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Knowledge and Innovation Management

Knowledge and Perception of farmers on Solar Irrigation Pumps (SIPs) in Gadag District, Karnataka State, India

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Table of Contents

1. Introduction **8**

1.2 Outline of the study 10

1.3 Significance of the study 11

1.4 Aim of the study 12

1.4.1 Specific objectives of the study 12

2. Literature review **13**

2.1 Sustainable Innovation 13

2.2 Karnataka's Surya Raitha Scheme 16

2.2.1 Selection of Suppliers and Beneficiaries of SIPs in Karnataka 17

2.2.2 Financial grants 18

2.3 Components of Solar Irrigation Pump (SIP) 18

3. Theoretical Background **20**

4. Methodology **24**

4.1 Description of the study area 24

4.2 Sampling framework 28

4.3 Research regions 29

4.4 Questionnaire 30

4.5 Interviews with farmers 30

4.6 Critical evaluation of the methodology 31

5. Findings **33**

5.1 Socio-demographic background 33

5.2 Farmers source of knowledge and information regarding SIPs 35

5.3 Problems in accessing information on SIPs 37

5.4 Perceived benefits on the usage of SIPs 38

5.5 Problems and risks associated with the use of SIPs 41

5.6 Comparative analysis of SIPs with conventional/ diesel pumps 43

5.7 Mediators role towards SIPs 44

5.8 Overall Perception of farmers on using SIPs 45

6.Discussion **46**

6.1 Farmers and Solar Irrigation Pumps 46

6.2 Additional challenges observed. 48

6.3 Ground Water Management 49
6.4 Using farmers wisdom for sustainable adoption of modern technologies 49
6.5 Limitations of the study 50
7. Conclusion 51
7.1 Policy recommendation 52

List of Figures

Figure 1: Movement towards sustainable innovation 14

Figure 2: A steady decline in prices of PV panels over time ($/watt) 15

Figure 3: Pictorial representation of Surya Raitha Scheme 16

Figure 4: A typical solar-powered irrigation system 19

Figure 5: Wisdom Hierarchy 22

Figure 6: Moving from data to increased understanding 23

Figure 8: Gadag district map 24

Figure 5: Farmer demonstrating his SIP at Ron Taluk, Gadag District, Karnataka, India 27

Figure 9: Farmer using Pipe irrigation method for watering crops though (canal system) SIP in Gadag Taluka 40

Figure 10: Farmer demonstrating SIPs Gadag Taluk, Karnataka, India 44

List of Tables

Table 1: Taluk wise annual average solar radiance (kWh/m^2) 25

Table 2: Research regions (Taluka) 29

Table 3: Socio-demographic background of the surveyed farmers 33

Table 4: Source of knowledge and information on SIPs 35

Table 5: Information Sources (Male v/s Female) 36

Table 6: Farmers problems in accessing information on SIP 37

Table 7: Perceived benefits on the usage of SIPs by farmers 38

Table 8: Problems and risk associated with the use of SIPs 41

Table 9: Analysis of SIPs over diesel pumps by farmers 43

Table 10: Perception of farmers on using SIPs 45

List of Abbreviations

SIPs - Solar Irrigation Pumps

GOI - Government of India

RSK - Raitha Samparka Kendra *(Farmers Information point)*

GHG - Greenhouse gas

JIS - Jain Irrigation System

PV – Photovoltaic

MNRE – Ministry of New and Renewable Energy

RKVY – Rashtriya Krishi Vikas Yojana *(Remunerative Approach for Agriculture and Allied sector Rejuvenation)*

AI – Artificial Intelligence

HP – Horse Power

NABARD – National Bank for Agriculture and Rural Development

AC – Alternating Current

DC – Direct Current

GHI – Global Horizontal Index

kWh/m^{2-} Kilowatt per square meter

BIS – Bureau of Indian Standards

IES – International Electronical Commission

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Abstract

Solar Irrigation Pumps (SIPs) constitutes for an eco-friendly and green energy options in pumping irrigation water in developing economies like India. Studies estimate that India's potential for harnessing solar energy to be 10 to 70 million solar irrigation pumps that could save around 255 billion liters of diesel per year (Pullenkav, 2016). The market potential for SIPs seems to be great as prices of photovoltaic PV panels continue to drop significantly in recent years. However, farmers' access to Solar Irrigation Pumps remains to be limited, especially in the agriculture sectors of India. Therefore the study focuses on understanding the farmer's point of view; their knowledge and perception with regards to the usage of SIPs at ground level, to understand the current challenges in the adoption of new technologies like the one with solar-powered irrigation pumps.

The study is thus based on the 50 in-depth farmers interviews held at five different taluks of Gadag district, India. This research address questions like, the benefits SIPs have over conventional methods of irrigation? What risks do SIPs pose? What are the existing schemes and regulations governing the promotion of SIPs? What are the farmers' opinions? What perception do farmers hold with regards to the innovation?.

Nonetheless, there are current challenges that this research tries to explore with the sustainability of SIPs over the long run. It found out that farmers' information sources and mentioned the problems in accessing information related to SIPs in rural regions of the district. The study explores the subsidy benefits under the scheme called “Surya raitha” and tries to address possible policy changes for agrarian development in general.

Research also stresses the importance of groundwater management in the region. SIPs can improve access to water for rural households; however, without a proper policy in check for moderate water consumption, there is a problem of overexploitation of groundwater in the region.

Finally, this study looks at different opinions of the farmers to understand the possible challenges and risks that come along with the adoption of SIPs. As such, it is the timely reflection of the past adopted farmers which clearly highlights the possible challenges and issues concerned with the nature of adoption of SIPs in Gadag district, Karnataka, India.

1. Introduction

Managing the agriculture land and improving the living standards of the people have been major challenges for ages and are expected to grow in importance in the next centuries.

India is by no means an exception. India's now vast population is expected to storm up to the world's biggest population in the next 20 years. Since its economy is growing at a steady rate, according to Christiaensen, Demery, & Kühl, (2006) major structural changes in the field of agriculture, like improvements in innovative methods of farming practices, have to happen to sustain poverty reduction and rural development.
Although agriculture share on GDP, which is around 15%, is consistently declining from the past 30 years (Rush & Cagliarini, 2011). India still stands among the largest irrigated areas around the world, with 70% of the rural households still depending on agriculture and allied activities for their livelihood (MOA & FW, 2017). Meanwhile, being the agrarian economy with 21.9% of its population who are still living below the poverty line, development in the agrarian sector becomes paramount (Ahluwalia, 1978).

Accordingly, the studies from Christiaensen, Demery, & Kühl (2006) and de Janvry & Sadoulet (2009) point out that, improvements in the agricultural sector have a significant effect on poverty reduction since it effectively targets the needy or poor sectors of the economy. Therefore, poverty reduction through the transfer of technologies on agriculture sector, particularly among rural farmers, must be seriously handled to improve the living standards of the society. In order to break the poverty cycle and thus unearthing the potentials of poor, it becomes evident the necessity of challenging paths and means of technology transfer to turn agriculture into a lucrative business.

Thus, longing to reduce poverty has imposed itself into various research and development on the agriculture sector, such as the introduction of new crop verities, transfer modern technologies to the rural farmers. However, even with all these advancements in research and development, it is quite common to see most farmers still relying primarily on rainfall alone for watering their crops, despite the positive effects expected by irrigation method of farming. Indeed, underground pumping increases the crop yield on average by four times, but rather it requires tremendous

amounts of energy. As of now, it's been evaluated that around 26 million diesel or electric pumps keep running on Indian ranches, making them the most dominant innovations of today (Varun Mehra, 2015). Meanwhile, using pumps that relay especially on electricity face the same challenges of any other grid-connected pumps which are susceptible to regular outrages or power cuts.

According to Centre for Study of Science, Technology and Policy (2016) report, some of the general issues faced by the usage of electric or diesel pump sets are: over-exploitation of groundwater, rising costs of fuel, reduced pump set efficiency, lower quality of power supply, poor metering facilities, lack of monitoring mechanisms, etc. Besides, diesel-based pumps trouble farmers with the higher cost of fuel consumption, which can be as much as €500/year, destroying what could be a potential profit for the farmers (Varun Mehra, 2015).

In order to mitigate all these problems and also to curb the usage of electric and diesel pumps, Ministry of New and Renewable Energy (MNRE) of GOI along with the collaboration of State government of Karnataka promoted the usage of solar-based irrigation pumps at farm level at different districts of the State (Shim, 2017). However, for any of the innovations to be successful, experience from those farmers who are using it becomes primordial for the successful implementation of solar irrigation pumps at a larger scale.

It is in this backdrop; the present paper tries to address and evaluate the perception of farmers on solar-based irrigation pumps. Understanding farmer's knowledge regarding an innovation helps to understand the benefits of such innovation, thereby to mitigate possible problems and risks associated with the same. Thus, the chapters discussed in this study are as follows.

The first chapter is introductory in nature followed by a brief literature review, which explains the components of SIPs, the scheme which provides SIPs to the farmers. The third chapter deals with the theoretical background that is necessary for this study. The fourth chapter is about methodology and data collection procedures. The fifth chapter deals with findings of the research, followed by its discussion and finally ends with a conclusion as the final chapters.

1.2 Outline of the study

Karnataka as a State ranks second among the arid parts of the country. Consequently, its dependence on underground pumping constitutes substantially a higher share of electricity consumption (~34 %) compared to the national average of (~20 %) (Planning Commision, 2014). A study by Karnataka's State Action Plan on Climate Change shows that major areas of the State are drought-prone and roughly around INR 56 billion was spent on electricity subsidies alone in the year 2012 (CSTEP, 2013).

According to the articles published by Anil Urs (2018) and Harishankar et al., (2014), Karnataka stands among the top states for carrying out the distribution of Solar Irrigation Pumps under the scheme name called " Surya Raitha ". Gadag a district that falls under the jurisdiction of Karnataka State is observably known for its highest number of solar irrigation pumps being installed in the region, it is also well known for its local steppe climatic conditions which generally fits for harvesting solar energy (Directorate of census operations, 2011). However, the knowledge required and perception of farmers on using such solar-based pumps for irrigation purposes is still unknown, which gives the scope for research development in the relevant field.

According to the studies from Rogers (1995), the promotion of new innovative methods of farming carries with it potential advantages to its adopters but also creates uncertainties in the minds of the people who are adopting such new innovations. However, studies from de Janvry & Sadoulet (2009), pointed out that the introduction of new innovative methods of farming in the agricultural sector is the stepping stone for poverty reduction and sustainable agriculture for the future generation. Nonetheless, for any such modern methods of framing practices (SIPs in our case) to be successful at a large scale, it becomes essential to study the knowledge and perception of the farmers who are adopting those innovations.

Interpretation of any information received is termed as perception (S.V.N. Rao, D.V. Rangnekar, 1995). Perception plays a significant role in making everyday decisions and farmers are not of an exemption. For example, farmers are bombarded with everyday decision making about the time of sowing, harvesting, cropping sequence, adoption of new technologies, the decision regarding what technologies would best suit them, etc. The role of perception on farmers decisions making

abilities are immense. Perception rather acts as a relative concept than absolute; however, much of farmers' perceptions are influenced by the social surroundings in which he leaves. Cognitive behavioural studies point out the interconnectedness of human perception with their decision-making abilities (Liu & Luo, 2018). Meanwhile, due to their past observations, most of them respond differently for the same situations which intern affects their opinion towards the adoption of new technologies (S.V.N. Rao, D.V. Rangnekar, 1995). It is in understanding these different opinions one can comment on the future sustainability of such innovations (Patel & Connolly, 2007).

