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Integrated Decision Making Tool for Rural Irrigation Applications: A Case in Southern India

by

Holly Lafontaine

A Thesis
Submitted to the Faculty of Graduate Studies
through Civil and Environmental Engineering
in Partial Fulfillment of the Requirements for
the Degree of Master of Applied Science at the
University of Windsor

Windsor, Ontario, Canada

2012

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Integrated Decision Making Tool for Rural Irrigation Applications: A Case in Southern India

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DECLARATION OF CO-AUTHORSHIP/PREVIOUS PUBLICATION

I hereby declare that this thesis incorporates material that is result of joint research, as follows: This thesis incorporates the outcome of a joint research undertaken in collaboration with Swami Vivekananda Youth Movement and the University of Windsor under the supervision of Dr. Balasubramaniam and Dr. Bolisetti. The collaboration is covered in Chapter I, III, and IV of the thesis. In all cases, the key ideas, primary contributions, experimental designs, data analysis and interpretation, were performed by the author, and the contribution of co-author was primarily through the provision of the needs assessment results and analysis.

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Chapter I, III, IV	Lafontain, H, Kashyap, S. and Drishya M. (2010). A Study to Understand the Efficacy of the ‘Ganga Kalyana Yojana’ in Heggadavenkote and Nanjangud Taluks: 2010 Status Report. Swami Vivekananda Youth Movement, Mysore, India: 2010	Published

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ABSTRACT

Operating within a systems analysis framework, a needs assessment was conducted to investigate an irrigation scheme in two taluks in Mysore District, Southern India. This investigation provided a deeper understanding of the overall system, its elements, functions, and temporal and spatial relationships between its elements. Using a combination of primary data from scheme participants, as well as secondary data from multiple sector stakeholders, it was discovered that improvements could be made to the irrigation scheme selection process. The Analytical Hierarchy Process (AHP) was used to create a decision making tool that considered four main socially, economically, and technically related criteria: water availability, water need, technology adoption, and minority status. The AHP performed with acceptable consistency for all datasets; however, further field testing will be required to test the model's broader application and relevancy. The application of the AHP model addressed the local needs of the taluks and incorporated current irrigation regulation to better align the development practitioner to water related policy.

DEDICATION

This thesis is dedicated to my loving Father, family, friends, and many mentors that have challenged me, have comforted me, and have provided me with guidance.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
BC	Backward Class
BPL	Below Poverty Line
CGWB	Central Groundwater Board
DSS	Decision Support System
GC	Government Corporation
GPH	Gallons Per Hour
GWP	Global Water Partnership
ICRA	International Centre for development oriented Research in Agriculture
IWRM	Integrated Water Resource Management
LSMS	Living Standards Measurement Survey
MAUT	Multi-Attribute Utility Theory
MCDM	Multi-Criterion Decision Making
MDGs	Millennium Development Goals
MLA	Member of Legislative Assembly
Rs.	Indian Rupees
SC	Scheduled Caste
SoI	Spheres of Influence
SSM	Soft Systems Methodology
ST	Scheduled Tribe

LIST OF DEFINITIONS

Backward Class – a minority status in India that typically represents specific groups of people based on socio-economic status. Categories of BC status covered in this research are I, IIA, IIIA, and IIIB

Below Poverty Line – a minority status primarily based off of annual income

Borehole – a bore well for the purposes of irrigation water

District – a geographical administrative boundary that distinguishes land within a State.

Failed Borehole – a dug well that produces less than 791 GPH

Government Corporation – corporations that are designated to implement government schemes

Non-Governmental Organization – an organization that operates independently from the government and is usually not for profit

Personal Borehole – refers to a borehole that was purchased by a participant outside of the irrigation scheme

Rupees – Indian currency with a conversion of approximately 1Canadian Dollar = 51 Indian Rupees as per March 2012

Scheme – is equivalent to using the word project and refers to the irrigation project in the study

Taluk – a geographical administrative boundary that distinguishes land within a District

CHAPTER 1

1 INTRODUCTION

1.1 Background

The question of how to use water and who decides has been troubling the international water community for decades. The idea of the sustainable use of water and water sharing however can be traced back centuries in India. For example, irrigation systems have been traced back to 3150 B.C. in Sanskrit inscription of interactions between Narada and Emperor Yudhisthhira; the construction of canals was traced back to the 14^{th} century; and the specific concept of state-controlled irrigation was rooted in the 19^{th} century [1]. In a development context, this question of how to use water and who should decide has been defined through human rights, cultural, and social lenses for development practitioners and social workers [2-4], through an economical lens for industrial, agricultural, corporate, and government actors [5], a political lens for government actors and water users [2, 6], as well as a technical lens for water practitioners and water technology developers [7]. This multi-dimensional aspect of water has placed it as one of the most inter-dependent and diversely applied resources globally with an increased focus on its integrated management. In Southern India, it is now common for the responsibility of water and its effective use to fall on the plates of not only government actors but also non-governmental organizations, corporate bodies, community based organizations, as well as user groups [8].

After the Dublin Conference and the commencement of the Global Water Partnership (GWP) in the 1990's, integrated water resources management (IWRM) became common language for policy makers, and was adopted as an integrated strategy to their national water initiatives [9]. Unfortunately, the adoption of integrated management language has not led to the expected success of such a systematic, multi-disciplinary approach and there is much uncertainty about what effective integrated water resources management looks like at a practical level [9]. It is well known that the challenges in the water sector transcend all actors, are multidimensional, and are highly dependent on spatial and temporal factors. These challenges are therefore considered to exist in a complex system that can greatly vary spatially and temporally. As the understanding of the complexities and limitations of the water sector grows, with it the human rights, social, cultural, economical, political, and technical lenses grow and transform. This transformation can be seen by the shift in the water development projects of the 60's. In India, these were characterized by top down priorities, implemented on a large scale with little consideration for user behavior or socio-economical implications [10] - and transformed to small scale, community led or participatory approaches to water initiatives that focus on user interaction with technological solutions, long term implications of the developed solutions for all actors, and the intention of meeting the need for sustainability and positive development [10, 11].

Although this shift has become more clearly conceptualized theoretically, there is still a gap in the practical implementation of IWRM. Biswas [12], discusses the challenges with the definition of IWRM and examines the multiple ways to interpret the theoretical conceptualization. Further, he [12] acknowledges how this has led to few successful examples of the implementation of the IWRM approach. In order for the integrated management of water resources to be successful, there needs to be a critical analysis of the current initiatives in the water sector, a better understanding of the interaction of actors and functions within a system, and the creation of practical ways for water and non-water practitioners to align their initiatives.

This research will examine the complex system that non-technical irrigation scheme implementers operate within, which key actors and functions define the system, which road blocks prevent a successful IWRM approach, and how better decisions can be made that align with water resource management policy, as well as realistic grass root challenges and capabilities.

1.2 Objectives of the Research

The major objectives of the present research are to:

1. Investigate an irrigation scheme from a systems analysis approach combining development theory and integrated water resource management theory to identify key social and technical factors influencing the potential for development benefits within the system
2. Examine the role of the implementer in the irrigation scheme in order to discover a technical integration approach that addresses better decision making in the selection process, and better aligns the development practitioner with water related policy

1.3 Pathway to Achieving Objectives

These objectives were achieved by:

1. Conducting a stakeholder assessment of key irrigation scheme actors.
2. Mapping out the system as a collective process with development and water practitioner input
3. Designing an interview tool that investigates key system components and their function from the perspective of the technology user
4. Using salient features of the system analysis to design a decision making tool
5. Using the analytical hierarchy process (AHP) as the decision making framework to represent the irrigation scheme selection process and validate specific system components
6. Conducting preliminary analysis on the decision making tool to determine its relevancy and consistency

The conceptual framework of the research is displayed in Figure 1-1. The research framework consists of the Needs Assessment, conducted in Mysore, Southern India, and the Solution Development. The Needs Assessment incorporated an exploratory and descriptive research methodology guided primarily by local experts in Southern India and literature from prominent research institutes in the development sector. The Solution Development used the Analytical Hierarchy Process (AHP) theory to represent the System Definition and apply a multi-criterion approach to irrigation scheme decision making.

The steps taken in the Needs Assessment consisted of a preliminary System Definition which informed the Preliminary Research Plan and the Comprehensive Interview Tool. The Comprehensive Interview Tool facilitated a unique exploration of technical and non-technical elements of the irrigation scheme which led to the Descriptive Analysis and re-informed the System Definition. Once the needs of the system could be clearly identified, these findings were used to develop a solution. The Solution Development examined four salient features from the System Definition: water availability, water need, technology adoption, and minority status. These four criteria were incorporated in an AHP decision making model to facilitate applicant selection for the irrigation scheme. The scope of this research will go as far as the Evaluation of Decision Making Tool stage where it will be tested for its relevancy and consistency; however, as indicated by the dashed arrow, the tool is meant to be dynamic and continuously informed by the System Definition that will continue to change. Application of the decision making tool should be further monitored and iterated upon according to local needs.

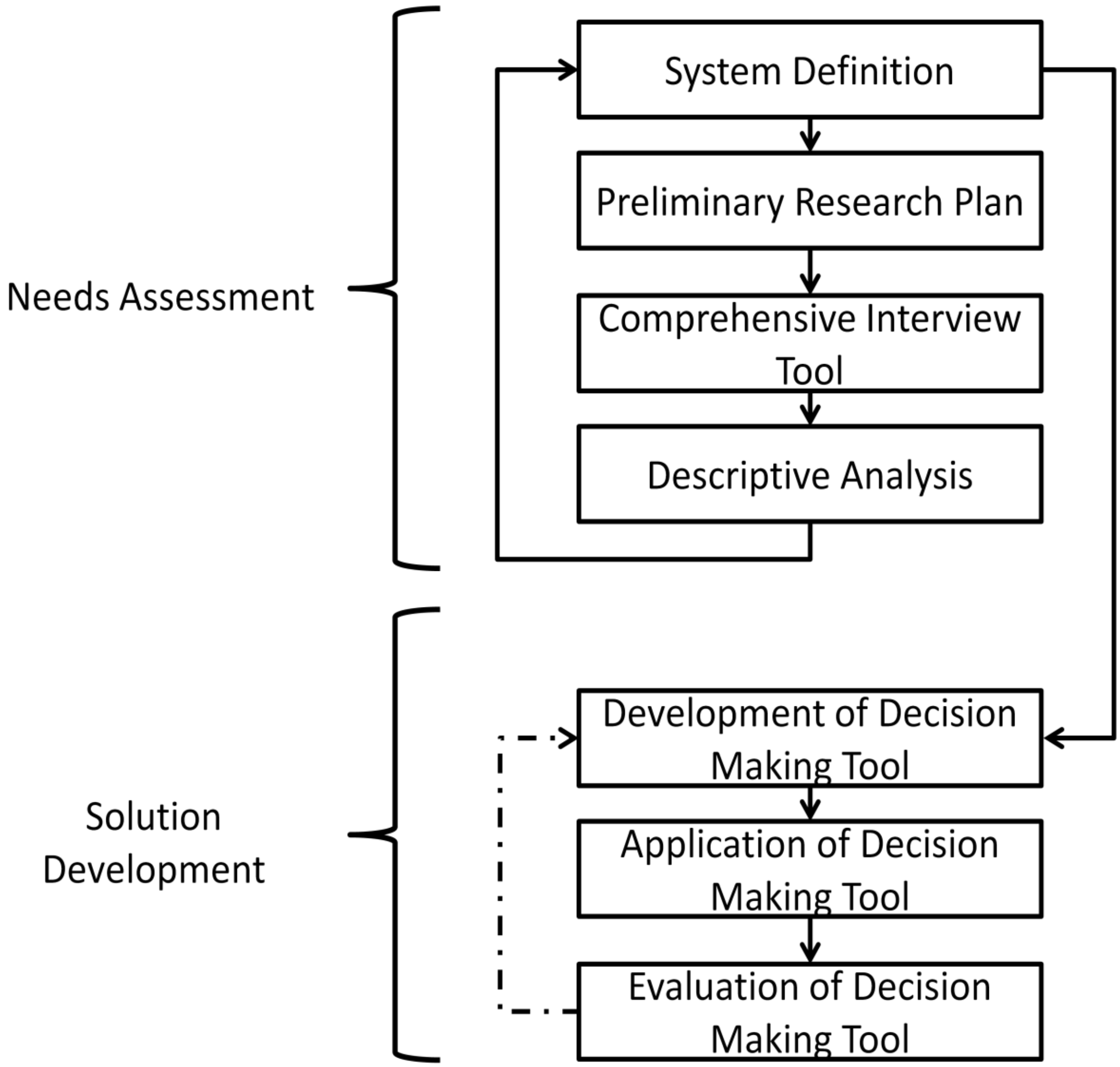


Figure 1-1: Research Conceptual Framework

1.4 Background and Current State of the Irrigation Scheme

The irrigation scheme started in 1996-1997 as a State Government initiative to support small scale or marginal farmers from certain classes of the society, specifically those classified as Backward Class (BC), Scheduled Caste (SC), and Scheduled Tribe (ST). The scheme originated as a loan scheme that provided farmers with a subsidized borehole and pump-set to irrigate their land and improve their agricultural productivity. Upon the successful implementation of the scheme, the participant would be required to re-pay the provided loan.

Now, the irrigation scheme provides full financial support for the drilling of a borehole and the installation of a pump-set to BC, SC, and ST farmers across the State of Karnataka. Currently there are four implementing Government Corporations (GCs) of the irrigation scheme that each focus on a specific group of marginalized farmers. All GCs are funded by the State of Karnataka Government and manage the allocation of funds, facilitate the selection process, and coordinate the implementation of the irrigation scheme. As depicted in Figure 1-2, funds are allocated to each GC based on the number of irrigation scheme participants that they serve. However, all GCs then operate with a common Drilling Agency, Pump-set/Accessories Agency, and Electrification Agency throughout the State. This research will focus on one GC that supports BC farmers in Mysore District.

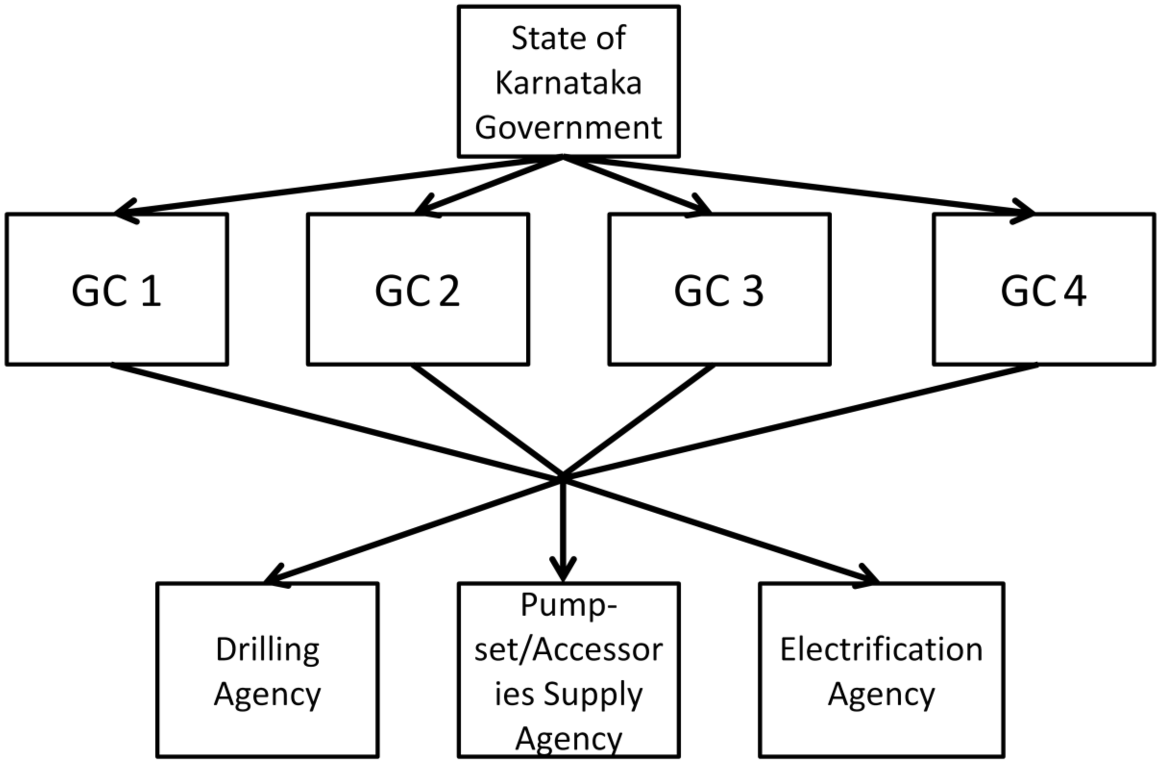


Figure 1-2: Irrigation Scheme Flow of Funds

The irrigation scheme began in Mysore District through the BC GC in the year 2000 - 2001. Although the GC is a non-water practitioner, they are well established as a GC and have much experience in the social development sector. The irrigation scheme is a key activity undertaken to meet three main objectives:

1. To improve the livelihoods of Below Poverty Line (BPL) BC communities
2. To assist the BC communities with development schemes
3. To promote entrepreneurship and support the overall development of the BC population

As part of the irrigation scheme requirement, the GC follows a specific applicant selection criteria as well as a two step selection process.

1.5 Criteria for Selection

Farmers that are selected to participate in the irrigation scheme fall into two broad categories: individual scheme or group scheme users. Each category requires the farmer to meet specific criteria in order to be considered for selection. Table 1-1 below displays the participant criteria for each category as well as the expected support in each case.

Table 1-1: Irrigation Scheme Selection Criteria and Potential Support

Category	Land Holding	Annual Income of Farmers in Rupees	# of Participants	# of Boreholes	Electrification Expense
Individual Scheme (I or IIA BC status)	Minimum of 2 acres in one location	Must be below Rs 22,000	1	1	Maintained by participant
Group Schemes (I, IIA, IIIA or IIIB BC status)	Minimum of 8 acres and up to 15 acres in one location	Must be below Rs 22,000	3	2	Maintained by GC for period of 2 years
	Minimum of 15 acres and up to 20 acres in one location	Must be below Rs 22,000	4	3	Maintained by local electrical supplier for period of 3 years

The selection process for the irrigation scheme contains two main approvals: one with the GC at the district level and the other by a Member of Legislative Assembly (MLA) at the taluk level. Each farmer is required to submit the appropriate documentation that proves BC status as well as current annual income and land holding size. Figure 1-3 below displays the steps involved to become an irrigation scheme participant. Applications are accepted from May – July each year. After verification of records at the GC's district office, the applications are sent to the taluk selection committee, which consists of 14 members chaired by the MLA. The committee examines the submitted applications and selects individual participants from I and IIA categories and group participants from I, IIA, IIIA and IIIB categories of BCs. Once a farmer is selected for an individual or group scheme, the borehole site is selected by a geologist or engineer, and finally the borehole, pump-set, and electrification are provided by approved private agencies.

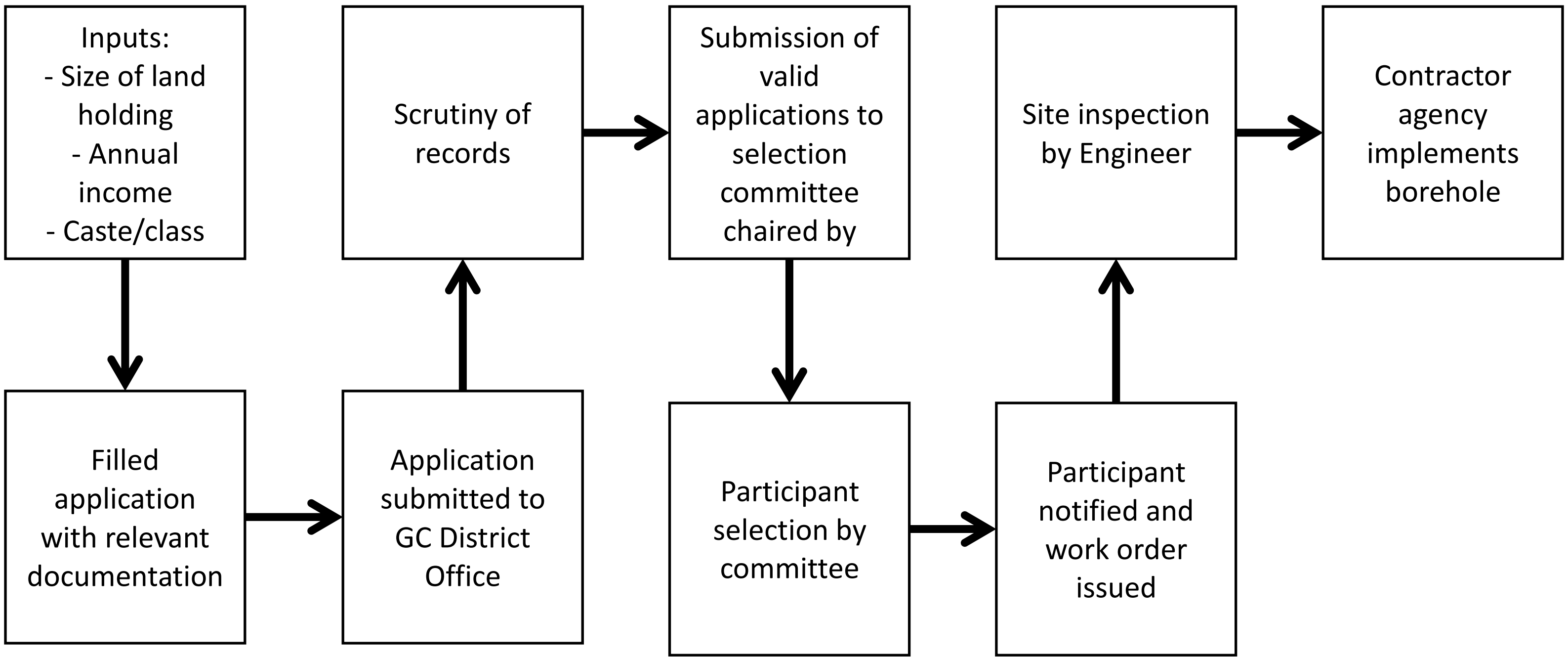


Figure 1-3: Irrigation Scheme Selection Process

1.6 Study Area

Mysore District is located in the southern region of Karnataka State in India as shown in Figure 1-4. For administrative convenience, Mysore District is further divided into seven different Taluks as shown below in Figure 1-4 and listed in Table 1-2. Due to data and resource availability, the study was scoped to include Heggadadevankote (HDK) and Nanjangud (NAN) Taluks in the southern part of Mysore District. In total there have been 159 irrigation scheme participants since 2000 – 2009 reaching over 60 villages distributed across HDK and NAN. Of the 159 participants, 145 were available at the time of the study. The participant selection for the study will be further discussed in the D section.

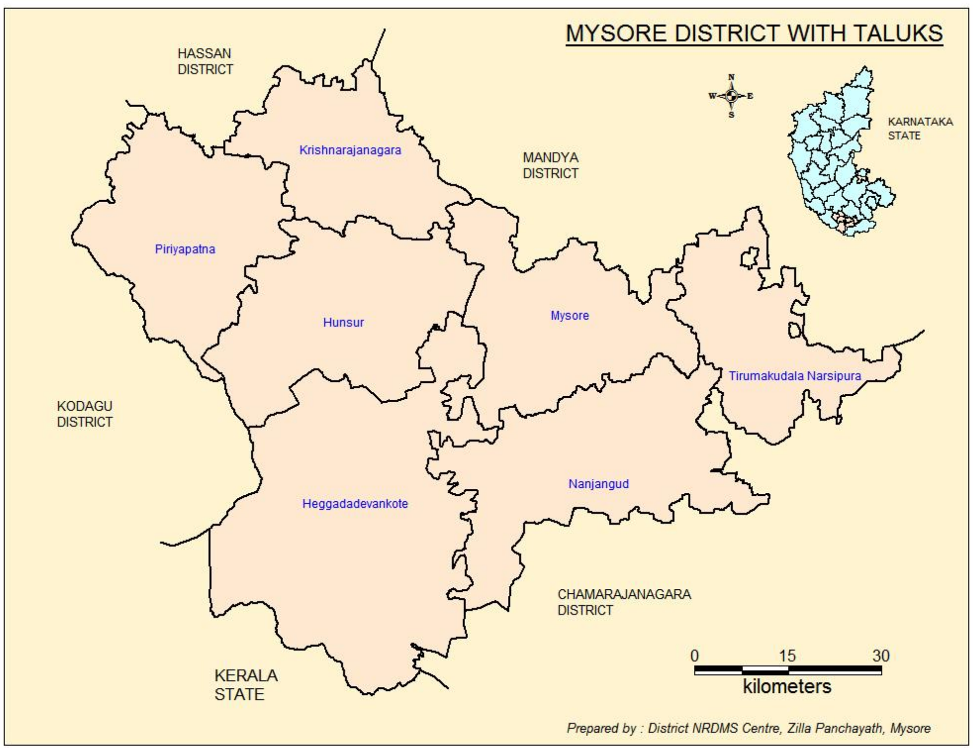


Figure 1-4: Map of Mysore District Adapted from the District NRDMS Centre

Together HDK and NAN represent approximately 23 % of the population in Mysore District. The population distribution taluk-wise in Mysore District is shown below in Table 1-2: HDK taluk has a population of 278,954 and NAN has a population of 406,595 (see population prediction for 2011 in Appendix B). Although Mysore District is generally seen as a relatively developed District, HDK still remains one of the most 'backward' taluks in the State [13] and NAN, although industrialized, is still plighted with low literacy rates, and a considerable BPL population of 95,000 in 2009 [14]. According to the 2001 India Census [15], the literacy rate is 52.8 % and 49.6 % in HDK and NAN taluks, respectively.

Table 1-2: Population Distribution, Mysore District

Total Mysore District Population: 2,995,670	
Taluk in Mysore District	**Total Population**
HD Kote	278,954
Nanjangud	408,595
Piriyapatna	254,367
Hunsur	288,024
KR Nagar	271,319
Mysore	1,177,941
T. Narasipura	316,470

As the two largest taluks in the District, HDK and NAN represent approximately 40 % of the total area in the District – HDK spanning 1630 km^2 and NAN spanning 985 km^2 [16]. Although HDK and NAN are bordering taluks, both represent different agro-climatic regions and vary in cropping pattern and water characteristics.

1.7 Agro-climatic and Groundwater Status

According to the National Agricultural Research Project[17, 18], HDK and NAN fall into two different agro-climatic regions with varying soil type distributions. HDK is part of the Southern Transition Zone and is dominated by red sandy soils while NAN is part of the Southern Dry Zone with red loamy and black soils. As indicated by the 2001 Census of India [15], both taluks are dominated by the agricultural industry with cultivators and agricultural labourers representing 86% and 73 % of the work force, respectively. The net area sown in each taluk is 668 km^2 and 492 km^2 in HDK and NAN, respectively, with 79 km^2 and 258 km^2 left fallow [14]. Dominate crops in both taluks are paddy, ragi, jowar, maize, sugarcane, tobacco, cotton, and a variety or pulses, oilseeds, fruits and vegetables. [14]. Table 1-3 below provides the crop distribution in Mysore District. Understanding the agricultural characteristics of each taluk is an integral part of understanding the water need of each taluk. With such a large percentage of the workforce dependent on agriculture, rain-fed and borehole irrigation are integral components of a farmers livelihood. Therefore, the agricultural characteristics and the water characteristics of a taluk must be explored together. This will be investigated further in the D section where the crop selection of a farmer will determine the water need.

Table 1-3: Crop Distribution, Mysore District [14]

Taluk Name	Crops Grown in Mysore District (km^2)										
	Paddy	Ragi	Jowar	Maize	Sugarcane	Tobacco	Cotton	Pulses	Oilseeds	Fruits	Vegetables
HD Kote	80	143	4.98	16.3	10.2	44.2	301	116	19.6	10.5	8.35
Nanjangud	255	30	65	2.69	25.2	2.75	105	158	49.2	4.30	1.63
Piriyapatna	58	141	0.74	135	1.90	387	1.08	206	27.3	5.22	4.22
Hunsur	145	228	3.95	114	4.81	293	85.3	327	47.4	27.9	5.16
KR Nagar	264	72	1.30	5.85	47.5	81.5	3.23	112	23.8	2.07	5.58
Mysore	112	155	42.3	3.91	19.7	0.15	29	199	105	9.05	23.5
T. Narasipura	305	27	0.70	8.79	20.3	0.00	0.00	81.7	19.9	10.5	2.02

According to the Mines and Geology Department and the Central Ground Water Board (CGWB) [16], 85 % of HDK is currently classified as safe with less than 70 % of groundwater development while 15 % is in a semi-critical state which represents 70 % to 90 % of groundwater development. In NAN, 65 % is classified as safe for groundwater resources, 25 % is in a semi-critical state and 10 % is classified as critical which represents groundwater development greater than 90 %. As of 2008-2009, it was estimated that groundwater development reached 56 % in the command area and 45 % in the non command area of HDK and 30 % in the command area and 87 % in the non command area in NAN. Table 1-4 displays the estimated groundwater development in Mysore District.

Table 1-4: Ground Water Development, Mysore District [16]

Taluk in Mysore District	Groundwater Development (Command Area)	Groundwater Development (Non Command Area)
HD Kote	56 %	45 %
Nanjangud	30 %	87 %
Periyapatna	12 %	27 %
Hunsur	5 %	46 %
KR Nagar	30 %	68 %
Mysore	12 %	85 %
T. Narasipura	27 %	97 %

The stage of water development is becoming an increasingly important factor to rural irrigation applications in the State of Karnataka. A weak coordination between the social and water development sectors has created an environment of unequal distribution of boreholes across the State and misallocation of irrigation technology [19]. Typically, record keeping amongst farmers is rare and the ability for rural organizations to maintain data in a useful, computational manner is limited by inconsistent access to electricity making allocation of technology, monitoring or data management difficult. Further, the implementation and monitoring of water policy is difficult in a context where economical management techniques cannot be as easily applied [11]. However, the Government of Karnataka has recently taken action to improve the monitoring of irrigation development through the Karnataka Act No. 25 of 2011 - The Karnataka Ground Water (Regulation and Control of Development and Management) Act, 2011 (KA No. 25) [20].

1.8 Water Policy

The Ministry of Water Resources, Government of India circulated a Bill in 1992 and in 1996 promoting the management and control of ground water development across India. In response to the emphasis on water management, the Government of Karnataka enacted Karnataka Act 44 of 2003 to protect sources of drinking water. In addition, the Government of Karnataka has recently enacted KA No. 25 of 2011 with the goal of the sustainable management of ground water for agriculture [20]. Although water management bodies have been established, monitoring water management at the grassroots or achieving alignment amongst all actors in the water sector is difficult; further, with no real way to ensure policy implementation, the accountability for exploitative use of irrigation water remains undefined [19]. In KA No. 25, the Government of Karnataka defines the Karnataka Ground Water Authority, as established under section three, to help connect different water sector actors.

Although, this Authority falls short in its social sector representation, it encourages coordination amongst key water and agricultural actors across the government. In addition, it provides clear guidelines that define new requirements for procuring irrigation boreholes as well as a permit or certificate system that helps encourage sustainable practices after the borehole is implemented. In light of this, social sector actors implementing irrigation related development schemes will be responsible for aligning their practices and procedures to this new policy. The implementation of the policy is slowly proliferating across the State and will eventually be implemented in every district. In order for social sector actors to meet the needs of this policy, they will need a mechanism to collect and manage data for: crop selection, farming practices and intended borehole use. In addition, participant selection and water management practices should be location specific and an understanding of groundwater development should be present. Social sector actors should be able to produce the policy related information to ensure that their scheme participants are able to obtain a permit or certificate for their borehole. Further, already installed boreholes that conflict with borehole regulation may be shutdown or user behaviour may need to be adjusted according to the policy.

Although these new requirements are intended to benefit users and create a sustainable water situation for the State, they should be facilitated into social sector practice in a manner that allows the development actor to continue their service to the community while operating with the technical knowledge through available information and technology. This research attempts to examine a decision making tool that will facilitate policy alignment and provide an implementable tool for the social sector actor working with small scale irrigation schemes.

CHAPTER 2

2 REVIEW OF LITERATURE

2.1 General

The literature review has been broken down into five main sections: Systems Thinking, Questionnaire Development and Interview Process, Integrated Decision Making, Integrated Water Resources Management (IWRM), and Analytical Hierarchy Process (AHP). The literature provided is intended to provide a perspective of the guiding principles that have shaped the conceptualization of the research (Systems Thinking, Integrated Decision Making, and IWRM) as well as the applications of the research in conducting the field work and constructing the decision making tool (Questionnaire Development and Interview Process, and Analytical Hierarchy Process).

2.2 Systems Thinking

Marashi and Davis [21] state that:

"Engineers dealing with large-scale, highly interconnected systems such as infrastructure, environmental, and industrial systems have a growing appreciation that they need to design and manage systems capable of fulfilling stakeholders' requirements in complex, uncertain, and dynamic situations."

Therefore, 'systems thinking' is becoming a fundamental element of project planning in all major infrastructure, environmental or service providing sectors due to the potential for societal impact as well as realized benefits, such as enhanced performance and sustainability.

Senge [22] defines a system by its "whole" and interconnected nature and discusses the hydrological cycle as an example of a system where the state or behaviour of a system element is different at any given location in time and space but all elements are affected by each other. Further, Senge [22] recognizes the long-term aspect of system change by stating that a system is “bound by invisible fabrics of interrelated actions, which often take years to fully play out their effects on each other.” Each of these definitions appreciates the ‘wholeness’ of a system and its parts, as well as value the functions and interactions of the part within the whole. For the purpose of this research an emphasis is placed on irrigation technology as a part of a greater whole. The system boundaries and elements will be greater defined in the D section.

There are a wide range of frameworks that help promote systems thinking. The International Centre for development oriented Research in Agriculture (ICRA) [23] examines the approach of Soft Systems Methodology (SSM) developed by Checkland [24]. The SSM differs from traditional approaches to constructing systems in that it is less focused on system model validation but operates in a more iterative manner that promotes a continues cycle of change as the understanding of the system changes [25]. Checkland [25] states that: “In the soft tradition, the world is assumed to be problematic, but it is also assumed that the process of inquiry into the problematic situations that make up the world can be organized as a system.” This bias toward the inquiry process which typically involves a prolonged state of ambiguity and divergence before focusing and converging was a fundamental element of the approach taken with this research [26]. The conceptual framework of the SSM is depicted in Figure 2-1.

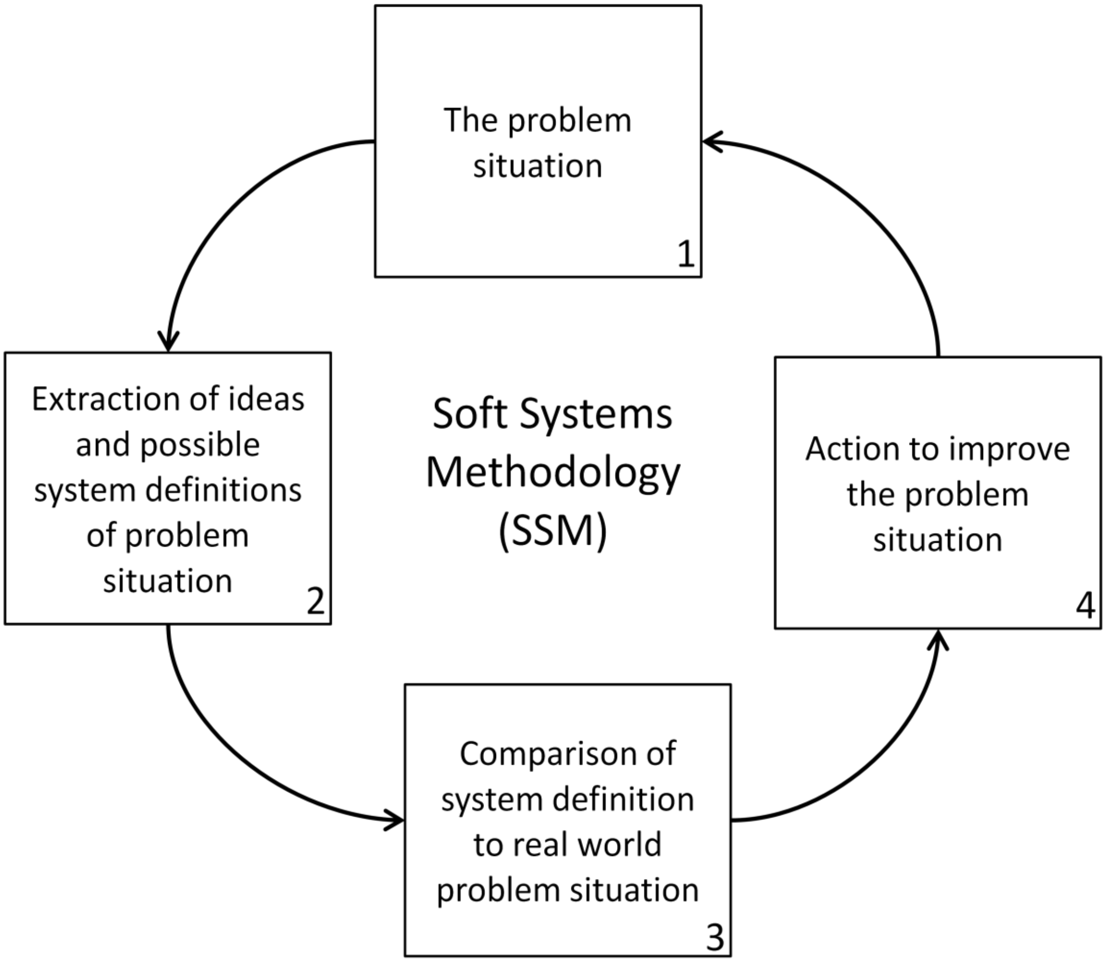


Figure 2-1: Soft Systems Methodology (adapted from Checkland, 1995)

When applying systems thinking to real world problem situations, Senge [22] describes the laws of the fifth discipline that guide systems thinkers. Two important factors considered in this research are: first, "compensating feedback" where encouraging a change in one part of the system may prevent the overall desired change by creating a problem in another part of the system or by amplifying the problem situation in the long-term; for example, implementing household running drinking water to improve sanitation but then having a water shortage due to overuse which eliminates the drinking water source. Second, the distance between cause and effect relationships are usually separated spatially and temporally [22] as shown in the previous example, the water shortage may occur months after the initial system change. Although describing system elements in a cause and effect manner help construct the system model; the distance between cause and effect, make it difficult to fully understand the causes of a problem situation while employing the second step in the SSM or evaluating and developing certainty around the implemented change in the fourth step of the SSM. However, ICRA [23] examines the use of the SSM in an iterative manner while continuously changing and adapting the second and fourth step of the SSM to help model the system in its near 'truest' form and allowing for an improved solution. This helps identify "compensating feedback" faster and redefines the system definition based on continuous learning. This idea of iteration was built directly into the Research Conceptual Framework in Figure 1-1 and the SSM combined with system thinking principles allowed for a broader understanding of the irrigation scheme system during the Needs Assessment.

