ADDIS ABABA UNIVERSITY

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An Integrated Approach to Water Supply Planning: Case of Addis Ababa (Nifas Silk Lafto sub city)

A Thesis Submitted to the School of Civil and Environmental Engineering Presented in Partial Fulfillment of the Requirements for the Degree of Master of Science (Water Supply and Environmental Engineering)

By: Amsal Eyassu Dalle

Advisor: Mebrate T. (Dr)

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ABSTRACT

In planning and designing a water supply planning system, the key emphasis for meeting the growing water demand in Addis Ababa and elsewhere in the world is often focused on the endless desire to search for new resources and development of them. Limited effort is devoted to addressing in the issue in an integrated approach which combines the supply and demand side in a sustainable approach. Integrated water supply planning is a significant issue for sustainable development to maximize economy, secure production and minimize environmental impacts. The identification of sustainable water demand management practices is technically challenging because of lack of educated staff and attitude.

Over the past few years, however, some efforts were seen in the developed countries to frame the water supply planning issue in an integrated fashion. However, this approach is not being practiced in developing countries, like Ethiopia, where the water supply problem is critical and the effort seems to repeat the track developed countries have taken without making the most out of the late comer position they maintain. With limited availability of water as a resource, the population pressure, the limited financial resource and other socio economic factors the traditional approach of endless investment is limited in its make to be a sustainable solution to water supply problems.

The analytical hierarchy process AHP, which is able to provide solutions for problems involved in determining the priorities of various policies, can also be successfully used to approach water policy and management. With regard to water shortage problem in the sub city of Nifas silk lafto, an AHP structure is constructed for helping decision making with a main objective and sub objectives. Among the various water policies, 22 policies are examined, and a set of six constraints is considered as criteria. A system is formed to support the judgments through a 3 round questionnaire for hierarchy in order to diminish the effect of subjective bias and interview with the manager of the sub city branch office of AAWSA. Computations are processed through AHP using excel. The results provide both qualitative and quantitative information on the policies as well as the priorities from the point of view of water supply planning and development. The AHP model gives not only the relative importance of each factor for each level but also the composite weights in relation to the main objective.

Key words: Water demand, Demand management, Analytic hierarchy process, Addis Ababa

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List of acronyms and abbreviation

AAWSA	Addis Ababa water and sewerage Authority
AHP	Analytical hierarchy process
DSM	Demand side management
EPA	Environmental protection agency
GIS	Geographical information system
IRM	Integrated resource planning
IWM	Integrated water management
IWRM	Integrated water resource management
NRW	Non revenue water
NWA	National water act
SADC	South African development community
WC	Water conservation
WDM	Water demand management
WHO	World health organization
WM	Water management
WSA	Water service authorities
WSI	Water service institutions

1. Introduction

1.1 Background of the study

Water is the most indispensable of all natural resources; it is essential for human beings, economic development and biological diversity. However, many countries have to face the challenge of rapidly growing water demands, driven by an increased population and economic growth, linked to urbanization, industrialization and mechanization (king, 2004). The resulting water scarcity is one of the most pervasive natural resource allocation problems faced by development planners. Hence water resource management turned out to be a political, social and economic issue of the present century and economists face new challenges of growing societal demands for water and changing laws and institutions (louw, 2002). Nevertheless, it is also recognized that water scarcity not only results from qualitative or quantitative scarcity, but also from inefficient use and poor water management (Dinar 2003). Therefore, the need for efficient, equitable and sustainable water allocation policies has increased and new water management studies aim at investigating innovate strategies to yield more efficient water allocation. (Rosegrant et al, .2000, Ringler, 2001).

The integration of Demand Side Management and Supply Side Management is a very topical and important issue internationally and particularly in areas where water resources are limited. Although it is widely recognized that Water Demand Management can reduce the overall water demands and therefore help to delay costly new infrastructure developments, there is considerable resistance to the acceptance of predicted water conservation savings when taking the decision on when to implement a new dam, pipeline or transfer scheme.

A common characteristic of water demand in urban areas worldwide is its relentless rise over many years, and projections of continuous growth over coming decades. The chief influencing factors are population growth, together with changes in lifestyle, demographic structure and the possible effects of climate change. This is compounded by rapid development, creeping urbanization and in some places the rising standard of living.

Meeting this increasing demand from existing resources is self-evidently an uphill struggle, particularly in water stressed or water scarce regions, in the developed and developing world alike. There are typically two potential responses; either ‘supply-side’, meeting demand with new resources or ‘demand side’, managing consumptive demand itself to postpone or avoid the need to develop new resources. Worldwide there is considerable pressure from the general public, regulatory agencies, and some governments to minimize the impacts of new supply projects (e.g. building new reservoirs or inter-regional transfer schemes), implying the emphasis should be shifted towards managing water demand by best utilizing the water that is already available.

1.2 Statement of the problem

In Addis, until fairly recently, emphasis has been placed on the supply side of water development. Demand management and improvement of patterns of water use has received less attention. Water managers and planners have given high priorities to locating, developing and managing new water resources. The aim was always to augment the national water budget with new water. The most popular way of achieving this aim was to control surface flows by building new dams. The Addis Ababa City Administrations has finally decided to go ahead with a decade-old project to construct two new water dams on the outskirts of the city to satisfy the increasing water demand of the city's residents at an estimated cost of some 8 billion birr. The Sibilu and Gerbi Dams, which are to be located some 30km north of Addis is planned to incorporate water treatment plants and reservoirs which have the capacity to supply 688,500 cubic meter water per day, the water dam projects are expected to increase the city's water supply substantially.

Some 100 million birr is expected to be paid as compensation to farmers relocated from the rivers' basin. The population growth of the town Addis Ababa has a great impact on existing water supply infrastructures, new projects to be implemented in the near future, to use the water efficiently and to assess different measures to conserve water usage; research is needed to integrate both supply and demand side water management strategies. Factors such as levels of service, existing living conditions, existing and proposed land use (master plan), existing per capita demands, current development trends, and demand values of other third world countries, were used in estimating the future water demands.

However, like many other developing countries the general approach taken by the City administration does not take in to consideration the need for other options in to account. A study conducted by the city attests that a significant portion of the water produced is lost in the distribution system. The size of the non-revenue water is approximately comparable to the gains which will be achieved if the new projects are in place. The way forward is not also exhaustive in its make as it does not model the benefits which can be achieved through the introduction of different demand side management measures. A simple modeling exercise done on current government housing schemes alone pointed significant savings in investment with the introduction of water efficient technologies. This research tries to reason with Addis Ababa city Administration on the need for integrated water supply planning.

1.3 Research objective

1.3.1 General objective

The general objective of this study is to develop and demonstrate an integrated water supply planning framework

1.3.2 Specific objectives

- To model the effect of demand side management measures on addressing water supply and demand gap
- To model the effect of non-demand side management measures on addressing water supply vs. demand gap.
- To develop an integrated approach to address the supply demand gap.
- To demonstrate a multi- criteria decision approach for water supply planning

1.4 Research questions

In order to achieve the above mentioned research objectives and seek answers for the stated problems, the following major research questions were designed

1. What is the current status of water supply planning policies and issues in the town Addis Ababa?
2. What are the major reasons for shifting from supply to demand side management of water supply planning?
3. What are the impacts of the conventional and demand side management systems in the planning framework of water supply?
4. What measures should be taken to ensure sustainable water supply service in the town Addis Ababa?

1.5 Significance of the study

Now a day's water shortage problem becomes significant in our city. The construction of new dams need very big investment as compared to our economic situation it may be difficult to implement these projects in short period of time rather wisely using our water resource is becoming more important. So shifting the water supply planning system from conventional one demand management is very necessary. In this regard, the result and finding of the proposed research work will be expected to have a great importance in changing the policy frameworks of the existing water supply planning. Besides, the study may also be utilized by the later researchers intending to work on the same subject or in the same study area. Moreover, this study will be a guideline for designers and engineers of this area in which regulation and policy of water management works takes place.

1.6 Scope and limitation of the study

This study is done on only in one sub city of the town Addis Ababa in sub city Nifas silk Lafto with selected woreda's with different living standard and the data were taken only from the boundary of the sub city. The limitation was the study is also the answers to the questionaries' may not be exact since it is the opinions of the peoples.

1.7 Thesis organization

Generally, the study has five chapters. The first chapter consists the introduction of the paper, statement of the problem, objectives, research questions methodology, scope and significance of the study. The second chapter of the study explored existing planning system of the water supply sector of the town and the new integrated approach with its importance to developing countries like Ethiopia. This chapter also included water supply policy of the town and institutional arrangement in the sector. The next chapter describes about the location and the general background of the study area of the selected sub city. The third chapter also is about over all methodology followed by data analysis and presentation. Finally, the last is the conclusion and recommendation.

To sum up, provision of adequate and quality urban infrastructure is the main concern all over the world. Especially water supply is an important sector of development. Therefore, many years efforts were done to resource development on the supply side management of the water sector.

Coming to sub city level, Nifas Silk Lafto sub city is one of the largest sub city in the city with number of population. Hence this paper aimed to have an integrated approach to the planning of water supply. To achieve the objective of the paper descriptive survey research method was used.

The sources of data for the study were primary and secondary data. Primary data was collected through interviews, key informant and personal observation from urban households, officials and different documents. Whereas secondary data was collected from different published and unpublished sources. The sample for the study was selected from the residents of Nifas Silk Laftosubcityworeda'susingsystematicsamplingmethod.

2. Literature review

2.1 Water demand management

The town Addis is categorized by large temporal and spatial variations in precipitation and with limited surface and ground water resources. The rapid growth and development in the region on scare resources to satisfy water demands. There are many variations on the definition of water demand management, but a good general description is: '*The management of the total quantity of water abstracted from a source of supply using measures to control waste and undue consumption*.' WDM may also be defined as the development and implementation of strategies, policies and measures aimed at influencing demand, so as to achieve efficient and sustainable use of the scarce water resource (Savenije and van der Zaag, 2002).

Another commonly used definition of WDM is '…adaptation and implementation of a strategy by a water institution to influence the water demand and usage in order to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability of water supply and political acceptability' (Jalil and Njiru, 2006, p.45).

Most definitions of WDM allocate the initiative for WDM to the service provider, which is expected to develop policies and invest in measures to achieve efficient water use both within the water distribution network (i.e. management of non-revenue water) and at the end-users' premises. WDM contrasts with the conventional supply-driven approach to water resources management, whose response to the ever increasing water demand is development of new water sources. There are five major categories of WDM measures (White and Fane, 2001): those measures that (i) increase system efficiency at the utility level; (ii) increase end use efficiency; (iii) promote locally available resources not currently being used, such as rainwater harvesting; (iv) promote substitution of resource use, e.g. use of waterless sanitation; and (v) use economic instruments to bring about an improvement in resource usage, such as use of tariffs.

A service provider could implement and/or promote a combination of one or more options that exist under each category. Urban water managers and policy makers need to make correct choices of the most viable options that fit within the socio- cultural, political, economic and environmental context. Ideally, these choices take into consideration the vision of the key city stakeholders and identified scenarios over the longer-term period.

2.2 Why Water Demand Management, Benefits

There are various benefits from WDM and they can be categorized in various ways. The most usual way of categorizing the benefits of WDM is dividing them to financial benefits and ecological benefits. Another way is to divide the benefits depending on who is benefited. The population in most developing countries is increasing rapidly. The rate of abstraction of fresh water has subsequently grown rapidly resulting in steadily declining per capital water availability. Practical distribution problems concerned with time, space and affordability lead to a widening gap between demand and supply in many parts of the world.

Benefits from Water Demand Management

Financial: Deferral in constructing new infrastructure for water and wastewater. Lower operating costs for the utility. Savings on water and energy bills on the consumers.

Ecological: Manage available water sources to ensure environmental sustainability. Less pollution (Micro pollutants). Less CO_2 emissions.

Social: Promote equity (developing countries). Less water borne illnesses.

Summary of benefits of a Water Demand Management program

2.3 Water Demand Management Measures

In the previous section the need for WDM was justified and major benefits from a WDM program were identified. In this section the various measures that can be part of a WDM program will be looked at. First of all, it has to be clear that a WDM program aims not only to reduce water use to the end users but also to reduce water use and water losses from the water service provider. The purpose of a WDM program is to reduce water use in total however possible this is.

2.3.1 Categories

According to Tate, 1990 WDM strategies can be divided into three categories: socio-political, economic and structural-operational.

Socio-political: Socio-political strategies include the strategies that are trying to change the users' behavior towards water usage and water wastage. This can be accomplished through sensitization of the public by education programs or media campaigns. Many users are not familiar with the great value of water and there is great potential for water demand reduction if the consumer is informed and changes behaviors that uses water wastefully, or discover new ways of using water more wisely.

Economic: Such measures are based on the theory that water apart from a social good is an economic good. So the water market is obeying the laws of supply and demand. So an increase in water price would theoretically result in a lower consumption of water. Such measures apart from rise in the price of water include penalties for excessive water use or financial incentives for efficient use of water.

Structural-operational: These measures include technological and engineering solutions that aim to reduce water consumption without lowering the level of service to the consumer. Such measures include the promotion of water efficient devices, alternatives to water supply (e.g. rainwater harvesting, water recycling) and adoption of plants that require less water for irrigation or no water at all (Brandes and Ferguson, 2003)

Another categorization of WDM measures is given by White and Fane (2001). According to him WDM measures aim to minimize either the overall or peak demand for water. The categories given are: increase system efficiency, increase end-use efficiency, promoting distributed sources of supply, substitute resource use and improve the market in resource usage.

Water Demand Reduction Actions	**System Management Actions**
Education and communication	Installation of district meters, pressure management, leak detection and repair
Council water conservation	Reduction of unbilled and illegal connections, metering and volumetric charging for all connections
Drought Management Plan, Permanent water conservation measures,	Optimization of raw water supply and treatment plant operations
Water conservation incentives for commercial customers	
The production and supply of recycled water to customers	

Table 2—1 Types of management measures

A comprehensive list of various WDM measures is given by Jalil and Njiru (2006), where measures are divided into the supply level and the consumer level. This categorization is very convenient for the purpose of this research. It also contains some measures that were not seen in other bibliographic references and are mostly concerned with the internal organization of the water service provider and other institutional issues.

In the above references the measures mentioned were generally the same but there were some unique methods in each of the sources. In the next pages some of the WDM measures that were thought to be applicable for urban domestic use are going to be discussed.

For the purpose of this study the measures were categorized in the first level as measures that are applied by the utility and as measures that are applied by the consumers. This categorization is not inclusive as measures need interaction from both the utility and the consumers in order to be successful but someone can see. Whether the measures are mostly applied by the consumers or the utility. At a second level the measures were put in broad groups and were discussed.

2.4 Measures applied by the water service provider

2.4.1 Addis Ababa water and sewerage authority

AAWSA is led by a general manager who is answerable to a board of directors. There are three deputy general managers leading the water production, resource management and service units. Since 2009 the authority has fully implemented business process reengineering (BPR). Hence, now it is structured in to processes unlike the earlier functional mode of organization.

There are two core processes, namely

1. Water production, distribution and catchment management core process.
2. Sewerage disposal service development and reuse core process

Besides the two core processes, support processes were engineered to assist the realization of the objectives of the two main processes. Also the eight branch offices were recognized in two sub processes after the model in the head office.

2.4.1.1 Increase system efficiency

These measures aimed at water conservation by the utility and not by the consumer. There are several processes involved in the drawing, treatment and transportation of water. Losses are very common in these processes. The water service provider could reduce these losses by leakage detection and repair, change in system operation such as pressure reduction and changed to operational use of water as water main flushing or reservoir cleaning.

The largest part of these losses is leakages from transmission mains and distribution networks and for a successful demand management program these losses have to be minimized. In order to achieve that, the utility has to implement a water loss management strategy.

There are various technologic solutions to aid achieving this objective. Some of these are leak detectors for detecting not visual leaks, pressure reduction valves, meters to meter the flow in different parts of the network and estimate losses and computerized systems to manage the network for the reduction of losses.

2.4.1.2 Economic measures:

There is a lot of discussion about whether water should be treated as an economic good or as a social commodity. The economics of water are analyzed in many books and articles like (Kay et al, 1997), (Kayaga, 2007a). It is not on the purpose of this research to make complicated analysis of the economics of water.

It is enough to say for the scope of this research that water is now days commonly considered as both a social and economic good. According to Dublin principle No 4: Water has an economic value in all its competing uses and should be recognized as an economic good.

Since drinking water requires pumping, treating and distribution it requires financial resources. These resources have to be recovered by the costumers of the water service provider. For this reason, there is a billing system in every utility referred as tariff. The ways a tariff can be constructed are various and serve different purposes. An explanation of the different kinds of tariffs and costs that should be recovered can be found in (Kayaga, 2007b).

