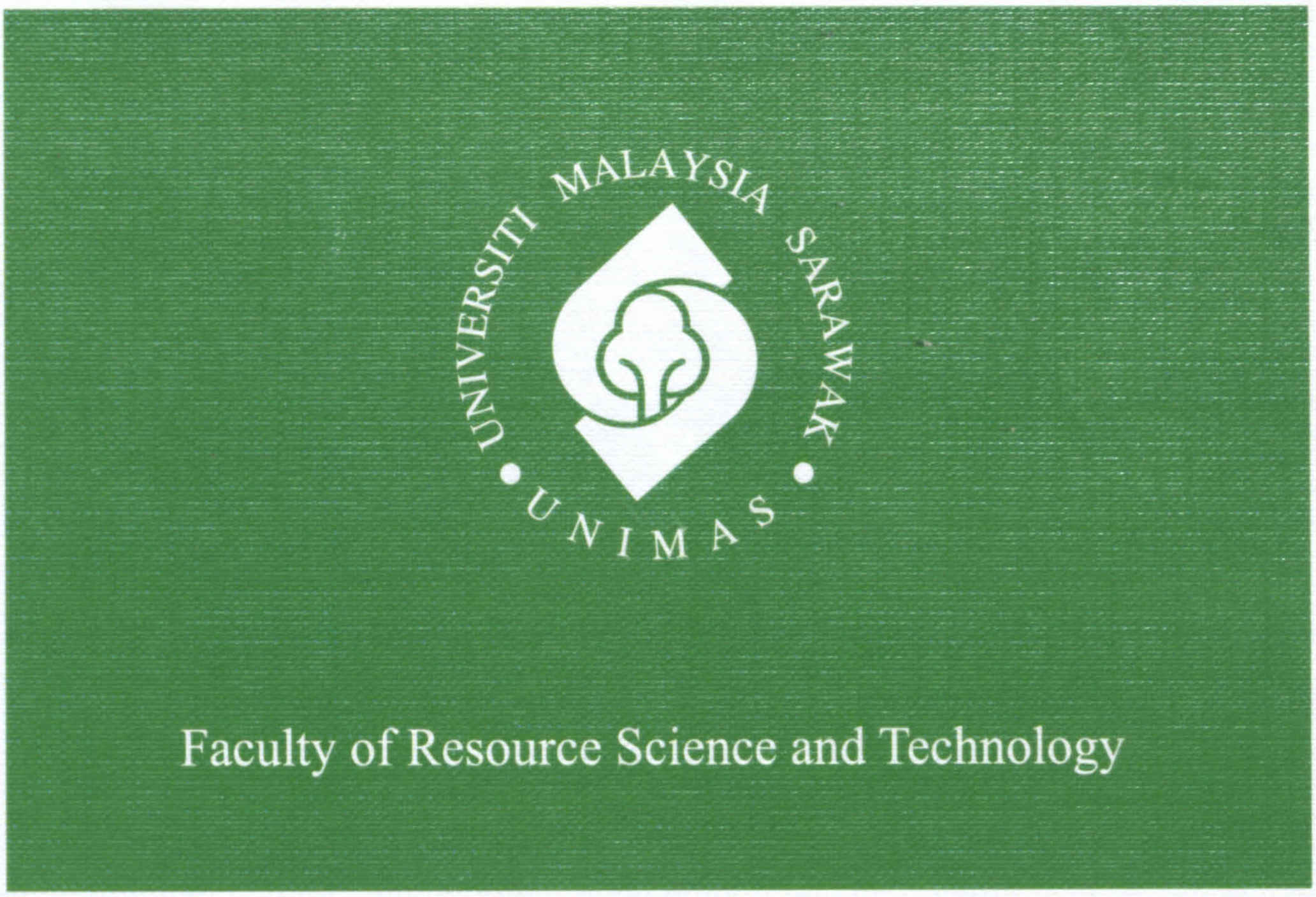

WATER RESOURCE MANAGEMENT IN RURAL AREAS: A CASE STUDY IN KUCHING DISTRICT, SARAWAK, MALAYSIA

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Masters of Environmental Science
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WATER RESOURCE MANAGEMENT IN RURAL AREAS:

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LIST OF ABBREVIATIONS

AWWRF	American Water Works Research Foundation
BAKAS	Water Supply and Environmental Sanitation
CCC	Catchment Conservation Committee
GFWS	Gravity Feed Water Supply
IWRM	Integrated Water Resources Management
JKKK	Jawatankuasa Keselamatan dan Kemajuan Kampung
JKM	Meteorological Department Malaysia
JKNS	Sarawak State Health Department
JKR	Public Work Department
KWB	Kuching Water Board
LWA	Local Water Authority
PVC	Polyvinyl Chloride
SPSS	Statistical Package for Social Sciences
TWM	Total Water Management
UN	United Nations
UNESCO	United Nation Educational, Scientific and Cultural Organization
WHO	World Health Organization

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18. Encik Samson Anak Manggang, Ketua Kaum, Kampung Semadang
19. Encik Kayis Anak genyai, Ketua Kaum Kampung Bengoh
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WATER RESOURCE MANAGEMENT IN RURAL AREAS: A CASE STUDY IN KUCHING DISTRICT, SARAWAK, MALAYSIA

ABSTRACT

Water covers more than 75 percent of the earth surface. About 94 percents of water is found in ocean as salt water while the rest of the water is found on the continents as fresh water. However, out of the available fresh water on the continent, 95 percent is stored as ground water or in glaciers and inland ice. Only a small fraction of the total freshwater on Earth water can be used by human. Besides being the basic element to sustain lives, it is also necessary to support the other living organism. Water cannot be created nor destroyed. The quantity remains the same within the hydrological cycles over billions of years. With increasing populations, the demand for water also increases. Water which presented itself in various forms is very unevenly distributed temporally and spatially. As rainfall is the main source of water, it is not always available in the quantity, where and where we wanted. Because of this, the water resources management is necessary to address these issues. Water resources management have to cover all aspect from source protection to ensure sustainable supplies. It will also include how water is distributed to ensure fair and equitable allocations to optimize use and prevent wastage. Water resource management is also important as a one of the ways to prevent pollution due to mismanagement of wastewater discharge. Water resource management in the rural areas is very important as most of the urban water supply sources originate from rural areas. By preventing the problem at source, water resource management in rural areas based on community based participation approach is seen as the basis for a sustainable water supply for the future.

This study explored the problems with water resources management that exist in the nine villages situated in the rural areas of Kuching District, Sarawak Malaysia. It was done by interviewing selected random samples from each village. In addition to that, other key informants were also interview for better understanding of the problems in the study area. The results of the interviews were analyzed using SPSS. The other information were also recorded and presented in this report.

This study had shown evidence of water depletion and deterioration of water quality in the area under study. By creating awareness, water resources will be seen not only as mere material but also as economic resources which need conservation and protection at all level of the hydrological and hydrosocial cycle.

Taking into account of the knowledge, attitude and aspiration of the local population, water resources management in this area have a bright future to become sustainable through community participation.

Key words: Water resource management, problems, sources protection and conservation, community based and sustainable water resources management.

PENGURUSAN SUMBER AIR DI KAWASAN LUAR BANDAR KAJIAN KES DI DAERAH KUCHING, SARAWAK, MALAYSIA

ABSTRAK

Air meliputi lebih dari 75 peratus daripada muka bumi. Lebih kurang 94 peratus air di dapati dalam lautan sebagai air masin sementara selebihnya didapati di daratan sebagai air tawar. Walaubagaimanapun, daripada jumlah air tawar yang wujud, sebanyak 95 peratus tersimpan sebagai air bawah tanah atau glaciers dan air batu. Hanya sebahagian kecil sahaja daripada jumlah air tawar di bumu boleh digunapakai oleh manusia. Selain dari menjadi elemen asas untuk menyokong kehidupan, ianya juga perlu untuk menyokong organisma hidup yang lain. Air tidak boleh dicipta atau dimusnahkan. Kuantitinya kekal sama dalam kitaran hidrologi lebih dari berbilion tahun lamanya. Dengan pertambahan penduduk, permintaan untuk air juga meningkat. Air wujud dalam berbagai bentuk, tidak seimbang dari segi masa dan tempat. Oleh kerana hujan merupakan sumber utama air tawar, ianya tidak sentiasa ada dalam kuantiti dan kuality mahupun bila atau di mana kita ingini. Oleh kerana ini, pengurusan sumber air diperlukan untuk mengutarakan isu tersebut ini. Pengurusan sumber air merangkumi semua perkara dari perlindungan sumber untuk menmastikan bekalan lestari. Ianya juga akan meliputi cara pembahagian air untuk memastikan pembahagian secara saksama, mengoptima penggunaan serta megelakkan pembaziran. Pengursan sumber air juga dilihat sebagai salah asatu cara untuk mengelakkan pencemaran akibat daripada pengurusan air buangan yang tidak betul. Pengurusan sumber air di luarbandar amat mustahak kerana kebanyakan bekalan air di Bandar berpunca dari kawasan luar bandar. Oleh yang demikian, dengan megelakkan masalah dari punca, pengurusan air di luar bandar berdasarkan penyertaan komuniti dilihat sebagai asas untuk bekalan air yang mampan di masa hadapan.

Kajian ini merunkai masalah berkaitan dengan pengurusan sumber air yang wujud di Sembilan buah kampong terletak di daerah Kuching Sarawa, Malaysia. Ianya dilakukan dengan menemuduga sampel yang dipilih secara dari setiap kampung. Selain daripada itu, pemberi maklumat penting juga ditemuduga untuk mengetahui secara mendalam masalh yang wujud di kawasn kajian. Hasil daripada temubual tersebut dianalisa menggunakan program SPSS dan maklumat dari pemberi maklumat penting juga direkod dan di nbentang dalam laporan ini.

Kajian ini telah menunjukkan bahawa terdapat bukti tentang berlakunya penyusutan kerosotan kualiti di kawasan kajian. Dengan meningkatkan kesedaran di kalangan penduduk setempat, sumber air akan dilihat bukan setakat sebagai benda tetapi sumber ekonomi yang memerlukan pemuliharaan dan penjagaan di setiap kitaran hidrologi dan hidrososial.

Mengambil kira tahap pengetahuan, sikap dan aspirasi penduduk, setempat, pengurusan sumber air di tempat ini mempunyai masa depan yang cerah untuk menjadi lastari melalui penyretaan komuniti setempat.

Kata kunci: Pengurusan sumber air, masalah air, penjagaan dan pemuliharaan sumber air berasaskan komuniti dan pengurusan sumber air secara lestari.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is becoming one of the largest, and certainly the most universal, of problems facing mankind as the earth moves into the twenty-first century. The task of supplying enough water of the required quality to growing populations and the safe disposal of waste water are straining many authorities to the limit (Winpenny, 1994).

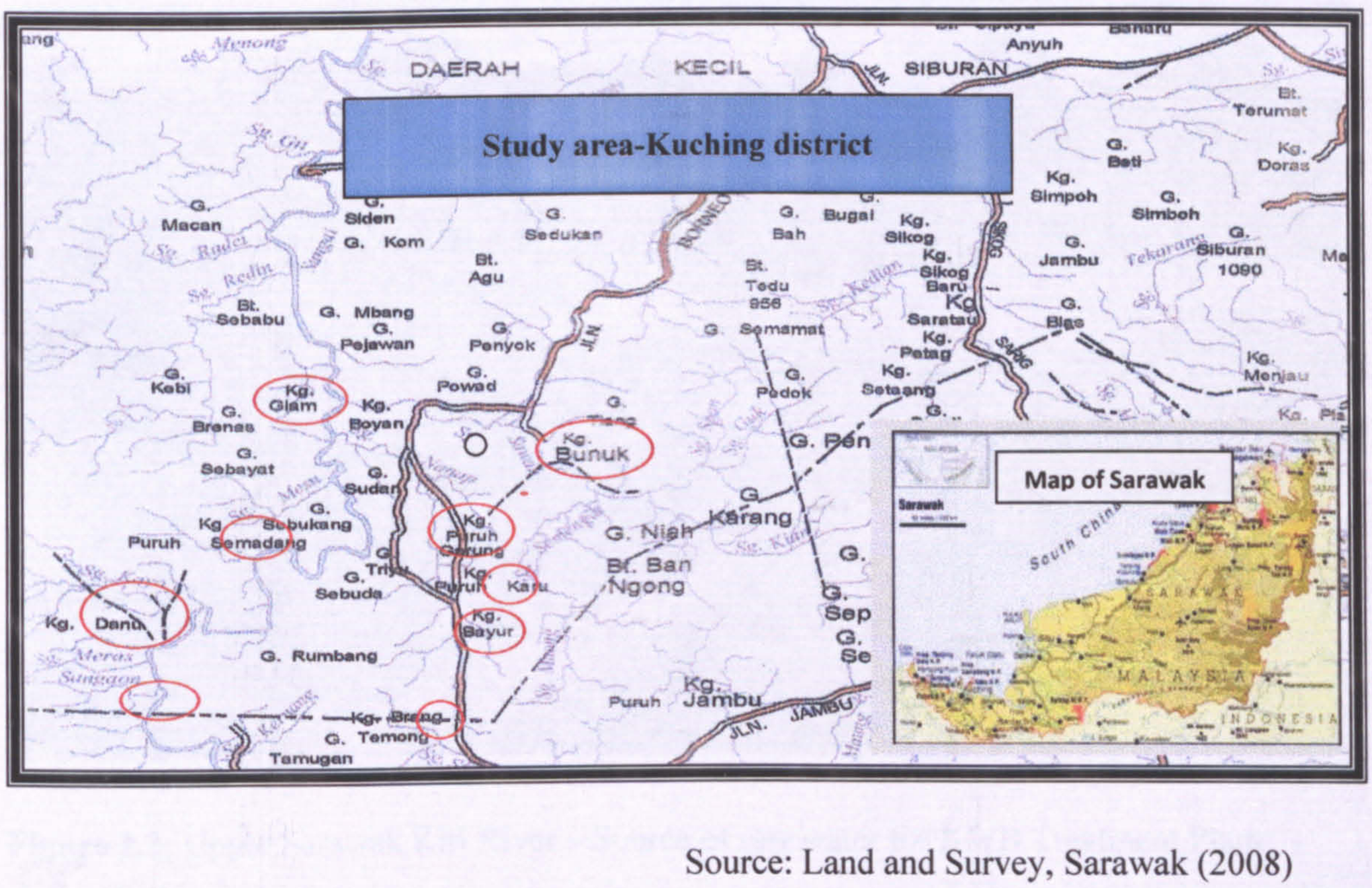
The problem mentioned above is definitely not an easy one to solve. Some argues that the heart of the problem lies in our perception of water. Winpenny (1994) argued the water problem that we face nowadays is our failure to see water as scarce commodities. The water problem facing us today is also partly due to the mismanagement of the finite water resource that we have taken for granted. What has been mentioned above might be happening on the global scale and involved many countries throughout the world. But, is it true that the problems above is just heard but not experienced? Is it true that what the people in the other part of the world is just a story to us or are we also facing that same problem locally? If it is true, what is the extent and what are the causes that may have contributed to the problems? However the problems above need some form of solution to minimise the impact that we face or it will escalate into much bigger problems.

There is a growing conflict in utilisation of limited water resources and environmental protection. We have to strike a bargain between protecting and conserving the environments and development by optimising water resource use through sustainable resource management. Failure to adhere to such requirement definitely will result in environmental degradation which the public involved will bear direct or indirect cost of rehabilitations.

This study will discuss the problems and intend to find out the answers to the above questions. The problems highlighted in this research will be discussed to find out some of the reasons behind the problems. The topic of this research was chosen because there are many unanswered questions in relation to water resources. These pressing issues do not only affect us but that which affected what is surrounding us. They affect us both directly and indirectly and all level of the society.

1.2 Background of study area

Kuching District in Sarawak, Malaysia has been chosen to conduct this study. Kuching is one of the districts in Sarawak. Being the capital city, it is also the administrative centre for the state. The area of Kuching District is 1862.8 square kilometres. The population of Kuching District is 681901, based on the census carried out by the Statistic Department in 2010.



Source: Land and Survey, Sarawak (2008)

Figure 1.1: Map showing study area

There are about 40 ethnic groups found in Sarawak. However, in Kuching itself, the major ethnic groups are the Chinese, Malays, Iban and Bidayuh. There are also some minor ethnic groups and expatriate who come to Sarawak to work. The majority of the urban dwellers are Chinese and the Malays. The Bidayuh inhabit Padawan and Siburan Sub District. However, this study does cover the whole of Kuching District. The nine Bidayuh villages chosen are situated in the Siburan and Padawan sub districts.

The Local Authority in charge of this area is Padawan Municipal Council (MPP). The council is responsible for the scavenging services and maintenance of cleanliness of the area concern. The scavenging service is important as far as water resources management is concern. Poor or no scavenging services resulted in solid waste being thrown into the river which is the source of pollution.

Figure 1.2: Upper Sarawak Kiri River – Source of raw water for KWB Treatment Plant

Table 1.1: Villages included in the study indicating headman, number of households, population and the number of samples

No.	Name of village	Name of Headman	No. of doors	Population	Sample
1	Kpg Danu, Km 51, Jln Puncak Borneo.Kuching	Encik Ahit Naii	51	154	9
2	Kpg Bayur, Km 45, Jln Puncak Borneo, 93250 Kuching	Encik Tora Jongsen	63	308	10
3	Kpg Semadang, KM 40, Jln Puncak Borneo, 93250 Kuching	Encik Samson Manggang	84	519	15
4	Kampung Karu, Km 39, Jln Puncak Borneo Kuching	Encik Henry Suwot Sawar	136	822	17
5	Kpg Timurang, Km 43, Jln Puncak Borneo, 932590 Kuching.	Encik Bom Amer	30	168	11
6	Kpg Garung, Km 38, Jln Puncak Borneo, 93250 Kuching.	Encik Tomi Dihed Dium	116	829	15
7	Kpg Bengoh, Km 42, Jln Puncak Borneo, 93250 Kuching.	Encik Kayis Ganyai	91	492	14
8	Kampung Giam, KM 35, Jln Puncak Borneo, 93250 Kuching.	Encik Harrison Sango Domba	64	430	10
9	Kampung Bunuk, KM 34, Jln Puncak Borneo, 93250 Kuching	Encik Bundu Suap	388	2318	47
		TOTAL	**1023**	**6040**	**148**

Basic infrastructures available include tar sealed road, Jalan Puncak Borneo which was completed in 1996. The twenty four hour electricity supply under the rural electrification scheme has also given a boost for the villages' development. Each village has own primary schools and two government clinics to serve the nearby area. Besides that, these areas are also installed with telecommunication tower to provide cellular telephone services to the area

Most of the villagers living in the nine villages are basically farmers and gardeners. The common crop planted being paddy. However, the trend has changed over the years.