In addition, this research adapted spray diagrams [27] into Spheres of Influence (SoI) used in the initial stages of the System Mapping. Similar to a network diagram, system elements operating at different levels of influence and connectivity could be seen.

2.3 Questionnaire Development and the Interview Process

Data collection through surveying for household data has been known to exist for more than 200 years [28]. In India, the annual National Sample Survey began in the 1950's and currently, the ten year census data supports much of India's long-term understanding regarding development indicators as well as policy development to address the needs of the nation at a household level. The World Bank [28] provides a comprehensive look at developing and implementing questionnaires in developing countries. According to The World Bank [28], there are five steps to consider when developing a questionnaire for research purposes: defining objectives, deciding on topics to be covered, developing the questions, integrating topics, and finally translating and field testing the questionnaire tool. Bradburn et al. [29] suggest a similar set of steps but provide a more detailed list of step-wise actions and discuss further revisions after the field testing of the questionnaire tool. Crawford [30] describes nine steps to questionnaire development that reflect a similar process. Both The World Bank [28] and Bradburn et al. [29] discuss the importance of stakeholder consultation and active involvement in the questionnaire development process as well as highlight the critical step of ensuring that all topics and questions included in the questionnaire connect and relate to the research question. This process not only facilitates a holistic picture of stakeholder interests but also allows for decisions to be made about the tool that reflect the opinions and needs of policy makers, researchers, data collectors, and data analyzers [29].

Crawford [30] defines the qualities of a good questionnaire to be: how well the questionnaire aligns to and achieves the research objectives, the ability of the questionnaire to obtain accurate information, the questionnaire's usability for the interviewer and respondent, and its ability to keep the interviewer and respondent engaged throughout the process. These qualities can best be achieved with the appropriate stakeholder involvement in the initial stages as well as with thorough field testing [29].

Bradburn et al. [29] examines the influence that the type of question asked has in obtaining accurate responses from the respondent. The bifurcation of threatening, and non-threatening questions provides a foundation for interviewers and it guides the approach to field work. The actual sensitivity of a question is dependent on the situation specific context that the question is asked within and should be determined in consultation with various stakeholders [29]. Additionally, the division between behavioural or fact related questions, knowledge seeking questions, or attitudinal related questions provides a framework for the questionnaire developer to scaffold questions that assist the respondent in remembering or minimizing bias in their response [29].

It is known that there is no one prescribed way to develop questionnaires or to conduct field work; therefore, the careful construction of the questionnaire tool and the experience of the interviewer are critical factors to consider when designing the research plan. When appropriate, questions can be adapted from already constructed questionnaires. The World Bank [28] provides a foundation on a wide range of topics covered in the Living Standards Measurement Study (LSMS) and Bradburn et al. [29] examine behavioural topics related to farming innovation and business expenditure.

In order to prepare an interviewer for field work, the training program should provide an opportunity for the interviewer to practice the questionnaire and experience an environment that best mimics the reality that they will operate their field work within. Sensitivity of respondents to questions should be carefully examined and interviewers should be properly prepared to handle ethical considerations and participant consent. Bradburn et al. [29] describe interviewing as a ‘voluntary conversation’ and highlights the importance of the interviewer to create a comfortable environment that stimulates a space for truth, and engagement.

This research has incorporated much of the lessons learned from the LSMS into the questionnaire development as well as incorporated a thorough interview training, and tool testing process to minimize bias and variability. This will be further highlighted in the D.

2.4 Integrated Decision Making

Decision making in development is a dynamic act that transcends policy development and implicates all actors directly or indirectly connected to the decision at hand. Langley et al. [31] explore decision making as an organizational act that requires a "convergent", "insightful", and "interwoven" approach. They describe a model that validates the decision process as one that is iterative in nature, that places a unique value on the decision maker, and that examines the effect of a decision in a broader system. Decision making was seen to exist on a spectrum from structured, sequential decision models, such as those found in many engineering design methodologies [32], to more anarchical decision models with little pattern, such as those represented in certain political contexts [33].

The desire for optimization in decision making was apparent from the mid 1950's with major advancements made to multi-criterion decision making (MCDM) models as well multi-attribute utility theory (MAUT) [34]. The platform for decision making has been characterized by a combination of experience, preferences, and knowledge, with a natural emphasis placed on experience or expert insight of the decision maker [35]. However, with the established controversies of "hunch" decision making and inefficiencies associated with information or data management, the concept of decision support systems (DSS) emerged[36]. Dyer et al. [34] describe the rise of the interdisciplinary application of MCDM and MAUT into the 80's and Enom and Kim [36] inventory the expansive use of DSSs from 1995 to 2001 in over 15 disciplines including agriculture, natural resources, and community planning. Firth [37] discusses the natural interdisciplinary state of an ecosystem and advocates for a stronger integration between knowledge of the ecosystem and decision making. Firth [37] also looks at two broad approaches to integration described as "patchwork quilt" and "woven tapestry." The patchwork method continuously incorporates new information into already existing structures or systems. On the other hand, the tapestry approach naturally incorporates and operates in an integrated manner from the beginning. According to Dhanya [38], water management in India requires integration of management, engineering, economics, sociology, and agronomy skills; however, she does not specify whether a patchwork or woven tapestry approach would be better. Currently, there is no one consistent type of decision making adopted in India; however, there are examples of the woven tapestry in the watershed department's partnership with a local NGO, patchwork integration on some governmental projects, as well as un-integrated approaches adopted for various projects in all sectors. Fundamentally, decision making that addresses the complex needs of today's society requires multi-criterion approaches and a foundational framework for integration amongst disciplines and sectors. This research was performed in a multi-disciplinary manner and aims to improve irrigation scheme decision making by aligning multiple development sectors: water, social, and agriculture through the creation of a multi-criterion Analytical Hierarchy Process (AHP) decision model.

2.5 Integrated Water Resources Management

According to Garcia [9], Integrated Water Resources Management (IWRM) has been around for almost 60 years drawing similarity to the Reasonable Use Principles developed by Todd in 1965. However, two well known introductions of IWRM as a principle approach to water management strategy were the Dublin Conference on Water and Environment in 1992 and the introduction of the Global Water Partnership (GWP) in the mid 1990s. Although the concept of IWRM has been defined and built into many national strategies worldwide, Garcia[9], van der Zaag [39], and Biswas [12] argue that there is still clarification needed on the meaning of IWRM, as well as critical examination of the practicality of IWRM. They suggest that until these steps are taken, the words will not transform water sector strategy or promote the successful implementation of IWRM in developing nations.

With a lack of shared meaning of the definition of IWRM, governments and local decision makers are inhibited from implementing effective IWRM approaches [12]. Dungumaro and Madulu [40] state that "how IWRM is implemented depends largely on how it is defined and what are the variables and institutions that are to be integrated." Currently accepted definitions of IWRM can vary; however, that provided by the GWP is the:

"coordinated development and management of water, land, and related resources in order to maximize economic and social welfare without compromising the sustainability of vital environmental systems."

Although this definition does allude to water resources being integrated and identifies a need for coordination in order to create sustainability, the vague nature of the definition limits its ability to provide clear guidance for the implementation of IWRM [12]. Merrey [41] describes the merit in the IWRM approach for its ability to promote systems thinking when dealing with water related problems as well as highlights it necessity when transitioning from the "single-minded single-sector water development in the past—Un-integrated Water Resources Management (UWRM)." However, Merrey [41] identifies key gaps in the creation of comprehensive IWRM plans and highlights how this can lead to diversion from the most critical issues in the water sector. Further, the complex nature of the plans, require resources that are beyond the capacity of those available in developing nations.

Biswas [12] and McDonnell [42] describe the interconnectedness of water issues today as inter-sectoral - spanning government, private, and non-governmental organizations, and interdisciplinary with influences from social, economical, environmental, legal and political realms of development. Similarly, Garcia [9], states that water became “the business of all” after the Second World Water Forum in Hague 2000. This shift in perspective, specifically in India, has now put the accountability and action into the hands of not only water practitioners but also into the hands of development practitioners. The 2012 Draft National Water Policy [19] in India identifies water resources projects as “multi-disciplinary with multiple stakeholders” but stresses that projects “are being planned and implemented in a fragmented manner” and that “a holistic and inter-disciplinary approach to water related problems is missing.” Further, the policy discusses the siloed nature of public agencies making decisions with little or no consultation of stakeholders and calls for improvements to ‘community based water management’[19].

Currently, the management of water is being addressed through two main approaches: supply based management and demand based management. Supply based water management supplies users with water with little repercussion to over using or mis-managing [43]. This approach was present in early water related development initiatives and still exists today in the development sector where control of water use cannot be as easily managed administratively [11]. On the other hand, demand based water management emerged as water resources became stressed and in some cases exploited rendering inequitable access and mis-use. This approach is characterized by tailoring the quantity and quality of water to the specific demand of its use in order to minimize over use and mis-management [43]. As the world population continues to grow and the dependency of water in the agricultural and industrial sectors also increases, the demand for water and its effective management have become of paramount concern. Gumbo et al. [44] argue that water demand management (WDM) is an integral component to IWRM and to achieving the Millennium Development Goals (MDG). Similarly Brooks and Brandes [43] advocate for what they call a "water soft path" that employs 'back casting' as a primary method for effective water control. With a comparable philosophy to demand based management, they stress the inclusion of anthropogenic as well as ecological perspectives in visioning what the water future should look like and then employ mapping back to a holistic idea of what the demand should be now. This approach offers a demand management approach that considers future implications of water availability and sustainability. The shift from supply based management to demand based management does not proclaim to be easy; however, is seen as a necessity. Gumbo et al. [44] address the capacity building requirements at all levels in the water management hierarchy and provides ample support for the need of improved human resource capacity in the water sector. In the State of Karnataka, Act No. 25 of 2011[20] focuses on the control and management of ground water use by incorporating elements of supply and demand based management. This policy requires groundwater users in 'notified areas' to receive a permit before drilling or digging new ground water sources or alternatively, obtain a certificate for ground water sources that were already in operation before the area became a 'notified area'. The Act will examine the availability of groundwater as a primary factor (supply based philosophy) as well as the purpose of the water structure, and the plan of water use and management (demand based philosophy). For agricultural applications the authority will examine the crops grown, water application technologies applied, and regular use patterns of water applications in order to assess the worthiness of a permit or certification [20]. Where crop changes are needed, these specifications will be provided as a requirement in the certification or permit. This level of management will require interaction amongst water and non-water practitioners as well as an effective framework for communication and decision making. Currently, the authority members largely represent political and technical experts; however, there is little to no representation of social experts. This research examines a decision making tool that promotes an IWRM approach for the social sector practitioner. It will help align the development worker with the demand based philosophy by creating a decision tool that considers farmer water management practices and crop selection, as well as provides the development practitioner with an IWRM tool that aligns with water related policy.

2.6 Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) was developed between 1971 and 1978 by Thomas L. Saaty with its origins in national defence [45]. Saaty describes the unique ability of the decision making model to mimic the natural organization of the human thought processes in structuring and organizing complicated problems. In a hierarchical manner, the AHP captures salient features that contribute to a decision of interest and then allows for a pair-wise comparison amongst the features. This comparison process leads to a prioritization of each feature within the model as well as a prioritization of possible decision options [45]. The hierarchies in the AHP must be created with careful consideration to the objective(s), the features affecting the objective(s), as well as the people involved. The development of the hierarchy should be informed by systems analysis and reflect the meaningful relationships between decision elements. Typically the desired objective it represented at the top of the hierarchy and the corresponding features below with the decision options at the base of the hierarchy [45]. The hierarchy can also be designed to consider feedback relationships; however, that is beyond the scope of this thesis. The AHP allows for technical and non-technical elements of a decision to be captured and valued within the same structure creating flexibility in its applications especially in the water sector where decisions are inter-sectoral, multi-disciplinary, and complex. The AHP has been applied to a number of fields of study including economics, national security, ecosystems management, rural development decision making, and IWRM [46-48]. The AHP typically is implemented in consultation with many stakeholders and key actors defined within the boundaries of the problem or the decision of interest. These actors provide various perspectives on the desired structure of the AHP as well as the desired prioritization of various features. In the water sector, Gallego-Ayala and Juizo [48] examine AHP theory combined with Strengths, Weaknesses, Opportunities, and Threats (SWOT) theory to develop an A'WOT decision making tool for IWRM. This application facilitated discussion around the key factors affecting IWRM strategy while identifying local strengths, weaknesses, opportunities, and threats. The results of the SWOT analysis were then used in the AHP model to determine priority areas for IWRM strategy. Oddershede et al. [47] tried to minimize disconnect between government incentive programs and community preferences by applying the AHP to community development in rural Chile. By comparing economic, education, infrastructure, and environmental features in relation to community activities, the prioritization revealed tradeoffs and specific areas of interest at the community level. In these applications of the AHP it functioned to address complex planning challenges as well as mitigated the challenges associated with group decision making in situations with many diverse stakeholders.

In more technical applications of the AHP, Sargaonkar et al. [49] combine Geographical Information Systems (GIS) with the AHP in order to prioritize sites for groundwater recharge. Ramakrishnan et al. [50] use the AHP to determine potential sites for water structures using remote sensing technology and GIS. Further, Gerdsri and Kocaoglu [51] examine the application of the AHP to technology road mapping for organizational alignment.

All of these applications have two things in common:

1. They facilitate a decision with clear indication of the factors that are being considered which provides an opportunity for accountability, scrutiny, and fluidity as systems and stakeholders change.
2. They facilitate a decision that is complex in nature with various stakeholders involved.

These two commonalities are crucial especially in examining the applicability of the AHP to rural irrigation applications in Southern India. First, the ability to explicitly identify the factors affecting a decision and then prioritizing and making a decision in a transparent manner helps improve the accountability of local decision makers in the social sector. The AHP also acts as a diagnostic tool by identifying when factors, that should play a role in decision making, are over-looked or under-valued such as the water sector policy elements addressed in this research. In order for a decision to be ‘ethical’, all decision makers or supportive tools should: not oversimplify complexity, be justified through evaluation of costs and benefits, consider plans for the future, and have the ability to adapt to a changing environment [46]. This level of scrutiny and adaptability facilitates a more critical and holistic approach to development that is often missing in the disjointed, sectoral situation that we see in Southern India today.

Secondly, Parkes et al. [52] discuss the integrated governance prism that examines the relationships between watersheds, eco-systems, social systems, and health/well-being. The complex nature of decisions in the water sector, create a need for a multi-criterion decision making tool like the AHP. Although many of the applications explored have either taken a technical approach or a consultation approach, the AHP is not limited to one or the other. This research examines an AHP that combines both technical and social criterion for decision making. It was developed through a systems analysis approach that involved consultation with irrigation scheme participants but also explored water management criteria and local irrigation related policy.

CHAPTER 3

3 DESIGN AND METHODOLOGY

The Design and Methodology consists of the Needs Assessment and the Solution Development as shown in the Research Conceptual Framework presented in Figure 1-1. The methodology examines the approach taken to conduct the exploratory research for the irrigation scheme, identifies the conceptual models incorporated in the research approach, and details the construction of the AHP tool.

3.1 Needs Assessment

The Needs Assessment was carried out in Mysore District, Southern India under the guidance of the University of Windsor, the partner NGO, as well as in consultation with the GC that implements and manages the irrigation scheme. The Needs Assessment is broken down into two main sections: System Mapping, and Research Plan. This research was classified as exploratory and descriptive research [30] which utilized secondary data from the GC and GC workers, CGWB [53], University of Agricultural Sciences [17, 18], Mines and Geology Department [16], Karnataka Human Development Report 2005 [13], the Directorate of Economics and Statistics [14], the Ministry of Water Resources [19], and the India Census 2001 [15]. In addition, primary data was collected from irrigation scheme participants.

3.1.1 System Mapping

In order to create the research plan, a preliminary System Definition was developed by mapping out the system of interest for the irrigation scheme. This preliminary work was facilitated by the University of Windsor, the partner NGO, and the GC. The system mapping was carried out in a series of steps: stakeholder identification, system scoping, component identification, function mapping, relationship mapping and finally the combination of these factors using a cause and effect diagram. Two frameworks were employed to carry out this process: Soft Systems Methodology (SSM) adapted from Checkland [24] as well as Spheres of Influence (SoI) adapted from the spray diagram [27].

The first two steps of the SSM in Figure 2-1 were employed to capture the various actors, functions, and relationships within the system as shown below in Figure 3-1. As can be seen, there were six main actors that communicated with farmers either through providing, training, support, or collaboration on various watershed initiatives: Watershed Department, Agricultural Department, Agricultural Marketing Department, the GC, the Contractors, and the NGO. The connection between actors was limited with no collaboration regarding the irrigation scheme; however, data sharing amongst some governmental departments was present. Further, collaborations amongst the Meteorological Department, Karnataka State Remote Sensing Application Centre, Mines and Geology Department, and the Watershed Department were present at the project planning level and these actors displayed a history of collaboration in the water sector; however, all of these departments operated separately from the GC implementing the irrigation scheme.

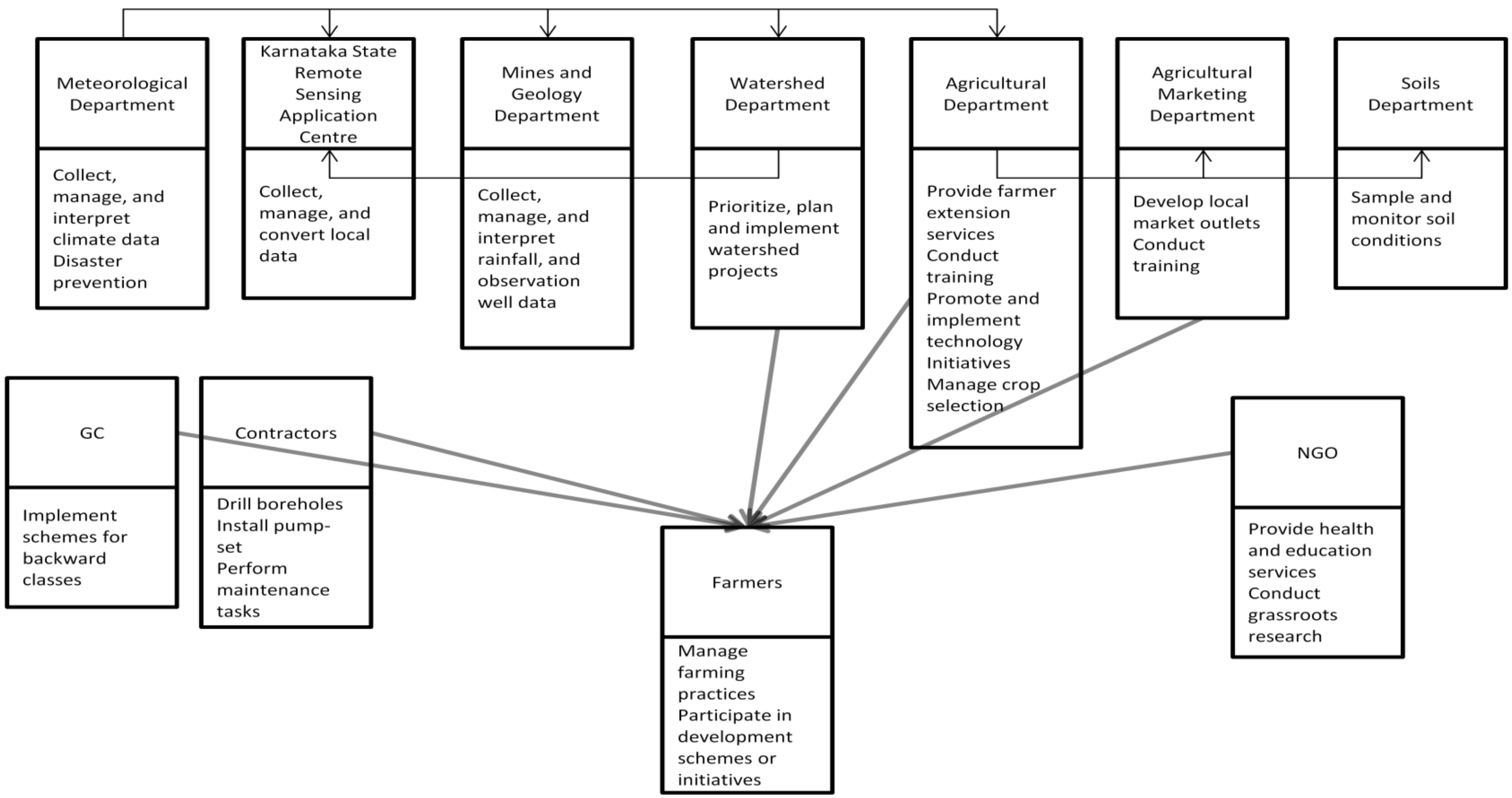


Figure 3-1: System Actors, Functions, and Interactions

Defining the problem situation and constructing the system definition were facilitated using the SoI as shown below in Figure 3-2. This was conducted through a facilitated meeting with the University of Windsor, the NGO, and a local expert from the water/agricultural sector.

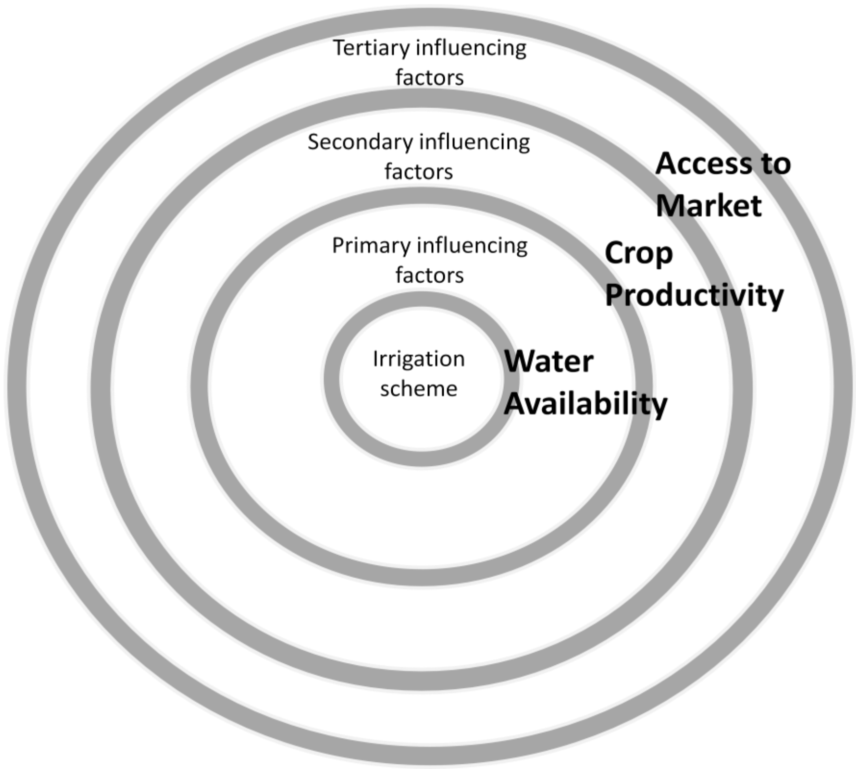


Figure 3-2: Spheres of Influence

Once the system was scoped, the main system components were identified, and connections between the components were established, a Fishbone Diagram was created to capture the initial system map as shown in Figure 3-3.

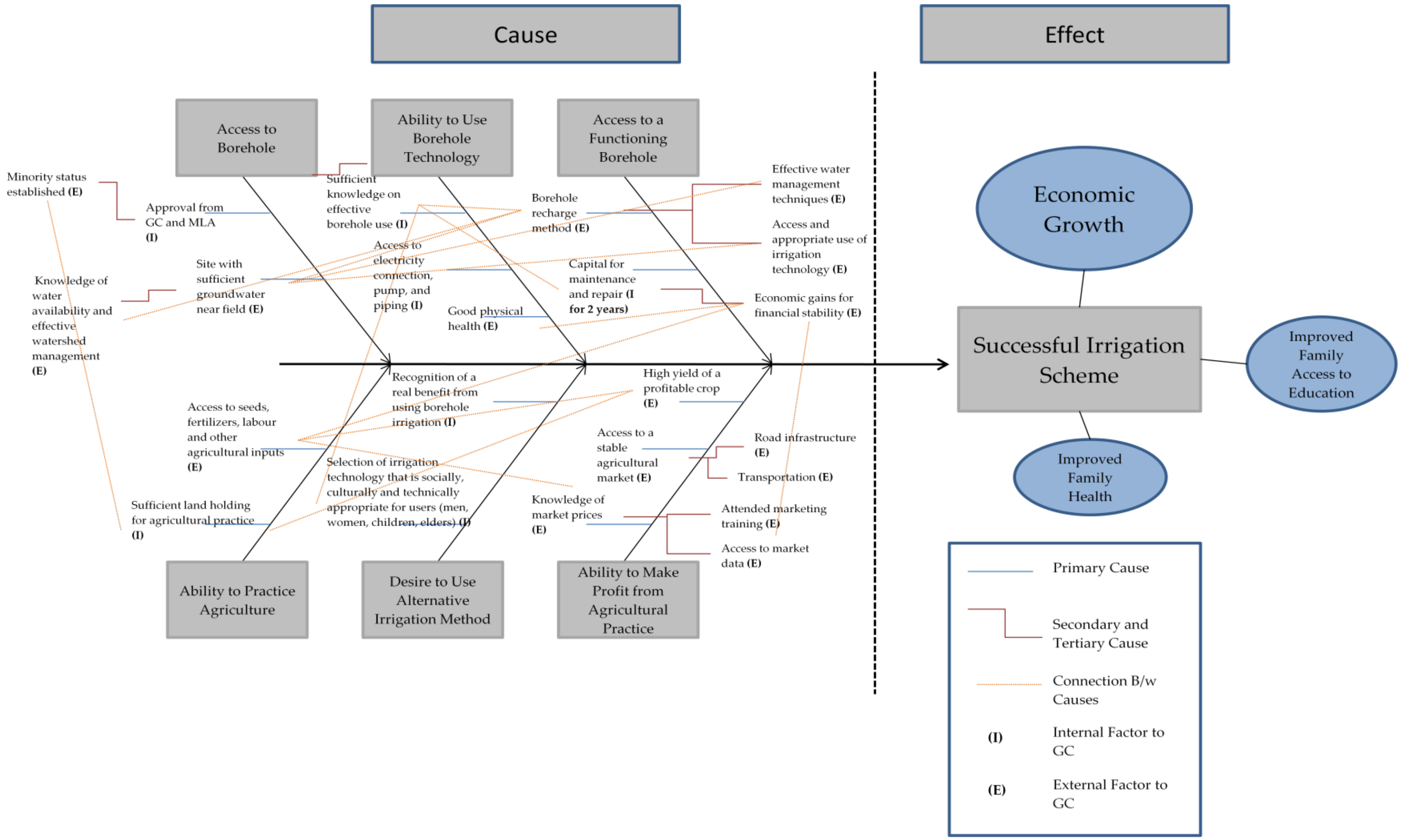


Figure 3-3: Fishbone Diagram of Initial System Map

These preliminary system maps aided in prioritizing system components of interest, and guided the development of the research plan.

3.1.2 Research Plan

The research plan was developed by the University of Windsor and the NGO and subsequently approved by the GC. The research plan consists of eleven main sections: Outcome Mapping, Taluk Selection, Sampling Plan, Ethical Considerations, Interview Tool Development, Interviewer Training, Pilot Test, Field Interviewing, Data Entry, Data Verification and Data Analysis Methodology.

3.1.2.1 Outcome Mapping

The main framework followed to develop the research plan was Outcome Mapping [8]. This social development framework acted as a planning and communication tool for the technical and non-technical stakeholders. The overview of the outcome map is displayed here in Figure 3-4 and the details are subsequently provided.

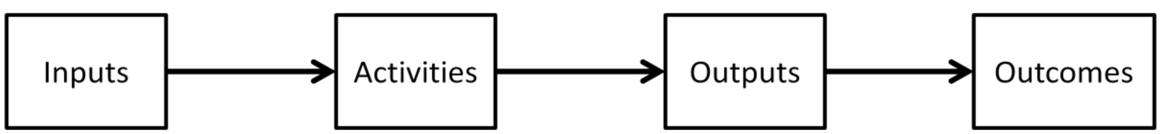


Figure 3-4: Outcome Map for Needs Assessment

First the desired research outcomes were discussed in relation to the research objective and the established system maps. Secondly, the tangible outputs were agreed upon to achieve the desired outcomes. Next, the necessary activities were planned taking into consideration the boundaries of the study (provided in sections: Taluk Selection and Sampling Plan), the available secondary data related to the outputs and outcomes, and human resource capacity based on funding and time. The detailed information required is provided in Table 3-2 below, following the details of the outcome map. Once the research team had an understanding of the available data and resources, the participant interview was selected as the main activity to investigate irrigation scheme details from the user perspective. The details of the interview tool will follow in the Interview Tool Development section. Finally, the necessary inputs and resources were collected to conduct the activities for the study. As can be seen, outcome mapping, as a planning tool, functioned in the reverse order from outcomes to inputs; however, in the implementation stage, the framework functioned in the forward direction until the outcomes were achieved. The established outcomes, outputs, activities, and inputs for the irrigation scheme Needs Assessment are provided below.

Research Goal:

Investigate an irrigation scheme from a systems analysis approach combining development theory and integrated water resource management theory to identify key social and technical factors influencing the potential for development benefits within the system

Outcomes:

1. To understand the socio-economic and organizational factors influencing the irrigation scheme in HDK and NAN taluks

2. To understand the technical factors affecting the appropriateness and effectiveness of the irrigation scheme in HDK and NAN taluks

Outputs:

The outputs related to the above two outcomes are provided below in Table 3-1.

Table 3-1: Outputs for Irrigation Outcome Map

1.	To understand the socio-economic and organizational factors influencing the irrigation scheme in HDK and NAN taluks
I.	To understand the socio-economic status of the irrigation scheme participants
II.	To determine the organizational structure of the irrigation scheme and implementation plan employed by the GC
III.	To understand the available support for BC farmers from other government or non-government organizations
2.	To understand the technical factors affecting the appropriateness and effectiveness of the irrigation scheme in HDK and NAN taluks
I.	To understand the implementation plan employed by the GC for the irrigation equipment selection, borehole site selection, and pump installation
II.	To determine the water use and irrigation techniques practiced by irrigation scheme participants
III.	To understand crop selections of irrigation scheme participants
IV.	To understand the applicable water and agriculture related policies in Mysore District

Activities and Data Collection:

The related activities for the outputs and outcomes of the irrigation outcome map are provided below in Table 3-2.

Table 3-2: Activities for Irrigation Outcome Map

Information Required for Selected Taluks	
Timeframe of Information: Project Implementation (2001 to 2009)	
Social/Cultural	
Information Required:	Relationship or Activity Required to Source Information:
1. Desired social/cultural outcomes of the irrigation scheme 2. Population census 3. Political structure within village and taluks 4. Flow of information and communication within taluks 5. Flow of information and communication within irrigation scheme to all actors 6. List of irrigation scheme participants 7. % participants SC/ST, women, men, etc. 8. % individual and % group scheme	1. GC 2. Mysore District Website 3. Mysore District Website 4. Consultation with NGO and Government Actors 5. GC, participant interview 6. GC 7. GC, participant interview 8. GC, participant interview
Economical	
Information Required:	Relationship or Activity Required to Source Information:
1. Desired economical outcomes of the irrigation scheme 2. BPL and income statistics 3. Market(s) location and commodity prices 4. Funding allocation for irrigation scheme 5. Bank involvement or other sources of funding for the participant 6. Annual income of irrigation participants due to agricultural practices 7. Common economic commitments in community or with family (dowry, cultural practices)	1. GC 2. Directorate of Economics and Statistics 3. Agricultural Marketing Department 4. GC 5. Participant interview 6. Participant interview 7. Participant interview
Health Related	
Information Required:	Relationship or Activity Required to Source Information:

1. Desired health related outcomes of the irrigation scheme 2. Weight or malnutrition statistics in relation to irrigation and crop selection	1. GC 2. Publically available data
Education Related	
Information Required:	Relationship or Activity Required to Source Information:
1. Desired education related outcomes of the irrigation scheme 2. No. of children attending school in relation to access to irrigation technology	1. GC 2. Publically available data
Technical	
Information Required:	Relationship or Activity Required to Source Information:
1. Desired technical outcomes of the irrigation scheme 2. Irrigation development in the study area 3. Locations of irrigation scheme boreholes 4. % of boreholes working and failed 5. Irrigation water use by participants 6. Cropping pattern of irrigation participants 7. Crop water requirement 8. Land use and land cover 9. Watershed and drainage plans 10. Soil and geomorphology status in study area 11. Topographic maps 12. Land size serviced by irrigation borehole	1. GC 2. Mines and Geology Department 3. Field visit 4. Participant interview 5. Participant interview 6. Participant interview 7. FAO Evapotranspiration 8. Karnataka Remote Sensing Application Centre, Directorate of Economics and Statistics 9. Karnataka Remote Sensing Application Centre, Mines and geology Department 10. Department of Mines and Geology, Karnataka Remote Sensing Application Centre 11. National Institute of Engineering College 12. GC, Participant interview

The research team was aware that health and education factors may influence the system as shown in the system mapping; however, it was beyond the scope of this study to consider them. Therefore, there is an opportunity to examine the influence that these factors may have in future work.

Inputs:

Necessary inputs for the Needs Assessment included:

1. Established relationships with main stakeholders as well as government and non-government actors with related data and information
2. Funding for project management, field work, data collection, interviewing, data analysis, and documentation
3. Research tools such as data management and data analysis programs
4. Training resources for field workers, data collectors, and interviewers
5. Ethical approvals from governing bodies at the partner NGO and the University of Windsor
6. Human resource capacity for all research tasks

3.1.2.2 Taluk Selection

Considering the irrigation scheme was implemented across the State of Karnataka, the study area was selected and scoped based on the desired research outcomes and resource availability.

HDK and NAN taluks were selected for the following reasons:

1. NAN is considered to be a more industrialized Taluk compared to HDK with a greater presence of factories including a sugarcane factory. This helped examine the secondary and tertiary factors affecting the irrigation scheme. ie. improved transport, access to markets, sources of materials etc.
2. HDK and NAN fall into two different agro-climatic zones that experience different rainfall patterns and soil types. By connecting Taluk differences to these agro-climatic details, a foundation for improvements based on the local conditions was investigated.
3. The irrigation scheme participant details for HDK and NAN were available in a timely manner.
4. The funding for the irrigation scheme research project facilitated a study within close proximity to Mysore Taluk making HDK and NAN practical selections.

3.1.2.3 Sampling Plan

Upon receiving the participant list from the GC, a preliminary field visit was conducted to interact with participants and determine a practical sampling plan for the interview. It was discovered that there was a total of 159 participants from 2000 – 2009 approved for the irrigation scheme in HDK and NAN. With a total of 159 participants, the budget and resources were sufficient to perform an evaluation with the full irrigation scheme population. Further, due to the small population in both Taluks, a population evaluation yielded more accurate results and captured the variability amongst respondents compared to selecting a sample size. Therefore, a plan was developed to meet every irrigation participant approved from 2000 – 2009; this included 80 members in HDK and 79 members in NAN.

Upon completion of the field interviewing, 14 irrigation scheme recipients were not interviewed for the irrigation scheme study. Some of these participants could not be located according to the provided information from the GC. Alternatively, the remaining participants were not available at the time of the field visits. Table 3-3 displays the pre and post sampling plan for the irrigation scheme interview as well as the expected error due to the 'missing' 14 participants. The following equation was employed to determine the error associated with the sample size:

$$n = \frac{N}{1 + Ne^2} \qquad \text{Equation 1}$$

Where,

n = sample size

N = population size

e = level of error

The level of error was determined to be 2.5 % which was reasonable for this study. A level of 5 % is commonly employed in research studies of socio-economic nature.

Table 3-3: Pre-Interview and Post-Interview Sampling

Sampling Plan	Taluk	Taluk Sample of Participants	Total Sample of Participants	Level of Statistical Sampling Error (%)
Pre-Interview Plan	HD Kote	80	159	0.00
	Nanjangud	79		
Post Interview Plan	HD Kote	72	145	2.46
	Nanjangud	73		

Further considerations of bias prevention are considered in the Interview Tool Development and Interviewer Training sections.

3.1.2.4 Ethical Considerations

As a requirement of socio-economic studies seeking personal information of participants, necessary clearances were sought and obtained from the Ethics Board of the partner NGO and the University of Windsor before the irrigation scheme participants were interviewed. In line with the ethical considerations, all data and information will be kept confidential and the privacy of the respondents will be maintained.

3.1.2.5 Interview Tool Development

The development of the interview tool mainly emerged through the system and outcome mapping processes combined with the literature review. Once the study system was scoped as described above in System Mapping and Taluk Selection, the areas of the system were then examined for the availability of secondary data and data sources as shown in Table 3-2. This provided the research team with an understanding of which pieces of the system could be informed from already existing data and what needed to be collected through the primary data collection. The irrigation scheme participants were prioritized as a main source of information that was necessary to gain a deeper understanding of the irrigation scheme, its function, and the interaction of a participant with the irrigation technology. The interview tool was then selected as the method for data collection and the objectives of the interview were defined. After re-examining the outcome map, the objectives of the interview tool were scoped to reflect the desired outputs of the study. Six of the seven outputs were reflected in the interview tool. Those related to the first outcome were:

I. To understand the socio-economic status of the irrigation scheme participants
II. To determine the organizational structure of the irrigation scheme and implementation plan employed by the GC from the participant perspective; and
III. To understand the available support for BC farmers from other government or non-government organizations.