According to Mukadasi & Lusiba (2006), knowledge and perception of farmers are critical for the successful implementation of new innovative practices of farming. They further stated that, for any new projects or policies under the agricultural sector to be successful, understanding the knowledge and perception dynamics of framers becomes crucial. There have been numerous studies on the perception of the farmers, the way they affect the adoption of new innovative practices that received limited attention. Even though the studies regarding the perception of farmers have received limited attention, as per, Negatu (2002) there is a direct relationship between farmers' perception and adoption of new innovation. Preservation of innovation, in a sense, is greatly influenced by the knowledge and information that is made available to the adopting farmer. By understanding them, one might be able to solve the future crisis (Negatu & Parikh, 1999; Orikiriza, Nyeko, & Sekamatte, 2012; Rahman, 2003). Furthermore, to prevent the failure of adoption and promote sustainable usage of SIPs a sound understanding of the knowledge and perception of farmers who are using it, becomes crucial.

1.3 Significance of the study

By understanding the farmer's perception of the usage of Solar Irrigation Pumps, it is possible to reduce the problems incurred and for equitable diffusion of technology in the coming years. Direct experiences, like the perceived information of Solar Irrigation Pumps by the farmers, also provides useful information on the ground reality on what's happing around the study area. Thus tries to answer the questions regarding what do farmers think about SIPs in general? Such kinds of analysis can not only help in understanding user experiences but also can help to evaluate and develop better strategies/policies in the future for further implementation of solar irrigation pumps at a larger scale.

Furthermore, researching on schemes like “Surya Raitha” in drought-prone areas like Gadag district helps policymakers and law-abiding investors in gaining useful information regarding the feasibility of such projects in the long run.

Finally, the study will be instrumental in filling the gap on farmer’s knowledge regarding SIPs, as well as to make the readers realise the subjective perception of farmers towards the usage of SIPs after its implementation. This medium, however, becomes vital, as the usage of solar pumps for irrigation purposes is rather a concept that is new in emerging economies like India and therefore requires an exceptional consideration towards the farmers who are adopting such innovations.

1.4 Aim of the study

The study focuses on the knowledge and perception of farmers on the usage of Solar Irrigation Pumps (SIPs) in Gadag district, Karnataka, India.

1.4.1 Specific objectives of the study

1 To find out the extent of awareness and address the possible gaps in accessing information regarding SIPs by the farmers in Gadag district, Karnataka, India.
2 To identify the benefits and risks associated with the usage of Solar Irrigation Pump (SIPs) by farmers of Gadag district, Karnataka, India.
3 To analyse the use of SIPs in comparison with other conventional methods of irrigation by the farmers in the study area.
4 To find out the perception of farmers on the usage of Solar Irrigation pumps in Gadag district, Karnataka, India.
5 To discuss the possible challenges faced by the farmers while using Solar Irrigation Pumps henceforth to evaluate further policy recommendations if any.

2. Literature review

In order to navigate this study forward, the subchapters discussed below represent abstract, as well as the concept of sustainable innovation, are defined and introduced. The subchapters also focuses on the scheme related to the promotion of Solar irrigation pumps around the study area; its goals and structure are discussed briefly. The last subchapters provide background information on the components of solar irrigation pumps that are necessary for this study.

2.1 Sustainable Innovation

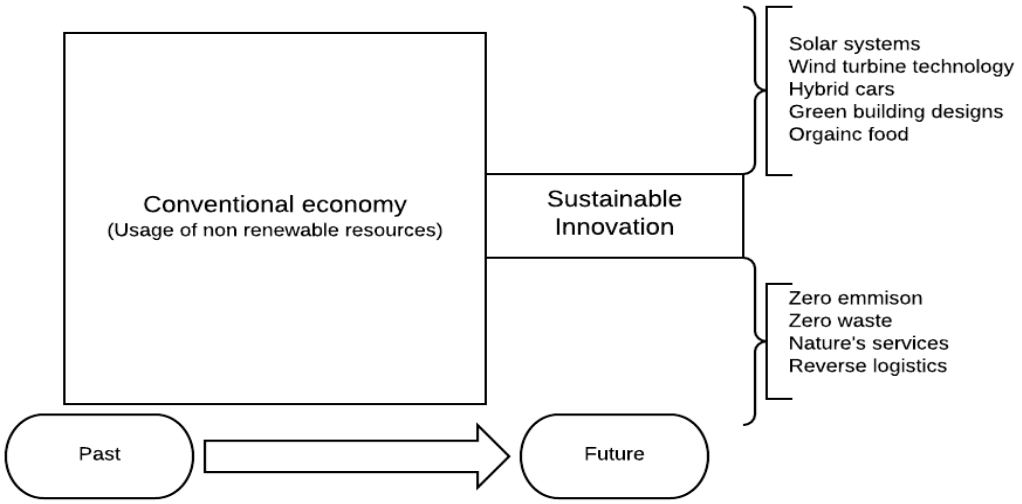
The word sustainability has remained a buzz word in recent decades but can be interpreted in many ways. According to the World Commission on Environment and Development (1987) report, sustainability defined as "*meeting the needs of the present without compromising the ability of future generations to meet their needs"*. In other words, it is making use of available resources in the best possible way.

Sustainable innovation, on the other hand, reflects on next-generation thinking over economic development. It tries to combine, protection of natural environment along with the advancements in innovation while providing basic needs and ventures that serve social needs and finally serve for human wellbeing (Sharma & Starik, 2008). It is the flood of advancement in innovation that is trying to push society towards a cleaner and greener economy along with clean business practices. According to, Larson (2011), referred to sustainable innovation as the collective, constructive and idealistic actions of individuals around the globe to rearrange economic development into a process that points out principal challenges on resource scarcity, poverty, and environmental protection.

Meanwhile, the dimensions of sustainable innovation reflect on three pillars; those are social, economic and environmental. The social dimensions reflect on the availability of resources or new innovations in order to keep the user families safe and secure. The farmer needs to be aware of the benefits and risks associated with innovation, his perceived confidence about the technology, government policies if any, etc. The economic dimension deals with the availability of funds that sponsor the innovation. In a sense, it represents the value of the given innovation in terms of price which might deteriorate over time. Finally, the environmental sustainability of innovation deals with the maintenance of ecological integrity by keeping the earth's environment in balance and consuming natural resources out of it (Larson, 2011; Sharma & Starik, 2008). In

assessing the sustainability of innovation, there needs to be a clear understanding of how these different dimensions influence the sustainably of a technology.

Figure 1: Movement towards sustainable innovation



Based on: Larson (2011)

Nonetheless, Governments & private sector companies are trying to push innovations that are sustainable in the agricultural community for many decades. Within this wide-ranging innovation community, solar-based irrigation pumping has gained popularity in recent days; for its goal on improving the access to irrigation facilities in rural parts of India. For example, according to the reports published by Agrawal & Jain (2016), India has set off a target of deploying 100000 solar pumps by 2020. Various other sustainable innovations like usage of biofuels for pumping, micro-hydropower plants, biomass waste for manuring crops and other renewable energy options are still getting adopted. However, solar irrigation pumps are still preferred due to its lower operational costs and no fuel inputs (Hiller et al., 2016).

According to the reports from (World bank, 2017) usage of solar irrigation pumps in developing economies like India provides to be an alternative for sustainable water supply. Meanwhile, the cost of using solar based innovation as the report mentioned had dropped significantly in recent

years. Costs for the solar PV panels utilised in these frameworks have dropped by up to 80%. What's more, is that these PV panels last up to 25 years, proving it to be operationally and environmentally sustainable innovation.

Figure 2: A steady decline in prices of PV panels over time ($/watt)

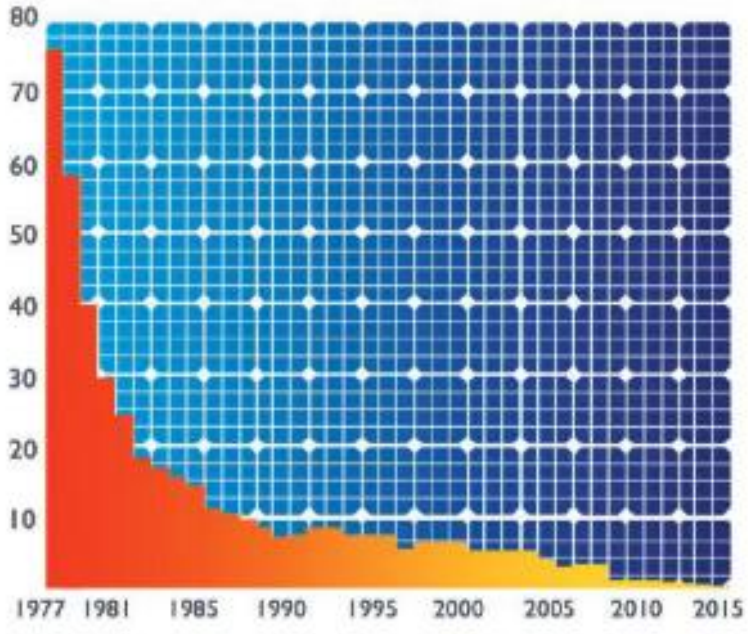
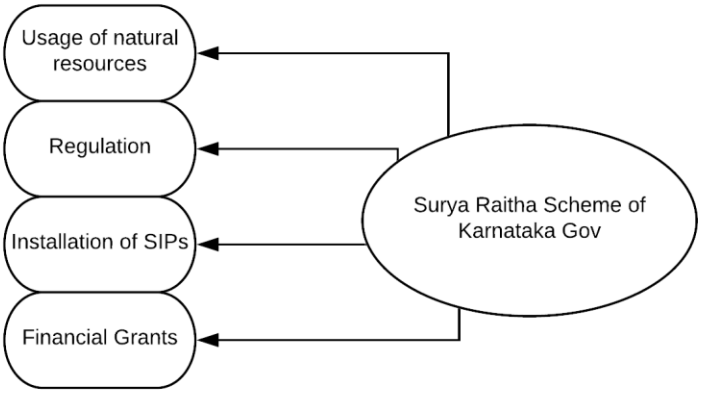


Image retrieved from: (World Bank Group, 2018) "Solar Pumping: The Basics.

These elements have made solar-based water pumping an incredibly suitable approach to access water across the nation, further creating environmental benefits on climate change actions. In the light of rapid expansion such innovations, there is need to think strategically on how make such innovation viable and sustainable for the farming communities. Different policies have been operating around India for the promotion of SIPs around the state. For instance, few State governments of India have made policies to sponsor the expenses of solar-based irrigation pumps to its farmers, while Karnataka as a State is one among them.

2.2 Karnataka's Surya Raitha Scheme

Figure 3: Pictorial representation of Surya Raitha Scheme



Source: Author model

Karnataka's Surya Raitha Scheme (2014 – 2021) focuses on the usage of solar energy for irrigation purposes to the farmers of the state. The project provides 90% of subsidies on the total capital cost of installation of stand-alone off-grid Solar Irrigation Pumps (SIPs) at farmer's site locations in Karnataka State. Two main organisations that remits subsidy benefits to the farmers are:

Rashtriya Krishi Vikas Yojana (RKVY) handled by the State Government of Karnataka that allocates up to 60% of the total cost of installation of SIPs & Ministry of New and Renewable Energy (MNRE) handled by the Central Government (GOI) that covers the remaining 40% of the total cost of installation of SIPs (Kishore, Shah, & Tewari, 2014).

