by access to energy. Such technologies will enhance education and health services by providing links to the world's knowledge base and opportunities for distance learning, as well as sup - porting initiatives in m-health (mobile health, also known as telemedicine). Connectivity will also open up participation in governance processes at local, regional and national levels. The key enablers of development in smart villages are sustainable access to electricity and clean and efficient cooking appliances. | ICT, Inclusive development, Sustainable Energy |

| | | | |
|---|---|---|---|
| 23 | (Kumar & Shekhar, 2015) | The concept behind the 'smart village' is that modern energy access acts as a catalyst for development – in education, health, food security, productive enterprise, environment and participatory democracy – that in turn supports further improvements in energy access. | Sustainable Energy |
| 24 | (Mulenga et al., 2017) | The IEEE Smart villages initiative defines a "Smart Village" as an off-grid community that integrates solar energy for the creation of locally owned entrepreneurial businesses and generation of affordable all whether agro-businesses. | Sustainable Energy, Smart Agriculture |
| 25 | (Holmes & Thomas, 2015) | The 'smart village' is a model in which, energy access acts as a catalyst for a range of development outcomes. If managed correctly, technology 'leapfrogging' could lead to rapid improvements in healthcare, nutrition, education, and economic security. Villagers could thus have the opportunity to capture many of the benefits of urban life while retaining valued aspects of rural life, and ensuring balanced development at a national level. | Sustainable Energy |
| 26 | (Heap et al., 2017) | The concept of 'Smart Villages' is that modern energy access in the form of sustainable renewable energy can contribute as a catalyst for development—education, health, food security, environment, productive enterprises, and participatory democracy—and for the alleviation of poverty. | Sustainable Energy |
| 27 | (Tiwari et al.) | A smart village is a bundle of services which are delivered to its residents and business in an effective and efficient manner. | Inclusive development |
| 28 | (Lopez-Ridaura et al., 2018) | CSA aims to simultaneously increase agricultural productivity, food security, and farmers' adaptive capacity to climate extremes, while also lowering greenhouse gas emissions | Smart Agriculture |

| | | | |
|---|---|---|---|
| 29 | (Khatri-Chhetri et al., 2017) | Adaptation options that sustainably increase productivity, enhance resilience to climatic stresses, and reduce greenhouse gas emissions are known as climate-smart agricultural (CSA)technologies, practices and services | Smart Agriculture |
| 30 | (Andrieu et al., 2017) | CSA aims to achieve three objectives or pillars: sustainably increasing agricultural productivity; enhancing resilience (adaptation); and reducing or removing greenhouse gas emissions, where possible, enhancing the achievement of national food security and development goals. | Smart Agriculture |
| 31 | (Sain et al., 2017) | Climate-smart agriculture (CSA) encourages sustainable development of agricultural systems through practices and approaches that achieve improved food security, increased resilience, and low-emissions development where possible and appropriate in the face of climate change. | Smart Agriculture |
| 32 | (Campbell et al., 2014) | CSA is defined by three objectives: firstly, increasing agricultural productivity to support increased incomes, food security and development; secondly, increasing adaptive capacity at multiple levels (from farm to nation); and thirdly, decreasing greenhouse gas emissions and increasing carbon sinks. | Smart Agriculture |

### 4.1.2 Frequency Analysis of the Systematic Review

On the basis of Table 4 we performed a frequency analysis, where the data was turned into dissectible information. Results from the analysis showed 17 papers mentioned Smart Agriculture in their articles, while 10 focused on Sustainable Energy as a key component of a smart village. Other noteworthy concepts were Inclusive development (8), ICT (2) and Knowledge based economy (2).

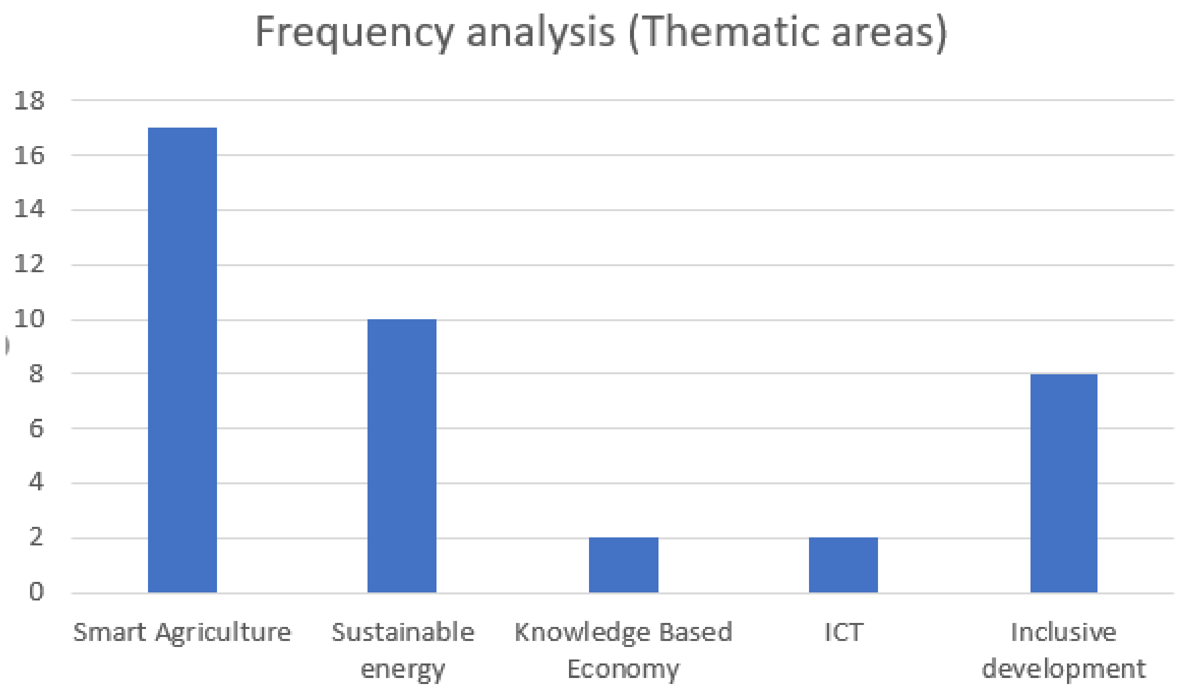


*Figure 5 Thematic Areas Based on Frequency*

**4.1.3 Efficacy of the analysis using NVIVO**

For the purpose of validation of the systematic review, NVIVO software was used. NVIVO is tool used by researchers in determining the accuracies of their qualitative analysis. Figure 6 Efficacy flowchart using NV is a flowchart. The sub-concepts are merged with the main concepts in order to strengthen the thematic areas importance and relevance in Smart Village concept.

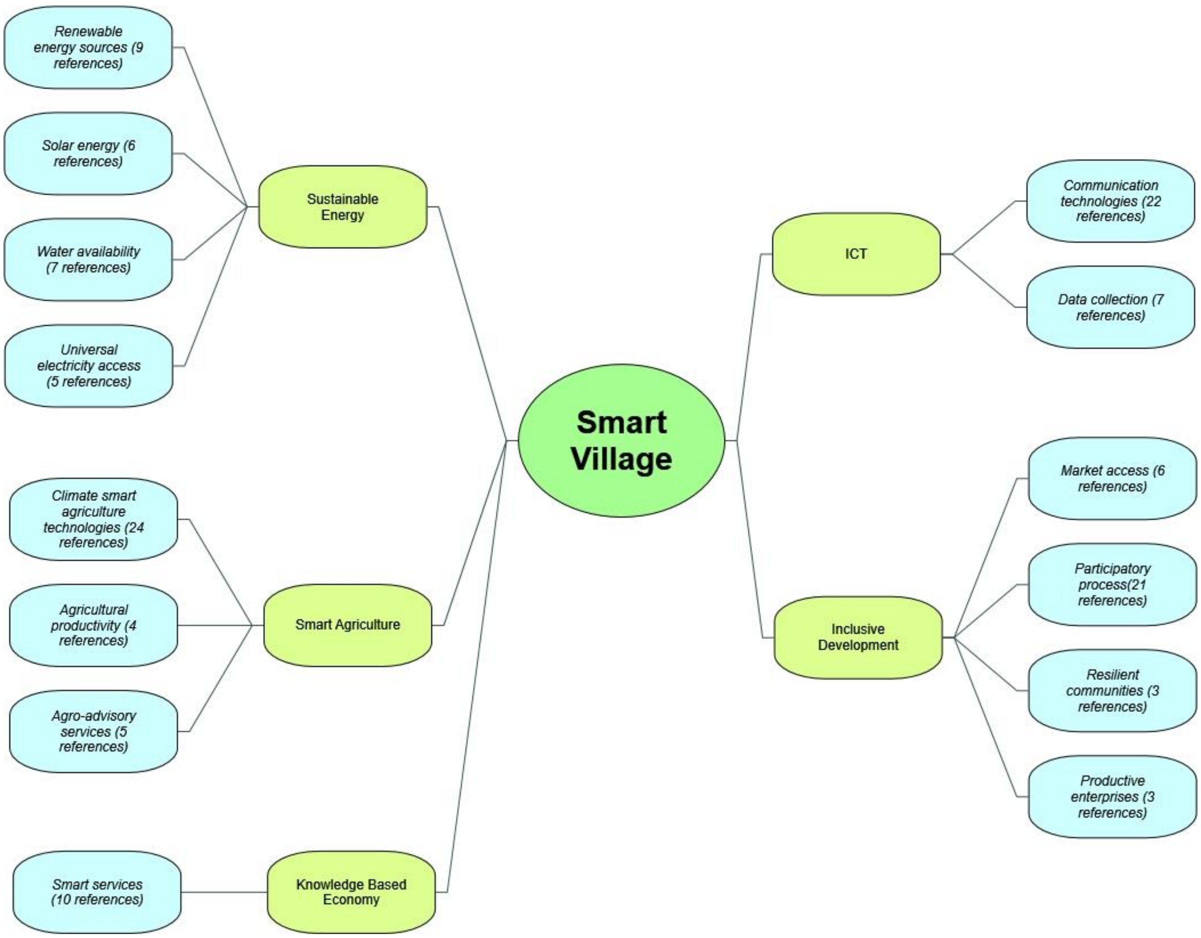


*Figure 6 Efficacy flowchart using NVivo*

**SOURCE: NVivo**

## 4.2 Expert Survey

30 expert surveys were conducted and analyzed individually using the matrix as shown in the methodology. Consistency Index (CI) was calculated for each survey and the results showed CI below 10%, therefore the results were merged using geometric mean of individual survey and the result yielded is as below. 32.5% were of the opinion that smart agriculture is the most important aspect while developing smart villages in Pakistan. Further 20% was the result for Sustainable energy as the key element of Smart village in Pakistan. Notable mentions include Knowledge Based economy (17.5%), ICT (15%) and inclusive development (12.5%).