Those outputs related to the second outcome were:

I. To understand the implementation plan employed by the GC for the irrigation equipment selection, borehole site selection, and pump installation from the participant perspective;
II. To determine the water use and irrigation techniques practiced by irrigation scheme participants; and
III. To understand crop selections of irrigation scheme participants.

In order to achieve the desired outputs, the interview tool was divided into five main sections: General Information, Agriculture and Technology, Economic Information, Education, and Irrigation Scheme Overview. Information related to the desired areas of interest were prioritized and ordered in a manner that would provide a logical progression for the interviewers and the participant in thinking and providing information, as well as opportunities for verification with responses. Interviewer instructions and reminders were provided on the interview tool to help guide the field work and create consistency in how questions were asked and which guiding language was used.

Once the interview tool was approved, it was translated into Kannada, the local language. The translation was facilitated by the partner NGO and tested with the interviewers and

NGO staff. Iterations were made during Interviewer Training, after the Pilot Test, and again before the final ethics approval. A copy of the interview tool is provided in Appendix C.

3.1.2.6 Interviewer Training

The interview training was carefully constructed to equip interviewers with the tools and techniques needed to obtain ‘true’ results from study participants. The training was conducted in a two part series: pre-pilot test training and post-pilot test training. Pre-pilot test training was conducted from October 8^{th} – 9^{th} 2010. A traditional approach to experiential training was adopted for the irrigation scheme study. The training program addressed a wide range of topics including: the interview environment, types of questions, minimizing bias, body language, variability, threatening versus non-threatening questions, attitude versus behavior questions, open-ended versus close ended questions, potential field challenges, and experience sharing. Trainees were exposed to interviewing field techniques and oriented on the interview tool. Potential field challenges were discussed and the trainees practiced with the interview tool in pairs. Feedback was provided by trained NGO staff before the interview was piloted in the field. A copy of the pre-pilot test training program is provided in Appendix C. The post-pilot test training re-oriented interviewers on changes made to the interview tool based on feedback from the pilot test. Interviewers were provided with all of the materials to conduct the study and reminded of the detailed coding procedure.

3.1.2.7 Pilot Test

On October 11^{th} 2010, the interview tool was tested in HDK with eight selected farmers. Each interviewer made notes and provided feedback on the feasibility and appropriateness of the interview tool. Further, members of the research team shadowed the trainees to observe potential challenges with the interview tool.

In addition, interviewers were screened and selected based on their field performance. Four surveyors were selected to continue in HDK and a new batch was screened for NAN. Three new surveyors were selected and trained by the end of October 2010.

3.1.2.8 Field Interviewing

Field interviewing took place from October 27th – November 10th 2010. All completed interviews were collected at the partner NGO and verified by the research team leaders. Upon verification, the interviewers were paid.

3.1.2.9 Data Entry

All data formats were verified and entered into the database from November 10th 2010 – February 15th 2011.

3.1.2.10 Data Verification

Upon initial analysis, errors and bias in the collected data were discovered. The members of the research team re-examined all interviews and conducted field verifications in order to correct the collected data. To do this, all farmers were re-visited in NAN from June 3rd – June 17th 2011. Field follow-up in HDK was conducted from June 18th – June 28th 2011. All data was corrected and updated in the database by July 11th 2011.

3.1.2.11 Data Analysis Methodology

Data analysis for the Needs Assessment employed a statistical software package, Statistical Package for Social Science (SPSS) to analyze each question from the participant interview. Each section of the analysis examined the current status of the irrigation scheme in HDK and NAN as well as examined the various system elements that have contributed to the potential success or failure of the irrigation scheme. Items such as market data, net income, and usage details were only captured for participants with a functional borehole at the time of the interview; others had sold their land, had not obtained an electrical connection or the borehole had failed. Other data bifurcations were made to examine differences in individual and group schemes.

In order to effectively evaluate each question, the data was interpreted and some questions were standardized to provide an easy comparison amongst all study participants. The standardization or analysis process for selected data is defined below:

1. *Net income* was calculated based on participant responses for 2009 and 2010 incomes and expenditures in interview question #40. This data was obtained for participants that had functional boreholes at the time of the study or had boreholes that operated for more than 4.5 years before failure. With limited record keeping, *Net Income* was estimated using the following equation:

$$\begin{aligned} Net\ Income = {} & Agricultural\ Income \\ & - Agricultural\ Expenditure \\ & + Nonagricultural\ Income \\ & - Nonagricultural\ Expenditure \end{aligned} \qquad \text{Equation 2}$$

    a. For net incomes that were less than 0:
        - If the farmer was growing a commercial crop(s) (ie. Sugarcane) then the *Agricultural Income* was calculated based on the market data provided by the study participant. The calculated *Agricultural Income* was then used in the *Net Income* equation to obtain a more accurate estimate.
        - If the participant was growing a non-commercial crop(s) then a minimum *Net Income* of Rs. 1,000 was assumed.

2. Respondents with an annual net income of less than Rs 12,000 were reported as below poverty line (BPL) according to the rural BPL standard.

3. The time taken for irrigation scheme approval and implementation processes were converted into yearly estimates based on the number of months or years reported

for each stage of the scheme in interview question six. The process time steps were determined to be 0.25, 0.5 0.75, 1.0 etc. The total time taken from application submission to the first use of the borehole was calculated by adding up the time taken for each step as shown below.

$$\begin{aligned} &Total\ Time\ for\ Scheme\ Implementation \\ &\quad = Time\ Taken\ for\ Application\ Approval \\ &\quad + Time\ Taken\ for\ Borewell\ Digging \\ &\quad + Time\ Taken\ for\ Electrification \end{aligned} \quad \text{Equation 3}$$

4. Maintenance data were split into three main repairs specified by respondents: motor repairs, starter repairs, and fuse and other repairs. The maintenance data was converted to the average number of repairs per year.

$$\begin{aligned} &Average\ repairs\ per\ year \\ &\quad = Total\ number\ of\ repairs \\ &\quad \div Number\ of\ benefitting\ years * \end{aligned} \quad \text{Equation 4}$$

*Number of benefitting years was considered from the sanction year

5. According to Karnataka State standards [14] - marginal, small and medium scale farmers were considered to have a land holding size of 0 – 2.5 acres, 2.5 – 5 acres, and 5 – 7 acres respectively for interview questions 17 and 18.

6. Annual crops that were reported in multiple seasons, for interview question 19, were assumed to be planted either in the summer season or its common planting season. This assumption was made based off of the reported selling season in interview question 40 and literature review.

7. To describe the status of agriculture, the following concepts were used from interview question nine: intensity of cultivation, and the types of crops grown. In this case, the intensity of cultivation examined the number of seasons that a participant could cultivate in.

Other data was interpreted in a descriptive manner, by reporting the direct qualitative and quantitative results of the questionnaire, which provided a deeper understanding of the current status of the irrigation scheme and the different factors related to the irrigation scheme and its use.

3.2 Solution Development

The solution development was constructed using the Analytical Hierarchy Process (AHP) decision making model to improve the selection process of the irrigation scheme. The focus on the selection process as the area of improvement will be discussed in the A section since the AHP was informed and developed based on the findings in the Needs Assessment. However, an overview of the proposed change from the original irrigation scheme selection process in Figure 1-3 is provided in Figure 3-5.

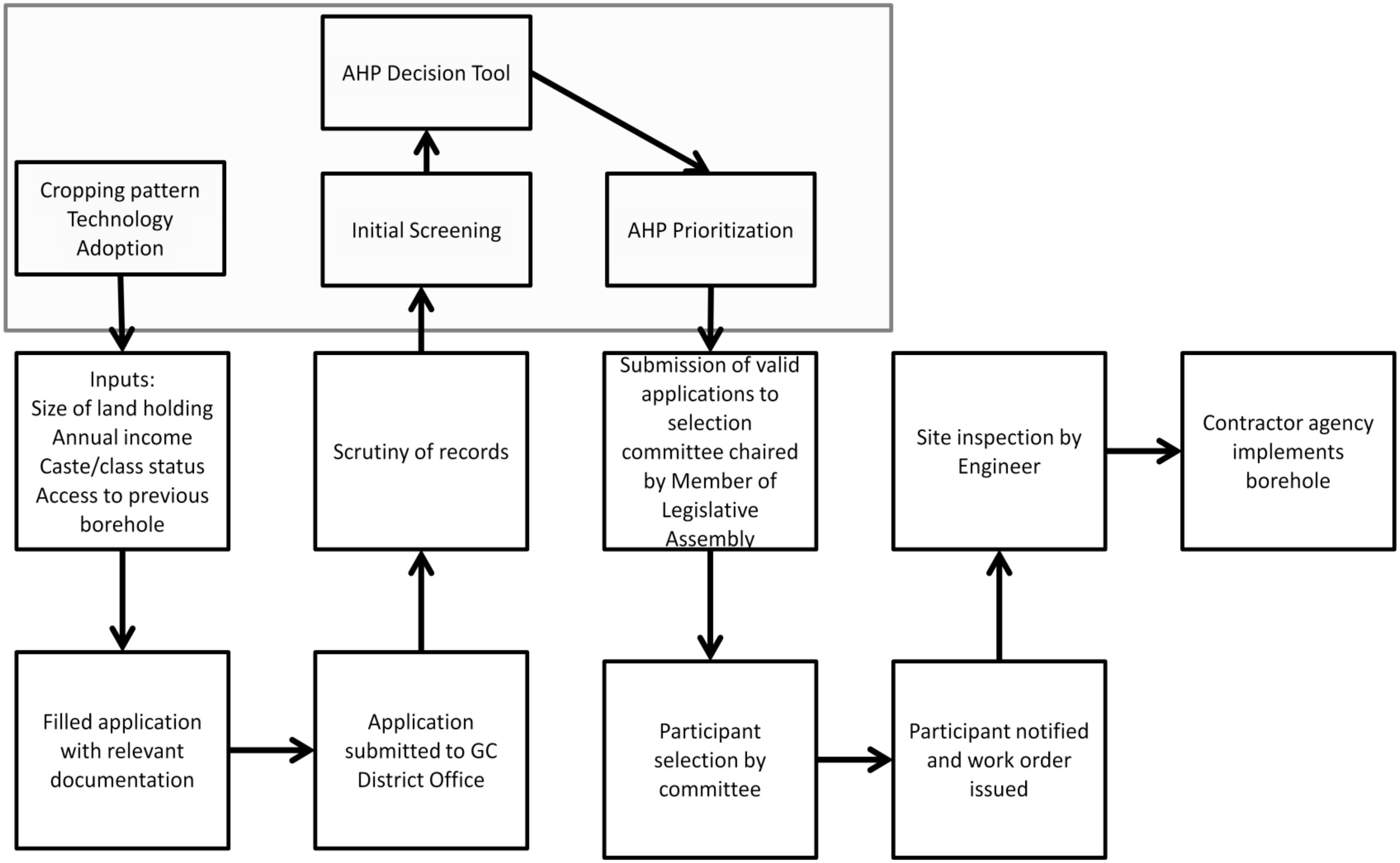


Figure 3-5: Proposed Irrigation Scheme Selection Process with AHP

The developed decision making tool consisted of four main decision criteria: Water Availability, Water Need, Technology Adoption, and Minority Status. This section provides an overview of the AHP methodology as well as the details of each decision criteria.

3.2.1 AHP Methodology

The AHP functioned as a decision making mathematical model that allowed selection options to be weighted against each other with respect to a specified criteria. The hierarchical structure of the AHP allowed for a system of quantitative and qualitative information to be represented together in the same model with each level in the hierarchy representing a different aspect of the system [45]. Figure 3-6 below displays the hierarchical structure of the irrigation scheme AHP model with the desired decision objective at the top, the salient system criteria in the middle level, and the selection options at the lowest level. As depicted in Figure 3-6, each selection option was weighted with respect to the decision criteria in the middle row of the hierarchy; similarly, the decision criteria were weighted with respect to the decision objective at the highest level of the hierarchy. The weighting of each selection option was conducted in a pair-wise manner using Satty's scale of one to nine [45] displayed in Table 3-4. Each option was compared to all other options in that level of the hierarchy and given a rating which was populated into a comparison matrix. By solving for the priority vector of the comparison matrix, the relative importance of each option was determined with respect to the criteria above it. The AHP comparison matrix construction is displayed below.

Table 3-4: Saaty's 1 to 9 Comparison Scale [45]

1	Elements are of equal importance
2	Judgment in between 1 and 3
3	Element A is weakly more important than B
4	Judgment in between 3 and 5
5	Element A is strongly more important than B
6	Judgment in between 5 and 7
7	Element A is very strongly more important than B
8	Judgment in between 7 and 9
9	Element A is absolutely more important than B

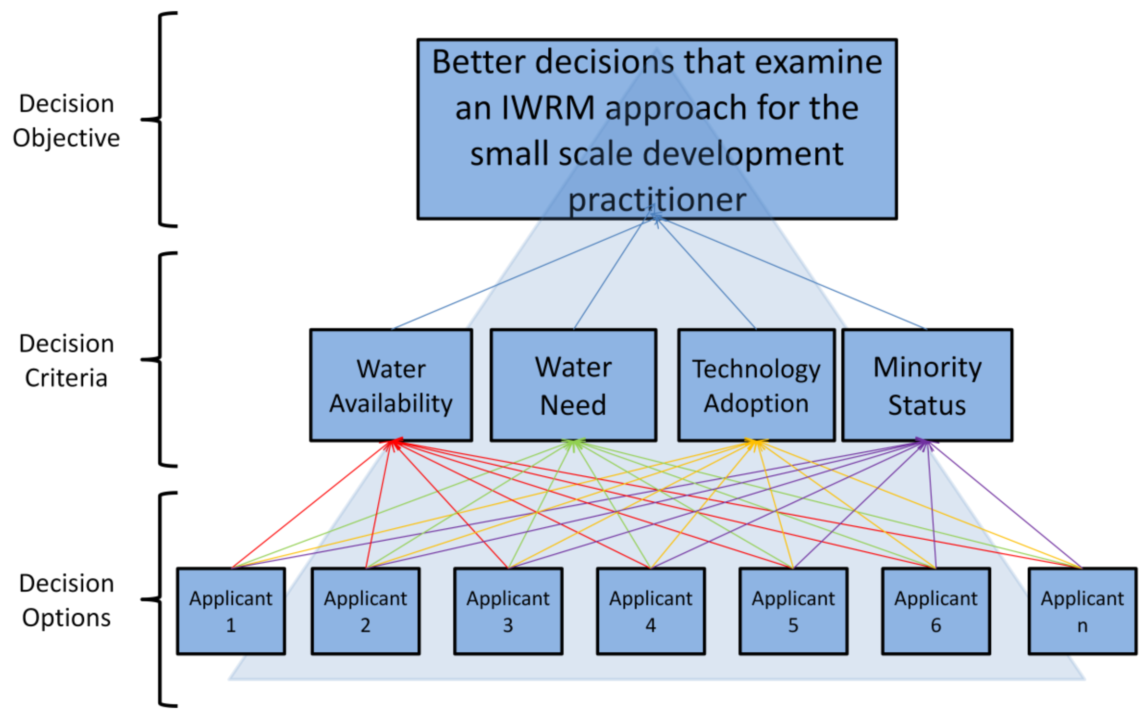


Figure 3-6: AHP Model for Irrigation Scheme

The AHP theory follows that the diagonal of every comparison matrix is 1 where a_{11}, a_{22}, and a_{33} signify the rating of option one, two, and three compared to themselves respectively; therefore a_{11}, a_{22}, and a_{33} each represent Saaty's rating of one – Elements are of equal importance [45].

$$Comparison\ Matrix\ A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

Further, it can be seen that a_{21} is the same as $1/a_{12}$ since a_{12} is the comparison of option one versus option two which is the reciprocal of the comparison of option tow versus option one. Therefore, we have

$$Comparison\ Matrix\ A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ 1/a_{12} & a_{22} & a_{23} \\ 1/a_{13} & 1/a_{23} & a_{33} \end{bmatrix}$$

The priority vector is then determined by solving for the principle eigenvector for the comparison matrix. The method employed in this research was first normalizing the matrix columns and then averaging the normalized rows as performed in Table 3-5 and Table 3-6. Applying matrix multiplication to the priority vector and dividing by the priority vector produced the eigenvalues as in Table 3-7. The maximum eigenvalue (λ_{max}) was then the average of the eigenvalues. Ideally, if the matrix is consistent, these eigenvalues will be close to the number of options in the matrix (*n*) [45].

In order to maintain internal consistency with the comparison matrix ratings, Saaty [45] developed a consistency index (C.I.) and a consistency ratio (C.R.). This index and ratio helped measure the transitivity of the matrix ratings as well as the intensity of transitivity. Both of these consistency measurements were useful as a monitoring tool when the decision model was employed. A C.R. of 0.1 or less was desired.

$$C.I. = \frac{(\lambda_{max} - n)}{(n - 1)} \qquad \text{Equation 5}$$

Where,

λ_{max} = maximum or principle eigenvalue

n = number of options in the matrix

$$C.R. = \frac{C.I.}{R.I.} \qquad \text{Equation 6}$$

Where,

R.I. = Random Index (experimentally determined for different *n* values [45])

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Sample calculations for the AHP are provided in the following section: Criteria Prioritization – Middle Level of the Hierarchy while remaining AHP calculations for the irrigation decision model are provided in Appendix D.

3.2.2 Criteria Prioritization – Middle Level of the Hierarchy

Four selected criterion were chosen for the AHP decision model based on the results of the Needs Assessment: Water Availability, Water Need, Technology Adoption and Minority Status. These four criteria were rated in the AHP model based on their placement in the system mapping in the Needs Assessment and reflected relevant criteria to the decision objective in Figure 3-6. Water Availability was classified as a primary influencing factor and therefore received a higher level of comparative importance on Saaty's one to nine scale [45]. Water Need and Technology Adoption were both classified as secondary influencing factors dependent on participant behavior. Finally, elements considered for Minority Status fell into secondary and tertiary influencing factors; therefore, receiving the lowest comparative importance. The ratings for the decision criteria are provided in the comparison matrix below. Further, the priority vector, C.I. and C.R. are provided. As suspected the Water Availability was weighted 0.43 as a primary influencing factor, Water Need and Technology Adoption were closely weighted as 0.28 and 0.20 respectively and Minority Status was rated as 0.09 as a tertiary influencing factor as shown in Table 3-7. The C.R. was acceptable at 0.03.

Table 3-5: Second Level AHP Comparison Matrix

	Water Availability	Water Need	Technology Adoption	Minority Status
Water Availability	1.00	2.00	2.00	4.00
Water Need	0.50	1.00	2.00	3.00
Technology Adoption	0.50	0.50	1.00	3.00
Minority Status	0.25	0.33	0.50	1.00
SUM of Columns	2.25	3.83	5.50	10.00

Table 3-6: Second Level AHP Prioritization Calculation

	Water Availability	Water Need	Technology Adoption	Minority Status	SUM of Rows	SUM of Rows/n
Water Availability	0.44	0.52	0.38	0.36	1.70	0.43
Water Need	0.22	0.26	0.38	0.27	1.13	0.28
Technology Adoption	0.22	0.13	0.19	0.27	0.81	0.20
Minority Status	0.11	0.09	0.06	0.09	0.35	0.09

Table 3-7: Second Level AHP C.I. and C.R. Calculation

	Water Availability	Water Need	Technology Adoption	Minority Status	Vector Priority	Matrix Multiplication	Matrix Multiplication / Vector Priority
Water Availability	1.00	2.00	2.00	4.00	0.43	1.75	4.10
Water Need	0.50	1.00	2.00	3.00	0.28	1.17	4.12
Technology Adoption	0.50	0.50	1.00	3.00	0.20	0.82	4.04
Minority Status	0.25	0.33	0.33	1.00	0.09	0.36	4.06
						λmax:	4.08

C.I.=	0.03
C.R.=	0.03

This criterion weighting was chosen based on the system that the irrigation scheme was operating within and remained as a fixed prioritization in the AHP model.

3.2.3 Relating Decision Criteria to Decision Options – Lowest Level of the Hierarchy

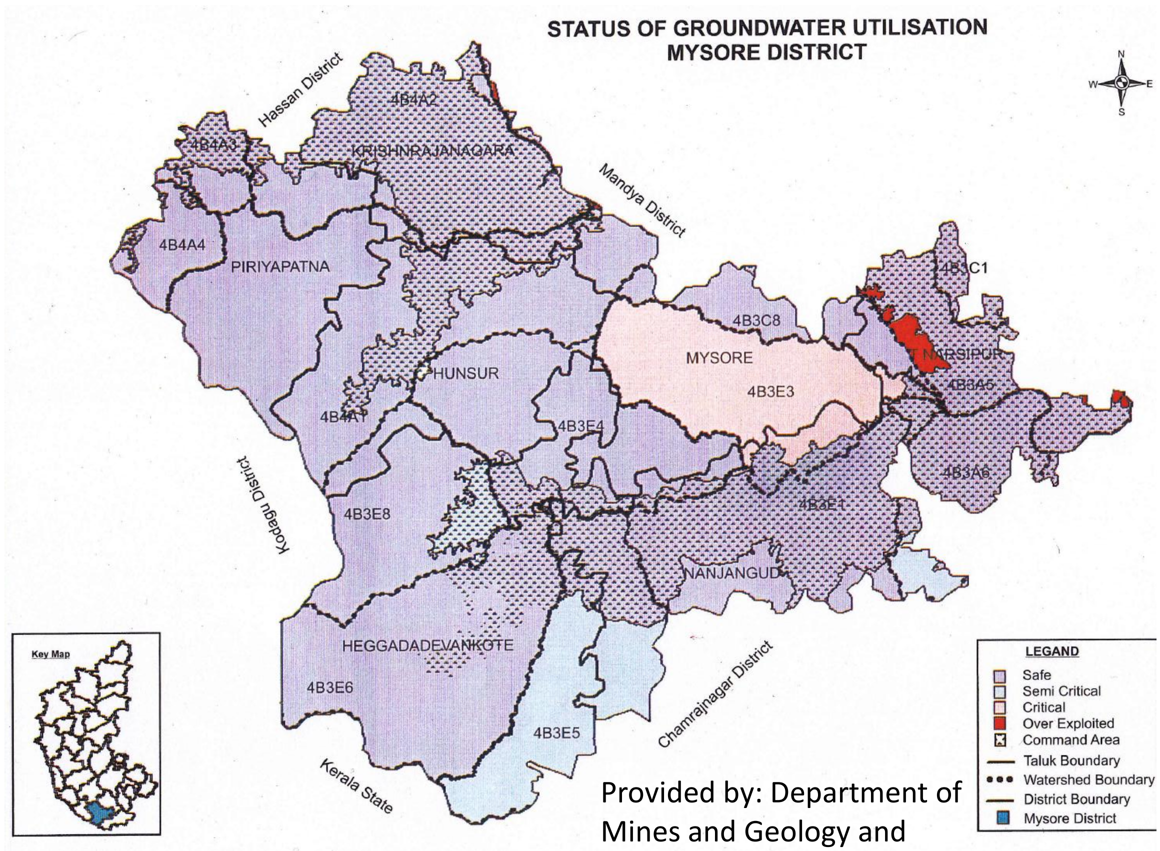
The lowest level of the hierarchy represented applicants to the irrigation scheme and required specific applicant information as inputs into the AHP decision tool. The tool was designed to be used each year during the selection process and facilitated data entry for each use. The development of the input applicant profiles were created through a combination of secondary data and applicant information. The details of the construction of the applicant profiles in relation to each decision criteria are provided in the following sections: Water Availability, Water Need, Technology Adoption, and Minority Status.

3.2.4 Water Availability

The Water Availability of an applicant was based on their geographical location and the state of groundwater development in their area. This information was taken from Dynamic Groundwater Resources of Karnataka - March 2009 [16] which used the ground water estimation method (GEM) to determine the state of groundwater development. There were four main classification of groundwater status: safe, semi critical, critical, and over exploited. The groundwater classifications and descriptions are provided in Table 3-8 and the groundwater status map is provided in Figure 3-7.

Table 3-8: Groundwater Classification adapted from [16]

Groundwater Status Classification	Description of Groundwater Classification
Safe	Groundwater development is < 70 % w/ no long term decline in groundwater trends OR Groundwater development is > 70 % and < 90 % w/ no long term decline in groundwater trends
Semi Critical	Groundwater development is > 70 % and < 90 % w/ a long term decline in either pre or post monsoon groundwater trends
Critical	Groundwater development is > 90 % and < 100 % w/ a long term decline in either pre or post monsoon groundwater trends OR Groundwater development is > 90 % and < 100 % w/ a long term decline in both pre or post monsoon groundwater trends OR Groundwater development is > 100 % w/ no long term decline in groundwater trends
Over Exploited	Groundwater development is > 100 % w/ a long term decline in groundwater trends



Provided by: Department of Mines and Geology and Central Ground Water Board South Western Region (Dec., 2010)

Figure 3-7: Groundwater Development Status, Mysore District taken from [16]

Based on the classification of the applicant, the comparison was converted to Saaty's one to nine scale as shown in Table 3-9.

Table 3-9: Water Availability Saaty Preference Scale

Water Availability				
GW Classification	Safe	Semi Critical	Critical	Over Exploited
Safe	1.00	5.00	7.00	9.00
Semi Critical	0.20	1.00	3.00	5.00
Critical	0.14	0.33	1.00	3.00
Over Exploited	0.11	0.20	0.33	1.00

Based on the researcher's judgment, the classification of safe was prioritized significantly more important than other categories due to the significant gap in the status of groundwater development in each of the classifications where up to 70 - 90 % of water development was still classified as safe. However, beyond the safe categorization, the need for conservation and limited exploitation of groundwater resources for the purposes of irrigation becomes increasingly important. Therefore, applicants that fell into semi critical, critical or over exploited statuses were de-prioritized compared to applicants that fell into the safe region to capture the significant gap in water availability in Saaty's one to nine scale. The input location and comparison matrix built into the tool are provided in Figure 3-8 and Figure 3-9; however the calculations employed for each dataset are provided in Appendix D with the final prioritizations. The priority vector, and corresponding C.I. and C.R. values were automatically calculated once the applicant groundwater statuses were input. This was conducted through a series of "IF" statements that linked the user input to the preferences in Table 3-9 and then linked to the final matrix multiplication as shown in Figure 3-10.

Water Availability	
Applicant	**Enter Water Status**
1	Safe
2	Safe
3	Safe
4	Safe
5	Safe
6	Safe
7	Safe
8	
9	
10	
11	
12	
13	
14	
15	

Figure 3-8: Water Availability Tool Input

Water Availability

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	7.00	7.00	7.00	7.00	7.00	7.00	7.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Figure 3-9: Water Availability Comparison Matrix

D29

	A	B	C	D	E	F
1		Third Level Priority Vectors				Second Level Priority Vector
2		Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43
3	1	0.14	0.35	0.11	0.14	0.28
4	2	0.14	0.17	0.11	0.14	0.20
5	3	0.14	0.02	0.33	0.14	0.09
6	4	0.14	0.17	0.11	0.14	
7	5	0.14	0.05	0.11	0.14	
8	6	0.14	0.17	0.11	0.14	
9	7	0.14	0.05	0.11	0.14	
10	8	0.00	0.00	0.00	0.00	
11	9	0.00	0.00	0.00	0.00	
12	10	0.00	0.00	0.00	0.00	
13	11	0.00	0.00	0.00	0.00	
14	12	0.00	0.00	0.00	0.00	
15	13	0.00	0.00	0.00	0.00	
16	14	0.00	0.00	0.00	0.00	
17	15	0.00	0.00	0.00	0.00	

	A	B
20	Final Applicant Priority	
21	1	0.1947
22	2	0.1450
23	3	0.1473
24	4	0.1450

Figure 3-10: Final Matrix Multiplication

The automatic nature of the design was created to minimize potential user mistakes at the input and allow for fast operation. The remaining three criteria in the AHP were automated in the exact same manner; however, the input details were constructed differently.

3.2.5 Water Need

The Water Need was built into the AHP model using Visual Basic for Applications (VBA) in Microsoft Excel. The Water Need was calculated using the inputs: crop selection, acreage, the growing start date, and rainfall to calculate the evapotraspiration (ET_c) for various crops, and effective rainfall (P_e) over the entire growing period. The Et_c of each crop was determined using the Blaney-Criddle equation for the reference evapotranspiration (ET_o), and the corresponding crop water coefficient (k_c) as displayed below [54].

$$ET_c = ET_o \times k_c \quad [54] \qquad \text{Equation 7}$$

where,

ET_o= reference evapotranspiration

k_c= crop water coefficient

The ET_o was calculated using the average monthly temperature (T_{mean}) for Mysore District and monthly constants for the percentage of daytime hours (p) based on the latitude for HDK and NAN of approximately 12° N. T_{mean} was averaged using normal minimum and maximum temperature data from 1901 – 2000 provided by the Meteorological Department [55].

$$ET_o = p(0.46(T_{mean}) + 8) \quad [54] \qquad \text{Equation 8}$$

where,

p = mean daily percentage of monthly daytime hours

T_{mean}= average monthly temperature

The monthly inputs and corresponding ET_o values are provided in Table 3-10.

Table 3-10: ETo Values Calculated Using Blaney-Criddle

	January	February	March	April	May	June	July	August	September	October	November	December
T_{max} (°C)	28.60	31.10	33.60	34.30	32.90	29.20	27.70	28.00	28.90	28.80	27.90	27.50
T_{min} (°C)	16.20	17.90	19.90	21.20	21.00	20.10	19.60	19.50	19.30	19.50	18.20	16.50
T_{mean} (°C)	22.40	24.50	26.75	27.75	26.95	24.65	23.65	23.75	24.10	24.15	23.05	22.00
p	0.26	0.27	0.27	0.28	0.29	0.29	0.29	0.28	0.28	0.27	0.26	0.26
ET_o (mm/day)	4.76	5.20	5.48	5.81	5.92	5.61	5.47	5.30	5.34	5.16	4.84	4.71

The crop coefficient (k_c) values and their respective growth stages were adopted from the FAO Irrigation Water Management: Training manual no.3 [54], Punmia, B.C. et al.[1], FAO Crop Water Information [56], FAO Irrigation and drainage paper 56 [57] and Netafim Irrigation India [58]. Although the crop coefficients may vary based on local conditions, this data was not available at the time of the study. As local data becomes available, the tool can easily be updated to reflect these changes. When available, k_c values were provided for four crop growth stages: initial stage, crop development stage, mid-season stage, and late season stage as shown for seven crop varieties in Figure 3-11. Alternatively, reasonable estimates were made for crops without coefficients available for each growth stage or where the growing period of each stage was unknown. The tool was created to accommodate either situation. All of the k_c values and corresponding crop growth stages are provided in Appendix D.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Crop Info		Kc					Growing Period (days)				
2	Crop Index	Crop Name	Initial stage	Crop dev. stage	Mid-season stage	Late season stage	Average Kc when stages N/A	Initial stage	Crop Development stage	Mid season stage	Late season stage	Total Growing Period when stages N/A
3	1a	Banana Year 1	0.5	0.8	1.1	1		120	90	120	60	
4	1b	Banana Year 2	1	1.1	1.2	1.1		120	60	180	5	
5	2	Barley/Oats/Wheat	0.35	0.75	1.15	0.45		15	25	50	30	
6	3	Bean, green	0.35	0.7	1.1	0.9		20	30	30	10	
7	4	Bean, dry	0.35	0.7	1.1	0.3		15	25	35	20	
8	5	Cabbage	0.45	0.75	1.05	0.9		40	60	50	15	
9	6	Carrot	0.45	0.75	1.05	0.9		20	30	50	20	
10	7a	Citrus 20% cover, no weed control	0.85	0.85	0.85	0.85		60	90	120	95	
11	7b	Citrus 20% cover, with weed control	0.5	0.475	0.45	0.55		60	90	120	95	
12	7c	Citrus 50% cover, no weed control	0.8	0.8	0.8	0.8		60	90	120	95	
13	7d	Citrus 50% cover, with weed control	0.65	0.625	0.6	0.65		60	90	120	95	
14	7e	Citrus 70% cover, no weed control	0.75	0.725	0.7	0.7		60	90	120	95	
15	7f	Citrus 70% cover, with weed control	0.7	0.675	0.65	0.7		60	90	120	95	

Figure 3-11: Crop Coefficients and Growth Stages

The overall water need is also affected by the available rainfall for the crop, known as effective rainfall (P_e). The effective rainfall is taken up by the crop and fulfills a portion of the water need [54]. Therefore, the overall water need was calculated using the Et_c and the P_e.

$$Water\ Need = ET_c - P_e \quad [54] \qquad \text{Equation 9}$$

where,

ET_c = crop evapotranspiration

P_e = effective rainfall

$$P_e = (0.8 \times P) - 25 \text{ for P > 75 mm/month} \quad [54]$$
$$P_e = (0.6 \times P) - 10 \text{ for P <= 75 mm/month} \quad [54] \qquad \text{Equation 10}$$

where,

P = monthly rainfall (mm/month)

This estimate for P_e was calculated according to the FAO Irrigation Water Management: Training manual no.3 [54]; however, P_e can be easily updated based on local available data for run-off, evaporation, and deep percolation past the root zone.

The above equations were applied for all crops except for paddy. Since paddy is grown in a flooded state, additional water is needed to saturate the soil, maintain the flooded level throughout the growing period, and compensate for percolation losses [54]. Therefore, a modified water need equation was employed.

$$Water\ Need = ET_c - P_e + SS + FW + PL \quad [54] \qquad \text{Equation 11}$$

where,

ET_c = crop evapotranspiration

P_e = effective rainfall

SS = soil saturation need

FW =flood water need

PL = percolation loss

The percolation loss was built in to the VBA and required the user to input the local percolation information based on soil type as shown in Figure 3-12. The application of the model distinguished between soil type in HDK and NAN. Therefore, the percolation was considered to be 8 mm/day for HDK taluk and 6 mm/day for NAN taluk. Further, monthly rainfall (P) was input by the user to complete the P_e calculation as shown in Figure 3-12. Both the monthly rainfall and percolation data were converted to meter units to reflect the needs of the VBA tool. Therefore, percolation became m/day and rainfall became m/month.

Monthly Rainfall Data For Applicant Location (mm/month)															
	Applicant 1	Applicant 2	Applicant 3	Applicant 4	Applicant 5	Applicant 6	Applicant 7	Applicant 8	Applicant 9	Applicant 10	Applicant 11	Applicant 12	Applicant 13	Applicant 14	Applicant 15
January	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ercolation Loss (mm/da	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

Figure 3-12: Monthly Rainfall and Percolation Tool Input

The function WaterRequired (CropIndex, StartDate, CropLandSize, FarmerRainfallIndex) returned the actual water need in cubic meters based on a specific crop, growing start date, crop land size, and farmer rainfall. The VBA code is provided in Appendix D. This function calculated the water need on a daily basis and summed the daily needs until the end of the growing period. The function performed this for each crop grown by every applicant. Once the water need was known for each crop, the total water need of each applicant, on a per acre basis, was determined and translated into a water need code of one to four. This one to four code was then converted into a Saaty [45] comparative preference based on researcher's judgement and populated into the matrix. The one to four code and Saaty [45] preferences are provided in Table 3-11 and Table 3-12.

Table 3-11: Water Need Codes

Water Need Code	Code Description
1	Water Need <= 2,500 m^3/acre
2	2,500 m^3/acre < Water Need < 5,000 m^3/acre
3	5,000 m^3/acre < Water Need < 7,500 m^3/acre
4	> 7,500 m^3/acre

Table 3-12: Water Need Saaty Preference Scale

Water Need				
	1	2	3	4
1	1.00	3.00	5.00	9.00
2	0.33	1.00	5.00	7.00
3	0.20	0.20	1.00	5.00
4	0.11	0.14	0.20	1.00

The selection of the code descriptions were based on a series of tests which examined the potential water needs while growing less water intensive crops during all three seasons (<=2, 500 m^3/acre) up to growing more water intensive crops during all three seasons (>

7, 500 m3/acre). The water need code one had a higher relative preference meaning that the applicant used less water per acre compared to the other applicants and most likely selected crops that were less water intensive. Similarly to Water Availability, the comparison matrix for Water Need was calculated with a series of “IF” statements built in to the model. The comparison matrix is provided below in Figure 3-13 while final prioritizations from the datasets are provided in Appendix D.

G6 =IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=1),'Priority Table Guide'!B10,IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=2),'Priority Table Guide'!C10,IF(AND(

Water Need

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	3.00	9.00	3.00	5.00	3.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.33	1.00	7.00	1.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	0.11	0.14	1.00	0.14	0.20	0.14	0.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	0.33	1.00	7.00	1.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	0.20	0.20	5.00	0.20	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	0.33	1.00	7.00	1.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	0.20	0.20	5.00	0.20	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	2.51	6.54	41.00	6.54	22.20	6.54	22.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Figure 3-13: Water Need Comparison Matrix

3.2.6 Technology Adoption

The Technology Adoption was created by examining two factors: Technology Selection and Time to Start. The Technology Selection of the applicant was broken into three different categories: No Appropriate Technology Selected, Farming Technology Adopted - Indirect Water Improvement, and Appropriate Technology Selected – Direct Water Improvement. Further, the Time to Start was categorized as: less than or equal to six months, six months to one year, and greater than one year. Each category was weighted zero, five, or 10 as shown in Table 3-13. Finally an applicant was provided with a total score based on the sum of the two factors.

In order to create the Saaty prioritization of the one to nine scale, all possible combinations of the two Technology Adoption factors were determined ranging from a score of zero to 20 as shown in Table 3-14. The results of the combinations were then prioritized as shown in

Table 3-15. The prioritization was linearly distributed based on researcher judgment with a comparative rating of 20 versus zero representing the highest Saaty preference of nine, where a rating of 20 meant the applicant fell into the categories: Appropriate Technology Selected – Direct Water Improvement, and a Time to Start of less than or equal to six months; alternatively, a rating of zero meant: No Appropriate Technology Selected. An improvement could be made with actual field data of the application efficiency of the technologies employed by the applicants; however, a linear approach was adopted for the scope of this research.