Stephenson (1999) demonstrates in his paper the theory of how the price of water can affect consumption. Water is an economic good so the laws of supply and demand should apply for it. Although in theory this is true in reality things are different. According to the theory demand should be successfully managed by the use of tariffs. But as he concludes in his paper "The theoretical correct way to control consumption would be to charge marginal costs on the top consumption, but the administration and lifeline requirements make this difficult". He also states that "In fact water pricing experiences throughout the world (Dinar and Subramanian, 1997) show that external objectives of politicians or administrators can destroy the efficiency of water use control through tariffs".

A paper from Greece (Kolokytha et al, 2004) demonstrates a similar research with the one attempted in this report. In that research a questionnaire survey was conducted to a sample of 300 consumers of water in the town of Kozanh, Greece. The survey was trying to assess the level of acceptance of alternative WDM policies by the consumers. An important finding of the research was that although most of the consumers found that water was highly priced, when they were asked if they adjust the consumption of water according to the tariff 75% of the sample replied no.

Another paper by (Fafouths et al, 2004) discusses about a similar research this time in the city of Thessaloniki and the town of Volos, Greece. In the same question as in the previous referred paper 80% of the consumers answered that they don't adjust demand according to the price of water in both of the cities. So there is strong evidence that water price by itself cannot control the water demand. Maybe other complementary measures are necessary.

There are other economic measures that could be placed by the utility to manage water demand. Penalties for large consumption of water can be an effective measure. The limits of the consumption should be carefully set and take into consideration various parameters that affect water consumption such as, property size, number of occupants and existence of a garden.

2.4.1.3 Education and information measures

The consumer is not always willing to do something to conserve water. After all the water flows from the tap. It is more convenient to use water as much as someone likes without considering the implications of this action. So it is the water service provider's responsibility to persuade the consumer to put some effort for water conservation.

In order to achieve this, the consumer needs to be informed and educated. Information is needed on the environmental impacts of water usage but also on indirect impacts to the consumer. By indirect impacts it mean the possibility of future water shortage to the consumer. Also information about different technologic solutions for water conservation that can be installed in the household can be provided. People are not always aware of the different options that they could use to save water. Also information about the benefits that the users can have with water conservation can be provided. Generally, any information that can promote water conservation to the consumers can be provided by the water service provider.

2.5 Measures applied by the end user, Water Conservation (WC)

Apart from measures that are applied by the utility there are measures that are implemented by the utility but the application of them depends on the user. A term that is mostly used by utilities to promote measures like this is Water Conservation.

Baumann, 1987:174-179 after considering several definitions of water conservation comes to the following definition: “Water conservation is any beneficial reduction in water use or in water losses.” As he says later water conservation practices are a specific subset of those practices which comprise efficient management of water resources. It is also important to note that on his definition the word beneficial is of great importance. The reduction in water use has to result in a net increase in social welfare.

For the scope of this research water conservation will be considered as the final user’s efficient use of water. So the research will be focused on the conservation of water by the end users and more specific domestic users. The measures were grouped in use of water efficient appliances, practice of water saving behaviors and use of alternative water saving technologies and are discussed next.

2.5.1 Use of water efficient appliances

There are several appliances in a typical household that consume water. There is a potential in reducing the water consumed by these appliances by replacing them with water efficient appliances. “By installing more efficient water fixtures and regularly checking for leaks, households can reduce per capita water use from 74 to 52 gallons per day” (from 280 liters to 196 liters) (EPA, 2007). Some issues that were found in the literature concerning water efficient appliances are discussed in this section. The main source for this section was EA (2003) unless is otherwise stated.

2.5.2 White goods

White goods that use water and can potentially save water are considered the washing machine and the dish washing machine. These are machines that mainly need water to function. Apart from water these machines use electricity and detergent. With efficient machines savings on water, electricity and detergent could be achieved.

Manufacturers have realized that consumers are nowadays more informed and educated on environmental issues so they have developed new more efficient machines regarding water, electricity and detergent use. Also some models are more effective regarding cleansing and noise production. They have also developed labels that inform the consumer on the energy use by each model. The rating of the labels is from A to the least use of energy to F to the most use of energy. This way the consumer can make the decision on which model to buy with the extra criterion of energy use.

Problems with ratings are that they are not independently assessed but its manufacturer rates the models of the company. So the reliability of the ratings is in question. Several studies in "Which" web site have proven that the manufacturers' claims are not always right.

There has been a drop in the prices of water efficient white goods and an increase in the variety of water efficient models available in the market. So there is an opportunity to promote the purchase of such goods to the users.

2.5.3 WCs

The WC is the most demanding water component of indoor household use. The water used in WCs in mainly for toilet flushing, showering, bathing and washing. The appliances involved in these tasks are toilet cisterns, shower heads and taps. For each of these appliances there are solutions for water conservation.

Toilet cisterns are used to flush the toilet. Approximately 30% of house consumption is used for flushing the toilet according to Keating and Howarth (2003). When in the past cisterns used to use 12 liters of water per flush nowadays there are ultra-low flush toilets that can flush with 4 liters. There are also dual flush systems that can flush with 6/3 liters per flush. The decision is in the user depending on the use of the toilet.

Concern about flushing systems is that although they might be technically perfect they are not always used correctly so the expected reduction in water use is not achieved. There are empirical beliefs that the users usually double flush the toilet because they are not satisfied by the single low flush resulting in an increase in water consumption rather than a reduction. But Keating and Howarth (2003) states that "the installation of cistern-displacement devices and retrofit dual-flush systems into real-life household situations can produce genuine water savings".

Water efficient shower heads can reduce water demand in the household. There are two ways that water efficient shower heads function. They either atomize water or they introduce air in the flow of the shower water. In both of these ways the water is spread in the outlet of the shower head, so less water is used for the same shower effect. Another method to reduce water used in the shower is to install a flow control valve. This valve is holding the flow constant to a low level.

Both of these measures can reduce the water consumption but there are some issues that can prevent this from happening. The user might take longer showers so the reduction in water consumption and the longer time in the shower even out. The reason for taking more time in the shower is that since water consumption is lower the hot water can last longer. So it is common that users exhaust the hot water.

Apart from showers people take baths often. Bath tubs can be water efficient as well. By selecting the proper size and shape of a bath tab depending on the size of the user water reduction can be achieved. But there is always the user's decision at the end on the level at which he /she is going to fill the bath tab.

Taps in the WC washbasin, can be water efficient. Water efficient taps work in the same way as the shower heads and are the most easily acceptable by the users because there is nothing to lose in terms of convenience or pleasure. Although water efficient taps are so simple to use but they are not widely used.

2.5.4 Practice water saving behaviors

Apart from technologic solutions such as water efficient appliances, an effective way of reducing the consumption of water in the household is to practice certain behaviors that reduce the consumption of water without lowering the level of service. Many water using tasks in the household are done without thinking the wastage of water. People do not think about the implications of water wastage when they apply everyday tasks like brushing their teeth or washing the dishes. The water flowing from the tap seems to be plenty and infinite. But this is not true.

Water saving behaviors is simple things that users usually neglect of doing. Practices Such as turning of the tap when brushing one's teeth can save water. Practices are Simple and do not need financial resources but the users are used in doing things their way.

2.5.5 Use of water saving alternative technologies

By "alternative technologies" mean technologies that are not widely used. Without doubt a technology might be considered as alternative in one place but might be common in another place. A technology but not yet fully developed is Grey water treatment and reuse. By this method we mean the treatment in the household level and on site reuse. The reuse of the treated water is mostly focused on flushing the toilet. Although there is certain water saving benefits in this technology there are concerns about the health risk associated with the in situ treatment of grey water (Warner, 2006).

Various technologies are available but there is controversy in the literature. The technology is not yet fully developed and there is a great variety of products. Although manufacturers advertise the good performance and efficiency of their products scientists have not come to a conclusion.

The fact that this is not a tested technology combined with the health risks make this technology less likely to be easily adopted by consumers. However, if consumers are recommended with criteria for buying the right product and they are informed about the benefits that this technology could have, it is possible to be acceptable.

The other more tested technology is rainwater collection. Rainwater is collected, treated and then used. Rainwater can be used either for non-potable uses or even for potable uses. The basic prerequisite for the application of rainwater collection systems is adequate rainfall. These systems cannot be applied in areas where there is a low level of rainfall.

2.6 Supply development versus demand management: the paradigm shift

The traditional approach of hydrologists and water resources engineers has been to focus on the supply side and the assessment of available water resources. Forecasts of water demands have often been provided by other departments, ministries or consultants, with a wide range of uncertainty because of the:

- Limited data on historic actual water use
- High levels of uncertainty in establishing efficiency of water use, with significant losses likely in irrigation, urban and industrial water use
- Uncertainties in the basic economic, social and demographic assumptions required for water demand forecasts.

As a result, there is a high degree of uncertainty in current forecasts of the supply-demand balance at national, regional and global levels. There are large variations in local availability - both in space and time. Thus, it is increasingly being recognized that supply and demand can only be balanced if water resources and water supply engineers address *both* sides of the balance. Donor agencies, such as the World Bank, have long advocated demand side management, and now national and local government agencies in different countries are participating in a number of programs that implement these policies.

For instance, SADC has played an important role in agreeing on key strategic objectives and defining an Action Plan of 31 priority projects - which includes one on the Economic Accounting of Water Use. However, water resource policy makers and professionals are now challenged to work out the practical implications of water demand management within *integrated water* resource planning, development and management. New approaches to water management are also beginning to focus on the way in which water is needed and used (efficiency, effectiveness and demand management) in each user sector, rather than simply predicting, planning and providing all its water demands.

Reasons for promoting water demand management include

- Excessive water use leads to over capitalization of infrastructure;
- Additional infrastructure brings high debt and high fixed water costs;
- WDM measures often have benefit to cost ratios in excess of 10:1 in urban situations;
- WDM measures can be introduced flexibly and incrementally;
- WDM can be a vehicle for socio-political objectives such as equity and gender issues;
- WDM only succeeds with community participation;
- Water saving technologies are not usually capital intensive or high technology;
- WDM requires measurement of all components of the water cycle and good management;
- Realistic water charges support sustainable water services

To enable this paradigm shift towards demand management, the importance of political intervention cannot be over emphasized. This can give major impetus to the campaign and without this kind of open and proactive political support, the wheels of change are almost certain to grind to a halt.

Table 2—2 Description of demand management options

Catagory	Name	Short description
Demand	Appliance oerformance standards	The introduction of national standards for the efficiency level of water using appliances manufactured, imported or sold
Demand	Non-residential program	The provision of advice to businesses on apportunities for water saving equipment and practices and financial support to encourage uptake.
Demand	Pressure and leakage reduction	Reducing excess pressure in the water supply system which reduces leaks and bursts, and a program if active leakage control which reduces leakage and other unauthorized use of a minimal level.
Demand	Residential outdoor program	Provision of targeted advise and support, including equipment or resources, to householders to assist in improving the efficiency of outdoor water use. This includes landscaping, species selection, mulching, maintenance, irrigation equipment and practices soil treatment.
Demand	Residential indoor program	Discounted or free installation of water efficient equipment in houses, and rebates on the purchase of water efficient clothes washers.
Demand	New developments (smart growth)	The application of innovative approaches to servicing new developments (Greenfield or infill) that first minimize water demand through water efficient appliances, fixtures and landscaping. Secondly, they maximize the use of available water from the lot or neighborhood, through roof water and storm water capture and reuse. The principles of water quality cascade are used, maximizing the potential for treatment and reuse of waste water for lower grade uses. Reductions in the cost of recirculation can be used to offset increased treatment costs.
Demand	Effluent reuse	The use of treated effluent from sewage treatment plants, reticulated to large users, households and agricultural use or environmental flow returns. This will only provide a benefit interms of yield if there is an offset in the required environmental or agricultural flow release. The avoided cost of sewage treatment upgrades which may not be required e.g. for nutrient removal can be deducted from this cost.

Table 2—3 Description of supply management options

Category	Name	Short description
Supply	Emergency supply readiness	The ability to build capacity to supply additional water in an emergency. This might, for example, include the ability to construct bores to access ground water, or to transfer water from a neighboring catchment, or to use advanced recycling to supplement supplies to a reservoir. The yield that is provided is based on the fact that the existing water supply system can be drawn down further knowing that there is an option available to supplement supplies. The risk weighted cost of the option is dependent on the probability of the need for it being triggered.
Supply	Accessing dead storage	This describes an option involving extending dam intakes to increase the effective capacity of storages. This allows for an increase in the safe yield as described above.
Supply	Agriculture efficiency transfers	The use of improved efficiency in agriculture to save water and thereby reduce flow releases from water storages which can then be allocated to urban use. Water savings in irrigated agriculture can be very low cost relative to urban water savings.
Supply	Weir raising	This involves the increase in the wall of weirs, allowing greater levels of storage.
Supply	Desalination	The construction of a desalination plant to operate continuously, rather than in the 'readiness mode' as described above.
Supply	New dam	The construction of a new dam, generally further from the center of demand than existing storages, often in neighboring catchments. In most cases there are significant transfer pipeline and pumping costs involved.

2.6.1 Stakeholder Benefits of Demand Reduction

In addition to improving the supply-demand balance, demand management alternatives offer multiple benefits, including environmental benefits over and above the economic benefit of lower costs. The tangible economic benefits include the energy savings in water heating and pumping, the foregone costs of water treatment, distribution system capacity, wastewater collection and treatment, as well as the savings in capital expenditures because of deferred, downsized, or eliminated water supply projects. Water savings may also produce environmental benefits by providing increases in the availability of water for streams, wetlands and estuaries.

In many cases, demand management programs are beneficial even where there is an abundant supply of water and no gap between demand and supply. Simply stated, the adoption of certain demand management measures can save money both for water providers and individual users.

Water demand management alternatives can be viewed as a means to enlarge the range of choice into a more holistic framework of integrated water resources management. Today, many water professionals share the view that a better understanding and careful management of water demand is critical to our ability to support the needs of a growing population and economic development without degrading the natural environments and ecosystems that sustain water resources systems.

While the practical experience with demand management continues to accumulate, the current state of knowledge may not be sufficient to meet the ambitious goals made in declarations from international meetings of water resources professionals.

2.7 The urban water planning framework

Integrated resource planning considers both demand and supply side options and treats them equally when determining how to close the supply demand gap. The Addis Ababa water and sewerage authority now need to experience a growing need to better understand the demand for water supply. Specifically, practitioners need new skills in detailed demand forecasting and how to develop, implement and evaluate demand management potions. Detailed supply side analysis will need to be considered in parallel with the demand-side actions. This includes a thorough understanding of the yield of the water supply system and the importance of the level of service objectives in determining the yield.

For water authorities and other stakeholders to plan and manage water needs more effectively, the IRP framework uses what is known as adaptive management. That is the IRP framework assists water authorities to

- Forecast water demand more accurately by understanding in detail where and how water is used
- Determine the gap between available supply and projected demand, the supply demand balance
- Develop and analyze options to fill the supply-demand gap that consider the full spectrum of options available using consistent economic and sustainability assessment methods.
- Plan and implement the preferred suite of options
- Evaluate the options implemented and the planning objectives identified

2.7.1 Need for integrated water resource management

The principal components of IWRM in urban areas are

- ✓ Supply optimization
- ✓ Demand management
- ✓ Participatory approaches to ensure equitable distribution
- ✓ Improved policy
- ✓ Regulatory and institutional framework
- ✓ Intersect oral approach to decision making (UNEP-international environmental technology center, 2003)

2.7.2 Urban water demand side management policies

Basically, policymakers can choose between two types of DSM policies: price policies and non-price policies, the latter including for example water restrictions on specific uses (such as irrigation or car washing), information and education campaigns to encourage water conservation, and rebates for adoption of water-efficient technologies. The choice of price or non-price instruments for water demand management has been at the core of a debate among economists and policy makers about both the effectiveness of alternative policy instruments in inducing efficient water use and their equity implications for residential users. While economists generally advocate higher residential water prices as a means of reducing demand, others argue that non-price policies constitute the only viable means to reduce residential demand.

The main argument is that water being a basic need and water demand being usually found price inelastic, then allocating it on the basis of price may place a larger cost burden on poorer and larger households. However, econometric studies indicate that the welfare loss of water service interruption usually exceeds that of a price increase (see Woo, 1994, using data from Hong-Kong; Roibás, García-Valiñas and Wall, 2007, using data from Seville, Spain; and Grafton and Ward, 2008, using data from Australia).

Another conclusion from previous studies is that households with different characteristics usually have different responses to the various policy instruments. In Southern California, households with lower income responded more to higher water prices than wealthier household groups (Renwick and Archibald, 1998).

The impact of the rationing policies also differed among households, mainly depending on the size of their landscaped areas. Another study confirmed the differences in households' responses to price rises; when separating indoor and outdoor use from 11 urban areas in Canada and the United States over a two-week period in a dry, and also a wet season, households with the largest incomes and lot sizes are found to have the least price elastic outdoor demand, while households with the lowest incomes and smallest lots are the most price elastic (Mansur and Olmstead, 2007). These latter findings emphasize the importance to use household data in order to be able to control for heterogeneity in responses to DSM policies.