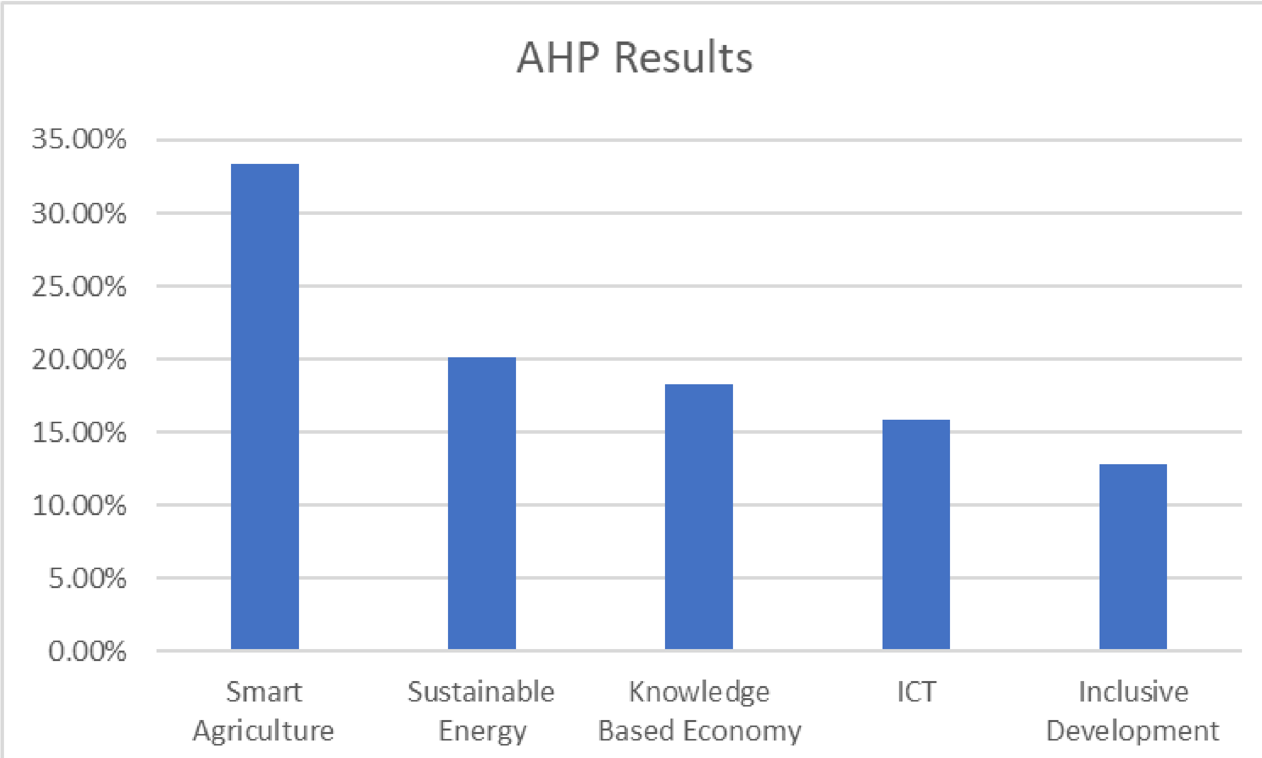


*Figure 7 Results of Expert Survey*

*** Note due to limitations of resources, Only Smart Agriculture was analyzed in further parts of the research**

## 4.3 Profile of Respondents

Using descriptive statistics, the profile of respondents was found. Majority of the households' heads education was either primary, middle or high school. While only a few (21) heads were bachelors or above. Household size was averaged at 6.8 and average age of respondents was 40. Most of the respondents were long time settlers with average being 40 years of residency in the area. Ownership of land stood at the average of 8.8 acres but with the max of 80 acres and minimum of 0 acres were also seen.

*Table 5 Profile of respondents*

| | N | Minimum | Maximum | Mean |
|---|---|---|---|---|
| Household Size | 100 | 2.00 | 14.00 | 6.80 |
| Age | 100 | 20.00 | 80.00 | 39.34 |
| No of educated members | 100 | 0.00 | 8.00 | 3.31 |
| Length of residency | 100 | 10.00 | 80.00 | 38.59 |
| Monthly income | 100 | 8000.00 | 300000.00 | 46880.00 |
| Monthly savings | 100 | 0.00 | 50000.00 | 6360.00 |
| Ownership of agriculture land (in acres) | 100 | 0.00 | 80.00 | 8.59 |

Majority of the respondents were either high school and below (79%), while only 21% were either bachelor and above.

*Table 6 Education Level of Household Heads*

| Head Education Level | Frequency |
|---|---|
| Primary School and below | 23 |
| Middle School | 28 |
| High School | 28 |
| Bachelors | 16 |
| Masters and above | 5 |
| Total | 100 |