Paddy farming is gradually changing toward planting of cash crop like pepper, banana, and rubber. Currently due to an increase of rubber prices, many tap rubber. The improved conditions of roads have enabled the local community in the area to look for jobs out of their villages. Some only come back to their villages occasionally and some choose to commute on daily basis to their place of work in the city.

Even though the number of villages chosen is small, it is very significant to this study. According to an Environmental Impact Assessment report in 1994 which was carried out by the Kuching Water Board (KWB), these villages are situated within the Sungai Sarawak Kiri water catchment reserve area which was gazetted in November, 1993. This is to protect the vital water supplying raw water for Batu Kitang Water Treatment Plant which supplies 95% of the domestic and industrial water demand for Kuching City. The area covered by the nine villages forms a proportion of the 633 square kilometres of the whole catchment area of Sarawak Kiri.

These villages have been chosen for several reasons: (1) They are located in the upper part Sarawak Kiri River which is the source of water supply in Kuching urban population (as mentioned earlier on). (2) The development activities in these areas can affect the whole of Kuching City which consume the water derived from this river. This implies that there is the need for the protection of the river and the water catchment area as a whole (3) the area for this study do not yet received any treated water supply. This means that the water supply that these villages consumed is heavily depended of streams and rivers. This make water supply very unreliable and may have adverse impact on the livelihood of the local population (4) the area have been relying on the water supply constructed on a *gotong royong* basis with the materials supplied by the State Health Department.

Situated in the coastal area of Sarawak, under the Koppen's classification, the area belongs to Type "Af" which defines constantly wet tropical weather condition with temperature above 18°C. The Jabatan Kajicuaca Malaysia (JKM) divides the rainfall pattern in Sarawak into 5 types. Type I regime, which include the coastal area exhibiting one minimum (January) and maximum (June-July). The annual rainfall ranges from 4000 mm to 5000 mm.

Pan evaporation data recorded in Kuching Airport since 1963 follows a cyclical pattern within the year with the mean annual total evaporation of about 1450 mm. Mean daily temperature varies slightly within the year and the average temperature is 26.6°C. The mean relative humidity is 85.3 percent.

The nine villages chosen above depended on surface water supply from stream and rivers ever since 1970s. A lot of efforts were put to provide clean water supply to the villagers as one of the ways to control disease and upgrade the quality of lives. Government agencies like the State Health Department have taken up the task to implement water supply project to cater for the needs of the rural population. This was done in the interest of health and hygiene. This scenario has not changed much until today. These villages got their water supply from streams which are piped to the individual household by means of Polyvinyl Chloride (PVC) pipes. This system is commonly known as Gravity Feed Water Supply (GFWS) system. This is because the system depended on the gravitational force to deliver water from the higher to the lower level. Unlike the other systems, GFWS system is very dependent on the stream flows and how the local communities managed them. It is also highly dependent on the amount of rainfall. This is because the nature of impounding dam is usually shallow and does not meant to store a large volume of water for long duration. The system is more appropriate when the water source is higher than the level of the villages to

which it water is to be supplied. The two components of water and elevation need to match for GFWS system to be feasible. The water resource in the rural areas is not as complex as that in the urban area. Unlike the urban water supply, the rural water supplies do not installed meters for the services and the water usage are not charged. The maintenance of the water supply system are done by the villagers themselves under the leadership of the village headmen and assisted by the committee in charge of the water supply. There is no mechanism to levy charges on water consumed. This gives the impression that water is free of charge and in unlimited supplies.

The problem is not only confined to the use of water from the GFWS system. Like any type of water supply system, the final discharge as a result of water use also posed problem to the environment. This is because as mentioned earlier, the scope of water resource management is not only confined to the water that is abstracted for the sources which then is distributed to be consumed. The water resources management also will include aspect of what happen after water usage. This will include waste water management and sewage water treatment prior to disposal to the water bodies. This is because from observation, this problem has not been taken seriously.

1.3 The background of study

Water resources management in rural areas had been chosen as the topic for this study to explore the management of the water resources which include water supply system, water consumption pattern and the local community perception of their water resources. Rural water resources mainly confined to those that involve village which do not yet have treated water supplies from the Kuching Water Board (KWB) or Public Work Department (JKR). Water resources serving these areas have simple management based on the local setting. The villages depend on the water systems built based on local communities participation with

financial input (for purchase of material) from the Sarawak State Health Department (JKNS), it is interesting to note that the construction of the water supply system have survived until today. On top of that, the construction of such water supply systems uses low technology with very minimum or no financial input to pay for labour cost. In most cases, at every stages of the water supply system construction, locals communities were usually immobilize to ensure the success of the project. The role of the village administration body locally known as "*Jawatankuasa Keselamatan dan Kemajuan Kampung*" (JKKK), is a very important community based organisation responsible for the success of the water resource and the wellbeing of the river within the community.

1.4 Scope of study

This research wanted to find out issues involving the management of water resources in the rural areas focussing on the role played by all the interested parties. Water resources management in the study area does not only cover the issue of supplies, demand and usage of water. It will also cover aspects of water discharged after use which contributed to pollutions of the water bodies downstream. As the local communities have benefited from the provision of clean water, it is also appropriate that they take the effort to protect and conserve their water sources, optimise the water uses by preventing wastages and ensure that water does not contribute to environmental pollution especially the water bodies. This is not a very important aspect to consider as the availability of the water supplies and the ease to obtain them is taken for granted all this while.

The area that was chosen is the upper part of the water catchment area which comprises of nine villages. This research cover the aspect of water supply which is meant for human consumption, but also studying water resources management as a holistic issue

viewed from various perspectives to cover the aspect of water source protection, abstraction, storage, distribution, consumption and waste water disposal.

In the context of this research, other aspects that involve water resource management has not been paid much attention as it should be, as water is still considered as infinite resource. To some, shortage is only said to happen when there is not sufficient water to use for bathing, washing and cooking and that water uses for other purpose do not really matter. However, the usage of water has definitely contributed to the water resources degradation to the water bodies which become the water sources for the other people residing downstream. As such, this research also included the empirical data of the water quality to reflect the anthropogenic activities in the upper part of the river from the Kuching Water Board to substantiate water pollution issue. Although the problem of water shortage is not so acute in the study area, it is good if the problem can be avoided.

1.5 Problem statement

In the past, water resources are plentiful and water shortage is not an issue. Growing population and land use conflict, resulted in depletion of resources and deterioration in water quantity and quality. The deterioration in water quality happens as a result of human activities upstream such as farming activities, logging and land development. At present, there had been no enforceable regulations that prohibit such action from happening. As a result, the water users, as the stakeholder becomes the victim to such activities.

The problem does not end there but extended into other related problem especially that related to health. The study conducted by the JKNS shows that occasional deaths happen as a result of water borne diseases like cholera, typhoid and Hepatitis A. Besides the problem mentioned above, many problems that involved personal hygiene and sanitation are also

equally important to mention here. This is because with the increasing population, river and streams become the ultimate dumping ground for the local community.

1.6 Hypothesis

The water resources in rural areas have not been managed well as not much effort is taken to protect the water sources resulting in waters resources depletion and pollution.

1.7 Research objectives

1.7.1 General objective

This research aims to determine the key problems relating to water resource management in the rural areas in Kuching District.

1.7.2 Specific objectives

The objectives of this study are:

(1) to identify the key causes of water resource depletion,

(2) to identify the factors contributing to the deterioration of water quality as perceived by the local population, and

(3) to study the relationship between respondents' age and level of education on their perception on causes of water resource depletion and quality deterioration.

1.8 Significance of the study

This research is hoped to create awareness among the stakeholders who are involved in the management of water resources in the rural areas. This is because studies like this have never been conducted in this area. The awareness resulted from this is hoped to benefit the water

user, as the stakeholders for the water supply system. It is also hoped that this study can generate new information especially one that involved indigenous knowledge. The result of this study hopefully can empower the rural communities affected by the problems of water in future decisions making. It is hoped that the suggestion made in this study will improve the current situation to make water resources sustainable despite of the growing population and demand. In the literature review, emphasis will be given on issues starting from source till point of discharge which will guide towards better management. Issues on water pollution will also be given emphasis as pollution determines the overall well being of the water supply. No single party should be made solely responsible to combat pollution especially that involves water source and water bodies. This study undertakes to address the issues and emphasise the community participation as an ultimate objectives of public awareness and initiatives.

The government has been crucial in supplying various effort of supplying water to the local communities. This study will also highlight this issue so as give the chance to the local communities to express their views on the implementation of projects related to water supply. The knowledge of the local communities shall never be taken lightly as their contribution in the planning, implementation and thereafter, the maintenance of the water related projects will affects them directly or indirectly. The role played by district administrators, where the district office is also very crucial as they are the ones who hold the blue print of the district development. The development plan by the government will be channelled to the local community through them as the implementer. This also means that the success and failure depend on their efficiency and with the support of the local population. The supervision made by the government agencies concern is thus necessary to make the project successful. The

cooperation from the villagers had become the key component in the past especially in the water supply project.

1.9 Definition of terms

Below are the definitions of the common terminologies which is used in this study.

1.9.1 Water Resources

According to Berkes (1989), resource is defined as those components of an ecosystem which provide goods and services useful to man. In the case of water, any of the entire range of natural waters (vapour, liquid, or solid) that occur on the Earth and that are of potential use to humans. These resources include the waters of the oceans, rivers, and lakes; groundwater and deep subsurface waters; and glaciers and permanent snowfields. Continuing increase in water use has led to growing concern over the availability and quality of water supplies.

1.9.2 Management

Joshi and Setty (2006), define management in the context of water as managing all water resources. It is defined as an act or manner of guiding or taking charge or handling, direction or control. In the context of this study, it is more focused on water and related issues on the management of water resources. The management issues are discussed further in the literature review.

1.9.3 Water resources management

Water Resources Management is an integrating theme for a number of water sub-sectors such as Hydropower, Water Supply and Sanitation, Irrigation and Drainage, and Environment. However an integrated approach of water management is widely applied to enable planners and managers managed water resources in a much holistic manners.

An integrated water resources management (IWRM) perspective ensures that social, economic, environmental and technical dimensions are taken into account in the management and development of water resources. However, in this context it is referred to as water resource management in rural areas. The literature review will discuss the issues of water in urban areas so as to give a better perspective of how water resources are managed.

Green (2003), argue that water resource management is about matching the variation in supply to the variation in demand. Water resources management should also consider as a whole of water availability and should not treat flood separately from drought to cater for water availability.

The World Bank (1988) explained that water resources management can brings large benefits which include irrigation, energy, flood control, drinking water and better navigation. Yet on the other hand its development program can generate high risk of impoverishment the people whose land and homes are expropriated for a project.

1.9.4 Rural areas

According to the Oxford Dictionary, rural area is defined as an area that is considered to be country. Rural areas are most times small towns that are not as heavily populated and may have a lot of agricultural activities. In the context of this study, the word "rural" is used to describe localities that do not receive treated water supply from the Local Water Authority (LWA) . In Kuching District, the LWA is Kuching Water Board (KWB).

1.9.5 Urban water supply

The supply of treated water in the urban area is done by the Kuching Water Board (KWB). The Board is responsible to for almost all aspect of water supply services and for doing so each household are installed with water meter to gauge the water usage and each household

are charged according the quantity of water used. The water charges by the KWB covers almost everything including the necessary repair that is needed in case of damage.

Urban water supply and sanitation differ in scale from rural water supply, project. This because urban water supply is larger and often require development of distant water supply and installation of infrastructures through city streets and involved household connection and the disposal and treatment of water borne waste. Urban water involved issues which include operation and maintenance, and also cost recovery. Cost recovery includes connection fees and flat rate or volumetric tariff. As for urban water supply and sanitation, artificially low tariff are a typically a major constraint on system on system expansion. Government need to keep the tariff low to keep the services affordable (Winpenny, 1994).

1.10 Limitation of the study

This study will be limited to those villages which have water supply system other than those villages getting their supply form the LWA having functioning or malfunctioning water supply system specific to GFWS system. The accuracy and validity of this study is very much dependent to the result from the interviews of the respondent. It cannot be denied that some of the answers given by the respondents may not be truthful and correct as expected. The population sample might not be big enough truly reflect the true picture of the situation. Besides previously active in funding and implementation of rural water supply, the JKNS also involved in the other environmental sanitation programme to maintain a clean environment like sewage disposal system and common drains construction in the villages. This effort is also taken into consideration in this study as it involves the water usage and in turn contributed to pollution of the water bodies. By doing so, the solid waste had become a main source of pollution to the rivers and streams.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter review literatures and discuss issues which serve as basis and theoretical framework of this study. The key words used here include importance, availability, usage, demand and problems related to water while highlighting the issues of supply, environmental and ecosystem sustainability with minimum conflicts from the stakeholders. Having the above topics discussed, the later part of this chapter will cover issues of water resource managements, especially ones that involve the rural areas which become the core interest of this study. The literature review here will serve as references and benchmarks of how water is managed other parts of the world. It will serve as valuable pool of works and ideas by the water experts and scholars over the past years. It is important for this study to know how the problems of water are addressed and how the problems are tackled.

2.2 Importance of water

Way back in 1988, the World Bank reported that sixty per cents of the world rural population lack access to safe water. This has the implication for health, productivity and quality of life. The poor suffer most. Their productive potential is reduced not only by the time and energy spent in obtaining enough water to meet their basic need but also by time loss to illness. In many rural areas, women walk long distances and spend much time fetching water (World Bank, 1988 cited in Ibuh, 2004). Now we are in the twenty-first century and that same problems still exist and in addition to that, water is fast becoming scarce. We are living in an era of water crisis. Hungry nations in particular need water not only to quench their thirst but to produce more food (Ali et al., 1987).

We are familiar with what happens within our surrounding. We see rain, we see it fall and we regarded rainfall as the main source of fresh water. Rainfall, which is also otherwise called as precipitation is condensed water vapour of atmosphere. Precipitation actually includes rain snow, fog and dew. Rainfall is not uniform over time and space. It is not uniform over time because it is not received throughout the year and because its intensity varies even within a day or sometimes within an hour. It is not uniform over space because it is not uniformly received over a given geographical area (Lozan et al., 2007) Rainfall is an important source of water but the total that fall from the skies is not an infallible indicator (Bouguerra, 2006). With climate change, the water that comes sometimes do not come at the time and place that we most wanted it. Sometime too much rain spells disaster when flood kill thousands of people. To some extend sources of water can be managed but some are beyond the control of human beings. Water is an element of great importance. Our planet is the only one where liquid water is known to exist. Water comes down, or falling as precipitation and flowing through the landscape, is a unique solvent carrying the nutrients essential for life (IUCN/UNEP/WWF, 1991).

According to Merret (1997), water is the fundamental requirement of all life on Earth. In the specific case of water, the human body cannot survive without it as it plays a very vital part in sanitation for our rural and urban communities, it is necessary to all form of agriculture, and is demanded for the majority of industrial processes. Water is the key source for human society. Water can be appropriated into the ownership of public and private bodies and therefore water is not only natural resource but is also economic resources too. Where would people be without water? Apart from what we know, not being alive, we may never have evolved the big brains that make us such a unique species. Some even said that learning how to keep, and transport water over land was the key to our survival when other similar species just kept dying off.

Allan (2002), claimed water is such a fundamental place in sustaining human life and livelihood that human societies have devoted much political energy and substantial economic resources to ensuring secure supplies, albeit without ensuring equitable access or freedom from the risk of water resource shortage for everyone.

Bougguerra (2003), wrote about the importance of water by saying that water forms as much as seventy-five percent of the human body and control our internal temperatures, as it does to the Earth's climate. The body of an adult weighing 80 kilograms contains 50 to 60 litres of water. Our life like that of plants and animals, are dependent on the biological function of water. Water dissolves and transport food and fuels through our organism and our metabolic tracts. On top of that, water is life and no life is possible without it. A human being cannot go without drinking for more than two days but can go without food for weeks. Bougguerra (2003) also reported that even two percent dehydration leads to a 20 percent loss of physical capabilities. For an healthy individual, at least two litres of water per day to needed to be consumed to stay alive and someone suffering from malnutrition or living in a tropical climate needs considerably more. Moreover it was noted that thirst appears as soon as our organs loss one percent of it and risk of death develop once the loss reached ten percent.

The human rights to water rest on the conviction that water is a public and common good. It is a life sustaining element that must be accessible to all people irrespective of their purchasing power. Instead, it is a mandate to humanity to handle this vital element carefully so that the future generation too will have enough drinking water. The concept of water as human right by no means implies that it must be free of cost for all (Lozan, et al., 2006, pp. 347). In central Asia for example, water resources is required for survival as it plays a central

role in political, economic and social processes (Kobori & Glantz, 1998 cited in Arsel and Spoor, 2010 pp. 1).

Water remain crucial for sustainable development for development the following reasons. Firstly, the key ingredients for many economic processes, especially for rural development on which the region is heavily dependent for water (Arsel and Spoor, 2010). Secondly, allocation of water as with finite resources that are unevenly distributed across the region and nations is an important factor in achieving peaceful relationship between communities at various political and spatial scales (Wolf, 2000 cited in Arsel and Spoor, 2010).

Water has served many functions in human life. Water is the best naturally solvents, making it ideal for washing and the transfer of waste. It's capacity to absorb oxygen particularly at low temperatures-enables it to maintain life in the rivers, lakes and oceans and readily oxidise organic pollution (Huston & Griffiths, 2008).

Gosh et al. (2009) pointed out that the significance of water in human life thus involves more than just consideration of health or that of economics, it also touches on very constitution in us as human, since it touches on our constitution in and through place. The importance of water in maintaining health and overall well being cannot be denied. It was once claimed that, Halfan Mabler, the former director of World Health Organization (WHO) once said that "The number of taps per thousand people will become a better indicator of health status than the number of hospital beds".

Water is such an important commodity, In 1990, Boutros Boutros Gali, the then United Nation (UN) Secretary General gave advance notice that the next war in the Middle East will be over water, not politics. In 1995, the World Bank Ismail Serageldin ruminated

that many of the wars in this century were about oil, but the wars in the next century will be about water (Selby, 2003).