2.7.3 Governmental Reforms and Regulations

2.7.3.1Water and energy policies of Ethiopia

2.7.3.1.1Water policy and related regulations

The Ethiopia water resource management policy was issued in 1999. The overall goal of water resources policy as stated in the policy document is "to enhance and promote all national efforts towards the efficient, equitable and optimum utilization of the available water resources of Ethiopia for significant socioeconomic development on sustainable basis". The fundamental principles of water resources management policy as stated in the document are:

- Water is a natural endowment commonly owned by all the peoples of Ethiopia
- Every Ethiopian citizen shall have access to sufficient water of acceptable quality, to satisfy basic human needs.
- Water shall be recognized both as an economic and a social good.
- Water resources development shall be underpinned on rural-centered, decentralized management, participatory approach as well as integrated framework.
- Management of water resources shall ensure social equity economic efficiently, systems reliability and sustainability norms.
- Promotion of the participation of all stakeholders, user communities; particularly women's participation in the relevant aspects of water resources management.

  - The water resource management policy has a series provisions for inland water transport; aquatic resources; water for tourism and recreation; cross-cutting issues such as water allocation and apportionment, environment, watershed management, water resources protection, water resources conservation, technological issues, management of water resources information, development of information management system, water pricing, ground water resources, disasters, emergencies and public safety, trans-boundary waters, stakeholders, gender, research and development and water quality management.

Governments play an important role in water demand management by creating a receptive regulatory environment and providing economic incentives for the adoption of conservation practices. However, few national policies exist at the present time. The primary focus of those that do exist is on the discharge of water after it is used. Both bottom- up (economic) and command-and-control (non- economic) policy options are available togovernments.

These activities come in the form of legislative mandates and programs that are adopted by watermanagement institutions. In the United States, the federal and state governments have accepted water conservation as a “good policy” for water resource management. As a result, water conservation mandates have become nearly ubiquitous and most federal water agencies have some water conservation responsibilities (Martin et al., 1994).

The Federal Energy Policy Act of 1992 is an example of the national effort to mandate uniform water efficiency standards for plumbing products (Vickers, 1993). Legislatures in almost all of the states have also followed the federal statutes. They have passed or are developing statutes that are aimed at improving the efficiency of water use.

Government mandates are often seen as a critical factor in the adoption of water conservation. However, the effectiveness of government mandates is dependent on an understanding of the national water resources situation. National programs of collecting and publishing reliable data on water use are an important prerequisite for the development of policies and regulations aimed at water demand management. At present, the limited data on water use in many countries are of poor quality and are usually restricted to estimates of water withdrawals.

Table 2—4 Factors or policy actions that influence demand

Supply-side options (influences yield)	Demand-side (influences demand)
New dams, pipelines, groundwater, desalination	Improve system efficiency (leakage, pressure management)
Changed environmental flow regime	Improve water-use market
Reuse schemes for environmental flows	- metering, billing and pricing
Indirect potable reuse into storages	- education and advisory services
Changed drought response strategies	Improve residential water use efficiency (incentives, retrofit, regulation)
- restrictions regime	- appliances and fixtures

2.7.4 Developing tools and skills for water demand management

The identification of tools and skills to enable the implementation of water demand management is very important, water demand management policy need to be identified with the constitutional need to support those policies, and the ways to educate people and raise their awareness of demand management issues.

Technical standards, methodologies and guidelines should all be considered as useful tools when implementing water use and demand management strategies at all levels. It is generally felt that economics has a pivotal role to play in demand management, and that more emphasis needs to be placed on understanding the role economics has to play.

Addressing the need for further application of cost-benefit analysis tool will help countries to manage water demand more effectively. There is a need to put a coherent framework on the economic skills required in practice. Demand management is becoming rapidly more important not only in water scared countries but also in where water resources are already stretched. It is crucial to raise awareness among all members of society of the value of this limited resource.

2.8 Water Demand Management Challenges

From the above sections it seems that the technological solutions exist and are very promising for reducing the water consumption in the domestic urban sector. But there are significant challenges that have to be overcome in order for a successful WDM program to be successful. There are also challenges to implementing WDM programs. The major challenges that were found in the literature and are applicable in the urban domestic sector are presented below. The major sources of these findings are from Jalil and Njiru, (2006) and Viessman, (1987) unless otherwise stated.

Education and training: There is lack of education among professionals in the water sector especially in issues regarding WDM. Most of the older professionals that have key places in utilities are oriented in the supply side approach. So WDM is neglected not because it is not applicable but because the decision makers are not completely aware of its purpose and benefits compared to the traditional supply side approach.

There is also lack of education to the consumers about the benefits of water conservation, water efficient appliances and environmental issues. Without having knowledge in issues like that the public cannot be engaged in doing something that will require effort and financial resources as WC.

Institutions: In some cases, the institutions that are dealing with water issues are old and are operating under yesterday’s policies and philosophies. There is also the issue of multiple institutions with no collaboration and lack of communication. Generally, it is common that there is not a proper organizational structure of the involved institutions which makes decision making difficult and causes lagging. So decisions are often made based on demoded approaches.

Legislation: A government cannot rely on the utility’s “good will” for the protection of the environment and the consumers. It is also important to have regulations about the responsibilities in the water sector. The government must place policies laws and regulations to ensure that the water supply sector is operating efficiently effectively and promotes the interests of the consumers. This includes the protection of the environment and ensuring the sustainable development. With proper regulations and policy, the WDM can be promoted because of its benefits for the utility, the consumers and the environment.

The situation in many countries is not at all similar to the above. There is lack of a uniform water policy, laws and regulations that are not applied and do not have a united approach. So it is usual in some countries that there is not a proper framework for the utilities operation. There is no guidance and the WDM cannot be promoted

Funding: WDM is a process that needs planning and implementation. For both of these steps funds are necessary to conduct the proper research and measurements, to develop the most appropriate program, to provide incentives to the consumers and purchase of hardware that is needed for the program. Although a WDM program can be financially beneficial in the long term funds are needed at the first steps to design and implement the program.

In many countries the situation is different. Funding for the water sector is based mostly on subsidies resulting in low budgets and declining infrastructure. There is a belief that water is a free good and anyone should use as much as he needs with low cost. This belief is starting to change in the most developed countries but is prevalent in low and middle income countries. Although water is a social good the costs for the production have to be recovered. What is more, costs for the development of new strategies that will be for the best of the consumers have to be paid by someone.

Level of implementation: Although it was shown that WDM has several benefits to all parts of the society it has to be decided the level of the implementation of such programs. The reduction in demand has limits and development of new sources is sometimes necessary. The challenge is to decide which one is the appropriate level of covering demand either by capacity expansion or demand management for offering the more benefits to the society.

Alternative technologies: There are various alternative technologies that could be part of a WDM program. Examples are in-house wastewater reuse and rainwater collection as discussed in above section. Although this kind of technologies can reduce water consumption there are limitations that prevent their application in WDM programs. These limitations are mainly public acceptance and not appropriate technologic solutions developed for the local context.

Increasing population and increasing industry has led to increasing demand for water. This fact combined with the scarcity of water in many parts of the world and the pollution of water resources has led to IWRM. The evolution of IWRM emphasizing on the economic value of water has produced a new approach to covering the demand for water, the WDM.

WDM can provide benefits to all parts of the society. Benefits are gained by the consumers, the communities, the utilities, the companies, the environment and the economy. The benefits are financial, environmental and social. Several case studies of WDM programs implemented around the world are proof that WDM can be applied in many cases and can provide the benefits without much cost to the society.

However most of the case studies are focused in big cities where there is an economy of scale and in situations where water scarcity was a great issue. Not many information was found in implementation of WDM programs in smaller towns.

But if there are benefits to be gained from WDM and the solutions for implementing such programs are there, why isn't WDM so spread in the world? It seems that there is much more room for implementation of WDM programs. Despite the existence of many effective measures, there are major challenges that make the implementation of WDM difficult. These challenges are the lack of education and training in water professionals and bodies, lack of proper institutional organization, lack of appropriate legislation, lack of funds, decision difficulties depending on the situation and lack of locally available alternative technologies.

It is obvious from this chapter that there are plenty of measures to include in a WDM strategy. The challenge is to pick the appropriate measures for the appropriate situation. The success of a WDM program is dependent on the social characteristics of the residents of the location to be implemented. It is also dependent on the perception of the responsible for water supply in WDM.

‘It is not only about digging wells or improving the water mains. Water must be tackled within in a much wider framework. It concerns not only science and technology but also cultural and social aspects’ explains Andras Szöllösi-Nagy, Director of UNESCO’s Division of Water Sciences (UNESCO, 2007).

So if the question to be answered is whether there is potential for WDM in a specific area an assessment of the current situation should be made to identify the problems that WDM could potentially solve. Then the perception of the stakeholders should be assessed. The main stakeholders would be the utility and the consumers. The utility is mostly concerned with technical and scientific issues and these perceptions should be identified. But the perception of the consumers can be identified only by assessing their acceptability of such measures. Decision making tools have been developed through much research for the implementations of different measures. And there are reliable technologies developed for the implementation of these measures. This leads to the research that was conducted for this project and is explained in more detail in the next section.

2.9 Summary of findings from the literature review

2.9.1 Best practiced case studies

A summary of water demand management experience in Zimbabwe identifies the principal forces that have led to conflicts in Zimbabwe’s water sector as the

- Depletion or degradation of the resource through inefficient use
- Doubling of population approximately every 20 years
- Unequal distribution of access to the resource

Rationing measures applied in the city of Bulawayo had important effects on levels of consumption in high and low density areas. Most major urban areas in Zimbabwe still have a supply oriented approach. To co-ordinate nationwide WDM approaches, satisfy additional demand and relive tension amongst users, WDM needs to be introduced through the national water policy and strategy provisions.

The university Nadal, South Africa has developed two tools to help hydrological practitioners move from national to local scale water use and demand management. Several southern African countries are leading the way with the development of new legislation and policy that pays specific regard to water demand management.

Typical water-saving devices in households {main findings}

1. Most of the water used in households is for toilet flushing (33%) and bathing and showering (20-32%). The lowest percentage of domestic use is for cooking and drinking (3%)
2. Different experiences show that savings can be achieved using various water saving devices in households, public places and industry (especially hotels and leisure centers). Nevertheless. These kinds of devices are not very widespread in households.
3. Water saving devices on tabs, and toilets with 6L/flush could achieve reductions in use of around 50%
4. It would be necessary to encourage market penetration of these devices by increasing the information for users and seeking the cooperation of producers (better information to consumers about the available technologies)
5. The impact of the use of household water saving devices on total urban demand is different depending on the proportion of household demand in total urban demand.
6. Polices, legislations

Namibia- public awareness campaign teaches how to save water in the home, and how to maintain low water gardens. It needs development of regional public awareness and communications programs to increase community awareness on sustainable water management.

South Africa-school’s liaison and school water audits encourage a cultural of awareness from an early age and teach parents via their children which needs raised institutional awareness of cultural issues.

2.10 Decision making tools

2.10.1 Analytic hierarchy process

AHP is a qualitative-quantitative analysis with the multi-objective decision making and comprehensive evaluation method. This method can help decision makers determine the quantitative experience in order to achieve optimal decisions (Satty, 1980). The basic steps involved in this method as follows.

1. Structuring a decision problem and selection of criteria

This step decomposes a decision problem in to its constituent parts. In its simplest form, this structure comprises a goal or a focus at the top most level, criteria (and sub criteria) at the intermediate level, while the lowest level contains the options. Arranging all the components in a hierarchy provides an overall view of the complex relationships.

2. Establish a pair-wise comparison decision matrix

This involves describing preferences over outcomes in the form of relative weights on a pair-wise comparison basis. The weight specification is simplified by using a pair-wise comparison decision matrix. The relative importance of two factors is rated using a scale with the values with the values 1,3,5,7, and 9, where 1 refers to ‘equally important’, 3 denotes ‘more important’, 5 equals ‘obviously more important’, 7 represents ‘strongly more important’ and 9 denotes ‘extremely more important’. Also, 2, 4, 6, and 8 are used for compromise between the above values. The reciprocal denotes inverse comparison (Satty, 1980).

3. Normalizing the decision matrix and calculate the priorities of this matrix

Construct an n-criteria evaluation matrix A in which every element aij is the quotient per ratio of preference values attached to the criteria. Transform the pair-wise preferences summarized in the evaluation matrix A into a vector of weights that could be attached to the multiple outcomes.

4. Checking consistency

The maximum Eigen value lamda max and a corresponding eigenvector w for the matrix A are calculated. The maximum eigen value is used to develop a consistency measure, using a procedure that accounts for the effects of the size of the criteria set. A consistency ratio CR is calculated as the ratio of CI and the random index. Compare the CR to the accepted upper limit value of 0.1. if the CR exceeds this value, A will be modified and evaluation process has to be repeated to improve consistency (Satty, 1980).

3. Methodology

3.1 Description of the study area

3.1.1 Geographical location and administrative division

Nifas silk lafto is one of the ten sub cities in Addis Ababa city administration. It covers an area of 5876.02 hectare. It situated in the south western part of Addis Ababa, bounded from south by oromia special zone from North West by Kolfe keranio, from east by Bole and Akaki kality and from north by Lideta and Kirkos. At present, the sub city divided into 12 woredas.

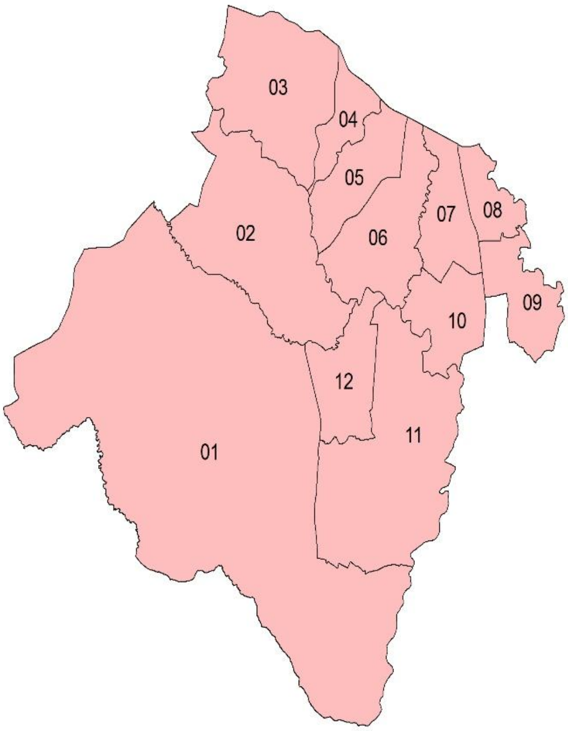

Figure 3.1 location of woredas in the sub city

3.1.2 Topography

Nifas silk lafto sub city is characterized by moderately steep type of topography with noticeable elevation difference and steep land scape around river gorges. Generally speaking in the sub city, the altitude range from 2074 to 2485 meters above sea level which has a range of 411 meters.

The highly elevated land exists in the south west while relatively lower elevation exists in south.

Figure 3.2 location of boundary for the sub city

3.1.3 Land area and population of nifas silk lafto

The land area covered by nifas silk lafto sub city is 5879.02 hectares, this constitutes 11.31%of the total land area of the city which makes the Nifas silk lafto sub city in 5th place in land area covered from the 10 sub cities. Among the 12 woredas in nifas silk lafto, the large area is covered by woreda 01 with 2592.83hectars that is 44.12%of the sub city land area, and woreda 08 covers the smallest land area of 105.84 hectares which is 1.8%of the sub city land area.

3.1.4 Population size and density of nifas silk lafto

According to the 2007 census, the total population with in this sub city is 285,457 which is 10.42% of the entire population of the city. Lots of people live in woreda 01 with population number of 39,512. Average of 48.58 people live in each hectare area of the sub city which makes Nifas silk lafto the 7th densely populated sub city in Addis.

3.1.5 Geography

The district is located in the southwestern suburb of the city. It borders with the districts of Kolfe Keranio, Lideta, Kirkos and Bole and Akaky Kaliti.