Table 3-13: Technology Adoption Category Ratings

Technology Selection		Time to Start	
Appropriate Technology Selected - Direct Water Improvement	10	<= 6 months	10
Farming Technology Employed - Indirect Water Improvement	5	6 months - 1 year	5
No Technology Selected	0	> 1 year	0

Table 3-14: Technology Adoption Possible Applicant Outcomes

Technology Selection	Time to Start	Possible Outcomes
10	10	20
10	5	15
10	0	10
0	0	0
0	0	0
0	0	0
5	10	15
5	5	10
5	0	5

Table 3-15: Technology Adoption Saaty Preference Scale

Technology Adoption					
Score Rating	20	15	10	5	0
20	1.00	3.00	5.00	7.00	9.00
15	0.33	1.00	3.00	5.00	7.00
10	0.20	0.33	1.00	3.00	5.00
5	0.14	0.20	0.33	1.00	3.00
0	0.11	0.14	0.20	0.33	1.00

Similarly to Water Need, the Technology Adoption comparison matrix was calculated with a series of "IF" statements which linked the user inputs to the comparison matrix.

The comparison matrix is provided below in Figure 3-14 while final prioritizations from the datasets are provided in Appendix D.

B18 =IF(COUNT(B3:B17)>=2,SUMIF(B3:B17,"<>#DIV/0!",B3:B17),FALSE)

Technology Adoption

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	3.00	3.00	1.00	3.00	3.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	9.00	9.00	3.00	9.00	9.00	9.00	9.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Figure 3-14: Technology Adoption Comparison Matrix

3.2.7 Minority Status

The Minority Status was determined by two main factors: acreage and income of the applicant. The irrigation scheme already examined applicants based on these criteria; however, the AHP tool provided further distinction between applicants by examining three land holding categories: marginal, small and medium; and two income brackets: below poverty line (BPL) and above poverty line (APL). Similarly to Technology Adoption, the final score of an applicant was determined by the summation of the applicant ratings in each factor. Each applicant obtained a score of 0 – 20 that was then translated into a Saaty comparison preference of one to nine based on researcher judgement. The Minority Status ratings, and Saaty preferences are provided in Table 3-16 - Table 3-18.

Table 3-16: Minority Status Category Ratings

<table>
<tr><th colspan="2">Land Holding</th><th colspan="2">Annual Income</th></tr>
<tr><td>Marginal (0 - 2.5 acres)</td><td>0</td><td>BPL (< Rs. 12,000)</td><td>0</td></tr>
<tr><td>Small (2.5 - 5 acres)</td><td>5</td><td rowspan="2">APL (> Rs. 12,000 & < Rs. 22,000)</td><td rowspan="2">10</td></tr>
<tr><td>Medium (5 - 7 acres)</td><td>10</td></tr>
</table>

Table 3-17: Minority Status Possible Applicant Outcomes

Land Holding	Annual Income	Possible Outcomes
0	0	0
0	10	10
5	0	5
5	10	15
10	0	10
10	10	20

Table 3-18: Minority Status Saaty Preference Scale

Minority Status					
Score Rating	0	5	10	15	20
0	1.00	3.00	5.00	7.00	9.00
5	0.33	1.00	3.00	5.00	7.00
10	0.20	0.33	1.00	3.00	5.00
15	0.14	0.20	0.33	1.00	3.00
20	0.11	0.14	0.20	0.33	1.00

Similarly to Technology Adoption, the Minority Status comparison matrix was calculated with a series of “IF” statements which linked the user inputs to the comparison matrix. The comparison matrix for Minority Status is provided below in Figure 3-15 while final prioritizations from the datasets are provided in Appendix D.

Minority Status

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	7.00	7.00	7.00	7.00	7.00	7.00	7.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Figure 3-15: Minority Status Comparison Matrix

3.2.8 AHP Tool Function

The AHP tool was created in Microsoft Excel so that it could be easily adapted by the GC or by similar small scale development organizations that focus on irrigation development in the water sector. The flow diagram from the inputs to the final prioritization is depicted in Figure 3-16. As described in previous sections, once the user entered the inputs into the tool, the remainder of the steps were automatically built in through the VBA code and internal equations present in each Microsoft Excel sheet. Each sheet was protected to prevent alterations of the internal equations during operation.

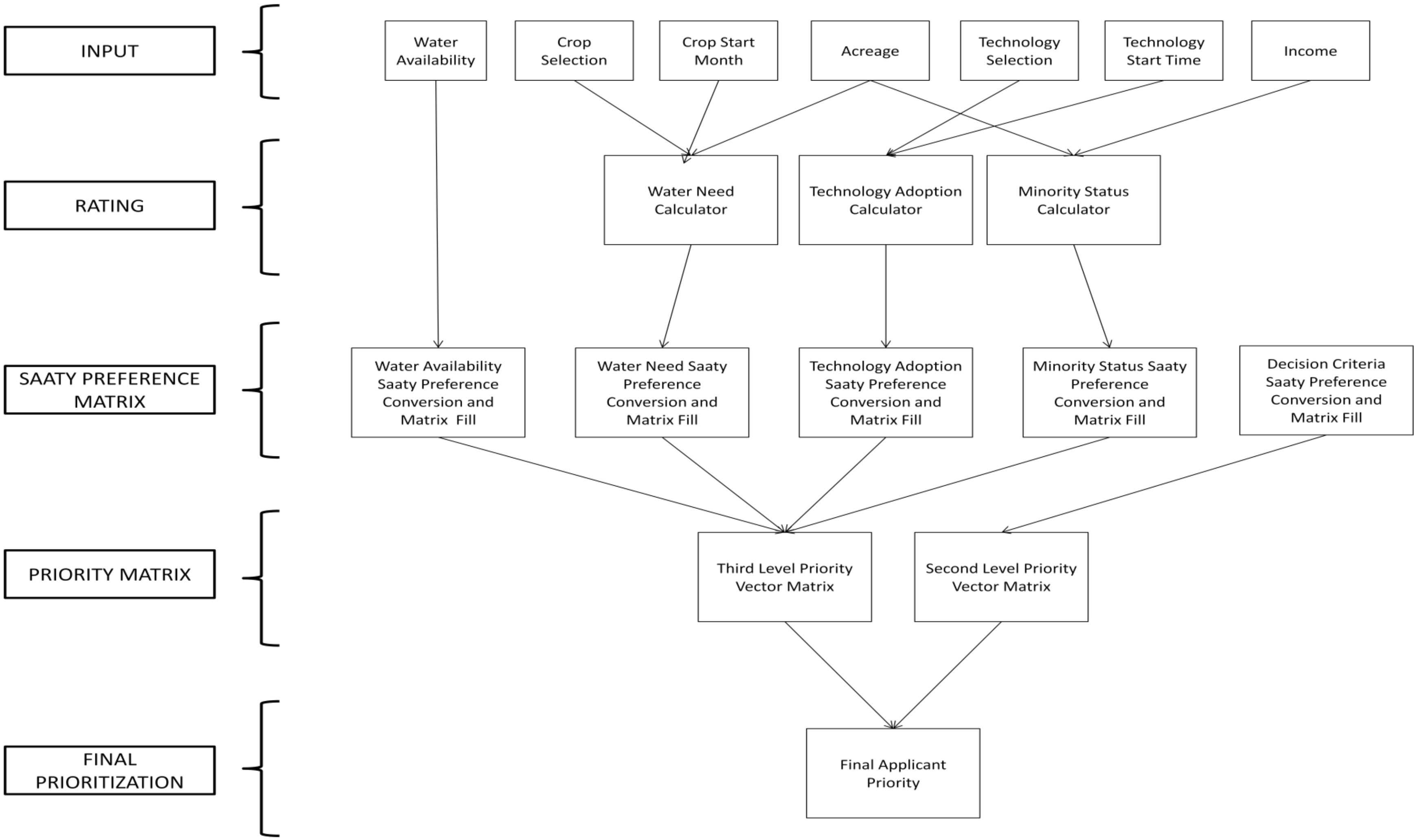


Figure 3-16: Flow Diagram of the AHP Tool

3.2.9 Choosing AHP

Although there were many decision making models that could have facilitated the irrigation scheme selection process, the AHP decision tool was selected for the following reasons:

1. The AHP decision making tool was designed to include qualitative and quantitative information.

2. The design of the AHP allowed for the pair-wise comparison of irrigation scheme applicants which minimized the arbitrariness of the decision making and provided a consistency measure of the transitivity of the priorities.

3. The AHP was easily incorporated into Microsoft Excel which was suitable to the local needs of the GC. The already existing knowledge using Microsoft Excel would provide an easier implementation of the tool with little training.

4. Since the preference tables are already built into the model, the AHP could be employed by hand during electricity failures if the inputs to the comparison matrices were already known.

5. The hierarchical structure of the AHP model mimicked system relationships, which is a fundamental characteristic of the AHP theory and a benefit to this system analysis combined with AHP adaptation.

The AHP model provided a lens to examine the irrigation scheme through and adapt salient features of the multi-dimensional system to the decision making model. As can be seen from the system map in Figure 3-3, the AHP structure employed in this research was scoped to address system elements related to Water Availability, Water Need, Technology Adoption, and Minority Status; however, further iterations upon the structure, and criteria weighting, and additional testing may provide a more complete system perspective. Adaptations to the AHP structure and examining different decision making models will be included in the Recommendations for Future Work section.

3.2.10 Sample Testing

In order to test the effectiveness of the AHP tool, seven sets of data were selected that contained applicant cases with known borehole failures. There were two cases from HDK taluk and five cases from NAN taluk. The selected cases were transformed into applicant profiles for Water Availability, Water Need, Technology Adoption, and Minority Status. Each set was input into the AHP tool to mimic a set of applicants that would apply to the irrigation scheme. The sets were created from collected data for known applicants from previous years as well as the GPS coordinates collected for borehole locations provided in Appendix E. The seven datasets are provided below in Table 3-19 to Table 3-25. Applicants with known failed boreholes are depicted with an "F". Data of applicants that applied for a group scheme were averaged to represent a single input. There were seven applicants removed from the datasets: four study participants had sold their land and were not available for consultation at the time of the study, and three applicant profiles were invalid due to missing information. The remaining applicants were input into the AHP tool and the final prioritizations, based on the constructed Saaty preferences, were generated.

Finally, the final prioritizations were normalized on a scale from zero to 100 % based on the minimum and maximum values of each dataset to examine the variation amongst outputs. Further, the percent difference from the minimum priority was determined to examine the distance of the true failed borehole from the predicted lowest prioritization in the model outputs.

$$Normalized\ Value = \frac{Value - Min}{Max - Min} \qquad \text{Equation 12}$$

$$Percent\ Difference\ from\ Minimum = \frac{Value - Min}{Min} \qquad \text{Equation 13}$$

Table 3-19: Dataset 1 for AHP Model

HDK Set 1	1	2	3	4 (F)	5	6	7
Water Availability	Safe	Semi Critical	Safe	Semi Critical	Semi Critical	Safe	Semi Critical
Water Need	1	2	4	2	3	2	3
Technology Adoption	15	15	20	15	15	15	15
Minority Status	15	15	15	15	15	15	15

Table 3-20: Dataset 2 for AHP Model

HDK Set 2	1	2 (F)
Water Availability	Safe	Safe
Water Need	3	3
Technology Adoption	15	20
Minority Status	15	10

Table 3-21: Dataset 3 for AHP Model

NAN Set 1	1	2	3	4	5	6	7	8 (F)	9	10 (F)
Water Availability	Semi Critical	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe
Water Need	4	4	2	4	1	3	1	1	2	2
Technology Adoption	15	0	0	15	0	0	15	0	0	0
Minority Status	10	15	15	10	10	15	15	10	15	15

Table 3-22: Dataset 4 for AHP Model

NAN Set 2	1 (F)	2
Water Availability	Safe	Safe
Water Need	3	3
Technology Adoption	15	0
Minority Status	15	15

Table 3-23: Dataset 5 for AHP Model

NAN Set 3	1	2	3	4	5 (F)	6
Water Availability	Safe	Semi Critical	Safe	Safe	Semi Critical	Safe
Water Need	2	4	2	1	3	3
Technology Adoption	0	0	0	15	15	15
Minority Status	15	10	15	10	15	15

Table 3-24: Dataset 6 for AHP Model

NAN Set 4	1	2 (F)	3	4	5	6	7
Water Availability	Safe	Safe	Safe	Safe	Safe	Safe	Semi Critical
Water Need	3	2	2	3	4	4	3
Technology Adoption	15	15	0	0	15	20	15
Minority Status	15	15	10	15	15	15	15

Table 3-25: Dataset 7 for AHP Model

NAN Set 5	1	2	3	4 (F)	5	6	7	8	9	10	11	12	13
Water Availability	Semi Critical	Semi Critical	Safe	Semi Critical	Safe	Safe	Safe	Semi Critical	Safe	Semi Critical	Semi Critical	Semi Critical	Safe
Water Need	4	4	1	2	2	4	4	2	2	1	2	4	2
Technology Adoption	20	15	15	15	15	10	15	15	15	20	15	10	15
Minority Status	10	15	15	10	10	15	15	15	10	15	10	10	15

CHAPTER 4

4 ANALYSIS OF RESULTS AND DISCUSSION

4.1 Needs Assessment Results

The results of the interview process were divided in three main sections: Borehole Use and Water Management, Socio-economic Status, and Scheme Observations. The results of the interview played an integral part in informing the system definition of the irrigation scheme and guiding the direction of the solution development. The critical findings from the Needs Assessment from the primary and secondary data are summarized at the end of this section.

4.1.1 Borehole Use and Water Management

The irrigation scheme interview examined 123 boreholes drilled from 2000 - 2009 which involved 145 participants. Among the 145 respondents, 83 were associated with an individual scheme and 62 were associated with a group scheme. Further, five participants were unavailable due to migration and had sold their land. Table 4-1 and Table 4-2 below display the year-wise borehole status in HDK and NAN taluks.

As of 2010, there were 80 boreholes functioning: 38 in HDK and 42 in NAN that serviced 89 participants. In total, 18 boreholes failed: seven in HDK and 11 in NAN which affected 21 participants. The borehole status in each Taluk is provided in Figure 4-1 and Figure 4-2. The acquisition of personal boreholes was also examined amongst respondents. In HDK and NAN, five and 12 participants, respectively, had obtained a personal borehole as of 2010. In addition, there were two members in HDK with two functioning boreholes including the scheme borehole and four members in NAN with two functioning boreholes including the scheme borehole. In order to obtain personal boreholes, there were four main payment methods reported by respondents: personal savings (47 %), bank loan (29 %), local money lender (18 %), or a local association (6 %). Participants that obtained a personal borehole after the failure of their scheme borehole are displayed in Table 4-1 and Table 4-2. Overall, most farmers used their borehole primarily for irrigation; however, a few farmers stated use for drinking water, household use, and for cattle.

Table 4-1: HDK Borehole Status as of 2010 Compared with Different Sanction Years

	Year Applicant Sanctioned									Cumulative 2010 Status	
	2000 - 2001	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	Number of Participants	Number of Boreholes
Functional Borehole	15	3	1	3	3	1	5	7	4	42	38
Failed Borehole	6	0	1	2	0	0	0	0	1	10	7
No Electrical Service	0	0	0	0	0	0	0	7	10	17	14
Sold land	2	1	0	0	0	0	0	0	0	3	3
Total	23	4	2	5	3	1	5	14	15	72	62

Table 4-2: NAN Borehole Status as of 2010 Compared with Different Sanction Years

	Year Applicant Sanctioned									Cumulative 2010 Status	
	2000 - 2001	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	Number of Participants	Number of Boreholes
Functional Borehole	3	9	3	1	2	8	7	10	4	47	42
Failed Borehole	0	3	1	0	2	3	1	1	0	11	11
No Electrical Service	0	0	0	0	0	0	1	2	7	10	8
Sold land	0	2	0	0	0	0	0	0	0	2	2
Broken	0	0	0	0	1	0	0	1	0	2	2
Not using	0	0	0	0	0	0	1	0	0	1	1
Total	3	14	4	1	5	11	10	14	11	73	66

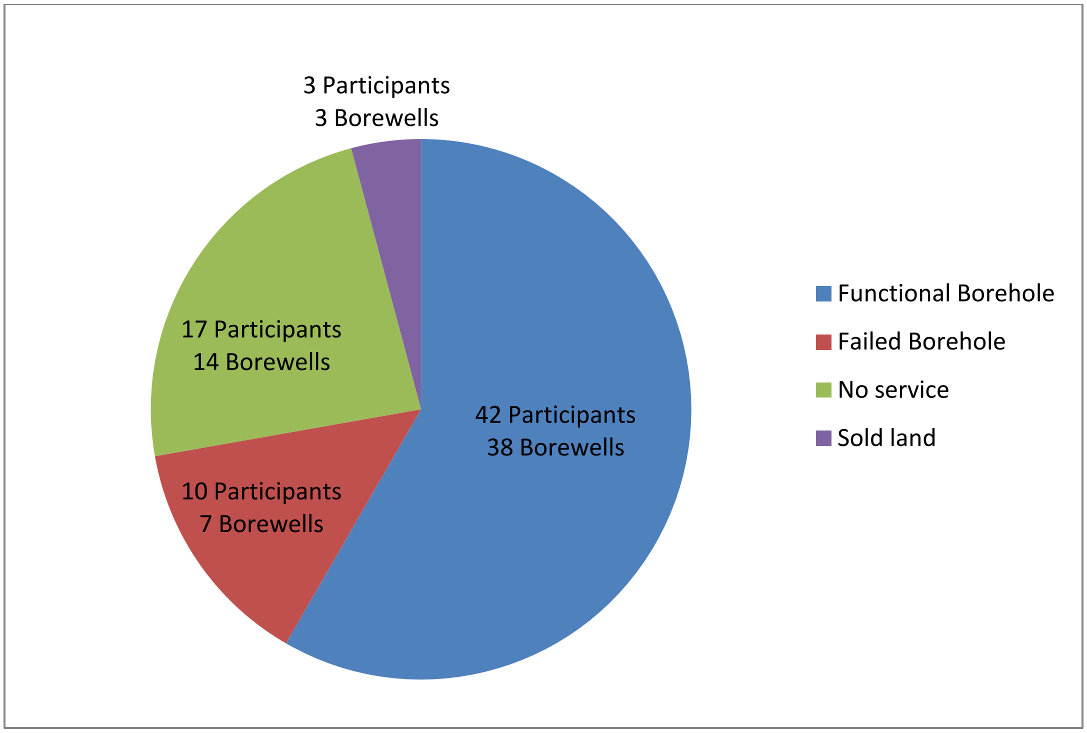


Figure 4-1: HDK Borehole Status as of 2010

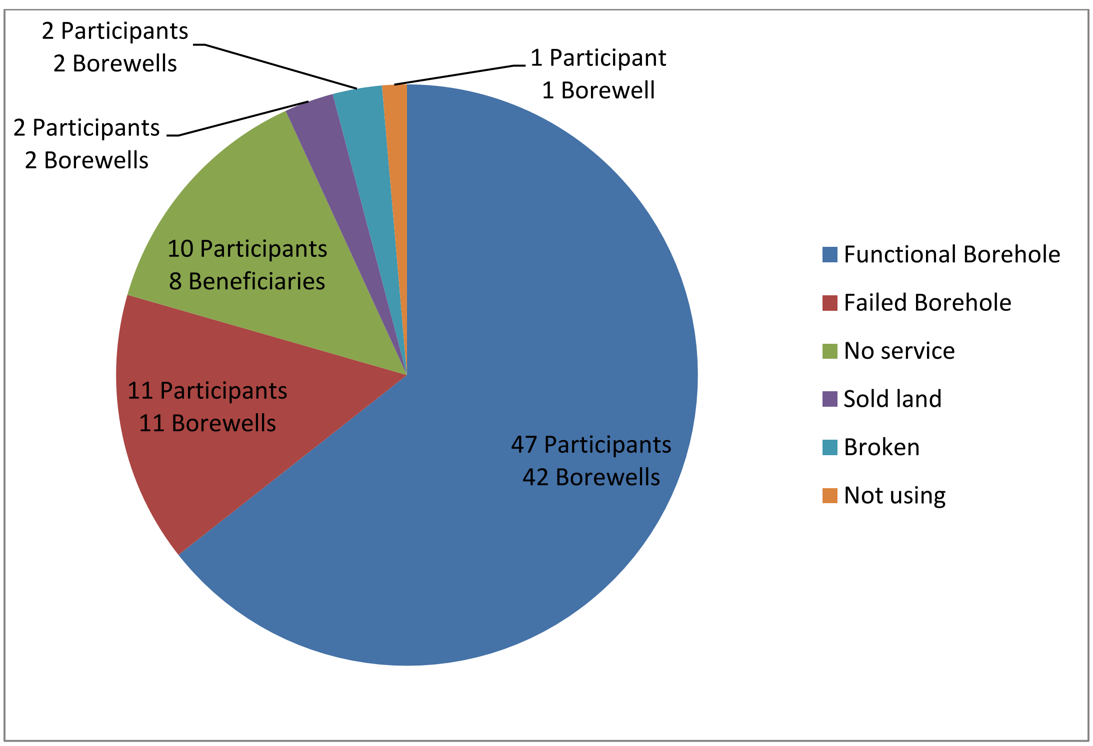


Figure 4-2: NAN Borehole Status as of 2010

Table 4-3: HDK Failed and Personal Boreholes as of 2010

<table>
<tr><th>Year Sanctioned</th><th>Borehole Depth at Sanction (m)</th><th>Water Yielding Capacity at Sanction (GPH)</th><th>Average Life of Borehole (Years)</th><th>Obtained Personal Borehole</th><th>Year Obtained</th><th>Payment Method</th></tr>
<tr><td>2000-01</td><td>98.4</td><td>1600</td><td>7.5</td><td>Yes</td><td>2010</td><td>Personal Savings</td></tr>
<tr><td>2000-01</td><td rowspan="2">60.5</td><td rowspan="2">1800</td><td rowspan="2">0</td><td rowspan="2">No</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>2000-01</td></tr>
<tr><td>2000-01</td><td rowspan="2">82.4</td><td rowspan="2">1600</td><td rowspan="2">4.5</td><td rowspan="2">No</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>2000-01</td></tr>
<tr><td>2000-01</td><td>93</td><td>1700</td><td>7.5</td><td>No</td><td>-</td><td>-</td></tr>
<tr><td>2002-03</td><td>93</td><td>1600</td><td>4.5</td><td>Yes</td><td>2010</td><td>Personal Savings</td></tr>
<tr><td>2003-04</td><td rowspan="2">61</td><td rowspan="2">1800</td><td rowspan="2">0.5</td><td rowspan="2">Yes</td><td rowspan="2">2010</td><td rowspan="2">Personal Savings</td></tr>
<tr><td>2003-04</td></tr>
<tr><td>2008-09</td><td>120</td><td>1200</td><td>0.5</td><td>No</td><td>-</td><td>-</td></tr>
</table>

Table 4-4: NAN Failed and Personal Boreholes as of 2010

Year Sanctioned	Borehole Depth at Sanction (m)	Water Yielding Capacity at Sanction (GPH)	Average Life of Borehole (Years)	Obtained Personal Borehole	Year Obtained	Payment Method
2001-02	92.9	1800	0	No	-	-
2001-02	84.3	1600	5.5	Yes	2010	Local Loan
2001-02	85.4	1400	0	Yes	2002	Personal Savings
2002-03	100.6	1600	0	Yes	2002	Personal Savings
2004-05	96	1200	N/A	Yes	2008	Personal Savings
2004-05	80	1300	N/A	No	-	-
2005-06	155	1200	2.5	No	-	-
2005-06	85	1800	3.5	Yes	2009	Local Loan
2005-06	90.5	1900	1.5	Yes	2008	Local Loan
2006-07	135	2500	1	Yes	2009	Bank Loan
2007-08	98	1500	0	Yes	2009	Local Association Loan

It was observed that the level of knowledge surrounding the usage of the borehole as a sustainable irrigation solution could be improved. Many respondents only operated the borehole in conjunction with electricity availability patterns as opposed to crop water requirements. Figure 4-3 displays the Taluk-wise borehole usage details expressed in 2010. In HDK participants were able to operate the borehole for approximately four hours per day depending on electricity availability and in NAN participants were operating for six to seven hours per day. A typical pattern of higher borehole use in the summer and winter seasons was depicted with some farmers displaying the same use all year round. One respondent had purchased three additional boreholes after the failure of the scheme borehole and as of 2010, only one borehole was functioning. Operating based on electricity patterns may not be as detrimental in 'over-exploited' water areas because the water availability is much less and a focus on recharge is necessary [16]; however, operating based on electricity availability in 'safe' water areas may lead to excess water use and little conservation especially when water intensive crop changes are adopted.

All participants reported a crop change after receiving the borehole. Major crops grown before the irrigation scheme included jowar, ragi and pulses; after receiving the scheme major crops grown included sugarcane, cotton, turmeric and vegetables. Based on the responses from participants, 65 % of the respondents grow annual cash crops of either sugarcane or banana.

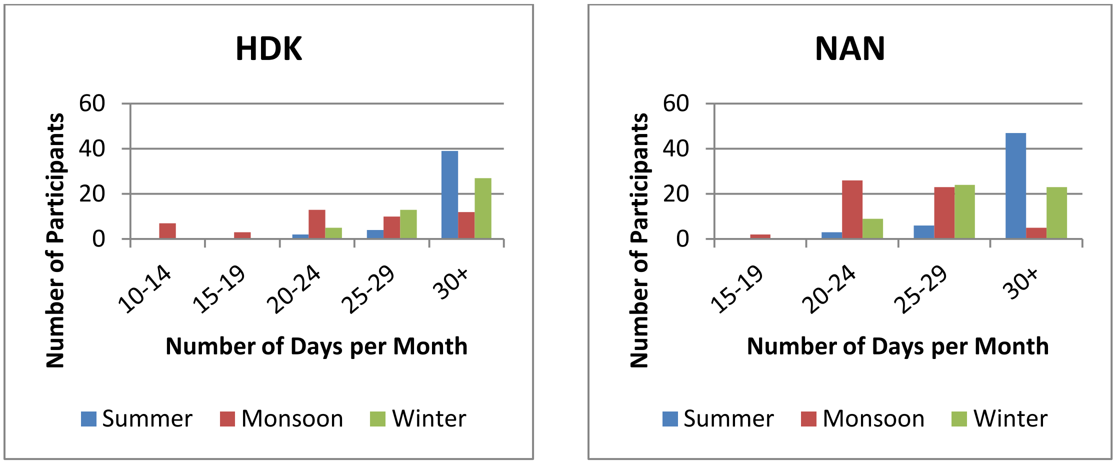


Figure 4-3:Taluk-wise Seasonal Borehole Usage as of 2010

Water recharge practices were not common amongst respondents; however, some participants expressed an interest in training or further information on additional irrigation related schemes. As of 2010, the implementation of alternative irrigation methods, such as sprinkler and drip irrigation were low with a total of 10 sprinkler systems and one drip irrigation system implemented by participants. Further, there was a high dependency on the irrigation borehole with only five respondents expressing access to canal irrigation and the remainder depending fully on rain-fed irrigation. Training on sustainable irrigation, mechanisms of rainwater harvesting, and ground water recharge were identified as critical issues to the sustenance of the irrigation scheme. It was discovered that such information and training was available with related departments like Agriculture, Watershed, and Horticulture; however there was no formal collaboration or relationship established within the scheme to introduce participants to such additional information.

For group schemes, all members displayed a sharing mechanism. None of the respondents specified any conflict in sharing the borehole or unequal sharing. In fact, group schemes tend to share the borehole as well as alternative technology. Once one member was able to invest in piping, tubing, or sprinkler jets, this technology was operated on all land associated with the group.

The majority of participants practiced indirect water improvement techniques through the use of furrow irrigation alone or furrow irrigation combined with polyvinyl chloride (PVC) piping. There were 30 respondents in HDK that were using on average 570 ft of PVC piping on their land. In NAN, there were 20 respondents that used on average 620 ft of PVC piping.

Additionally, some participants had to invest an additional Rs 40, 000 to install the motor with galvanized iron (GI) piping because they were provided with PVC piping from the supply agency. In NAN, this led to two cases of fallen motors due to the usage of PVC piping for the motor installation instead of GI piping.

Finally, the long term maintenance of the irrigation scheme was examined from the participant perspective. The average number of repairs was determined for the motor, starter, as well as the fuse and other minor maintenance items. Table 4-5 below shows the average number of repairs per year for the beneficiaries as well as the average annual cost. Motor repairs were the most frequent repairs conducted by beneficiaries and also had the highest associated cost. According to the GC, repairs and maintenance for group schemes should be handled by the scheme provided that funding permits; however, there was no explicit information that concluded group schemes were receiving this benefit. The majority of respondents specified support from the local mechanic or a family member. Further, some supply agencies provide a warranty for the supplied equipment for the first two years but only one respondent had reported communication with such an agency.

Table 4-5: Average Annual Repair and Costs for Irrigation Scheme Boreholes

	HD Kote		**Nanjangud**	
Repair Type	Avg Repairs/Year	Avg Cost/Year (Rupees)	Avg Repairs/Year	Avg Cost/Year (Rupees)
Motor	1.42	3550	1.48	4190
Starter	0.69	590	0.88	700
Fuse and Other	0.59	330	0.44	250

Overall, many participants had expressed interest in alternative irrigation methods, such as sprinkler or drip, but were unsure of other schemes that could provide them with this equipment. When respondents were asked about what improvements could be made to the irrigation scheme, most respondents commented on the provision for better quality equipment (i.e., motor, piping), and for continued support from the GC regarding repairs and assistance with the electricity connection. Some participants stated that the middleman (multiple contractual agencies and stakeholders in between) should be removed and the GC should take a larger role in the implementation process to make sure that every step of the scheme is conducted in a timely manner. Finally, a few respondents suggested that a GC official visit the borehole site more frequently, recommending one visit per month or one visit every three months.

4.1.2 Socio-economic Status

The socio-economic status of the irrigation scheme participants was captured for the year 2010. The socio-economic status examined the caste and gender breakdown of participants, family statistics, and economic status.

4.1.2.1 Participant Overview

The scheme interview covered 145 participants in HDK and NAN distributed over 61 villages. The gender breakdown of respondents, in group and individual schemes, for both Taluks is provided below in Figure 4-4. In total, approximately 12 % of respondents were female with an equal distribution between Taluks.

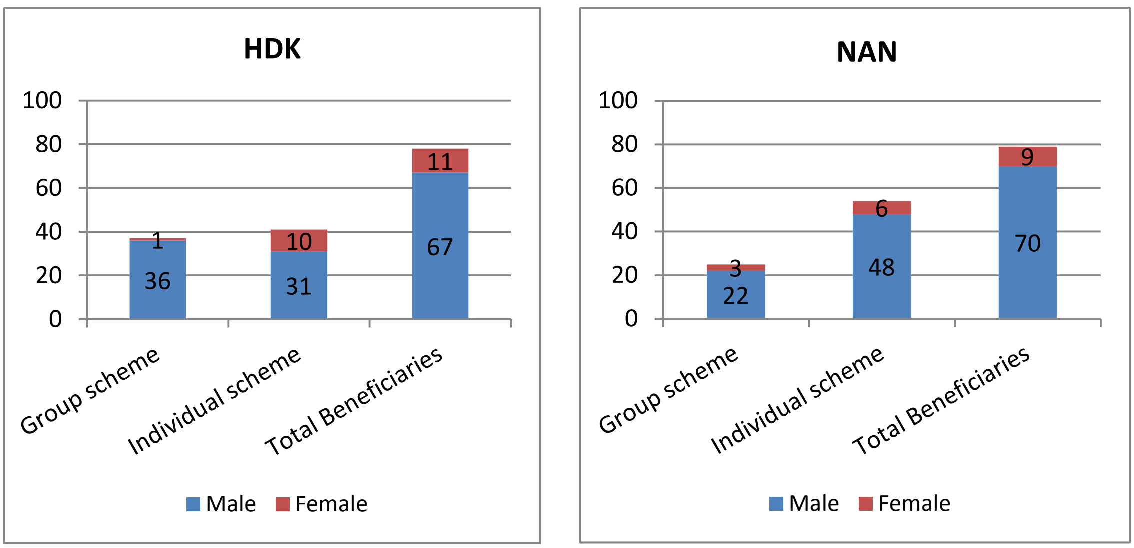


Figure 4-4: Taluk-wise Gender Distribution of Irrigation Scheme Participants in HDK and NAN

When examining the caste-wise distribution of the participants, it was discovered that the Vokkaliga and the Parivara Nayka castes represent the largest number of participants in HDK representing 42% of the participants in both Taluks. Figure 4-5 displays the caste breakdown of participants in HDK. In NAN, the Lingayat and Kuruba castes represent 58% of the participants as depicted in Figure 4-6.

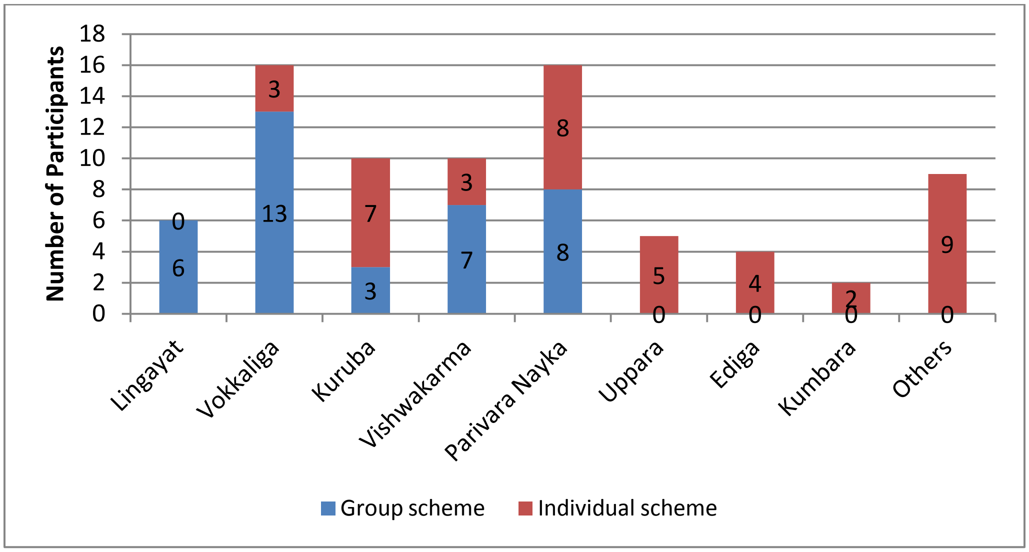


Figure 4-5: HDK Caste Distribution of Irrigation Scheme Participants

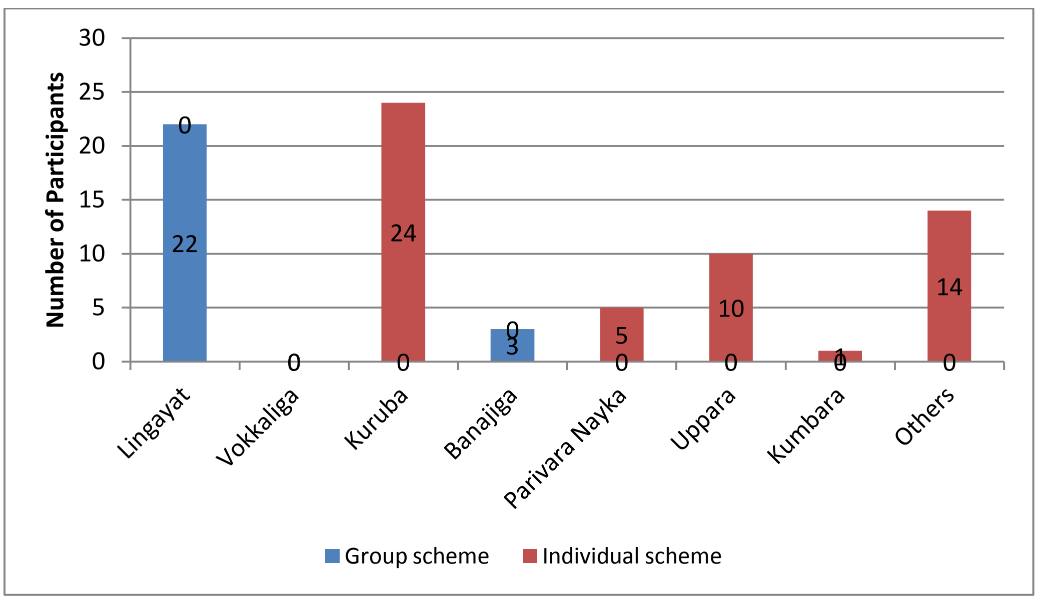


Figure 4-6: NAN Caste Distribution of Irrigation Scheme Participants

The age and level of education of all respondents are represented in Figure 4-7 and Figure 4-8 below. It can be seen that the majority of participants range from 40 years of age to 70 years of age. Further, more than 50 % of participants have not received any formal education and only 5 % have studied above 12th standard.