Our use of water is creating a crisis for much of the world. Global water withdrawals are believed to have grown more than 35 fold for the past three centuries, and are projected to increase 30-35% by 2000. Current patterns of freshwater use cannot be sustained if human population reached 10 billion by the year 2050 (UICN/UNEP/WWF, 1991).

According to Merrett (1997), whether water is priced or not, we should recognize it as an important commodity and value it as an economic resource. This is because in most societies, the collection and distribution of fresh water requires human labour and often, civil engineering infrastructures. In addition that, more recently, this understanding has been accepted because of the economic and financial cost imposed by the laws to protect water quality and because water scarcity and the associated competition between the users as a result of global shift to privatisation of public sectors. Water importance is not only limited to its availability within the hydrological cycle. It involves nature conservation, for rivers, lakes wetlands estuaries and coastal water. We must also not forget about the need to manage land drainage, flood controls and coastal defence, dam projects and the use of water by households. Agricultural sectors, being the biggest user of fresh water play a vital role in the management of water and determine the sustainability of water usage in many countries. The importance of water also encompassed the treatment of wastewater and also its disposal.

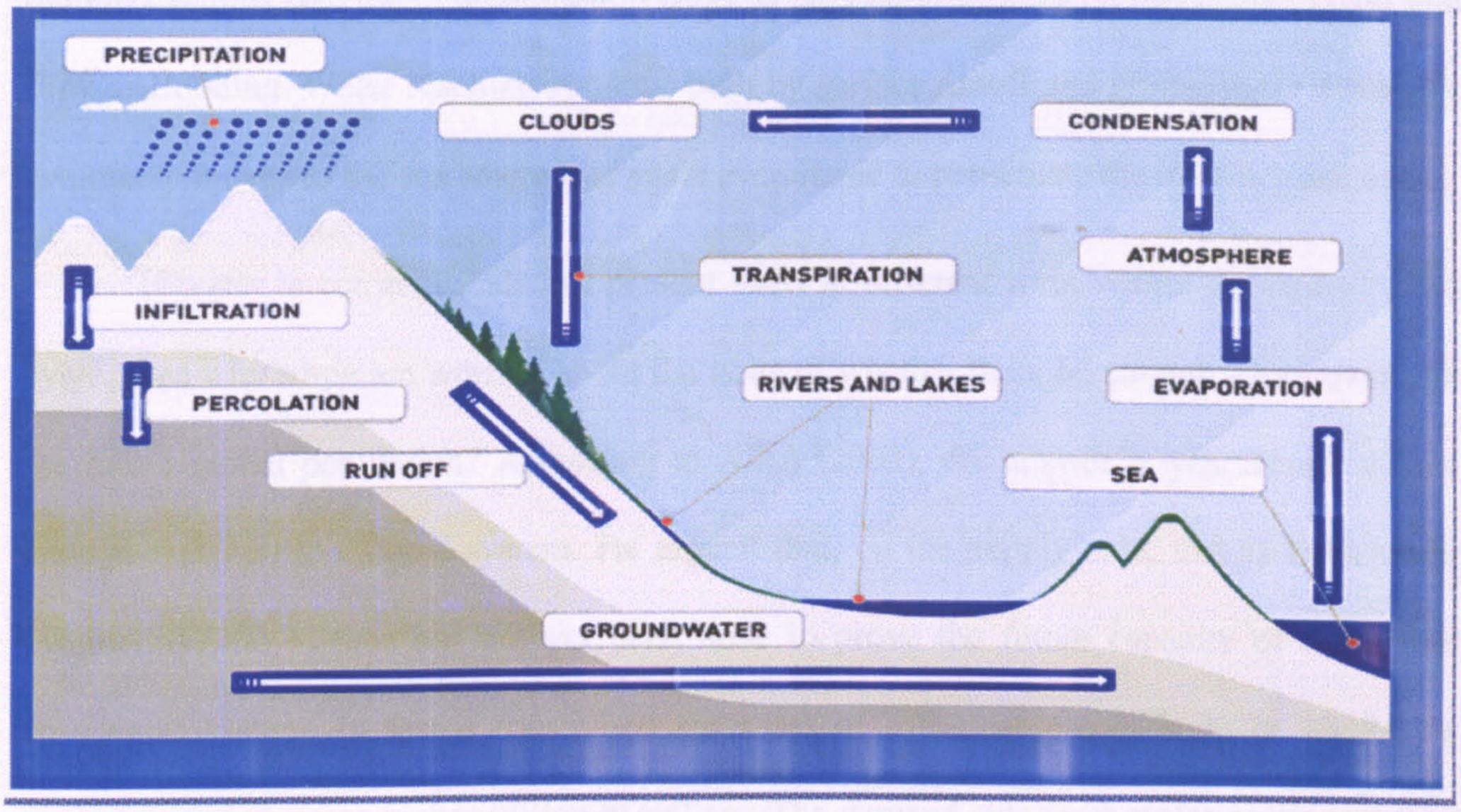
2.3 Hydrological cycle and water distribution

Water can present itself in different forms. As described by Merret (1997), water occurs in fluid, solid and gaseous form in the ocean, ashore and in the atmosphere. According to the current estimates, about 97 percent of the total quantity is located in the ocean in the form of salt water. Another two percents are contained in ice masses covering Greenland and the

Antarctic as a result of several thousand years of storing atmospheric precipitation. About 0.6 percent is in the form of freshwater as groundwater, lakes and rivers. The percentage which remains in the atmosphere in the form of water vapour is smaller but very significant. He added that the hydrological cycle and the availability of water of special importance for nature as a whole including mankind. The availability of water determines the presence of vegetation and deserts (Lozan et al., 2007). Water is continuously moving above and below the soil surface, water maintain and links the planet's ecosystem. Some is returned directly to the atmosphere partly via plants. The rest flows into and over the ground, permeating through organism, recharging underground aquifers, replenishing rivers and lakes, entering the ocean and returning to the atmosphere (IUCN/UNEP/WWF, 1991).

Lozan et al. (2007) described that the Earths' atmosphere is endowed with a unique system in its environment called hydrological cycle. It is this cycle which is powered by the energy from the sun creates all water resources on land. Although rain is considered as the only natural source of water on land, it is the hydrological cycle which creates the rain. In simple term, hydrological cycles represents path of movement of water from sea to atmosphere, from atmosphere to land and from land back to sea. In a broader sense, it is a condensed form of water vapour floating in air and the vapour is gaseous from of liquid water in sea. The hydrological cycle is powered by solar energy. The sun heats water from the ocean, lakes, rivers and the Earth's surface. This water then evaporates into the atmosphere. Additional water is drawn from the soil by plants, and is then evaporated into the atmosphere from leaves and stems. This process is called transpiration. As the air rises and the temperature drops, the moisture-laden air condenses, forming clouds and eventually resulting in precipitation in the form of rain or snow. Surface run-off makes its way back to the ocean via rivers. Other water seeps into the soil. This process is called infiltration. If the rock below

the soil is permeable, then the water percolates the rock and is stored as groundwater. To better understand the hydrological cycle is explained below.



Source: BBC – Education Scotland (2012)

Figure 2.1: Hydrological Cycle

The above diagram describes the constant movement of water above, on, and below the Earth's surface. The cycle operates across all scales, from the global to the smallest stream catchment (Smith, 1998 cited in BBC-Education, 2012), and involves the movement of water along evapotranspiration, precipitation, surface runoff, sub-surface flow and groundwater pathways. In essence, water is evaporated from the land, oceans and vegetation to the atmosphere, using the radiant energy from the Sun, and is recycled back in the form of rain or snow. When moisture from the atmosphere falls to the Earth's surface it becomes subdivided into different interconnected pathways. Precipitation (excluding snow and hail) wets vegetation, directly enters surface water bodies or begins to infiltrate into the ground to replenish soil moisture. Excess water percolates to the zone of saturation, or groundwater,

from where it moves downward and laterally to sites of groundwater discharge. The rate of infiltration varies with land use, soil characteristics and the duration and intensity of the rainfall event. If the rate of precipitation exceeds the rate of infiltration this leads to overland flow or flooding. Water reaching streams, both by surface runoff and groundwater discharge eventually moves to the sea where it is again evaporated to perpetuate the hydrological cycle.

If water is constantly always present itself in different form within the hydrological cycle, then why some are worried about the issue of whether there be enough water available for future global population? According to Allan (2002), the answer is yes. There will be enough water in the global system. He argued that, on the supply side, that is fresh water availability, the science has not yet been done to prove the future capacity of the global freshwater system. In fact a researched estimates of sufficient precision to be useful for politician and decision maker billion of dollars. The demand side fresh water needs is driven by rising population. Bouguerra (2003) argued that the existing quantity is enough to meet the need of a population 10 times than the current population.

Water is very unevenly distributed. In some part of the world like Iceland, it has 600, 000 cubic kilometres while Kuwait has merely 75 cubic kilometres. He added that water is considered as a substance indispensible for life and health, now features among the basic human rights. Of the approximately 1,360 million cubic kilometres of water on earth, 97.3 percent is contained in the oceans. Although the oceans are important for such purposes as navigation, fisheries cooling water supply, a source of water for desalination, and their role in climatological process, however ocean water is not readily available for satisfying many of man's water need. What is more important for the purpose of many water using activities are fresh water resources (Cox, 1987).

Water influences almost every aspect of human lives up to the extent of the country's economy. According to Allan (2002), some claim that country's economy can only become strong, diverse and secure if it can access a minimum per head of 1000 cubic metres of freshwater for its population. However, even scientist cannot answer exactly what the question posed about the global freshwater system. The most common question pertaining to water availability is that whether there is enough water in the world soil profile, surface water, and ground waters to meet the national average water consumption per day for 10 billion people. Water supplies are uncertain. Extreme within year variability in precipitation and stream flow tends to be the rule, rather than the exception in water supply, especially in arid region where efficient water allocation is more critical. It is the mobile nature of water that created physical uncertainty (Easter et al., 1991).

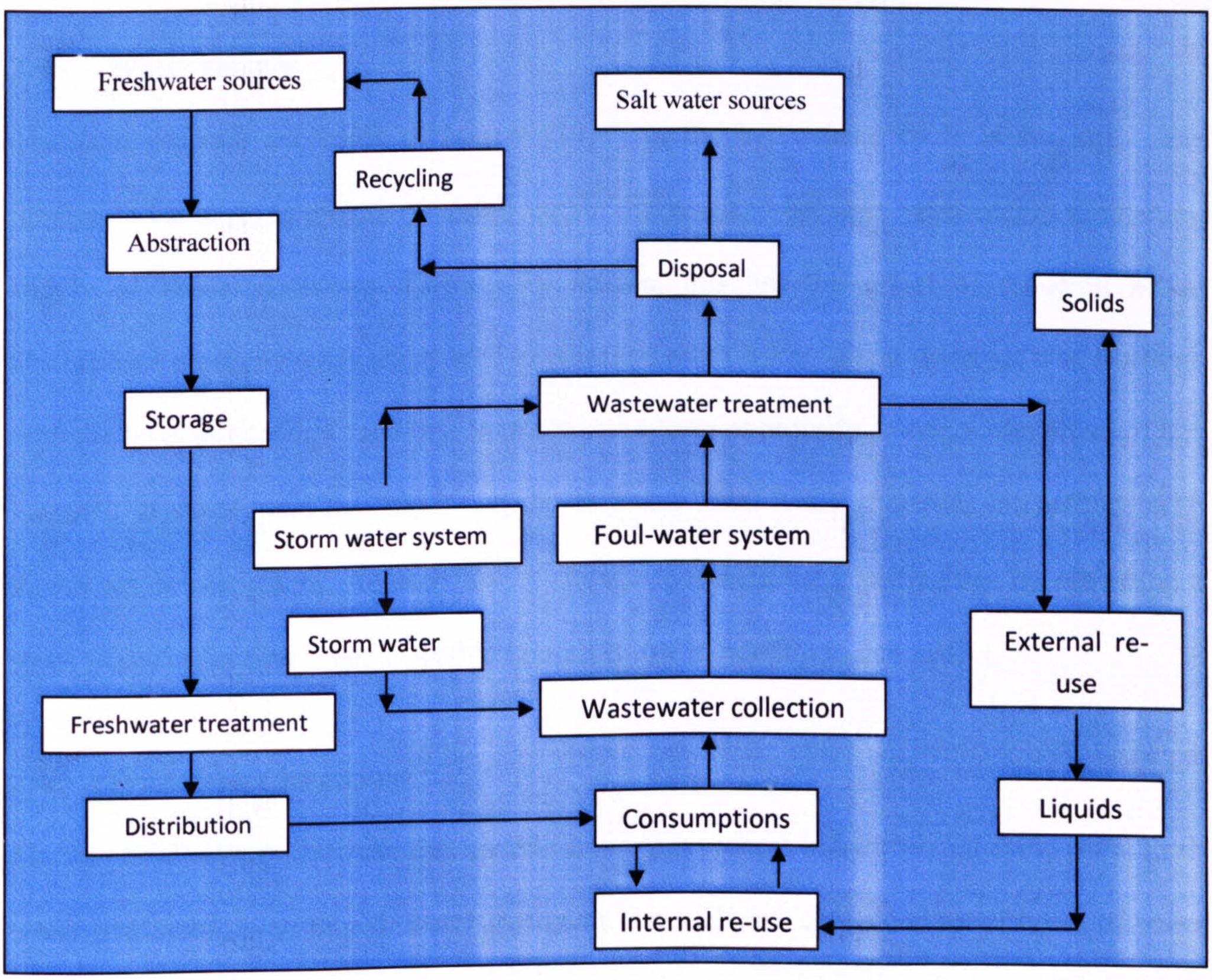
2.3.1 Water allocation

According to Bouguerra (2003), in term of allocation, each year throughout the world, 69 percent of fresh water is accounted for by agriculture, 23 percent by industry and 8 percent by domestic consumption. But even then, there are major difference between continents, where agriculture sectors consume 33 percent in Europe, 88 percent in Africa and 86 percent in Asia respectively. As asserted by Allan (2002), at a global level, there is certainly neither about volumes of fresh water available nor about the capacity to use water effectively. On the other hand, it was pointed out that water access and water scarcity cannot be disentangled from attempts to move towards sustainability and conservation of resources base with prevalent development discourse and new resources management (Arsel and Spoor, 2010).

2.4 The hydrosocial cycle

There is another important aspect to consider when dealing with the issue of water is thehydrosocial cycle. Hydrosocial cycle is very important as the route taken by water has an

important impact on the water resource management. What do we actually meant by hydrosocial cycle? According to Merret (1997), hydrosocial cycle involves the various processes that the water goes through. There are seven most important processes within thehydrosocial cycle. They are **abstraction**, **storage**, fresh water **treatment**, fresh water **distribution**, **waste water collection**, waste water **treatment** and waste water **disposal**. All these process are important in water resource management. It does not matter urban or rural. Each of these processes will be considered in turn, the demand side activity of consumption, which lies between freshwater distribution and wastewater collection. The explanation and the engineering activities of the hydrosocial cycle in the supply of fresh water services as illustrated in figure below.



Source: Stephen Merret, 1997

Figure 2.2. Model of hydrosocial cycle

2.4.1 Water abstraction

Merret (1997) described that the starting point of the hydrosocial cycle is the natural flow in a catchment which is available for the conversion from natural resources to social product. The flow varies during the course of the year because of the changing seasons. These annual supply variations differ between regions and countries. The available resource is from effective rainfall and some area minus that lost both through transpirations by foliage and through surface evaporation. Abstraction takes place from groundwater, from freshwater surface sources.

2.4.2 Water storage

The next process, according to Merret (1997) in the hydrosocial cycle is **storage.** The inevitable variation in effective rainfall within the year and between years makes the natural supply of water inconstant. During dry season, this has the effect of reducing actual abstractions precisely when users need to consume more water. Water demands also fluctuate with the level of economic activity. Without some form of buffering devices, the effect of this variance in supply and demand would be to create local water shortages, sometimes with disastrous consequences. As such, water storage moderate these difficulties by providing a stock of water for time when effective rainfall is low in relation to demand.

2.4.3 Fresh water treatment

Merret (1997) also pointed out that another important process in hydrosocial cycle is the fresh water treatment. Even though water treatment is not always case done to all types of water supply especially in rural. However when water treatment is done, the process is used to remove both undesirable natural substances and man-made contaminants. This introduces the concept of water quality to place alongside that of water quantity. Treatment can also include

the addition of soluble element such as fluoride, to enhance water function in the interest of public health.

Pollution of the natural world, including its freshwater resources, is the result of human society's activities of production and consumptions. The usage of water consumers often results in water degradation. This can either be gradual and in some due to repeated uses.

2.4.4 Water distribution and consumption

Distribution of water can be done by various means depending on how the water is used. Common distributions are by means of pipes, canals and channels. An important point to consider is that consumption equals water production minus water losses. However, in the context of hydrological cycle, there is no water loss. Distribution of water embraces both bulk transmission and retail networks to individual consumers, be they farmers, industrialist, or families. Bulk flows from abstraction and storage location almost always requires pumping facilities. The more forceful the pumping action, the greater will be the water pressure and the faster the rate of flow. This can contribute to problems of pipe burst and leakage as these problems often vary directly with water pressure. The loss of water due to leakage is of great significance. In 2009 alone, the KWB reported 3629 numbers of leaks from pipes and services and this account for 32.26 percent of the total treated water production by the board (KWB, 2009).This occurs between the point of abstraction and the points of consumption. So it is worth noting that leakage are usually treated as demand side issue in current technical literature and lost water is treated as use and is further suggested that the control of distribution losses is a form of demand management.

Allan (2002), claimed that an individual need each year only a cubic metres of drinking water, between 50 to 100 cubic metres for other domestic use though a much lower actual use is the norm in many rural communities. By contrast, an individual need each year

at least 1000 cubic metres of water either naturally occurring in soil profile, or transported to the profiles by irrigation system to raise the food need of that individual. While water is treated as a free good in temperate humid regions, in semi arid and the Middle East and North Africa, agricultural water is expensively won because cost of storage and distribution. Allan (2002) suggested that there are two variable that affect the use of water. The first variable is the growth in population and second, the use of water per head. Potential water availability globally being unknown, guest in circulation differ according to assumptions.

2.4.4.1 Commercial water use

These types of uses include the uses in commercial buildings, offices buildings and institutions. It is sometimes refers to as used of water which is being paid for. In the local scenario, commercial use is more significant and relevant to the urban area. In Kuching District the consumption of treated water account for 29.05% of the total water demands (KWB, 2009).

