5 Water Group results

The result of the study carried out on the water resource in Kundasang is presented in this chapter. As the aim was a holistic understanding of the water resource various methods were used to gain information about the: *Distribution, quality and quantity of the water resource.* This variety of method is due to the idea that one single methods will not be sufficient for analysing a natural resource.

The methods used were water sampling to measure the quality of the water, and a flow meter to get an idea on how to estimate the quantity of water. Furthermore different interview methods were used to understand the human action and thinking regarding the water resource. Twenty one users of the resource were interviewed. They were mostly farmers, except for some hotel and restaurant owners. The health condition in Kundasang was briefly investigated by interviewing the local health clinic and the Ass. Director of the hospital in Ranau. Mr. Chung and the Group Manager at KPD were some of the key informants who contributed with information about the technical description of the system, as well as their view upon the consumers and the institutional arrangement. These latter subject was also the aim when interviewing other key informants as the Ass. District Officer and the Head of Division of DID in Ranau as well as the Ass. Director of state DID. All together 31 people have been interviewed. If nothing else is stated, the information is our own findings.

From the information the present water resource, distribution and management in Kundasang will be described. In the common discussion the present system and its capability to cope with future changes will be discussed.

5.1 Distribution

In the distribution section the focus is put on catchment area and the supply system will be described physical as well as technical. This section will furthermore, look into the human actions and perspectives from the users and institutions.

5.1.1 The water catchment area

The main part of the catchment area for Kundasang is located in the Mt. Kinabalu National park. The water drains into two river systems which make up the water supply for Kundasang.

One situated in the western part is the Sungai (river) Liwagu. The other river system is the Sungai Mesilau in the eastern Kundasang area (appendix 1). KPD is managing the water supply system in Kundasang. The system has four intakes. Three of them are situated in the Sungai Mesilau river system. These are the Mantaki, Mesilau East and Mesilau West. The fourth intake which is the Kamaowanan intake is located on the Sungai Liwagu. The main part of the KPD-water is supplied from the Sungai Mesilau river system where the main intake is located at Mesilau West. There are a lot of farmers who get their water from private intakes. These farmers get their water from the river or stream nearest to the farm. As many farmers are situated near the Sungai Liwagu, this river have an important function in supplying the private pipelines in the Kundasang area. The run-off from Kundasang drains into the Naradaw river.

5.1.2 Technical description of the KPD-system

All of the KPD intakes are more or less build in the same way. The river is dammed up in a small pond. The water is led through a rough mechanical filter directly into the pipeline system. The overflow continues its flow in the riverbed. The main intake for KPD at Mesilau West is a bit different from the other intakes. Approx. 200 m after the intake the pipe runs into a sedimentation tank. A sedimentation tank is a tank where the flow rate will decrease so sand and silt particles will have time to settle. The sedimentation tank has an overflow pipe which runs out in the river.

From the intakes the water flows directly to the 12 steel tanks situated in the area (See appendix 3). From the Mesilau West intake 0,54 MGal a day flow to the treatment plant which consists of 2 valve less automatic water filters and a storage tank. This tank has a capacity of 250000 Gal. The households and the farms before the treatment plant get the water without any treatment directly from the main pipes (Chung, pers.comm.).

At present, the gravity driven system can not support the outer areas in the system sufficiently. As long as the system only gets pressure from gravity a further expansion of the system will not be possible (Chung, pers.comm.).

The maintenance of the system is KPD´s responsibility. If a user of the system locate a leakage or some other malfunction they can report it to the KPD who will come and repair it. In general this is working out fine (farm interview), but at some places there were leaks for the ten day period we stayed in the area and they were not repaired.

A lot of the pipelines are lying above ground. This is an advantage because it makes it easier to locate the leaks and easier to repair it (Chung, pers.comm.). The disadvantages are that the pipes are more exposed to human activity and natural components (mud slides, heavy rain ect.). The steel tanks for storage of the water are not in the best of conditions. The tanks are leaking quite a lot of water. We have no data on how much they actually leak. The result is based on visual observations only.

5.1.3 The users

Water is used by farmers, households, social and commercial activities in the Kundasang area. KPD is supplying 940 households in 21 kampongs, 360 farms, commercial and social activity in Kundasang .

The water can be paid either by flat-rate or according to water meter. The flat-rate for irrigation water is 40 RM pr. ha per month. The payment for constructions is paid by the farmers themselves. They have the opportunity to take a loan free of interest from KPD. A farmer mentions a prize of 1000 RM for the system. Because of the possibility to take advantageous loans most farmers can expand the irrigation system. This financial support provides the farmer the opportunity to increase the area which is cultivated.