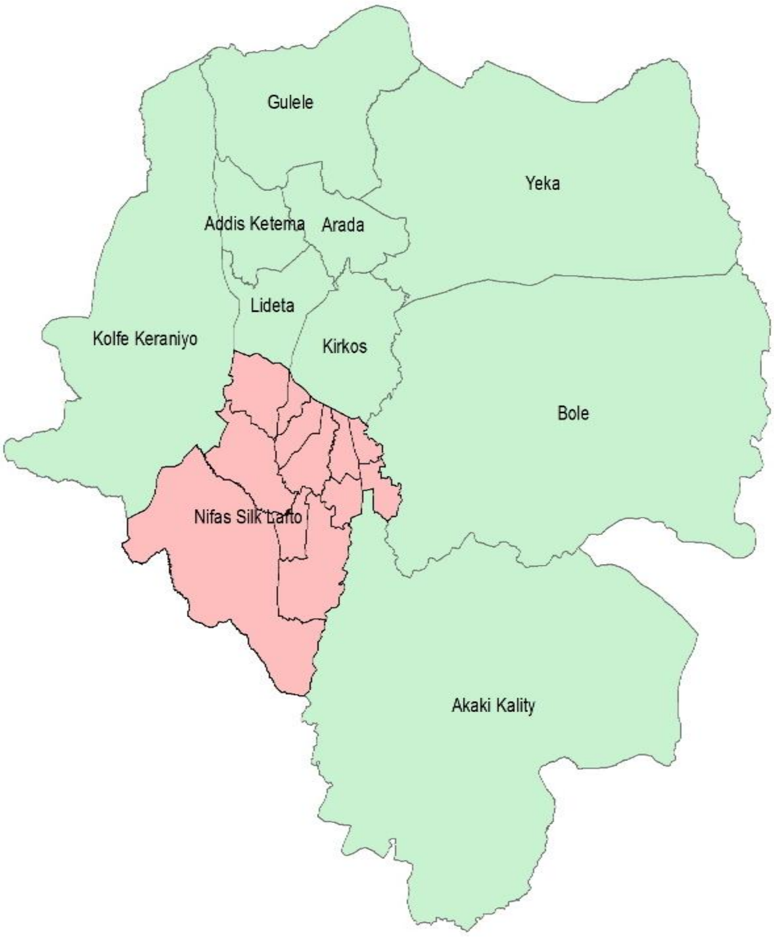

Figure 3.3 Location of the sub city

3.1.6 Nifas silk lafto AAWSA branch

The sub city has a total number of 63,662 total consumers of which 53,070 are domestic and 10,356 are non-domestic under the type of usage where the rest 238 are bonos. The Nifas silk branch of AAWSA distribute water for 16 woredas which are, 1 for Akaki, 6 for kirkos and the rest 9 woredas for nifas silk lafto. Since the system of distributing water is isolated the branch office is responsible for this woredas.

3.2 Method selection

The aim of this research as defined in the first section is to assess the potential of implementing water demand management tools and asses the people's attitude of demand management that help to build an integrated framework for the supply planning of water.

The nature of the research problem indicates that data have to be collected from several sources. The problem is not focused on one unit but on two. The units that had to be researched in order to answer the research questions were the water service provider of the town (utility) main director of the sub city and the costumers of the utility. The reason for this was that, as it was discussed in the literature review, the success of a WDM program depends on both the- utility and the costumers. Although the utility designs and implements the program, some of the measures focus on the users. So the success of these measures depends on the acceptability by the user and whether he/she decides to follow them.

Another reason for multiple sources of data is to support the validity and reliability of data. Triangulation of data makes the results from data more concrete, so research is more valid. The sources of data were decided to be the consumers, the utility managers and documents from the utility. Data from the consumers provide information on their current practice regarding water conservation and their potential to accept new measures. Data from managers of the utility provide information on the current practice regarding WDM and the perception of the managers in WDM. So the willingness to implement such measures could be assessed. The documents from the utility were useful because they provide information in institutional issues, financial issues and sources of water. All these issues can help in detecting possible limitations in implementing a WDM program.

Data from the consumer was decided to be collected by the method of a survey. The reason for this selection was that surveys can give information about the general population by examining only a small sample of it. Results obtained from a survey can be very accurate and valid if it is well designed and administered. On the other hand, there are issues of bias and the time limitations but generally it was thought that it would be the best way to get the necessary results in the time limits that existed.

Data from the utility managers were decided to be collected by face to face interviews. This selection was made due to the fact that interviews can provide accurate data from well informed and key positioned units. Managers of a utility are the people that make decisions on the short mid and long term time horizon for the operation of the utility. They are the people that will potentially decide the implementation of a WDM program and they are the most informed people on the water sector in the area. So they are the best target to interview and extract valuable information.

Data from the utility documents would be collected by a desktop study. The selection and collection of these documents would provide an insight into the utility's structure and financial status. Documents like that are not always easily accessible due to the sensitive nature of the data documented.

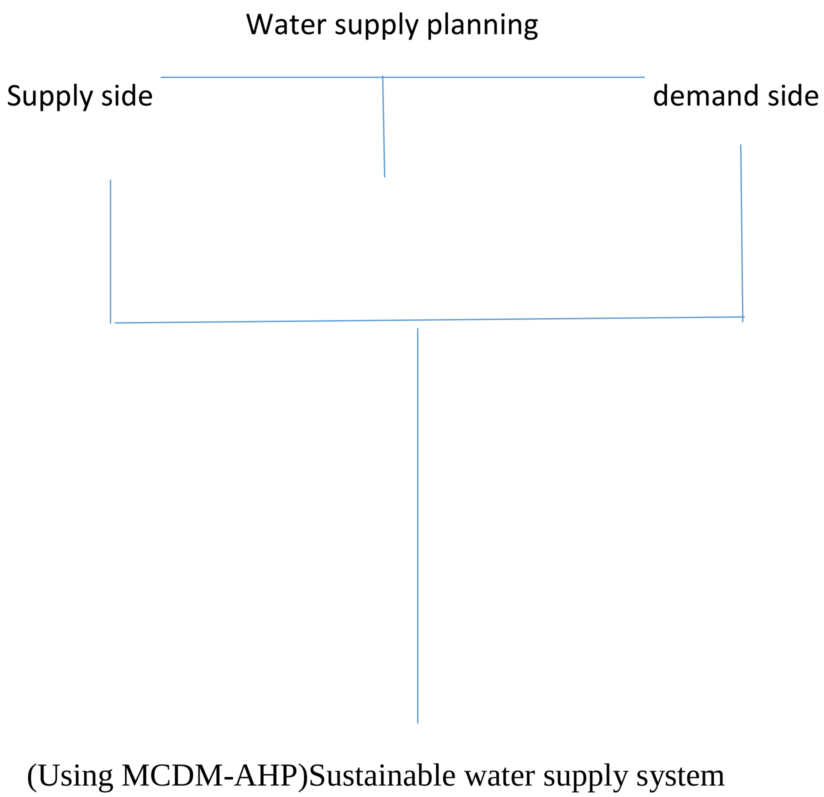

Figure 3.4 Representing the overall methodology

In the next sections the development of the methodology for each data collection method will be described.

3.3 Survey

After selecting the method which is Analytic hierarchy process a survey for the data collection from the consumers, the questionnaire for the survey had to be designed. Several issues were considered in order to produce a well-designed questionnaire to assist in getting the correct information and to give a weight to the alternative and criteria pair wise.

Length: The length of the questionnaire in each level would have to be 2 page in length. The reason for this was that surveyed users should not be intimidated by the view of a long questionnaire. People are busy and not always willing to appoint more than ten minutes for answering a questionnaire. The response then would be low and it would be possible that a low amount of questionnaires would be answered and results would not be valid.

Layout: The layout and presentation of the questionnaire would have to be designed in a way that it is easy to answer and friendly to the user. Issues like size of font and the answering way had to be considered.

Questions: The purpose of the questionnaire was to provide the necessary data for this research. But what kind of data is needed and which are the appropriate questions to obtain these data? So the questionnaire was open and in easy form.

Language: The language used to express the questions needed to be simple and concise which Amharic is. Questions had to be clear so people could answer the questionnaire easily and would not misunderstand any of the questions.

3.4 Questions

The research questions that were placed and are relevant to the end users of the utility demand that information was needed on: current practice on water conservation, perception of water management measures and potential for adopting water conservation technologies and measures including ranking policies.

These issues had to be translated into questions that would provide the necessary data. The questions of the questionnaire were divided into four categories:

3.4.1Environmental awareness: From these questions information about the respondent on his/her attitude on water shortage were gathered. This information is important because the acceptability of water conservation measures would depend on the user's environmental sensitization.

3.4.2Water conservation current practices: From these questions information about the respondent's current practice on water conservation was gathered. Questions were trying to assess the use of water efficient appliances, practices and alternative technologies such as rainwater harvesting and reuse of water in the household.

3.4.3Potential of adopting water conservation measures: These questionnaire were focused on the user's willingness to use water efficient appliances, alternative technologies and practices. The user's responsiveness to water price was also assessed.

3.4.4Water conservation measures: There was a ranking question at the end of the questionnaire 1 that was asking for possible measures that the utility could take for water conservation. By this question possible measures that the users would be willing to follow were discovered. It is very possible that if the users propose some measures they will be willing to follow them although this would not be always right.

3.5 Sampling

Sampling is very important for getting accurate results by questionnaire surveys. Characteristics of the population that may affect a research like the one in this report would be, sex, age, education, income and whether the respondent is the water bill payer or not. Ideally the above characteristics of the general population should be retrieved from records and then the respondents should be selected in such a way that the sample is representative of the general population. Or the characteristics of each respondent should be recorded so the results would be weighed against these factors.

Instead random sampling was used. From experience the population of Nifas silk lafto sub city is not evenly distributed in terms of income and education. Six places of the region were selected. Two high income two middle income and two low income regions were finally selected. The target was to collect 15 questionnaires from each region including institutions. So a street was randomly selected and a questionnaire was administered to every third house in that street. If the respondent was negative in answering the questionnaire the next house was selected and so on. This way, 45 questionnaires were administered in total.

3.6 Methodology

Analysis, scenario (main aspects) generation, evaluation and decision each referring to a major step. The analysis phase essentially describes the representative water supply planning issues with demand and supply side and produces a basic input for the next phase. Here the existing water supply planning framework, the gap between demand and supply, the attitude of the consumers as well as data's taken from stakeholders are the essential inputs for the water supply demand planning features.

In the scenario generation phase, reference scenarios are developed as 'developments which cannot be directly influenced by decision makers' i.e. population growth, life style. Since such changes influence the water balance in terms of supply and demand it is significant to demonstrate different scenarios, especially representing the baseline.

In the evaluation phase

1. Defining possible alternatives (with their reasonable time frame of application) and evaluation criteria

2. Simulating the comprehensive scenario's which combine reference scenarios and alternatives

3.6.1 Analytic hierarchy process (AHP)

AHP as a powerful tool in decision analysis

A brief introduction to methodology.

AHP was first developed in the early 1970s by Thomas L, Satty and has played an important role in modern decision making fields. When the AHP logic hierarchical structure is formulated, one should first yield the judgment matrices based on pairwise comparison of all elements in each hierarchy with respect to the higher hierarchy according to certain criteria of comparison with in certain scales. The scales are given in table

Table 3—1 Scale of relative importance

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	One is slightly in favor over another
5	Essential or strong	One is strongly in favor over another
7	Very strong importance	One is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed between the two adjacent judgments
	Reciprocals of above numbers	If activity I has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared to i.

The basic idea of AHP is that the factors in a complex system are grouped on different logic levels, forming a chain, or hierarchy, where by the lower level elements can be compared in pairwise matrices with respect to the higher level, and so on, so that finally the composite priorities of all levels are achieved.

The steps for using the AHP can be summarized as

1. Model the problem as a hierarchy containing the design goal, alternatives for reaching it and the criteria for evaluating the alternatives.
2. Establish priorities among the elements of the hierarchy by making a series of judgments based on pair wise comparison of the elements.
3. Synthesize these judgments to yield a set of overall priorities for the hierarchy
4. Check the consistency of the judgments
5. Come to a final decision based on the results of the process

The application of AHP

Determination of hierarchies and their factors. First level target (T)

'T' minimize the gap between demand and supply and to solve the water shortage so that the sub city or city, as a capital, can have its normal activities in cultural and economic development.

Second level strategies (or sub objectives) ('S')

S1 - guarantee for environment and recreation water use

S2- guarantee for domestic water use

S3- guarantee for water recharge in order to maintain ground water balance

S4- develop the city economy and expand production of existing resources

S5 - guarantee for institutional water use (schools, hospitals)

S6- guarantee for industrial water use

	Second level of strategies

Third level constraints (or criteria) (‘C’)

C1 -shortage in water supply

C2 -water pollution

C3- restriction in funding

C4- technical feasibility

C5- defect in institutional management and legal system

C6- restricted economic development

Fourth level policies (or counter measures) (‘P’)

Water management programs

P1- Meter testing and replacement programs

P2- Leak detection and repair program

P3- Social conservation incentives programs

P4- Distribution system audit program

Government regulation

P5- National water management laws and policies

P6- Water use restrictions

Public education

P7- Primary and secondary school programs

P8- Mass media advertising campaign

P9- Dissemination of information through personal contact

P10- Promotional campaigns and events

Economic incentives

P11- Penalties for excessive use

P12- Water pricing and rate making policies

P13- Pressure reduction

Methods applied by the end user

P14- Using of ultra-low flush toilet

P15- Using of shower flow restrictions

P16- Using of water efficient tabs

P17- Using of low flush shower heads

Government measures

P18- Control the population growth

P19- Establish a centralized water management and planning institution

P20- Install water saving facility for public service

P21- Construct GERBI and SIBILU dams

P22- Ground water exploitation

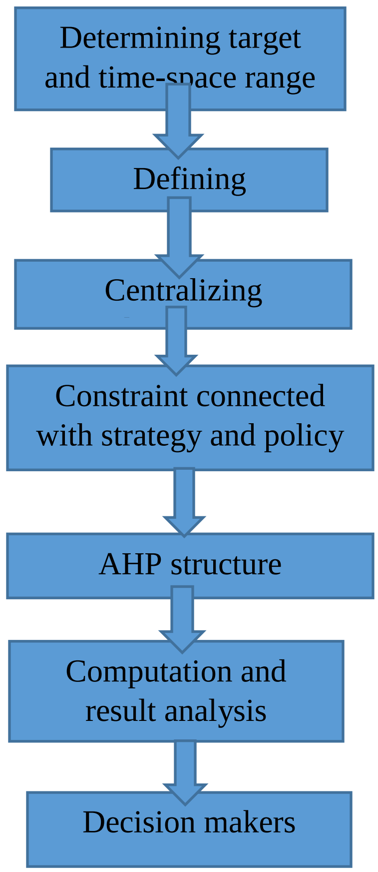

Figure 3.5 AHP model formulation process

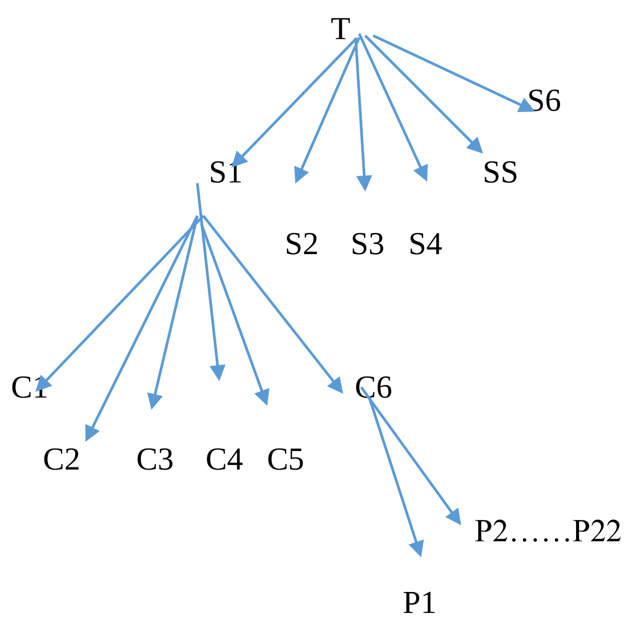

Figure 3.5 Explanation of how AHP is calculated

3.6.2 Information from expert support system

The first round questions assesses the people's perception on the water demand management and interview with the service providers provides a flexible form, allowing those interviewed to give their opinions and criticism on suggested measures to add or modify them, and to list the possible effective factors for policy implementation. The information will help to determine C and P level factors. Levels for the main target, T and strategies of sub objectives S are set up mainly through government planning sectors.

Then from the first round results of which 6 constraints and 22 policies are finally chosen dealing with 4 main aspects.

The second round questioner is concerned with T-S and S-C levels. To answer

A, which of the strategies Si and Sj (i, j….6) is more important for the main target?

B, which of the constraints C1 and C2 is more critical to strategy Si? The same for C1 and C3, C2 and C3 etc.

The questionnaire and interviews are added to answer 2 kinds of questions

a. Giving for each policy the possible value of implementation in the near future (1-5) year, middle run (5-10) years and long run (10-20) years.
b. For each constraint Ce of level C, give the pairwise comparison of policies Pi and Pj in level P. for instance

   C1 (water shortage); answer "which of the two policies has less water shortage effect? The same for P1 and P3 etc. (the scoring follows the same scales shown in table in the ranking process)

   C2 (water supply); answer "which of the 2 policies, P1and P2 can provide more water?" the same for P1 and P3 etc.

   C3 (funds); answer "which of the 2 policies P1 and P2 cost less? The same for P1 and P3 etc.

4. Result analysis and discussion

The computation is performed on a modified AHP model using excel. The results for levels T-S-C are summarized in Table, where the first row is the priority of strategy conditional to target T. each column stands for the priority value of constraints C in coping with strategy Si. The last column is the composite weight vector of constraint level C to T.