2.4.4.2 Domestic use

The UN (1995), reported that another type of water use is the domestic use. These includes water for household purposes such as drinking, food preparations, bathing, washing clothes and dishes, flushing toilets and watering of lawn and gardens. The water consumed by the domestic sector within the jurisdiction of KWB is 54.07%. There is no mean to find out the actual amount of water used by the domestic sectors in the rural area. This is because the uses of water are not monitored using meters. These types of water supply can be from public water supply and also self supplied. In this context, the use of water is more of the domestic water use in the rural areas.

2.4.4.3 Industrial water use

This type of use is that used for industrial purposes such as fabrication processing, washing and cooling. It includes industry like steel, chemical, mining, petroleum refining and others. These categories of user are also very significant as they contributed heavily to water pollution. This is because due to its large share of water withdrawn that does not evaporate and the quality of the water returned to the water bodies. The development of industrial water withdrawal is one of the main causes of water pollution in the world while the use of water for cooling purposes only has minor effects on the water quality (Lozan et al., 2007).

2.4.4.4 Public water use

One of the water use which is considered as important is the public water use. This type of water use is supplied from the public water supply for the purpose of fire fighting, street washing municipal parks and swimming pool.

2.4.4.5 Other uses

The other uses as described in the UN report (1995) includes in-stream use, Irrigation use livestock use, mining water use, municipal use.

2.4.5 Water demand

Merret (1997) pointed out that the consumption of fresh water is most conveniently analysed from the point of view of three large battalions: They are households, farmers, and industries. A secure water supply is of vital importance for the health of the population and for the economy. Drinking water demands depend on: (1) the number of inhabitants with the access to drinking water, (2) meteorological and climatological conditions, (3) the price of water, (4) price of drinking water and (5) an environmental policy that aims at moderate use of drinking water (UNESCO, 2005).

Water demand in urban areas in many countries is expected to increase more rapidly in percentage terms than water demand for irrigation. As claimed by Selby (2003), economic development inevitably leads to increase per capita water demand and that global climate change is likely to increase regularity of drought, and one has nothing less than a recipe for disaster.

The United Nations (2000) reported that demand for water is increasing and is driven by several well-known factors which include the water needed to satisfy the following: Firstly, the population growth which results in increasing demand for domestic water supplies. Secondly, it accompanies the expansion of agriculture and irrigation to meet the food requirement of increasing population. Thirdly, supply for industrial expansion and mining. Fourthly, the high energy requirements which draw on stored water for hydro electricity generation or cooling water for other forms of electricity generation. The fifth reason is the high volume of water required to satisfy clean water supplies for basic health and sanitation. Allan (2002) asserted that the first demands on naturally occurring water by human communities were made to meet their social need. They need water for drinking and t meets their food needs. The raising of food was integral to the society. On top of that, food was raised to ensure subsistence. It was not economic activity in the twentieth century sense. The demand placed by subsistence users are by definition associated with low technology and were environmentally benign.

Vincent and Ali (1997) also mentioned that water consumption increase more than six fold, from under one billion litres per day in 1970 to nearly five billion litres per day as compared to the consumption of energy which rose from one billion tonnes to just three billion tonnes. However Allan (2002), argued that the global hydrological system is evidently in surplus as it is able to meet the most demanding element of global water demand, the

global consumption of food. He added that assuming that medium water consumption scenario of 1500 cubic metres per person per year (m^3 ppy) global fresh water needs are about 8.25 billion cubic metres per person per year (bnm^3 ppy) is well within the estimates of global freshwater availability. El-Ashry & Gibbons (1986) pointed out that in the past, it is commonly believed in the past water demand was satisfied by developing new water source However, environmental, engineering, and financial constraints make traditional supply –side responses less tenable.

Winpenny (1994) argued that for greater reliance on management of demand for water has to be a large extent been made in the above criticism of comprehensive planning and central allocation, on the one hand, and supply augmentation on the other. The aim of management demand is to ensure that a given supply of water is distributed to accord more closely with its optimal use pattern. In theory, this will be achieved when marginal unit of water for each use has the same value. If not possible, the total welfare could be increased by redistributing water. Although this theoretical ideal is unlikely achieved, in reality, however demand management measures can help to move an existing allocation to new supply schemes where these are costly in economic and environmental terms. In Malaysia for example Ali et al. (1987) pointed out that comparing water demand with resources, there appears to be in abundant for relevant uses. It is difficult to meet the growing human needs for water in those situations where sufficient water is also needed to maintain the functioning of sensitive aquatic ecosystem and to protect the integrity of the water resources (Falkenmark 1994, 1999, Ashton 2000a, cited in Bruch et al., 2005, pp.169).

2.4.5.1 Factors affecting water demand

One of the factors determining the elasticity of demand of house-hold consumers is the margin of discretionary water use, typically for outdoor purposes, or wastage and leaks

within the consumers' control. Whereas in industrial demand elasticity depends on the scope of reducing waste and adopting water efficient and recycling measures, or using treated water. On the other hand, in agriculture, elasticity is proportionate to the farmers' degree of choice over quantities grown, the choice of crops, the methods of application (Winpenny, 1994).

2.4.6 Storm and waste water collection

According to Merrett (1997), the physical character of the consumption process some users of water use up most or all the water they received and returned little or none into the rivers and the seas. However some users discharge the bulk after use in the degraded form of water. In some cases the users are able to reuse the water over and over with little treatment within the loop. In cases where there is no internal re-use which leaves the consumption as waste water. Most waste water requires collection and treatment in specially designed plants.

In the case of domestic wastewater, the collection of sewage is through pipes connected to a main sewer and thence to a sewage works. The nature of the treatment process is determined by the quality of the storm and wastewater received at the sewage treatment works and the targeted quality of the effluent that leaves the works.

2.4.7 Waste water disposal

Merrett (1997) further stressed that wastewater which is neither internally nor externally re-used may be recycled, or releases into the freshwater network, where it supplements the natural flows stream from it points of disposal. A special case of recycling is the artificial recharged of aquifers and recycling suggests that a distinctive concept of supply of water for abstraction is seen as appropriate, which brings together both effective rainfall and recycling.

2.5 Problems related to water

According to Bouguerra (2006), the United Nation predicts that in 2025 two third of the world's population will live in regions suffering from water shortage taking into assumption that management, consumption and resource level remain unchanged between now and then.

2.5.1 Water scarcity

Considering the fact that about 76 % of the planet is made up of water, there should be no issue of water scarcity. However, most of the water presents itself in the form of salt water in the ocean. Only 0.6 percent of the total water which is categorised as fresh water is readily available for human consumptions. That fresh water is our main concern. Fresh water is a scarce resource. (Lozan et al., 2007, pp: 291). Water scarcity can be defined as the level at which current demands cannot be met although the concept of water scarcity may appear to be useful for setting quantifiable level of water usage and availability, it is relative measures which defines the relationship between water demand and water availability rather than a specific benchmark for human needs (United Nation Report, 2000).

It is predicted that by the year 2015, almost half of the earth's population will leave in areas with physical or economic water scarcity (Arsel and Spoor, 2010). To access whether water impedes economic development, it is necessary to determine where it is scarce and not sufficient to meet the demand and it is increasing with population and economic growth and potentially climate change (Lozan et al., 2007).

Water scarcity comprises the two fundamental factors of inadequate water supply, which may threaten human health: Firstly quantitative scarcity of available and usable freshwater, secondly scarcity of water is the qualitatively capable of being used by humans for drinking, bathing, washing cleansing (Lozan et al., 2007).

Attempt to resolve the increasing competition for progressively scarcer water resources are often achieved in ways that damage or degrade the ecosystem concerned (Chroda 1996; Bruch et al., 2005). Meanwhile, Selby (2003) pointed out that from ecological perspective, water crises arise above all from the fact that, while already-high populations are inexorably rising, however natural supplies are limited and constant. The earth, on the other hand have limit to its carrying capacity.

2.5.1.1 Factors contributing to water scarcity

(i) Land use

Land does have a great impact on the water resources and its management. In fact, inappropriate land use may result in desertification which is the hallmark of the degradation of soils and as well as a negative effect on water resources (Lozan et al., 2007).

(ii) Population pressure

Another important factor which contributed to water scarcity problem is population pressure. This is often attributed to the increased in water demand and pollution of existing water supply due to opening up of land (Coxhead and Shively, 2005).

(iii) Climate change

Climate change affect water in term of quality and quantity, hence become one of the factors which resulted in scarcity of water.

2.5.2 Water pollution

The potential of pollution as a result of such act is also equally important for us to consider. What about the river to where the waste water are discharged. It may be true that the pollution as a result of the water usage is minimal but in some areas according to Ali et al. (1987).

According to Stead and Stead (1992), humankind is overspending its natural capital and it goes to the air, water and the ground in the form of environmentally degrading pollution. Ali et al. (1987) pointed out that water pollution has been defined as a resource out of place, as refuse matter, of any kind or description whatever deposited into public waters, and as man-made or man-induced alteration of the chemical, physical, biological and radiological integrity of water". As for legal purposes, it is sometimes defined as the discharge of wastes into public waters or taking other action with regard to public waters that causes bad effects. He further added that despite vigorous efforts by the countries, the pollution level in the rivers and water bodies have not yet reduced. In some cases, they have actually risen.

The World Resources Institute (1994-95), reported that the disposal of human waste directly affects the quality of fresh water resources. Contaminated drinking water, in turn, transmits diseases such as diarrhoea, typhoid and cholera. In fact according to the report these diseases were widespread during the late 19th and the 20th centuries in Europe and North America, where they ranked among the leading causes of death and illness. Green (2003), described pollution as the obvious examples of externality and water manage is riddled with externalities of one kind or another.

According to El-Ashry and Gibbons (1986), water is no less physically abundant today than it was decades ago, but it is now oversubscribed and, often polluted. According to Selby (2003), river as a multi-functional transport route, religious site, wash house rubbish dump and open sewer; the river regularly floods and thousands die each year from water borne diseases as a result.

According to Bruch (2005), as what happen in Danube River, he pointed out that many years of human activity and polluted effluent had produced high load of nutrient and toxic, in turn, contributed to euthrophication.

2.5.2.1 Causes of water pollution

As humankind incessantly produces and consume, it continue to deplete its resources and to foul its nest with its own waste and pollutants. The resulting problems includes environmental catastrophe, poor air and water quality, loss of species, climate change, land degradation and a lower quality of life, now and posterity. In fact developed nation like the United States, Western European countries, and Japan are overpopulated because they are depleting their soils, water and environments and because required to import a high percentage of the natural resources and energy to power their economies. For example, the United States imported about half of its oil and is rapidly depleting it soil and water resources (Stead and Stead, 1992).

Winpenny (1994) pointed that most pollution has its origin in industry, even if a few cleaner water saving procedures are beginning to see the light of the day. This is because industry makes abundant use of the stream; it also enlists the water for cleaning, air conditioning, cooling and transportation. The oil refining, food processing, metalworking, chemical and paper pulp industries also consume huge quantities of water.

The state of pollution of fresh water in the Asia-Pacific regions is already severe. Rapid industrial and urban development, combined with patchy regulatory regimes has led to serious pollution. Groundwater contamination combined with groundwater mining may threaten significant sources of water, though data is not systematic. Degradation and deforestation of upland areas is well documented, with adverse effects on water quality (UNITED NATIONS, 2005).

Water pollution in Malaysia, for example, has affected the environment and caused concern over the quality of the river water. Major pollutants are domestic and industrial

sewage, effluents from palm oil mills rubber factories, animal husbandry, and tin mines, and silt from logging and urban expansion (Ali et al., 1987).

2.5.2.2 Types of water pollution

Two different types of pollution sources are identified as point source and non-point source. The best example of point source is a pipe from an industry or city that deposit waste into the river. Water can be seriously contaminated by heavy metals, solvent, fats or polychloride byphenyls (insulating and cooling materials used in condensers and transformers) often to such a degree that any later salvaging is possible. This situation is all the more worrying in that global relocation, driven by low wage and lax environmental control, tend to take place in poor countries where water resource are already emaciated and polluted by organic matter, and where ideas of recycling and waste processing are sick joke. Chemical pollution remains the chief worry in the industrialized countries, as biological pollution is under better control. It should not be overlooked pathogens such as *E. coli* and *Cryptosporidium*, or algae toxin such as microcystine which damage chromosomes and leads to abnormally small brain in Laboratory animals (Bouguerra, 2006).

2.5.2.3 Common pollutants

Chemical compounds used in agriculture and forestry, such as pesticides, herbicides and even fertilizers, can become pollutants if they occur above certain concentration in stream water or in ground water. Water management and watershed planning should include assessing the risk of contamination from sources. The number of instances of serious agrochemical pollution has increased to the point that many restrictions on use, controls or methods of application, or even prohibitions have been enacted into laws in many countries (Easter and Hufschmidt, 1991). The trend is that some countries are linked with certain type of pollution.

Morocco, Thailand and Malaysia for example are linked electronic industry pollution (Bouguerra, 2006). In Tunisia and Mexico, pollution is in the form of dyes for the production of jeans, whereas in the state of Minas Gerais the incident of silo explosion had resulted in the release of caustic soda released into two rivers eliminating the supply of drinking water for half a million of people.

Kageson (1998) noted that many metals have been used extensively for decades and consequently large quantity are stored in technosphere or partly dispersed into the soils water and sediments. The concentration of heavy metals in rivers varies greatly between water unaffected by human activities and heavy metal hot spots near mining area and industries. According to Kageson (1998), other common pollutants are the leaching of nitrogen to ground and surface water results from a combination of high loads and poor agricultural practices.

Bouguerra (2006) described chemical pollution was seen as the curse of the rich and biological pollution as the curse of the poor. In some parts of France, water contamination incidents have gradually become part of daily life as drinking water is contaminated with pesticide atrazine, while elsewhere a recent dossier had empathize the scale of nitrate pollution. In Malaysia, the major pollutants are domestic and industrial sewage, effluents from palm oil mills, rubber factories, animal husbandry, and the tin mines and silts from logging and factories (Ali et al., 1987).

2.5.2.4 Consequence of water pollution

The consequence of water pollution is the widespread of water borne diseases. Bouguerra (2006), pointed that in 1993, the WHO General assembly solemnly declared "Protecting Water is Protecting Lives!". Yet one hospital bed in two around the world is occupied by someone suffering from a water related illness. According to the UN, 36000 people died

every day from lack of safe drinking water and sanitation. He added that more than a billion human beings do not access to safe drinking water and another two billion have neither drain for wastewater nor sufficient water for their personal hygiene. On top of that, the WHO estimated that1.5 billion people on earth are infected with parasites originating in faecal matter. In fact, Kageson (1998) noted that lack of clean water and urban sanitation were found to decline with increasing income.

2.5.3 Water quality

Increasing demand on water for various use and increasing understanding of the importance of quality has focussed attention on proper definition of quality (Ali et al., 1987). Lozan et al. (2007) argued that the concern about water is not only to its quantity but also, and increasingly to its quality. He added that water bodies throughout the world have become subject to pollution loads, with sometimes irreversible consequences. The degradation of water resources is attributable to such factors expansion of irrigation, over-use or misuse of fertilizers, insecticides and pesticides, discharge of industrial waste untreated sewage, domestic waste, toxic chemical dumps and air pollutants.

Humankind is being no kinder to its water. Besides using water as an irreplaceable rate, toxic chemical and other waste products are being poured into the waterways regardless of who is downstream and led to a major decline in the availability of safe drinking water throughout the world (Stead and Stead, 1992). The relationship between the quantity and the quality of water is critical to the management of water for beneficial use. Water quality has the bearing on allocation in respect of the following (a) The constraint on useable water resources by the pollution of water, (b) the need to define useable water in such a way that water is set aside to manage water quality issues and maintain water quality for beneficial

uses, (c) the need to recognize the quality of water when allocating water for specific uses (UNESCO, 2000).

Touching on quality issues, Allan (2002) suggested that fresh water for drinking should have less than 500 parts per million of dissolve solid. Fresh water of poorer quality can be used for other domestic and many others industrial uses.. Water for agriculture can be as poor as 1500. Water deteriorates along the rivers from the upstream to the downstream due to anthropogenic pressures, mainly originating in agriculture (Arsel and Spoor, 2010).

The study carried out by the UN in 2000, showed that both the quantity and the quality of water are affected by the return of water from human activity. These returns may comprise both point source and diffuse effect of water use, where water is applied to land and results in infiltration to the immediate sub-surface layer or to swallow groundwater and in some cases further infiltrates from groundwater to surface water bodies. Some water return this way become un-useable due to its deterioration in quality. Added to these effects, water may be unsuitable for use because it include substances which are present in its natural state (United Nations, 2000). At the same time, the impact of industry in water quality is expected to increase, even with water being removed from beneficial purpose by becoming more heavily polluted (UNESCO, 2005).

Frequent rains, low temperature, high humidity and high wind speed can mitigate the ill effects using poor quality of water but prolonged drought, high temperature and water and drier climate can aggravate the ill effects of poor quality water (Joshi and Setty, 2006). Pollution and water quality are directly related. As asserted by Lozan et al. (2007), due to increasing quantities and concentration of pollutants and higher water temperatures the water quality will doubtless deteriorate.

Where water quality is concerned, there are standard value of drinking water and the guidelines for the discharge of various substances into ground water (Kageson, 1998). As stated by Kageson (1998), if the quality of water is allowed to deteriorate even further mobility and other damaging activities should be reduced until the situation is reached when ecosystems no longer suffer from unacceptable strain.

2.5.4 Water source depletion

Water sources can be depleted in due time. The example given by Winpenny (1994) indicated that the abuse of water does have results which are in effect, irreversible such as in the case of underground aquifer to the point it is contaminated with saline water or polluted with heavy metal residues. Environment degradation in the form of erosion depletion pollution is a form of market failure. Water for example a component of the environment which is the supplying natural resources which is used to create economic goods is often un-priced or incorrectly priced (Syers and Rimmer, 1994). Stead and Stead (1992), pointed out that resources are being depleted at an increasingly rapid rates, and the environment is being degraded by an overflow of pollutants and waste product.

2.6 Water resources management

Water management is an interdisciplinary field concerned with the management of water resources. People in this field are concerned with ensuring that a supply of clean, potable water will be available to people who need it, while balancing the needs of industry and the environment. There are many writings by water experts from all over the world to discuss the issues of water management.

The management of water resource has influence the history and culture of not only the Asian but all parts of the world. All of the ancient civilization flourished along the river

banks or in the vicinity of water bodies. The availability of water resources has been necessary, but not a sufficient, condition for the survival and growth of many civilization. In fact many civilizations have perished due to improper usage of water resources (Ali et al., 1987).