Most of the households whom KPD supplies pay monthly flat-rate. The flat-rate is independent of the amount of water they use. The current payment is either 5 or 10 RM per month. The 5 RM is paid by the users living in the outer areas of the KPD-systems due to the low water pressure in these areas. The 10 RM is paid by the users who are centrally placed in the system. Here the water pressure is high and more continuous. Concerning the commercial activities, KPD states that the hotel Perkasa is paying 2800 RM per month. This payment is the hotel's guarantee for being ensured water even in the dry season (Mr. Chung, pers.comm.). Fairy-Garden hotel is in another situation, the KPD has asked the hotel to be self-supplied, because the KPD is not able to supply them.

KPD has recently introduced a new payment system which is a water meter payment of 4 RM

per 1000 gallon. There is a general dislike from the users point of view regarding the water meters. One of the dislikes is that it would be more expensive for the users. The KPD disagrees on this statement, because they believe that the users will change their behaviour and therefore use the water in a more economical feasible way. At present KPD thinks that there is a large over consumption of the resource (Mr. Chung, pers., comm.).

When using the semi-structured interviews (see appendix 5) the respondents seem satisfied with the amount of water they received. In a combination with the PRA method, matrix-scoring, it was possible to get some more sensible information from the users.

The matrix was made so the respondent should define the water users in some categories. This gave a broad set of groups from the respondents, because they had different opinions and knowledge about who is consuming water in the Kundasang area. Most respondents mentioned and specified only groups closely situated next to the respondents residence. The variety of groups which were mentioned were farmers, households, the respondent's kampong, the neighbouring kampong, Kundasang, salesmen, hotels, restaurants, police, school, church, mosque and the community house. The choice of the respondent was to some extent influenced by the interpreter, if examples of the groups were given.

The topics addressed in the matrix was: Which groups were using, polluting and paying for the water. The matrix was also focussing on which groups had the best opportunity to receive additional water (see appendix 4).

Concerning the users it was generally stated that the farmers were the group which used the most. But many other groups were mentioned to this question.

The issue of who is polluting the water was a difficult task for many people to understand. The difficulty was concerning the respondent's understanding of the term pollution. Even though it was an unclear term for a lot of the respondents, there was a tendency towards the farmers being the group which polluted the most. Many farmers were actually aware of their role as polluter. However the matrix only stated that the farmers pollute the most, and it did not show if this pollution was crucial or alarming for the area.

Even though the users seemed satisfied with the amount of water they received, there was a tendency towards the attitude that they thought they were paying too much for the water. This opinion had an influence on the users behaviour, because some people bypass KPD's system

because their own cost-benefit analysis. Therefore some users construct their private pipelines. In the long term this can undermine the KPD's management, if a equilibrium is not found.

The users opportunity to receive more water is linked to the power of the different groups in the Kundasang area. The information from the matrix did not give a clear overview of who had the best opportunity. However those respondents who mentioned the hotels as a category meant that the hotels had the most influence on the distribution of the water. Apparently the opportunity for the users to receive additional water was more linked to the present use than the payment of the resource.

A part of the interviews were trying to identify, if there were any formal or informal organisation on how to install private pipelines. In some kampongs they organise internally who are entitled to put private pipelines in the streams. In one kampong there is a rule that locals do not need a permission to make a private pipeline while foreigners have to get a permission from the kampong which can be given after a kampong discussion. Another rule found in the study area is that a farmer was allowed to block the stream completely for those further downstream.

Some farmers argue that as long as they do not take all the water from the stream there will be no reasons for complains from those downstream. This attitude seems to be common for all kinds of farmers: those taking water themselves, those having intakes downstream from others intakes and those being supplied by KPD. In general there was not any perception that private intakes are unfair to other users. It also seems to be found legal making private intakes, despite the rules of KPD and the state (see section 5.1.4 on institutions). It is not even considered illegal from the farmers point of view to have a private installation connected to the pipes of KPD.

While KPD rules and state legislation concerning intakes were not strictly respected, timetables seem to be kept. The time-tables are co-ordinating when the farmers are using water during the dry season. The time-table are made as an agreement between KPD and the kampong leaders. As an example of the difficulties in respecting the different rules, one farmer had an illegal addition to KPD's pipe and at the same time he found it very troublesome that he was using labour to go from field to field to respect the time-tables.

The users were not interested in any alternative system because the current system was seen as the best guarantee for water supply. Some farmers complain that they were bound to have their own supply because they could not afford to pay KPD. Concerning the potential alternatives

the respondents were asked about their viewpoints on the unique system of KPD's integrated system of irrigation and household.