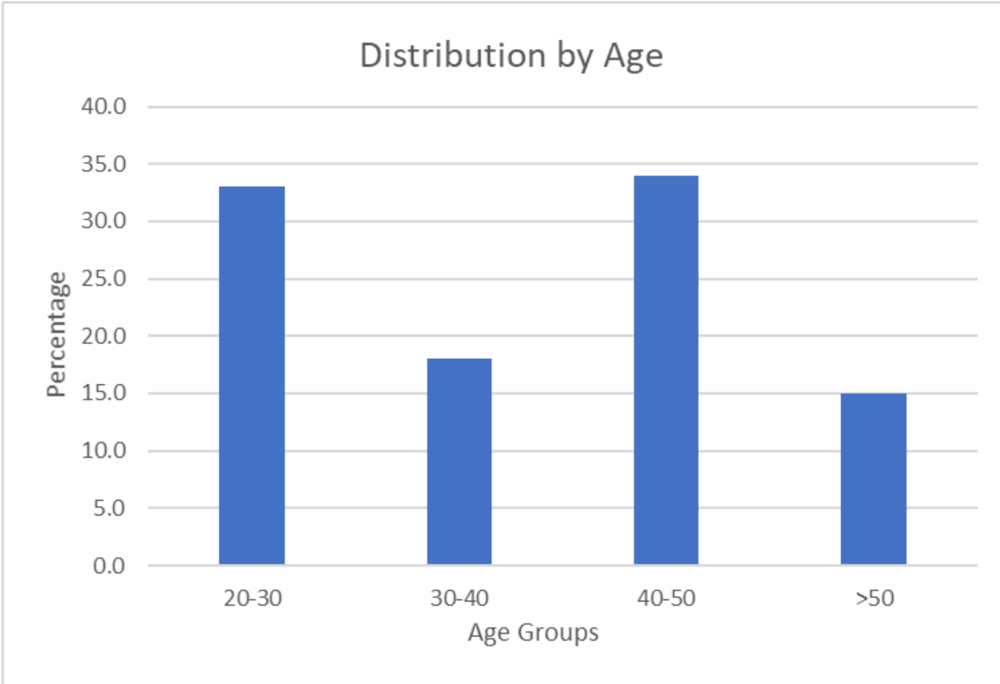


*Figure 8 Age of Respondents*

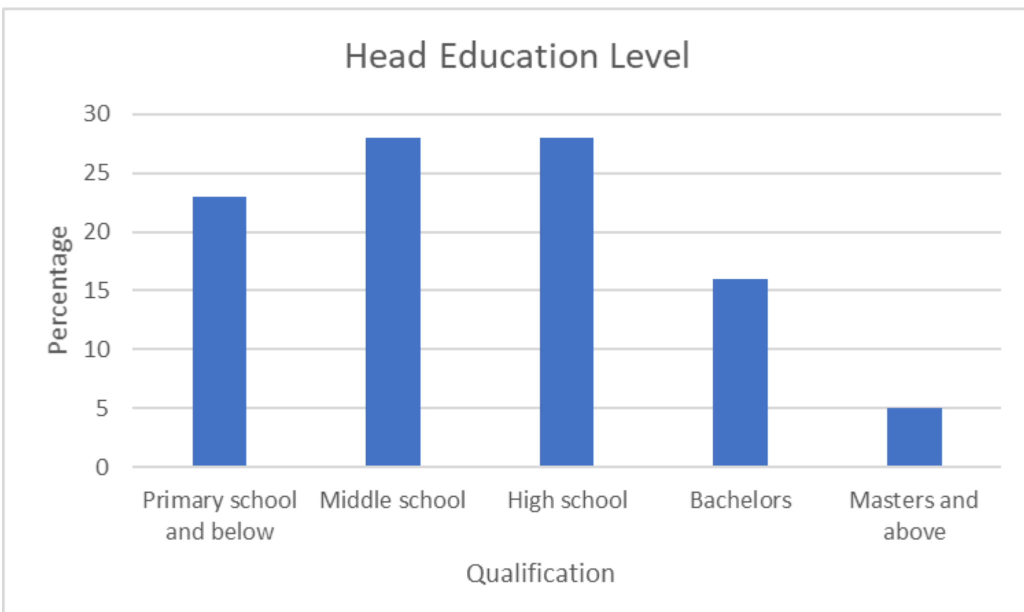


*Figure 9 Education Level of Household Heads*


*Figure 10 No of Years Living in the Area*

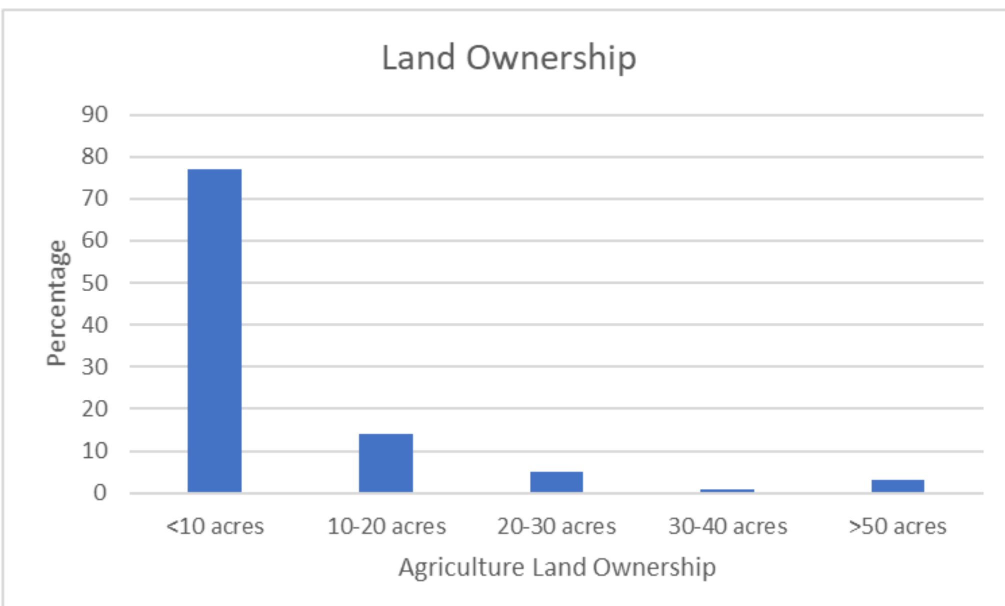


*Figure 11 Amount of Land Owned by the Respondents*

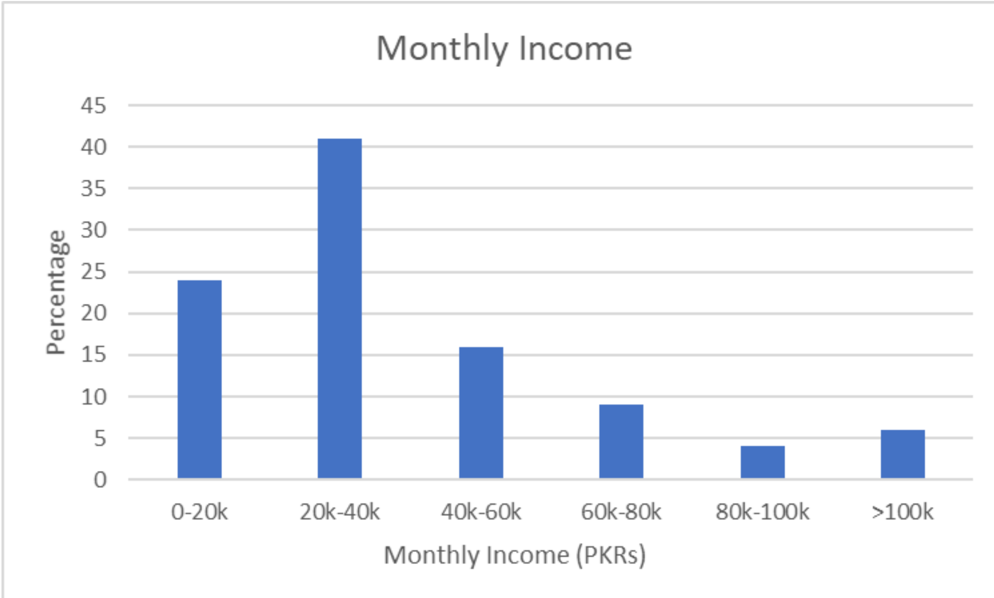


*Figure 12 Income Level of Respondents*

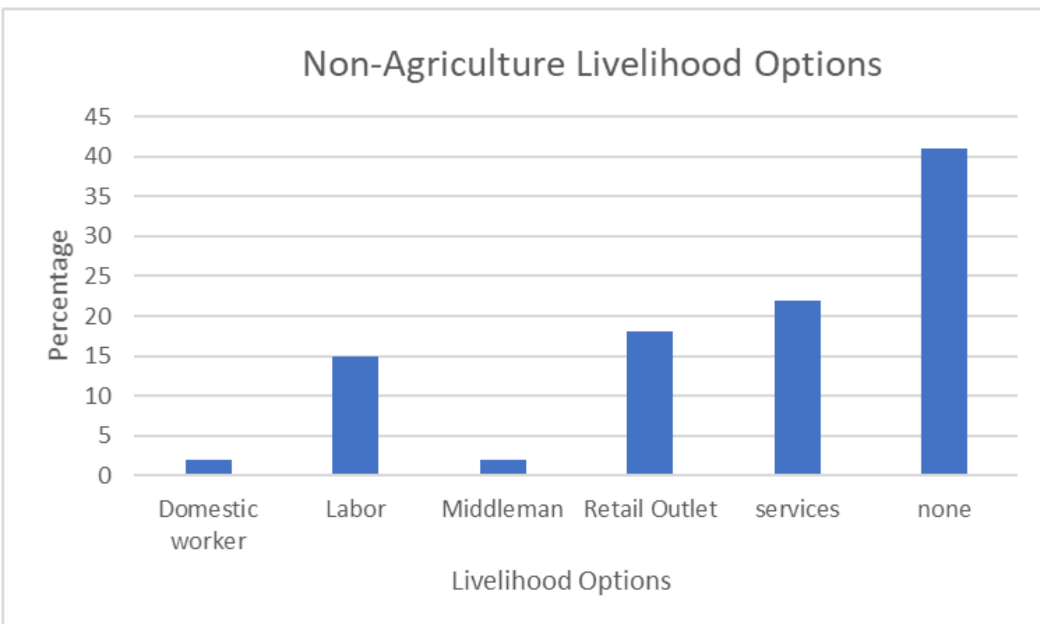


*Figure 13 Livelihood Options*

### 4.3.1 Frequency Analysis for Barriers

Barriers that could not be used in Likert scale were individually analyzed through frequency analysis. Three such barriers were highlighted including major consumption of income on agriculture land (B1), borrowed loan (B3) and is the agricultural training sufficient in your area (B11). The two biggest barriers were the major consumption of inputs in agricultural lands which was pesticides and agricultural training which majority agreed was not sufficient in their area.