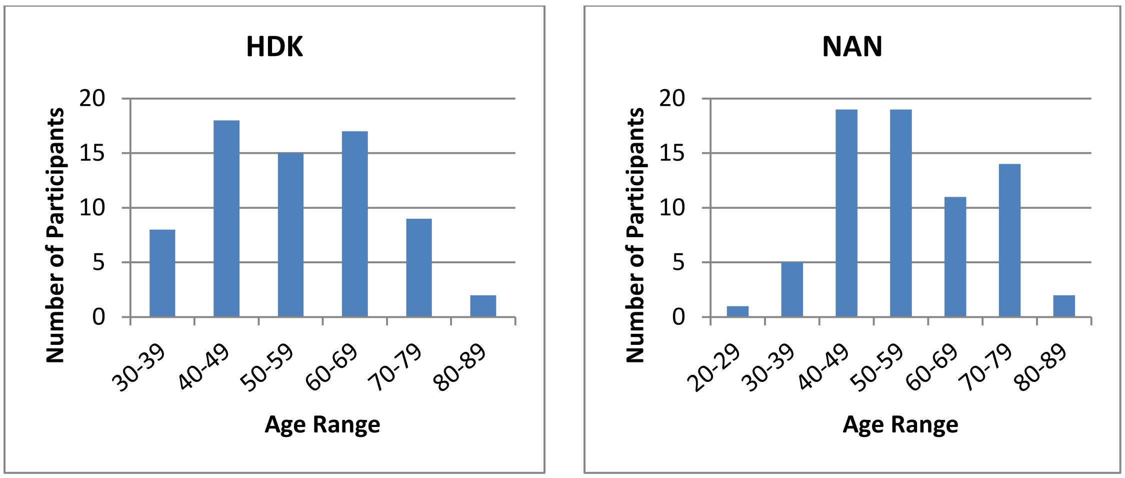


Figure 4-7: Taluk-wise Age Distribution of Irrigation Participants in HDK and NAN

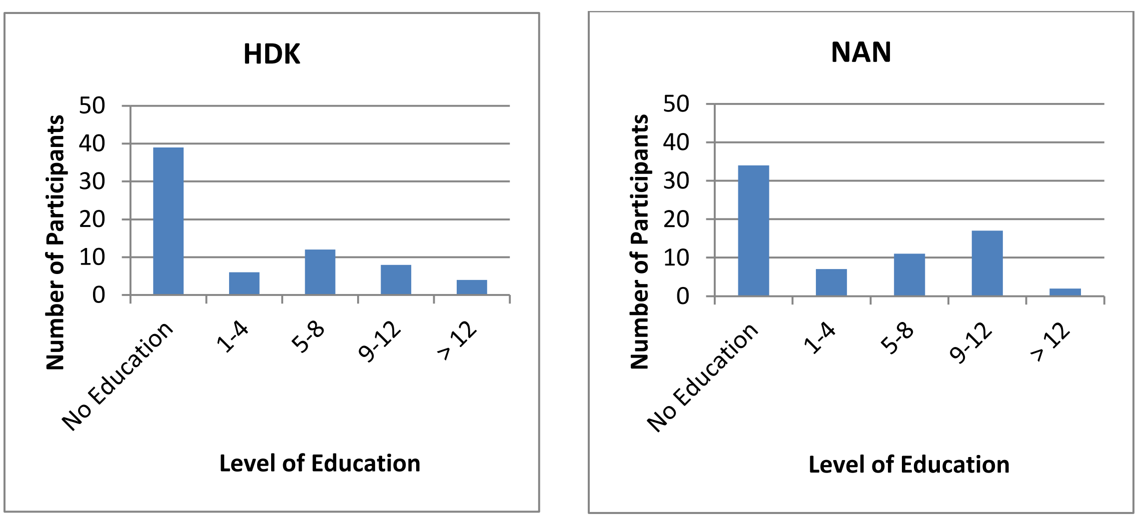


Figure 4-8: Taluk-wise Level of Education of Irrigation Scheme Participants in HDK and NAN

4.1.2.2 Household Statistics

The average number of household members for respondents was approximately five members with a minimum of one member per household and a maximum of 14 members per household. Figure 4-9 displays the Taluk-wise dependency of household members on the cultivatable land under the irrigation scheme. As depicted below, most farmers were cultivating on two to four acres of land.

In HDK, 82 % of households with more than five members farmed on two to five acres of land and depended on agriculture as the primary source of income. As of 2010, 57 % of these households were using their irrigation scheme borehole where as 43 % of boreholes either failed or had no electrical service. In NAN, 81 % households with more than five members relied on two to four acres of land and depended on agriculture as a primary source of income. In 2010, 69 % of these households had a working irrigation scheme borehole with 31 % not using due to failure, no electrical service, or a breakdown.

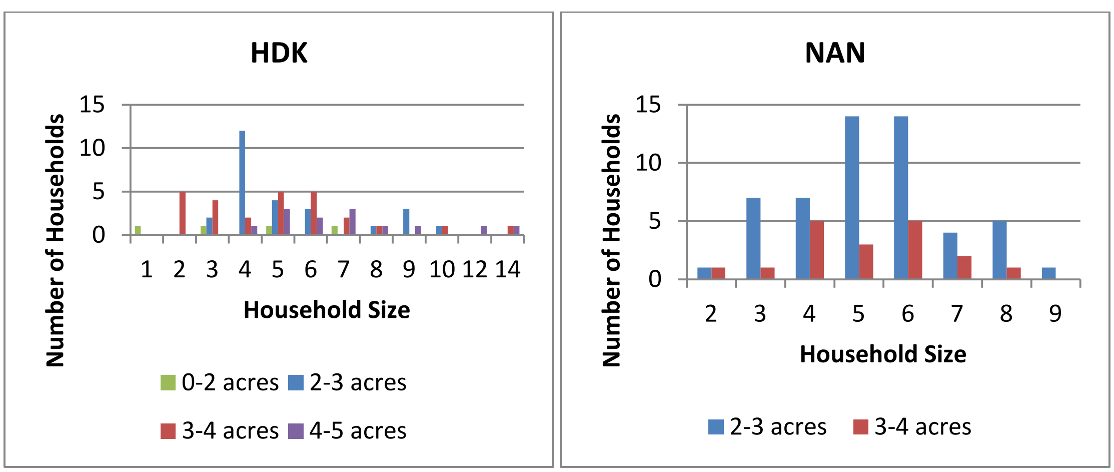


Figure 4-9: Taluk-wise Household Dependency on Cultivatable Land in HDK and NAN

Overall, 80 % of households in each Taluk were dependent on agriculture as the main source of income and approximately 13 % of households relied on one other family occupation such as daily agricultural labour or daily low-income labour in Mysore. Only 7 % of households in each Taluk relied on more than one other family occupation. Figure 4-10 displays the number of family occupations amongst respondents in HDK and NAN.

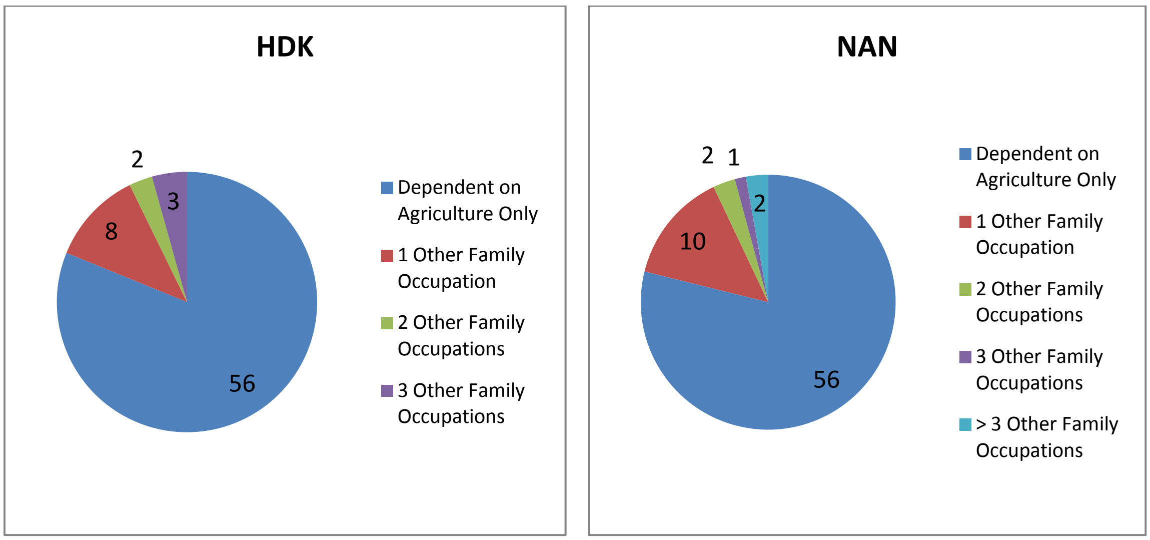


Figure 4-10: Taluk-wise Distribution of Household Occupations as of 2010 in HDK and NAN

4.1.2.3 Net Income Statistics

Income and expenditure data were captured for the years 2009 and 2010 from participants. However, all respondents in HDK and NAN reported that they do not keep income and expenditure records; therefore, responses for the most recent years were obtained. Of all valid respondents with working boreholes as of 2010, 55 % in HDK and 60 % in NAN reported net incomes of greater than Rs 20,000 for both 2009 and 2010. Only four family members in HDK and three members in NAN had an annual income at BPL levels of less than Rs 12,000 for 2009 and 2010.

Figure 4-11 to Figure 4-16 display the overall net income status for respondents in each Taluk as of 2009 and 2010. Further, the 2009 and 2010 net income is compared for various irrigation scheme sanction years. There were no significant differences between incomes for participants in different scheme years or those with and without other family occupations. In 2009 and 2010, group scheme net incomes were, on average, Rs 4,400 more than net incomes of individual schemes. Without baseline data, regular monitoring, or a sufficient control group, there was no conclusive evidence to indicate that the irrigation scheme had or had not impacted the net income reported in 2009 and 2010; however, this information could be used in future studies and may provide a foundation for further research.

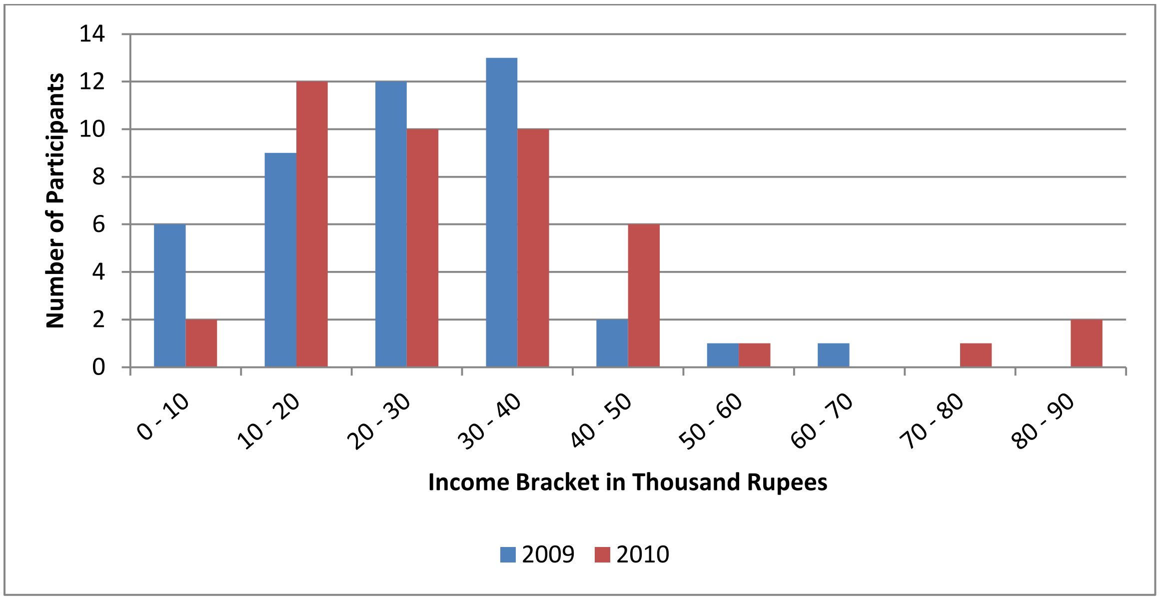


Figure 4-11: HDK Annual Income Status of Irrigation Scheme Participants for 2009 and 2010

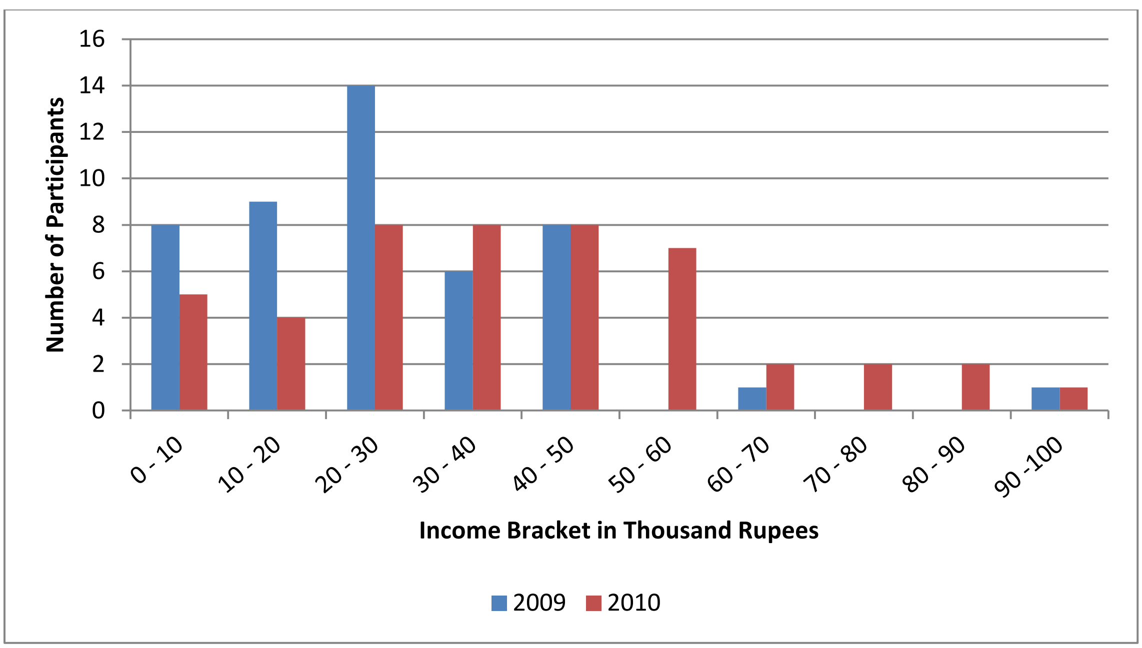


Figure 4-12: NAN Annual Income Status of Irrigation Scheme Participants for 2009 and 2010

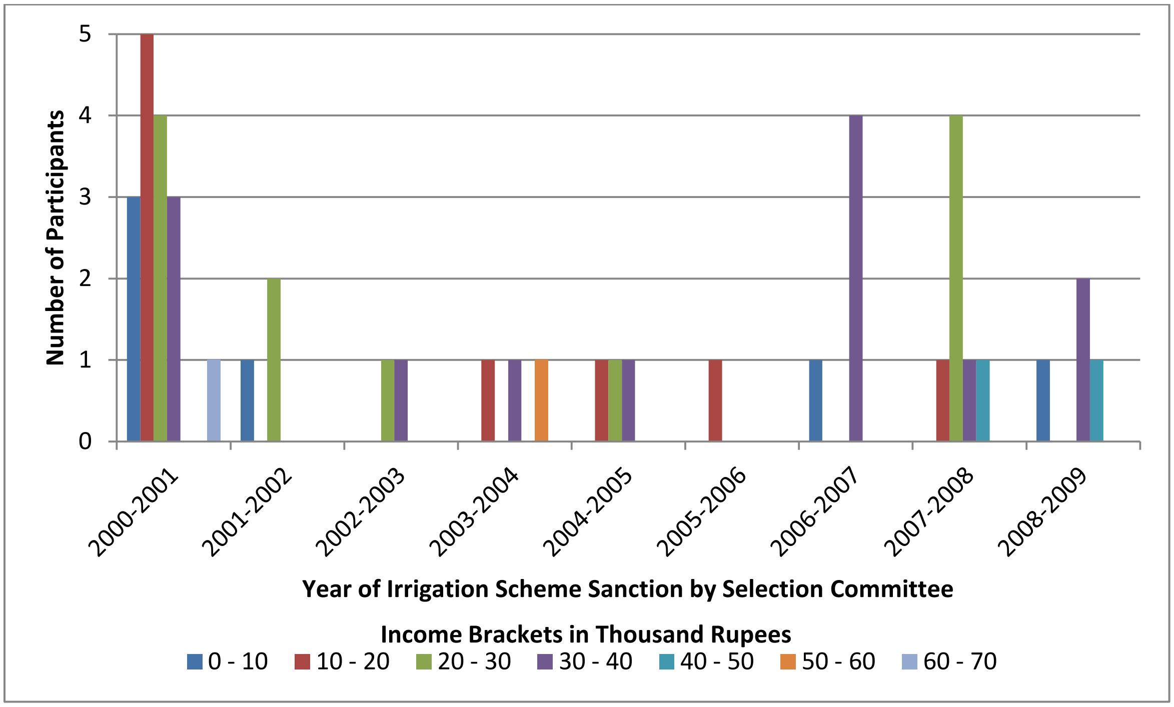


Figure 4-13: HDK Annual Income Status for 2009 Distributed by Irrigation Scheme Sanction Year

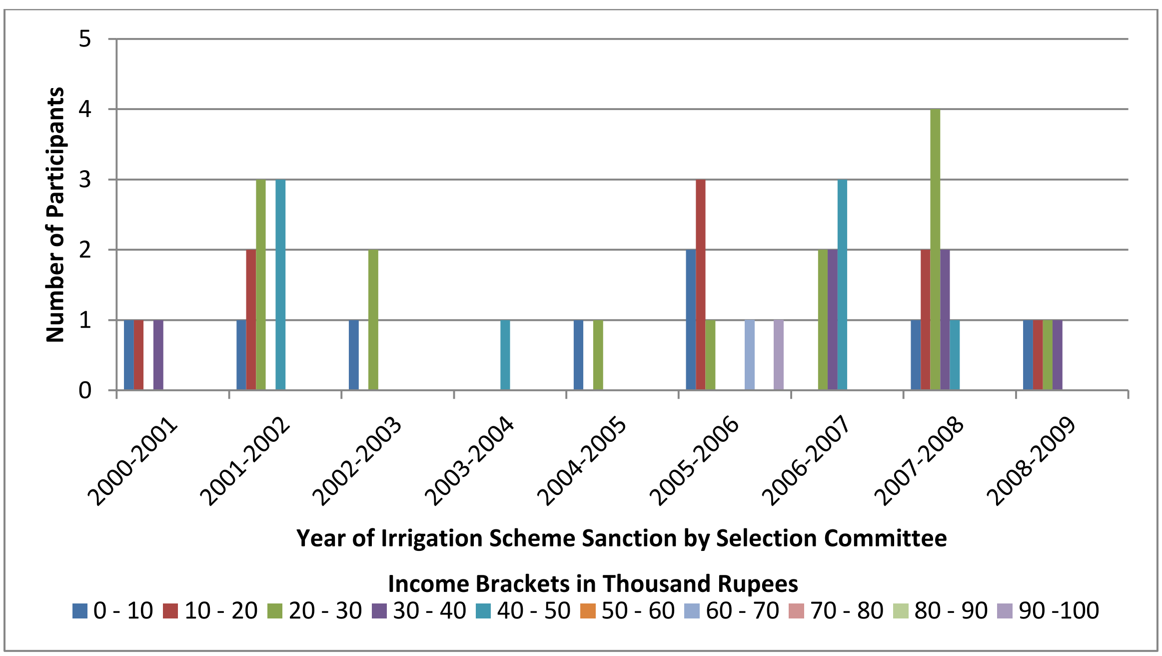


Figure 4-14: NAN Annual Income Status for 2009 Distributed by Irrigation Scheme Sanction Year

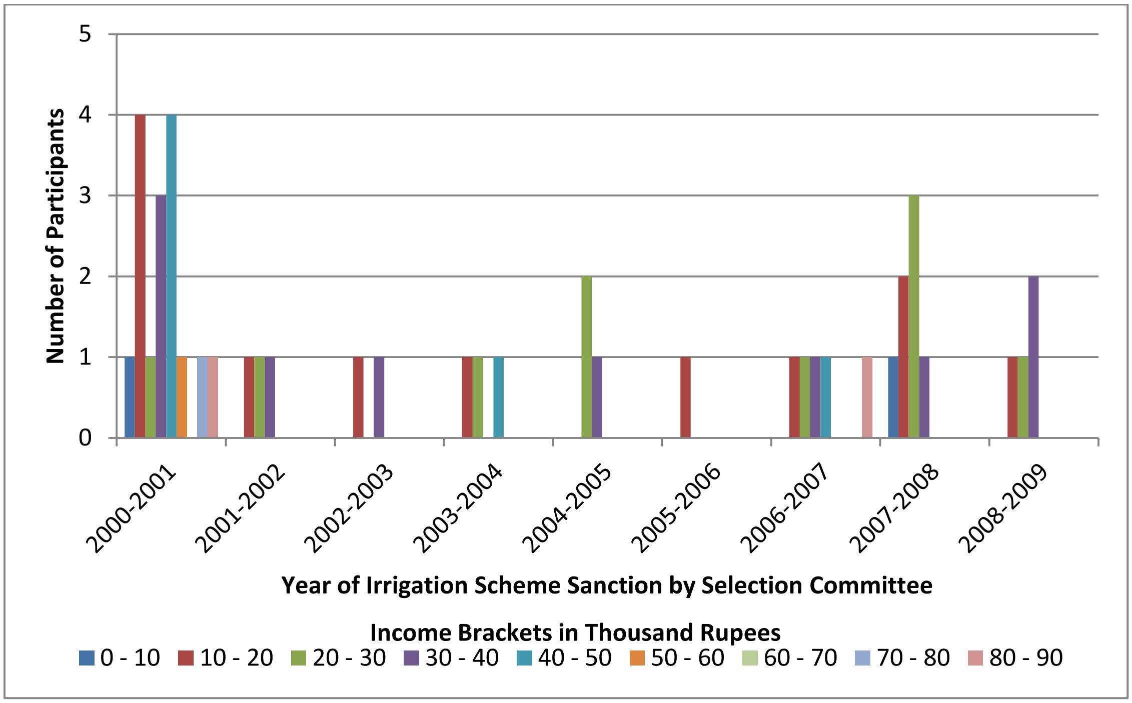


Figure 4-15: HDK Annual Income Status for 2010 Distributed by Irrigation Scheme Sanction Year

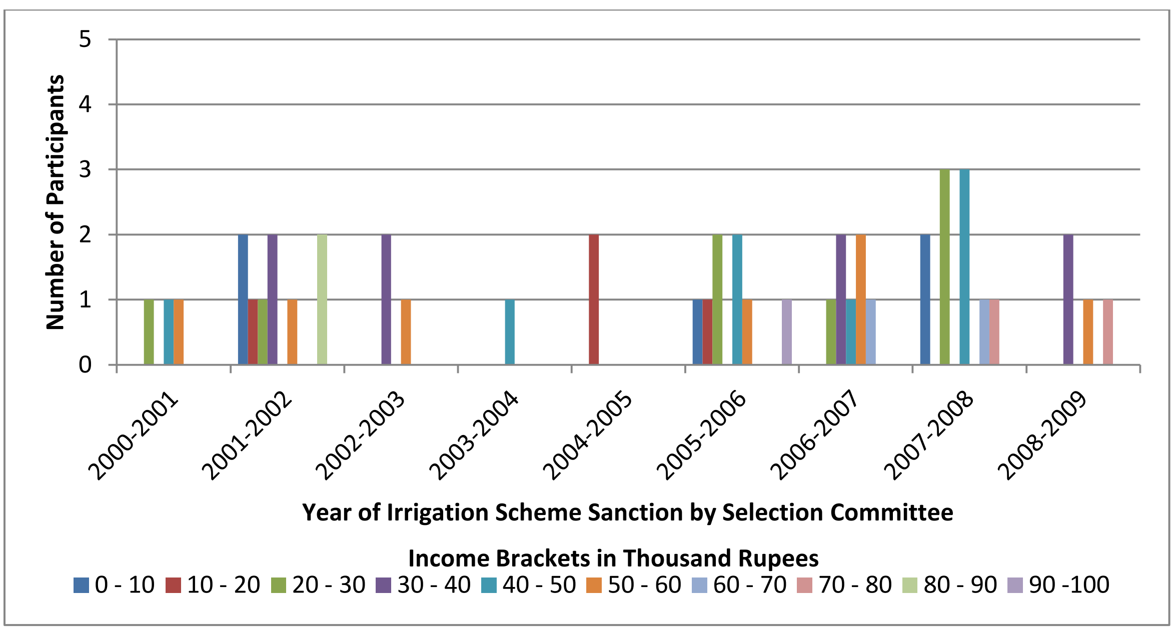


Figure 4-16: NAN Annual Income Status for 2010 Distributed by Irrigation Scheme Sanction Year

4.1.3 Additional Scheme ObservationsThis section provides additional

observations of the scheme taken from the interview process, secondary documentation provided by the GC or other departments, as well as field observations made by the research team.

1. All applicants were required to submit documentation regarding land ownership, annual income, and proof of backward class status. The process undergone to verify application documentation was not examined in this research due to constraints in stakeholder availability, documentation availability, and study resources. Some respondents expressed multiple land ownership, had the ability to invest in a personal borehole, or owned housing that suggested Above Poverty Line (APL) status; these factors may not have been captured in the application process.

2. While the role of Panchayath Raj (a government department) was not clear in the selection process, participants reported that the Grama Panchayath (GP) played a major role in advertising the irrigation scheme and GP members were frequently contacted for queries related to borehole maintenance and repair.

3. Some taluk officials expressed a limitation in human resources at the taluk and district levels by involved officials to effectively evaluate applications or take an active role in following up with applicant visits.

4. Although the selection process was clear, the grounds for accepting or rejecting applications in conjunction with funding availability, was not clear according to the scheme documentation. Although there was provision for 10 participants each year, it was discovered that funding for all 10 allotments may not be provided and in some cases only two applicants were selected.

5. It was not clear whether scheme targets were formulated based on budgetary allocations alone or other factors like taluk development indicators, the population of backward classes, existing ground water tables, ground water quality within each taluk, levels of ground water withdrawal or other existing irrigation opportunities.

6. On average, it took approximately two years before a participant could use their borehole as shown in Table 4-6. However, there were cases reported where the entire process took up to five years due to delays in the electrification of the

borehole. In some cases it was observed that the participant was required to obtain electrical poles and a connection from Chamundeshwari Electricity Supply Company (CHESCOM) before the actual electrification could be completed by the approved private agency. There were 27 cases identified where the borehole and pump-set were supplied but the electrification was delayed.

Table 4-6: Time Taken for Scheme Processes

	Application Approval (Years)	Borewell Digging (Years)	Electricity Connection (Years)	Full Scheme Completion (Years)
Average Time Taken in HDK	0.52	0.51	1.03	1.90
Average Time Taken in NAN	0.65	0.55	0.88	1.99

7. The irrigation scheme was implemented by three other GCs; however, from the available documentation and interviews, there were no shared strategies amongst the four corporations, no communication regarding best practices with the implementation of the irrigation scheme, and no shared support when faced with challenges. Increased communication and the development of a stronger support network amongst all four GCs could increase the efficiency of the scheme and also help the GCs streamline their activities.

8. Almost all participants with a functional borehole identified that the access to the irrigation scheme improved their crop yields. However, this was based off of participant perception from the interview.

9. Annual scheme targets were based off of the number of participants matching the financial allocation from the State Government. There was no monitoring built into the scheme in order to develop more effective targets and indicators of success. Many participants reported that this interview was the first follow-up that they have received since the implementation of the borehole. Monitoring data related to crop selection, crop yield, sustainable water management behaviours, and agriculturally related income and expenditures would greatly improve the GC’s ability to monitor or evaluate the performance of the irrigation scheme.

4.1.4 Needs Assessment Findings

As a result of the Needs Assessment, there were a number of potential areas of scheme improvement that were highlighted by the research team from the above observations; however, the Solution Development was scoped to address the irrigation scheme selection process conducted by the GC and the MLA as shown in Figure 3-5. The purpose of the scoping was not to diminish the importance of the other system elements, but rather provide a solution that addressed multiple needs in the system while aligning the GC to the broader policy implications of the irrigation scheme development. Further, the understanding gained by investigating the system in such a broad manner, provided an opportunity to discover potential areas of 'compensating feedback' and capture the distance and complexity of cause and effect relationships within the system. This process of re-defining the system problem situation based on the needs assessment and focusing on the selection process as the area of improvement achieved the third and fourth step of the SSM. Although, the system definition will continue to change, it was assumed that the Needs Assessment provided an improved system definition that a solution could be constructed from this research.

By focusing on the selection process, it was discovered that a multi-criterion decision making tool would allow the GC and MLA to consider the irrigation scheme applicants from the social and economical criteria already in place and also integrate criteria related to water sustainability, and technology adoption. Further, the tool criteria would align to the new Karnataka State irrigation regulations established under K.A. No. 25 of 2011 [20], and it would enhance the transparency of the selection process for participants by making the criteria more integrated and explicit. Finally, the multi-criterion decision making tool, an Analytical Hierarchy Process (AHP) model, would address challenges associated with limited baseline data by using and managing information related to crop selection, annual income and technology adoption thereby gathering this data to use as a baseline for future research.

The implementation of the decision tool could be facilitated using Microsoft Excel which was already commonly used amongst the GC and such a solution required no further human resources demand. Table 4-7 provides a snapshot of before and after the selection process, before using the AHP model and after. Limitations to the implementation will be discussed in the AHP Results section and further opportunities for research will be provided in the Recommendations for Future Work section.

Table 4-7: Salient System Features Captured in Status Quo and with AHP

Salient System Features – *items italicized refer to requirements in K.A. No. 25 of 2011*	Status Quo/Current Situation	With AHP tool - * refers to items that have been improved from the status quo
Location	X	X
Landholding Size	X	X*
Crop Type		X
Cropping Pattern		X
Intended Borehole Use	X	X
Water Need		X
Water Availability Status		X
Farming Technique		X
Farming Technology		X
Water Technology		X
Annual Income	X	X*
Backward Class Category	X	X
Existence of Competitive Users		
Likelihood of Adversely Affecting Drinking Water in Vicinity		
Quality of Groundwater for Use		
Transparency in Selection Process	X	X*

4.2 AHP Results

The results of the AHP examined the final prioritization of seven different datasets of real case studies, with at least one known failed borehole in each set from HDK and NAN. These datasets specify values for each criterion in the AHP model where each criterion has a different range. Water Availability ranges from 'safe' to 'over exploited' with safe being preferred; Water Need ranges from one to four with one being preferred; Technology Adoption ranges from zero to 20 with 20 being preferred; and Minority Status ranges from zero to 20 with zero being preferred. Table 4-8 to Table 4-14 summarize the results from the model using the seven datasets.

The AHP prioritization values range from 0 – 1.0, with 1.0 being the most preferred and zero being the least preferred. AHP prioritizations of the same value are considered to be equally preferred. These trends are further highlighted using symbols in each of the tables: a solid black circle indicates the most preferred applicant and a solid white circle indicates the least preferred applicant. Three-quarter, half, and one-quarter black circles indicate middle ranges of preference. Ranking the alternatives can in turn be generated from comparing these preference values. To show these rankings on a % scale, a normalized prioritization is calculated and shown for each applicant.

In dataset one, applicant one was ranked as the most preferred and applicants five and seven were ranked as the least preferred. In this dataset there was a clear distinction between the top three applicants and the bottom four applicants. Further, there were two sets of like cases: applicants seven and five as well as applicants two and four. The failed borehole was ranked fourth. Minority Status in this dataset did not create any variation amongst the applicants.

In dataset two, the failed borehole was ranked as the most preferred applicant with a preference of 0.573. The % difference from the least preferred applicant was 34 %. In this dataset the differences in Technology Adoption and Minority Status created the distinction between applicants considering Water Availability and Water Need were rated the same.

Dataset three contained two failed boreholes. One of the failures was ranked second and the other was ranked fourth. The most preferred applicant was applicant seven with a preference of 0.159. Even though applicants with the failed boreholes were rated zero for Technology Adoption, both displayed a lower Water Need. When further examining the results, it was surprising to see applicant one with a ‘semi critical’ Water Availability status ranked above two applicants with ‘safe’ Water Availability status. This will be further explored in Criteria Weighting and Like-Cases.

In dataset four, the failed borehole was rated as the highest preference with a rating of 0.576. This was 36 % from the lowest predicted applicant in the model. In this case, the variation in preference was determined by Technology Adoption.

Table 4-8: AHP Results Set 1

HDK Set 1	Water Availability	Water Need	Technology Adoption	Minority Status	Final Prioritization	% Difference from Minimum	Normalized Prioritization
1	Safe	1	15	15	● 0.246	● 237%	● 100%
2	Semi Critical	2	15	15	○ 0.1065	○ 46%	○ 19%
3	Safe	4	20	15	◕ 0.1986	◕ 172%	◕ 73%
4 (F)	Semi Critical	2	15	15	○ 0.1065	○ 46%	○ 19%
5	Semi Critical	3	15	15	○ 0.073	○ 0%	○ 0%
6	Safe	2	15	15	◕ 0.1963	◕ 169%	◕ 71%
7	Semi Critical	3	15	15	○ 0.073	○ 0%	○ 0%

Table 4-9: AHP Results Set 2

HDK Set 2	Water Availability	Water Need	Technology Adoption	Minority Status	Final Prioritization	% Difference from Minimum	Normalized Prioritization
1	Safe	3	15	15	○ 0.427	○ 0%	○ 0%
2 (F)	Safe	3	20	10	● 0.573	● 34%	● 100%

Table 4-10: AHP Results Set 3

NAN Set 1	Water Availability	Water Need	Technology Adoption	Minority Status	Final Prioritization	% Difference from Minimum	Normalized Prioritization
1	Semi Critical	4	15	10	0.079	25%	17%
2	Safe	4	0	15	0.063	0%	0%
3	Safe	2	0	15	0.086	37%	24%
4	Safe	4	15	10	0.1165	85%	56%
5	Safe	1	0	10	0.125	98%	65%
6	Safe	3	0	15	0.072	14%	9%
7	Safe	1	15	15	0.159	152%	100%
8 (F)	Safe	1	0	10	0.125	98%	65%
9	Safe	2	0	15	0.086	37%	24%
10 (F)	Safe	2	0	15	0.086	37%	24%

Table 4-11: AHP Results Set 4

NAN Set 2	Water Availability	Water Need	Technology Adoption	Minority Status	Final Prioritization	% Difference from Minimum	Normalized Prioritization
1 (F)	Safe	3	15	15	0.576	36%	100
2	Safe	3	0	15	0.424	0%	0

Table 4-12: AHP Results Set 5

NAN Set 3	Water Availability	Water Need	Technology Adoption	Minority Status	Final Prioritization	% Difference from Minimum	Normalized Prioritization
1	Safe	2	0	15	◑ 0.175	◑ 182%	◑ 48%
2	Semi Critical	4	0	10	○ 0.062	○ 0%	○ 0%
3	Safe	2	0	15	◑ 0.175	◑ 182%	◑ 48%
4	Safe	1	15	10	● 0.295	● 376%	● 100%
5 (F)	Semi Critical	3	15	15	○ 0.108	○ 74%	○ 20%
6	Safe	3	15	15	◑ 0.185	◑ 198%	◑ 53%

Table 4-13: AHP Results Set 6

NAN Set 4	Water Availability	Water Need	Technology Adoption	Minority Status	Final Prioritization	% Difference from Minimum	Normalized Prioritization
1	Safe	3	15	15	◑ 0.136	◑ 89%	◑ 46%
2 (F)	Safe	2	15	15	● 0.2	● 192%	● 100%
3	Safe	2	0	10	● 0.194	● 182%	● 95%
4	Safe	3	0	15	◔ 0.111	◔ 48%	◔ 25%
5	Safe	4	15	15	◔ 0.117	◔ 58%	◔ 30%
6	Safe	4	20	15	◕ 0.159	◕ 126%	◕ 66%
7	Semi Critical	3	15	15	○ 0.081	○ 0%	○ 0%

Table 4-14: AHP Results Set 7

NAN Set 5	Water Availability	Water Need	Technology Adoption	Minority Status	Final Prioritization	% Difference from Minimum	Normalized Prioritization
1	Semi Critical	4	20	10	0.063	103%	32%
2	Semi Critical	4	15	15	0.033	6%	2%
3	Safe	1	15	15	0.13	319%	100%
4 (F)	Semi Critical	2	15	10	0.0605	95%	30%
5	Safe	2	15	10	0.107	245%	77%
6	Safe	4	10	15	0.07	126%	39%
7	Safe	4	15	15	0.079	155%	48%
8	Semi Critical	2	15	15	0.054	74%	23%
9	Safe	2	15	10	0.1066	244%	76%
10	Semi Critical	1	20	15	0.107	245%	77%
11	Semi Critical	2	15	10	0.0605	95%	30%
12	Semi Critical	4	10	10	0.031	0%	0%
13	Safe	2	15	15	0.0996	221%	69%

Table 4-15: Consistency Measurement for Datasets

		Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5	Dataset 6	Dataset 7
Second Level	C.I.	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	C.R.	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Water Availability	C.I.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C.R.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Need	C.I.	0.08	0.00	0.07	0.00	0.09	0.07	0.02
	C.R.	0.06	0.00	0.04	0.00	0.07	0.05	0.01
Technology Adoption	C.I.	0.00	0.00	0.00	0.00	0.00	0.02	0.01
	C.R.	0.00	0.00	0.00	0.00	0.00	0.015	0.004
Minority Status	C.I.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C.R.	0.00	0.00	0.00	0.00	0.00	0.00	0.00

In dataset five applicant four was ranked as the highest preference at 0.295 and applicant two was ranked as the lowest preference at 0.062. The applicant with the failed borehole was ranked fifth out of six with a difference of 74 % from the predicted failure in the model. There was one like case identified with applicant one and applicant three. The results of this dataset provided a clear preference for applicant four with applicants one, three, and six all close to the second preference rank.

In dataset six, applicant two, with the failed borehole, was ranked as the highest preference and applicant seven was ranked as the lowest preference. There were no like cases produced from the model in this dataset. The Minority Status did not provide much variation in the applicant inputs with all applicants rated as 15 except for applicant three which was rated 10.

In dataset seven, applicant three was ranked as the highest preference and applicant 12 was ranked as the lowest preference. The applicant with the failed borehole was ranked tenth. This dataset contained seven applicants with 'semi critical' Water Availability statuses. Out of all seven, only applicant ten ranked above other applicants with 'safe' Water Availability statuses.

Overall, three of the seven data trials the failed borehole was prioritized in mid-range. In one trail with two failed boreholes, one was placed in mid-range and the other as a higher priority. Finally, in three data trials the failures received a higher priority. To further test the validity of the model, the AHP consistency index (C.I.) and consistency ratios (C.R.) were calculated. As shown in Table 4-15, trials using the seven datasets displayed acceptable C.I. and C.R. values of less than 0.1 for each level of the AHP model.