According to Berkes (1989) asserted that effective water management is dependent on the interrelated action of a unified set of water users. Managing the common water resource may break down if one or more aspect is neglected There are considerable variation in method around the world. However the activities must be performed if water is not to be used efficiently or the system itself ceases to function. By adapting to collective means of water managements it is not only relatively efficient but also equitable. Hence by maintaining equity claims on the water resources and by distributing operating cost and benefits fairly shared. Water resource management and water resource services are in the state of transition and many aspects of the policies have yet to be implemented (Pollard et al., 2001).

Samson and Daft (2003) mentioned that management is defined as the attainment of organisational goal in an effective and efficient manner through planning, organising, leading and controlling organisation resources. There are two important ideas expressed in management definition which included four function of planning, organizing leading and controlling and the next aspect is attainment of the organizational goal in and effective and efficient manner. What is water resource management? There are many authors who addressed the topics of water resources management.

The World Water Council in 2000 reported that the dependence of development upon water management is more pronounce. The availability and management of water is increasingly seen as perhaps the defining constraint upon development with an increasing numbers of countries reaching conditions of water scarcity (Green, 2003).

When discussing the issues on water, Bardhan, (2005) asserted that the history of local community–level cooperation in water management in South Asia for example, have shown mixed results. Several example even rather low organizational level have proven to be successful, while of course some are failure finding the community come back to the previous time, scrambling for water. Meanwhile Ali et al. (1987) reported that with increased economic and social development efforts on one hand and the demographic on the other, not only is the overall demand for water rising, but its quality is also deteriorating.

Water is not cheap natural resource as common man perceive. Due to spatial and time factors, it becomes a costly resource when it is available at required time in required quantity at required place. Nothing can substitute water and no amount of money can create water. As all the human activities including agriculture, industry, and human health are focally around availability of water, managing water resources can lead to prosperity or destroy an economy. (Joshi and Setty, 2006). They also argued that the objective of water management include the halting of damage caused to soil and to conserve water at a given locality for further use and to improve the utility of a given quantity of water. The meaning of water management, on the other hand is signified in totality of water use in a given situation. It is sustainable development in making efficient use of our natural resources without putting at risk the future generation to do similarly. Water resources development that is not sustainable is ill planned. Consequently, there are many ways to jeopardize the future use of water, either by over exploitation (mining) of resources or by destroying resources for future use. Besides the physical aspect of sustainability, there are social, financial and institutional sustainability. On top of that, the concept of basin focussed IRWM as it demonstrate that the river basin is not a holistic system and that water in its virtual form freely crosses basin boundaries in very large quantities.

It is internationally recognised that water has important public goods characteristic and in most countries is required to social functions. It is to protect water from degradation which is function that the governments and their agents must do because of the scales of the issues: (a) The environment and maintaining environmental value which depends on water source; (b) Maintaining the availability of water for essential needs both domestic and for food production; (c) Protecting water quality suitable for human consumption; Maintaining cultural heritage and traditional water use; (d) Maintaining the amenity values of water for leisure, recreation and enjoyment by the public; (f) Maintaining equity among water users (UN, 2000). Based on the above facts, water is not a trivial matter and it involved everybody including the governments of every countries.

Lee (1990), suggested that the term management may denote a variety of very different activities and in most of the case studies involving water management is generally interpreted as the management of one or another dominant water use. The definition used in Bogota to explain water management: " ... to administer, on behalf of the nation, the water available for public use within the area of its jurisdiction; to this end, it is empowered to grant, control, suspend or regulate the right to use surface water or groundwater, as well as permits for the exploitation of forest and riverbeds" Such definition provides adequate basis for a type for the basis for a type of water management directed towards the integrated management of resources. Efforts must be taken in term of dialogue concerning the definition of water management which would be directed towards achievement clear understandings of the difference between management of resources and management of water uses.

By understanding how the use, management and distribution of water had been changing, we can gain a better understanding of the power dynamics between various actors and identify important question whose answers hold the key to understand the region. Water-

related developments are central to socioeconomics and political transformation in all countries. It was argued that there exist a complex relationship between sustainable water management, agricultural development and poverty reduction (Arsel and Spoor, 2010).

According to Staddon (2010), water management is a highly complex and contested enterprise. Water has been subjected to human regulation since before Roman time, and is now regulated by a large number of different organisation, agreement and process operating at spatial scales. Today inevitably involve multiple goals or objectives, many of which may be conflicting. It is difficult, if not impossible, to please all stakeholders all the time.

According to Arsel and Spoor (2010), when discussing on the issues of water management and water use, put the blame on growing inefficiency in water management, conveying facilities and severe deterioration of physical infrastructure. These factors have been resulted in unnecessary water wastage. There are different approaches of water management. In Thailand for example, traditional public participation in water management has been more prevalent. A study by Thailand Development Research Institute found that US $ 1.6 billion in Thai government fund for 550,000 small water resource across the country were wasted over the past two decade because the sources have been neither fully used nor properly maintained. By contrast, most water sources managed by local populations are in good condition, providing clean drinking water all year round. In view of this the Thai Government would soon transfer the power to manage small water sources to local administrative organization, as part of the general programmes for decentralization and devolution (Bruch et al., 2005)

2.6.1. Approaches to water resources management

2.6.1.1 Watershed approach to water resources management

The wider scope of water resources management can be seen from the water basin perspective. The basin is an area drained by the river or an area that can usually delineate on the map with relative ease, although there are situation where anomalies arise. The basin is also referred by synonyms river basin, drainage basin, catchment and catchment area. Another approach to solve the lack of cooperation among the various agencies that deal with management of water whether for power generation, water supply irrigation navigation, recreation, pollution control fisheries etc. The IWRM is seen as a way out for water management which need all managing agencies need coordinated effort in managing activities affecting water resources within a watershed (Colombi, 2009).

There are many pressures that management and planning of the forested area have to take into account including its use for mining, timber production water resource protection, conservation needs and recreation. Considering water development options, the quality of water is a serious concern, as is potential for conflict between alternative use of the catchment resources where the most obvious conflict was between agricultural production in the upper catchment and water quality at favourable dam sites down streams (Dixon et al, 1990).

According to a 1996 report of the American Water Works Research Foundation (AWWRF), Total Water Management (TWM) is the exercise of stewardship of water resources for the greatest good of society and the environment. A basic principle of TWM is that the supply is renewable, but limited, and should be managed on a sustainable-use basis. All over the world, rain is the main source of fresh water.

One of the approaches to manage water resource is through managing the watershed. Watersheds and the proper management of them have become a major focus of resource

managers in countries around the world. Much of this interest is the result of land use practices that have led to increased soil erosion. These watershed problems are especially acute in developing countries where growing populations are exerting intense pressure on increasingly scarce land and water resources. Most people in these areas live and work on the land, So as rural population increase, land formerly farmed extensively are now being farmed more intensively, while formerly fallow lands, usually more susceptible to erosion, are being cultivated. Deforestation of upland areas, a result of more intensive agriculture and excessive timber extraction, has also accelerated soil erosion and downstream damage (Easter and Hufschmidt, 1991).

Much of the world that needs vigilant water management faces extremes variability in precipitation and stream flow throughout the year. The technical aspect of creating securities involves developing storage facilities to capture water during period of high stream flows usually during high rainfall periods and preserving it for times of low stream flow and high demand (Easter et al., 1998).

2.6.1.2 Water supply management

According to Colombi (2009), simple observation of the world around us suggested that abstracting more water from the worlds' river and aquifers may not be the complete answers to the problems of providing food and water security. Although cheaper and more socially and environmentally acceptable alternatives may exist to meet the overall long term objectives of these water development plans, they cannot be explored because they lie outside the framework set by the terms of reference.

2.6.1.3 Water distribution management

According to Berkes (1989), water distribution below the source can be treated as a commodity which requires cost so that allocation rules and the institutional setting differ.

There are always problems in water distribution. Water is best managed by those with land, the users of it. Surface water was admittedly complicated by the need to administer large scale gravity flow system over a wide area (Woods and Jones, 1990).

2.6.1.4 Water usage management

Berkes (1989) outlined two factors that relate water utilization. Firstly, is the need to evolve efficient and rational use of the water supply? This is because where water is unevenly distributed across geographical regions and throughout different seasons. Secondly is the protection of rights of the legitimate water users in manners which guarantees equitable distribution of water.

Water is a scarce resource. Because of that, the uses of the available water resources need to be optimised. Water need to be used efficiently. This is to seek improvement in users' efficiency aim to squeeze more water out of the water services and out of the given volume of fresh water. One of the elements is to promote water efficient user appliances through a programme of demonstration and information, cheap loans and subsidies, and public education campaign (Winpenny, 1994).

In Spain for example, it was suggested that all water users should pay more for their water services and thus help reduce public deficit and induce the farmers to use water efficiently. It also suggested that water consumption be reduced in a manner consistent with the relative with scarcity of water across basins and drought cycles (Easter et al., 1998). Efficient water use is critical to the economic wellbeing of many regions and countries

around the world. In many cases, technical approaches to expanding water resources are not economically or politically viable (Easter et al., 1998).

2.6.1.5 Water demand management

The task in water resource planning became one of predicting by how much demand for water would inevitably increase in the future and then providing for this increase (Green, 2003).

In the past, increase water demand was satisfied by developing new water sources. But environmental engineering, and financial constraint make traditional supply –side responses less tenable than they were once were. It was further pointed out that there are many factors which affect demand especially that in the urban areas. Firstly, the demand for water to water lawn and air-conditioning results in the demand for water almost double in hot summer months. The next factor that affects demand is the number of resident per water meter and their house hold income level. The other factor which is no less important is the population density and last but least is the price of water (El-Ashry and Gibbons, 1986).

There are many control measures which can be taken in order to manage the demand. It was reported in Thailand (UN, 2000) that the following steps were taken. Because of the resource constraint that they faced, they have resorted to residential water audits. The government also give rebate for the replacement of flush toilet and other water efficient devices as water conservation measure. Even washing are label so as to differentiate from that of the ordinary with that are water saving. Even commercial and industrial water usage is subjected to audits which encourage the interested parties to replace toilets and shower. Selby (2003) suggested that besides rewarding those who saved water, education should be combined with pricing to send clear massage of the water scarcity.

2.6.1.6 Pollution management and control

Issue of pollution is affecting everybody on the planet. According to Colombi (2009), simple observation of the world around us suggested that abstracting more water from the worlds' river may not be the complete answers to the problems of providing food and water security. Although cheaper and more socially and environmentally acceptable alternatives may exist to meet the overall long term objectives of these water development plans, they cannot be explored because they lie outside the framework set by the terms of reference. One of the more prominent problems of water pollution is by nitrate and other chemical associated with agricultural land use and have been the topic of recent study (Syers and Rimmer, 1994).

(i) Policy

Water policy is a comprehensive process of institutionally interrelated parts and a coherent framework requiring clear articulation of goals, careful de-alienate the water problems, a solid data and information basis, and well thought implementation process. In addition to that, development and management of water resources needs to be planned and implemented in the context of a national water policy. The water policy act as guidelines for waters service provider, government and non government organisation together with the relevant stakeholders in dealing with water. With increased economic and social development efforts on the one hand, and demographic pressures on the other, not only is the overall demand for water rising, but its quality is also deteriorating. There are several development options relating to water which has resulted in conflicting demand for the same body of water and resolution of these conflicts assumes an important dimension in water management policies and strategies (Ali et al., 1987).

In some cases, exhortation and appeals to public-spiritedness are often used as a temporary device, capitalising on public concern over droughts (Winpenny, 1994).

The components of policies involving water according to Easter and Hufschmidt (1991) are that of successful soils and water management programs and policies which must focus on the many land users whose actions directly affect soil loss rate. Policies must be translated through the various level of government to influence these many individuals who have different objectives and priorities which is a challenging task for developing countries like Malaysia.

El-Ashry and Gibbons (1986) pointed out that the existing policies do not adequately protect water quality. This because the traditional management practices was considered to have led to land and water quality degradation. The common evidence includes soil erosion, land subsidence, soil salinization, and water logging, high salinity level in ground and surface water, and toxic elements in surface and subsurface return flows. These negative consequences of some water uses are being borne by the downstream water users and the society as a whole.

Winpenny (1994) suggested that there are three layer of reinforcing policies which can be used to promote efficient use of water. There are, firstly is the enabling conditions which is considered as actions to change the institutional, legal and economic framework within which water is supplied and used, Secondly, are the incentives which include policies that can be used to influence the behaviour of users directly by providing them with an incentives to use the resource more carefully; these actions include both market based and non market base. Thirdly, is the direct intervention through investment, spending programmes, or targeted programmes to encourage the use of water efficiently and water saving activities? In Singapore, for example, the Ministry of the Environment was formed in 1972 to look into issue on to provide environmental infrastructure including measures to prevent and control water pollution and manage solid waste. As reported by the United

Nation the potential pollution can be prevented through proper land use planning, judicious siting of industries, development and building plan controls and provision of waste collection and treatment facilities. The preventive measures are to be established and control must be stringently enforced to ensure that waste collection and treatment facilities are properly operated and maintained (United Nation, 1988).

The only meaningful policy option from an ecological perspective is to reduce population growth. This is because according to Selby (2003), water resources after all are scarce, fixed and finite, and hence it is human over consumption, and above all population growth, that most demand attention. A crucial step in averting water crisis is to slow unprecedented population growth occurring in so many parts of the world's countries.

(ii) Enforcement

According to Winpenny (1994), exhortation and appeals to public are often used as a temporary device, capitalizing on public concern over drought. In some cases it becomes a permanent feature of policy. Regulations and restrictions, if properly enforced, are predictable in their effects and their needs can be readily understood by consumers. Enforcement is the last resort to ensure compliance in pollution control. This is because it is easy said than done. Besides the long process it is also costly to implement. However enforcement should be taken in curbing water theft and severe wastage scenario.

2.7 Problems in Water Resource Management

The issue involving water use, growing inefficiency in water management reflect inadequacy of water conveying facilities and severe deterioration of physical and infrastructure (Arsel and Spoor, 2010). At the watershed level, there are problem involving property rights. As described by Easter and Hufschmidt (1991), property rights are unclear in many upland areas.

As these uplands is where the water sources are, the farmers do not have secure claims over the long terms benefits of their actions. The incentives to invest in practices that conserve land and water resources do not exist. Most upland and forest are usually defined as public lands, and the occupants have limited rights to the lands. According to Gosh et al. (2009), resources such as water, air, national parks and farming land being degraded due to unregulated use by the society.

2.8 Significance of water resource for sustainable natural resources management

There are contradicting views on water problems. According to Lozan et al. (2006), water problems are not really global problems. They have to be solved region by region. The natural system boundary is the catchment which can include territories from different nations.

Taking as an example of what had been practiced in Australia was that, with the introduction of Water Management Act in 2000, emphasised and pressed for microeconomic reform of water industry. Among the key aspects agrees were (a) ecological sustainability and (b) the introduction of mechanisms which permitted a more efficient allocation of water. The reform packages involved among others, (1) pricing should be consumption and full cost recovery based and cross subsidies should be removed; the best scientific information available should be used to review water allocation; (3) environmental allocation should be restored in over-allocated water systems; (4) water allocation should be separated from land title and water allocation be tradable; and (5) public consultation should take place concerning irrigation management, environmental issues and water trading (Gosh et al., 2009 pp 156).

The need to conserve water and allocate it to socially more valuable uses has not always been evident. In some societies water has long been treated as a scarce resource.

In the majority of countries, however water has been treated as though it were available in unlimited quantities, and supplied at zero or low cost to consumers who resent the idea of water as economic resource. Winpenny (1994) argued that it is the past failure to recognise the economic value of water has led to wasteful and environmentally damaging use of resource.

One can deduce that the issues of access to information, public participations, and accountability mechanism are increasingly recognized as a key to the sustainability of development finance. It is established that when the public is meaningfully involved during the project preparation and implementation stages, the success of such project increases (Bruch et al., 2005).

Joshi and Setty (2006) stressed the fact that each unit of water is to be used more efficiently, so that water is conserved. As water resources are depleting, the inevitability of devising more efficient methods is more relevant. It is absolutely necessary to realise that water is a scarce natural resource, although renewable by natural ways. The ecological constraints and climatological restrictions have made many regions drier than others. Even in water surplus regions, water must be used more efficiently. Berkes (1989), pointed out that water being the flow resources by nature it is difficult to control the distribution across many user argues strongly for establishment of collective rules on water allocation.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discuss the research design based on a one shot cross sectional analysis of rural water resources management which was carried out in Kuching District. The research was divided into several sections to include: (1) population and sampling techniques, (2) research instruments, and finally (3) the procedures of data collection, specific variables under investigation, data analysis and methodological issues related to the studies.

3.2 Research design

A cross-sectional approach using structured open and close ended questionnaires formed the basis and core element of this research. This has enabled the researcher to obtain fresh, relevant and reliable data and information. The other methods included interviews with village headman, the committee member in-charge of water supply and also relevant key informants. Besides all these procedures, small group's discussion, dialogues and personal observations were also carried out. Empirical data to substantiate some issues were obtained from relevant authorities like the Kuching Water Board, Kuching District Office, Siburan Agricultural Station. The testing procedures in testing for water quality parameters and procedures in accordance with international drinking determined by the WHO will be included in this research. Secondary data were also obtained from the Sarawak State Health Department in Kuching District and in some cases, visit to the data source mere done to get the updated data to compliment data that were made available before this. This was done in order to have a better understanding of the issues and substantiate point discussed.

3.3 Study area and population

Kuching District in Sarawak, Malaysia was chosen as the location to carry out this research. This was done based on the following reasons: (1) Kuching is the capital city of Sarawak. Most of the administrative activities have their main office here; (2) In Kuching District, most of the villages are accessible by road and this help to facilitate the process of data collection. The area of Kuching district is 1862.8 km² with a population of 637,292 (based on the population survey carried out by the Statistic Department). The actual area where the study was carried out is shown in Figure 1.1.

3.4 Sampling

Nine villages (as shown in Table 1.1) in the Bunuk operational area out of twenty seven villages were chosen for this research which is shown in Appendix B. These villages chosen are situated in the upper stream of Sarawak Kiri. Sarawak Kiri is the source of raw water for KWB treatment plant at Batu Kitang. This makes these villages significant for this research. Batu Kitang Water Treatment supply treated water to almost 600, 000 population of Kuching City according to the KWB 2009 annual report (KWB, 2009).