Meanwhile, as per the reports from (Karanataka Renewable Energy Development Ltd, 2019), within the state, more than 221 million volts of energy have been deployed until now using the scheme "Surya Raitha".

The goals of the scheme are as follows goals

- To improve the quality of irrigation by providing an uninterrupted power supply during the day.

- Reduce carbon footprints with reduced dependency on electricity and diesel pumps.
- Reduce the transmission and distribution cost of electricity by replacing grid-connected power supply by locally generated power supply.
- To enhance the rural power sector with suitable financial grants and subsidies.
- Provide remunerative cash income for farmers with an option on buying extra power generated via a net metering basis to curb the usage of groundwater and thereby to mitigate over-exploitation of groundwater.

  Based on : (Govinfo, 2018; Karnataka Renewable Energy Development Ltd, 2014; Kumar.S, 2018; Shah, Verma, & Durga, 2014).

Under the scheme, the Government of Karnataka mentions on buying extra power generated via net metering basis at Rs. 9.56 (0.12 €) per unit of electricity saved from those farmers who had previously not opted for any kinds of subsidy benefits & at Rs. 7.20 (0.1 €) per unit of electricity saved from those farmers who had previously opted for subsidy benefits (Harishankar et al., 2014; Santhanam, 2015). The main aim of such buyback of the power supply directly from the farmers was to curb the excessive usage of groundwater and thereby also to provide an additional source of income to the farmers. However, the feasibility of such buyback of power generated through the SIPs is still unknown and will be discussed in the latter part of the study.

2.2.1 Selection of Suppliers and Beneficiaries of SIPs in Karnataka

The directorate of RKVY, which operates at the central government, bids the tender online for the supply of SIPs on the farmer's field through an open tender system. The approval of companies are rather complex. Those companies that have been manufacturing Photovoltaic (PV) pumps in India with more than three years of good track record are only being approved for the bidding procedures (Kishore et al., 2014). Then these companies are selected based on the lowest bidder, which again acts as the base price for the supply of SIPs. All other manufacturers of PV pumping are mandatorily made to match with these base prices; once base price has been approved by the committee for the supply of SIPs. The base price includes everything that Solar Irrigation Pump has to offer, starting from the Photovoltaic (PV) sheets to pump sets until it reaches the farmer's site locations.

For example, in 2011 -12 the base price of the surface pump (5 hp) which is being used predominantly around the State, cost Rs 5,37,000 (6991€). The farmer who had bought this

featured solar pumping system received a subsidy benefits of (90%*6991) = 6291€ from the Government and paid almost 700€ in cash (Kishore et al., 2014).

Subsidies were made available only for those pumps purchased through the approved companies from the State Government. Some of the major companies supplying SIPs in Karnataka State are Jain Irrigation System, Omega solar, Avi solar tech, etc., However, according to (Kishore et al., 2014) the number of companies participating in the bids for the supply of SIPs has been increased recently giving room for more competition. Meanwhile, dealing with local farmers are quite cumbersome and requires contact with the local dealers; these companies later hire local dealers or mediators for effective business purposes.

As per the Surya Raitha scheme, eligibility criteria set by State Government of Karnataka for possible subsidy benefits on the installation of SIPs are as follows:

- Farmer should have a minimum of 0.5 hectares of land
- Land should be fertile with an active irrigation facility on it

These eligibility criteria are more transparent and are usually known to farmers before the time of application. The selected farmers are then asked to deposit 10 % of the base price as a mandatory deposit before getting an active SIP connection in his/her field (Karnataka Renewable Energy Development, 2014; Kishore et al., 2014).

2.2.2 Financial grants

Many banks including National Bank for Agricultural and Rural Development (NABARD), commercial banks, regional rural banks, central and state cooperative banks, provide financial assistance to farmers about the installation of solar irrigation pumps. They offer grants in the form of loans to farmers who intend to purchase and install SIPs at their site locations.

2.3 Components of Solar Irrigation Pump (SIP)

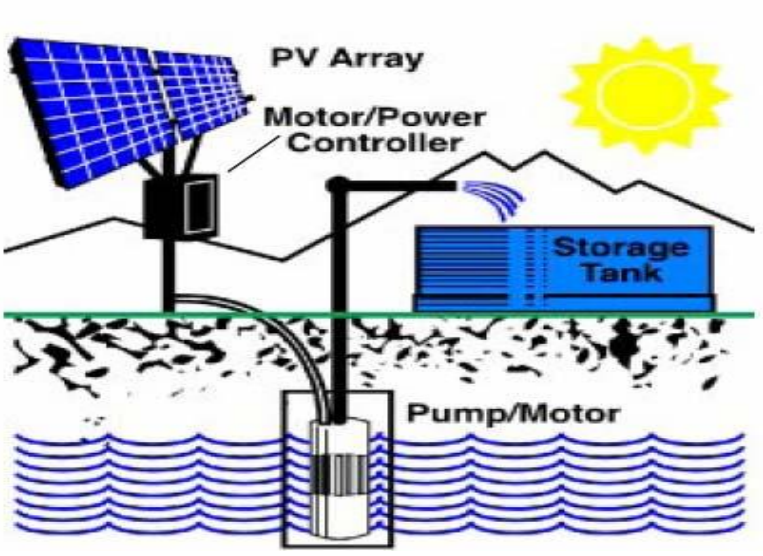
Solar Irrigation Pumps uses photovoltaic (PV) panels to harness electricity from naturally available solar energy to flush water out for irrigation purposes. It essentially has three main components to it (Eker, 2017; Pullenkav, 2016). The components, including all the cables and parts, must conform to the international standard specifications be it (BIS/IEC).

1. **Solar PV panels**: Are generally packed in parallel arrays connected to a power controller which absorbs sunlight as an energy source and converts it into hydraulic energy to pump water for irrigation purposes.
2. **Power controller:** Acts just like a connector between solar PV panels and the Pump set. Its function is to control and monitor the power generated through PV panels and optimise it as per the requirement of the pump.
3. **Pump Set**: Usually consists of a motor that runs on electricity generated through the converter. Most motors run either AC (alternate current) or DC (direct current). DC motors are economical when the distance between the pumps and PV panels is shorter in range, and low water is demanded (World Bank Group, 2018). Its function is to pump the water under pressure. The elevation difference between the source of water and irrigation land dictates the workload of the pump. The pump has to draw certain amounts of energy which the PV panels supply.

   The following types of pump sets can be used after the approval of the concerned ministry

   - Submersible AC pump set
   - Submersible DC pump set
   - Surface-mounted DC motor pump

Figure 4: A typical solar-powered irrigation system



Based on: Eker (2017)

3. Theoretical Background

Theories are made to clarify, foresee, and get insights, and in many cases, to challenge and expand existing knowledge of framework within the limits of critical thinking (Dickson et al., 2018). The chapter discussed below addresses the possible assumption and theories of the study and thus supports the finding of the study.

Data, information, knowledge and wisdom

Before further exploring, it becomes necessary to understand the concept of data, information, knowledge, and wisdom, typically known as the DIKW approach. By understanding the relations between these terms, it is possible to view the context of the study in a more clear, concise, and a complete manner.

- **Data**

  Data is raw in itself. They can be facts that or it can be collected for analysis purposes. It essentially and has no implications or meaning, beyond its reality. It can be in any structure, usable or not and need not have any importance of its own. In the programming world, a spreadsheet by large begins by holding a set of data in its raw form (Ahsan & Shah, 2006; Bernstein, 2011).

- **Information**

  Information is that data that has its significance by the method of relational connection, that is through the power of others. It can be useful, and at the same time, it need not be of any use. In the programming world, a relational database makes information from the data which are stored previously (Ahsan & Shah, 2006; Rowley, 2007).

- **Knowledge**

  Knowledge can be summarised in many different ways. According to the traditional philosophy, Plato defined knowledge as "*justified true beliefs*" but however the nature of the belief system is quite contradictory. According to Baškarada & Koronios (2013), they said by combining information that we get is knowledge. They viewed knowledge as a deterministic procedure. When somebody retains or memorises information (as a less aspiring student does), at that point, they have missed the true essence of knowledge. The information might have a certain significance to them; however, it doesn't accommodate all by itself for further exploration of knowledge. For instance, a younger grade student

remembers the "times table" in a chronological way. They can reveal that "3 x 3= 9" since they have memorised that information from the “times table”. However, in any case, when asked what is "1234 x 200", they cannot react clearly because the knowledge required for it, wasn’t actually in their memorising table. To accurately respond to such an inquiry requires a genuine intellectual or cognitive understanding which explores the further dimension of knowledge (Ahsan & Shah, 2006).

- **Understanding**

  Understanding is interpretable and probabilistic in nature. It is subjective and explanatory. According to Ahsan & Shah (2006), it is the procedure by which one can take the existing knowledge from within and blend new knowledge out of formerly held knowledge. The distinction between understanding and knowledge is similar to the distinction between "*learning*" and "*memorising*" (Intezari, Pauleen, & Taskin, 2016). Individuals who have understanding skills can attempt valuable activities since they can blend new knowledge from their previously held understanding.

- **Wisdom**

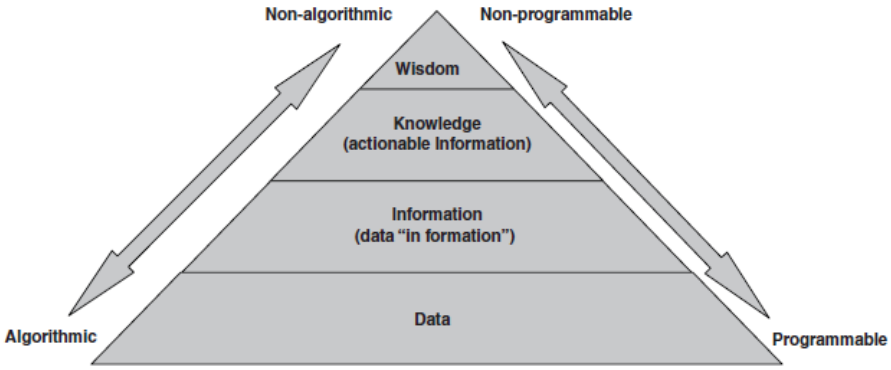
  Wisdom belongs to those concepts which are rather hard to define. Wisdom is that which individuals usually recognise when they experience it. What becomes more fascinating about wisdom is that it is generally experienced more clearly during the decision-making process of an individual to see the bigger picture of an outcome (Bernstein, 2011).

  According to Aven (2013), mentions that wisdom is the integration of data, information, knowledge and profound understanding that resonates with uncertainties of life. There is an awareness of how things should play out, and it is wisdom that generally guides with this process of not knowing. It is an experiential and embodiment of most philosophical movements.

- In contrast to the past four dimensions, it poses inquiries and introspective questions for which there was no answer beforehand. Wisdom is, therefore, the ability to observe and judge and at the same time, make the distinction between the dualities like good and bad; right or wrong. It is what makes the final judgment sensible and socially acceptable (Baškarada & Koronios, 2013).