4.2.1 Borehole Prediction

In testing the seven datasets, the AHP model did not identify the failed boreholes as the lowest priority. There are many possible reasons for the prediction of the higher priorities for the failed boreholes; however, two main reasons are considered below:

1. The data used for the inputs were based off of 2010 data collected from study participants; however, these participants actually applied for the scheme and obtained the borehole from 2000 – 2008 creating a lag in the time of the borehole failure and the applied data. Further, this factor was amplified by the fact of changing water availability statuses in both HDK and NAN. According to the CGWB [53], the groundwater availability in 2004 was very different to that of 2009. Both HDK and NAN experienced a higher percentage of semi-critical, critical, and over exploited areas in 2004 as opposed to 2009. Therefore, this may have affected the AHP model's ability to capture failed boreholes from the past. In all higher prioritization cases of failed boreholes, the applicants fell into a 'safe' category for water availability according to 2009 data but may have been categorized differently at their time of application.

2. The current AHP model does capture factors affecting borehole failures such as geomorphology. This data is very site-specific and would require extensive field research which was beyond the scope of this study. In future research and adaptations of this AHP model, site-specific data could be gathered and integrated into the model, and the model could be re-tested with new datasets to explore an improvement in the model's effect on ranking failed boreholes.

4.2.2 Criteria Weighting and Like-Cases

To examine the influence that the criteria weighting had in the overall prediction of the priorities, NAN dataset 1 displayed a case where applicant one was categorized as 'semi critical' and both applicants two and six were categorized as 'safe' for Water Availability. However, applicant one displayed higher preferences in both Technology Adoption and Minority Status with inputs of 15 and 10 respectively. The AHP model resulted in prioritizing applicant one over both applicants two and six, which shows that the model can differentiate between alternatives with slight differences amongst criteria.

It is also sensitive enough to change preference for changes in each of the criteria. For example, in the above case, Water Availability was weighted 0.43 in the AHP model while Technology Adoption was weighted 0.2 and Minority Status was weighted 0.09; despite the lower weighted values of Technology Adoption and Minority Status criteria, they were shown to have an effect on the overall preference.

The AHP model predicted all like-cases with like prioritizations in each dataset. For example, this was displayed in Table 4-12 for dataset five. The AHP model also captured a range of percent differences across the seven datasets. The Minority Status inputs did not greatly vary amongst applicants with a rating of 10 or 15 in every dataset and a rating of 15 for every applicant in dataset one. Further sensitivity for like-cases could be improved in future testing or applications of the model by improving the distinction between BPL and APL for income, which was not captured during these trials. Also, the time to start for technology adoption was assumed to be less than six months since the true start date was unknown; improving this data could also aid in creating a more robust AHP model. The inputs for the datasets for this testing covered the 'safe' and 'semi critical' statuses for Water Availability but did not capture 'critical' or 'over exploited'. All inputs of one to four were captured for Water Need. The inputs of zero, 10, 15, and 20 were captured for Technology Adoption. Finally, only the inputs 10, and 15 were captured for Minority Status.

In future adaptations of the AHP model it is important to consider the environment it was developed in. This model was created from the investigation in HDK and NAN with BC status participants. Therefore, the built in weighting system was conducive to rural irrigation development applications ranging from one to seven acres of land holding size, crop selections common to the Southern India region, soil variation in the Southern Dry Zone and Southern Transition Zone of Karnataka, and employed for participants with specific socio-economic backgrounds. In addition, the tool was applied in an environment where the current rate of technology adoption was low amongst participants but also promoted through policy, and government schemes, and where participants expressed an interest. Therefore, the current weighting was intended to encourage better water management amongst applicants and provide leverage to other water related government schemes. However, if applied in an environment with high rates of technology adoption already employed, the criteria would lose meaning and become moot. This would be the case for any of the criteria. Therefore, continuous cycles of the SSM should be conducted to ensure that the tool adapts to such changes over time. Checkland [24] and ICRA[23], highlight the benefits of continuous SSM cycles in providing a better solution to the problem situation. This research completed one full cycle of the SSM with two iterations of the system definition or problem situation.

4.2.3 Consistency and Transitivity

The AHP model displayed acceptable C.I. values in Table 4-15. This may have been achieved by fixing the preference tables for each criteria and building the comparison matrix calculations directly into the AHP model. The challenges to transitivity that some AHP models face can be caused by inconsistent perceptions in the comparison matrix amongst decision makers or indicative of a system that does not operate in a transitive manner[45, 59]. As displayed in the results, this model prevents these challenges with the detailed construction of the AHP preferences.

4.2.4 Reduction in Arbitrary Results

In addition to challenges previously discussed with moot factors and transitivity, the arbitrary nature of the AHP is often criticized [59-61]. Further, major flaws in the structure of the AHP, can lead to results that are not representative of reality [59-61]. This research employed the SSM and an extensive needs assessment to create the AHP structure, the AHP criteria, and preference tables in order to minimize the arbitrariness of the model and the final outputs. However, it was realized that the background knowledge of the model development and the broader understanding of the system enhanced the ability to effectively interpret the results and understand the final prioritizations.

4.2.5 Compensating Feedback and Complexity

It was determined that the AHP solution addressed the irrigation scheme needs by providing a more transparent, multi-criterion decision making tool that helps align the implementing GC to irrigation related water policy while improving the management of baseline data and encouraging sustainable behaviours amongst participants. According to the systems maps created in the Needs Assessment, these improvements may have implications across a number of primary, secondary, and tertiary elements of the system in Figure 3-3; however, if other system challenges are not addressed, the potential influence of the AHP model may be reduced by ‘compensating feedback’. Areas of possible compensating feedback are highlighted below:

1. The Needs Assessment identified challenges associated with electricity availability amongst participants; therefore even if an applicant is selected using the AHP, there is no guarantee that they will obtain the benefits of the irrigation scheme or other water related technology.

2. Participants identified a lack of awareness of other government schemes that provide financial support related to sustainable agriculture or technology

adoption; further, without additional support, participants may not have the financial capital to invest in such technologies or practices on their own.

3. Although other government departments offer training, if it does not reach participants, adopted techniques may be applied incorrectly of inefficiently.

4. Acquiring baseline data and improved data management does not guarantee that monitoring and evaluating will be conducted without the proper indicators identified or the human resource capacity.

5. Agricultural and water sustainability are naturally difficult to predict in a complex human and natural system. If benefits are not realized by positive deviants, negative attitudes and beliefs may form about sustainable technology or practise.

CHAPTER 5

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 General

This research connected ideas and concepts from development theory and from different actors across the water sector. The integrated and complex nature of the irrigation scheme was investigated through a Soft Systems Methodology (SSM) to allow for system exploration, the development of a system definition, and the creation of a system solution. Further the role of the GC in the irrigation scheme selection process was investigated and an AHP multi-criterion decision making model was designed to better align the development practitioner with water related policy. There were five main themes explored throughout this research and will be discussed below:

1. The need to improve water management was addressed by the 2012 Draft Water Policy and through the implementation of K.A. No. 25 of 2011 across the State of Karnataka. Further, the need for an integrated water resource management (IWRM) approach to water sector initiatives was established. It was discovered that irrigation schemes implemented by development sector actors are often implemented based on socio-economical factors alone and over look the long term water trends of the area or water related policy requirements. Further, encouraging development organizations to implement IWRM solutions without the proper tools, background information, established relationships, or technical knowledge has led to little change in the sector and few realized benefits. This research established a practical AHP decision making tool that addressed socio-economical as well as water related criteria to provide an integrated tool for development sector users. The tool was designed for HDK and NAN taluks to improve the applicant selection process for a GC implementing irrigation schemes throughout the district. In line with the IWRM approach, a systems analysis methodology was employed to determine the salient features for integration. The AHP tool was designed to operate with locally available data related to crop water requirements, soil conditions, rainfall, as well as groundwater development. The needs of the tool require the development sector actor to engage with related government organizations that maintain and produce the required data. This collaboration will help connect the segregated actors while also improving the

decision criteria already in place for the irrigation scheme implementer. The tool also requires input from the scheme applicant to examine economic and social factors, as well as farming practices. In considering these system factors, the AHP model better aligns to irrigation policy K.A. No. 25 of 2011 by including the following six factors in the application selection process: location, crop type, intended borehole use, water need, water availability status, and water management technology. Considering these factors in the irrigation scheme selection process enables participants to obtain borehole certification in necessary through K.A. No. 25 of 2011. Finally, the tool was designed using Microsoft Excel in order to facilitate an easy implementation into already existing practices amongst implementing offices in the study area.

2. The needs assessment revealed a dependency on the irrigation scheme with approximately 80 % of participant households relying primarily on agriculture as the main source of income as well as the majority of participants relying on rain-fed irrigation without the borehole. In addition, the adoption of water management technology was quite low with 10 sprinkler systems and 1 drip irrigation system adopted amongst respondents. The challenges established with lower adoption rates of water management technology seemed to evolve from a lack of knowledge of other supportive schemes, little financial capital to independently invest, and little understanding of sustainable techniques. Although the irrigation scheme implementer did not address these issues directly, increased collaboration amongst actors associated with the data requirements for the AHP tool, may provide a platform for further collaboration on water related development schemes and training programs for scheme participants. Further, by incorporating known water management criteria into the selection process of one scheme, it could validate and provide support for other related schemes. Applicants would be required to provide information related to farming and water management techniques already adopted or provide a plan of what they plan to adopt in the future. By creating a selection process that displays preference toward more sustainable practices, applicants may be encouraged to invest resources in adopting such practices or seek available support to adopt sustainable practices.

3. According to participants and irrigation scheme documentation, there was uncertainty around the selection process employed for the irrigation scheme. Although the selection criteria for the socio-economical factors were apparent, the management of applicant information, and how applicants were distinguished beyond the initial criteria was unclear. Further, some applicants expressed connection to the Grama Panchayath or members of the MLA while others had no

communication with these governing bodies. The AHP decision tool provided a multi-criteria solution with clear applicant distinctions. Due to the scrutiny taken in developing the preference tables for the AHP model, the basis of acceptance or rejection of a scheme applicant would be transparent and easy to communicate. Further, if employed as a learning tool, applicants could receive clear feedback and advice on how to improve their farming practices, or improve their cropping pattern to meet the local water situation.

4. One of the challenges identified in the research was a lack of baseline data regarding irrigation behaviours of scheme applicants. Since 2000 there was little follow up to determine the influence or impact that the irrigation scheme had. Further, with no baseline data available, it was difficult to track progress or draw backs related to the scheme from earlier participants. One of the benefits of the AHP was its ability to maintain the input data in Microsoft Excel. This would provide the implementing agency with an opportunity to re-examine the socio-economic status of a participant at the time of application as well as participant behavior related to crop selection and technology adoption.

5. The function of the AHP tool was tested with seven datasets of previous applicants with at least one known failed borehole in each dataset. The AHP tool did not predict the failed boreholes as the lowest priority in each dataset based on 2009 data; however, this may have been due to the lag in applying 2009 data to an applicant from 2000 – 2008. The AHP model captured variation in the input to avoid all like cases in the results as well as displayed sensitivity to the built in criteria weighting preventing dominance in one of the criterion. The datasets tested, included 'safe' and 'semi critical' Water Availability statuses and provided little variation in the Minority Status input. Further field testing in the study area and testing a greater variety of inputs would enhance the understanding of the AHP tool function. The AHP tool tested to be consistent at all levels of the hierarchy and maintained high levels of transitivity in the decision making results. Finally, the AHP tool provided flexibility with local data availability for crop water coefficients, rainfall, soil percolation, and water availability. In order to improve the understanding of the AHP performance, the AHP tool requires field testing and further exploration of the selected criteria and the criteria weighting. Based on the system definition the Water Availability was weighted 0.42, Water Need was weighted 0.28, Technology Adoption was weighted 0.20, and Minority Status was weighted 0.09.

Overall, the SSM provided a framework for the needs assessment and solution development to connect and influence each other. This research completed one full cycle of the SSM with two iterations of the problem situation. However, the system definition and appropriate system solutions will continue to grow and evolve with further SSM cycles. Since the AHP model is intended to represent a system through its hierarchical nature, the second level of the AHP may be adjusted overtime.

5.2 Recommendations for Future Work

As highlighted in needs assessment results, there are multiple opportunities for future research in this field:

5.2.1.1 System Considerations

1. The research team acknowledged that health and education were important elements of the system; however it was beyond to scope of this research to investigate their impact and relation to the irrigation scheme. Opportunities exist to investigate nutritional changes at the household due to the access to irrigation technology or changes made to household spending. Access to irrigation may improve income to provide the opportunity for education investments; alternatively, it could also promote excess field labour.

2. There seemed to be a commonality in changing cropping patterns once applicants received the irrigation technology. This similar phenomenon has been cited by other authors and the overall conflict between cropping pattern selection, marketability, potential for economic growth, and the impacts to biodiversity, soil conditions, and water quality could be further investigated.

3. Data management was an overall challenge in testing and evaluating the tool and gaining a full understanding of the irrigation scheme. The idea of evidence based decision making for development organizations as well as farmers could be further investigated. Data management is much more complex in a development context and its applicability and implementation could be considered.

4. The access to irrigation technology for women and the implications it has for women could be considered. Only 12% of participants in the study were women and this scheme did not have any particular reservation for women or other minority statuses beyond the backward classes.

5. It was discovered in the needs assessment that the GC and other government departments or related NGOs work in a segregated manner with little collaboration. This was further supported in the Draft Water Policy of 2012. Part of the motivation of the AHP tool is to promote greater collaboration and integration amongst the different actors across different sectors. Mechanisms to promote this collaboration and further integration could be investigated.

5.2.1.2 Model Considerations

1. The developed model should be field tested with the most up to date data for a new set of applicants in HDK and NAN. Testing the tool in real time, will provide a deeper understanding of how well the tool performs in HDK and NAN as well as highlight operational challenges with the implementation.

2. Further investigating the model criteria and adapting it to reflect the system could be examined. For example, another criterion that could be considered in the AHP model would be related to market access. The relationship between market access, crop selection or economic gain was not addressed; however, the presence of the agent system in HDK and NAN was noted in the needs assessment.

3. Additional consideration could be given to agricultural inputs such as fertilizer or pesticides. The assumptions of improved economic growth due to the access to irrigation technology are also dependent on other agricultural investments. The effect of these or incorporating them into the model may be investigated.

4. The application of the AHP decision making tool throughout Karnataka or in other rural irrigation applications could be considered.

5. The process taken to create the AHP model and this type of solution versus other participatory approaches could be compared. The Watershed Department works closely with an NGO to implement water projects in a community centered manner. Adaptations of participatory measures in the planning and implementing of the irrigation scheme could be investigated.

6. Applying different models for decision making of the irrigation scheme selection process and comparing the results to the AHP model could be conducted.

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APPENDICES

A. APPENDIX A

A.1. Letters of Permission For Use of Co-authored and Published Material

https://webmail1.uwindsor.ca/Session/1573626-zcQXbb313UgByrhR8Wk4-hmpmdas/Message.wssp?Mailbox=INBOX&MSG=8765&PrintVersion=&

From:	"Dr. R Balasubramaniam (Balu)" <drrbalu@gmail.com>
Subject:	Re: Using the GKY report in my thesis
Date:	Wed, 14 Mar 2012 07:08:51 +0530
To:	"Lafontaine H" <lafont1@uwindsor.ca>
Cc:	Tirupati Bolisetti <tirupati@uwindsor.ca>

Holly,

I feel that you can use the report by referencing it as a SVYM report. Permission from us is enough and you can treat this email as permission to do so.

All the best,

RB

On Mar 13, 2012, at 9:15 PM, Lafontaine H wrote:

> Dear Dr. Bolisetti and Dr. RB, As you know, I would like to use sections of the GKY Report in my thesis; however, I am not sure what the best approach to doing this is. When I asked the grad studies department here about referencing work that you co-authored they said that depending on who owns the report I may be able to use it directly and reference it or I may need permission. I would like to use large sections from the introduction, methodology, as well as the analysis and discussion; however, I am not clear as to whether I need permission from SVYM or from the DBCDC to do this. Please advise. If I do not hear back, I will assume that I am able to freely use the report without permission and only include the referencing. Thank you for your guidance. Holly

B. APPENDIX B

B.1. Taluk Population Estimate for 2011

	A	B	C	D	E	F
1	Taluk Name	2001 Population	Population Estimate 2011			
2	Piriyapatna	224254	254367		r=	0.0126
3	Hunsur	253926	288024		t=	10
4	KR Nagar	239199	271319			
5	Mysore	1038490	1177941			
6	HD Kote	245930	278954			
7	Nanjangud	360223	408595			
8	T. Narasipura	279005	316470			
9	District Total	2641027	**2995670**			
10						
11		District Population Provided in 2011 Census	**2994744**	ERROR=	0.030915	
12	P(2011)=P(2001)*e^(t*r)					
13	t= 10 years					
14	r= 0.0126	*based on decadal district exponential growth rates provided in the 2011 census				
15		Government of India. (2012). Providional population totals paper 1 of 2011: Karnataka. (Ch. 3) *Size, growth rate and distribution of population.*				
16						
17						

C. APPENDIX C

C.1. Interview Tool

Ganga Kalyan Yojana Participant Survey

Surveyor:
SI Number:

Introduction:

Dear Sir/Madam thank you for agreeing to participate in this survey today. I really appreciate your time and support. This will take about 2 hours of your time. The survey is broken down into 5 different sections:

1. General Information
2. Agriculture and Technology
3. Economic Information
4. Education
5. GKY Scheme Overview

I will ask you a series of questions in each section and you will be asked to answer each question to the best of your ability. If you have any questions throughout the survey, please let me know and I will do my best to answer all of your questions. Are you ready to begin?

If the participant is ready to begin then proceed to the first question. If they are not ready to begin, then address any questions or concerns that they may have first. Once they are satisfied with the introduction ask once more "Are you ready to begin?". Once they are ready, proceed to the first question.

Section 1 – General Information:

1) Can you please state your name?

____

If person is different from the listed beneficiary, then state relationship:______________________

2) How many members are in your household?

_____

3) What are the ages of each member?

Female Members	Male Members
_____ 0 – 6	_____ 0 – 6
_____ 6 – 15	_____ 6 – 15
_____ 15 – 60	_____ 15 – 60
_____ 60+	_____ 60+

4) How did you come to know about the Ganga Kalyan Yojana Scheme?

☐ Word of mouth
☐ Grama Panchayat
☐ DBCDC
☐ Radio
☐ Newspaper
☐ TV

Surveyor:
SI Number:

☐ Other Please specify__________________

5) Why did you apply for the Ganga Kalyan Yojana Scheme?

____

____

____

____

____

6) Please specify which steps you took in becoming a GKY Scheme participant and when each step was completed?

Steps Involved	Date/Duration
☐ Application Submitted to Taluk Level Backward Classes Development Department Officer	
☐ Application Submitted to DBCDC District Office	
☐ Approval from DBCDC District Office	
☐ Approval from MLA	
☐ Borewell Dug	
☐ Pump Recieved	
☐ Electricity Connected	

7) Do you feel that the process was completed in an acceptable time frame?

☐ Strongly Agree

☐ Agree

☐ Unsure

☐ Disagree

☐ Strongly Disagree Reason:______________________________

8) Do you feel that the process to becoming a GKY Scheme participant was easy to complete?

☐ Strongly Agree

☐ Agree

☐ Unsure

☐ Disagree

☐ Strongly Disagree Reason:____________________________

9) Please answer the following regarding your Group Scheme:

Surveyor:
SI Number:

Number of Participants	Number of borewells

10) Are any of the borewells shared?

☐ Yes

☐ No **If No, then skip to question 14**

11) How do you determine when each person uses the borewell and the quantity of water each person uses?

____

____

____

____

12) Do you feel that the water is shared equally between each person?

☐ Yes **If Yes, skip to question14**

☐ No

13) How do you think equitable distribution of water can be achieved between the people using this borewell?

____

____

____

____

14) Besides yourself, are there any other users of the borewell that are not involved in the GKY Scheme?

☐ No other users

☐ Community members ______ # of members

☐ Village leaders ______# of members

☐ Other, Please specify__________________ ______ # of members

15) Besides irrigating your crops, is the borewell and pumpset used for any other purpose?

☐ No other use

☐ Drinking water ______ L per day

☐ Domestic use ______ L per day

☐ Other ______ L per day

Please specify___________________

Surveyor:
SI Number:

Section 2 – Agriculture and Technology:

16) How many years have you been farming in Heggadadevanakote/Nanjangud?

_____ years

17) How many acres of farm land do you have of the following?

_____ acres owned _____ acres leased/rented ______ acres rented to others

18) How many acres of land do you cultivate under the GKY Scheme?

_____ acres

19) During which seasons do you grow crops and what crops do you grow?

Summer (March – June)				
Crop	Acres	Fertilizer Inputs (kg)	Seed Inputs (kg)	Labour Required (# of people)
Rainy Season (June – November)				
Crop	Acres	Fertilizer Inputs (kg)	Seed Inputs (kg)	Labour Required (# of people)

Surveyor:
SI Number:

Winter (November – March)				
Crop	**Acres**	**Fertilizer Inputs (kg)**	**Seed Inputs (kg)**	**Labour Required (# of people)**

20) Did you grow any different crops before receiving the GKY borewell and pumpset?

☐ Yes ***If Yes, then fill in the Box***

☐ No

BOX: IF YES THEN FILL IN THE FOLLOWING CHART

Season	Crop

i. Why did you change the crops that you grow?

____

____

Surveyor:
SI Number:

21) How frequently do you use the GKY irrigation technology in each season?

Summer (March – June)

_______ hours per day _______ days per month

Monsoon (June – November)

_______ hours per day _______ days per month

Winter (November – March)

_______ hours per day _______ days per month

22) What other methods do you use on a regular basis to water your crops?

☐ No other methods

☐ Rain-fed irrigation

☐ Canal irrigation

☐ Other, Please specify________________________

23) On a scale from 0 to 100 how easy is it to use the GKY borewell and pumpset? (operate)

0 25 50 75 100

****0=very difficult 25=difficult 50= average ease of use 75=easy 100=very easy****

24) During your regular use of the borewell and pumpset are there any challenges that you frequently face?

____

____

____

____

____

____

25) Is there anything that you think could improve this technology? (change to the Kannada version)

____

____

____

____

____

____

26) Is there any periodical maintenance for this system?

☐ Yes ****If Yes, then fill in the Box****

☐ No ****If No, then skip to question 27****

Surveyor:
SI Number:

BOX: IF YES THEN FILL IN THE FOLLOWING CHART

Maintenance Conducted	Frequency of Maintenance	Conducted By	Cost of Maintenance

27) How many hours in a day do you have power?

____

28) What do you do to water your crops when there is no power?

____

____

____

____

____

29) Besides power cuts, have there been other situations that have prevented you from using the GKY Scheme?

☐ No other situations
☐ No water available
☐ Can't afford electricity
☐ Broken technology - Specify problem____
☐ Don't know how to use
☐ Don't want to use

30) What type of irrigation system do you have?

☐ No other irrigation system
☐ Furrow
☐ Sprinkler
☐ Drip
☐ Micro-tube
☐ Other Please specify ________________

Surveyor:
SI Number:

31) What is the horsepower of your GKY pump?

_____ HP

32) How far down is the motor/pump located inside the borewell?

_____ m/ft

33) How many inches of water are in the pipe during operation?

_____ in

34) Do you keep records of your crop yields?

☐ Yes

☐ No

35) Do you feel like your crop yields have been improved by the GKY Scheme?

☐ Strongly Agree

☐ Agree

☐ Unsure

☐ Disagree

☐ Strongly Disagree Reason:________________________

36) Going back as far as you can remember, what were the yields of your crops each season?

		YEAR: 2010							
SEASONS	CROP:								
WINTER (November, December, January, February)	SEASON TOTAL:								
SUMMER (March, April, May)	SEASON TOTAL:								
MONSOON (June, July, August, September, October)	SEASON TOTAL:								

		YEAR: 2009							
SEASONS	CROP:								
WINTER (November, December, January, February)	SEASON TOTAL:								

Surveyor:
SI Number:

SUMMER (March, April, May)	SEASON TOTAL:								
MONSOON (June, July, August, September, October)	SEASON TOTAL:								

		YEAR: 2008							
SEASONS	CROP:								
WINTER (November, December, January, February)	SEASON TOTAL:								
SUMMER (March, April, May)	SEASON TOTAL:								
MONSOON (June, July, August, September, October)	SEASON TOTAL:								

37) Over the past 10 years, do you remember any seasons that you experienced a change in your crop yield due to some major event ie. flood/drought, elephant attack, pest attack etc.?

If the change was an increase then mark a '+'. If the change was a decrease then mark a '-'

SEASON	YEAR	CROP(S) AFFECTED	CHANGE IN YIELD	REASON FOR CHANGE

Surveyor:
SI Number:

Section 3 - Economic:

38) Please specify the following information regarding the funding for your GKY Scheme:

Total Cost (Rs.)	Government Support (Rs.)	Type of Support	% Interest on Gov. Loan	Amount of Loan Paid Back (Rs.)	Participant Contribution (Rs.)		% Interest on Personal Loan	Amount of Loan Paid Back (Rs.)
		☐ Loan			Loan	Savings		
		☐ Subsidy						

39) Do you sell any of your crops?

☐ Yes *If, Yes, answer questions in Box 1*

☐ No *If No, answer questions in Box 2*

BOX 1: IF <u>YES</u> THEN ANSWER THE FOLLOWING QUESTIONS

Crop Sold	Selling Price	Sold To	Distance from market to home

Now proceed to question 40

BOX 2: IF NO THEN ANSWER THE FOLLOWING QUESTION

i. Why are none of your crops sold at a market?

____

____

____

40) Do you keep records of your income and expenditures?

☐ Yes

☐ No

Surveyor:
SI Number:

41) Going as far back as you can remember, what was your income and expenditures each season?

YEAR: 2010					
SEASONS	MONTHS	Agricultural Income	Agricultural Expenditure	Non-Agricultural Income (labour, livestock, land, business)	Personal Expenditure
WINTER	NOVEMBER				
	DECEMBER				
	JANUARY				
	FEBRUARY				
	SEASON TOTAL				
SUMMER	MARCH				
	APRIL				
	MAY				
	SEASON TOTAL				
MONSOON	JUNE				
	JULY				
	AUGUST				
	SEPTEMBER				
	OCTOBER				
	SEASON TOTAL				

YEAR: 2009					
SEASONS	MONTHS	Agricultural Income	Agricultural Expenditure	Non-Agricultural Income	Personal Expenditure
WINTER	NOVEMBER				
	DECEMBER				
	JANUARY				
	FEBRUARY				
	SEASON TOTAL				
SUMMER	MARCH				
	APRIL				
	MAY				
	SEASON TOTAL				
MONSOON	JUNE				
	JULY				
	AUGUST				
	SEPTEMBER				

Surveyor:
SI Number:

	OCTOBER				
	SEASON TOTAL				

YEAR: 2008					
SEASONS	**MONTHS**	**Agricultural Income**	**Agricultural Expenditure**	**Non-Agricultural Income**	**Personal Expenditure**
WINTER	NOVEMBER				
	DECEMBER				
	JANUARY				
	FEBRUARY				
	SEASON TOTAL				
SUMMER	MARCH				
	APRIL				
	MAY				
	SEASON TOTAL				
MONSOON	JUNE				
	JULY				
	AUGUST				
	SEPTEMBER				
	OCTOBER				
	SEASON TOTAL				

42) Have you purchased any new assets after becoming a GKY Scheme participant? For example, land, livestock, gold etc. and what was the cost?

Asset	Number of Items Owned	Initial Cost or Capital (Rs.)
☐ Land	acres	
☐ Poultry		
☐ Goat & Sheep		
☐ Cow & Buffalo		
☐ Farming Equipment		
☐ Electronics		
☐ Home Appliances/Furniture		
☐ Gold		
☐ Business		
☐ Other		

Surveyor:
SI Number:

43) Since receiving the GKY Scheme, have you:

☐ Obtained any additional loans **If selected, then fill in Box 1**
☐ Paid off any loans **If selected, then fill in Box 2**
☐ Provided loans to another person **If selected, then fill in Box 3**

Box 1: Additional Loans Obtained

Loan Amount	% Interest on Loan	Source of Loan	Purpose of Loan	Date Obtained

Box 2: Paid Off Loans

Loan Amount	% Interest on Loan	Source of Loan	Date Loan Paid

Box 3: Loans Provided to Others

Loan Amount	% Interest on Loan	Date Provided	Amount Paid Back

44) Are you or your wife part of a Self Help Group (SHG)?

☐ Yes **If, Yes, answer questions in Box 1**

☐ No **If No, then proceed to question 45**

BOX 1: IF <u>YES</u> THEN ANSWER THE FOLLOWING QUESTIONS

Date Joined SHG	Frequency of Saving (weekly/monthly)	Amount Saved

<u>Section 4 -Education:</u>

45) Do any of the children in the house attend school/college?

☐ Yes **If, Yes, answer questions in Box 1**

☐ No **If No, answer questions in Box 2**

Surveyor:
SI Number:

BOX 1: IF <u>YES</u> THEN ANSWER THE FOLLOWING QUESTIONS

i. How many children do you financially support to attend school?

Primary: _______ High school: _______ College: _______

ii. How much do you spend on registration fees per child each year?

Primary: __________Rs. High school: __________Rs. College: __________Rs.

iii. How much do you spend on extra school fees for books, uniforms, travel etc. each year?

Primary: __________Rs. High school: __________Rs. College: __________Rs.

Now proceed to question 45

BOX 2: IF <u>NO</u> THEN ANSWER THE FOLLOWING QUESTIONS

i. Why do the children living with you not attend school?

- [ ] Personal choice
- [ ] Can't afford the school fees
- [ ] Children are needed in the field
- [ ] Physical/Mental handicap
- [ ] Other Please specify____________________

<u>Section 5 - GKY Scheme Overview:</u>

46) When seeking support or information about the GKY Scheme, who do you most frequently communicate with? This can be a person or an institution name.

____ (Please specify name and position)

47) When was the last time you contacted this person/institution?

____ (Please specify the date)

48) What was the purpose of your communication?

____

____

____

49) On a scale of 0 to 100, rate the support you received from this recent communication?

0 25 50 75 100

0= no support 25=little support 50= average support 75=good support 100=great support

Surveyor:
SI Number:

50) Please specify below regarding your communication with the following people about the GKY Scheme?

Contact	Frequency of Communication	Purpose of Communication
Taluk Level Backward Classes Development Department Officer		
Grama Panchayat		
DBCDC District Manager		
Mysore Contractor		
Bank		
Other		

51) On a scale of 0 to 100, how would you rate each of the following benefits of the GKY Scheme with respect to your experience?

Improving Access to Water for Irrigation:

0 25 50 75 100

0=no improvement 25=little improvement 50=average improvement 75=good improvement 100= great improvement

Increasing Agricultural Yields:

0 25 50 75 100

0=no increase 25=little increase 50=average increase 75=good increase 100= great increase

Increasing Income:

0 25 50 75 100

0=no increase 25=little increase 50=average increase 75=good increase 100= great increase

52) On a scale of 0 to 100, how would you rate the overall success of your GKY Scheme?

0 25 50 75 100

0=not successful 25=little success 50= average level of success 75=more successful 100=very successful

53) What is one thing that you like best about the GKY Scheme?

____

____

____

____

____

54) What is the most important change you would like to see to improve the GKY Scheme?

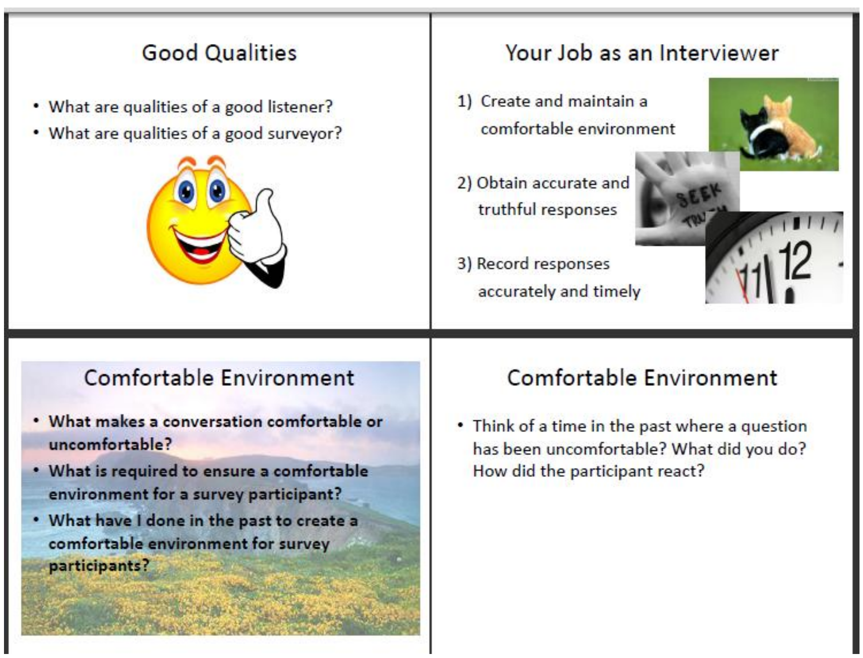
____

____

____

____

C.2. Training Program



Types of Questions

Three types:

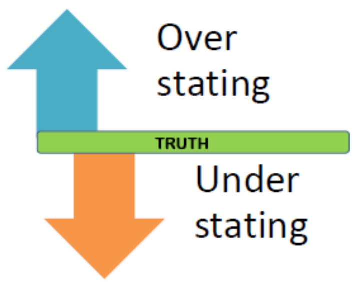
1) Behaviour and facts – seek to know what actions people take or the truth about something

Types of Questions

2) Knowledge – seek to learn what a person knows about a particular topic

3) Attitudes – seek to learn about how a person feels about a particular topic

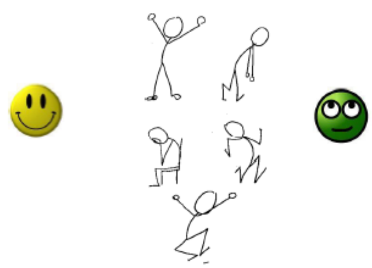
Biases



Two Types of Biases

- Motivated
  - Financial gain
  - Social status
  - Perception of others
- Unmotivated
  - Can't remember perfectly
  - Knowledge of a situation
  - Exposure and awareness
  - Surveyor induced

Body Language



Variability

- How a question answer might change based on how the question is asked:

1) Would you recommend the GKY Scheme to another farmer?

2) Having participated in the GKY Scheme yourself, would you recommend it to someone else?

3) Would you tell other farmers to participate in the GKY Scheme?

As a surveyor…

- I need to know what type of questions I am asking
- It is important for me to be aware of biases and how to minimize them with my body language
- I need to prevent variability and be consistent with the questions that I ask

Skill Building Session 2: Asking Questions Part II

Outline

- Non-threatening vs. Threatening
- Why do we need to know?
- How to reduce threat?

Non-threatening vs. Threatening


No right or wrong answer....what might be threatening to one person may not be to another.

Non-threatening

- When asking questions in the field, what might be some non-threatening questions?

Threatening

- When asking questions in the field, what might be some threatening questions?

SEXUAL BEHAVIOUR

Why do we need to know?

- Using a sensitive tone of voice and changing our body language can help maintain a comfortable environment
- Making sure that questions are worded in a manner to generate a sense of security and safety
- Ensuring that honest and open answers are provided to improve the overall results of the study

How to reduce the threat?

- Asking threatening questions in between non-threatening questions
- Starting with least threatening question and move gradually to the most threatening question
- Wording the question so that the commonality of the topic is highlighted
- Ensuring confidentiality
- Providing a self-administered survey
- Surveyor staying relaxed and non-judgemental

As a surveyor...

- I need to understand that people feel threatened by different questions
- It is important that threatening questions are identified and the proper environment and security are provided for the participant
- I need to look for how questions are worded and address when a question should be changed

Skill Building Session 3: Attitudes and Behaviour

Outline

- Opinions vs. Attitudes
- Components of attitudes
- Connection between attitudes and behaviour
- Assessing the strength of attitudes

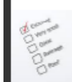
Opinions vs. Attitudes

• Can be measured with one question	• Can be measured by a series of questions

- Attitude Object – something that a person can develop an attitude about. Each question should only have one attitude object.

Three Components of Attitudes

- Cognitive – beliefs or values about the attitude object

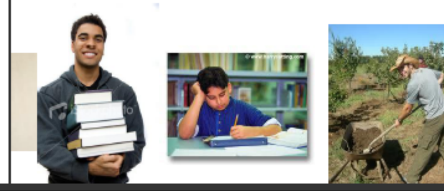


- Evaluative – evaluation of the attitude object

- Behavioural – actions that are related to the attitude

Attitudes and Behaviours

Attitude → Intended Behaviour → Actual Behaviour



Assessing Attitudes

- Building a strength dimension

Strongly disagree Disagree Mutual Agree Strongly agree	OR	0 1 2 3 4 5 6 7 8 9 10

- Using a series of independent questions

Challenges

- Order of the question responses
- Making assumptions about a behaviour based on the expressed attitude

As a surveyor…

- It is important to understand the differences between opinions, attitudes, and behaviours
- I need to ensure that the order of the strength dimensions are appropriate to determine honest attitudes
- I need to identify where an improper assumption is being made about a behaviour because of an attitude

Skill Building Session 4: Recording Close-ended and Open-ended Questions

Outline

- Recording close-ended questions
- Field coding
- Recording open-ended questions

Close-ended Questions

❑Rs. 0 – 1000
❑Rs. 1000 – 2000
❑Rs. 2000 – 5000
❑Rs. 5000 - 10000
❑Rs. > 10000

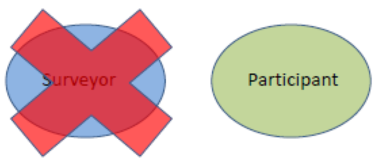
❑Paddy
❑Ragi
❑Jowar
❑Oilseeds
❑Sugarcane
❑Other

❑Yes
❑No

❑Grapes
❑Oranges
❑Bananas
❑Mangos
❑Other

Field Coding

- Guessing or assuming what the participant means
- Fitting the participants answer into the available options



Open-ended Questions

- No pre-determined answers
- Write the response down verbatim
- Must capture exactly what the participant is saying
- Takes more time
- Must be patient to let the participant get out their response
- Good for development questions

Recording Responses Reflection

- From your past experience, what are the best ways to record responses from a participant?
- Think of a time when it was difficult to determine what the participant was saying, how did you manage to clarify the response?