The farmers have different opinions on KPD's work but basically KPD is said to be doing a good job. Anyway the argument of having a private intake in addition to the supply from KPD for the sake of safety was often mentioned.

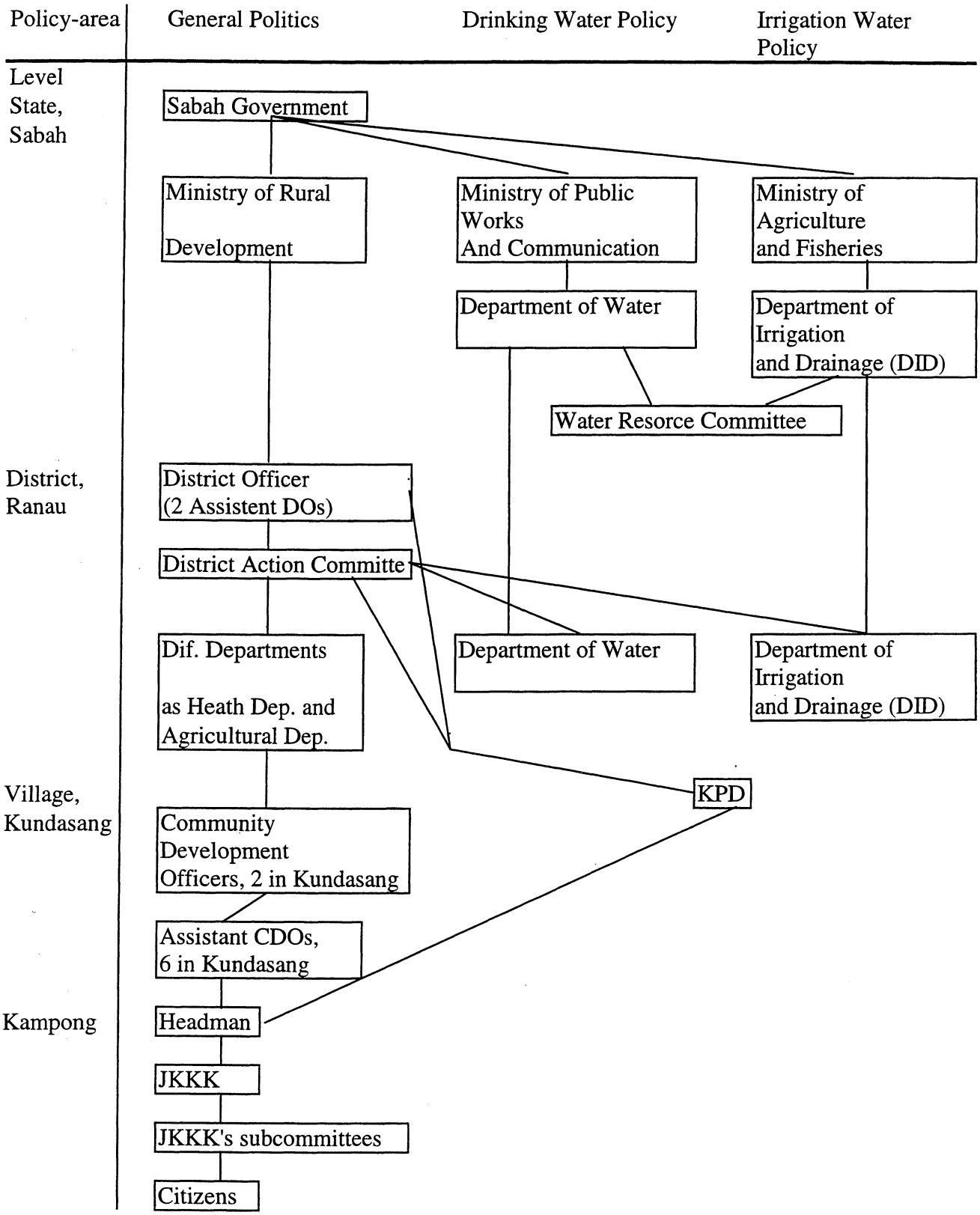
5.1.4 Institutional arrangement

The unique situation of Kundasang is that the agricultural organization (KPD) is responsible for the water supply management. Anywhere else in Sabah it would be another governmental institution which would be in charge of the water supply. This situation is due to the former State Prime Minister who in 1976 was asking for a better water management in Kundasang. Before this the local Department of Irrigation and Drainage (DID) had implemented an irrigation scheme, which was maintained by the Public Works Department. The State Prime Minister gave the authority to a friend who at that time was the chairman of KPD (Prof. Mohamad, pers.comm.).