- **Wisdom hierarchy**

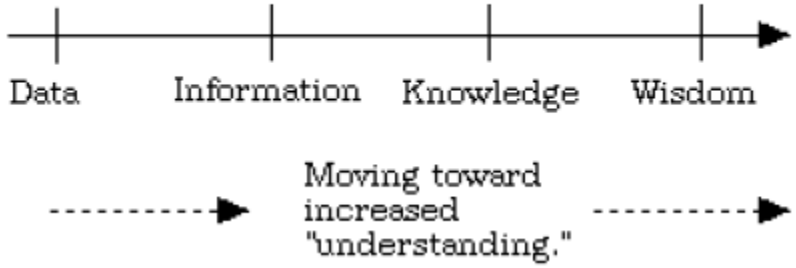
Figure 5: Wisdom Hierarchy



Based on: Rowley and Jennifer (2007)

Wisdom has fortunately been looked for by many, if not for all; throughout the time (Liew, 2013). However, the importance of having practical wisdom has not been given so much recognition until recently. Practical wisdom stands with its multi-aspect components discussed previously and gives a plausible objective view on all the people that are associated and strive for a more promising future (Ahsan & Shah, 2006; Bernstein, 2011). The understandings of the practical wisdom of farmers are among the key factors in solving problems in innovation, humane, and social issues. Assuming that, practical wisdom be developed among farmers efficiently and cultivated by society, in general, can be among the crucial factors in poverty reduction and rural development of the society.

Figure 6: Moving from data to increased understanding



Source : (Ahsan & Shah, 2006)

The previously discussed dimensions of knowledge; data, information, knowledge, and wisdom are not characterised by a type of straight equivalent scale; rather they are fluid in nature. Even though the terms are often talked and explained together, the points on the scales are not closely related (Aven, 2013).

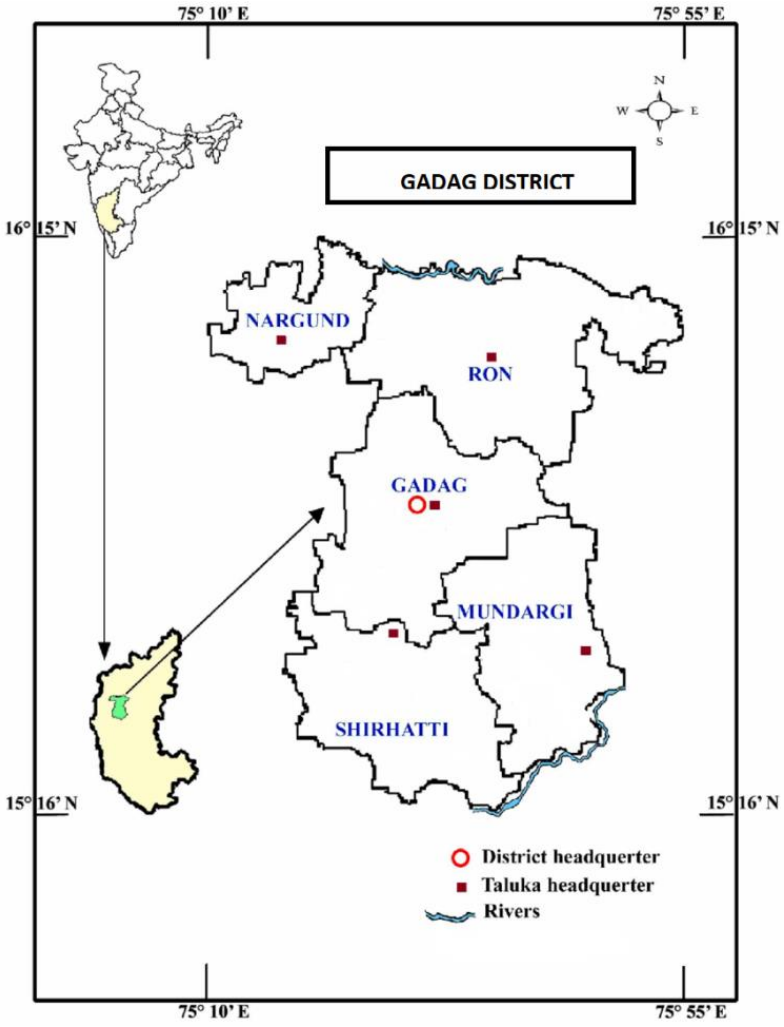
They can even be expressed in relation to the time. The data, information, and knowledge look at past dimension while the wisdom which is the final step airs into the future dimensions (Intezari et al., 2016). Hence, the reason for explaining the DIKW approach here in the study is to move towards an increased understanding of farmers' thoughts over Solar irrigation pumps. The benefits and risks that farmers perceive regarding new innovation are more based on the practical wisdom gathered through years of experience at the farm. Simply put, the study is based on farmers' wisdom and experiences that they have gained over a period of time. That eventually tries to solve the problems pertaining to the adoption of new innovative technologies in the study area. Furthermore, in order to interpret farmers' perception and to comment on the viability of solar pumps for the long long, understanding of farmers wisdom and the dimensions of knowledge becomes primordial.

4. Methodology

The subsections discussed in this chapter include the methodological aspects used for data collection procedures. These subsections discussed below, includes chapters like the description of the study area, sampling framework, structuring of the questionnaires used, interview methods and finally ends with the critical evaluation.

4.1 Description of the study area

Figure 7: Gadag district map



Source: https://goo.gl/images/1giq9Q

The choice of the district for the study was selected as it is assumed that, observably the district contributes to a greater number of farmers adopting SIPs than any other districts within the state (Santhanam, 2015; Shah et al., 2014). Also, by personal experiences and from the hearings of

news channels, the study area was explicitly chosen as it constituted for more number SIPs getting installed. The choice of the district was further influenced by other factors like the report from the Centre of Ecological Sciences which shows the potentials for harnessing solar energy in Gadag district (Ramachandra, Hegde, & Jain, 2013).

The district consists of five major taluks, namely (Gadag, Ron, Shrihatti, Mundargi, and Nargund. The district falls under semi-arid parts of Karnataka State with an annual rainfall of less than 750 mm (GWI Booklet Gadag District, 2009). Hence it is categorised under low rainfall and drought-prone areas (GWI Booklet Gadag District, 2009) which further enhances the potential for harvesting water though Solar Irrigation Pumps.

The potential for using SIPs at Gadag district further depends on various factors like availability of groundwater, cropping pattern, available resources like solar radiance, temperature and other alternatives for running the pumps efficiently (Pullenkav, 2016).

- **Solar Radiation:** As per the data from the Karnataka renewable energy development website, the average annual solar radiance of the district stands at 5.86 kWh/m^2 measured in terms of Global Horizontal Irradiance (GHI). GHI is the total amount of solar radiation received from above to the horizontal surface of the ground. The below table summarises the average annual solar radiance of different taluks in the district.

Table 1: Taluk wise annual average solar radiance (kWh/m^2)

Taluk	Annual avg (GHI) (kWh/m^2)
Gadag	5.9
Ron	5.85
Shrihatti	5.85
Mundargi	5.9
Nargund	5.84

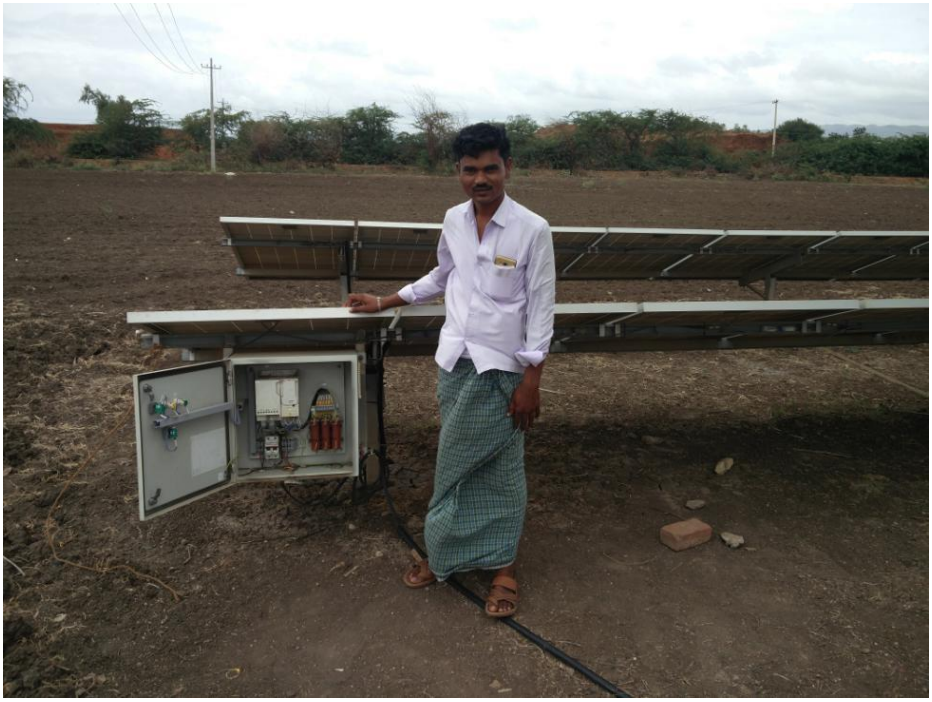
Based on: (KREDL, 2019)

- The above data suggests that the average annual solar radiance in the whole district, consisting of five taluks is sufficient for the development of SIPs in the region. Furthermore, the Solar Irrigation pumps require solar radiation during the non-monsoon

months of the year to energies the pumping systems, as periods of low radiation coincides with the rainy season of the year in Gadag district i.e, from June to August months, SIPs are better off and productive during sunny seasons (KREDL, 2019).

- **Land Utilization and cropping pattern**: The present area of land utilization sequence stands at 86 % of the land is irrigated and 7 % of the land accounted for forest lands. The cropping pattern encourages the usage of short duration crops with intercropping adoption processes. Major crops grown in these areas includes 40 % of cereals (jowar, maize, wheat), 26 % pulses (Bengal gram and Green gram), 24% oilseeds (Groundnut and sunflower) and 10 % fruits and vegetables (National Informatics Center, 2019).
- **Climate**: The temperature of the district is relatively hotter around the year and it ranges from 37.3°C max to 16.5°C min (National Informatics Center, 2019) and suits very well for water harvesting through SIPs
- **Groundwater availability**: In the district, groundwater is made available through dug wells, bore wells, tanks, canals, ponds, etc. Borewells were highest in number; around 26,856 units with depth up to 90 m were recorded in the year 2009. The depth to water levels in the district stands at 4 to 23 meters below ground level with the potential to pump water at the rate of 35liters/second (GWI Booklet Gadag District, 2009). All in all, the district fall under the semi-arid zones of Karnataka with huge potential for tapping groundwater sources through the use of solar irrigation pumps.

Figure 8: Farmer demonstrating his SIP at Ron Taluk, Gadag District, Karnataka, India



4.2 Sampling framework

According to Turner (2003), sampling frameworks consist of all the source material or gadget from which the samples are drawn. It consists of every one of those inside a populace that can be tested, and it may include people, family units or organisations.

As the study demanded perception of those farmers who had adopted SIPs on their farm, finding such farmers that are suitable for the study was indeed a difficult task. Nonetheless, different steps that were used for selecting farmers for interview procedures are listed below.