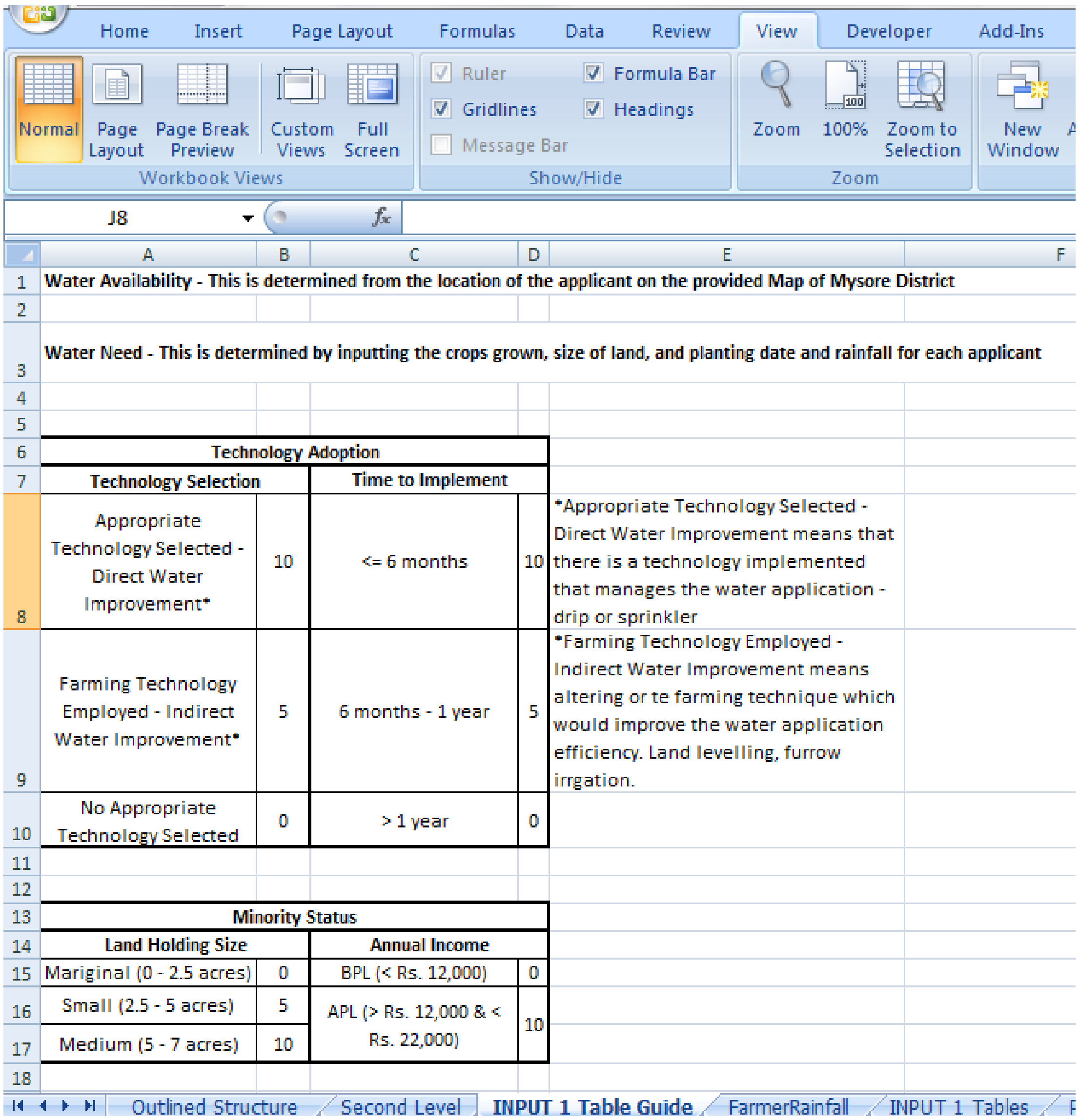
As a surveyor…

- I need to make sure that all possible options are available for the participant to answer the question
- I need to make sure that the participant chooses the most appropriate answer to ensure that their response is accurately coded
- I need to pay close attention to the response of open-ended questions and capture all that the respondent is saying

D. APPENDIX D

D.1. AHP Input Guide

This is built into the Microsoft Excel file to aid the user in determining the input values for each of the four criteria.



Water Availability - This is determined from the location of the applicant on the provided Map of Mysore District

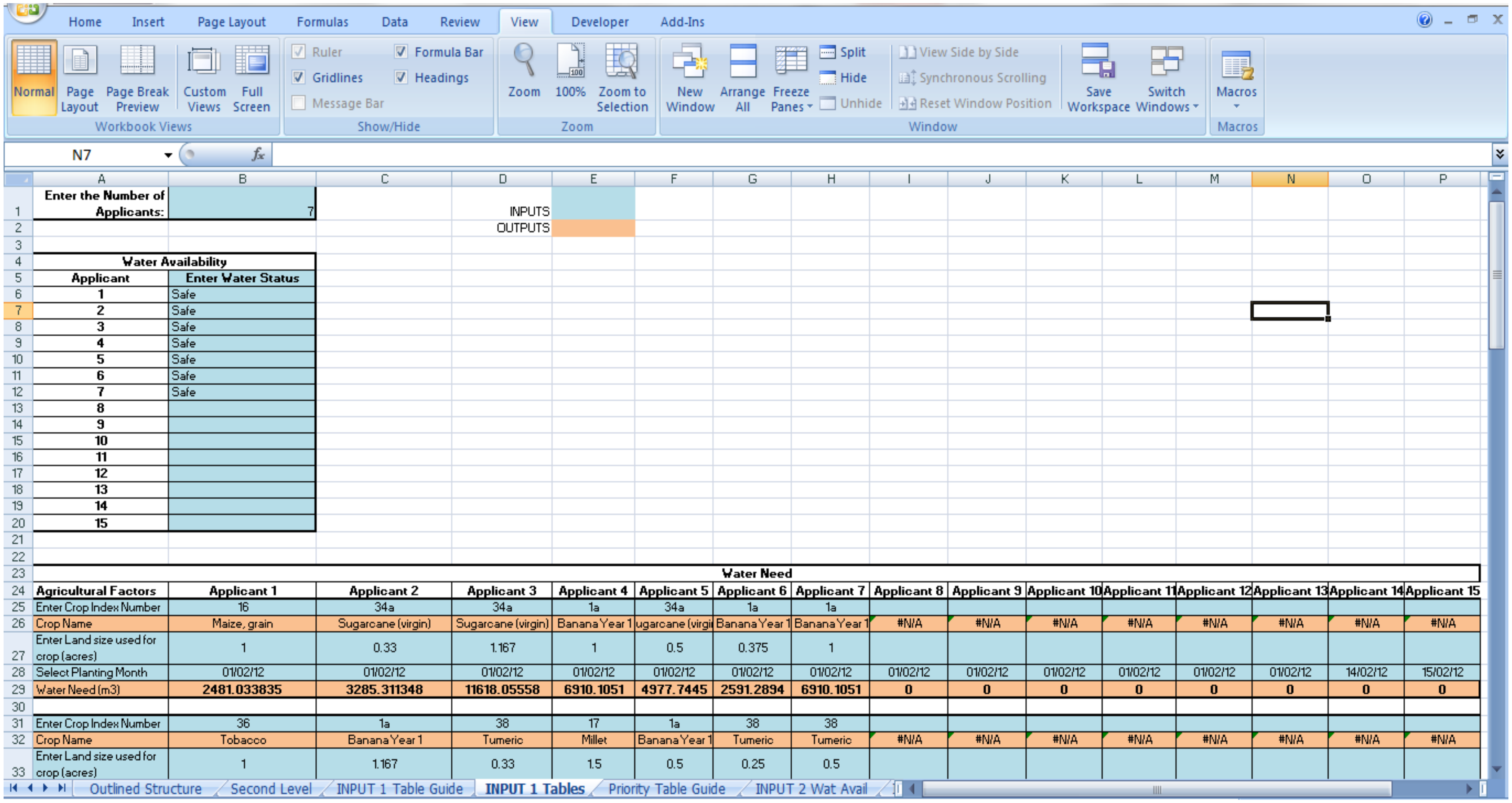
Water Need - This is determined by inputting the crops grown, size of land, and planting date and rainfall for each applicant

Technology Adoption				
Technology Selection		**Time to Implement**		
Appropriate Technology Selected - Direct Water Improvement*	10	<= 6 months	10	*Appropriate Technology Selected - Direct Water Improvement means that there is a technology implemented that manages the water application - drip or sprinkler
Farming Technology Employed - Indirect Water Improvement*	5	6 months - 1 year	5	*Farming Technology Employed - Indirect Water Improvement means altering or te farming technique which would improve the water application efficiency. Land levelling, furrow irrgation.
No Appropriate Technology Selected	0	> 1 year	0	

Minority Status			
Land Holding Size		**Annual Income**	
Mariginal (0 - 2.5 acres)	0	BPL (< Rs. 12,000)	0
Small (2.5 - 5 acres)	5	APL (> Rs. 12,000 & < Rs. 22,000)	10
Medium (5 - 7 acres)	10		

D.2. AHP Input Tables

This is the main input of the tool. Once the input values are entered here, the built in calculations perform the AHP comparison.



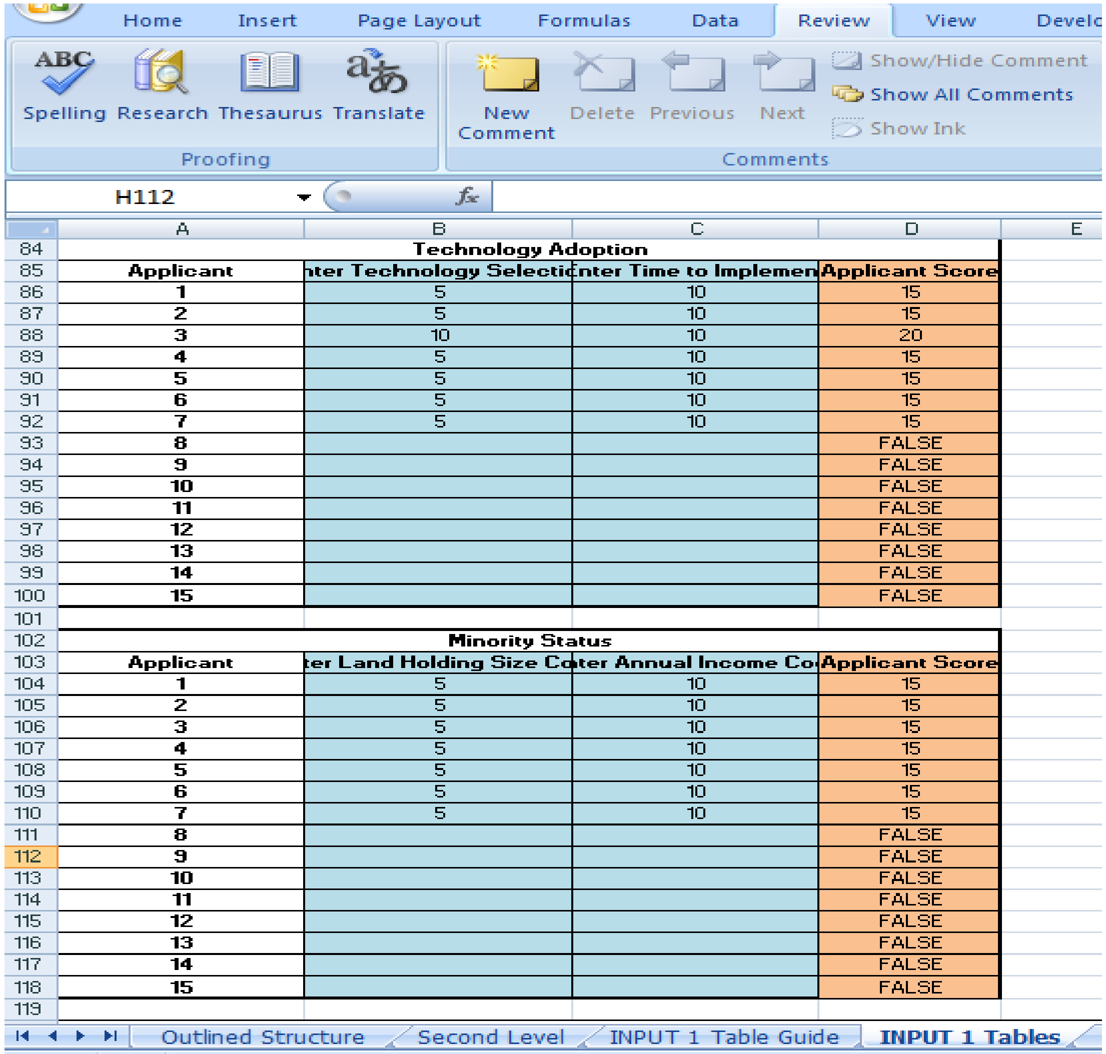
Enter the Number of Applicants:	7

INPUTS
OUTPUTS

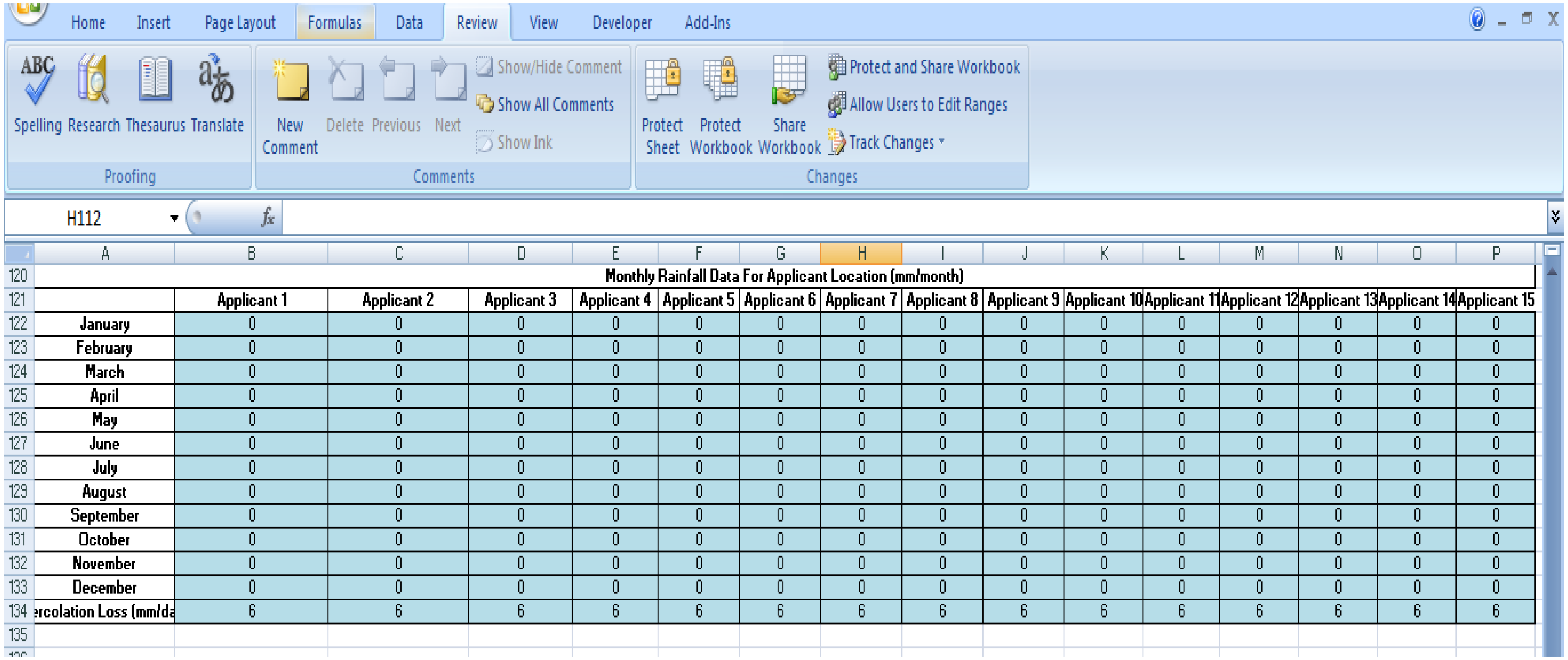
Water Availability	
Applicant	Enter Water Status
1	Safe
2	Safe
3	Safe
4	Safe
5	Safe
6	Safe
7	Safe
8	
9	
10	
11	
12	
13	
14	
15	

Water Need

Agricultural Factors	Applicant 1	Applicant 2	Applicant 3	Applicant 4	Applicant 5	Applicant 6	Applicant 7	Applicant 8	Applicant 9	Applicant 10	Applicant 11	Applicant 12	Applicant 13	Applicant 14	Applicant 15
Enter Crop Index Number	16	34a	34a	1a	34a	1a	1a								
Crop Name	Maize, grain	Sugarcane (virgin)	Sugarcane (virgin)	Banana Year 1	ugarcane (virgi	Banana Year 1	Banana Year 1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Enter Land size used for crop (acres)	1	0.33	1.167	1	0.5	0.375	1								
Select Planting Month	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	01/02/12	14/02/12	15/02/12
Water Need (m3)	2481.033835	3285.311348	11618.05558	6910.1051	4977.7445	2591.2894	6910.1051	0	0	0	0	0	0	0	0
Enter Crop Index Number	36	1a	38	17	1a	38	38								
Crop Name	Tobacco	Banana Year 1	Tumeric	Millet	Banana Year 1	Tumeric	Tumeric	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Enter Land size used for crop (acres)	1	1.167	0.33	1.5	0.5	0.25	0.5								



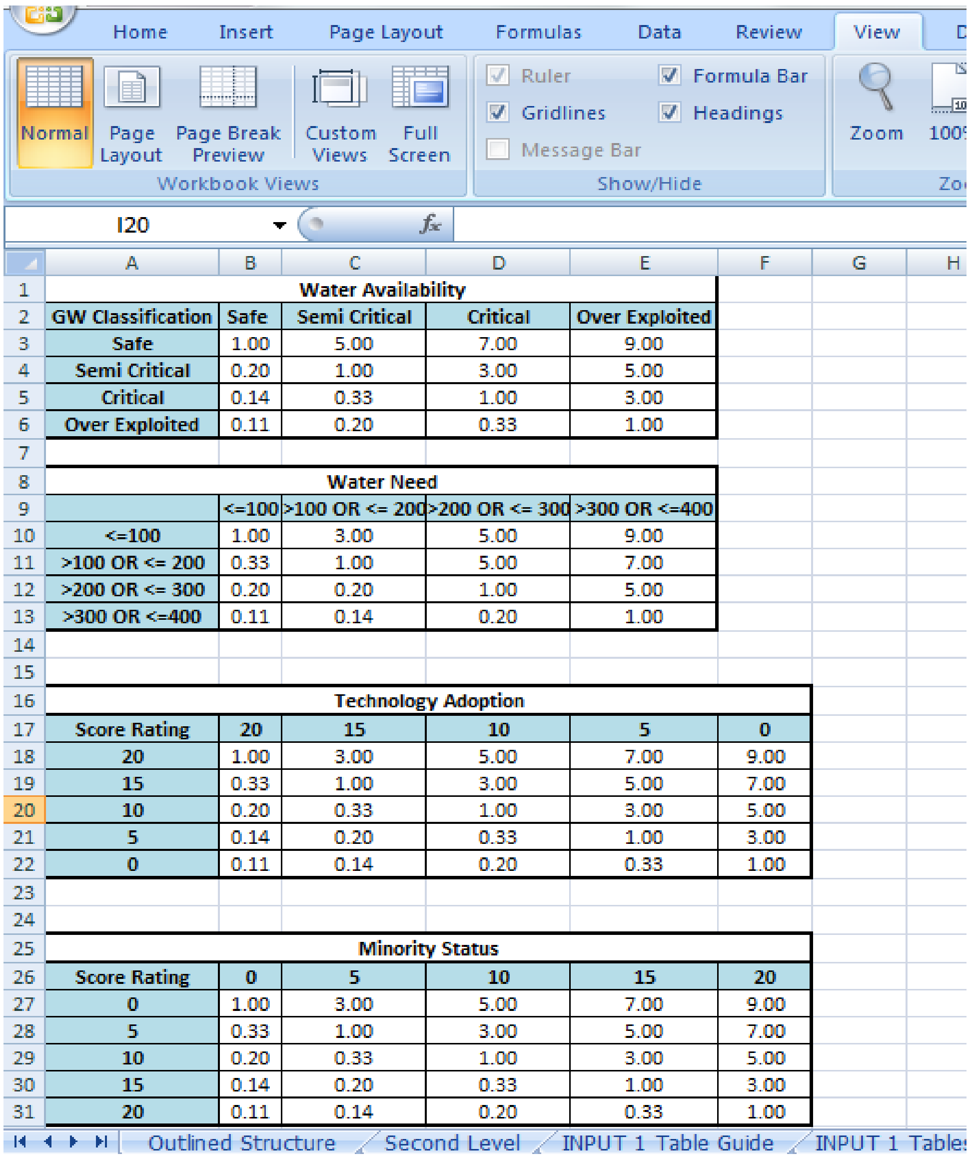
	A	B	C	D	E
84	Technology Adoption				
85	**Applicant**	**nter Technology Selectio**	**nter Time to Implemen**	**Applicant Score**	
86	1	5	10	15	
87	2	5	10	15	
88	3	10	10	20	
89	4	5	10	15	
90	5	5	10	15	
91	6	5	10	15	
92	7	5	10	15	
93	8			FALSE	
94	9			FALSE	
95	10			FALSE	
96	11			FALSE	
97	12			FALSE	
98	13			FALSE	
99	14			FALSE	
100	15			FALSE	
101					
102	Minority Status				
103	**Applicant**	**ter Land Holding Size Co**	**ter Annual Income Co**	**Applicant Score**	
104	1	5	10	15	
105	2	5	10	15	
106	3	5	10	15	
107	4	5	10	15	
108	5	5	10	15	
109	6	5	10	15	
110	7	5	10	15	
111	8			FALSE	
112	9			FALSE	
113	10			FALSE	
114	11			FALSE	
115	12			FALSE	
116	13			FALSE	
117	14			FALSE	
118	15			FALSE	
119					



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
120	Monthly Rainfall Data For Applicant Location (mm/month)															
121		Applicant 1	Applicant 2	Applicant 3	Applicant 4	Applicant 5	Applicant 6	Applicant 7	Applicant 8	Applicant 9	Applicant 10	Applicant 11	Applicant 12	Applicant 13	Applicant 14	Applicant 15
122	January	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123	February	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124	March	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125	April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127	June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128	July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129	August	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	September	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	October	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132	November	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133	December	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134	ercolation Loss (mm/da	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
135																

D.3. AHP Preference Tables

These preference tables allow the inputs to be converted into Satty's one to nine comparison scale and then populated into the comparison matrix.



Water Availability				
GW Classification	Safe	Semi Critical	Critical	Over Exploited
Safe	1.00	5.00	7.00	9.00
Semi Critical	0.20	1.00	3.00	5.00
Critical	0.14	0.33	1.00	3.00
Over Exploited	0.11	0.20	0.33	1.00

Water Need				
	<=100	>100 OR <= 200	>200 OR <= 300	>300 OR <=400
<=100	1.00	3.00	5.00	9.00
>100 OR <= 200	0.33	1.00	5.00	7.00
>200 OR <= 300	0.20	0.20	1.00	5.00
>300 OR <=400	0.11	0.14	0.20	1.00

Technology Adoption					
Score Rating	20	15	10	5	0
20	1.00	3.00	5.00	7.00	9.00
15	0.33	1.00	3.00	5.00	7.00
10	0.20	0.33	1.00	3.00	5.00
5	0.14	0.20	0.33	1.00	3.00
0	0.11	0.14	0.20	0.33	1.00

Minority Status					
Score Rating	0	5	10	15	20
0	1.00	3.00	5.00	7.00	9.00
5	0.33	1.00	3.00	5.00	7.00
10	0.20	0.33	1.00	3.00	5.00
15	0.14	0.20	0.33	1.00	3.00
20	0.11	0.14	0.20	0.33	1.00

D.4. Crop Water Coefficients and Growing Periods

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Crop Info		Kc					Growing Period (days)					Added Water	
2	Crop Index	Crop Name	Initial stage	Crop dev. stage	Mid-season stage	Late season stage	Average Kc when stages N/A	Initial stage	Crop Development stage	Mid season stage	Late season stage	Total Growing Period when stages N/A	Additional Water Needs (m)	Percolation Loss? (True/False)
3	1a	Banana Year 1	0.5	0.8	1.1	1		120	90	120	60			
4	1b	Banana Year 2	1	1.1	1.2	1.1		120	60	180	5			
5	2	Barley/Oats/Wheat	0.35	0.75	1.15	0.45		15	25	50	30			
6	3	Bean, green	0.35	0.7	1.1	0.9		20	30	30	10			
7	4	Bean, dry	0.35	0.7	1.1	0.3		15	25	35	20			
8	5	Cabbage	0.45	0.75	1.05	0.9		40	60	50	15			
9	6	Carrot	0.45	0.75	1.05	0.9		20	30	50	20			
10	7a	Citrus 20% cover, no weed control	0.85	0.85	0.85	0.85		60	90	120	95			
11	7b	Citrus 20% cover, with weed control	0.5	0.475	0.45	0.55		60	90	120	95			
12	7c	Citrus 50% cover, no weed control	0.8	0.8	0.8	0.8		60	90	120	95			
13	7d	Citrus 50% cover, with weed control	0.65	0.625	0.6	0.65		60	90	120	95			
14	7e	Citrus 70% cover, no weed control	0.75	0.725	0.7	0.7		60	90	120	95			
15	7f	Citrus 70% cover, with weed control	0.7	0.675	0.65	0.7		60	90	120	95			
16	8	Cotton/Flax	0.45	0.75	1.15	0.75		30	50	60	55			
17	9	Cucumber	0.45	0.7	0.9	0.75		25	35	50	20			
18	10	Eggplant	0.45	0.75	1.15	0.8		30	40	40	20			
19	11	Ginger					0.725					240		
20	12	Grain/small	0.35	0.75	1.1	0.65		25	35	65	40			
21	13a	Green gram, cowpeas harvested fresh	0.4	0.725	1.05	0.6		20	30	30	20			
22	13b	Green gram, cowpeas harvested dry	0.4	0.725	1.05	0.35		20	30	30	20			
23	14	Lettuce	0.45	0.6	1	0.9		25	35	30	10			
24	15	Maize, sweet	0.4	0.8	1.15	1		20	25	25	10			

Minority Status / Blaney Criddle / Water Availability / FarmerRainfall / Months / ETo / GrowPerandKc

24	15	Maize, sweet	0.4	0.8	1.15	1		20	25	25	10			
25	16	Maize, grain	0.4	0.8	1.15	0.7		25	35	40	30			
26	17	Millet	0.35	0.7	1.1	0.65		15	25	40	25			
27	18	Oilseeds (Mustard, Rapeseed)					0.7					150		
28	19	Onion, green	0.5	0.7	1	1		20	45	20	10			
29	20	Onion, dry	0.5	0.75	1.05	0.85		20	35	110	45			
30	21	Peanut/Groundnut	0.45	0.75	1.05	0.7		27.5	37.5	45	25			
31	22	Pea, fresh	0.45	0.8	1.15	1.05		17.5	27.5	35	15			
32	23	Pepper, chilli	0.35	0.7	1.05	0.9		30	40	110	30			
33	24	Potato	0.45	0.75	1.15	0.85		25	30	40	30			
34	25	Pulses (lentils, chickpea)	0.45	0.75	1.1	0.5		25	35	70	40			
35	26	Radish	0.45	0.6	0.9	0.9		10	10	15	5			
36	27	Rice	1.15	1.175	1.2	0.75		30	30	80	40		0.3	TRUE
37	28	Sesame	0.35	0.725	1.1	0.25		20	30	40	20			
38	29	Sorghum	0.35	0.75	1.1	0.65		25	35	45	30			
39	30	Soybean	0.35	0.75	1.1	0.6		15	15	40	15			
40	31	Spinach	0.45	0.6	1	0.9		20	30	40	10			
41	32	Squash	0.45	0.7	0.9	0.75		25	35	25	15			
42	33	Sugarbeet	0.45	0.8	1.15	0.8		35	60	70	40			
43	34a	Sugarcane (virgin)	0.4	0.825	1.25	0.75		50	70	220	140			
44	34b	Sugarcane (ratoon)	0.4	0.825	1.25	0.75		30	50	180	60			
45	35	Sunflower	0.35	0.75	1.15	0.55		25	35	45	25			
46	36	Tobacco	0.35	0.75	1.1	0.9		20	30	30	30			
47	37	Tomato	0.45	0.75	1.15	0.8		30	40	40	25			
48	38	Tumeric					0.725					240		
49	39	Veg Crop					1					120		
50	40	Water melon	0.4	0.7	1	0.75		10	20	20	30			

Minority Status | Blaney Criddle | Water Availability | FarmerRainfall | Months | ETo | **GrowPerandKc**

D.5. Farmer Rainfall and Percolation Conversion Table

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		Monthly Rainfall Data for Applicant Location (m/month)														
2	**Month**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
3	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	**3**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	**4**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	**5**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	**6**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	**7**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	**8**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	**9**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	**10**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	**11**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	**12**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	**Percolation Loss (m/day)**	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006

D.6. VBA Code

```
Attribute VB_Name = "Module1"
Public Function WaterRequired(CropIndex, StartDate As Date, CropLandSize As Double,
FarmerRainfallIndex)

'+--------------------------------------
'| WaterRequired
'| Output: Water Required for an entire growth period of 1 crop in M3
'| Input: Crop Index, Start Date, Land Size
'| Description: Using the input Crop Index, Start Date and Land Size Calculate total water required based on
growth period of crop, and various ETo, Kc values found
'| in tables located on speific sheets
'+--------------------------------------

'[Declare Variables]

    Dim GrowTableRange As Range 'Identifies the sheet containing Growth Periods and Kc
    Dim EToTableRange As Range 'Identifies the sheet containing the Eto Values
    Dim FarmerRainfallRange As Range 'Identifies sheet comtaining WaterRainfall Tables

    Dim Kc As Double
    Dim ETo As Double
    Dim AdditionalWaterNeeds As Double
    Dim EffectiveRainfall As Double

    Dim GrowingPeriod As Integer
    Dim CurrentDate As Date

    Dim EndDate As Date
    Dim InitialStartDate As Date
    Dim FirstOfNextMonth As Date

   ' Dim DaysInCurrentMonth As Integer


    Dim WaterCounter As Double ' Used to collect (Sum) each day's water requirement
    Dim AcresToM2 As Double

'[Set ranges to identify sheets for Growth Period, Kc, ETo tables]

    Set GrowTableRange = Sheets("GrowPerandKc").Columns("A:N") 'Set Range as GrowPeriod and Kc
Table
    Set EToTableRange = Sheets("ETo").Columns("A:D") 'Set ETO Table range
    Set FarmerRainfallRange = Sheets("FarmerRainfall").Columns("A:N")

'[Set initial Values]
    'Save StartDate
    InitialStartDate = StartDate
    'Conversion Factor Acres to Square Meters
    AcresToM2 = 4046.85642

    'Set Additional WaterNeeds
    AdditionalWaterNeeds = Application.VLookup(CropIndex, GrowTableRange, 13, False)

    'Set Water Counter to 0
```

```
    WaterCounter = 0

      '[CROP INITIAL STAGE LOOP]
         'Set Growing Period for Initial Stage
         GrowingPeriod = Round(Application.VLookup(CropIndex, GrowTableRange, 8, False), 0)

         'Determine End Date for initial stage
         EndDate = DateAdd("d", GrowingPeriod, StartDate)

      For CurrentDate = StartDate To EndDate

         'Set Kc for current date
         Kc = Application.VLookup(CropIndex, GrowTableRange, 3, False)

         'set ETo for current date
         ETo = Application.VLookup(Month(CurrentDate), EToTableRange, 4, False)

         'Determine total days in current month (take the day after subtracting 1 day from the first of the next
month)
         FirstOfNextMonth = DateAdd("m", 1, DateSerial(Year(CurrentDate), Month(CurrentDate), 1))
         DaysInCurrentMonth = Day(DateAdd("d", -1, FirstOfNextMonth))

         'set Effective rainfall for current date
         EffectiveRainfall = Application.VLookup(Month(CurrentDate), FarmerRainfallRange,
FarmerRainfallIndex + 1, False)

         'Add today's Kc x ETo to the WaterCounter
         WaterCounter = WaterCounter + (Kc * ETo) - (EffectiveRainfall / DaysInCurrentMonth)

         'Percolation loss calculation
         If Application.VLookup(CropIndex, GrowTableRange, 14, False) = True Then
            WaterCounter = WaterCounter + Application.VLookup("Percolation Loss (m/day)",
FarmerRainfallRange, FarmerRainfallIndex + 1, False)
         End If
      Next

      '[ CROP DEV STAGE LOOP ]
      'Shift Start Date for Development Stage
      StartDate = DateAdd("d", 1, EndDate)

         'Set Growing Period for Development Stage
         GrowingPeriod = Round(Application.VLookup(CropIndex, GrowTableRange, 9, False), 0)

         'Determine End Date for Development stage
         EndDate = DateAdd("d", GrowingPeriod, StartDate)


      For CurrentDate = StartDate To EndDate

         'Set Kc for current date
         Kc = Application.VLookup(CropIndex, GrowTableRange, 4, False)

         'set ETo for current date
         ETo = Application.VLookup(Month(CurrentDate), EToTableRange, 4, False)
```

```
        'Determine total days in current month (take the day after subtracting 1 day from the first of the next month)
        FirstOfNextMonth = DateAdd("m", 1, DateSerial(Year(CurrentDate), Month(CurrentDate), 1))
        DaysInCurrentMonth = Day(DateAdd("d", -1, FirstOfNextMonth))

        'set Effective rainfall for current date
        EffectiveRainfall = Application.VLookup(Month(CurrentDate), FarmerRainfallRange, FarmerRainfallIndex + 1, False)

        'Add today's Kc x ETo to the WaterCounter
        WaterCounter = WaterCounter + (Kc * ETo) - (EffectiveRainfall / DaysInCurrentMonth)

        'Percolation loss calculation
        If Application.VLookup(CropIndex, GrowTableRange, 14, False) = True Then
          WaterCounter = WaterCounter + Application.VLookup("Percolation Loss (m/day)", FarmerRainfallRange, FarmerRainfallIndex + 1, False)
        End If

    Next


    '[ CROP MID SEASON LOOP ]
    'Shift Start Date for Mid Season Stage
        StartDate = DateAdd("d", 1, EndDate)

        'Set Growing Period for Mid season
        GrowingPeriod = Round(Application.VLookup(CropIndex, GrowTableRange, 10, False), 0)

        'Determine End Date for Mid Season stage
        EndDate = DateAdd("d", GrowingPeriod, StartDate)


    For CurrentDate = StartDate To EndDate

        'Set Kc for current date
        Kc = Application.VLookup(CropIndex, GrowTableRange, 5, False)

        'set ETo for current date
        ETo = Application.VLookup(Month(CurrentDate), EToTableRange, 4, False)

        'Determine total days in current month (take the day after subtracting 1 day from the first of the next month)
        FirstOfNextMonth = DateAdd("m", 1, DateSerial(Year(CurrentDate), Month(CurrentDate), 1))
        DaysInCurrentMonth = Day(DateAdd("d", -1, FirstOfNextMonth))

        'set Effective rainfall for current date
        EffectiveRainfall = Application.VLookup(Month(CurrentDate), FarmerRainfallRange, FarmerRainfallIndex + 1, False)

        'Add today's Kc x ETo to the WaterCounter
        WaterCounter = WaterCounter + (Kc * ETo) - (EffectiveRainfall / DaysInCurrentMonth)

        'Percolation loss calculation
        If Application.VLookup(CropIndex, GrowTableRange, 14, False) = True Then
```

```
            WaterCounter = WaterCounter + Application.VLookup("Percolation Loss (m/day)",
FarmerRainfallRange, FarmerRainfallIndex + 1, False)
        End If

    Next


'[ LATE SEASON LOOP ]
    'Shift Start Date for Late Season Stage
        StartDate = DateAdd("d", 1, EndDate)

        'Set Growing Period for Late season
        GrowingPeriod = Round(Application.VLookup(CropIndex, GrowTableRange, 11, False), 0)

        'Determine End Date for Late Season stage
        EndDate = DateAdd("d", GrowingPeriod, StartDate)


    For CurrentDate = StartDate To EndDate

        'Set Kc for current date
        Kc = Application.VLookup(CropIndex, GrowTableRange, 6, False)

        'set ETo for current date
        ETo = Application.VLookup(Month(CurrentDate), EToTableRange, 4, False)

        'Determine total days in current month (take the day after subtracting 1 day from the first of the next
month)
        FirstOfNextMonth = DateAdd("m", 1, DateSerial(Year(CurrentDate), Month(CurrentDate), 1))
        DaysInCurrentMonth = Day(DateAdd("d", -1, FirstOfNextMonth))

        'set Effective rainfall for current date
        EffectiveRainfall = Application.VLookup(Month(CurrentDate), FarmerRainfallRange,
FarmerRainfallIndex + 1, False)

        'Add today's Kc x ETo to the WaterCounter
        WaterCounter = WaterCounter + (Kc * ETo) - (EffectiveRainfall / DaysInCurrentMonth)

        'Percolation loss calculation
        If Application.VLookup(CropIndex, GrowTableRange, 14, False) = True Then
            WaterCounter = WaterCounter + Application.VLookup("Percolation Loss (m/day)",
FarmerRainfallRange, FarmerRainfallIndex + 1, False)
        End If

    Next


If Application.VLookup(CropIndex, GrowTableRange, 3, False) = 0 Then
    '[ LOOP WHEN STAGES N/A ]
        'Set WaterCounter to zero
          WaterCounter = 0
        'Set Growing Period for N/A stage
        GrowingPeriod = Round(Application.VLookup(CropIndex, GrowTableRange, 12, False), 0)

        'Determine End Date for N/A stages
```

```
        EndDate = DateAdd("d", GrowingPeriod, InitialStartDate)


    For CurrentDate = InitialStartDate To EndDate

        'Set Kc for current date
        Kc = Application.VLookup(CropIndex, GrowTableRange, 7, False)

        'set ETo for current date
        ETo = Application.VLookup(Month(CurrentDate), EToTableRange, 4, False)

        'Determine total days in current month (take the day after subtracting 1 day from the first of the next
month)
        FirstOfNextMonth = DateAdd("m", 1, DateSerial(Year(CurrentDate), Month(CurrentDate), 1))
        DaysInCurrentMonth = Day(DateAdd("d", -1, FirstOfNextMonth))

        'set Effective rainfall for current date
        EffectiveRainfall = Application.VLookup(Month(CurrentDate), FarmerRainfallRange,
FarmerRainfallIndex + 1, False)

        'Add today's Kc x ETo to the WaterCounter
        WaterCounter = WaterCounter + (Kc * ETo) - (EffectiveRainfall / DaysInCurrentMonth)

        'Percolation loss calculation
        If Application.VLookup(CropIndex, GrowTableRange, 14, False) = True Then
          WaterCounter = WaterCounter + Application.VLookup("Percolation Loss (m/day)",
FarmerRainfallRange, FarmerRainfallIndex + 1, False)
        End If

    Next

End If

' OUTPUT WaterRequired in M3

WaterRequired = (WaterCounter + AdditionalWaterNeeds) * CropLandSize * AcresToM2

Application.Calculate

End Function
```

D.7. AHP Matrix Calculations

The following matrices represent the four pair-wise comparison matrices for each of the datasets. There is a matrix for Water Availability, Water Need, Technology Adoption, and Minority Status for each of the datasets shown below. The number of applicants in each dataset is displayed in the upper right corner of the figure and the matrix is populated according to the input data and built in preference tables. The vector priorities for each matrix were calculated and the final priority matrices follow in the next section.