The institutional arrangement is illustrated to get an idea of how the many institutions involved interact in the water resource management (the organisation diagram made by inputs from Ass. Director N.G. King, state DID, Head of DID in Ranau, Philip Chung and Group Manager at KPD, Assistant District Officer in Development in Ranau, Prof. Mohamad & Ass. Prof. Oksen).

In the institutional arrangement the focus have been concentrated on the interactions at the district level. As shown in the organisation diagram, the District Officer and the district's board "the District Action Committee" have an important position. The District Officer and two Assistant District Officers (ADO) are civil servants who are appointed by the state government. The District Officer is considered as the leader of the district and this can be a life-long position (Prof. Mohamad, pers.com). In the District Action Committee different institutions e.g. the Departments of Water, the Department of Agriculture, the Department of Health and the Department of Irrigation and Drainage participate in the meetings of the committee, if there is a subject within their resort. If the water management in Kundasang is on the agenda, KPD and other relevant actors are invited to take part in the meetings. This could for instance be hotels (ADO in Development, pers.comm.). Partial for securing the political element in the committee two politicians elected in Ranau for the State Assembly are also participating.

Figure 2 Institutional arrangement



This unique institutional arrangement is due to KPD's role as manager of the water resource in Kundasang. KPD's overall goal is rural development and their target is mainly focusing at the agricultural production. So when KPD is dealing with water supply it is a special task, and the organisation at state level is perhaps not considering the management of water. It may only be at the Kundasang level that the organisation is concerning about water supply.

At other places in Sabah it is the district Department of Water which takes care of the drinking water management and the Department of Irrigation and Drainage (DID) which would be in charge of the irrigation management. These departments would co-operate in a Water Board. This is not the case in Kundasang.

The water supply system in Kundasang is an integrated system, which means there is no differentiation between the water for drinking purposes and the irrigation water. This is reflected in the institutional arrangement. Normally the overall organisation of KPD is referring directly to the Ministry of Agriculture and Fisheries, but when KPD is working with water, it must refer to the Department of Water and the DID. The first mentioned department is under the Ministry of Public Works and Communication, while DID is under the Ministry of Agriculture and Fisheries. This can course institutional conflicts, because the different ministries have different policies.

Considering the Kundasang level, an important distinction has to be made between the authority to control and the authority to supply. The DID and the Department of Water have usually the authority to control and supply both the irrigation system and the drinking system as above mentioned. But because of KPD's responsibility in Kundasang as the authority to supply, there is a division of the duties. Concerning the irrigation water, KPD has made a distinction between themselves as supplier and the authority to control. KPD consider the DID as the authority to control. However the DID does not consider themselves as the controlling authority, and thereby pretends that KPD is the only authority in Kundasang.

Between the DID and KPD there is limited communication and co-operation (Head of DID in Ranau and Chung and Group Manager, 1998). It appears that the two institutions have different understandings in the division of authorities which may result in a lack of control concerning the management of the irrigation water. Considering the drinking water, KPD did not mentioned any interaction with the district Department of Water, and the latter department was not available for an interview during our stay in Kundasang.

Too much emphasis on institutional setup; too little exposition of concrete practices regarding supply, monitoring, maintenance, enforcement

The limited communication, between KPD on the one hand and the two institutions the DID and the Department of Water (both at district as well as state level) on the other hand, may change the institutional arrangement. The influence on the institutional arrangement is concerning the link between the political decisions made by the state politicians and the implementations made by KPD. It may give a better opportunity for the DO to be involved, because he arranges the communication between the two departments and KPD. The DO is therefore always involved in the political decision. This is illustrated in the organisation figure 2. It may be so that the DO is more concerned about other local interests and these contradicts with the overall state policies.

The people can by voting participated in the political system at the federal, state, and kampong level. The voters have to elect two politicians from the district to the Federal as well as the State Assembly. Furthermore the people can elect one headman at kampong level. This leaves the district (Ranau district) and the local (Kundasang village) level without any direct elected politicians.

The following part is concerning the legislation on the water resource. The water resource in Sabah is defined as a state property by Ass. Director in state DID, N.G. King. In opposition to this the KPD considers water as a common property. For the time being there is no state legislation concerning the use of the resource (Ass. Director in the state DID N.G. King and KPD). The present legislation only concerns the construction and the sale of the water resource. This gives a certain institution the authority to construct and manage the sale of water in an area (Ass. Director NG King, state DID). In Kundasang KPD is given the authority to deal with both things. But the users of water have the opportunity to apply for a permit to construct their own pipelines at the District Office (ADO and district DID). Therefore, it is not illegal to use the water, but to construct a private pipeline without permission.