The two key informants selected for this research from each village are the village headman (KK) and the committee in charge of water supply sub-committee. Besides the key informant, at least ten percent of the household in the villages were also interviewed using the questionnaire as shown in Appendix A. In addition to that, personal interviews were also carried out to seek information on water related current issues.

The study also obtained empirical and secondary data from relevant department like the Sarawak State Department and KWB to emphasise certain issues. The data included the parameter which the department monitor for the water quality to comply with the

international drinking water standard as prescribed by the WHO. To make the data collected representative of actual situation, a total of nine villages was selected based on the systematic random digits statistical formula (Coolican, 1999), and the list of village selected is shown in Appendix C. Great care was taken to ensure the relevancy of the data collected.

3.5 Instruments

The study deployed structured of both open-ended and closed-ended questionnaires as per **Appendix A.** The survey instrument was tested prior to its usage in collecting data in the field to ensure its practicability, reliability and relevancy. Some parts of the questionnaires need to be amended and fine tuned to adapt to the actual requirement on the ground. Besides the above methods applied, the study also employed other form of data collection through face to face small group discussion and direct personal observations. Face to face interviews of the informal leaders and those stake holders like the officers, District officer of Kuching District, the local Agriculture office which is located in Siburan.

3.6 Variables

The variable that have been included in the study were:

(1) The nature of rural water resource management, (2) administration, (3) knowledge, attitude and practices related to water resources, (4) water quality based on the common parameter required by the Ministry of Health Malaysia, (5) water borne diseases in Kuching district, (6) source protection and pollution control.

3.7 Data collection

The main source of data collection was firstly by interviewing the respondents pre-determined

during the population sampling procedure. Secondly, the other means of extracting data was by having informal meeting and discussion with those stake holders. Thirdly, is by personal observation of the study and last but not least, is the collection of secondary data from the State Health Department and Kuching District Health Office which also acted as the Divisional Health Office. There were instances whereby other government agencies need to be approached to clarify on certain issues pertaining to water resources. Some of the relevant head of department were approached to gather data pertaining to water resources management in the research area.

Figure 3.1. Group discussion to gather information

3.8 Data analysis

For the purpose of analyzing the data, Statistical Package for Social Sciences (SPSS) computer program was used. This enabled the data collected be analyzed both quantitatively and qualitatively to higher degree of accuracy. The findings and outcome of the study was

presented in the form of graph, tables, charts and also described statistically in term of frequency, means and standard deviations.

3.9 Water quality data of the study area

Gathering of empirical data on water quality was gathered from several sources. The most important sources for water quality are from the KWB.

Appendix C1 and C2 shows the raw water quality monitored by the KWB over a period of one year and one month respectively

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter reports the findings and discuss the analysis of the socio-economic data obtained from the study area. The study involved nine villages based on the methodologies as discussed in the previous chapters. Besides the data obtained by carrying out interviews using the questionnaires, data were obtained from the JKKK of the villages, especially the kampong profile of each villages. The data obtained from the respondents using questionnaires as shown in Appendix A. The data obtained from the questionnaires were analysed using the SPSS.

4.1.1 Demographic profile of respondents

4.1.1.1 Population structures and dynamics

This study interviewed the nine village headman as the main person to provide information on water resources situation in the villages. In addition to that, nine village committee members were also interviewed. For this matter, the committee members chosen to fulfil these criteria were those who is in-charge of issues of water supply. Besides the two key person mentioned above, another ten percents ware also interviewed to provide us with the infor nation from the perspective general villagers. There were nine headmen and nine village safety and development committee members interviewed. Another category of respondent interviewed comprised of ten percent the total families available in the villages which are also the head of the household. The study have interviewed a total of 148 respondent in nine villages previously chosen which is shown in Table 4.1

Table 4.1: Number of respondents by place of interview and percentage

Place of interview	Number of respondents	Percentage
Bayur	10	6.8
Bengoh	14	9.5
Bunuk	48	32.4
Danu	9	6.1
Garung	15	10.1
Giam	10	6.8
Karu	18	12.2
Semadang	16	10.8
Timurang	8	5.4
Total	**148**	**100.0**

4.1.1.2 Category of respondent by village

There were three categories of respondents in this research. They are the village headmen, committee in charge of the water supply in the villages concerned. The third category interviewed were the head of the family. Normally the father were interviewed, however in the absence of the father, the mother will be interviewed. The outcome of the study is as shown in Table 4.2

Table 4.2: Number of respondents by category and percentage

Category of respondent	Number of respondents	Percentage
Headman	9	6.1
Pipe committee	9	6.1
Villagers	130	87.8
Total	148	100.0

The headmen comprised of 9(6.1 %) of the respondent while another 9 (6.1%) are the committee members in-charge of the water supply in the village. These are the local leaders who are responsible for the administration of the villages and the committee member in-charge of water supply is the key person responsible of the water administration of the village. The remainder 130(87.8%) are the head of the household, and usually the adult male or female.

4.1.1.3 Ethnicity of respondents

All of the respondent involved for this interview is of Bidayuh ethnicity. They are further ethnically subdivided into Bengoh-Danu, Bra-ang, Biperoh and Bunuk. These sub-ethnic all speak Biatah dialect.

The Bengoh, Semedang and Giam are those who dwell within the proximity of Kuching Kiri River. Timurang, Bayur, Garung, Karu and Bunuk are located in the tributary of Sarawak Kiri River. The distribution is shown in the Table 4.3

Table 4.3: Distribution of respondents by sub-ethnic

Name of village	Sub-ethnic group
Kpg. Danu	Bengoh-Danu
Bengoh	Bengoh Danu
Timurang	Braang
Bayur	Braang
Karu	Biperoh
Garung	Biperoh
Semadang	Biperoh
Giam	Biperoh
Bunuk	Bunuk

4.1.1.4 Age of respondents

For the purpose of this study, only adult member of the family were interviewed. The age of the respondent range from 26 years and above and the distribution is shown in Table 4.4 Age was taken as one of the criteria to reflect the rationality of the answers provided in the interview. This is hoped that a correct conclusion can be drawn at the later part of the study.

It is important criteria as age of the respondents were chosen among those who are adult and can give rational answer.

Table 4.4: Number of respondents by age and percentage

Age (In years)	Number of respondents	Percentage
18 and younger	0	0
18-25	0	0
26-40	39	26.4
41-55	70	47.3
55 and above	39	26.4
Total	148	100.0

4.1.1.5 Gender profile of respondents

Majority of the respondent were interviewed were male, which comprised of 109 (73.6%). The female categories are those categories linked to domestic water use. Their views is important in determining the water demand and conservation. The finding of the study is shown in Table 4.5

Table 4.5: Number of respondents by gender and percentage

Gender	Number of respondents	Percentage
Male	109	73.6
Female	39	26.4
Total	148	100.0

4.1.1.6 Education level of respondents

Result of the interviewed showed that out of 148 respondents interviewed, 90 (60.8%) of the respondents have at least attended formal education until secondary school. This give hope that any awareness on water related issues in the future can be understood and accepted. We

also have a healthy pool of respondent in the community who have tertiary education. These groups of people can actually assist in any water resource protection and conservation initiative activities in the communities.

Table 4.6: Number of respondents by level of education and percentage

Education Level	Number of respondents	Percentage
No. formal education	17	11.5
Primary school	24	16.2
Secondary school	90	60.8
Tertiary education	17	11.5
Total	148	100.0

4.1.1.7 Occupation profile of respondents

The respondent interviewed working in the public sector is 44(29.7%) when compared to the private sectors is 36 (24.3%). The respondent working in the public sectors is mostly those who have bought other houses in town. This implies that they are occasional water user for this matter. They may be transferred to other places according to their job placements. Due to the improved condition of the road linking the city to the villages, most of those working in the private sector prefer to commute to work from the village. This explains the increase in demand of water in the morning or evening when these people go to work or return from work. Those who are self employed are permanent resident of the villager while the rest of the respondent are pensioners. The pensioners are also important category in this study because out of the 9 headman, 5 are pensioners. Their role in the village administration is vital in leading the villagers to achieve common goal. They are the link between the villagers

and the government. Besides, they need to become the role model for the villagers. The outcome of the study is shown in Table 4.7

Table 4.7: Number of respondents by occupation and percentage

Occupation	Number of respondents	Percentage
Unemployed	28	18.9
Public Sectors	44	29.7
Private sectors	36	24.3
Self Employed	31	20.9
Others	9	6.1
Total	148	100.0

4.1.1.8 Income status of respondents

If the income of the respondent is reflective of the income of the community as a whole, it implies that majority of the population lives below the poverty line. This result may not be conclusive as issue of income is considered confidential to some people. This means that the answers given during the interview may not reflect the actual income of the respondent. Some viewed income differently. They viewed income as only the monetary income whereas their actual income might be more that they thought. The outcome of study is as in Table 4.8.

Table 4.8: Number of respondents by income and percentage

Monthly income level	Number of respondents	Percentage
Less than RM 500.00	48	32.4
RM 500.00 - 1000.00	27	18.2
RM 1001.00 – 2000.00	38	25.7
RM 2001.00 – 4000.00	29	19.6
RM 4001.00 and above	6	4.1
Total	**148**	**100.0**

4.1.1.9 Types of water supply

The study showed that the 96(64.9%) respondent got their water from both their usual water supply system (usually GFWS) . Besides their regular water source for domestic purposes like drinking, cooking and for personal hygiene, they also depend on rivers and stream for bathing and recreational purposes. For this matter, all types of water sources need to be protected from pollution. This is very important as the villages that were included in the study have impact on the raw water supply at Batu Kitang Water Treatment Plant. The quality of water as in Appendix C1 and C2)

Table 4.9: Number of respondents by type of water supply and percentage

Type of water supply	Number of respondents	Percentage
Direct from stream and rivers	1	0.7
Pipe gravity feed	42	28.4
Rain water	7	4.7
Pipe gravity feed and rivers	96	64.9
Piped gravity feed and rainwater tank.	2	1.4
Total	148	100.0

4.1.1.10 Age of current water supply system

The outcome of the study shows that 113 (76.4 %) of the respondent still depend on the water supply system that is more than twenty years. This showed also that the water system built more than twenty years ago is still useful in providing water for the villagers under study. This may indicate that the water system built is actually reliable. The water systems built by the State health department were meant to last for only fifteen years.

The outcome of the study is shown in Table 4.10

Table 4.10: Number of respondents by age of water supply system and percentage

Age of water supply system	Number of respondents	Percentage
0 – 5 years	0	0
6 – 10 years	3	2.0
11 – 20 years	32	21.6
More than 20 years	113	76.4
Total	**148**	**100.0**

4.2. Findings of respondents level of agreement on various water supply issues

4.2.1. Maintenance of local water supply system

This section of the report discussed the information obtained from the rating based on the questionnaires used to find out the opinion of the respondent on issue related to their water supply in their respective area. This is useful in determining the degree of acceptance on certain issues covering various aspects of water resources and management.

4.2.1.1 Repair and maintenance of water supply system to be done by committee

Out of 148 respondents interviewed, 55 (37.2 %) strongly agreed that the repairing of the water supply system is the responsibilities of the committee members while 48(32.4%) said that they agreed to the ideas. However, from the committee members' view, most of them feel the responsibilities should not fall on the shoulder of the committee alone. This is because, the post held as the committee is a voluntary one and without any monetary rewards. If any repairs need to be done it should be done collectively by the villagers. If the repair is minor, the committee can make use of the village fund to pay those who are entrusted to carry out the repair. The outcome of the study is shown in Table 4.11

Table 4.11: Number and percentage of respondents by level of agreement that maintaining and repairing of water supply is responsibility of committee

Level of agreement	Number of respondents	Percentage
Strongly agree	55	37.2
Agree	48	32.4
Moderately agree	19	12.8
Disagree	13	8.8
Strongly disagree	13	8.8
Total	148	100.0

4.2.1.2 Repair and maintenance of water supply system to be done by government

A total number of 55 (37.2%) of the respondents strongly believed that the repair work of the water system should be done by the government when compared to 19(12.8%) strongly disagreed to the idea. While a high proportion of the respondents have the impression that the government, the actual fact is that they cannot wait for the government to the rescue if the water supply systems break down. The result of the study is as shown in Table 4.12

Table 4.12: Number and percentage of respondents by level of agreement that it is government's responsibility to repair and maintain water supply system

Level of agreement	Number of respondents	Percentage
Strongly agree	55	37.2
Agree	28	18.9
Moderately agree	26	17.6
Disagree	20	13.5
Strongly disagree	19	12.8
Total	148	100.0

4.2.1.3 Cost for repair of the water supply system be borne by government

Of the total of 148 respondents interviewed, 41 or 27.7% strongly agreed that the cost of repair of the water supply system be borne by the government . The difference is not too significant when compared to those who moderately agreed to the idea. The details is shown in Table 4.13

Table 4.13: Number and percentage of respondents by level of agreement that cost for repair of the water supply system be borne by government

Level of agreement	Number of respondents	Percentage
Strongly agree	41	27.7
Agree	28	18.9
Moderately agree	39	26.4
Disagree	27	18.2
Strongly disagree	13	8.8
Total	148	100.0

4.2.1.4 Village fund for water supply

Even though the respondents want the cost to be borne by the government, they feel it is necessary for the village should have stand by fund for repairing pipe in case of pipe burst or leakage. A total 83 (56.1%) of the 148 respondents strongly agree to the idea. This indicates that there is quite a high degree of independence among the communities under study. The evident is shown below in Table 4.14.

Table 4.14: Number and percentage of respondents by level of agreement on the need for village fund for water supply

Level of agreement	Number of respondents	Percentage
Strongly agree	83	56.1
Agree	40	27.0
Moderately agree	20	13.5
Disagree	4	2.7
Strongly disagree	1	0.7
Total	148	100.0

4.2.1.5 Fund for water supply system burden for villagers

From the start of the implementation of water supply project in the study area, it was required of the villagers to pay a token sum for the water supply project to proceed. This willingness to pay the token sum is meant to create feeling of ownership of the villagers for the project. From the information that was obtained from the local key informant, the yearly house contribution in the range of RM 5.00 to RM 20.00 is not viewed as a burden to them. Some do receive some form of donation from the private companies operating in the study areas.

The outcome of this study showed that fund collected for the repair of the water supply system is a burden for them. This formed 62 (41.9%) out of the 148 respondents interviewed. However there is no uniformity in the amount of fund collected for this purpose.

Table 4.15: Number and percentage of respondents by level of agreement on whether fund collected for water supply system is a burden

Level of agreement	Number of respondents	Percentage
Strongly agree	62	41.9
Agree	41	27.7
Moderately agree	26	17.6
Disagree	18	12.2
Strongly disagree	1	.7
Total	148	100.0

4.2.2 Environmental issues related to water supply

4.2.2.1 Water catchment area should be totally protected

Out of 148 respondents interviewed, Of the respondent interviewed, 111 (75%) of them strongly agree that the water catchment area should be totally protected and gazetted by the government. However there is potential land use conflict in the implementation of this system. If for example, the land owner happen to own the land which happen to be within the catchment would find it difficult to surrender their land for such purpose. To ensure compliance, there need to be some form of government intervention. The idea is a good one, however the implementation is still questionable. The outcome of this study on this issue is shown in Table 4.16

Table 4.16: Number and percentage of respondents' by level of agreement on the protection of catchment areas

Level of agreement	Number of respondents	Percentage
Strongly agree	111	75.0
Agree	26	17.6
Moderately agree	5	3.4
Disagree	6	4.1
Total	148	100.0

4.2.2.2 Water supply pollution

Out of 148 respondents interviewed, the level of acceptance among them does not show any great differences. This can be seen from the 45 (30.4 %) just moderately agree to the issue. This showed that the perception of the community pollution is not as bad as what we first suspect. This may imply that the pollution of the water resources is still tolerable. However it also can be perceived as there is still something that we can do to save the situation. The detail is shown in Table 4.17

Table 4.17: Number and percentage of respondents by level of agreement on the extent of pollution of water supply

Level of agreement	Number of respondents	Percentage
Strongly agree	24	16.2
Agree	30	20.3
Moderately	45	30.4
Disagree	30	20.3
Strongly disagree	19	12.8
Total	148	100.0

4.2.2.3 Pollution of water supply by villagers

When the issue of villagers causing the water supply pollution, some moderately agree while 51(34.5%) the respondents disagree to the idea. However the outcome of the study is depicted in Table 4.18

Table 4.18: Number and percentage of respondents by level of agreement that water supply pollution is caused by villagers

Level of agreement	Number of respondents	Percentage
Strongly agree	9	6.1
Agree	29	19.6
Moderately agree	49	33.1
Disagree	51	34.5
Strongly disagree	10	6.8
Total	**148**	**100.0**

4.2.2.4 Farming activities related to water pollution

Unprotected water sources can result in many outcomes. The land owner who owns a piece of land, for example, which happens to be in the catchment area, may insist that he has the right to develop the land. Because there is no written law to forbid such act, it is not possible for anybody to stop the land owners to do so. This resulted in pollution which is mainly caused by farming activities carried out in the up-stream of the catchment area. This is viewed as dangerous as the current method of farming used modern pesticides. However the outcome of this study shows that there is no significant degree of acceptance as only 19(12.8%) strongly agree that agricultural activities in the catchment actually caused pollution. This call for inputs from the relevant authorities to increase the level of awareness among the communities involved on the danger of agricultural inputs especially pesticide especially the one having long term residual effect. The result of the finding is shown in Table 4.19 below.

Table 4.19: Number and percentage of respondents by level of agreement that water pollution is related to farming

Level of agreement	Number of respondents	Percentage
Strongly agree	19	12.8
Agree	35	23.6
Moderately agree	47	31.8
Disagree	38	25.7
Strongly disagree	9	6.1
Total	148	100.0

4.2.2.5 Land development and water pollution

Land development is not the main issue in the study area. Because of this, large scale land development is not significant in polluting water supply meant for consumption. However, the water that is greatly affected by land development does affect water resources meant for other

purposes. In fact only 13 (8.8%) strongly agree that land development is the cause of water pollution among the respondents interviewed. Detail is as shown in Table 4.20 below

Table 4.20: Number and percentage of respondents by level of agreement that water pollution is cause by land development

Level of agreement	Number of respondents	Percentage
Strongly agree	13	8.8
Agree	31	20.9
Moderately agree	17	11.5
Disagree	37	25.0
Strongly disagree	50	33.8
Total	148	100.0

4.2.2.6 Water pollution by deforestation for timber/logging

Logging activities do not contribute pollution directly to water supply system in the study area. Hence there seem to be conflicting views among the respondent as they do not see any significance to this issue. It can be conclude from the number of respondent strongly agree with that strongly disagree are equal at 37 (25%). Where else 40 (27.0%) merely disagree on the issue. The detail result of the study is shown in Table 4.21

Table 4.21: Number and percentage of respondents by level of agreement that water pollution is caused by deforestation for timber/logging

Level of agreement	Number of respondents	Percentage
Strongly agree	37	25.0
Agree	27	18.2
Moderately agree	7	4.7
Disagree	40	27.0
Strongly disagree	37	25.0
Total	148	100.0

4.2.2.7 Deforestation and plantation

Most of the villager here are small scale farmer tending to their individual plots of land. The crop that they plant comprise of paddy and maize for subsistence. Besides that, they also plant varieties of other crops on the same plot. This is usually done on an annual basis. Some of the villagers plant cash crop like pepper, rubber and cocoa. As this area is situated within the water catchment has been gazetted as Water Catchment Reserved in 1993, no large scale plantation or industry approved by the state planning unit. However this study shows that even though the scale of deforestation for farming is small, the impact is still noticeable. The deforestation has been the traditional practice among the local here which is for shifting cultivation. This is evident from the result shown in Table 4.22 where of the 148 respondents, only 44 (29.7%) agreed that deforestation contributed to water pollution.