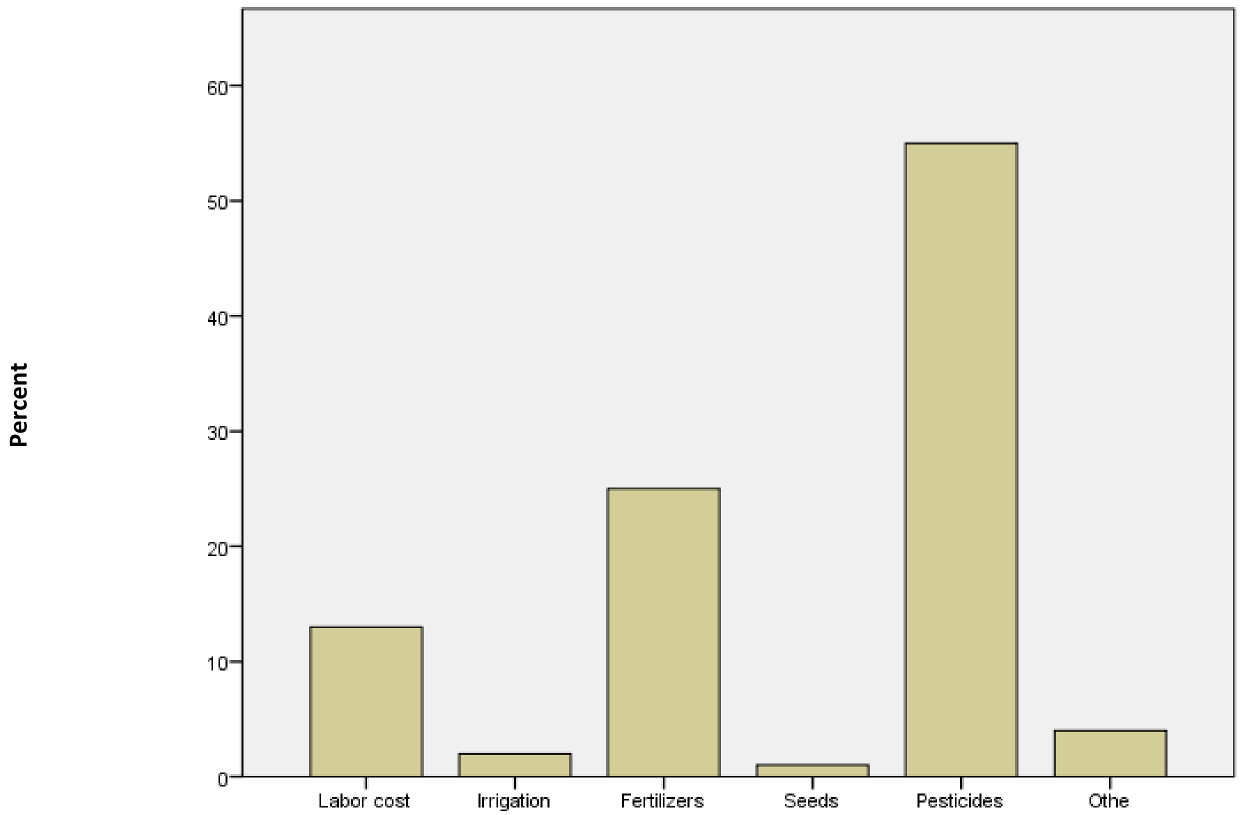


*Figure 14 Major consumption of income in agricultural inputs*

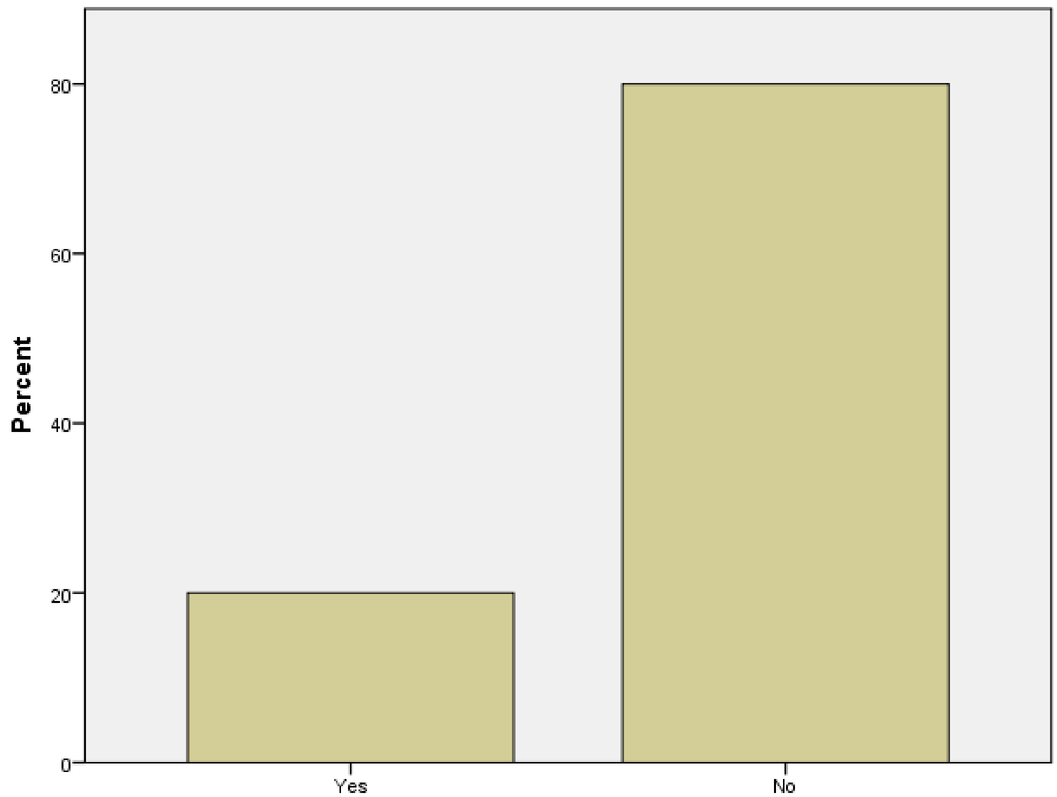


*Figure 15 Loan borrowing frequency*

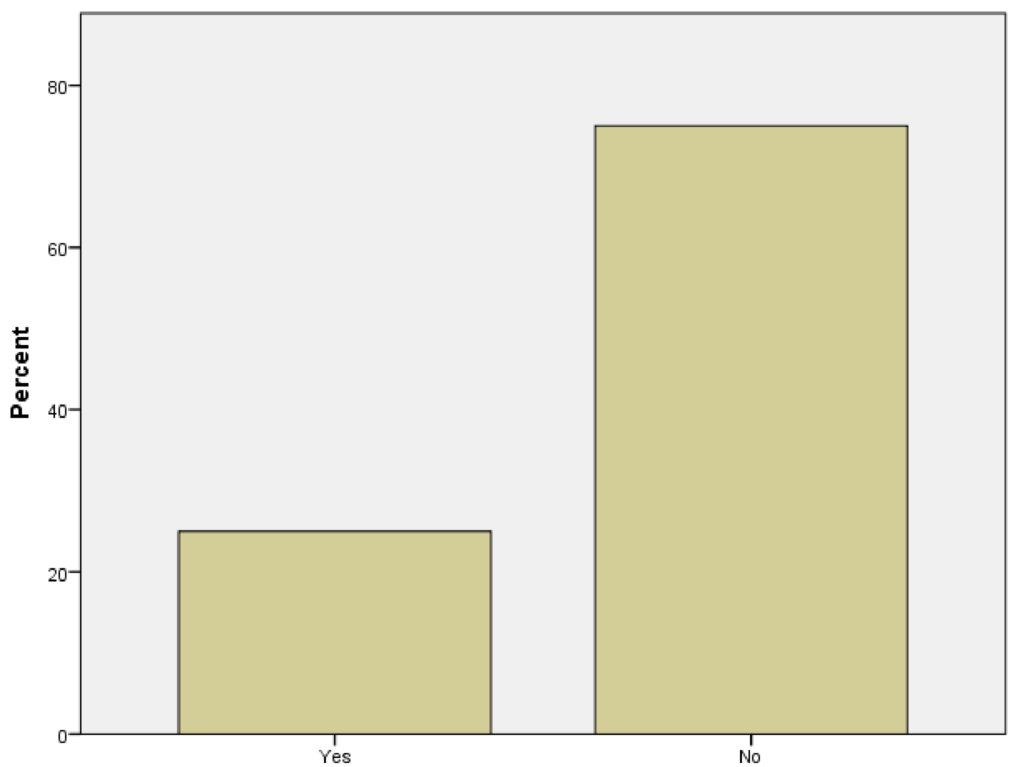


*Figure 16 Agricultural training sufficiency*

### 4.3.2 Descriptive Statistics for Access to Basic Services

*Table 7 Access to basic services*

| Basic Services | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Access to Electricity | 100 | 70.00 | 100.00 | 96.83 | 6.46 |
| Access to Gas supply | 100 | 0.00 | 80.00 | 22.03 | 13.93 |
| Access to Clean water supply | 100 | 0.00 | 75.00 | 28.77 | 17.49 |
| Access to Sanitation | 100 | 0.00 | 30.00 | 2.62 | 6.82 |
| Access to Television | 100 | 60.00 | 100.00 | 96.13 | 7.37 |
| Access to Broadband | 100 | 0.00 | 80.00 | 10.80 | 20.53 |
| Access to Mobile internet (3g and 4g) | 100 | 30.00 | 100.00 | 87.44 | 18.73 |
| Access to government portals | 100 | 0.00 | 90.00 | 5.22 | 15.74 |

Access to gas supply, sanitation, clean water, broadband and government portals were below the threshold level. While access to electricity, mobile phones and televisions were sufficiently high.

## 4.4 Extracting barriers for implementation of Smart village in Pakistan using Factor Analysis

### 4.4.1 KMO Measures and Bartlett's Test

KMO and Bartlett's values are shown below for barriers. Table shows that KMO value is adequate for sampling adequacy i.e., 0.546. The Bartlett's test of sphericity value is 1094.819 which is acceptable (Azeem et al., 2017; Mao et al., 2015) and significance value is 0.000 which is below than 0.001. Hence, the correlation matrix is not an identity matrix and PCA can be proceeded.

*Table 8 KMO and Bartlett's Test for Barriers*

| KMO and Bartlett's Test | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .546 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1094.819 |
| | Df | 300 |
| | Sig. | .000 |

### 4.4.2 Factor Extraction through Principal Component Method

The purpose of this investigation is to find out underlying barriers preventing implementation of smart villages in Pakistan. Different respondents of diverse socio-economic backgrounds were surveyed. From the survey the determinants were found. To properly analyze the survey, Factor analysis using Principal component method was done. The analysis has the ability to reduce large number of indicators into fewer groups. Variables that our sufficiently correlated are conceptually tied to each other and therefore are grouped together into one group.

*Table 9 Total Variance for Barriers*

| Total Variance Explained | | | | | | |
|---|---|---|---|---|---|---|
| | Initial Eigenvalues | | | Rotation Sums of Squared Loadings | | |
| Component | Total | % Variance | Cumulative % | Total | % Variance | %Cumulative |
| 1 | 4.408 | 17.632 | 17.632 | 3.152 | 12.609 | 12.609 |
| 2 | 2.891 | 11.565 | 29.198 | 2.908 | 11.631 | 24.241 |
| 3 | 2.268 | 9.073 | 38.271 | 2.355 | 9.419 | 33.660 |
| 4 | 2.177 | 8.708 | 46.978 | 2.232 | 8.928 | 42.588 |
| 5 | 1.603 | 6.413 | 53.392 | 1.870 | 7.481 | 50.068 |
| 6 | 1.542 | 6.166 | 59.558 | 1.850 | 7.402 | 57.470 |
| 7 | 1.339 | 5.356 | 64.914 | 1.570 | 6.280 | 63.750 |
| 8 | 1.187 | 4.750 | 69.664 | 1.478 | 5.914 | 69.664 |
| 9 | .983 | 3.931 | 73.595 | | | |
| 10 | .894 | 3.574 | 77.169 | | | |
| 11 | .839 | 3.355 | 80.524 | | | |
| 12 | .778 | 3.111 | 83.635 | | | |
| 13 | .647 | 2.589 | 86.223 | | | |
| 14 | .522 | 2.090 | 88.313 | | | |
| 15 | .467 | 1.868 | 90.181 | | | |

| | | | |
|---|---|---|---|
| 16 | .444 | 1.777 | 91.958 |
| 17 | .406 | 1.624 | 93.582 |
| 18 | .333 | 1.334 | 94.916 |
| 19 | .309 | 1.237 | 96.153 |
| 20 | .223 | .890 | 97.043 |
| 21 | .197 | .789 | 97.832 |
| 22 | .188 | .751 | 98.583 |
| 23 | .149 | .596 | 99.179 |
| 24 | .126 | .505 | 99.684 |
| 25 | .079 | .316 | 100.000 |

Extraction Method: Principal Component Analysis.

Through varimax rotation method 8 components were found. These eight components explain the total variance of 69.664 % which is acceptable.

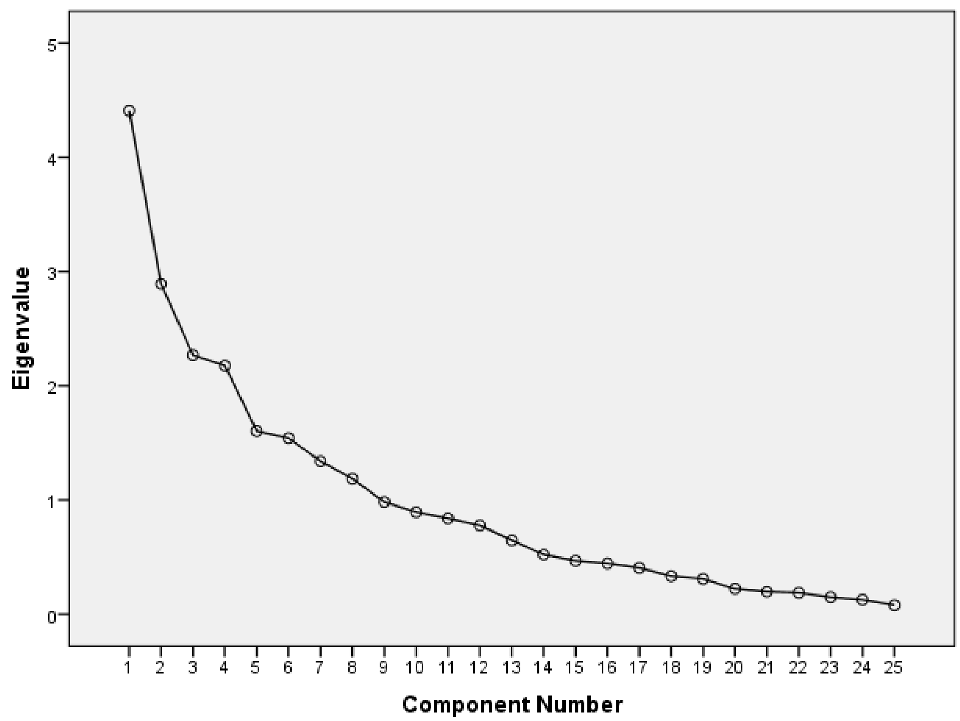


*Figure 17 Scree plot*

In the above plot we can clearly see 8 components being found through the eigenvalues.