Main aspects

1. Water conservation, making full use of available water
2. Administrative and institutional system reforms
3. Regulation of economic water use structure
4. Planning of social and economic development scales

4.1 Determining the weights of criteria using the AHP method

Using the decision hierarchy shown in Fig 3.4, the criteria weights for strategy identification can be calculated using the AHP method. The constructed pair wise comparison matrices for each strategy and constraints with their priority value indicators are listed below in tables.

4.1.1 Determination of priority for pairwise combination of criteria's with sub objective

Table 4—1 pairwise comparison for Domestic water use

Pair wise comparision for " Domestic water use"							
'S1'	C1	C2	C3	C4	C5	C6	PRIORITY
C1	1.00	3.00	3.00	0.33	5.00	0.33	0.22
C2	0.33	1.00	0.17	1.00	2.00	7.00	0.15
C3	0.33	6.00	1.00	3.00	5.00	3.00	0.26
C4	3.00	1.00	0.33	1.00	0.11	0.33	0.10
C5	0.20	0.50	0.20	9.00	1.00	3.00	0.16
C6	3.00	0.14	0.33	3.00	0.33	1.00	0.12
sum	7.87	11.64	5.03	17.33	13.44	14.67	1.00

4.1.2 Determination of priority of sub objective 2

Table 4—2 pair wise comparison for "Environment recreation water use"

Pair wise comparision for " Environment-recreation water use"							
S2	C1	C2	C3	C4	C5	C6	PRIORITY
C1	1.00	7.00	2.00	1.00	3.00	4.00	0.33
C2	0.14	1.00	2.00	5.00	1.00	7.00	0.22
C3	0.50	0.50	1.00	0.20	3.00	1.00	0.10
C4	1.00	0.20	5.00	1.00	0.25	3.00	0.15
C5	0.33	1.00	0.33	3.00	1.00	1.00	0.12
C6	1.00	0.14	1.00	0.33	1.00	1.00	0.08
sum	3.98	9.84	11.33	10.53	9.25	17.00	1.00

4.1.3 Determination of priority of sub objective 3

Table 4—3 pair wise comparison for water recharge

Pair wise comparision for " WATER RECHARGE"							
S3	C1	C2	C3	C4	C5	C6	PRIORITY
C1	1.00	5.00	3.00	3.00	3.00	1.00	0.29
C2	0.20	1.00	0.20	3.00	5.00	3.00	0.16
C3	0.33	2.00	1.00	3.00	7.00	5.00	0.24
C4	0.33	0.33	0.33	1.00	5.00	3.00	0.12
C5	0.33	0.20	0.14	3.00	1.00	2.00	0.09
C6	0.33	3.00	0.20	0.33	0.50	1.00	0.09
sum	2.53	11.53	4.88	13.33	21.50	15.00	1.00

4.1.4 Determination of priority of sub objective 4

Table 4—4 pair wise comparison for City economy

Pair wise comparision for " CITY ECONOMY"							
S4	C1	C2	C3	C4	C5	C6	PRIORITY
C1	1.00	3.00	2.00	3.00	1.00	5.00	0.25
C2	0.33	1.00	0.20	3.00	5.00	3.00	0.18
C3	0.50	5.00	1.00	3.00	3.00	1.00	0.25
C4	0.33	0.33	0.33	1.00	5.00	3.00	0.14
C5	1.00	0.20	0.33	3.00	1.00	3.00	0.13
C6	0.33	0.33	1.00	0.33	0.33	1.00	0.06
sum	3.50	9.87	4.87	13.33	15.33	16.00	1.00

4.1.5 Determination of priority for sub objective 5

Table 4—5 pair wise comparison for institutional water use

Pair wise comparision for " INSTITUTIONAL WATER USE"							
S5	C1	C2	C3	C4	C5	C6	PRIORITY
C1	1.00	3.00	5.00	3.00	3.00	1.00	0.31
C2	0.33	1.00	3.00	5.00	1.00	3.00	0.22
C3	0.20	0.33	1.00	3.00	2.00	1.00	0.13
C4	0.33	0.20	0.33	4.00	1.00	3.00	0.14
C5	0.33	1.00	0.50	1.00	1.00	3.00	0.11
C6	1.00	0.33	1.00	0.33	0.33	1.00	0.09
sum	3.20	5.87	10.83	16.33	8.33	12.00	1.00

4.1.6 Determination of priority for sub objective 6

Table 4—6 pair wise comparison for industrial water use

Pair wise comparision for " INDUSTRIALWATER USE"							
S6	C1	C2	C3	C4	C5	C6	PRIORITY
C1	1.00	3.00	4.00	5.00	0.33	2.00	0.26
C2	0.33	1.00	3.00	3.00	5.00	7.00	0.26
C3	0.25	0.33	1.00	0.33	3.00	5.00	0.13
C4	0.20	0.33	3.00	1.00	5.00	0.33	0.13
C5	3.00	0.20	0.33	0.20	1.00	0.33	0.11
C6	0.50	0.14	0.20	3.00	3.00	1.00	0.11
sum	5.28	5.01	11.53	12.53	17.33	15.67	1.00

4.1.7 Determination of priority for constraint 1

Table 4—7 pair wise comparison for shortage of water

Pair wise comparision for " SHORTAGE OF WATER"							
C1	S1	S2	S3	S4	S5	S6	PRIORITY
S1	1.00	3.00	1.00	3.00	0.33	0.20	0.18
S2	0.33	1.00	2.00	7.00	5.00	9.00	0.36
S3	1.00	0.50	1.00	3.00	1.00	1.00	0.10
S4	0.33	0.14	0.33	1.00	3.00	0.33	0.06
S5	3.00	0.20	1.00	0.33	1.00	0.33	0.10
S6	5.00	0.11	1.00	3.00	3.00	1.00	0.19
sum	10.67	4.95	6.33	17.33	13.33	11.87	1.00

4.1.8 Determination of priority for constraint 2

Table 4—8 pair wise comparison for pollution

Pair wise comparision for " POLLUTION"							
C2	S1	S2	S3	S4	S5	S6	PRIORITY
S1	1.00	5.00	3.00	1.00	0.33	3.00	0.25
S2	0.20	1.00	3.00	3.00	3.00	0.20	0.16
S3	0.33	0.33	1.00	3.00	1.00	7.00	0.21
S4	1.00	0.33	0.33	1.00	1.00	0.33	0.07
S5	3.00	0.33	1.00	1.00	1.00	0.33	0.14
S6	0.33	5.00	0.14	3.00	3.00	1.00	0.18
sum	5.87	12.00	8.48	12.00	9.33	11.87	1.00

4.1.9 Determination of priority for constraint 3

Table 4—9 pairwise comparison for funding

Pair wise comparision for " FUNDING"							
C3	S1	S2	S3	S4	S5	S6	PRIORITY
S1	1.00	0.20	1.00	3.00	1.00	3.00	0.15
S2	5.00	1.00	2.00	3.00	3.00	7.00	0.38
S3	1.00	0.50	1.00	3.00	5.00	1.00	0.20
S4	0.33	0.33	0.33	1.00	2.00	3.00	0.11
S5	1.00	0.33	0.20	0.50	1.00	3.00	0.10
S6	0.33	0.14	1.00	0.33	0.33	1.00	0.06
sum	8.67	2.51	5.53	10.83	12.33	18.00	1.00

4.1.10 Determination of priority for constraint 4

Table 4—10 pairwise comparison for technique

Pair wise comparision for " TECNIQUE"							
C4	S1	S2	S3	S4	S5	S6	PRIORITY
S1	1.00	3.00	1.00	3.00	0.33	0.20	0.18
S2	0.33	1.00	3.00	3.00	5.00	9.00	0.35
S3	1.00	0.33	1.00	3.00	5.00	1.00	0.14
S4	0.33	0.33	0.33	1.00	1.00	0.33	0.05
S5	3.00	0.20	0.20	1.00	1.00	0.33	0.09
S6	5.00	0.11	1.00	3.00	3.00	1.00	0.19
sum	10.67	4.98	6.53	14.00	15.33	11.87	1.00

4.1.11 Determination of priority for constraint 5

Table 4—11 pairwise comparison for institution

Pair wise comparision for " INSTITUTION"							
C5	S1	S2	S3	S4	S5	S6	PRIORITY
S1	1.00	5.00	3.00	1.00	0.33	3.00	0.23
S2	0.20	1.00	3.00	1.00	5.00	0.20	0.17
S3	0.33	0.33	1.00	3.00	5.00	1.00	0.17
S4	1.00	1.00	0.33	1.00	1.00	5.00	0.15
S5	3.00	0.20	0.20	1.00	1.00	3.00	0.15
S6	0.33	5.00	1.00	0.20	0.33	1.00	0.14
sum	5.87	12.53	8.53	7.20	12.67	13.20	1.00

4.1.12 Determination of priority for constraint 6

Table 4—12 pair wise comparison for economy

Pair wise comparision for " ECONOMY"							
C6	S1	S2	S3	S4	S5	S6	PRIORITY
S1	1.00	1.00	3.00	1.00	0.33	3.00	0.17
S2	1.00	1.00	3.00	1.00	5.00	0.20	0.18
S3	0.33	0.33	1.00	3.00	1.00	1.00	0.13
S4	1.00	1.00	0.33	1.00	1.00	7.00	0.22
S5	3.00	0.20	1.00	1.00	1.00	0.33	0.12
S6	0.33	5.00	1.00	0.14	3.00	1.00	0.18
sum	6.67	8.53	9.33	7.14	11.33	12.53	1.00

The spread sheet analysis of the strategies with the constraints with the computation, the detail calculation for each matrix is explained in the Annex.

4.2 composite priority for sub objective with each criteria

Table 4—13 priorities of level T-S-C

	S1 **0.25**	**S2** **0.28**	**S3** **0.21**	**S4** **0.22**	**S5** **0.16**	**S6** **0.19**	**CW**
C1	0.22	0.33	0.29	0.25	0.31	0.26	0.33
C2	0.15	0.22	0.16	0.18	0.22	0.26	0.26
C3	0.26	0.10	0.24	0.25	0.13	0.13	0.25
C4	0.10	0.15	0.12	0.12	0.14	0.13	0.14
C5	0.16	0.12	0.09	0.09	0.11	0.11	0.16
C6	0.12	0.08	0.09	0.09	0.09	0.11	0.12

4.3 Explanation of the results

The results show that

A, under the main target T, S2 (0.28) has the highest value of, this means Addis as a capital city, should take care of domestic water consumption in the future. The second is S1 (0.25) which is connected with S5 by including institutional water consumption or water use, etc. S3, S4, S5 and S6 have nearly the same value of 0.21-0.19 indicating the same level of importance. In this case, it is difficult to say that one is more important than the other just by a little difference in weights.

B. among the 6 selected constraints, “water shortage” has the highest priority (0.33) which largely exceeds the other ones, and this means that it will be the most urgent factor. The next most crucial constraints are C2 “water pollution” and C3, “lack of funding” with values of 0.26 and 0.25, respectively with respect of the main target, the overall composite weights are listed below. The results indicate that

Table 4—14 Composite priorities of policies

policy	Order	policy	Order	policy	order
P1	11	P9	21	P17	20
P2	9	P10	7	P18	15
P3	3	P11	13	P19	2
P4	10	P12	22	P20	17
P5	4	P13	14	P21	1
P6	16	P14	19	P22	12
P7	6	P15	19		
P8	5	P16	8		

With respect to the main aspects, the overall composite weights are listed in next table, the results indicate that:

A, The highest weight is found for policy P21, i.e. construct Gerbi and Sibilu dams, they are to be located some 30 km north of Addis and it can provide enough water for the city as well as domestic use of the surrounding areas. The second priority is found to characterize policy P19, i.e. establish a centralized water management and planning institution. These policies demand that water exploitation with in the region should be put in the first place to meet future water demand.

B, among the 22 selected water policies, “social conservation incentives” has a high priority. It will be, apart from seeking new sources, the most effective way to reduce water consumption by using incentives from the government.

C, the next important policy is P5, i.e. “national water management law” in spite of its needing educated staff, it still gets a high priority for the long run.

D, “mass media advertising campaign” (P8) and “primary and secondary school programs” (P7) have great potential. This means reduction excess usage of water through education without affecting productivity.

E, P20, i.e. “install water saving facility for public service,” and (P11)” water use restriction” followed by (P18) “control of population growth “ have relatively less weight due to our economic situation.

F, P12 “water pricing” following (P9) “dissemination of information”, (P17) using low flush shower heads”, (P14) “using of ultra-low flush toilet “and (P15) “using of shower flow restriction”, which needs much effort to be done and to succeed ranks the last in the weighting process.

The town Addis is characterized by large temporal and spatial variations in precipitation and with limited surface and ground water resources. The rapid growth and development in the region on scare resources to satisfy water demands. The dwindling availability of water to meet development needs has become a significant regional issue, especially as a number of countries are facing serious water deficit.

In Addis, until fairly recently, emphasis has been placed on the supply side of water development. Demand management and improvement of patterns of water use has received less attention. Water managers and planners have given high priorities to locating, developing and managing new water sources. The aim was always to augment the national water budget with new water. The most popular way of achieving this aim was to control surface flows by building new dams and creating multi-purpose reservoirs.

However, this is no longer achievable with the limited water resources available. First, water demand at current price is increasing rapidly and it will soon be impossible to satisfy the needs with only mobilized resources. Second easily mobilizable resources have already been exploited and the development of new resources would be possible at high costs in economic as well as environmental terms.

5. Conclusion and recommendation

5.1 conclusion

The research project focused on an integrated approach to the water supply planning and to combine the two side management systems to a better result using a model AHP. In this section the conclusions from the project will be presented by combining the findings from every section.

- The model has the advantages of examining the existing situation by different constraints and objectives to select the best alternatives using an engineering aspect which lead to developing an integrated approach to address the supply demand gap. The existing conventional approach has a weakness in not taking the consideration of the need of other options in to account. The way forward is not also exhaustive in its make as it does not model the benefits which can be achieved through the introduction of different demand side management measures.
- The AHP method is referenced to drive the weights of the criteria. Using excel, the method is used for assessing strategies based on the original data. The evaluation results illustrate the usefulness of the proposed method in identifying leading water supply management practices.
- The results of the model show that among the six effective criteria in presentation of alternatives, shortage in water supply has a priority rather than the other which reflect to the first alternative or policy which is to construct the new dams.
- From other hand, results of this research show efficiency of AHP model in presentation of optimal alternatives in controlling and decreasing the water shortage problem in the study area.
- Since the imperfect definition of factors may cause either difficulty in comparison or omission of information, AHP structure identification and element selection of each hierarchy can have a direct effect on the results.
- The skill of establishing the questionnaire table, the way of putting questions, and showing respect to the interviewee do play an important role on the judgments.

- Like other systems analysis methods, AHP still has its limits for application. But nevertheless, the research shows that in dealing with the decision making problems of a multi hierarchy and multi variable system, AHP provides a powerful tool through synthesizing various options and finally gives both qualitative and quantitative analysis, and the process itself is in fact a process of understanding the complex system.

5.2 Recommendation

- In this part some recommendations can be made for future research, Similar studies to this can contribute as case studies in answering the question about the possibility of implementing WDM programs in other towns.
- Analyzing the existing situation in planning framework of the water sector is important for developing response and implement the two side management options in an integrated manner.
- Future research is also needed in the possibility of implementing alternative technologies in towns like Addis.
- Urban water managers and planners and policy makers need to make correct choices of the most viable options that feet with in the socio cultural, political, economic and environmental context.
- The government shall promote using of water saving devices to facilitate consumers to choose water saving devices, which is similar to energy efficiency labeling scheme for electrical light appliances.
- Regular launch public education and publicity programs to promote water conservation in all sectors, particularly targeting at the young people current measures.

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Appendix I

Glossary

Demand side management-any measure or initiative that will result in a reduction in the expected water use or water demand.

Distribution management- any function relating to the management, maintenance and operation of any system of structures, pipes, valves, pumps, meters or other associated equipment, including all mains. Connection pipes and water installations that are used or intended to be used in connection with the supply of water.

Domestic/residential consumers- refers to a utility or municipal classification of customer, usually domestic or residential consumers are homeowners of single and multiple family homes. While their consumption is low, the numbers of dwellings are large impacting on demand.

Industrial consumers- industrial consumers are the largest water users per account, these are industries, factories and manufacturing establishments.

Inefficient use of water-water used for a specific purpose over and above the accepted and available best practices and benchmarks or water used for a purpose where very little benefit is derived from it.

Integrated planning-a method of analyzing the change in demand and operation of water institutions that evaluates a variety of supply side and demand side management measures to determine the optimal way of providing water services.

Non-revenue water-the total of apparent and real losses plus the proportion of authorized consumption which is not billed.

Public/institutional consumers-refers mostly to government and diplomatic consumers, examples include government office complexes, public parks, hospitals, firefighting etc.