Table 4.22: Number and percentage of respondents by level of agreement that water pollution is due to deforestation for plantation

Level of agreement	Number of respondents	Percentage
Strongly agree	29	19.6
Agree	44	29.7
Moderately agree	23	15.5
Disagree	25	16.9
Strongly disagree	27	18.2
Total	**148**	**100.0**

4.2.3 Water sufficiency

4.2.3.1 Water shortage problem

Water shortage cannot be avoided especially the water supply is greatly dependent on rainfall. The study carried out impressively showed that 79(53.4%) claimed that they faced water shortage. The shortage is more often experienced in the dry season. This might be due to the fact that the impounding dam for the water supply was not built to store large amount of water to last for a long period of time. The finding is shown in table 4.23

Table 4.23: Number and percentage of respondents by level of agreement that there is water shortage

Level of agreement	Number of respondents	Percentage
Strongly agree	79	53.4
Agree	32	21.6
Moderately agree	23	15.5
Disagree	11	7.4
Strongly disagree	3	2.0
Total	148	100.0

4.2.3.2 Time of the day when villagers faced water shortage

Time of The intraday shortage of water often happens during early in the morning or late in the evening. However shortage is more acute in the evening that that in the morning also felt during the weekend. This is because some of the villagers who work in the government and private sectors only return to the village to spend their weekend. This is even worse when after dry weather.

Table 4.24: Number and percentage of respondents by level of agreement on what time of the day water shortage occur

View	Number of respondents	Percentage
Strongly agree	62	41.9
Agree	54	36.5
Moderately agree	20	13.5
Disagree	12	8.1
Total	**148**	**100.0**

4.2.3.3 Impact of agricultural activities on water shortage

The respondents strongly disagreed that the shortage is due to agricultural activities. This is because, most of the agricultural activities are considered as rain-fed. The cultivation of crops and land development for agricultural activities do not depend on the available water sources for irrigation. Because of this, the direct impact of agricultural activities on the

shortage of water supply is not significant. This is shown in Table 4.25 where 61(41.2 %) of respondents disagree that agricultural activities contributed to water shortage.

Table 4.25: Number and percentage of respondents by level of agreement on the impact of agricultural activities in relation to shortage of water

Level of agreement	Number of respondents	Percentage
Strongly agree	19	12.8
Agree	35	23.6
Moderate agree	47	31.8
Disagree	38	25.7
Strongly disagree	9	6.1
Total	148	100.0

4.2.3.4 Impact of logging on water shortage

Logging activities does not contribute to the shortage of water in the study area. This is because logging activity is not available especially those villages involved in the study. That means to say logging activities is not really an important cause of water shortage. The result is shown in Table 4.26

Table 4.26: Number and percentage of respondents' by level of agreement on the impact of logging in relation to water shortage -

Level of agreement	Number of respondents	Percentage
Strongly agree	31	20.9
Agree	23	15.5
Moderately agree	21	14.2
Disagree	49	33.1
Strongly disagree	24	16.2
Total	148	100.0

4.2.3.5 Impact of natural phenomena on water shortage

The respondents perceive nature can contribute to water shortage. This can be seen from the outcome of the interviews where 46(31%) of the respondents strongly agree that nature do

have impact on water shortage. While 42(28.4%) of the respondents do agree that there is relation between water shortage and nature. Please refer to table 4.27 below for detail.

Table 4.27: Number and percentage of respondents' by level of agreement on impact of natural phenomena on water shortage

Level of agreement	Number of respondents	Percentage
Strongly agree	46	31.1
Agree	42	28.4
Moderately agree	29	19.6
Disagree	23	5.5
Strongly disagree	8	5.4
Total	148	100.0

4.2.3.6 Pipe leakage and water shortage

Out of 148 respondents interviewed, 72(48.6%) strongly agreed that leakage contributed to the shortage of water in the study area. Leakage to the water supply system happens due to many reasons. Some of the damages to the pipe causing leakage are done unintentionally by the land owners where the pipe passed. Other reason is due to the joints that are not done properly or using low quality spare parts. The finding is shown in Table 4.28 below.

Table 4.28: Number and percentage of respondents' by level of agreement that water shortage is caused by pipe leakage

Level of agreement	Number of respondents	Percentage
Strongly agree	72	48.6
Agree	50	33.8
Moderately agree	15	10.1
Disagree	4	2.7
Strongly disagree	7	4.7
Total	148	100.0

4.2.3.7 Water wastage and abuse

Only 27(18.2%) strongly agree that water shortage is caused by wastage and abuse while 61(41.2 %) merely agreed that water shortage is caused by wastage and abuse. Abused in this context is making use of the water supply to rear fish and not off the tap when not in use. It was observed that some of faucets were left with water running even not in used. Such act can contribute to acute water shortage.

Table 4.29: Number and percentage of respondents by level of agreement that water shortage is caused by wastage and abuse

Level of agreement	Number of respondents	Percentage
Strongly agree	27	18.2
Agree	61	41.2
Moderately agree	40	27.0
Disagree	20	13.5
Total	148	100.0

4.2.4 Respondents overall view and expectation

4.2.4.1 Water supply safety

The water safety varies from village to village. Even for GFS and the diverse source of water supply 53 (35.8%) of the respondents agree that water supply are safe. Most of the villages have water supplied to their home except for Kampung Giam where the current present water supply system is not piped to individual houses. The villagers obtained their water supply from the stand pipe and rainwater storage.

Table 4.30: Number and percentage of respondents by level of agreement whether water supply is safe

Level of agreement	Number of respondents	Percentage
Strongly agree	53	35.8
Agree	49	33.1
Moderately agree	14	9.5
Disagree	15	10.1
Strongly disagree	17	11.5
Total	**148**	**100.0**

4.2.4 2 Boiling of water for safety

The respondents agreed that by boiling water; make them feel that the water is safer to drink. This is can be seen from the study which shows that 91 (61%) of the respondent strongly agreed that drinking water after being boiled is safer. The widespread publicity on water borne diseases by the relevant authorities had instilled awareness among the local communities.

Table 4.31: Number and percentage of respondents' by level of agreement on relationship between boiling of water and safety

Level of agreement	Number of respondents	Percentage
Strongly agree	91	61.5
Agree	40	27.0
Moderately agree	6	4.1
Disagree	7	4.7
Strongly disagree	4	2.7
Total	148	100.0

4.2.4.3 Danger of farming and gardening in water catchment area

Of the total of 148 respondents interviewed, 55(37.2%) strongly agreed that farming and gardening activities in upstream of the catchment area is dangerous. Information obtained from the agricultural station is Siburan reveals that the current trend of the farmers using pesticides to control weed and pest in their garden. Besides that, the increasing use of fertilizers also contributed to the danger posed on the water supply. It was observed that the

water supply for some villages still have active farming activities going on. Due to this trend, it is highly likely that the excess pesticide will get into the water system and consumed by the villagers.

Table 4.32: Number and percentage of respondents' by level of agreement on the danger of farming in water catchment area

Level of agreement	Number of respondents	Percentage
Strongly agree	55	37.2
Agree	45	30.4
Moderately agree	18	12.2
Disagree	13	8.8
Strongly disagree	17	11.5
Total	148	100.0

4.2.4.4 Reliable water sources

The villagers really look forward to have clean water resources. The study showed that 100 (67.6%) of the respondents hope for a more reliable water like the one supplied by KWB.

Table 4.33: Number and percentage of respondents' by level of agreement on the need to have more reliable water supply

Level of agreement	Number of respondents	Percent
Strongly agree	100	67.6
Agree	36	24.3
Moderately agree	3	2.0
Disagree	4	2.7
Strongly disagree	5	3.4
Total	148	100.0

4.2.4.5 Wise use of water

Based on the study 86(58.1 %) strongly agreed that water should be used wisely. This is because water is not always a readily available water resource. Even though there is rainfall all year round, it is sometime not readily available when it is most needed. Conservation of water need to be done even though the source is still available for the village people. The detailed based on the answer given by the respondent is as shown in Table 4.34.

Table 4.34: Number and percentage of respondents' by level of agreement that water need to be used wisely

Level of agreement	Number of respondents	Percentage
Strongly agree	86	58.1
Agree	42	28.4
Moderately agree	8	5.4
Disagree	2	1.4
Strongly disagree	10	6.8
Total	148	100.0

4.2.4.6 Law needed to protect water catchment area

When asked about the need to have special law to protect the,89 (60.1%) respondents strongly agreed that such law should be passed and enforced which is as shown in Table 3.35

Table 4.35: Number and percentage of respondents by level of agreement law is needed to protect the water catchment area

Level of agreement	Number of respondents	Percentage
Strongly agree	89	60.1
Agree	40	27.0
Moderately agree	11	7.4
Disagree	4	2.7
Strongly disagree	4	2.7
Total	148	100.0

4.2.4.7 Clean water and spread of diseases

Water and outbreak of diseases are closely related. From the study 95 (64.2 %) of the respondents strongly agreed that there is a strong linked in the role of water in preventing the spread of diseases. This is shown in Table 4.36 below

Table 4.36: Number and percentage of respondents by level of agreement that spread of diseases can be related to water supply

Level of agreement	Number of respondents	Percent
Strongly agree	95	64.2
Agree	41	27.7
Moderately agree	3	2.0
Disagree	4	2.7
Strongly disagree	5	3.4
Total	148	100.0

4.2.4.8 Level of satisfaction on quality of water supply

Quality is an important issue when discussing about water. However this study showed that the respondents are not satisfied with the quality of water in their respective places. The study revealed that 48 (32.4 %) of the villagers only agreed to that. This might be due to some area faces problems with the quality of water especially during dry season.

Table 4.37: Number and percentage of respondents by level of agreement on their level of satisfaction with present water quality

Level of agreement	Number of respondents	Percentage
Strongly agree	25	16.9
Agree	48	32.4
Moderately agree	31	20.9
Disagree	31	20.9
Strongly disagree	13	8.8
Total	148	100.0

4.2.4.9 Satisfaction level of current water supply system

The villages under study have individual catchment area for their water supply system. However the management of their water supply system are similar if not the same. The same goes to the amount of water and the water demand. However from the study46 (31.1 %) are satisfied with the water supply system available in their respective area. Only some though are unsatisfied with their water supply systems.

Table 4.38. Number and percentage of respondents by level of agreement on satisfaction with current water supply system

Level of agreement	Number of respondents	Percentage
Strongly agree	30	20.3
Agree	46	31.1
Moderately agree	25	16.9
Disagree	31	20.9
Strongly disagree	16	10.8
Total	**148**	**100.0**

4.2.4.10 Climate change impact on water supply

According to this study 71 (48.0%) of the respondents strongly agreed that climate change have a great impact on the water supply.

Table 4.39. Number and percentage of respondents by level of agreement that climate have impact on water supply

Level of agreement	Number of respondents	Percentage
Strongly agree	71	48.0
Agree	57	38.5
Moderately agree	19	12.8
Disagree	1	0.7
Total	148	100.0

4.2.4.11 Need for treated water supply

From the study, 125 (84.5%) of the respondents suggested that there is an urgent need to have treated water supply. This is due to the increasing population and increase water demand. This is also due to the fact that the available resources is becoming unreliable and polluted. This is shown in Table 4.40 below

Table 4.40. Number and percentage of respondents by level of agreement on the need to have treated water supply

Level of agreement	Number of respondents	Percentage
Strongly agree	125	84.5
Agree	13	8.8
Moderately agree	3	2.0
Disagree	3	2.0
Strongly disagree	4	2.7
Total	148	100.0

4.3 Analysis of variance (ANOVA) of the study based on respondents' level of agreement.

From a simple analysis of variance (ANOVA) using SPSS (Version 20), it was found that there is some significant relationship between the responses to the suggested causes of water shortage with level of education and occupation. Another aspect of the analysis was to ascertain the relationship between water pollution with level of education and occupation.

4.3.1 The ANOVA for responses to causes of water shortage by level of education

As shown in Table 4.41, there are three significant difference in the mean score relations by the respondents based on the ANOVA for responses to causes of water shortage by level of education. It was indicated that the respondents strongly agreed that the main causes of water shortage is due to population increase. The result of the study also revealed that the age of the water supply system are over twenty years. It is so much older than the design period of fifteen years.

The next cause of shortage according to the study is due to the natural phenomena. This was very much expected from the study as most of the water supply system depended entirely on water from streams and river. These water sources depended very much on rainfall. Long draught causes the low water level in the stream and subsequently affects the water supply system.

There is however a weak relationship between water shortage and the increase of runoff and holding capacity. This might be due to the fact that there is some misperception of the respondents the anthropogenic activities like farming and agricultural activities on the direct link with water shortage. This might explain the borderline relationship of factors.

There are three insignificant ANOVA for responses to ascertain the causes of water shortage. That includes water shortage due to logging, wastage and abuse and pipe leakage and abuse. The detail of the analysis to show the significance level is shown in Table 4.41.

Table 4.41: The ANOVA for responses to causes of water shortage by levels of education

Causes of water shortage	F-statistics	Significance Level
Increase in water demand due to population increase	7.113	.000
Water shortage caused by natural phenomena	5.102	.002
Increase runoff and reduced holding capacity	2.671	.050
Water shortage due to logging activities	2.562	.057
Water shortage caused by wastage and abuse	1.000	.395
Water shortage caused by pipe leakage and broken pipelines	.865	.461

* Confidence interval 95%

4.3.2 ANOVA for responses to causes of water shortage by occupation

The ANOVA for the responses to causes of water shortage by occupation did not show any correlation in all cases. The possibilities for this trend might be due to the fact that there is no stratification of respondents which might have resulted in different outcome. In this case, there is no significant correlation established between the two variables. The detail of the analysis is shown in Table 4.42.

Table 4.42: The ANOVA for responses to causes of water shortage by occupation

Causes of water shortage	**F-statistics**	**Significance Level**
Water shortage due to logging activities	2.241	.067
Increased runoff and reduced holding capacity	1.199	.314
Increase in demand	1.990	.099
Water shortage caused by natural phenomena	.781	.539
Water shortage caused by pipe leakage and broken pipelines	.668	.615
Water shortage caused by wastage and abuse	.332	.856

* Confidence interval 95%

4.3.3 ANOVA for responses to suggested causes of water pollution by level of education

The ANOVA result indicated that there was indeed a significant difference in the mean score by the respondents to suggested causes of pollution by level of education. This implied that the higher the level of education of respondents, the more knowledgeable they are about the issues pertaining to water pollution. This is good for the future management as the knowledge can be used to protect the water source. There are three aspects for which significant correlation were indicated.

Firstly, the result shows a strong relationship for responses suggested cause of pollution by agricultural activities. This was due to the fact that the use of pesticides in the upper parts of the water catchment area can result in chemical pollution.

Secondly, another cause of concern was that pollution as a result of deforestation by plantation. Although there is no large scale plantation in the study area, there are still deforestation activities going on. This might be the possible explanations for such a result as interpreted by the respondents.

The other factors which also caused concern among the respondents include pollution caused by forest degradation by villagers also by logging.

This concern was actually not significant in issues on housing development as the factor for water pollution. The result of the analysis is shown Table 4.43.

Table 4.43 : The ANOVA for responses to suggested causes of water pollution by level of education

Causes of water pollution	**F-statistics**	**Significance Level***
Pollution caused by agricultural activities	6.111	.001
Pollution caused by deforestation by plantation development	4.923	.003
Pollution caused by villagers	4.560	.004
Pollution caused by forest degradation by logging	3.045	.031
Pollution caused by housing development	1.509	.215

* Confidence interval 95%

4.3.4 ANOVA for responses on suggested causes of water pollution by occupation

The outcome of the ANOVA for responses on suggested causes of pollution by population (Table 4.44). It is clearly indicated there is a high significant in the correlation where the respondents strongly agreed that forest degradation by logging the causes of water pollution by level of occupation. The result also indicated that there is a weak significant correlation on issues involving deforestation that leads leading to pollution.

Table 4.44: The ANOVA for responses to causes of water pollution by occupation

Causes of water pollution	**F-statistics**	**Significance Level***
Pollution caused by forest degradation by logging	5.548	.000
Pollution caused by deforestation by plantation development	2.806	.028
Pollution caused by housing development	1.248	.294
Pollution caused by agricultural activities	.594	.667
Pollution caused by villagers	.471	.757

* Confidence interval 95%

4.3.5 The conclusion on analysis result.

Based on the analysis result, it can be concluded that there is a significant correlation in this study as to ascertain the depletion and pollution of water resources. The results have also indicated that this study had managed to come up with the answer for the problem statement and achieved the three specific objectives previously stated.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Water resources management covers both water hydrological and hydrosocial cycle of water. Hydrological cycle occurs naturally powered by the solar energy, explaining the continuous journey of water. Hydrosocial cycle involved water source, abstraction, storage, distribution usage and waste water disposal. The anthropogenic activities influence hydrosocial cycle like pollution of water sources, over abstraction, inequitable and inefficient distribution, excessive usage and improper or even no waste water treatment prior to final discharge to the water bodies like rivers and ultimately to the sea. The rapid population growth has drastically increase water demand while at the same time increase rate of pollution of the water resources. To sustain water resources all parties should strive towards sustainable water resource management no matter rural or urban. However management in rural area is very important as in many cases the water discharged by water users in rural areas become the source for urban water supply. For proper and sustainable resource management, water should be regarded as scarce economic resources. It cannot be viewed as fragmented discipline but it must be managed an integrated and holistically manner.