*Table 10 Rotated Component Matrix*

| | Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Reliance on traditional agricultural method | .764 | | | | | | | |
| Cost of latest agricultural machinery | .711 | | | | | | | |
| Perceived increase in income level with new technologies | .677 | | | | | | | |
| Difficulty delivering products from farm to market | .618 | | | | | | | |
| Rural conflicts | .555 | | | | | | | |
| Food Insecurity | | .865 | | | | | | |
| Experience of negative change in yields of crops | | .699 | | | | | | |
| Likelihood of adopting crop insurance | | .674 | | | | | | |
| Decrease in soil fertility | | .596 | | | | | | |
| Agriculture being affected by change in weather patterns | | .548 | | | | | | |
| Acceptance of locals on agricultural policies by public institutions | | | .823 | | | | | |
| Introduction of any new agricultural techniques | | | .723 | | | | | |
| Allowing public officials to implement smart projects on their lands | | | .686 | | | | | |
| Information about solar tube wells | | | | .808 | | | | |
| Information about High density farming | | | | .646 | | | | |
| Information about tunnel farming | | | | .546 | | | | |
| Increase in agricultural production using new technologies | | | | | | | | |
| Information about water conservation technologies | | | | | .821 | | | |
| Level of trust in the community | | | | | | .814 | | |
| Willingness to seek new information about agriculture | | | | | | .589 | | |
| Difficulty in irrigation of fields | | | | | | .532 | | |
| Barrier regarding funding by public institutions | | | | | | | .751 | |
| Drone spraying techniques and cost | | | | | | | .539 | |
| Encouragement of females in agricultural work | | | | | | | | .756 |
| Level of trust in public institutions | | | | | | | | .617 |

**Extraction Method: Principal Component Analysis.**
**Rotation Method: Varimax with Kaiser Normalization.**

**a. Rotation converged in 15 iterations.**

---

Finally, the method used for rotation was varimax with Kaiser Normalization. The rotation converged in 15 iterations and the variables were sorted into conceptually similar groups.

| Groups | *Difficulty improving productivity and low savings* | *Erratic Weather and overuse of land* | *Low Level of Trust in Public Institutions about Introducing Agricultural Change* | *Lack of knowledge about productivity increasing technologies* | *Low usage of Water Conservation Practices* | *Low Social Cohesion and less Acceptability to New Knowledge* | *High Cost of New Technologies and Limited support from the Public Institutions* | *Conservatism and Corrupt Political Culture* |
|---|---|---|---|---|---|---|---|---|
| Factors | Reliance on traditional agricultural method | Food Insecurity | Acceptance of locals on agricultural policies by public institutions | Information about solar tube wells | Information about water conservation technologies | Level of trust in the community | Barrier regarding funding by public institutions | Encouragement of females in agricultural work |
| | Cost of latest machinery | Experience of negative change in yields of crops | Introduction of any new agricultural techniques | Information about High density farming | | Willingness to seek new information about agriculture | Drone spraying techniques and cost | Level of trust in public institutions |
| | Perceived increase in income level with new technologies | Likelihood of adopting crop insurance | Allowing public officials to implement smart projects on their lands | Information about tunnel farming | | Difficulty in irrigation of fields | | |
| | Difficulty delivering products from farm to market | Decrease in soil fertility | | | | | | |
| | Rural conflicts | Agriculture being affected by change in weather patterns | | | | | | |
| **Barrier Index** | **2.9820** | **2.9060** | **3.1967** | **2.8200** | **3.2500** | **2.6200** | **3.3150** | **3.1750** |

*Table 11 Barriers computed after factor analysis*

The eight components were named accordingly to their contents. Furthermore, Barrier index was found using the equation:

$$Barrier\ Index = \frac{B_1 + B_2 + B_3 + \cdots . B_n}{n}$$ *Equation 3 Barrier Composite Index*

Where 'B' are the barriers from separate groups and 'n' is total number of barriers.

After factor extraction, internal reliability of each factor was also checked to see whether all the variables in these eight factors shows maximum reliability and that internal reliability will not increase if a certain variable is deleted. Consequently, no variable was found showing possibility of increase in internal reliability value if deleted.

### 4.4.3 Anderson-Rubin test for Effectiveness of the Factor Analysis

Anderson-Rubin (A-R) test is a way to access the effectiveness of the factor analysis. The groups that have been made are checked for consistency, using the mean score and standard deviation of each group we can accept the analysis as consistent and good for interpretation. In this test, mean value should be 0 and Standard deviation as 1. Below table (Table 12 Anderson-Rubin test for factor analysis) show the consistency for each group that has been extracted from factor analysis.

*Table 12 Anderson-Rubin test for factor analysis*

| **Anderson-Rubin Test** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 | Group 7 | Group 8 |
| | **Difficulty improving productivity and low savings** | **Weather and overuse of land** | **Trust in Public Institutions about introducing agricultural change** | **Lack of knowledge about productivity increasing technologies** | **Water Conservation practices** | **social cohesion and openness to knowledge** | **Cost of new technologies and limited support from the public institutions** | **Conservatism and political culture** |
| Frequency | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Std. Deviation | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

### 4.4.4 Explanation of Barriers

For the purpose of finding the major barriers, data was standardized using the following formula: 1.7 and below was turned to low barrier, 1.7 to 3.5 was considered as moderate barrier and 3.5 to 5 as high barrier. In this way the barriers were highlighted for their relevance and importance.

#### 4.4.4.1 Difficulty improving productivity and low savings

*Table 13 Difficulty improving productivity and low savings*

| Classification | | Percent | Cumulative Percent |
|---|---|---|---|
| | Low Barrier | 23.0 | 23.0 |
| | Moderate Barrier | 35.0 | 58.0 |
| | High Barrier | 42.0 | 100.0 |
| | Total | 100.0 | |

The main concern of farmers in the area was that because of low quality seeds, pesticides and fertilizers the productivity of their crops was not improving. This in turn has led to farmers having low savings to improve the technological advancements on their agriculture lands. The production level of their crops was also decreasing due to little support from the public institutions with regard to proper seeds, pesticides and fertilizers. Factors like ‘Reliance on traditional agricultural methods’ and ‘Cost of latest machinery’ were major obstacles for improving productivity and savings. Overall, this Group had an index of 2.98, making this a moderate level barrier.

#### 4.4.4.2 Erratic Weather and Overuse of Land

*Table 14 Erratic Weather and overuse of land*

| Classification | Percent | Cumulative Percent |
|---|---|---|
| Low Barrier | 14.0 | 14.0 |
| Moderate Barrier | 51.0 | 65.0 |
| High Barrier | 35.0 | 100.0 |
| Total | 100.0 | |

The major barrier was found to be by the locals about change in weather patterns and untimely rain and storms. Especially before harvest of wheat a strong storm has several times destroyed a large portion of crops. Thereby, leaving a lot of farmers in debt and unable to implement any new techniques and technologies for the benefit of their agricultural production. Changes in weather patterns has devastated a lot of small farmers, facing hardships that decrease the ability of the farmer to improve upon their lands. Furthermore, overuse of land has decreased the soil fertility. Due to excessive use of land throughout the years and usage of polluted water has caused the soil fertility to decrease and hence the production has decreased to some extent. Increased amounts for agricultural inputs and decreased soil fertility have caused farmers to be stunted in their old, traditional practices. Factors including 'Experience of negative change in yield of crops' and 'Decrease in soil fertility' are major negative variables caused by the effect of Weather and Overuse of land. The total barrier index for this group is 2.91, making it a moderate barrier towards the role of Smart Agriculture in Sustainable Rural Development.

#### 4.4.4.3 Low Level of Trust in Public Institutions about Introducing Agricultural Change

*Table 15 Low Level of Trust in Public Institutions about introducing agricultural change*

| Classification | Percent | Cumulative Percent |
|---|---|---|
| Low Barrier | 10.0 | 10.0 |
| Moderate Barrier | 42.0 | 52.0 |
| High Barrier | 48.0 | 100.0 |
| Total | 100.0 | |

Throughout the survey one most observable thing was the people of the villages were not satisfied with their municipal corporations and public institutions. Every failure in crop production was ultimately blamed to those institutions. Young people especially had low trust in public institutions compared to middle aged people. Therefore, any agricultural policy introduction would be faced with skeptical villagers. ‘Acceptance of locals on agricultural policies by public institutions’ and ‘Allowing public officials to implement smart projects on their lands’ were met with criticism and negative response by the locals. This means any new agricultural technologies introduced would have to face this major barrier by the concerned departments. The barrier index of this group stands at 3.20 making it a moderate to high barrier for institutions to deal with for improvement in Smart Agriculture.

#### 4.4.4.4 Lack of knowledge about productivity increasing technologies

*Table 16 Lack of knowledge about productivity increasing technologies*

| Classification | Percent | Cumulative Percent |
|---|---|---|
| Low Barrier | 19.0 | 19.0 |
| Moderate Barrier | 56.0 | 75.0 |
| High Barrier | 25.0 | 100.0 |
| Total | 100.0 | |

As we saw in the profile of respondents ( Table 5 Profile of respondents), majority of the villagers were high school and below. This means the level of education is on the lower side which hampers the growth of any new technological advancements in their agricultural lands. The locals had little to no idea about the latest techniques that are being used around the world to increase agriculture production. Only a few people knew about those technological developments but were unable to implement due to low savings or trust in those technologies. When asked about 'Information about solar tube wells, High density Farming and tunnel farming'; few respondents had sufficient knowledge about these latest agricultural practices. The barrier index was 2.82 making this a moderate barrier for institutions to deal with in implementation.

#### 4.4.4.5 Low usage of Water Conservation Practices

*Table 17 Low usage of Water Conservation practices*

| Classification | Percent | Cumulative Percent |
|---|---|---|
| Low Barrier | 29.0 | 29.0 |
| Moderate Barrier | 27.0 | 56.0 |
| High Barrier | 44.0 | 100.0 |
| Total | 100.0 | |

When asked about the access of water, majority agreed they had sufficient water availability. Some of the educated respondents although agreed the situation of water availability will worsen with time, therefore a need for water conservation methods is necessary. Most of the respondents did not know about the issues related to water wastage in agriculture and were skeptic about using technologies such as drip irrigation in their fields. This barrier is especially relevant to Pakistan as it is a water intensive country with 1017 Cubic meters per Capita Annual water availability(Rehman et al., 2019)) and is very close to water scarcity threshold of 1000 cubic meters. This alone makes this barrier a very important one for the relevant authorities to assess and decrease the water consumption by agricultural sector. The barrier index is 3.30 making it a high barrier and urgency is required due to climate change and melting of glaciers.

#### 4.4.4.6 Low Social Cohesion and less Acceptability to New Knowledge

*Table 18 Low Social cohesion and Less Acceptability to New knowledge*

| Classification | Percent | Cumulative Percent |
|---|---|---|
| Low Barrier | 26.0 | 26.0 |
| Moderate Barrier | 59.0 | 85.0 |
| High Barrier | 15.0 | 100.0 |
| Total | 100.0 | |

Level of trust in a community is an important factor when considering a wholesome approach towards a smart village. The fact that the community plays an important role in any major change, the trust and social cohesion between the people are necessary for collective action. Here the trust in the community was low causing a mitigating effect towards implementation. Together with 'low level of trust' and less 'Willingness to seek new information about agriculture' causes the community to remain in the old practices while neglecting any future possibilities of improvement in agriculture. The barrier index is 2.62 making this a moderate barrier.