Raw water-water that has not been treated. Water found rivers, lakes and other sources in its natural form, which may or may not be abstracted for a purpose and treated.

Retrofitting-the modification, adaptation or replacement of an existing device, fitting or appliance.

Supply side management-any measure or initiative that will increase the capacity of a water resource or water supply system to supply water.

Water conservation- the term water conservation is used interchangeably with water demand management. So that it is clear what is meant by water conservation, it refers to long term water use efficacy through both wise use and the reduction in usage.

Water demand- water demand, water use and water consumption are often applied interchangeably when discussing water resources. Each term has its strength and weakness and can often become confusing. To add to this confusion is the fact that economists, engineers and planners often use the three terms but with different meanings.

Water institutions-water institution include both water management institutions and water service institutions as defined in the national water act and the water service act respectively.

Water wastage- water lost through leaks or water usage that does not result in any direct benefit to a consumer

Appendix II

Questionnaires

My name is Amsal Eyassu. I m a student of Addis Ababa university, Institute of technology. As part of my MSc research project I am conducting the following survey, the purpose of this questioner is to assess the perception of the residents of some selected woredas in Nifas Silk Lafto Sub city of water demand measures and their willingness to follow management measures and their attitude about using the different measures to save water.

Answering these questionaries' is not compulsory, but it would help the utility to assess the perception of the residents about certain issues, and possibly improve the service provided and mainly to me it helps to weight the alternatives that are inputs for the model AHP to rank the alternatives with different criteria's.

All information gathered from this questioner will be used for academic purpose and only be presented only in a weighted form. Furthermore it will remain anonyms, treated confidentially and be destroyed after the production of the final report.

Thank you for taking time to answer the questioner

First round questionnaire

1. Do you consider water shortage an important environmental problem?

    Answers yes not particularly not at all

2. Do you think you live in an area where water shortage is a problem?

    Answers yes not particularly not at all

3. How would you describe your self-regarding water use?

    Answers wasteful normal conservative

4. Are you willing to take more steps towards water conservation?

Answers yes maybe no

5. Are you willing to use water saving technologies?

Answers yes maybe no

6. Do you think the government should help the consumers by giving more information about water management?

Answers yes maybe no

7. Do you consider water demand management can make a change to economic development of a city?

Answers yes maybe no

8. Are you willing to learn and gather information about water saving technologies?

Answers yes maybe no

9. Are you willing to buy new saving appliances in order to save water?

Answers yes maybe no

10. In your view of managing water what rank will you give for these managing measures?

A. Water use restrictions, ether permanent or temporary

B .Leakage detection and repair

C. Increase system efficiency

D. Information and education campaigns to encourage water conservation

E. Regulation of efficiency of water using appliances

F. Use of reclaimed water to reduce the need for fresh water

G. Price structure reform

H. creating awareness using Medias, newspaper and so

Second round questionnaire

Table 6—1 Scale of relative importance

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	One is slightly in favor over another
5	Essential or strong	One is strongly in favor over another
7	Verystrong importance	One is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed between the two adjacent judgments
	Reciprocals of above numbers	If activity I has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared to i.

Based on the given table above give relative importance of each sub objective and constraint a value relating with the other.

For S1 guarantee for domestic water use, for example c1.....c2 (7), c4 (5)....c5

C1.....C2 C2....C3 C3.....C4 C4.....C5 C5.....C6

C1.....C3 C2....C4 C3.....C5 C4.....C6

C1....C4 C2....C5 C3.....C6

C1.....C5 C2....C6

C1....C6

For S2 guarantee for environment and recreational water use

C1.....C2 C2....C3 C3.....C4 C4.....C5 C5.....C6

C1.....C3 C2....C4 C3.....C5 C4.....C6

C1....C4 C2....C5 C3.....C6

C1.....C5 C2....C6

C1....C6

For 'S3' guarantee for water recharge

C1…..C2 C2….C3 C3…..C4 C4…..C5 C5…..C6

C1…..C3 C2….C4 C3…..C5 C4…..C6

C1….C4 C2….C5 C3…..C6

C1…..C5 C2….C6

C1….C6

For 'S4' develop city economy and expand production

C1…..C2 C2….C3 C3…..C4 C4…..C5 C5…..C6

C1…..C3 C2….C4 C3…..C5 C4…..C6

C1….C4 C2….C5 C3…..C6

C1…..C5 C2….C6

C1….C6

For 'S5' guarantee for institutional water use

C1…..C2 C2….C3 C3…..C4 C4…..C5 C5…..C6

C1…..C3 C2….C4 C3…..C5 C4…..C6

C1….C4 C2….C5 C3…..C6

C1…..C5 C2….C6

C1….C6

For 'S6' guarantee for industrial water use

C1.....C2	*C2....C3*	*C3.....C4*	*C4.....C5*	*C5.....C6*
C1.....C3	*C2....C4*	*C3.....C5*	*C4.....C6*	
C1....C4	*C2....C5*	*C3.....C6*		
C1.....C5	*C2....C6*			
C1....C6				

For 'C1' shortage in water supply

S1.....S2	*S2....S3*	*S3.....S4*	*S4.....S5*	*S5.....S6*
S1.....S3	*S2....S4*	*S3.....S5*	*S4.....S6*	
S1....S4	*S2....S5*	*S3.....S6*		
S1.....S5	*S2....S6*			
S1....S6				

For 'C2' water pollution

S1.....S2	*S2....S3*	*S3.....S4*	*S4.....S5*	*S5.....S6*
S1.....S3	*S2....S4*	*S3.....S5*	*S4.....S6*	
S1....S4	*S2....S5*	*S3.....S6*		
S1.....S5	*S2....S6*			
S1....S6				

For 'C3' restriction in funding

S1.....S2	*S2....S3*	*S3.....S4*	*S4.....S5*	*S5.....S6*
S1.....S3	*S2....S4*	*S3.....S5*	*S4.....S6*	
S1....S4	*S2....S5*	*S3.....S6*		
S1.....S5	*S2....S6*			
S1....S6				

For 'C4' technical feasibility

S1.....S2	*S2....S3*	*S3.....S4*	*S4.....S5*	*S5.....S6*
S1.....S3	*S2....S4*	*S3.....S5*	*S4.....S6*	
S1....S4	*S2....S5*	*S3.....S6*		
S1.....S5	*S2....S6*			
S1....S6				

For'C5' deficit in institutional management and legal system

S1.....S2	*S2....S3*	*S3.....S4*	*S4.....S5*	*S5.....S6*
S1.....S3	*S2....S4*	*S3.....S5*	*S4.....S6*	
S1....S4	*S2....S5*	*S3.....S6*		
S1.....S5	*S2....S6*			
S1....S6				

For ‘C6’ restricted economic development

S1…..S2	*S2….S3*	*S3…..S4*	*S4…..S5*	*S5…..S6*
S1…..S3	*S2….S4*	*S3…..S5*	*S4…..S6*	
S1….S4	*S2….S5*	*S3…..S6*		
S1…..S5	*S2….S6*			
S1….S6				

Third round questionnaire

1. From the following listed sub objectives ‘S1’ up to ‘S6’, which is more important to solve the water shortage in your sub city? (Rank them)

‘S1’ guarantee for domestic water use ----------

‘S2’ guarantee for environment and recreational water use----------

‘S3’ guarantee for water recharge---------

‘S4’ develop city economy and expand production-----------

‘S5’ guarantee for institutional water use---------

‘S6’ guarantee for industrial water use-----------

2. Which of the constraints ‘C1’ up to ‘C6’ is more critical to each strategy? (Mark them using 1, 2, 3….) ‘C1’ shortage in water supply

‘C2’ water pollution

‘C3’ restriction in funding

‘C4’ technical feasibility

‘C5’ deficit in institutional management and legal system

‘C6’ restricted economic development

	C1	C2	C3	C4	C5	C6
For S1	-------	--------	---------	--------	---------	---------
For S2	---------	---------	---------	----------	---------	---------
For S3	---------	---------	---------	--------	---------	--------
For S4	----------	----------	----------	---------	---------	---------
For S5	---------	---------	---------	--------	---------	--------
For S6	---------	---------	---------	---------	----------	---------

Transcript of interview with department head of water supply of AAWSA (Nifas silk branch) Mr Wubshet

Question1: Do you think there is a water shortage problem in the area?

Reply: For now water is of adequate quantity to cover the needs of the sub city population.

Q2: What do you think about the sustainability of the water sources that the utility uses to cover demand?

R: The utility relies in groundwater and surface water only (Akaki and Legedadi). Most of the sources of the utility are boreholes. These sources have variations in the groundwater table from season to season. This is mainly due to the over drawing of water by the agriculture needs, especially during the summer. During the summer the demand is bigger and rainfall is less so groundwater is not renewed and the table level falls. But this effect is just temporary and later the water level returns to its usual levels.

So in my opinion there is no problem in the short term. But in the future with increasing demand and possible pollution of the groundwater there might be a problem and other sources of water will have to be searched.

Q3: Does the utility promote water conservation to the consumers this period?

R: The utility is thinking to promote water conservation from time to time.

Q4: Do you think something more should be done on this matter? And if yes what would that be?

R: Water is the most valuable natural resource so water conservation can be seen only as a positive thing. Apart from the environmental benefits there are financial benefits for the utility from the reduction in operating costs. There are some possible measures like the promotion of water efficient appliances or the reconstruction of the water tariff. There is also the option of reusing the treated water from the wastewater treatment plant. There are technologies that can be used for water conservation but they are not widespread. More research is needed and pilot implementations so the benefits and the costs will be more obvious. This way the acceptability by the consumers of such measures will be discovered.

The utility is willing to adopt such measures in its program. But coordination is needed by a responsible institution. A general board should be responsible for the water issues nationally. So a national water policy will be able to be designed and implemented.

Q5: In your opinion what other measures could be implemented for Water Demand Management by the utility?

R: There is an option for the reduction of NRW. The utility is thinking of implementing a Water loss Management program. It is considering ways of repairing non visible leaks by special leak detection equipment. The utility is also considering of installing meters to the water sources so it will have a better view on water losses and manage them in a more effective way.

Q6: In your opinion, which are the limitations to implementing Water Demand Management programs in utilities with similar characteristics as yours?

R: I believe that currently managers of such utilities are overloaded with supervisory and administrative responsibilities and they cannot focus on more important issues like setting goals and objectives for the utility.

There is also a lack of expertise staff in utilities. There are always new trends and research in the sector and we cannot stay informed. Consultants are necessary to inform us for solutions for a more efficient and environmental friendly operation of the utility.

More coordination is needed. A national water policy is essential for the encouragement of implementing WDM measures.

Q7: Do you have something to add?

R: yes, our system regarding water supply planning must be integrated with supply and demand management strategies that will build a sustainable water supply framework for the near future.

Annex

Step 1 Pair wise comparison for " Domestic water use"

Matrix 1	'S1'	C1	C2	C3	C4	C5	C6	PRIORITY
	C1	1.00	3.00	3.00	0.33	5.00	0.33	0.22
	C2	0.33	1.00	0.17	1.00	2.00	7.00	0.15
	C3	0.33	6.00	1.00	3.00	5.00	3.00	0.26
	C4	3.00	1.00	0.33	1.00	0.11	0.33	0.10
	C5	0.20	0.50	0.20	9.00	1.00	3.00	0.16
	C6	3.00	0.14	0.33	3.00	0.33	1.00	0.12
	sum	7.87	11.64	5.03	17.33	13.44	14.67	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6	26.88095	7.722222	58.66667	31.14815	45.77778		
	25.12222	6	4.4	41.61111	8.944444	20.94444	176.1957672	0.24223322
	21.66667	18.92857	6	66.11111	25	64.11111	107.0222222	0.14713371
	7.466667	13.10317	9.966667	6	19	10	201.8174603	0.27745782
	36.63333	12.22857	5.083333	28.16667	6	13.16667	65.53650794	0.09009932
	15.2254	14.45238	10.75714	11.14286	17.95238	6	101.2785714	0.13923737
							75.53015873	0.10383855
MATRIX3	3154.714	2279.957	1446.428	3720.506	2743.755	2604.204		
	1354.049	1751.907	932.2934	2749.375	2166.458	2217.341	15949.56437	0.21174676
	3121.108	2908.101	1762.244	4270.631	3551.24	3147.911	11171.42406	0.14831206
	1483.013	923.4706	439.068	2324.785	1006.464	1625.387	18761.23554	0.24907456
	1267.727	1787.064	820.0599	3478.779	2185.061	2698.678	7802.186772	0.103582
	1519.708	1151.858	512.5652	2845.143	1299.583	2073.136	12237.36941	0.16246358
							9401.992047	0.12482105
MATRIX4	30507369	26731964	14456039	49786376	31856016	36674833		
	19747137	17832185	9355074	34072864	21204019	25257794	190012596.5	0.21934565
	34903372	31251543	16732003	58371989	37270871	43174772	127469073.8	0.14714702
	14493002	12093595	6458978	23461969	14280242	17156309	221704550.3	0.25593003
	21008918	18631840	9647440	36498950	22045075	26991292	87944095.19	0.1015204
	16971144	14311210	7552847	28043620	16882813	20554706	134823515.4	0.1556368
							104316340.4	0.1204201

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	10.38015
ROW 2	4.678541
ROW 3	4.234888
ROW 4	5.070217
ROW 5	4.731848
ROW 6	10.34103
	6.572779

3,CALCULATE CONSITENCY INDEX(CI)

CI	0.114556

0.1271186	0.2577	0.596026	0.019231	0.371901	0.022727
0.0423729	0.0859	0.033113	0.057692	0.14876	0.477273
0.0423729	0.5153	0.198675	0.173077	0.371901	0.204545
0.3813559	0.0859	0.066225	0.057692	0.008264	0.022727
0.0254237	0.0429	0.039735	0.519231	0.07438	0.204545
0.3813559	0.0123	0.066225	0.173077	0.024793	0.068182
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.276841
ROW 2	0.688433
ROW 3	1.083835
ROW 4	0.51473
ROW 5	0.73645
ROW 6	1.245268
CR	0.091799

Step 1 Pair wise comparison for " Environment-recreation water use"

Matrix 1	S2	C1	C2	C3	C4	C5	C6	PRIORITY
	C1	1.00	7.00	2.00	1.00	3.00	4.00	0.33
	C2	0.14	1.00	2.00	5.00	1.00	7.00	0.22
	C3	0.50	0.50	1.00	0.20	3.00	1.00	0.10
	C4	1.00	0.20	5.00	1.00	0.25	3.00	0.15
	C5	0.33	1.00	0.33	3.00	1.00	1.00	0.12
	C6	1.00	0.14	1.00	0.33	1.00	1.00	0.08
	sum	3.98	9.84	11.33	10.53	9.25	17.00	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	9	18.77143	28	47.73333	23.25	65		
	13.61905	6	36.61905	15.87619	16.67857	32.57143	191.7547619	0.34955694
	3.271429	7.682857	6	12.73333	9.05	11.1	121.3642857	0.2212395
	7.611905	10.57857	15.48333	5.75	21.7	16.65	49.83761905	0.09085086
	4.97619	5.242857	19.33333	11.73333	5.75	19.66667	77.77380952	0.14177679
	3.187075	8.852381	6.285714	5.580952	8.22619	9	66.70238095	0.12159427
							41.13231293	0.07498163
MATRIX3	1114.447	1698.943	2704.534	1994.181	2479.934	3344.222		
	631.7337	1116.713	1593.765	1680.385	1456.471	2372.631	13336.26108	0.33172584
	331.0406	434.0134	850.8315	595.8826	678.1613	1019.378	8851.699525	0.22017696
	468.0464	647.3029	1306.63	1109.042	880.0525	1683.552	3909.307253	0.09724002
	360.0413	601.7677	863.7786	811.6366	827.564	1194.263	6094.6263	0.15159759
	281.9084	343.0712	753.141	551.5496	521.0732	900.9706	4659.051344	0.11588913
							3351.713935	0.08337045
MATRIX4	5979594	8894908	15289321	12757812	12622198	19846913		
	3916853	5790201	10084986	8440363	8194412	13092952	75390745.27	0.33485728
	1735206	2559891	4443055	3669977	3646888	5735678	49519767.45	0.21994815
	2673629	3910183	6886449	5672505	5571177	8867988	21790695.1	0.09678606
	2081863	3091677	5342540	4474415	4376560	6943106	33581931.29	0.14915828
	1479972	2168613	3799323	3118995	3095624	4887090	26310161.27	0.11685982
							18549617.26	0.08239041

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	8.619855
ROW 2	4.950999
ROW 3	2.613025
ROW 4	10.299
ROW 5	5.711252
ROW 6	6.104763
	6.383149

3,CALCULATE CONSITENCY INDEX(CI)