5.2 Conclusion

Based on the ANOVA result in chapter 4 above, it can be concluded that there are significant correlations which answered the problems pertaining to water resource management previously stated that:-

(a) this study have been able to establish evident of water depletion and the sources of water depletion determined based on the local populations' perception,

(b) there are evident of water quality deterioration and the causes ascertained based on the perception of the local population and

(c) finally this study have been able to establish the relationship between the respondents' age and level of education on their perception on causes of water resource depletion and quality deterioration.

It must be admitted here that the quality of this study could have been better with bigger samples and covering a wider area. However, given the chance to do so, a better and more thorough study of this nature can be done with better results.

5.3 Recommendations

The outcome of this study strongly indicated that management of water resources in rural areas need to be done in an integrated and holistic approach before depletion of water resources becomes a reality. It can be done thorough various approaches which are outlined below.

5.3.1 Water catchment conservation and protection approach

One of the many ways by which water resources can be managed is by protecting its sources. Water catchment need to be recognises as protected area. Totally protected area status may not be possible in most cases. However protection must be done to ensure the water sources comply with minimum water quality standards based on its intended use. To do so, vegetation cover should be conserved. No indiscriminate cutting of trees in large scale allowed.

5.3.2 Water distribution

Water need to be distributed equitably among the local population. In the case of rural water scenario, this might not be so simple. However whatever water that is available should be

used wisely. The leakage of pipe supplying water to individual household should be repaired without delay.

5.3.3 Watershed protection and conservation approach

Water resource conservation must not be limited to conservation and protection of portable water. It should take into consideration issue like waste water disposal. As water bodies such as rivers belong to the society. To protect them, it has to be community based and any idea brought forward must be feasible and accepted by the local population. It need not be high tech in nature but workable. He added that the pilot project locally known as "*Tagang System*" undertaken by the Fishery Unit of the Agricultural Department. The word *Tagang* is an Iban word which means prohibit, or stop. The system basically is the release of fish fries into the stream to multiply. This can only be successful if the water in the river is clean enough to survive. This system needs local community participation to ensure that the rivers are not heavily polluted. To do so, the local community have to strive for a better system to treat the water so as to make the water discharge into the river will not become source of pollution. To make this possible, he suggested that private sectors carry out adoption programme under the supervision of the relevant authority preferably the Sarawak River Board. There need to be an enabling environment and political backing. The ministry of Environment should take the initiate to sell the idea to the general public. The participating parties should include the Natural Resources and Environmental Board, The Sarawak River Board, Padawan Municipal Council and the Ministry of Tourism

This system basically is the releasing of fish fries in the selected parts of the rivers and the villagers involved must agree not to carry out fishing activities five kilometres upstream and downstream from the release point.. The period given will be until the fish reach maturity and

reproduce. After that the villagers are allowed to fish and release or purchase the fish at market price. By doing so, the community have reasons to protect their rivers. The rivers which once being the source of water for the villagers might be one day become source of income for the villagers living near the rivers.

5.3.4 Income generating activities

Water resources in rural areas have great income generating potential. It is not by selling water but by protecting its cleanliness. The annual rafting event conducted by the Padawan Municipal Council (MPP) is also a good platform to create awareness on river cleanliness, safety and potential. This activity should include school, Institute of Higher learning and corporate bodies. It should be well publicised to attract more people to the event. Great picnic spot can be developed and promoted. The must be continuous effort to create awareness among the local communities so as to treasure the rivers an important asset which can be developed to generate income for the communities.

5.3.5 Eco-development

In line with the status of being gazetted as Water catchment Reserve in 1994, no large scale land development is allowed to be carried out within the watershed. The nature's potential of this area can be tapped through eco-development. The most promising potential that can be seen in the study area is eco tourism. This is because as discussed in the literature review, there must be benefit derived from protecting the natural environment. The rivers that passed through Bengoh, Danu, Semadang and Giam have once been famous for exotic fish like *Empurau* and *Semah*.

5.3.6 River adoption programme

River adoption programme may be one of the approaches whereby it needs corporate sectors involvement through financial. Sarawak River Board can be matchmaker for this system.

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APPENDIX A

QUESTIONNAIRE

STUDY ON WATER RESOURCE MANAGEMENT IN RURAL AREAS

PART I

1 **RESPONDENT ID(REFER TO NAME LIST):**

2 **PLACE OF INTERVIEW**

PLEASE MARK (√) IN THE BOXES WHERE APPLICABLE.

3 **RESPONDENT CATEGORY**

HEADMAN

COMMITTEE MEMBERS

Villager

4 **AGE (IN YEARS)**

18 and younger

18 - 25

26 - 40

41 - 55

55 and older

5 **GENDER**

Male

Female

6 **EDUCATION LEVEL**

NO FORMAL EDUCATION

PRIMARY EDUCATION

SECONDARY EDUCATION

TERTIARY EDUCATION

7 **OCCUPATION**

UNEMPLOYED ☐

PUBLIC SECTOR/GOVERNMENT ☐

PRIVATE SECTOR ☐

SELF-EMPLOYED ☐

OTHERS (SPECIFIED) ☐ _____

8 **MONTHLY INCOME LEVEL**

LESS THAN RM 500 ☐

RM 501 - RM 1000 ☐

RM 1001 - RM2000 ☐

RM 2001 - RM 4000 ☐

RM 4001 AND ABOVE ☐

9 **WHAT IS YOUR SOURCE OF WATER**

DIRECT FROM STREAM AND RIVERS ☐

PIPE GRAVITY FEED ☐

RAIN WATER ☐

PIPE GRAVITY FEED AND RIVERS ☐

PIPED GRAVITY FEED AND RAIN WATER TANK ☐

10 **HOW OLD IS THE WATER SUPPLY SYSTEM IN THIS AREA**

0 - 5 YRS ☐

6 - 10 YRS ☐

11 - 20 YRS ☐

> 20 YRS ☐

PART 2

FOR THE FOLLOWING QUESTIONS TICK (√) IN THE BOXES INDICATING YOUR OPINION.

STRONGLY AGREE	1
AGREE	2
MODERATLY AGREE	3
DISAGREED	4
STRONGLY DISAGREE	5

1	**MAINTAINING & REPAIRING THE WATER SUPPLY SYSTEM IS THE RESPOSIBILTY OF THE COMMITTEE**	1	2	3	4	5
2	**MAINTAINING & REPAIRING THE WATER SUPPLY SYSTEM IS THE RESPOSIBILTY OF THE GOVERNMENT**	1	2	3	4	5
3	**REPAIR COST OF WATER SUPPLY SYSTEM SHOULD BE BORNE BY THE VILLAGERS**	1	2	3	4	5
4	**THE VILLAGERS SHOULD HAVE FUND FOR WATER SUPPLY**	1	2	3	4	5
5	**THE FUND COLLECTED IS A BURDEN FOR THE VILLAGERS**	1	2	3	4	5
6	**THE WATER CATCHMENT AREAS SHOULD BE FULLY PROTECTED AND UNDISTURBED**	1	2	3	4	5
7	**THE WATER NOW IS HEAVILY POLLUTED**	1	2	3	4	5
8	**POLLUTION IS MAINLY CAUSED BY THE VILLAGERS**	1	2	3	4	5
9	**POLLUTION IS CAUSED BY AGRICULTURAL**	1	2	3	4	5

10	**POLLUTION IS MAINLY CAUSED BY HOUSING DEVELOPMENT**	1	2	3	4	5
11	**POLLUTION IS MAINLY CAUSED BY DEFRORESTRATION FOR TIMBER/LOGGING**	1	2	3	4	5
12	**POLLUTION IS MAINLY CAUSED BY DEFRORESTRATION FOR PLANTATIONS**	1	2	3	4	5
13	**WE ALWAYS FACE WATER SHORTAGE**	1	2	3	4	5
14	**SHORTAGES OF SUPPLY IS ALWAYS IN THE EVENING/PEAK HOURS**	1	2	3	4	5
15	**WATER SHORTAGE IS CAUSED BY AGRICULTURE ACTIVITIES**	1	2	3	4	5
16	**WATER SHORTAGE IS CAUSED BY LOGGING ACTIVITIES**	1	2	3	4	5
17	**SHORTAGE IS CAUSED BY NATURAL PHENOMENA**	1	2	3	4	5
18	**WATER SHORTAGE IS CAUSED BY LEAKAGES AND BROKEN PIPES LINES**	1	2	3	4	5
19	**WATER SHORTAGE IS CAUSED BY WASTAGE AND ABUSE**	1	2	3	4	5
20	**OUR WATER SUPPLY IS SAVE**	1	2	3	4	5
21	**BOILING MAKE WATER SAFER TO DRINK**	1	2	3	4	5
22	**FARMING AND GARDENING IN THE WATER CATCHMENT AREA IS DANGEROUS**	1	2	3	4	5
23	**MORE RELIABLE WATER SOURCES IS NEEDED FOR THE VILLAGERS**	1	2	3	4	5

24	**WATER NEED TO BE USED WISELY**	1	2	3	4	5
25	**THE WATER CATCHMENT AREAS SHOULD BE PROTECTED BY THE LAWS**	1	2	3	4	5
26	**CLEAN WATER SUPPLY CAN HELP TO PREVENT SPREAD OF DISEASES**	1	2	3	4	5
27	**I AM SATISFIED WITH THE CURRENT WATER SUPPLY QUALITY**	1	2	3	4	5
28	**I AM SATISFIED WITH THE CURRENT WATER SUPPLY SYSTEM**	1	2	3	4	5
29	**WATER SUPPLY IS CAN BE AFFECTED BY CLIMATE CHANGE**	1	2	3	4	5
30	**RURAL VILLAGES MUST HAVE TREATED WATER SUPPLY**	1	2	3	4	5

THANK YOU FOR YOUR COPERATION

STUDY AREA

DISTRICT: KUCHING						
AREA: BUNUK						
No.	**Name of village**	**Name of Headman**	**No. of doors**	**Population**	**Types of Water - supply**	**Date of completion**
1	**DANU**	**AHIT AK NAII**	**51**	**154**	**PG**	**13.05.99**
2	**BENGOH**	KAYIS AK GANYAI	91	492	PG	05.08.92
3	**TABA SAIT**	NANAK AK BAGO	50	342	PG	12.08.93
4	**PAIN BOJONG**	TATUK AK SIMBAS	32	206	PG	25.05.01
5	**SEMBAN**	BUJUS AK KIAN	48	343	PG	03.08.73
6	**PEL. REJOI**	REPON AK TESON	38	246	PG	16.10.83
7	**SIKOG**	BUDI AK SANJON	151	944	PG/TAH	1996
8	**MAMBONG**	DORIK AK TIMA	180	1111	PG	1982
9	**BANGAU**	SIMEK AK BAEH	42	263	PG	10.12.88
10	**PETAG**	JATONG AK BANA	65	431	PG/TAH	14.07.94
11	**SITANG**	JNJUNG AK RAMA	46	252	PG	05.10.98
12	**RABAK SIMBOK**	SIJIP AK MAJAN	44	226	PG	11.10.96
13	**BUNUK**	BUNDU ANAK SUWAP	388	2318	PG	17.08.96
14	**PUNAU**	JOSEPH AK NAYAB	90	507	PG/TAH	30.06.90
15	**SAAH**	JOSEPH AK NAYAB	27	142	PG	30.06.90
16	**BAWANG**	UNJIU AK NYATUT	122	722	PG	21.05.88
17	**BERATAN**	BIKAR AK BASENG	136	786	LAK	2005
18	**SIBATUH**	BIKAR AK ABAESNG	21	134	LAK	2005
19	**KARU**	HENRY SUWOT AK SAWAR	136	822	PG/TAH	13.04.01
20	**SEMADANG**	SAMSON AK MANGANG	84	519	PG	30.08.01
21	**GARUNG**	TOMMY DIHED AK DIUM	116	829	PG	22.10.96
22	**GIAM LAMA**	SAB AK SAMBAT	38	205	PG/TAH	13.10.01
23	**GIAM BARU**	HARRISON SANGO DOMBA	64	430	PG/TAH	07.01.96
24	**GIT**	KIDAT	60	350	PG	06.02.96
25	**GERAIT**	ROBERTSON SONJA AKIL	46	325	PG	2002
26	**BAYUR**	ROIBAT AK SOM	63	308	PG	22.12.06
27	**TIMURANG**	BOM AK AMER	30	168	PG	15.08.01
			2259	**13575**		

Source: Divisional Health Office, Kuching

Monthly Physico – Chemical Analysis for Raw Water Sources

Batu Kitang Water Treatment Plant for Month Of April, 2012

Location / Parameter		Total	Batu Kitang Intakes	RW - Kampung Batu Kitang	Sungai Sarawak Kanan	RW – Kampung Keranji	RW- Kampung Seniawan	RW- Kampung Buso	Sungai Simboh	Sungai Staat
Samples analysed		57	19	12	11	3	3	3	3	3
Colour (Hazen)	Min.	30	40	40	50	50	40	30	30	
	Avg.	49	51	55	67	73	67	40	40	
	Max.	70	70	80	80	90	90	50	50	
Turbidity (NTU)	Min.	16	14	13	17	18	19	19	19	
	Avg.	69	48	50	53	55	55	40	40	
	Max.	392	81	115	86	91	87	63	63	
(Al^{3+})	Min.	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	Avg.	0.06	0.07	0.02	0.02	0.01	0.02	<0.01	<0.01	
	Max.	0.12	0.60	0.06	0.04	0.02	0.03	<0.01	<0.01	
pH	Min.	6.9	6.9	6.8	6.9	6.9	6.9	6.9	6.9	
	Avg.	7.0	7.1	7.0	7.0	7.0	7.0	7.0	7.0	
	Max.	7.1	7.9	7.1	7.1	7,1	7.1	7.1	7.1	
($CaCO_3$)	Min.	8	28	20	24	24	20	20	20	
	Avg.	23	32	35	33	28	29	31	33	
	Max.	41	44	50	40	36	40	36	44	
($CaCO_3$)	Min.	14	12	12	52	44	60	42	44	
	Avg.	48	56	60	66	53	62	59	63	
	Max.	90	104	126	80	60	66	68	76	
Solid (TDS)	Min.									
	Avg.	19	25	23	34	28	27	31	32	
		32	35	35	36	31	32	33	34	
	Avg.									
	Avg.	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	Avg.	-	-	-	-	-	-	-	-	
		-	0.01	0.01	0.01	0.02	0.02	0.01	0.01	

Source : Kuching Water Board (2012)

Annual Physico-chemical Analysis for Raw Water Quality – Kuching Water Board, 2010

2010 month / Parameter		Batu Kitang raw water intake point												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Sample Analysed		20	17	23	21	20	20	22	21	20	21	21	21	247
Colour (Hazen)	Min	20	40	30	35	20	20	30	10	20	30	30	20	10
	Avg	56	61	51	69	63	50	55	46	58	43	51	61	55
	Max	95	95	80	250	130	85	95	80	175	80	80	150	250
Turbidity (NTU)	Min	20	12	17	15	19	7.8	13	19	12	15	24	13	7.8
	Avg	83	50	57	61	70	44	63	40	49	44	57	59	56
	Max	334	189	160	243	213	220	266	115	340	179	232	199	340
Residual Alum (Al^{3+})	Min	0.05	<0.05	<0.05	0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Avg	0.15	0.09	0.10	0.14	0.14	0.05	0.04	0.04	0.03	0.04	0.05	0.03	0.08
	Max	0.35	0.20	0.25	0.35	0.25	0.15	0.20	0.16	0.11	0.19	0.22	0.15	0.35
pH (H^+)	Min	6.3	6.8	6.9	6.5	6.1	6.9	6.7	6.9	6.4	6.9	6.9	6.5	6.1
	Avg	7.0	7.0	7.0	6.9	6.8	7.0	7.0	7.0	6.9	7.0	7.0	6.9	7.0
	Max	7.1	7.1	7.1	7.1	7.1	7.1	7.5	7.1	7.1	7.1	7.1	7.1	7.54
Total Alkalinity ($CaCo_3$)	Min	4	8	16	8	18	4	8	8	8	20	8	4	4
	Avg	19	23	16	23	25	19	23	26	15	27	23	13	21
	Max	28	32	36	36	36	40	40	40	28	44	40	28	44
Total Hardness ($CaCo_3$)	Min	10	30	10	14	18	10	10	12	12	28	12	10	10
	Avg	33	41	29	31	61	32	31	36	27	44	33	27	35
	Max	52	54	54	58	50	50	46	54	48	58	42	48	58
Total Dissolved Solid	Min	19	20	16	17	20	26	18	20	18	21	26	17	16
	Avg	32	31	31	30	31	37	36	33	34	39	34	33	33
	Max	56	38	41	40	40	47	49	45	46	50	41	44	56
Ammonia (N)	Min	0.04	0.02	0.04	<0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.02	0.04	<0.02
	Avg	0.13	0.12	0.14	0.13	0.19	0.10	0.15	0.11	0.13	0.36	0.16	0.14	0.16
	Max	0.52	0.40	0.52	0.28	0.72	0.20	0.52	0.24	0.36	1.02	1.04	0.44	1.04
Total Iron (Fe^{3+})	Min	0.10	0.20	0.15	0.20	0.10	0.15	0.16	0.10	0.10	0.20	0.20	0.15	0.10
	Avg	0.69	0.86	0.70	0.78	0.58	0.32	0.58	0.45	0.75	0.87	0.64	0.68	0.66
	Max	2.5	2.20	2.50	2.80	1.20	0.80	1.80	0.90	3.50	2.00	1.60	1.40	3.50
Chloride (Cl)	Min	<0.5	0.5	0.5	<0.5	0.5	0.5	0.5	<0.5	<0.5	0.5	<0.5	0.5	<0.5
	Avg	1.2	1.0	1.1	1.1	0.9	1.3	1.0	1.0	1.1	1.5	1.2	1.1	1.1
	Max	2.5	2.5	2.5	2.5	2.5	3.0	2.5	2.5	2.5	2.5	2.5	1.5	3.0
Suspended Solids	Min	14	4	8	4	5	4	6	8	6	7	11	1	1
	Avg	87	47	38	43	57	39	54	30	36	40	57	51	48
	Max	330	144	127	204	181	232	229	99	312	164	208	230	330
BOD	Avg	2.5	2.1	2.1	1.4	1.9	1.7	0.9	1.9	1.7	1.2	1.2	0.8	1.6
Cyanide	Avg	0.03	0.02	<0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
Silica	Avg	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	Avg	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Kuching Water Board (2010)