#### 4.4.4.7 High Cost of New Technologies and Limited support from the Public Institutions

*Table 19 High Cost of New Technologies and Limited support from the Public Institutions*

| Classification | Percent | Cumulative Percent |
|---|---|---|
| Moderate Barrier | 55.0 | 55.0 |
| High Barrier | 45.0 | 100.0 |
| Total | 100.0 | |

The cost of new technologies was considered to be very high by most farmers especially small farmers. This along with limited support by the relevant public authorities in reaching out to the farmers were seen as a major barrier towards implementation of smart villages. Some of the respondents had little savings thus making it hard for them to implement any new technologies in their fields. 'Barrier regarding funding by Public Institutions' was very high, furthermore most of the respondents had little idea on how to approach the relevant departments and start the process. In other words, the bureaucratic red tape was a major hurdle for the respondents to apply for funding for their agricultural lands. The barrier index was 3.3 making this a moderate to high barrier.

#### 4.4.4.8 Conservatism and Corrupt Political Culture

*Table 20 Conservatism and Corrupt Political culture*

| Classification | Percent | Cumulative Percent |
|---|---|---|
| Low Barrier | 13.0 | 13.0 |
| Moderate Barrier | 45.0 | 58.0 |
| High Barrier | 42.0 | 100.0 |
| Total | 100.0 | |

Conservatism and the political culture of our country hampers much of the efforts for improvement in agriculture. Many respondents were extremely conservative when asked if they would allow women in their farming. Along with this, our political culture or administrative setup is unfavorable to farmers especially small farmers. Therefore, many do no approach these institutions and have very low trust that they may be able to help in improving the agricultural situation for their lands. Furthermore, the bribery system that is in our institutions make many small farmers reluctant to ask for help in any new techniques. The barrier index was 3.20 making this a moderate to high barrier.

## 4.5 Acceptability Index

*Table 21 Acceptability Index*

| | **Frequency** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** | **Variance** |
|---|---|---|---|---|---|---|
| **Acceptability Index** | 100 | 2.08 | 4.15 | **2.94** | 0.40 | 0.16 |

Using the composite index method (See: Acceptability Index= $\frac{A_1+A_2+A_3+\cdots.A_n}{n}$. Equation 2 Composite Index), Acceptability Index was found. Since closer to value of 1 means Highest acceptability and value of 5 means lowest acceptability, the results showed the Acceptability Index at **2.94**. This indicates there is a **Moderate Level** of Acceptability among the local populations on implementation of Smart village in Pakistan. Furthermore, the low value of variance and standard deviation shows that majority of the locals were of the same opinion.

## 4.6 Framework for Smart Village in Pakistan

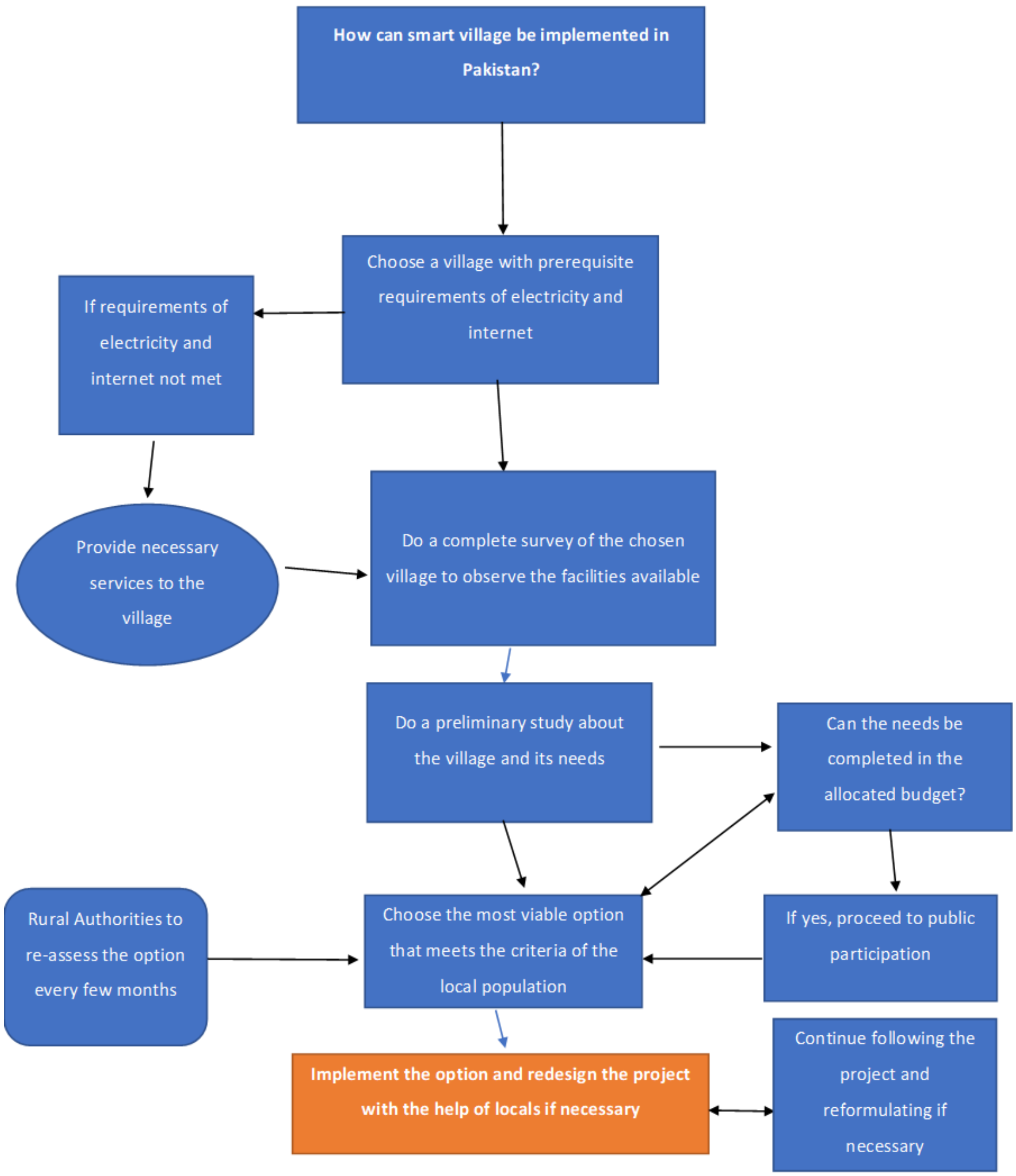


*Figure 18 Smart Village Framework*

The start of any smart village implementation requires a thorough survey of the village you are planning to implement the project on. The framework has been devised through the research and with help of the researchers and the local villagers alike. The main aspect if this framework is to include what is needed and not use extra resources that might not be useful to the local villagers.

In this case it is highly recommended to have continuous participatory process before, during and after implementation of any smart village project because in the end the locals will benefit from the project and it must be in accordance to their needs which may change overtime. Therefore, recommendations are for continuously involving the locals in the process of any change. This way the project will be successful not only in the short term but in the long term as well. In doing this there are two main factors of village life that will improve: first the quality of life of the villages will improve and secondly the rural to urban migrations will be mitigated.

## 4.7 Conclusion

Smart village was a concept that was ambiguous in some ways but clear in other ways, as it provided the necessary policies to comprehensively improve the rural areas. In this research the concept has been streamlined. Using systematic review, the main concepts of the smart village were identified. Further working on implementation of smart village in Pakistan, expert survey was carried out in form of an AHP survey. The survey yielded acceptable results and the main concept that Pakistan needs to focus on to make their villages smart-er were identified i.e., Smart agriculture. Furthermore, the survey carried out with the local villagers of Multan focused on the main barriers that is causing failure of implementation of smart village in Pakistan. Among those barriers the greatest were the low level of trust in public institutions and low level of knowledge related to smart agriculture technologies. Furthermore, the farmers that were keen to invest had low savings due to low productivity. Majority agreed that weather patterns were changing and the untimely rains and storms were causing their crops to have low production, hence their profit margin was so low that they barely had money for their next crop. The analysis proceeded through Factor Analysis which helped in identifying the barriers. Among those barriers included ‘Difficulty improving productivity and low savings for the farmers’, ‘High Cost of new technologies and limited support from the public institutions’ and ‘Low usage of Water Conservation practices. These barriers were highlighted through Factor analysis using Principal component method and varimax rotation. Acceptability of smart villages was computed through composite index method and the resultant value showed moderate acceptability among the locals. Finally, the framework was made through the help of the findings and the experts. The concluding remarks for this research stem from structural issues to administrative issues that are mitigating the implementation of smart villages in Pakistan, but through focused policy measures and greater administrative efforts these barriers can be solved and smart villages in Pakistan can become a reality instead of only a research problem.

# REFERENCES


Abbas, H. B., & Routray, J. K. (2014). Vulnerability to flood-induced public health risks in Sudan. *Disaster Prevention and Management*.

Affairs, P. D. o. t. U. N. D. o. E. a. S. (2018, 16 May, 2018). *68% of the world population projected to live in urban areas by 2050, says UN*. United Nations. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Aggarwal, P. K., Jarvis, A., Campbell, B. M., Zougmore, R. B., Khatri-Chhetri, A., Vermeulen, S. J., Loboguerrero, A. M., Sebastian, L. S., Kinyangi, J., Bonilla-Findji, O., Radeny, M., Recha, J., Martinez-Baron, D., Ramirez-Villegas, J., Huyer, S., Thornton, P., Wollenberg, E., Hansen, J., Alvarez-Toro, P., Aguilar-Ariza, A., Arango-Londono, D., Patino-Bravo, V., Rivera, O., Ouedraogo, M., & Yen, B. T. (2018). The climate-smart village approach: framework of an integrative strategy for scaling up adaptation options in agriculture [Article]. *Ecology and Society*, *23*(1), 15, Article 14. https://doi.org/10.5751/es-09844-230114

Anderson, A., Loomba, P., Orajaka, I., Numfor, J., Saha, S., Janko, S., Johnson, N., Podmore, R., & Larsen, R. (2017). Empowering smart communities: electrification, education, and sustainable entrepreneurship in IEEE Smart Village Initiatives. *Ieee Electrification Magazine*, *5*(2), 6-16.

Anderson, T. W., & Rubin, H. (1949). Estimation of the parameters of a single equation in a complete system of stochastic equations. *The Annals of Mathematical Statistics*, *20*(1), 46-63.

Andrieu, N., Sogoba, B., Zougmore, R., Howland, F., Samake, O., Bonilla-Findji, O., Lizarazo, M., Nowak, A., Dembele, C., & Corner-Dolloff, C. (2017). Prioritizing investments for climate-smart agriculture: Lessons learned from Mali. *Agricultural Systems*, *154*, 13-24.

Anwar, M., Chaudhry, I. S., & Khan, M. B. (2009). Factors affecting cotton production in Pakistan: Empirical evidence from Multan district.

Arslan, A., Cavatassi, R., Alfani, F., Mccarthy, N., Lipper, L., & Kokwe, M. (2018). Diversification under climate variability as part of a CSA strategy in rural Zambia. *The Journal of Development Studies*, *54*(3), 457-480.