The first step used in finding suitable farmers were from development workers of the region. Development workers working at Raitha Samaparka Kendra (RSK) translated as (*Farmers Information Point*), RSKs acts like an information provider for farmers on agriculture and allied activities. Their main objective was in helping farmers by providing technical knowledge on crop production, crop selection, transfer of any modern technologies and also to interface the knowledge between public and private sector technologies (Patil, 2014). Development workers working at RSKs are usually familiar with the region and knew farmers who had locally adopted solar irrigation pumps in the region of Gadag district. They are, however, located in taluka levels, using their contacts was resourceful in finding suitable farmers for the study purposes. For convenience reasons, they have been informed about the study beforehand, and the list of farmers' names and site locations were collected during the start of the data collection procedures. Also, by doing so, researcher felt it would give RSKs more information about research ideas, further utilising their contacts to find more suitable farmers of a similar kind.

The second logical step used in finding samples for the survey was by direct contacting the market representatives of Agri- private companies supplying SIPs around the district. Precisely market representative working under Jain Irrigation System helped in contacting information-rich farmers. They further recommended contacts of other farmers who are trying out Solar Irrigation Pumps around the district.

A similar approach; in making use of farmers' contact directly, that is by moving from one adopted farmer to other, at different site locations were also deployed in finding out farmers those are relevant for the study.

4.3 Research regions

Meanwhile, research regions covered under the survey comprised of 5 talukas with 50 different farmers selected randomly based on the names given by development workers and suppliers of SIPs within in the district. Below, *Table 1* summarises the total numbers of the farmers that are intervened within five taluks of the Gadag district.

Table 2: Research regions (Taluka)

(N=50)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Gadag	22	44.0	44.0	44.0
	Ron	8	16.0	16.0	60.0
	Shrihatti	9	18.0	18.0	78.0
	Mundargi	6	12.0	12.0	90.0
	Nargund	5	10.0	10.0	100.0
	Total	50	100.0	100.0	

We had samples of 22 responding farmers from Gadag taluk alone, that is 44% of the samples were from Gadag taluk itself. The reasons for this could be due to proper assistance and guidance by development workers, especially from those residing closer to the Gadag taluka region. By observation, their connections among the farmers were quite good. Adding to this, as the taluk represents for its district headquarters on agriculture extension activities majority of Agri-extension programs take place at the same taluka itself.

The development workers also motioned about frequent Agricultural fairs and exhibition programs that occur every year in Gadag taluk, which might also be possible push factors in influencing more adopters of Solar Irrigation Pumps (SIPs) in Gadag taluk compared with other talukas.

Furthermore, samples also included farmers from Ron (8), Shrihatti (9), Mundargi (6) and Nargund (5) based on the names derived through data collection procedures. So, all most all the farmer interviewers had pre-installed solar irrigation pumps in their farmlands.

Meanwhile, the regions interviewed were accessible by road, but in a few places, the locations were quite remote, so the researcher had to primarily rely on local auto-rickshaw services for travelling around the regions.

4.4 Questionnaire

The study engaged in both primary and secondary data collection methods. According to Johnston (2014) and Kothari (2004), primary data are those data that are collected for the first time. The primary data in this study were collected with a self-planned survey dependent questionnaire that addressed on collecting possible information on farmer's knowledge and perception regarding SIPs addressing the possible issue on problems and benefits they think are useful on the usage of SIPs.

The questioner used for the survey is made of different sections; *Section A* was used to collect background information like farmers' sex, education, taluk or area of the survey, information on the size of farmlands and occupation. *Section B* managed to ascertain answers regarding their source of information on SIPs and knowledge gaps they face in accessing information regarding SIPs. *Section C* referred to identifying the benefits and risks associated with the usage of Solar Irrigation Pump (SIPs). This section also faced questions on the feasibility of SIPs over conventional methods of irrigation methods. The feasibility of SIPs helps in identifying problems and patterns of behaviour that might affect the adoption of new technologies (Hall, 2017). *Section D* evaluated questions on their overall perception towards SIPs. Finally, *Section G* evaluated some of the controlled questions that at the end, helped in verifying the answers held previously.

Meanwhile, secondary data includes those data that are collected from someone else (Bricki & Green, 2007). The secondary data used for this research are collected through literature, magazines, newspaper reviews, and articles that explain the components of SIPs, policies and the DIKW approach that were necessary for the study.

4.5 Interviews with farmers

According to Punch (2005), the studies point out that there can be no right or wrong methods in data collection procedures. In other words, data has to be collected in such a way that it helps to answer the objectives of the study in a systematic way. In this context, as this study is more

related to the knowledge and perception of farmers using solar irrigation pumps, their opinions, and experiences on using solar irrigation pumps become instrumental. Hence qualitative data collection methods like personal interviews are explicatively chosen. However, in order to understand, farmers background information, preliminary statistical questions were also being used

A total of 50 farmers were interviewed; all interviews were conducted during September – October months of 2018 and usually took place at the farmer's site locations. The questionnaires were administered with a structured one on one interview procedure. And in a few cases, telephonic conversations were also being used. One on one interview methods not only get higher responses but also helps to be more open with the respondents (Curtis, Gesler, Smith, & Washburn, 2000; Kothari, 2004).

The researcher later familiarised with the objective and purpose of the study. Further built the necessary confidentiality and anonymity of the study, which not only helped to lay off any fears from the respondents but also to be more honest and open with the respondents. The period of interviews with the farmers ranged from 15 to 20 minutes. Even though the format of the original questionnaires was in English, the language used for interview processes were in "*Kannada"* a regional local language of Karnataka State. The whole of the interview process with farmers were completed in around one and a half months.

During the survey procedures, at the end of the day, a specific time was allotted for checking and correcting the answers from the questionnaires while they were fresh in the memory. The farmer's answers were recorded using a recorder and analysed with the help of SPSS and Microsoft Excel at later stages. The transcribed files were listened carefully and thematically presented at the findings section.

4.6 Critical evaluation of the methodology

The methods used for data collection were subjective in nature; hence it becomes difficult to analyse the situation mathematically resulting in possible biases arising out of it.

The possible source of errors made while conducting the survey might include:

- Farmers might find it difficult to understand a few questions due to language barriers, and possible errors in the transmission of interpretation from Kannada (local language) to English.
- As the time interval for conducting the survey was short, there could be errors in building confidentiality and trust among the respondents.
- The source of errors in procedural evaluation, as the findings of the study, was based on subjective evaluation of the respondent's answers.
- Findings only reflect the common sense of the respondents and can be unscientific in various scenarios.
- Finally, one to one interview procedure has positive effects on finding out in-depth perceptual studies; however, it is person dependent, and opinions of farmers can be biased in many cases.

5. Findings

This section details the findings of the study based on the interviews held at Gadag district, Karnataka, India, on the usage of Solar Irrigation Pumps (SIPs) and their knowledge and perception regarding the same.

5.1 Socio-demographic background

Farmers in Gadag district are highly diverse with varying socio-demographic conditions. Even though all the farmers had met the criteria of getting the subsidy benefits and had SIPs preinstalled in their farmlands. However, in order to understand their decision-making ability towards the adoption of SIPs, in general, a brief descriptive analysis was carried on and presented below in *Table 2*.

Table 3: Socio-demographic background of the surveyed farmers

Variable (N=50)	Frequency	Percent
Age (Years)		
35 or younger	15	30%
36 to 50	20	40%
51 or above	15	30%
Gender		
Male	39	78%
Female	11	22%
Education		
Illiterate	11	22%
Primary school (Up to 7 yrs)	11	22%
High school (8 to 10 yrs)	13	26%
Pre-University (11 to 12 yrs)	8	16%
Degree (13 yrs or above)	7	14%
Occupation		
Agriculture as main occupation	27	54%
Agriculture as subsidiary occupation	23	46%
Size of Farm Land		
Small farmer (<1 hectare)	24	48%
Marginal farmers (1 to 2 hectares)	18	36%
Large farmers (>2 hectares)	8	16%

Descriptive analysis of the survey results are summarised in *Table 2* based on participant's age group, gender, occupation, education, and size of farmland. According to studies from Chi & Yamada (2002), the age of the farmers was said to have an influence over farmer's decision-making ability towards new technologies. The majority of the respondents in the survey, however, belonged to the age group of 36 to 50. Of the total 50 respondents, there were a greater number of male farmers (39) compared to female farmers (11). In many instances there were couples for the interview procedures. In such circumstances, they were asked to agree on one among principal interviewees for data collection procedures.

According to Huyer (2016), providing women with enough knowledge and information are the first steps towards gender equality and women empowerment. However, this was not reflective; in many cases, women in the rural parts of Gadag district did not want to respond to the questions when their husbands were not around. Men in rural parts of Gadag district had a domineering role towards their spouses which intern impacted the women in taking part in survey questionnaires. The findings point out these differences between men and women in the Gadag district could hinder the needed information for the survey. The gender gap differences can be described by the fact that men make decisions with regards to agriculture, family, land and use of technologies, contributing to the majority of farm decisions (Doss, 2018; Huyer, 2016; Mishra, 2015). Meanwhile, close to 54% of the respondents had agriculture as their main occupation, where differences in labour allocation between men and women were observed. For instances, men performed all the hard labour-intensive practices like ploughing the land, sowing and other activities, while women were occupied with less labour-intensive practises like irrigation, cleaning and harvesting crops.

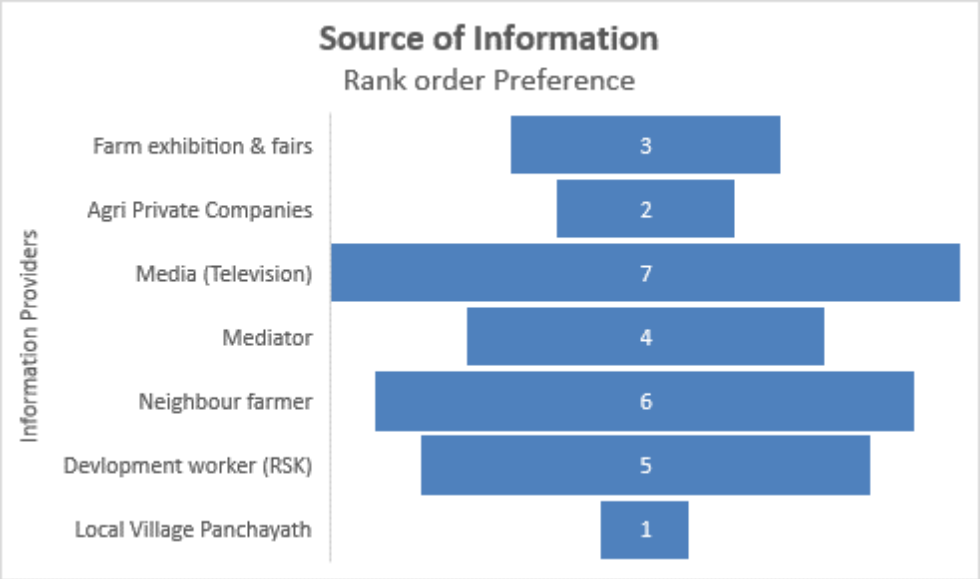
Meanwhile, studies like Hall (2017) and Mawusi & Elmqvist (2004) point out the positive correlation between the level of education and technology adoption. The majority, 26% of the adopters, had at least completed high school education of 8 to 10 years of education.