D.7.1 Dataset 1

Water Availability

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	5.00	1.00	5.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.20	1.00	0.20	1.00	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	5.00	1.00	5.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	0.20	1.00	0.20	1.00	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	0.20	1.00	0.20	1.00	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	5.00	1.00	5.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	0.20	1.00	0.20	1.00	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	3.80	19.00	3.80	19.00	19.00	3.80	19.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

G6 =IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=1),'Priority Table Guide'!B10,IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=2),'Priority Table Guide'!C10,IF(AND(

Water Need

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	3.00	9.00	3.00	5.00	3.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.33	1.00	7.00	1.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	0.11	0.14	1.00	0.14	0.20	0.14	0.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	0.33	1.00	7.00	1.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	0.20	0.20	5.00	0.20	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	0.33	1.00	7.00	1.00	5.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	0.20	0.20	5.00	0.20	1.00	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	2.51	6.54	41.00	6.54	22.20	6.54	22.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

Ready 100%

B18 =IF(COUNT(B3:B17)>=2,SUMIF(B3:B17,"<>#DIV/0!",B3:B17),FALSE)

Technology Adoption

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	3.00	3.00	1.00	3.00	3.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	9.00	9.00	3.00	9.00	9.00	9.00	9.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | **INPUT 4 Tech Adop** | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

A1 Minority Status

Minority Status

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	7.00	7.00	7.00	7.00	7.00	7.00	7.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / INPUT 5 Min Stat / Final Priority / Tech Adop / Minority

D.7.2 Dataset 2

R11

	Water Availability															Number of Applicants:	2
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**		
1	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
2	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE		
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE		
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE		
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE		
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE		
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00		
SUM of Columns	2.00	2.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE		

SUM of

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / INPUT 5 Min Stat / Final Priority / Tech Adop / Minority

C4 fx 1

Water Need

Number of Applicants: 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	2.00	2.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | **INPUT 3 Wat Need** | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

B18 =IF(COUNT(B3:B17)>=2,SUMIF(B3:B17,"<>#DIV/0!",B3:B17),FALSE)

Technology Adoption

Number of Applicants: 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	0.33	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	3.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	4.00	1.33	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

A1 | Minority Status

Minority Status

Number of Applicants: 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	0.33	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	3.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	4.00	1.33	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | **INPUT 5 Min Stat** | Final Priority | Tech Adop | Minority

D.7.3 Dataset 3

S1 =‘INPUT 1 Tables’!B1

Water Availability

Number of Applicants: 10

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	FALSE	FALSE	FALSE	FALSE	FALSE
2	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
3	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
4	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
5	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
6	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
7	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
8	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
9	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
10	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	46.00	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / INPUT 5 Min Stat / Final Priority / Tech Adop / Minority

R10

Water Need

Number of Applicants: 10

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	0.14	1.00	0.11	0.20	0.11	0.11	0.14	0.14	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	0.14	1.00	0.11	0.20	0.11	0.11	0.14	0.14	FALSE	FALSE	FALSE	FALSE	FALSE
3	7.00	7.00	1.00	7.00	0.33	5.00	0.33	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	0.14	1.00	0.11	0.20	0.11	0.11	0.14	0.14	FALSE	FALSE	FALSE	FALSE	FALSE
5	9.00	9.00	3.00	9.00	1.00	5.00	1.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE
6	5.00	5.00	0.20	5.00	0.20	1.00	0.20	0.20	0.20	0.20	FALSE	FALSE	FALSE	FALSE	FALSE
7	9.00	9.00	3.00	9.00	1.00	5.00	1.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE
8	9.00	9.00	3.00	9.00	1.00	5.00	1.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE
9	7.00	7.00	1.00	7.00	0.33	5.00	0.33	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
10	7.00	7.00	1.00	7.00	0.33	5.00	0.33	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	56.00	56.00	12.63	56.00	4.53	31.60	4.53	4.53	12.63	12.63	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | **INPUT 3 Wat Need** | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

E4 =IF(AND('INPUT 1 Tables'!D87=20,'INPUT 1 Tables'!D89=20),'Priority Table Guide'!B18,IF(AND('INPUT 1 Tables'!D87=20,'INPUT 1 Tables'!D89=15),'Priority Table Guide'!C18,IF(

Technology Adoption

Number of Applicants: 10

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	7.00	7.00	1.00	7.00	7.00	1.00	7.00	7.00	7.00	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.14	1.00	1.00	0.14	1.00	1.00	0.14	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
3	0.14	1.00	1.00	0.14	1.00	1.00	0.14	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	7.00	7.00	1.00	7.00	7.00	1.00	7.00	7.00	7.00	FALSE	FALSE	FALSE	FALSE	FALSE
5	0.14	1.00	1.00	0.14	1.00	1.00	0.14	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
6	0.14	1.00	1.00	0.14	1.00	1.00	0.14	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	7.00	7.00	1.00	7.00	7.00	1.00	7.00	7.00	7.00	FALSE	FALSE	FALSE	FALSE	FALSE
8	0.14	1.00	1.00	0.14	1.00	1.00	0.14	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
9	0.14	1.00	1.00	0.14	1.00	1.00	0.14	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
10	0.14	1.00	1.00	0.14	1.00	1.00	0.14	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	4.00	28.00	28.00	4.00	28.00	28.00	4.00	28.00	28.00	28.00	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | **INPUT 4 Tech Adop** | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

Ready

Minority Status

Number of Applicants: 10

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	3.00	3.00	1.00	1.00	3.00	3.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.33	1.00	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
3	0.33	1.00	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	3.00	3.00	1.00	1.00	3.00	3.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	3.00	3.00	1.00	1.00	3.00	3.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE
6	0.33	1.00	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
7	0.33	1.00	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
8	1.00	3.00	3.00	1.00	1.00	3.00	3.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE
9	0.33	1.00	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
10	0.33	1.00	1.00	0.33	0.33	1.00	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	6.00	18.00	18.00	6.00	6.00	18.00	18.00	6.00	18.00	18.00	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | **INPUT 5 Min Stat** | Final Priority | Tech Adop | Minority

D.7.4 Dataset 4

D15 {=1/TRANSPOSE(E5:P5)}

Water Availability

Number of Applicants: 2

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	2.00	2.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

D15 {=1/TRANSPOSE(E5:P5)}

Water Need

Number of Applicants: 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	2.00	2.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | **INPUT 3 Wat Need** | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

D15 {=1/TRANSPOSE(E5:P5)}

Technology Adoption

Number of Applicants: 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	7.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.14	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	1.14	8.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | **INPUT 4 Tech Adop** | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

D15 {=1/TRANSPOSE(E5:P5)}

Minority Status

Number of Applicants: 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	2.00	2.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | **INPUT 5 Min Stat** | Final Priority | Tech Adop | Minority

D.7.5 Dataset 5

Water Availability

Number of Applicants: 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	5.00	1.00	1.00	5.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.20	1.00	0.20	0.20	1.00	0.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	5.00	1.00	1.00	5.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	5.00	1.00	1.00	5.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	0.20	1.00	0.20	0.20	1.00	0.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	5.00	1.00	1.00	5.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	4.40	22.00	4.40	4.40	22.00	4.40	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

G6 =IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=1),'Priority Table Guide'!B10,IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=2),'Priority Table Guide'!C10,IF(AND(

Water Need

Number of Applicants: 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	7.00	1.00	0.33	5.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	0.14	1.00	0.14	0.11	0.20	0.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	7.00	1.00	0.33	5.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	3.00	9.00	3.00	1.00	5.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	0.20	5.00	0.20	0.20	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	0.20	5.00	0.20	0.20	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	5.54	34.00	5.54	2.18	17.20	17.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | **INPUT 3 Wat Need** | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

Ready

B18 =IF(COUNT(B3:B17)>=2,SUMIF(B3:B17,"<>#DIV/0!",B3:B17),FALSE)

Technology Adoption

Number of Applicants: 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	1.00	0.14	0.14	0.14	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	1.00	0.14	0.14	0.14	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	1.00	1.00	0.14	0.14	0.14	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	7.00	7.00	7.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	7.00	7.00	7.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	7.00	7.00	7.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	24.00	24.00	24.00	3.43	3.43	3.43	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

Ready Average: 13.71 Count: 15 Sum: 82.29 100%

Minority Status

Number of Applicants: 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	0.33	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	3.00	1.00	3.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	0.33	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	3.00	1.00	3.00	1.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	0.33	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	0.33	1.00	0.33	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	10.00	3.33	10.00	3.33	10.00	10.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

D.7.6 Dataset 6

Water Availability

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	1.00	1.00	1.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	1.00	1.00	1.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	1.00	1.00	1.00	1.00	1.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	1.00	1.00	1.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	1.00	1.00	1.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	1.00	1.00	1.00	1.00	1.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	0.20	0.20	0.20	0.20	0.20	0.20	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	6.20	6.20	6.20	6.20	6.20	6.20	31.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / INPUT 5 Min Stat / Final Priority / Tech Adop / Minority

G6 =IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=1),'Priority Table Guide'!B10,IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=2),'Priority Table Guide'!C10,IF(AND(

Water Need

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	0.20	0.20	1.00	5.00	5.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	5.00	1.00	1.00	5.00	7.00	7.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	5.00	1.00	1.00	5.00	7.00	7.00	5.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	0.20	0.20	1.00	5.00	5.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	0.20	0.14	0.14	0.20	1.00	1.00	0.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	0.20	0.14	0.14	0.20	1.00	1.00	0.20	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	0.20	0.20	1.00	5.00	5.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	13.40	2.89	2.89	13.40	31.00	31.00	13.40	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | **INPUT 3 Wat Need** | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

B18 =IF(COUNT(B3:B17)>=2,SUMIF(B3:B17,"<>#DIV/0!",B3:B17),FALSE)

Technology Adoption

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	7.00	7.00	1.00	0.33	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	7.00	7.00	1.00	0.33	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	0.14	0.14	1.00	1.00	0.14	0.11	0.14	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	0.14	0.14	1.00	1.00	0.14	0.11	0.14	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	7.00	7.00	1.00	0.33	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	3.00	3.00	9.00	9.00	3.00	1.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	1.00	7.00	7.00	1.00	0.33	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	7.29	7.29	39.00	39.00	7.29	2.56	7.29	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

A1 Minority Status

Minority Status

Number of Applicants: 7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	3.00	3.00	1.00	3.00	3.00	3.00	3.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	1.00	1.00	0.33	1.00	1.00	1.00	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE	FALSE
11	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE	FALSE
12	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE	FALSE
13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	9.00	9.00	3.00	9.00	9.00	9.00	9.00	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | **INPUT 5 Min Stat** | Final Priority | Tech Adop | Minority

Ready 100%

D.7.7 Dataset 7

Water Availability

Number of Applicants: 13

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	0.20	1.00	0.20	0.20	0.20	1.00	0.20	1.00	1.00	1.00	0.20	FALSE	FALSE
2	1.00	1.00	0.20	1.00	0.20	0.20	0.20	1.00	0.20	1.00	1.00	1.00	0.20	FALSE	FALSE
3	5.00	5.00	1.00	5.00	1.00	1.00	1.00	5.00	1.00	5.00	5.00	5.00	1.00	FALSE	FALSE
4	1.00	1.00	0.20	1.00	0.20	0.20	0.20	1.00	0.20	1.00	1.00	1.00	0.20	FALSE	FALSE
5	5.00	5.00	1.00	5.00	1.00	1.00	1.00	5.00	1.00	5.00	5.00	5.00	1.00	FALSE	FALSE
6	5.00	5.00	1.00	5.00	1.00	1.00	1.00	5.00	1.00	5.00	5.00	5.00	1.00	FALSE	FALSE
7	5.00	5.00	1.00	5.00	1.00	1.00	1.00	5.00	1.00	5.00	5.00	5.00	1.00	FALSE	FALSE
8	1.00	1.00	0.20	1.00	0.20	0.20	0.20	1.00	0.20	1.00	1.00	1.00	0.20	FALSE	FALSE
9	5.00	5.00	1.00	5.00	1.00	1.00	1.00	5.00	1.00	5.00	5.00	5.00	1.00	FALSE	FALSE
10	1.00	1.00	0.20	1.00	0.20	0.20	0.20	1.00	0.20	1.00	1.00	1.00	0.20	FALSE	FALSE
11	1.00	1.00	0.20	1.00	0.20	0.20	0.20	1.00	0.20	1.00	1.00	1.00	0.20	FALSE	FALSE
12	1.00	1.00	0.20	1.00	0.20	0.20	0.20	1.00	0.20	1.00	1.00	1.00	0.20	FALSE	FALSE
13	5.00	5.00	1.00	5.00	1.00	1.00	1.00	5.00	1.00	5.00	5.00	5.00	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	37.00	37.00	7.40	37.00	7.40	7.40	7.40	37.00	7.40	37.00	37.00	37.00	7.40	FALSE	FALSE

G6 =IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=1),'Priority Table Guide'!B10,IF(AND('INPUT 1 Tables'!E82=1,'INPUT 1 Tables'!G82=2),'Priority Table Guide'!C10,IF(AND(

Water Need

Number of Applicants: 13

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	1.00	0.11	0.14	0.14	1.00	1.00	0.14	0.14	0.11	0.14	1.00	0.14	FALSE	FALSE
2	1.00	1.00	0.11	0.14	0.14	1.00	1.00	0.14	0.14	0.11	0.14	1.00	0.14	FALSE	FALSE
3	9.00	9.00	1.00	3.00	3.00	9.00	9.00	3.00	3.00	1.00	3.00	9.00	3.00	FALSE	FALSE
4	7.00	7.00	0.33	1.00	1.00	7.00	7.00	1.00	1.00	0.33	1.00	7.00	1.00	FALSE	FALSE
5	7.00	7.00	0.33	1.00	1.00	7.00	7.00	1.00	1.00	0.33	1.00	7.00	1.00	FALSE	FALSE
6	1.00	1.00	0.11	0.14	0.14	1.00	1.00	0.142857	0.14	0.11	0.14	1.00	0.14	FALSE	FALSE
7	1.00	1.00	0.11	0.14	0.14	1.00	1.00	0.14	0.14	0.11	0.14	1.00	0.14	FALSE	FALSE
8	7.00	7.00	0.33	1.00	1.00	7.00	7.00	1.00	1.00	0.33	1.00	7.00	1.00	FALSE	FALSE
9	7.00	7.00	0.33	1.00	1.00	7.00	7.00	1.00	1.00	0.33	1.00	7.00	1.00	FALSE	FALSE
10	9.00	9.00	1.00	3.00	3.00	9.00	9.00	3.00	3.00	1.00	3.00	9.00	3.00	FALSE	FALSE
11	7.00	7.00	0.33	1.00	1.00	7.00	7.00	1.00	1.00	0.33	1.00	7.00	1.00	FALSE	FALSE
12	1.00	1.00	0.11	0.14	0.14	1.00	1.00	0.14	0.14	0.11	0.14	1.00	0.14	FALSE	FALSE
13	7.00	7.00	0.33	1.00	1.00	7.00	7.00	1.00	1.00	0.33	1.00	7.00	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	65.00	65.00	4.56	12.71	12.71	65.00	65.00	12.71	12.71	4.56	12.71	65.00	12.71	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

B18 =IF(COUNT(B3:B17)>=2,SUMIF(B3:B17,"<>#DIV/0!",B3:B17),FALSE)

Technology Adoption

Number of Applicants: 13

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	3.00	3.00	3.00	3.00	5.00	3.00	3.00	3.00	1.00	3.00	5.00	3.00	FALSE	FALSE
2	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
3	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
4	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
5	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
6	0.20	0.33	0.33	0.33	0.33	1.00	0.33	0.33	0.33	0.20	0.33	1.00	0.33	FALSE	FALSE
7	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
8	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
9	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
10	1.00	3.00	3.00	3.00	3.00	5.00	3.00	3.00	3.00	1.00	3.00	5.00	3.00	FALSE	FALSE
11	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
12	0.20	0.33	0.33	0.33	0.33	1.00	0.33	0.33	0.33	0.20	0.33	1.00	0.33	FALSE	FALSE
13	0.33	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	0.33	1.00	3.00	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	5.40	15.67	15.67	15.67	15.67	39.00	15.67	15.67	15.67	5.40	15.67	39.00	15.67	FALSE	FALSE

SUM of

INPUT 2 Wat Avail | INPUT 3 Wat Need | INPUT 4 Tech Adop | INPUT 5 Min Stat | Final Priority | Tech Adop | Minority

Ready — Average: 17.68 Count: 15 Sum: 229.80 100%

A1 Minority Status

Minority Status

Number of Applicants: 13

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	3.00	3.00	1.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	FALSE	FALSE
2	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	FALSE	FALSE
3	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	FALSE	FALSE
4	1.00	3.00	3.00	1.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	FALSE	FALSE
5	1.00	3.00	3.00	1.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	FALSE	FALSE
6	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	FALSE	FALSE
7	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	FALSE	FALSE
8	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	FALSE	FALSE
9	1.00	3.00	3.00	1.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	FALSE	FALSE
10	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	FALSE	FALSE
11	1.00	3.00	3.00	1.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	FALSE	FALSE
12	1.00	3.00	3.00	1.00	1.00	3.00	3.00	3.00	1.00	3.00	1.00	1.00	3.00	FALSE	FALSE
13	0.33	1.00	1.00	0.33	0.33	1.00	1.00	1.00	0.33	1.00	0.33	0.33	1.00	FALSE	FALSE
14	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00	FALSE
15	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1.00
SUM of Columns	8.33	25.00	25.00	8.33	8.33	25.00	25.00	25.00	8.33	25.00	8.33	8.33	25.00	FALSE	FALSE

SUM of

D.8. AHP Final Prioritizations of Datasets

D.8.1 Dataset 1

J12

	A	B	C	D	E	F
1		Third Level Priority Vectors				Second Level Priority Vector
2		Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43
3	1	0.26	0.35	0.11	0.14	0.28
4	2	0.05	0.17	0.11	0.14	0.20
5	3	0.26	0.02	0.33	0.14	0.09
6	4	0.05	0.17	0.11	0.14	
7	5	0.05	0.05	0.11	0.14	
8	6	0.26	0.17	0.11	0.14	
9	7	0.05	0.05	0.11	0.14	
10	8	0.00	0.00	0.00	0.00	
11	9	0.00	0.00	0.00	0.00	
12	10	0.00	0.00	0.00	0.00	
13	11	0.00	0.00	0.00	0.00	
14	12	0.00	0.00	0.00	0.00	
15	13	0.00	0.00	0.00	0.00	
16	14	0.00	0.00	0.00	0.00	
17	15	0.00	0.00	0.00	0.00	

	A	B
20	Final Applicant Priority	
21	1	0.2460
22	2	0.1065
23	3	0.1986
24	4	0.1065
25	5	0.0730
26	6	0.1963
27	7	0.0730
28	8	0.0000
29	9	0.0000
30	10	0.0000
31	11	0.0000
32	12	0.0000
33	13	0.0000
34	14	0.0000
35	15	0.0000

Final Priority / Tech Adop / Minority Status / Blaney Criddle / Farr

D.8.2 Dataset 2

	A	B	C	D	E	F
1		Third Level Priority Vectors				Second Level Priority Vector
2		Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43
3	1	0.50	0.50	0.25	0.25	0.28
4	2	0.50	0.50	0.75	0.75	0.20
5	3	0.00	0.00	0.00	0.00	0.09
6	4	0.00	0.00	0.00	0.00	
7	5	0.00	0.00	0.00	0.00	
8	6	0.00	0.00	0.00	0.00	
9	7	0.00	0.00	0.00	0.00	
10	8	0.00	0.00	0.00	0.00	
11	9	0.00	0.00	0.00	0.00	
12	10	0.00	0.00	0.00	0.00	
13	11	0.00	0.00	0.00	0.00	
14	12	0.00	0.00	0.00	0.00	
15	13	0.00	0.00	0.00	0.00	
16	14	0.00	0.00	0.00	0.00	
17	15	0.00	0.00	0.00	0.00	
18						
19						

	A	B
20	Final Applicant Priority	
21	1	0.42722744
22	2	0.57277256
23	3	0
24	4	0
25	5	0
26	6	0
27	7	0
28	8	0
29	9	0
30	10	0
31	11	0
32	12	0
33	13	0
34	14	0
35	15	0

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / IN

D.8.3 Dataset 3

	Third Level Priority Vectors				Second Level Priority Vector
	Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43
1	0.02	0.02	0.25	0.17	0.28
2	0.11	0.02	0.04	0.06	0.20
3	0.11	0.10	0.04	0.06	0.09
4	0.11	0.02	0.25	0.17	
5	0.11	0.20	0.04	0.17	
6	0.11	0.05	0.04	0.06	
7	0.11	0.20	0.25	0.06	
8	0.11	0.20	0.04	0.17	
9	0.11	0.10	0.04	0.06	
10	0.11	0.10	0.04	0.06	
11	0.00	0.00	0.00	0.00	
12	0.00	0.00	0.00	0.00	
13	0.00	0.00	0.00	0.00	
14	0.00	0.00	0.00	0.00	
15	0.00	0.00	0.00	0.00	

Final Applicant Priority	
1	0.07944699
2	0.06319768
3	0.08649272
4	0.11650829
5	0.12518889
6	0.07201808
7	0.15897302
8	0.12518889
9	0.08649272
10	0.08649272
11	0
12	0
13	0
14	0
15	0

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop

D.8.4 Dataset 4

	Third Level Priority Vectors				Second Level Priority Vector
	Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43
1	0.50	0.50	0.88	0.50	0.28
2	0.50	0.50	0.13	0.50	0.20
3	0.00	0.00	0.00	0.00	0.09
4	0.00	0.00	0.00	0.00	
5	0.00	0.00	0.00	0.00	
6	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.00	0.00	
8	0.00	0.00	0.00	0.00	
9	0.00	0.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	
11	0.00	0.00	0.00	0.00	
12	0.00	0.00	0.00	0.00	
13	0.00	0.00	0.00	0.00	
14	0.00	0.00	0.00	0.00	
15	0.00	0.00	0.00	0.00	

Final Applicant Priority	
1	0.5762079
2	0.4237921
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / IN

D.8.5 Dataset 5

K13

	A	B	C	D	E	F
1		Third Level Priority Vectors				Second Level Priority Vector
2		Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43
3	1	0.23	0.22	0.04	0.10	0.28
4	2	0.05	0.03	0.04	0.30	0.20
5	3	0.23	0.22	0.04	0.10	0.09
6	4	0.23	0.40	0.29	0.30	
7	5	0.05	0.07	0.29	0.10	
8	6	0.23	0.07	0.29	0.10	
9	7	0.00	0.00	0.00	0.00	
10	8	0.00	0.00	0.00	0.00	
11	9	0.00	0.00	0.00	0.00	
12	10	0.00	0.00	0.00	0.00	
13	11	0.00	0.00	0.00	0.00	
14	12	0.00	0.00	0.00	0.00	
15	13	0.00	0.00	0.00	0.00	
16	14	0.00	0.00	0.00	0.00	
17	15	0.00	0.00	0.00	0.00	
18						
19						
20	Final Applicant Priority					
21	1	0.17542676				
22	2	0.0615155				
23	3	0.17542676				
24	4	0.29500348				
25	5	0.10756784				
26	6	0.18505965				
27	7	0				
28	8	0				
29	9	0				
30	10	0				
31	11	0				
32	12	0				
33	13	0				
34	14	0				
35	15	0				

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / INPU

D.8.6 Dataset 6

	Third Level Priority Vectors				Second Level Priority Vector
	Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43
1	0.16	0.10	0.15	0.11	0.28
2	0.16	0.32	0.15	0.11	0.20
3	0.16	0.32	0.02	0.33	0.09
4	0.16	0.10	0.02	0.11	
5	0.16	0.03	0.15	0.11	
6	0.16	0.03	0.36	0.11	
7	0.03	0.10	0.15	0.11	
8	0.00	0.00	0.00	0.00	
9	0.00	0.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	
11	0.00	0.00	0.00	0.00	
12	0.00	0.00	0.00	0.00	
13	0.00	0.00	0.00	0.00	
14	0.00	0.00	0.00	0.00	
15	0.00	0.00	0.00	0.00	

Final Applicant Priority	
1	0.13632092
2	0.20009145
3	0.19449873
4	0.11120172
5	0.11706578
6	0.15949465
7	0.08132673
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

D.8.7 Dataset 7

	A	B	C	D	E	F	G
1		Third Level Priority Vectors				Second Level Priority Vector	
2		Water Availability	Irregation Water Requirement	Technology Adoption	Minority Status	0.43	
3	1	0.03	0.01	0.18	0.12	0.28	
4	2	0.03	0.01	0.07	0.04	0.20	
5	3	0.14	0.20	0.07	0.04	0.09	
6	4	0.03	0.09	0.07	0.12		
7	5	0.14	0.09	0.07	0.12		
8	6	0.14	0.01	0.02	0.04		
9	7	0.14	0.01	0.07	0.04		
10	8	0.03	0.09	0.07	0.04		
11	9	0.14	0.09	0.07	0.12		
12	10	0.03	0.20	0.18	0.04		
13	11	0.03	0.09	0.07	0.12		
14	12	0.03	0.01	0.02	0.12		
15	13	0.14	0.09	0.07	0.04		
16	14	0.00	0.00	0.00	0.00		
17	15	0.00	0.00	0.00	0.00		
18							
19							
20	Final Applicant Priority						
21	1	0.06300203					
22	2	0.03254871					
23	3	0.129815					
24	4	0.06053306					
25	5	0.10660927					
26	6	0.07026276					
27	7	0.07862492					
28	8	0.05350352					
29	9	0.10660927					
30	10	0.10716257					
31	11	0.06053306					
32	12	0.03121608					
33	13	0.09957974					
34	14	0					
35	15	0					

INPUT 2 Wat Avail / INPUT 3 Wat Need / INPUT 4 Tech Adop / INPU

E. APPENDIX E

This data was provided from the interview and displays the crop index, acreage, and growing start date for each of the applicants. In addition the technology adoption data is displayed. If the participant was using piping as an improved water transport mechanism for their land then they were considered to have a rating of five for the model scoring; if the applicant adopted drip or sprinkler technology they were considered to have a rating of 10. Finally, if the applicant did not adopt technology, they received a score of zero.

E.1. Input for Dataset 1

1	2	3	4	5	6	7
16	34a	34a	1a	34a	1a	1a
1	0.33	1.167	1	0.5	0.375	1
Feb	Feb	Feb	Feb	Feb	Feb	Feb
36	1a	38	17	1a	38	38
1	1.167	0.33	1.5	0.5	0.25	0.5
Feb	Feb	Feb	Feb	Feb	Feb	Feb
	8	1a	25	38	39	37
	0.67	1.0833	0.67	0.5	0.625	0.125
	Feb	Feb	Oct	Feb	Feb	Feb
	37			37	8	39
	0.083			0.5	0.25	0.125
	Feb			Feb	June	Feb
	17			3	25	
	0.5			0.25	0.03125	
	Feb			June	Oct	
	2			23		
	0.583			0.25		
	June			June		
	23					
	0.083					
	June					

Tech Adoption	PVC Pipes (ft)	PVC from scheme (ft)	spr/drip system	Pipe (ft)	# of jets
	700				
5	300				
	400				
5	100	800			
	100	800			
		800			
10	1200		1	600	10
5		200			
		500			
5	600	400			
5	600				
	600				
	680				
5					
	500				

E.2. Input for Dataset 2

1.00	2.00
34a	34a
2	0.625
Feb	Feb
38	1a
0.75	0.25
Feb	Feb
37	38
0.5	0.125
Feb	Feb
	37
	0.125
	Feb
	17
	0.375
	Feb
	27
	0.375
	June
	25
	0.5
	Feb

Tech Adoption	PVC Pipes (ft)	PVC from scheme (ft)	spr/drip system	Pipe (ft)	# of jets
5	600				
10			1	440	5
	900				

E.3. Inputs for Dataset 3

1	2	3	4	5	6	7	8	9	10
34a	34a	37	34a	16	34a	16	16	16	17
2	2	1	2	0.5	1	1	1	1	1
Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb
1a		9		8	16	17	35	7c	27
0.33		1		0.5	0.5	0.5	1	1	1
Feb		Feb		June	Feb	Feb	Feb	Feb	June
		16		3	16	39		17	25
		0.5		0.25	0.375	0.5		1	1
		June		June	June	Feb		June	Oct
		23		17	17	16		25	
		0.5		0.375	0.5	0.5		1	
		June		June	June	June		Oct	
		3		3	3	17			
		0.5		0.25	0.25	0.5			
		June		Oct	Oct	June			
		27				19			
		1				1			
		June				Oct			
		17							
		0.5							
		June							
		37							
		1							

		Oct								
		25								
		0.5								
		Oct								

Tech Adoption	PVC Pipes (ft)	PVC from scheme (ft)	spr/drip system	Pipe (ft)	# of jets	Rubber (ft)
5	620					
5	900					
0						
0						
0						
5						300
0						
0						
5						328
0						
0						
0						

E.4. Inputs for Dataset 4

1	2
34a	34a
1	2
Feb	Feb
1a	8
0.33	0.5
Feb	May
37	17
0.5	0.5
Feb	Feb
27	36
0.167	0.5
June	Feb
17	
0.167	
June	

Tech Adoption	PVC Pipes (ft)	PVC from scheme (ft)	spr/drip system	Pipe (ft)	# of jets	Rubber (ft)
5	1692					
0						
0	1200					
0						

E.5. Inputs for Dataset 5

1	2	3	4	5	6
8	27	16	16	38	34a
1	1.5	0.5	0.5	1	1
May	Feb	Feb	Feb	May	Feb
1a	27	8	16	34a	16
1.5	2	0.5	0.375	1.33	0.33
Feb	June	May	Jun	Feb	Feb
17		17	17	37	1a
2		0.375	0.5	0.33	0.67
June		Feb	June	Feb	Feb
25		27	25	7c	28
0.5		0.5	0.25	0.167	0.33
Oct		June	Oct	Feb	Feb
		25		36	17
		0.25		0.67	0.33
		Oct		Feb	June
				17	
				0.67	
				June	

Tech Adoption	PVC Pipes (ft)	PVC from scheme (ft)	spr/drip system	Pipe (ft)	# of jets	Rubber (ft)
0						
0						
0						
5						984
						984
5						984
	800					
5	1000					
	400					

E.6. Inputs for Dataset 6

1	2	3	4	5	6	7
34a	38	16	34a	34a	34a	17
2	0.5	0.5	2	2	2	1
Feb	May	Feb	Feb	Feb	Feb	Feb
38	9	8	8		1a	34a
1.75	0.5	0.5	1		0.5	1.5
May	Feb	May	May		Feb	Feb
35		17	17			
1		0.5	1			
June		Feb	Feb			
40		25	27			
0.5		0.5	1			
Oct		Oct	June			
			17			
			1			
			June			
			25			
			0.5			
			Oct			

Tech Adoption	PVC Pipes (ft)	PVC from scheme (ft)	spr/drip system	Pipe (ft)	# of jets	Rubber (ft)
5	226.8					
5	984					
0						
0						
5	492					
10			1	440	3	
5						656
						328

E.7. Inputs for Dataset 7

1	2	3	4	5	6	7	8	9	10	11	12	13
34a	34a	37	16	16	34a	34a	16	8	36	38	34a	16
2	2	1.5	0.5	1	2	2	1	1	1	0.5	2	1
Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb
	38	17	8	17	37		17	17	13a	37		28
	1	0.75	1	0.5	1		0.5	0.5	0.5	0.5		0.5
	May	Feb	June	Feb	Feb		Feb	Feb	June	Feb		Feb
			23	25			25		23	8		34a
			0.5	0.5			0.5		0.5	1.5		1
			June	Feb			Feb		June	June		June
			17						17	17		13a
			0.5						0.5	0.5		0.25
			June						June	June		June
									37	25		16
									0.5	0.5		0.375
									Oct	Oct		June
									25	3		17
									0.5	0.5		0.5
									Oct	Oct		June
									40			
									0.5			
									Oct			

Tech Adoption	PVC Pipes (ft)	PVC from scheme (ft)	spr/drip system	Pipe (ft)	# of jets	Rubber (ft)
10			1	600	3	
5						590.4
5	656					
5						656
5						590.4
0						
5	125					
5						656
5						295.2
10			1	800	5	
5						295.2
0						
5	1180.8					

E.8. Borehole GPS Coordinates

HDK Borehole Locations						NAN Borehole Locations								
ID	Latitude	Longitude	ID	Latitude	Longitude	ID	Latitude	Longitude	ID	Latitude	Longitude	ID	Latitude	Longitude
5	12.04226	76.38745	50	12.1182	76.33792	79	12.09689	76.74275	113	11.93835	76.54652	144	12.04859	76.66923
9	12.07027	76.27731	51	12.11704	76.34154	80	12.10252	76.74109	114	11.92754	76.57977	145	12.04777	76.67018
11	12.0703	76.27635	52	12.12073	76.34583	81	12.00386	76.77511	115	11.94283	76.59741	147	12.204	76.62845
13	12.04603	76.31534	53	12.11804	76.33452	82	12.00361	76.77329	116	11.93854	76.55236			
15	12.05359	76.39297	54	12.11415	76.31279	83	12.03945	76.70542	117	11.93985	76.505			
19	12.06835	76.28952	55	12.06343	76.26752	84	12.03413	76.70738	118	11.93983	76.50694			
21	12.07222	76.29448	56	12.06432	76.26691	86	12.0288	76.69037	119	11.92772	76.51258			
23	12.04554	76.29559	57	12.06497	76.26813	87	12.02947	76.69098	120	11.94091	76.51414			
25	12.05237	76.33496	58	12.06463	76.26942	88	12.05033	76.67798	121	11.95313	76.51275			
27	12.23157	76.48192	59	12.06393	76.26293	89	12.07482	76.71296	122	11.9531	76.51386			
29	12.09323	76.40214	60	12.07439	76.2612	91	12.06383	76.71407	123	11.95744	76.50686			
30	12.1379	76.40158	61	12.07466	76.25995	92	12.06364	76.71433	124	12.00691	76.54668			
31	12.14281	76.38308	62	12.07583	76.26208	93	12.06219	76.71413	125	12.00736	76.54703			
32	12.15082	76.37818	63	12.07447	76.26129	94	12.06803	76.71767	126	12.00734	76.54697			
33	12.11869	76.34801	64	12.00765	76.30605	95	12.05958	76.70899	127	12.0236	76.66133			
34	12.1207	76.32698	65	12.01908	76.33437	96	12.06378	76.71054	128	12.01229	76.61622			
35	12.12458	76.32779	66	12.04108	76.33995	98	12.06797	76.52116	129	12.01111	76.61568			
36	12.12942	76.32872	67	11.9915	76.41137	99	12.01235	76.5195	130	12.01228	76.61479			
37	12.12828	76.32703	68	11.99076	76.41026	100	12.02384	76.50591	131	12.01293	76.61703			
38	12.1336	76.32911	69	11.94545	76.33318	101	11.98632	76.4991	132	12.01424	76.58691			
39	12.13377	76.32869	70	11.96918	76.33983	102	11.99827	76.54918	133	12.01389	76.58851			
40	12.13264	76.32752	71	11.91756	76.32574	103	11.99425	76.55335	134	12.07036	76.56841			
41	12.13274	76.32727	72	11.91681	76.32536	104	11.97351	76.55773	136	12.07423	76.57667			
42	12.13102	76.32583	73	11.9123	76.29062	105	11.98413	76.56347	137	12.07365	76.57649			

43	12.13082	76.32563	74	11.95254	76.43443	106	11.98696	76.56424	138	12.07236	76.59487			
44	12.15047	76.29481	75	12.15483	76.3037	107	11.97687	76.55585	139	12.07815	76.66238			
45	12.15024	76.29236	76	12.15363	76.30327	109	11.99178	76.54067	140	12.07346	76.66197			
47	12.18139	76.28945	77	12.15418	76.30201	110	11.95415	76.54801	141	12.07942	76.66429			
48	12.12438	76.34385	148	12.19021	76.31105	111	11.95161	76.54808	142	12.06284	76.66051			
49	12.12697	76.34893	149	12.19036	76.31026	112	11.9387	76.54852	143	12.06442	76.65964			

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