Aryal, J. P., Rahut, D. B., Maharjan, S., & Erenstein, O. (2018). Factors affecting the adoption of multiple climate-smart agricultural practices in the Indo-Gangetic Plains of India [Article]. *Natural Resources Forum*, *42*(3), 141-158. https://doi.org/10.1111/1477-8947.12152

Ashley, C., & Maxwell, S. (2001). Rethinking rural development. *Development policy review*, *19*(4), 395-425.

Ayaz, M., Ammad-Uddin, M., Sharif, Z., Mansour, A., & Aggoune, E.-H. M. (2019). Internet-of-Things (IoT)-based smart agriculture: Toward making the fields talk. *Ieee Access*, *7*, 129551-129583.

Azeem, S., Naeem, M. A., & Waheed, A. (2017). Examining barriers and measures to promote the adoption of green building practices in Pakistan. *Smart and Sustainable Built Environment*, *6*(3), 86-100. https://doi.org/10.1108/SASBE-06-2017-0023

Budziewicz-Guzlecka, A. (2019). SMART VILLAGE AS A DIRECTION FOR RURAL DEVELOPMENT. Economic Science for Rural Development Conference Proceedings,

Campbell, B. M., Thornton, P., Zougmoré, R., Van Asten, P., & Lipper, L. (2014). Sustainable intensification: What is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability*, *8*, 39-43.

Chirinda, N., Arenas, L., Loaiza, S., Trujillo, C., Katto, M., Chaparro, P., Nunez, J., Arango, J., Martinez-Baron, D., Loboguerrero, A. M., Becerra Lopez-Lavalle, L. A., Avila, I., Guzman, M., Peters, M., Twyman, J., Garcia, M., Serna, L., Escobar, D., Arora, D., Tapasco, J., Mazabel, L., Correa, F., Ishitani, M., Da Silva, M., Graterol, E., Jaramillo, S., Pinto, A., Zuluaga, A., Lozano, N., Byrnes, R., LaHue, G., Alvarez, C., Rao, I., & Barahona, R. (2017). Novel Technological and Management Options for Accelerating Transformational Changes in Rice and Livestock Systems [Article]. *Sustainability*, *9*(11), 16, Article 1891. https://doi.org/10.3390/su9111891

Ciuffoletti, A. (2018). Low-Cost IoT: A Holistic Approach [Article]. *Journal of Sensor and Actuator Networks*, *7*(2), 19, Article 19. https://doi.org/10.3390/jsan7020019

Dax, T. (1996). Defining rural areas–International comparisons and the OECD indicators1. *Rural Society*, *6*(3), 3-18.

De-Pablos-Heredero, C., Montes-Botella, J. L., & Garcia-Martinez, A. (2018). Sustainability in Smart Farms: Its Impact on Performance [Article]. *Sustainability*, *10*(6), 16, Article 1713. https://doi.org/10.3390/su10061713

Declaration, B. (2018). Bled Declaration.(2018). *Bled Declaration for a smarter future of the rural areas in EU*.

Declaration, C. (2016). A better life in rural areas. In.

Duffy, C., Murray, U., Nowak, A., Girvetz, E. H., Corner-Dolloff, C., Twyman, J., Huyer, S., Jarvis, A., & Spillane, C. (2017). National level indicators for gender, poverty, food security, nutrition and health in Climate-Smart Agriculture (CSA) activities.

Ellis, F., & Biggs, S. (2001). Evolving themes in rural development 1950s-2000s. *Development policy review*, *19*(4), 437-448.

Faridi, M. Z., & Bashir, F. (2010). Households Saving Behaviour in Pakistan: A Case of Multan District. *Pakistan Journal of Social Sciences (PJSS)*, *30*(1).

Fennell, S., Kaur, P., Jhunjhunwala, A., Narayanan, D., Loyola, C., Bedi, J., & Singh, Y. (2018). Examining linkages between Smart Villages and Smart Cities: Learning from rural youth accessing the internet in India [Article]. *Telecommunications Policy*, *42*(10), 810-823. https://doi.org/10.1016/j.telpol.2018.06.002

Fu, B., Wang, S., Zhang, J., Hou, Z., & Li, J. (2019). Unravelling the complexity in achieving the 17 sustainable-development goals. *National Science Review*, *6*(3), 386-388.

Gain, A. K., Mojtahed, V., Biscaro, C., Balbi, S., & Giupponi, C. (2015). An integrated approach of flood risk assessment in the eastern part of Dhaka City. *Natural hazards*, *79*(3), 1499-1530.

Girvetz, E. H., Corner-Dolloff, C., Lamanna, C., & Rosenstock, T. S. (2017). 'CSA-Plan': strategies to put Climate-Smart Agriculture (CSA) into practice.

Giupponi, C., Mojtahed, V., Gain, A. K., Biscaro, C., & Balbi, S. (2015). Integrated risk assessment of water-related disasters. In *Hydro-meteorological hazards, risks and disasters* (pp. 163-200). Elsevier.

Goodwin, M. (1998). The governance of rural areas: some emerging research issues and agendas. *Journal of Rural Studies*, *14*(1), 5-12.

Grothmann, T., & Reusswig, F. (2006). People at risk of flooding: Why some residents take precautionary action while others do not. *Natural hazards*, *38*(1), 101-120.

Hazell, P., & Lutz, E. (1998). Integrating environmental and sustainability concerns into rural development policies. *E. Lutz (ed), with H. Binswanger, P. Hazell*, 9-21.

Heap, B., Holmes, J., & Jones, B. (2017). Can Smart Villages help to stem biodiversity loss?

Heap, R. (2015). Smart villages: New thinking for off-grid communities worldwide. *Essay Compilation, Banson*.

Ho, W. S., Hashim, H., & Lim, J. S. (2014). Integrated biomass and solar town concept for a smart eco-village in Iskandar Malaysia (IM) [Article]. *Renewable Energy*, *69*, 190-201. https://doi.org/10.1016/j.renene.2014.02.053

Holmes, J. (2017). The Smart Villages initiative: Findings 2014–2017. In *Smart Villages program: Energy as a catalyst for development*.

Holmes, J., Jones, B., & Heap, B. (2015). Smart villages [Editorial Material]. *Science*, *350*(6259), 359-359. https://doi.org/10.1126/science.aad6521

Holmes, J., & Thomas, M. (2015). Introducing the Smart Villages Concept. *INTERNATIONAL JOURNAL ON GREEN GROWTH AND DEVELOPMENT*, 151.

Imran, M. A., Ali, A., Ashfaq, M., Hassan, S., Culas, R., & Ma, C. (2018). Impact of Climate Smart Agriculture (CSA) practices on cotton production and livelihood of farmers in Punjab, Pakistan. *Sustainability*, *10*(6), 2101.

Jagustovic, R., Zougmore, R. B., Kessler, A., Ritsema, C. J., Keesstra, S., & Reynolds, M. (2019). Contribution of systems thinking and complex adaptive system attributes to sustainable food production: Example from a climate-smart village [Article]. *Agricultural Systems*, *171*, 65-75. https://doi.org/10.1016/j.agsy.2018.12.008

Katara, S. K. (2016). Envisioning smart villages through information and communication technologies–a framework for implementation in India. International Conference on Digital Transformation and Global Society,

Kellens, W., Zaalberg, R., Neutens, T., Vanneuville, W., & De Maeyer, P. (2011). An analysis of the public perception of flood risk on the Belgian coast. *Risk Analysis: An International Journal*, *31*(7), 1055-1068.

Khatri-Chhetri, A., Aggarwal, P. K., Joshi, P., & Vyas, S. (2017). Farmers' prioritization of climate-smart agriculture (CSA) technologies. *Agricultural Systems*, *151*, 184-191.

Kongsager, R. (2017). Barriers to the Adoption of Alley Cropping as a Climate-Smart Agriculture Practice: Lessons from Maize Cultivation among the Maya in Southern Belize [Article]. *Forests*, *8*(7), 23, Article 260. https://doi.org/10.3390/f8070260

Kumar, D., & Shekhar, S. (2015). Rural Energy Supply Models for Smart Villages. *School of Earth Sciences, Central University of Karnataka, Gulbarmartga-585367, Karnataka, India*, *1*(5), 1-8.

Lopez-Ridaura, S., Frelat, R., van Wijk, M. T., Valbuena, D., Krupnik, T. J., & Jat, M. (2018). Climate smart agriculture, farm household typologies and food security: an ex-ante assessment from Eastern India. *Agricultural Systems*, *159*, 57-68.

Mansuri, G., Sami, M. F., Ali, M., Doan, H. T. T., Javed, B., & Pandey, P. (2018). *When water becomes a hazard: A diagnostic report on the state of water supply, sanitation and poverty in Pakistan and its impact on child stunting*.

Mao, C., Shen, Q., Pan, W., & Ye, K. (2015). Major Barriers to Off-Site Construction: The Developer's Perspective in China. *Journal of Management in Engineering*, *31*(3). https://doi.org/10.1061/

Miceli, R., Sotgiu, I., & Settanni, M. (2008). Disaster preparedness and perception of flood risk: A study in an alpine valley in Italy. *Journal of environmental psychology*, *28*(2), 164-173.

Muhammad, N., McElwee, G., & Dana, L.-P. (2017). Barriers to the development and progress of entrepreneurship in rural Pakistan. *International Journal of Entrepreneurial Behavior & Research*.

Mulenga, R., Kalezhi, J., & Musonda, S. K. (2017). Integration and Remote Monitoring of Wireless Sensor Networks in the Development of SMART Villages. *Zambia ICT Journal*, *1*(1), 30-34.

Naldi, L., Nilsson, P., Westlund, H., & Wixe, S. (2015). What is smart rural development? [Article]. *Journal of Rural Studies*, *40*, 90-101. https://doi.org/10.1016/j.jrurstud.2015.06.006

Nasiakou, A., Vavalis, M., & Zimeris, D. (2016). Smart energy for smart irrigation. *Computers and Electronics in Agriculture*, *129*, 74-83.

PICCOLO, A., & RAUNIG, K. Monitoring and Evaluation of Climate-Smart Agriculture.

Qasim, S., Khan, A. N., Shrestha, R. P., & Qasim, M. (2015). Risk perception of the people in the flood prone Khyber Pukhthunkhwa province of Pakistan. *International Journal of Disaster Risk Reduction*, *14*, 373-378.

Quinney, M., Bonilla Findji, O., & Jarvis, A. (2016). CSA Indicators Database Summary and Key Findings.

Rai, R. K., Bhatta, L. D., Acharya, U., & Bhatta, A. P. (2018). Assessing climate-resilient agriculture for smallholders [Article]. *Environmental Development*, *27*, 26-33. https://doi.org/10.1016/j.envdev.2018.06.002

Ranade, P., Londhe, S., & Mishra, A. (2015). Smart villages through information technology–need of emerging India. *Int. J. Inf. Technol*, *3*(7).