48 % of adopters belonged to smallholder farmers with the average size of land holdings less than one hectare. This when probed, found out that, the maximum allocated capacity of pumps under the scheme was kept under 5Hp, thereby targeting most of the smallholder farmers.

Nevertheless, 36% of marginal farmers & 16% of the large farmers had also adopted SIPs in their farmlands.

5.2 Farmers source of knowledge and information regarding SIPs

Table 4: Source of knowledge and information on SIPs



Source: Own compilation of the data

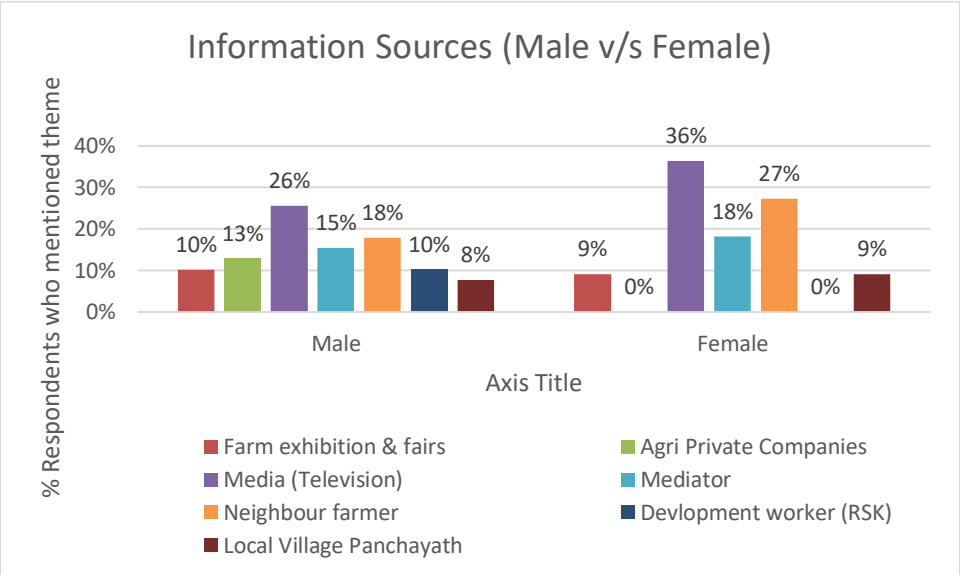
In order to understand farmers' source of knowledge and information regarding SIPs, farmers were asked to list their sources of information on SIPs by asking open-ended questions. *Table 4* sums up the rank order preference of farmers on information sources (1 being the least preferred source and 7 being highly preferred sources of information). Majority ranked Media/Television for proving useful information regarding SIPs. However, information from neighbour farmers, development workers, mediator, farm exhibition &fairs, Agri private suppliers, local village panchayath had also played a role in providing significant information farmers.

Meanwhile, framers also gave higher-order preferences to the knowledge and information received from the neighbour farmers and family members as well. Communal meetings were quite common in villages around the Gadag district. These kinds of meetings not only helped farmers to gain valuable insights within the community but also to discuss ongoing problems regarding the use of modern technologies. Mouth to mouth communication is still the preferred source of information sharing in and around villages of Gadag district. To replicate this, when

asked which source of information they trusted the most, the majority of the respondents preferred neighbour farmers as their most trusted source of information. Adding to this one farmer mentioned," *I trust my neighbour more than anyone else, if it works for him, then I will try it on my farm too".*

Adding to this, development workers/ employees of Raitha Samparka Kendra (RSK) working at Gadag district had their role in providing farmers the necessary information regarding SIPs. Development workers helped farmers in their installation procedures of the pumps and other site-specific information. In context to this, during the interview, some farmers did say that they do consult development workers if there were any problems regarding SIPs. One farmer mentioned that *"I trust extension workers as they are employees of the government agencies and their information has values in my decision-making abilities".*

Table 5: Information Sources (Male v/s Female)



When information sources were compared between male v/s female. There was no much difference in the way male and female farmers perceived information. However, 26% of the male and 36% of the female respondents preferred media as their main source of information providers. It was interesting to note that none of the female farmers had mentioned Agri – private suppliers of SIPs or development workers as their preferred source of information. Conversely, they favoured information sources from Media, neighbour farmers, farm exhibitions and fairs & local villages panchayath.

5.3 Problems in accessing information on SIPs

Table 6: Farmers problems in accessing information on SIP

Type of challenge	Interviewees (50) % of respondents who mentioned the theme
Lower levels of education, inability to read and write	14%
Poor relations with suppliers and extension workers	22%
Uneven power supply to watch television	10%
Need to travel to town for information providers/development workers -poor access to roads	16%
Poverty issues	
Lack of financial sustainability	14%
Lack of money to purchase newspapers/internet/television or needed information	38%

Source: Own compilation of the data

Meanwhile, some of the major challenges farmers perceived in accessing information on SIPs were related to poverty issues. 38% of the respondents mentioned that they lacked money to purchase needed information, whether it be newspaper/internet/television. However, 22% of the respondent farmers said that poor relations with development workers and suppliers were also reasons for not getting useful information. They said contact with development workers becomes difficult post the installation of the solar pumps as they get busy with the daily routine works. While 14% of the respondents cited reasons for their inability to read and write which hindered them from getting useful information. They said they had to depend on mediators or other well-educated persons from family for needed information while taking major decisions regarding farm operations. Adding to this, 16% of the respondents mentioned that they had to travel to town to meet extension workers get useful information. For instance, some of the interview respondents lived in rural parts of the Gadag district were access to roads, and constant power supply was a challenge which also hindered them from getting needed information. Lastly, 10%

of the respondents mentioned that uneven power supply to watch television hindered them from accessing useful information regarding Solar Pumps.

5.4 Perceived benefits on the usage of SIPs

Table 7: Perceived benefits on the usage of SIPs by farmers

Type of benefits	Interviewees (50) % of respondents who mentioned the theme
Rural access to renewable energy -Unhappy with diesel pumps	12%
Savings from diesel cost	58%
Independence from frequent power cuts (electric pumps)	36%
Subsidy benefits under the scheme "Surya Raitha."	62%
Improved crop productivity due to uninterpreted water supply	32%
Time-saving by not opting for manual, labour-intensive irrigation practices	30%
Improved potential for efficient water management if combined with drip or pipe irrigation methods	22%
Flexible to use SIPs on climate changes	28%
Convenient than other methods of irrigation	20%

Source: Own compilation of data

In order to understand the positive perception of farmers towards using SIPs, respondents were asked open-ended questions regarding how Solar Pumps could benefit them. The resultant answers were reflected in *Table 7*.

From the interview, the majority, 62% of the respondents mentioned subsidy benefits from the scheme as the reasons for their adoption. However, when asked economically, 58% of the respondents mentioned saving from diesel cost as a major advantage of using SIPs. Based on this, one farmer mentioned: "*A 5HP solar pump installed on the farm, Saved me Rs 50000 to 60000 (650 to 750 €) per year worth of diesel costs*". Meanwhile, 12% said that they were

unhappy using diesel pumps due to noise pollution it caused, and accessibility of fuel in rural parts was also a limiting factor for them to adopt SIPs.

Meanwhile, due to restricted hours of electricity supply in rural areas, farmers had to rely on both electric and diesel pumps in many areas. Even now solar irrigation pumps are not the only source of irrigation methods used by the farmers. However, 36% of the farmers did mention that independence from frequent power cuts was an added advantage of using SIPs. They also mentioned that they would rely more on SIPs instead of diesel or electric pumps, as maintenance and operational costs of using SIPs were less significant compared with diesel pumps.

Usage of SIPs also provided farmers to be adoptable with previous methods of irrigation facilities; 28 % of the respondents mentioned that using SIPs provided them an option to be flexible whenever the climate was bad. Based on this one farmer said, "*whenever the weather was bad or not enough sunlight was available for the day, I would simply shift back to electric pump*".

Meanwhile, 30% of the farmers interviewed mentioned that usage of SIPs saves them a lot of time which otherwise spent on unnecessary labour-intensive practices. Unlike diesel or electric pumps, SIPs required minimum intervention from the farmers once started. They perceived this as an added benefit on using SIPs.

Majority of the farmers intervened had combined SIPs along with pipe irrigation, drip or sprinkler irrigation for efficient water management from the borewells. Pipe irrigation and drip irrigation systems were commonly used systems for watering crops by the farmers in Gadag district, farmers later connected pipe irrigation with the canal systems for efficient water irrigation practices. Nearly 22% of the interviewees mentioned this theme. Later farmers who used SIPs along with pipe or drip irrigation on crops said that SIPs when combined with pipe or drip irrigation methods, had better yields compared with sprinklers. This when probed, found out that with solar irrigation pumps crops get watered with slower time intervals due to reduced thrust of water from the pumps, hence improving the timeliness of watering with drip or pipe irrigation was more convenient and productive. The below *Figure 9* depicts farmers using canal type of irrigation method for watering his crops through a solar irrigation pump.

Figure 9: Farmer using Pipe irrigation method for watering crops though (canal system) SIP in Gadag Taluka

Nonetheless, most farmers reported that, through improved access to energy, SIPs had helped them to diversify crop production portfolios by uninterpreted water services. This argument was supported by 32% of the intervened farmers.

5.5 Problems and risks associated with the use of SIPs

Table 8: Problems and risk associated with the use of SIPs

Type of challenge	Interviewees (50) % of respondents who mentioned the theme
Problems of theft	8%
"Surya Raitha" as a scheme is overpriced and expensive	22%
SIPs work well only during sunny days	42%
Lack of training	
Lack of training and services by development workers or private suppliers post installation	15%
Lack of technical knowledge on the maintenance issue	16%
Market Access problems	
Unavailability of spare parts	10%

Source: Own compilation of data

Table 8 summarises the challenges and risks associated with the usage of SIPs in the Gadag district. One major challenge faced by farmers in using SIPs was that SIPs could only work well during sunny times of the day. 42% of the interviewed farmers mentioned this theme as a major problem while using SIPs. Timeliness of water outsourced from the pump was not consistent throughout the day. This, however, depended on the climate conditions of the region. Water output from the pumps depended mainly on the availability of sunlight. That is during middays, water thrust from the pumps was faster compared with other times of the day. However, with this problem, one farmer integrated well by using a mixed farming structure. Based on his experience he mentioned, during sunny times of the day, "*I irrigate my main crop (rice) in the middays and let pumps run on vegetable crops in the evening as water from the pump is slower in the evening*" i.e. between 4 to 6 pm.

Despite the fact that subsidy benefits covered 90% of the capital cost of installation of SIPs, nearly 22% of the interviewed farmers still thought that SIPs under the scheme were overpriced.

Based on this one farmer mentioned that "*Cost of installation on SIP was too high, the government is not subsidising enough to help farmers like us; all the money goes to suppliers or the rich*". This farmer however completely lacked the previous knowledge on subsidy benefits and believed that suppliers were making supernormal profits at the cost of the farmer. In other instances, farmers reported problems of theft in rural regions of the district. SIPs were vulnerable innovation and were susceptible to steeling. 4 out of 50 farmers interviewed reported problems of theft, SIPs parts being stolen from their region. SIPs lacked monitoring mechanisms and insurance facilities that could have possibly saved the farmer from theft-related activities

Meanwhile, optimal usage and maintenance of SIP required technical knowledge and skills related to the handling and operation of such innovation; another problem mentioned by the adopted farmers was the lack of training and services by the development workers post-installation of the pumps. Development workers or private suppliers needs to be available for farmers; however, this was often not in place, training, and services in rural parts of Gadag district post-installation of SIPs were lacking, 16 % of the interviewed farmers lacked technical knowledge on maintenance and handling of SIPs.