0.07663

0.251497	0.711176	0.176471	0.094937	0.324324	0.235294
0.0359281	0.101597	0.176471	0.474684	0.108108	0.411765
0.1257485	0.050798	0.088235	0.018987	0.324324	0.058824
0.251497	0.020319	0.441176	0.094937	0.027027	0.176471
0.0838323	0.101597	0.029412	0.28481	0.108108	0.058824
0.251497	0.014514	0.088235	0.031646	0.108108	0.058824
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.886421
ROW 2	1.088963
ROW 3	0.252904
ROW 4	1.536181
ROW 5	0.667416
ROW 6	0.502974
CR	0.061407

Step 1 Pair wise comparison for " WATER RECHARGE"

Matrix 1	S3	C1	C2	C3	C4	C5	C6	PRIORITY
	C1	1.00	5.00	3.00	3.00	3.00	1.00	0.29
	C2	0.20	1.00	0.20	3.00	5.00	3.00	0.16
	C3	0.33	2.00	1.00	3.00	7.00	5.00	0.24
	C4	0.33	0.33	0.33	1.00	5.00	3.00	0.12
	C5	0.33	0.20	0.14	3.00	1.00	2.00	0.09
	C6	0.33	3.00	0.20	0.33	0.50	1.00	0.09
	sum	2.53	11.53	4.88	13.33	21.50	15.00	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	5.333333	20.6	8.628571	39.33333	67.5	47		
	4.133333	13.4	3.314286	23.2	28.5	26.2	188.3952381	0.298890653
	6.066667	23.06667	5.4	35.66667	42.5	39.33333	98.74761905	0.15666394
	3.511111	13	3.047619	20	16.5	19	152.0333333	0.241202181
	2.420952	9.352381	2.725714	8.695238	20	14.64762	75.05873016	0.119081316
	1.611111	8.277778	2.18254	12.76667	20.06667	13.33333	57.84190476	0.091766675
							58.23809524	0.092395235
MATRIX3	543.178	2116.614	567.3257	2969.079	4255.948	3492.491		
	290.2038	1126.177	303.5435	1637.968	2280.304	1883.299	13944.63513	0.291063292
	451.9483	1745.362	468.344	2551.405	3524.189	2926.515	7521.495238	0.15699451
	231.7272	888.4194	237.2337	1334.44	1778.29	1500.514	11667.7636	0.243538655
	170.6522	659.4021	179.5877	944.2273	1383.2	1119.492	5970.625185	0.124623542
	170.9353	658.4632	175.8267	933.2987	1316.963	1092.72	4456.561738	0.09302083
							4348.207238	0.09075917
MATRIX4	3176987	12267413	3299101	17767340	24903818	20579508		
	1712262	6611240	1777877	9577319	13419999	11091282	81994166.76	0.291248216
	2656551	10257194	2758281	14859299	20819869	17207663	44189977.34	0.15696546
	1360095	5251237	1412009	7608767	10657018	8809503	68558857.71	0.24352519
	1011430	3905353	1050326	5655852	7929509	6552018	35098630.08	0.124672447
	991199.1	3827316	1029245	5543446	7769007	6420427	26104488.22	0.092724714
							25580640.25	0.090863974

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	8.689345
ROW 2	6.585063
ROW 3	2.823181
ROW 4	7.814645
ROW 5	7.054433
ROW 6	4.950867
	6.319589

3,CALCULATE CONSITENCY INDEX(CI)

0.063918

0.3947368	0.433526	0.615234	0.225	0.139535	0.066667
0.0789474	0.086705	0.041016	0.225	0.232558	0.2
0.1315789	0.17341	0.205078	0.225	0.325581	0.333333
0.1315789	0.028902	0.068359	0.075	0.232558	0.2
0.1315789	0.017341	0.029297	0.225	0.046512	0.133333
0.1315789	0.260116	0.041016	0.025	0.023256	0.066667
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.530756
ROW 2	1.033627
ROW 3	0.687516
ROW 4	0.974271
ROW 5	0.65412
ROW 6	0.449855
CR	0.05122

Step 1 Pair wise comparison for " CITY ECONOMY"

Matrix 1	S4	C1	C2	C3	C4	C5	C6	PRIORITY
	C1	1.00	3.00	2.00	3.00	1.00	5.00	0.25
	C2	0.33	1.00	0.20	3.00	5.00	3.00	0.18
	C3	0.50	5.00	1.00	3.00	3.00	1.00	0.25
	C4	0.33	0.33	0.33	1.00	5.00	3.00	0.14
	C5	1.00	0.20	0.33	3.00	1.00	3.00	0.13
	C6	0.33	0.33	1.00	0.33	0.33	1.00	0.06
	sum	3.50	9.87	4.87	13.33	15.33	16.00	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6.666667	18.86667	10.93333	25.66667	39.66667	33		
	7.766667	6	6.733333	23.6	26.93333	31.86667	134.8	0.24098396
	7	13.43333	6	31.83333	46.83333	37.5	102.9	0.18395586
	6.944444	5.333333	6.066667	20	14	24	142.6	0.25492813
	4.233333	7.066667	6.706667	11.6	20	20.93333	76.344444	0.1364821
	1.722222	6.844444	2.955556	6.666667	7.333333	6.666667	70.54	0.1261054
							32.188889	0.05754455
MATRIX3	670.5052	1028.916	784.8	2157.876	2679.298	2897.573		
	478.2993	807.2874	583.7055	1552.16	1887.778	2042.649	10218.967	0.24831344
	676.9081	1050.667	821.0356	2117.627	2577.804	2878.453	7351.8788	0.17864528
	369.6741	614.3807	434.397	1219.63	1439.23	1559.689	10122.495	0.24596922
	331.3274	558.8388	400.483	1092.48	1388.258	1453.013	5637	0.13697498
	174.1511	246.2696	191.9793	562.6622	679.9659	743.7319	5224.4003	0.12694911
							2598.76	0.06314797
MATRIX4	3662995	5881724	4337807	11895065	14557393	15717249		
	2656938	4268745	3148253	8625961	10553732	11398117	56052233	0.24735494
	3650384	5857788	4323478	11848650	14497191	15660067	40651746	0.17939357
	2035116	3270470	2411011	6608623	8083956	8729966	55837558	0.24640759
	1877412	3017670	2224526	6097065	7462644	8056067	31139143	0.13741506
	927326.8	1488542	1097559	3012145	3685870	3978976	28735383	0.12680742
							14190420	0.06262142

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	8.594865
ROW 2	5.62775
ROW 3	4.499105
ROW 4	6.197654
ROW 5	7.269792
ROW 6	6.506884
	6.449342

3,CALCULATE CONSITENCY INDEX(CI)

0.089868

0.2857143	0.304054	0.410959	0.225	0.065217	0.3125
0.0952381	0.101351	0.041096	0.225	0.326087	0.1875
0.1428571	0.506757	0.205479	0.225	0.195652	0.0625
0.0952381	0.033784	0.068493	0.075	0.326087	0.1875
0.2857143	0.02027	0.068493	0.225	0.065217	0.1875
0.0952381	0.033784	0.205479	0.025	0.021739	0.0625
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.125982
ROW 2	1.009582
ROW 3	1.108614
ROW 4	0.851651
ROW 5	0.921864
ROW 6	0.40747
CR	0.072016

Step 1 Pair wise comparison for " INSTITUTIONAL WATER USE"

Matrix 1

S5	C1	C2	C3	C4	C5	C6	PRIORITY
C1	1.00	3.00	5.00	3.00	3.00	1.00	0.31
C2	0.33	1.00	3.00	5.00	1.00	3.00	0.22
C3	0.20	0.33	1.00	3.00	2.00	1.00	0.13
C4	0.33	0.20	0.33	4.00	1.00	3.00	0.14
C5	0.33	1.00	0.50	1.00	1.00	3.00	0.11
C6	1.00	0.33	1.00	0.33	0.33	1.00	0.09
sum	3.20	5.87	10.83	16.33	8.33	12.00	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6	11.6	22.5	48.33333	22.33333	34		
	6.266667	6	12.83333	37	15	27.33333	144.766667	0.31416377
	3.177778	4.2	6	19.6	8.266667	18.2	104.433333	0.22663484
	5.133333	4.111111	7.433333	21	7.866667	19.26667	59.4444444	0.1290027
	4.433333	4.366667	9	13.5	6	12.83333	64.8111111	0.14064911
	2.533333	4.4	8.277778	9.666667	6.333333	6	50.1333333	0.1087963
							37.2111111	0.08075328
MATRIX3	613.4489	679.5259	1260.589	2805.367	1223.556	2352.4		
	441.6593	500.4711	931.2926	2020.144	890.2222	1680	8934.88593	0.30943986
	247.8222	284.0178	532.1489	1125.726	502.6237	924.96	6463.78963	0.22385895
	271.6689	320.8911	599.2444	1279.36	572.1822	1043.346	3617.29852	0.12527707
	210.9756	253.5933	470.3704	1040.8	462.3889	847.9889	4086.69259	0.14153349
	161.9783	184.3496	341.6556	793.9889	343.0519	660.5778	3286.11704	0.11380734
							2485.60198	0.08608329
MATRIX4	2390149	2759134	5137300	11243097	4967054	9269148		
	1731517	1998802	3721698	8143357	3597862	6713538	35765882.8	0.30948675
	971033.1	1120898	2087110	4565790	2017371	3764092	25906773.5	0.22417462
	1094164	1263376	2352445	5145657	2273780	4241678	14526294.4	0.12569788
	875654.3	1011442	1883338	4119773	1820549	3395587	16371100.7	0.14166123
	660531.8	762923.3	1420528	3108769	1373568	2562435	13106343	0.11341086
							9888755.21	0.08556866

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	7.975047
ROW 2	5.581496
ROW 3	3.371097
ROW 4	7.227663
ROW 5	9.681925
ROW 6	4.485247
	6.387079

3,CALCULATE CONSITENCY INDEX(CI)

0.077416

0.3125	0.511364	0.461538	0.183673	0.36	0.083333
0.1041667	0.170455	0.276923	0.306122	0.12	0.25
0.0625	0.056818	0.092308	0.183673	0.24	0.083333
0.1041667	0.034091	0.030769	0.244898	0.12	0.25
0.1041667	0.170455	0.046154	0.061224	0.12	0.25
0.3125	0.056818	0.092308	0.020408	0.04	0.083333
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.468171
ROW 2	1.25123
ROW 3	0.42374
ROW 4	1.02388
ROW 5	1.098035
ROW 6	0.383797
CR	0.062037

Step 1 Pair wise comparison for " INDUSTRIALWATER USE"

Matrix 1	S6	C1	C2	C3	C4	C5	C6	PRIORITY
	C1	1.00	3.00	4.00	5.00	0.33	2.00	0.26
	C2	0.33	1.00	3.00	3.00	5.00	7.00	0.26
	C3	0.25	0.33	1.00	0.33	3.00	5.00	0.13
	C4	0.20	0.33	3.00	1.00	5.00	0.33	0.13
	C5	3.00	0.20	0.33	0.20	1.00	0.33	0.11
	C6	0.50	0.14	0.20	3.00	3.00	1.00	0.11
	sum	5.28	5.01	11.53	12.53	17.33	15.67	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6	9.352381	32.51111	26.4	58.66667	46.77778		
	20.51667	6	19.4	30.66667	55.11111	32.33333	179.7079365	0.28680307
	12.17778	2.842063	6	18.51667	24.41667	13.94444	164.0277778	0.26177848
	16.42778	3.314286	9.533333	6	21.73333	20.06667	77.89761905	0.12431992
	6.356667	9.625397	13.93333	17.11111	6	9.8	77.07539683	0.1230077
	10.69762	3.452381	12.82857	9.595238	22.48095	6	62.82650794	0.10026733
							65.0547619	0.10382349
MATRIX3	1930.821	1018.309	2240.764	2658.3	3638.602	2421.77		
	1682.447	1026.747	2374.847	2522.122	3732.034	2773.713	13908.5655	0.25495591
	813.0117	492.5271	1182.668	1182.447	1879.972	1439.727	14111.90977	0.25868338
	734.0434	498.9743	1273.027	1312.283	2091.107	1462.341	6990.352235	0.12813914
	829.3723	305.0986	849.4409	1020.36	1871.791	1263.827	7371.774977	0.13513094
	655.9586	426.1258	973.4197	1125.649	1609.397	1239.783	6139.890787	0.11254945
							6030.333679	0.11054118
MATRIX4	13820733	7583890	18227184	20277774	31305509	22214963		
	13672763	7516200	18097846	20110144	31141876	22185182	113430053.6	0.26069019
	6731519	3693186	8893817	9892465	15328366	10927824	112724011.3	0.25906753
	6948604	3802734	9205688	10216919	15938062	11369295	55467176.05	0.12747722
	5935706	3194953	7706753	8650164	13424604	9502375	57481301.28	0.13210618
	5749186	3165926	7639963	8484389	13168702	9389135	48414555.51	0.11126857
							47597301.44	0.10939032

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	9.304248
ROW 2	5.406011
ROW 3	1.623488
ROW 4	3.440261
ROW 5	5.956313
ROW 6	15.73237
	6.910448

3,CALCULATE CONSITENCY INDEX(CI)

0.18209

0.1892744	0.598859	0.346821	0.398936	0.019231	0.12766
0.0630915	0.19962	0.260116	0.239362	0.288462	0.446809
0.0473186	0.06654	0.086705	0.026596	0.173077	0.319149
0.0378549	0.06654	0.260116	0.079787	0.288462	0.021277
0.5678233	0.039924	0.028902	0.015957	0.057692	0.021277
0.0946372	0.028517	0.017341	0.239362	0.173077	0.06383
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.425526
ROW 2	1.400522
ROW 3	0.206958
ROW 4	0.45448
ROW 5	0.66275
ROW 6	1.720969
CR	0.145917

Step 1 Pair wise comparison for " SHORTAGE OF WATER"

Matrix 1	C1	S1	S2	S3	S4	S5	S6	PRIORITY
	S1	1.00	3.00	1.00	3.00	0.33	0.20	0.18
	S2	0.33	1.00	2.00	7.00	5.00	9.00	0.36
	S3	1.00	0.50	1.00	3.00	1.00	1.00	0.10
	S4	0.33	0.14	0.33	1.00	3.00	0.33	0.06
	S5	3.00	0.20	1.00	0.33	1.00	0.33	0.10
	S6	5.00	0.11	1.00	3.00	3.00	1.00	0.19
	sum	10.67	4.95	6.33	17.33	13.33	11.87	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6	7.01746	9.533333	30.71111	26.26667	29.51111		
	65	6	20.66667	49.66667	60.11111	24.06667	109.0396825	0.187347275
	11.16667	4.739683	6	15.83333	16.83333	8.033333	225.5111111	0.387463455
	11.71429	2.089418	4.619048	6	8.15873	3.352381	62.60634921	0.107567526
	8.844444	9.984656	5.844444	15.06667	6	4.177778	35.93386243	0.061740011
	21.03704	16.75079	11.22222	25.77778	18.22222	6	49.91798942	0.085766934
							99.01005291	0.170114798
MATRIX3	1811.49	950.161	885.9779	2024.494	1685.827	812.2963		
	2630.528	1697.187	1718.477	4445.504	3620.321	2790.677	8170.245267	0.173936579
	945.4346	470.96	502.0772	1229.049	1055.784	663.4144	16902.6935	0.359841912
	470.6466	266.7875	295.5905	782.0099	670.039	507.4072	4866.718695	0.10360771
	1084.782	311.0439	477.2775	1148.558	1165.938	648.8997	2992.480672	0.063707004
	1929.695	637.629	906.9704	2239.594	2177.37	1312.659	4836.499095	0.102964364
							9203.916426	0.195942433
MATRIX4	10967614	5333488	5822356	14318861	12519874	7898273		
	22259055	10280704	11682983	28866990	25669381	16281245	56860465.19	0.179524915
	6430130	3013383	3367944	8284294	7327937	4594919	115040358.4	0.363215646
	3907862	1779769	2035012	5019625	4481378	2820560	33018606.46	0.10424928
	6292048	2866232	3219756	7856081	7000619	4256968	20044207.38	0.063285353
	11979464	5454586	6152542	15047990	13416554	8220952	31491704.52	0.099428409
							60272088.65	0.190296396

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	9.498053
ROW 2	4.986417
ROW 3	7.046081
ROW 4	2.330969
ROW 5	5.885719
ROW 6	13.42914
	7.196063

3,CALCULATE CONSITENCY INDEX(CI)

0.239213

0.09375	0.605575	0.157895	0.173077	0.025	0.016854
0.03125	0.201858	0.315789	0.403846	0.375	0.758427
0.09375	0.100929	0.157895	0.173077	0.075	0.08427
0.03125	0.028837	0.052632	0.057692	0.225	0.02809
0.28125	0.040372	0.157895	0.019231	0.075	0.02809
0.46875	0.022429	0.157895	0.173077	0.225	0.08427
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	1.705137
ROW 2	1.811145
ROW 3	0.734549
ROW 4	0.147516
ROW 5	0.585208
ROW 6	2.555517
CR	0.191692

Step 1 Pair wise comparison for " POLLUTION"