Rehman, A., Chandio, A. A., Hussain, I., & Jingdong, L. (2019). Fertilizer consumption, water availability and credit distribution: Major factors affecting agricultural productivity in Pakistan. *Journal of the Saudi Society of Agricultural Sciences*, *18*(3), 269-274.

Reytar, K., Hanson, C., & Henninger, N. (2014). Indicators of sustainable agriculture: a scoping analysis. *World Resources Institute: Washington, DC, USA*.

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockström, J. (2019). Six transformations to achieve the sustainable development goals. *Nature Sustainability*, *2*(9), 805-814.

Sain, G., Loboguerrero, A. M., Corner-Dolloff, C., Lizarazo, M., Nowak, A., Martínez-Barón, D., & Andrieu, N. (2017). Costs and benefits of climate-smart agriculture: The case of the Dry Corridor in Guatemala. *Agricultural Systems*, *151*, 163-173.

Salvia, M., Cornacchia, C., Di Renzo, G., Braccio, G., Annunziato, M., Colangelo, A., Orifici, L., & Lapenna, V. (2016). Promoting smartness among local areas in a Southern Italian region: The Smart Basilicata Project. *Indoor and Built Environment*, *25*(7), 1024-1038.

Shahzad, M. F., & Abdulai, A. (2020). The heterogeneous effects of adoption of climate-smart agriculture on household welfare in Pakistan. *Applied Economics*, 1-26.

Simelton, E., Dam, B. V., & Catacutan, D. (2015). Trees and agroforestry for coping with extreme weather events: experiences from northern and central Viet Nam [Article]. *Agroforestry Systems*, *89*(6), 1065-1082. https://doi.org/10.1007/s10457-015-9835-5

Šimková, E. (2007). Strategic approaches to rural tourism and sustainable development of rural areas. *Agricultural Economics*, *53*(6), 263-270.

Srivatsa, P. (2015). Rural Urban Migration: Disturbing the Equilibrium between Smart Cities and Smart Villages. *FIIB Business Review*, *4*(3), 3-10.

Statistics, P. B. o. (2017). *POPULATION AND HOUSEHOLD DETAIL FROM BLOCK TO DISTRICT LEVEL PUNJAB (MULTAN DISTRICT)*. Islamabad Retrieved from https://www.pbs.gov.pk/sites/default/files/bwpsr/punjab/MULTAN_BLOCKWISE.pdf

Tiwari, P., Sachan, P., Maurya, R., Singh, A., & Nigam, A. SMART VILLAGE–AN APPROACH FOR SUSTAINABLE VILLAGES. *NEW INITIATIVE IN AGRICULTURE AND RURAL DEVELOPMENT*, 102.

van Gevelt, T., Holzeis, C. C., Fennell, S., Heap, B., Holmes, J., Depret, M. H., Jones, B., & Safdar, M. T. (2018). Achieving universal energy access and rural development through smart villages [Article]. *Energy for Sustainable Development*, *43*, 139-142. https://doi.org/10.1016/j.esd.2018.01.005

Visvizi, A., & Lytras, M. D. (2018). Rescaling and refocusing smart cities research: from mega cities to smart villages [Article]. *Journal of Science and Technology Policy Management*, *9*(2), 134-145. https://doi.org/10.1108/jstpm-02-2018-0020

Visvizi, A., Lytras, M. D., & Mudri, G. (2019a). Smart Villages: Relevance, Approaches, Policymaking Implications. In *Smart Villages in the EU and Beyond* (pp. 1-12). Emerald Publishing Limited.

Visvizi, A., Lytras, M. D., & Mudri, G. (2019b). Smart villages: Relevance, approaches, policymaking implications. In *Smart Villages in the EU and Beyond*. Emerald Publishing Limited.

Viswanadham, N., & Vedula, S. (2010). Design of Smart Villages. *Indian School of Business. Hyderabad 500032*.

Westermann, O., Förch, W., Thornton, P., Körner, J., Cramer, L., & Campbell, B. (2018). Scaling up agricultural interventions: Case studies of climate-smart agriculture. *Agricultural Systems*, *165*, 283-293.
Wollenberg, E. K., Campbell, B. M., Holmgren, P., Seymour, F., Sibanda, L. M., & Braun, J. v. (2011). Actions needed to halt deforestation and promote climate-smart agriculture.
Wolski, O., & Wójcik, M. (2019). Smart villages revisited: Conceptual background and new challenges at the local level. *Smart Villages in the EU and Beyond; Visvizi, A., Lytras, MD, Mudri, G., Eds*, 29-48.
Zavratnik, V., Kos, A., & Duh, E. S. (2018). Smart Villages: Comprehensive Review of Initiatives and Practices [Review]. *Sustainability*, *10*(7), 14, Article 2559. https://doi.org/10.3390/su10072559
Zavratnik, V., Kos, A., & Stojmenova Duh, E. (2018). Smart villages: Comprehensive review of initiatives and practices. *Sustainability*, *10*(7), 2559.

# Appendix 1: Smart Village Survey

Smart Agriculture Survey

Respected Sir /Madam,

This questionnaire is a part of my MS thesis research titled "**Smart Village for Sustainable Rural Development in Pakistan**". I would appreciate your taking the time to complete the following survey. It should take few minutes of your time. Your responses are voluntary and will be confidential. All responses will be compiled together and analyzed as a group. Please note there is only one answer required for each question. I shall be very grateful for your co-operation and help.

Note: Kindly choose only one option.

**SECTION 1: HOUSEHOLD INFORMATION**

**1. Age: __________**

**2. Gender**

o Female o Male o Other

**3. Marital Status**

o Married o Unmarried o Widowed o Divorced o Separated

**4. Please specify the gender of the head of your household**

o Female o Male o Other

**5. Head Education Level**

o Primary school and below  o Middle school  o High school  o Bachelors

o Masters and above

**6. Household size: ___________**

**7. No of females in your house: ________**

**8. No of educated family members: _________**

**9. Length of residency (in years): __________**

**10. Monthly income ____________**

**11. Monthly Savings _____________**

**12. Where do you spend the most of your income on your agricultural land?**

o Labor cost  o Irrigation  o Fertilizers  o Other (please specify)

o Seeds  o Pesticides  o Harvesting

**13. Have you taken insurance? If yes, mention the type**

o Yes (specify)  o No

**14. Have you borrowed loan in past few years?**

o Yes  o No

**15. Source of your livelihood other than agriculture? ________________**

**16. Do you own any Agricultural Land, if yes how much (in acres)?**

| | |
|---|---|
| o Yes<br>Owned AREA: | o No |

**17. If yes, are you directly involved in sowing your land?**

| | |
|---|---|
| o Yes | o No |

**18. What type of farming do you use on your land? _______________**

**19. What types of crop do you sow? ____________**

**20. Which crop has the most significant contribution to your income? ___________**

**21. In which season, you perform agricultural activities? _________**

**22. Do you think the education/training provided in your area can help improve agriculture?**

o Yes o No

**23. Have you used any latest agricultural techniques? If yes, please specify.**

**24. Do you know any workshop or mechanic who can deal in repairing the latest machinery?**

o Yes o No

*25-33.*

| Utility Services | Yes/ No (% age) |
|---|---|
| Electricity | |
| Gas supply | |
| Clean water supply | |
| Sanitation | |
| Television | |
| Broadband | |
| Mobile internet (3G,4G) | |
| Access to Government portals (websites, SMS, Mobile Applications) | |
| Road Accessibility (Farm to market) | |

**1- Extremely Unlikely**

**2- Unlikely**

**3- Moderate**

**4- Likely**

**5- Extremely Likely**

| QUESTIONS | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 33. What is the level of food insecurity in your area? | | | | | |
| 34. Have you faced any barrier regarding funding or financial aid from public institutions? If yes, please mention the scale. | | | | | |
| 35. How much do you think agriculture is being affected by change in weather patterns? | | | | | |
| 36. How difficult it is for you to deliver your products to the market? | | | | | |
| 37. How much have you experienced negative changes over the past few years in yield of crops? Please mention the main reasons. | | | | | |
| 38. How much do you face difficulties in irrigating your fields? | | | | | |
| ***39. What is your level of trust in public institutions?*** | | | | | |
| ***40. What is your level of trust in the community?*** | | | | | |
| 41. How much do you rely on traditional agricultural methods? | | | | | |
| 42. How much soil fertility has been decreased in your area? | | | | | |
| 43. How much do you think it would cost to introduce the latest machinery in agriculture? | | | | | |
| ***44. How much information do you have about drip irrigation?*** | | | | | |
| ***45. How much information do you have about tunnel farming?*** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| ***46. How much information do you have about solar tube wells?*** | | | | | |
| ***47. How much information do you have about drone spraying techniques?*** | | | | | |
| ***48. How much information do you have about High-density farming?*** | | | | | |
| 49. Do you consider rural conflicts as a barrier in improving the agricultural production? | | | | | |
| ***50. At what extent your income level will increase if you introduce new technology in agriculture*** | | | | | |
| ***51. How much technology will increase agricultural production?*** | | | | | |
| ***52. How much do you encourage more female participation in your agricultural work?*** | | | | | |
| ***53. Have you introduced any new agricultural techniques in your area?*** | | | | | |
| ***54. Will you allow public officials to implement any new agricultural techniques on your land?*** | | | | | |
| ***55. If public institution introduces any new agricultural smart policies, will you accept them?*** | | | | | |
| ***56. How much are you willing in future to seek information about new agricultural technologies?*** | | | | | |
| ***57. What is your likelihood of getting crop insurance in future?*** | | | | | |

# Appendix 2: AHP Expert Survey

| Option A | Very strongly | | Strongly | | Moderately | | Equally | | Moderately | | Strongly | | Very strongly | Option B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Smart Agriculture | 7 | 6 | 5 | **4** | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Sustainable Energy |
| Smart Agriculture | 7 | **6** | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | ICT |
| Smart Agriculture | 7 | 6 | 5 | **4** | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Inclusive Development |
| Smart Agriculture | 7 | **6** | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Knowledge Based Economy |
| Sustainable Energy | 7 | 6 | **5** | 4 | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | ICT |
| Sustainable Energy | 7 | 6 | 5 | 4 | 3 | **2** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Inclusive Development |
| Sustainable Energy | 7 | 6 | 5 | **4** | 3 | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Knowledge Based Economy |
| ICT | 7 | 6 | 5 | 4 | **3** | 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Inclusive Development |
| ICT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | **3** | 4 | 5 | 6 | 7 | Knowledge Based Economy |
| Inclusive Development | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 4 | **5** | 6 | 7 | Knowledge Based Economy |