Problems regarding the design and capacity of SIPs were also observed, SIP needs to be convenient and must fit according to the needs of the farmer. Almost all of the SIPs installed were strictly 5HP and lacked options for watering bigger farmlands. This was because of the cap on capacity of SIPs under the scheme "Surya Raitha" which was strictly maintained under 5HP. Citing this unavailability of spare parts was an issue of concern. Nearly 10 % of the sample reported unavailability of spare parts. They said, either they had to travel to the nearby towns for spare parts or spare parts were not readily available for them.

Another issue was the lack of groundwater management. Even when "Surya Raitha" as a scheme mentions on buyback of extra power generated on a net metering basis. Nearly all farmers intervened were reluctant with this information. Farmers' responded that they did not know much about selling extra power generated on a net metering basis. Once the pump was installed, there was no cost per unit for the resource water being used; hence, there was an indiscriminate use of resources. The risk is that farmers could pump water as much as they could or how much ever they needed.

5.6 Comparative analysis of SIPs with conventional/ diesel pumps

The key factors that determine the feasibility of SIPs are understood on how SIPs are compared with other forms of conventional methods of irrigation (diesel pumps) in the study area. Below, *Table 9* sumps up the respondent's answers on how they perceived SIPs better or worse than diesel pumps. The advantages and disadvantages of using SIPs from the farmer's perspectives are compiled and listed.

Table 9: Analysis of SIPs over diesel pumps by farmers

	Advantages	**Disadvantages**
Solar Irrigation Pumps	Long life span	Pumps were nonfunctional during monsoon seasons or when not, enough sunlight was available
	Low maintenance and operation cost	Repair often required a highly skilled technician or contacts from the suppliers of SIPs
	Water thrust from the pumps was continuous	Rate of water thrust is slower
	The operation did not require frequent visits and pumps could be left alone to run	Installation of SIPs had to go through a lot of paperwork and involved cumbersome procedures
Diesel Pumps	Installation was easy and fast	Higher maintenance cost due to uneven fluctuations in fuel prices
	Could use it thought-out the year	The short life span of the pumps
	Investment cost was lower	Noise and air pollution
	Rate of water thrust is faster	

Source: Own compilation of data

Figure 10: Farmer demonstrating SIPs Gadag Taluk, Karnataka, India

5.7 Mediators role towards SIPs

Mediators played an important role in farmers' adoption regarding SIPs. They acted like an informal agent serving farmers with the necessary information in return for the commissions received from the farmers. Interviews were also conducted with 3 of the mediators from around the study area. Their job was to help farmers with necessary information about SIPs and also help major Agribusiness companies to come in contact with the suitable farmers. They kept in close contact with both the parties and received commissions as a part of their two –way information receiving and passing medium. Most of them lived close by to the village areas where they could be in close contact with the farmers providing necessary information at different time internals of the seasons. One of the mediators said that "*Some farmers are reluctant about the adoption of SIPs, they simply do not know about the subsidy benefits and its*

advantages, that is where I can help them". These are the times when mediators come up with their ideas on the implementation of SIPs for suitable farmers. It was observable that they usually work informally with around 10 to 50 farmers all-round the year waiting for their opportunities

5.8 Overall Perception of farmers on using SIPs

Table 10: Perception of farmers on using SIPs

Type	Interviewees (50) % of respondents who mentioned the theme
Happy with the innovation -Has all the needed qualities	84%
Not sure	10%
Disinterest towards the innovation	6%
Would recommend SIPs to other farmers	92%

Source: Own compilation of data

Out of 50 farmers being interviewed, 84% of the farmers thought that SIPs had all the needed qualities for using them as an alternative method of irrigation and they were quite happy with the innovation. However, 10% of farmers expressed that they were not sure, and need more time for further evaluation. Meanwhile, 6% of respondents showed disinterest towards the innovation, this when probed, lack of support from development workers and suppliers were found to be the major reasons for their disinterest.

Later when asked if they would recommend SIPs to other farmers, 92% of respondents said that they would happily recommend it to other farmers. Citing reasons like savings from diesel costs, time-saving, continues water supply from the pumps, easy operation & convenience than other pumps as the key reasons for their recommendation.

These above findings convince that farmers generally perceived Solar irrigation pumps in a positive manner which also influences other farmers on the subsequent adoption of SIPs through interpersonal communication as stated by Ekman & Lankoski (2014) and Rogers (1995).

6.Discussion

Previously the study focused mainly on the findings that were collected through interview procedures. Here in this section, the findings will be further discussed and elaborated to match with the objectives of the study. The subsections discussed below are brief extensions that were identified during interview procedures.

6.1 Farmers and Solar Irrigation Pumps

As per the findings, it is quite clear from the survey that the majority of the farmer's knowledge and information regarding SIPs have been acquired through television/media. While interpersonal, farmer to farmer communication also played a significant role in acquiring information regarding SIPs. According to the studies pointed out by Muriuki (2016), everything that has ever been accomplished by humans is through the modes of effective communication. They argued that problems in the diffusion of innovation derive majorly from ineffective communication between members of adopters. However, Ekman & Lankoski (2014) expressed that person to person communication was the most effective push factor for any dissemination of new information. Reasoning from this, possible knowledge gaps with farmers regarding SIPs could be due to ineffective interpersonal communication or in our case by the farmers who perceive these new innovations, SIPs as not meeting their personal or psychological needs due to lack of awareness. Findings of the research point out this distinction were 22 % of the respondents mentioned that their poor relation with development workers hindered them from getting useful information regarding solar pumps. Therefore formal knowledge providing institutes, particularly development workers and extension agents, even though they are preferred sources of information needs to enhance their contribution towards building local knowledge of the farmers.

Nonetheless, the usage of Solar Irrigation Pumps can have varying advantages, especially in areas where the availability of fuels for maintenance of diesel pumps was not guaranteed (Purohit & Michaelowa, 2008). Besides, it can help access to the availability of water in resource scares regions of Gadag district by clean energy harvesting practises. The desire for adopting SIPs by the farmers can be explained based on the positive perception that they hold towards using SIPs in comparison with other methods of irrigation. In response to this, before the installation of SIPs, farmers depended heavily on diesel pump sets, electric or some sort of

tractors used for irrigation purposes were farmers had to keep a tab on every manual labor-intensive practice for irrigation purposes. However, after the installation of SIPs, 30% of the respondents mentioned that time savings from the uninterpreted water supply were a huge advantage of using SIPs. Thus, the usage of SIPs in the region has largely replaced diesel pumps but not the electric ones. Farmers said they save more of diesel costs compared with the cost of using SIPs as SIPs had almost zero operational cost. According to the report published by Wilson, Arun Srinivas, & Sasi Kumar (2015) mentions, in India, electricity generated through solar pumps costs only half of the amount of money as that of electricity generated through diesel pumps, thus contributing many farmers to adopt and switch to solar-powered pumps. Reducing the dependency on electric and fuel supplies through better access to energy and water are important stepping stones for poverty reduction in rural parts of Karnataka. Farmers from the rural parts of the district now could benefit greatly from the use of SIPs. Continuous access to water and energy through solar pumps in rural parts of the district has greatly influenced farmer's livelihoods by enhancing their choice of crops. They could now cultivate more crops annually which in turn can increase their crop productivity with an option of greener and cleaner irrigation facilities

Not to mention, SIPs role in environmental benefits, it plays a significant role in reducing Green House Gas (GHG) emissions and also helps to mitigate climate change actions through improved access to renewable energy sources (Pullenkav, 2016; Raymond & Jain, 2018). Countries like India are also promoting the usage of SIPs at the national level to reduce emissions from agriculture. It is a known fact that SIPs are eco-friendly and do not produce any carbon emissions. Life cycle evaluations of Solar Irrigation Pumps, demonstrate a possible decrease in carbon emission per unit of energy utilized for water harvesting (CO_2-eq/kWh) of up to 95% as compared with pumps working under grid electricity (worldwide normal vitality blend) up to 98% as compared with pumps working under diesel (Pullenkav, 2016).

All in all, the farmer's general perception was that they were quite happy with the innovation. Unintentionally, it depended on the degree to which they are disappointed with their present method of irrigation and the advantages they see on using Solar Irrigation Pumps as pointed out in the findings section. Nonetheless, the choice to adopt a new innovation as mentioned by

Negatu & Parikh (1999) depends invariably on getting the greatest incentive from using newly lead innovation; that is solar irrigation pumps in our case.

However, as far as the policy "Surya Raitha" is considered, some farmers did think subsidy benefits as overpriced. Farmers, however, hoped to recover the costs of investment on SIPs in less than 1.5 years. Nonetheless, the Government of Karnataka and admirative bureaucrats did the job well in making it possible for the rural farmers to access improved, innovative methods of irrigation. Each one of the respondents had met the eligibility criteria for the subsidy benefits. However, there are certain areas that require further strengthening for the successful implementation of SIPs at a larger scale. Those are areas related to groundwater management & in providing proper training and services to the farmers on handling SIPs in a sustainable way. Framers in rural regions lacked knowledge on the operation and maintenance of SIPs due to which resulted in further problems discussed below

6.2 Additional challenges observed.

- Lack of technical skills on the quality and maintenance of SIPs by the farmers due to which rats and rodents destroying the PV panels and connecting wires were observed.
- Dead squirrels and silt deposition inside the bore wells, which later caused problems in the running of the motor
- Farmers lacked structured solutions from development workers, follow up services from extension agents or suppliers were clearly missing. Farmers had to travel to the towns to get in touch with the service providers if there were any problems pertaining to the solar irrigation pumps.
- Still, many respondents from the rural parts of the district considered SIPs as a risky investment. Access to finance was difficult in the rural parts of the district. Banks often did not have a clear line of credit for solar-powered operations. High-end subsidies can be reduced when there are multiple options form banking systems that support the promotion of Solar Irrigation Pumps. However, additional incentives for banking are also requisite for financial institutions to provide support with regards to SIPs.

6.3 Ground Water Management

Groundwater management is an issue with the use of SIPs. Even though there were clear-cut policy goals and plans on buying of extra power generated by the farmers at a net meeting basis. The policy "Surya raitha" with good objectives, rather failed with its governance. Unlike other pumps, the use of SIPs had lower operational costs hence making it cheaper to pump water compared with other conventional pumps. The risk was that farmers could pump as much water as they needed or sell it to neighbour farmers. A proper institutional framework on the cost of usage of water was rather missing; groundwater overexploitation could be an issue of concern if not managed well could ultimately lead to depletion of groundwater in the region (CSTEP, 2016).

Nonetheless, the risk of water depletion from the ground exits irrespective of the energy resources used, whether it be through electricity supply at a subsidised rate or through the use of diesel pumps. Policy decision-makers need to be aware of such risk posed by the use of SIPs before making it available at such subsidized rates; a detailed water accounting is mandatory for making decisive action on policy restrictions. Linking proper user based net metering facilities on the amount of water being consumed or keeping a threshold on the amount of water abstraction becomes indispensable.