Matrix 1	C2	S1	S2	S3	S4	S5	S6	PRIORITY
	S1	1.00	5.00	3.00	1.00	0.33	3.00	0.25
	S2	0.20	1.00	3.00	3.00	3.00	0.20	0.16
	S3	0.33	0.33	1.00	3.00	1.00	7.00	0.21
	S4	1.00	0.33	0.33	1.00	1.00	0.33	0.07
	S5	3.00	0.33	1.00	1.00	1.00	0.33	0.14
	S6	0.33	5.00	0.14	3.00	3.00	1.00	0.18
	sum	5.87	12.00	8.48	12.00	9.33	11.87	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6	26.44444	22.09524	35.33333	28.66667	28.44444		
	13.46667	6	10.62857	18.8	12.66667	24	146.984127	0.258474387
	9.066667	38.66667	6	29.33333	27.11111	16.4	85.56190476	0.150462239
	5.288889	7.777778	5.714286	6	4.666667	6.4	126.5777778	0.222589433
	7.511111	18	12.38095	10	6	17.06667	35.84761905	0.063038721
	13.71429	13.71429	20.28571	24.7619	24.25397	6	70.95873016	0.124782279
							102.7301587	0.180652941
MATRIX3	1384.737	2352.593	1680.051	2560.288	2132.769	2053.74		
	781.6804	1506.455	1176.203	1734.146	1496.025	1181.858	12164.17637	0.247230497
	1213.201	1644.825	1483.268	2076.495	1609.676	2033.126	7876.368254	0.160083048
	342.8402	625.9189	455.7037	741.8582	616.2794	587.2649	10060.59118	0.204476232
	731.7333	1205.192	909.1979	1509.57	1275.581	1117.497	3369.865256	0.068490742
	846.3182	1940.783	1133.996	1877.13	1523.429	1660.334	6748.771781	0.137165242
							8981.990426	0.182554239
MATRIX4	9971215	17723978	13020294	20087753	16604297	16336899		
	6376413	11225194	8320447	12819468	10591641	10429640	93744435.05	0.248219672
	8375624	14957282	10888308	16825335	13866054	13845149	59762803.85	0.158241965
	2719176	4845867	3552471	5492514	4539087	4469769	78757752.09	0.208537428
	5455057	9683518	7110394	10994526	9086981	8943064	25618883.69	0.067834543
	7228235	13013274	9509958	14696108	12163322	11898914	51273540.28	0.135763807
							68509811.5	0.181402586

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	9.367289
ROW 2	8.58245
ROW 3	3.653783
ROW 4	3.645055
ROW 5	5.414963
ROW 6	8.195222
	6.47646

3,CALCULATE CONSITENCY INDEX(CI)

0.095292

0.170455	0.416667	0.353933	0.083333	0.035714	0.252809
0.034091	0.083333	0.353933	0.25	0.321429	0.016854
0.056818	0.027778	0.117978	0.25	0.107143	0.589888
0.170455	0.027778	0.039326	0.083333	0.107143	0.02809
0.511364	0.027778	0.117978	0.083333	0.107143	0.02809
0.056818	0.416667	0.016854	0.25	0.321429	0.08427
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.325146
ROW 2	1.358104
ROW 3	0.76195
ROW 4	0.247261
ROW 5	0.735156
ROW 6	1.486635
CR	0.076362

Step 1 Pair wise comparison for " FUNDING"

Matrix 1	C3	S1	S2	S3	S4	S5	S6	PRIORITY
	S1	1.00	0.20	1.00	3.00	1.00	3.00	0.15
	S2	5.00	1.00	2.00	3.00	3.00	7.00	0.38
	S3	1.00	0.50	1.00	3.00	5.00	1.00	0.20
	S4	0.33	0.33	0.33	1.00	2.00	3.00	0.11
	S5	1.00	0.33	0.20	0.50	1.00	3.00	0.10
	S6	0.33	0.14	1.00	0.33	0.33	1.00	0.06
	sum	8.67	2.51	5.53	10.83	12.33	18.00	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6	2.661905	6.6	11.1	14.6	20.4		
	18.33333	6	17.6	30.83333	29.33333	49	61.36190476	0.152307183
	10.83333	4.009524	6	13.33333	18.83333	32.5	151.1	0.375047278
	5.666667	1.995238	5.066667	6	8	15.66667	85.50952381	0.212244303
	5.033333	1.561905	5.233333	6.6	6	13.03333	42.3952381	0.105229773
	2.825397	1.074603	2.796825	5.261905	7.095238	6	37.46190476	0.092984682
							25.05396825	0.062186781
MATRIX3	350.3263	125.2786	315.7514	506.9783	611.1254	953.92		
	871.4778	315.3605	778.9778	1259.6	1545.467	2399.367	2863.38	0.150950973
	465.6833	167.8952	435.0811	699.1889	839.0413	1261.817	7170.249365	0.377999469
	243.9995	88.67259	218.9998	363.2119	443.8413	670.3	3868.706508	0.203949532
	219.9537	80.29852	193.4015	321.5867	399.1383	609.0967	2029.025026	0.10696565
	149.4349	53.21095	134.9146	211.7579	252.6841	412.1016	1823.475291	0.096129529
							1214.104127	0.064004847
MATRIX4	779616.9	281196	703501.2	1138849	1382618	2138367		
	1948710	702879.6	1758205	2846289	3455755	5345344	6424147.5	0.151085296
	1055780	380850.8	952753.9	1542754	1873182	2895780	16057182.87	0.377638312
	551154.5	198814.8	497216	805114.3	977641.3	1511886	8701099.793	0.204635437
	494377	178326.4	445944.2	722022.6	876743.6	1356204	4541827.342	0.106816247
	330380.6	119148.7	298176.2	482554.2	585732.5	906137.2	4073617.923	0.095804738
							2722129.416	0.06401997

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	6.84908
ROW 2	7.317728
ROW 3	2.660361
ROW 4	5.052165
ROW 5	14.5991
ROW 6	6.263597
	7.123672

3,CALCULATE CONSITENCY INDEX(CI)

0.224734

0.1153846	0.079696	0.180723	0.276923	0.081081	0.166667
0.5769231	0.398482	0.361446	0.276923	0.243243	0.388889
0.1153846	0.199241	0.180723	0.276923	0.405405	0.055556
0.0384615	0.132827	0.060241	0.092308	0.162162	0.166667
0.1153846	0.132827	0.036145	0.046154	0.081081	0.166667
0.0384615	0.056926	0.180723	0.030769	0.027027	0.055556
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	1.034795
ROW 2	2.763455
ROW 3	0.544404
ROW 4	0.539653
ROW 5	1.398663
ROW 6	0.400995
CR	0.18009

Step 1 Pair wise comparison for " TECNIQUE"

Matrix 1	C4	S1	S2	S3	S4	S5	S6	PRIORITY
	S1	1.00	3.00	1.00	3.00	0.33	0.20	0.18
	S2	0.33	1.00	3.00	3.00	5.00	9.00	0.35
	S3	1.00	0.33	1.00	3.00	5.00	1.00	0.14
	S4	0.33	0.33	0.33	1.00	1.00	0.33	0.05
	S5	3.00	0.20	0.20	1.00	1.00	0.33	0.09
	S6	5.00	0.11	1.00	3.00	3.00	1.00	0.19
	sum	10.67	4.98	6.53	14.00	15.33	11.87	1.00

step 2 calculation of priority

							EIGEN VECTOR	**NORMALZED EIGEN VALUE**
MATRIX2	6	7.422222	12.26667	18.93333	24.26667	29.51111		
	64.66667	6	17.33333	48	55.11111	23.73333	98.4	0.175269158
	23.11111	5.777778	6	18	18	7.866667	214.8444444	0.382678911
	5.777778	2.014815	2.533333	6	6.444444	4.4	78.75555556	0.140278657
	8.266667	9.837037	4.666667	13.2	6	3.6	27.17037037	0.048395609
	21.03704	17.15556	8.933333	27.33333	16.22222	6	45.57037037	0.081169517
							96.68148148	0.172208149
MATRIX3	1730.29	943.0795	700.6933	1931.224	1521.798	797.4519		
	2408.79	1662.118	1592.047	3488.533	3236.919	2739.141	7624.535967	0.174518933
	1069.254	589.1595	619.52	1383.526	1338.864	1057.56	15127.54831	0.346256297
	404.0099	220.5774	205.5783	493.037	445.5572	314.2558	6057.884444	0.138659655
	995.1802	294.72	393.5131	969.4933	1006.201	615.4153	2083.015638	0.047678399
	1860.326	628.2733	807.5654	1924.701	1987.575	1312.927	4274.523128	0.097840081
							8521.36823	0.195046636
MATRIX4	9793020	4987637	4787783	11563363	10600657	7294508		
	19600317	9416693	9523271	22783081	21432948	14841989	49026967.48	0.177248371
	7790483	3716842	3736327	8993031	8429291	5768888	97598298.81	0.35284947
	2677414	1306264	1292089	3114047	2896657	1985520	38434862	0.138954478
	5390544	2557280	2502562	6132484	5662898	3748948	13271991.09	0.047982548
	10793841	5109685	5042150	12304628	11412936	7610309	25994715.76	0.093979319
							52273548.45	0.188985813

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	9.423328
ROW 2	4.300912
ROW 3	5.427709
ROW 4	3.308788
ROW 5	6.04269
ROW 6	13.55671
	7.010023

3,CALCULATE CONSITENCY INDEX(CI)

0.202005

0.09375	0.602679	0.153061	0.214286	0.021739	0.016854
0.03125	0.200893	0.459184	0.214286	0.326087	0.758427
0.09375	0.066964	0.153061	0.214286	0.326087	0.08427
0.03125	0.066964	0.05102	0.071429	0.065217	0.02809
0.28125	0.040179	0.030612	0.071429	0.065217	0.02809
0.46875	0.022321	0.153061	0.214286	0.195652	0.08427
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	1.67027
ROW 2	1.517574
ROW 3	0.754204
ROW 4	0.158764
ROW 5	0.567888
ROW 6	2.562026
CR	0.161876

Step 1 Pair wise comparison for " INSTITUTION"

Matrix 1	C5	S1	S2	S3	S4	S5	S6	PRIORITY
	S1	1.00	5.00	3.00	1.00	0.33	3.00	0.23
	S2	0.20	1.00	3.00	1.00	5.00	0.20	0.17
	S3	0.33	0.33	1.00	3.00	5.00	1.00	0.17
	S4	1.00	1.00	0.33	1.00	1.00	5.00	0.15
	S5	3.00	0.20	0.20	1.00	1.00	3.00	0.15
	S6	0.33	5.00	1.00	0.20	0.33	1.00	0.14
	sum	5.87	12.53	8.53	7.20	12.67	13.20	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIGEN VALUE
MATRIX2	6	27.06667	24.4	16.93333	42.66667	16		
	17.46667	6	8.133333	16.24	26.13333	24	133.0666667	0.230605706
	19.06667	11.33333	6	11.86667	15.11111	33.06667	97.97333333	0.16978865
	6.977778	32.31111	11.86667	6	10.66667	16.53333	96.44444444	0.167139072
	8.106667	31.46667	13.33333	6.4	6	20.24	84.35555556	0.146188921
	3.2	12.26667	18.13333	9.066667	30.97778	6	85.54666667	0.148253127
							79.64444444	0.138024524
MATRIX3	1489.233	2687.313	1572.907	1350.443	2264.32	2791.964		
	766.6489	2242.404	1500.146	972.0178	2098.441	1633.849	12156.17896	0.225619536
	737.8726	1916.61	1535.313	1045.831	2441.932	1475.911	9213.50637	0.171003326
	1013.736	1249.541	1017.481	1037.876	1961.6	1693.796	9153.46963	0.169889039
	1010.546	1203.2	1056.697	1066.823	2100.952	1674.489	7974.030222	0.147998561
	912.7917	1707.046	916.077	775.6373	1199.561	1758.101	8112.70637	0.1505724
							7269.214815	0.134917138
MATRIX4	11644317	22220597	15113093	12251007	23607587	21857526		
	8565076	16492270	11576150	9298645	18380081	16050975	106694126.2	0.226554826
	8576177	15987693	11389528	9300436	18394132	15912764	80363196.62	0.170643602
	7798922	14024769	9711642	8131321	15591069	14394080	79560730.22	0.168939641
	7940122	14158322	9856332	8286713	15908756	14615767	69651801.59	0.147898974
	6947296	13450268	9070344	7298398	14036648	13102929	70766012.51	0.150264895
							63905883.02	0.135698062

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	9.669387
ROW 2	8.661557
ROW 3	3.94679
ROW 4	9.929399
ROW 5	8.05906
ROW 6	2.343602
	7.101633

3,CALCULATE CONSITENCY INDEX(CI)

0.220327

0.1704545	0.398936	0.351563	0.138889	0.026316	0.227273
0.0340909	0.079787	0.351563	0.138889	0.394737	0.015152
0.0568182	0.026596	0.117188	0.416667	0.394737	0.075758
0.1704545	0.079787	0.039063	0.138889	0.078947	0.378788
0.5113636	0.015957	0.023438	0.138889	0.078947	0.227273
0.0568182	0.398936	0.117188	0.027778	0.026316	0.075758
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	2.190646
ROW 2	1.478039
ROW 3	0.666769
ROW 4	1.468548
ROW 5	1.210994
ROW 6	0.318022
CR	0.176558

Step 1 Pair wise comparison for " ECONOMY"

Matrix 1	C6	S1	S2	S3	S4	S5	S6	PRIORITY
	S1	1.00	1.00	3.00	1.00	0.33	3.00	0.17
	S2	1.00	1.00	3.00	1.00	5.00	0.20	0.18
	S3	0.33	0.33	1.00	3.00	1.00	1.00	0.13
	S4	1.00	1.00	0.33	1.00	1.00	7.00	0.22
	S5	3.00	0.20	1.00	1.00	1.00	0.33	0.12
	S6	0.33	5.00	1.00	0.14	3.00	1.00	0.18
	sum	6.67	8.53	9.33	7.14	11.33	12.53	1.00

step 2 calculation of priority

							EIGEN VECTOR	NORMALZED EIG
MATRIX2	6	19.06667	12.66667	12.7619	18.66667	16.31111		
	19.06667	6	14.53333	17.02857	14.93333	15.06667	85.47301587	0.168813515
	7.333333	9.2	6	7.809524	9.777778	24.4	86.62857143	0.171095796
	8.444444	38.31111	14.66667	6	28.66667	17.86667	64.52063492	0.127431507
	7.644444	6.4	12.26667	8.247619	6	17.70667	113.9555556	0.225067967
	15.14286	11.40952	21.04762	11.61905	32.25397	6	58.26539683	0.115077096
							97.47301587	0.19251412
MATRIX3	989.887	1139.825	1188.565	920.2167	1524.52	1350.608		
	821.484	1453.105	1165.963	859.393	1651.327	1415.075	7113.621446	0.170775416
	773.5918	890.3839	1010.638	708.1126	1402.479	863.6902	7366.347175	0.176842557
	1429.047	1142.991	1567.446	1354.716	1793.421	1794.817	5648.895097	0.135611997
	641.4916	853.4075	830.6912	607.0434	1201.752	880.2602	9082.437531	0.218040426
	898.2851	1270.84	1176.261	957.3585	1378.975	1747.166	5014.646293	0.120385701
							7428.885543	0.178343904
MATRIX4	6341919	7912105	8004210	6197204	10403149	9329771		
	6467425	8275884	8232313	6351759	10764251	9641208	48188357.17	0.170728963
	4966471	6179300	6269888	4830225	8213452	7192146	49732840.11	0.176200989
	8264782	10045250	10339716	8049462	13324203	12047275	37651482.25	0.133397337
	4407813	5549012	5582233	4306558	7298998	6476847	62070688	0.219913373
	6665286	8409324	8439430	6558404	10901138	10012220	33621460.95	0.119119171
							50985801.11	0.180640168

2,APPROXIMATION OF LAMBADA(MAX)

ROW 1	9.155876
ROW 2	11.64227
ROW 3	6.072979
ROW 4	7.27443
ROW 5	5.149944
ROW 6	4.177961
	7.245576

3,CALCULATE CONSITENCY INDEX(CI)

0.249115

0.15	0.117188	0.321429	0.14	0.029412	0.239362
0.15	0.117188	0.321429	0.14	0.441176	0.015957
0.05	0.039063	0.107143	0.42	0.088235	0.079787
0.15	0.117188	0.035714	0.14	0.088235	0.558511
0.45	0.023438	0.107143	0.14	0.088235	0.026596
0.05	0.585938	0.107143	0.02	0.264706	0.079787
1	1	1	1	1	1

STEP 3 CALCULATION OF CONSISTENCY INDEX

1, CALCULATE THE WEIGHTED RATING FOR EACH ROW IN MATRIX 1

ROW 1	1.563173
ROW 2	2.051379
ROW 3	0.810119
ROW 4	1.599744
ROW 5	0.613457
ROW 6	0.754708
CR	0.199628