6.4 Using farmers wisdom for sustainable adoption of modern technologies

The study findings point out at the direct experiences of the farmers; the research made an effort in understanding farmers perception on SIPs, benefits and risks that farmers face while using modern technologies like SIPs have been identified and mentioned explicitly. The crux of the problem is in transmitting these detailed understandings derived from farmers itself, into a general set of rules and regulations for sustainable adoption of innovation for the future. Thereby to transfer that knowledge into a large number of farmers. Access to such type of knowledge can be enhanced through training and education services to farmers. Agricultural extension organisations, cooperatives, farm fairs and exhibitions can be made use for transmission of knowledge to the farmers. These also requires that farmers become well integrated with the market economy for the development of sustainable adoption practises.

6.5 Limitations of the study

The assessment of the study on farmers' perception, on the usage of SIPs, provides insights into the potential that can possibly change the way agriculture and irrigation methods are carried out around the study area. However, this study also includes some of the limitations that might include;

Factors that influence the acceptability of new innovation might vary from region to region or might also be influenced by different cultural settings (Sahin, 2016). Thus, the findings from the study are limited to the study area alone. Hence there needs to be additional analysis, the impacts of similar policies (*Surya Raitha*) with other states need to be compared for further evaluation of its sustainability on a larger scale.

The thought which says, adoption of new technology has a positive effect on the welfare of the individual has been flawed in many cases. The supposition of equal opportunity for all on the adoption of the new process has varying criticisms (Lyytinen & Damsgaard, 2001; Moldaschl, 2010). Interestingly in our case, the subsidy benefits on the accessibility of SIPs to farmers might result in greater inequalities among the rich and poor. Only the affordable ones could buy and install the pumps which could further broaden the financial hole between the richer and poorer sections of the society. Even though these discrepancies can be seen at all levels of social hierarchy, a proper restructuring of the subsidy benefits needs to be considered for equal opportunity to the sections of society.

Last but not least, the secondary information gathered regarding solar irrigation pumps is still limited to some of the books and journals that were being used while writing this research

7. Conclusion

In totality, the study offers insights into farmers' knowledge and perception of using Solar Irrigation Pumps (SIPs) in Gadag district, Karnataka, India. The principal conclusion for the objectives of the research are as follows:

- Media/ Telviosn played an important role in the dissemination of information to the farmers. Other sources like neighbour farmers, development workers, mediators, farm fairs and exhibitions also played a significant role in providing information regarding SIPs to the farmers. Meanwhile, lack of power supply in rural areas, poor access to roads due to which contacts with information providers and hindered farmers from getting useful information regarding SIPs.
- Farmers perceptions on the benefits of SIPs included a list of positive perceptions as pointed out in the findings section. For example, farmers thought that the usage of Solar irrigation pumps as an alternative method for irrigation purposes is convenient and requires less attention and time saving than other conventional methods of irrigation. They also considered savings from diesel cost as a major advantage of using SIPs over conventional pumps.In addition to this, savings from labour costs, subsidy benefits, improved access to quality water and less exposure to noise pollution were other reasons which farmers perceived as added advantage on using SIPs.
- Meanwhile, farmers did face ceratin riks and problems post the installation of SIPs which did include, theft, markets access problems in rural parts of the study area. In addition to this, social problems included administrative bottlenecks, absence of interference from development workers and suppliers in rural parts of the district and follow up of innovation after the implementation of technology were missing.
- Comparative analysis of SIPs over diesel pumps shows that timeliness of water through SIPs were slower compared to diesel pumps, as it majorly depended on climatic conditions for the day. Solar pumps did lead to higher water use efficiency; however, they did not save water. While using SIPs, the total irrigated land could increase leading to increased crop productivity, while it does not result in decrease in the volume water being pumped in anyways.

- Based on the interactions with the adopted farmers, the survey results convince that this technology works. The overall perception of farmers was that they were quite happy with solar irrigation pumps and each one of the respondents said that they would happily recommend it to other farmers. The positive perception towards the usage of SIPs that farmers hold is likely to have a positive impact on the nature of the adoption of SIPs in near the future.

7.1 Policy recommendation

The subsidy benefits that is, 90% on the total cost of installation on the pumps from the scheme "Surya Raitha" are bit too high and might create more problems than benefits. As mentioned earlier SIPs have lower operational costs once installed, therefore the innovation must be promoted with alternative methods of financing than by providing higher subsidy rates. Continued higher subsidy rates can also be taken advantage of by the richer sections of the society. They might only install the pumps for subsidy benefits. Hence, they might jeopardise the system for inequality, were the wealthier could take advantage over the poorer. Higher subsidy rates are also hard to justify because they could limit the number of pumps being installed in the region resulting in a slower rate of adoption. Further they could create other problems like open market access of SIPs to other competitors. So far, major agri- private companies like Jain Irrigation System (JIS) dominated the market and acted like a monopoly company resulting in unavailability of spare parts in the region. Provision for other competitors needs to be prioritised and fairly eased out by reducing the subsidy benefits.

There needs to be an alternative method of financing for solar irrigation pumps either through banks or through micro-financing. Banks need to provide proper lines of credit facilities with regards to Solar irrigation pumps opening up the possibility for smallholder farmers to independently adopt solar pumping systems. Meanwhile, buyback of surplus supply of electricity at an attractive price is a good method to mitigate the extra loss of groundwater, however, it needs to be implemented in a realistic way. Farmers need to be educated so that there is sufficient awareness among the users.

While considering all the positive externalities on using solar irrigation pumps as discussed earlier an alternative subsidy benefits could be a lump sum subsidy benefits directly into the farmer's bank accounts. These kinds of subsidies in India are generally familiarized with the

fertiliser subsidies (The Hindu Business Line, 2019). However, as the findings point out on farmers' thought of expressing SIPs as an overpriced and risky investment might be reduced with lump-sum subsidy benefits as the subsidy is granted directly into the farmer's bank accounts thereby eliminating the role of mediators in influencing farmers' decisions on the adoption of SIPs.

Adding to this, more research and development related to the field of impact assessment containing the impact of Solar irrigation pumps on yields, income and productivity of crops before and after its implementation needs to be carried out elaborately. Rural farmers in India rely primarily on site-specific information. This can even be done through field tests comparing different methods of irrigation at farm exhibitions and fairs or even at agricultural institutions. The field site can also be used for training related activities regarding handling SIPs. It also becomes very necessary to understand the shift in cropping patterns, irrigation timing & scheduling before and after the implementation of SIPs in order to mitigate risk in the future.

Raising Awareness regarding SIPs

Solar-powered irrigation SIPs have the potential for poverty reduction and rural development through sustainable access to water and energy. There is also incredible potential for creative types of financing, innovative methods of implementation that are essential for its sustenance and water supply. Simultaneously, there are dangers for SIPs getting failed due to lack of training on how to configure, set up frameworks etc

Hence there needs to be awareness creation regarding usage of SIPs that are suitable for different farming systems & sizes; multiple options for a different choice of SIPs with varying sizes need to be provided. Agri private companies and extension workers can also provide support for the capacity development of farmers at all levels by offering training based on benefits and risks of using SIPs, choice of cropping patterns for more efficient water management practices.

Last but not the least, it is important to consider social justice while providing modern technologies to the small scale farming communities, women in rural regions are more vulnerable as they are often tied with conditions that are hard to justify. It is necessary to formulate schemes and programs that address vulnerable groups in mind, for example, how can more number of women take advantage of new innovative technologies and thus participate in

ongoing poverty reduction and women empowerment in general. All such queries needs to be addressed for an inclusive and prosperous future.

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Appendix

Survey questionnaire on knowledge and perception of farmers on the usage of Solar Irrigation Pumps (SIPs) in Gadag district, Karnataka, India

A) Background Information

1. Age…...
2. Taluka .....
3. Gender..... (M) or (F)
4. Education .....
    a) Illiterate
    b) Primary School (up to 7 yrs.)
    c) High School (8 to 10 yrs.)
    d) Pre- University (11 to 12 yrs.)
    e) Degree (13 & above)

5.Occupation.....

    a) Agriculture as the main occupation
    b) Agriculture as a subsidiary occupation

6. Size of farmland.....

    a) Small farmer (<1 hectare)
    b) Marginal farmer (1 to 2 hectares)
    c) Large farmer (>2 hectares)

B) Farmers source of information regarding SIPs

1. How did you come to know about SIPs?
2. What knowledge you had about SIPs before?
3. What are your sources of information?
4. Which source of information you frequently use during certain problems?
5. Which source of information do you trust the most? & why?
6. Who helped you in the adoption of SIPs?
7. What other information regarding SIPs would you like to get?

8. What are the problems you faced in accessing information regarding SIPs?
9. What are your thoughts on living in rural parts of the region what hinders them from getting useful information regarding SIPs?
10. How lack of finances influences in accessing information?
11. What role does development workers have in providing information regarding SIPs?

C) Perceptual benefits and risk associated with the usage of SIPs

1. What are the benefits you think of having a SIP?
2. What made you shift from conventional pumps to SIPs?
3. Why are SIPs better or worse than conventional pumps? (Specify?)
4. What advantages do you think that gave the most benefits for you on using SIPs?
5. Have you received any form of training on the usage of SIPs? If so, by who?
6. What are the reasons for your adoption of SIPs?
7. What do you think of the buyback of power option provided under the scheme? How effective is it?
8. Is the usage of SIPs different from other pumps?
9. What advantages do SIPs have over diesel pumps?
10. How was productivity after shifting from conventional methods of irrigation to SIPs?
11. Do you know about the subsidy benefits provided under the scheme? What do you think about it?
12. Can SIPs run all round the year? Or all-round the day?
13. What other benefits do you think SIPs have over other methods of irrigation? (Specify?)
14. What are the problems or or risks you face on using SIPs? (Specify ?)
15. How is the timeliness of water influenced after the usage of SIPs?
16. What other pumps do you use along with SIPs? What advantages do SIPs have over it?
17. Why are your thoughts on the feasibility of SIPs in the long run?
18. What changes would you want to see in this innovation (SIPs)?

D) The overall perception of farmers on usage of SIPs

1. What do you think of SIPs in general?
2. Does it have all the needed qualities?

- Yes
- No

3. Would you recommend it to other farmers?
4. For what reasons would you recommend?
5. What other things would you like to add with this regard?

E) Controlled questions

1. What do you think about new innovations in general?
2. How do you think researcher like me could help you better off?

Declaration of Authorship

I, *Gangadhar Holaikar, Pavan Raj,* matriculation number 673958, born on 15th of April 1992, from India, declare that I had completed this master's thesis attached to this declaration independently using the references listed below. I do confirm that it has not been submitted anywhere else. All passages of the thesis which were taken word-for-word or paraphrased from publications or other sources are marked appropriately.

Supervisor*:* *Prof. Dr Andrea Knierim*
Second Supervisor: *Dr Maria Gerster - Bentay*a
The topic of Thesis: "*Knowledge and Perception of farmers on Solar Irrigation Pumps (SIPs) in Gadag District, Karnataka State, India."*

I furthermore declare that the supervisor has been given an unencrypted electronic document (in one of the formats *.doc, *.docx, *.pdf, *.rtf) of the thesis which exactly and without exception corresponds to the contents and wording of the printed copy. I am aware that the electronic version can be checked for plagiarism by software analysis. I also consent to the thesis that being placed and available for borrowing in the Institute's library, as well as an abstract of this thesis, is being presented on the Institute's website.

Place, Date _____ Signature _____