As a consequence of having the authority to manage the resource without voluminous legislation in the area, KPD has made some rules to protect their work. KPD has made their own policy, which states that private users are not allowed to take water upstream a KPD intake (Philip Chung and Group Manager, KPD). Although KPD's authority only gives them the right to manage and not legislate. In the State legislation their is no bill stating where private users are allowed to take water in the rivers or streams (Ass. Director NG King, state DID). The KPD is facing problems when it comes to enforcing their own rules, because they do not have the power behind it (Philip Chung and Group Manager at KPD).

It is seen that the farmers construct their own pipelines (farmer int. and Philip Chung and

Group Manager at KPD) which may be illegal according to the state legislation, but the farmers know that no authority will enforce the legislation. If the construction is upstream the intakes of KPD it will also circumvent KPD's policy. In a situation where KPD acknowledge that private pipelines are constructed illegally then KPD will give the law-breaker several warnings before removing the pipelines. Another way of doing it is talking to the local kampong headman about the specific cases (Philip Chung and Group Manager at KPD). This can be seen as a far more pragmatic way of finding solutions, than in the rest of Ranau District. When DID, which is in charge of the irrigation water supply in the district except for Kundasang area, finds illegal pipelines they just cut it (DID in Ranau). As DID daily is checking their pipelines for maintenance, they can also check for illegal use of the water resource (DID in Ranau). KPD would also like to check their pipelines and thereby have a better overview of the current situation, but due to lack of manpower it is not possible (Philip Chung and Group Manager at KPD).

The more pragmatic way of dealing with illegal pipelines is perhaps due to the fact that the irrigation users in Ranau are citizens and do not pay any fee for the irrigation water while users in Kundasang are consumers of KPD and are charged for their use of water. Therefore KPD has to be more gentle towards their users than DID to their citizens in Ranau.

There are changes on their way in the water policy concerning the institutional arrangement as well as the legislation. The main change will have its background in the bill which has been prepared the last three years, and may pass through the State Assembly next year in 1999 (Ass. Director NG King, state DID). One perspective is to get a more extensive and better legislation which is supposed to integrate the use of industrial, drinking and irrigation water. Another perspective is a change in the institutions arrangement, so it will be heading towards a more holistic view upon the water resource. Therefore both the input as well as the output of the water resource will be considered, which means that a waste water policy is on its way (Ass. Director in State DID N.G. King, Prof. Mutedza Mohamad and also Philip Chung and Group Manager at KPD).

The change in the institutional arrangement has already been started by establishing the "Water Resource Committee" at state level. This Committee is supposed to integrate the different aspect in the water resource management from various policies point of view. But the Committee has not been given that much power (Prof. Mohamad) and is more seen as an interim institution to the "Water Resource Council". The above mentioned bill hand over the state authority to manage the resource to the Council. By it the Council will have better opportunity to realise a integrated water policy. The Council will consist of 14 persons from

different departments and it will have the power to decentralise or centralise a certain task in the policy-making and management (Ass. Director NG King, state DID). The Council is going to be consisting of members from various departments as the Department of Agriculture, the Department of Tourism, the Department of Water and the Economic Unit (the most important institution). These different institutions have their own defined interests and thereby their own water policies which will make a clash of interests.

5.2 Quality

For the use of the water resource the quality is an important factor. Especially for the households where the water is used as drinking water the quality is an important factor. The quality of the water can be affected in different ways. The most important of these factors are dealt with in this section.

5.2.1 The effects of micro-organisms on the water quality

There are a lot of diseases which can be transmitted by water. It can be organisms such as viruses, protozoa and bacteria that transmit the diseases. A virus which could use water for transmitting could for example be the poliovirus. The amoebas and the parasite *Giadia lamblia* are some examples of protozoaen. Some of the most common bacteria which causes diseases are *Salmonella typhi* and *Vibrio cholerae*. All these organism's are associated with the intestinal tract in animals and humans. Therefore if the faeces from animals or humans gets into the water, the possibility for a transmitter route is established (Brock T.D et al. 1994). This can happen if there is a leakage in the pipes and sewage water get into the pipes or if the raw water contains bacteria and is not treated probably before drinking.

The most used indicator to determine the amount of micro-biological activity in the water is the *Eschericihia coli* (E.coli) which is one species in the coliform group. E.coli and the rest of the coliform group are good indicators because they are very rarely found living outside the intestinal tract and is therefore an indicator of faeces in the water (Jørgensen, 1998). At the same time coliform bacteria reacts in the same way as the patogenic organisms to treatment and die approximately at the same mortality rate as them (Brock T.D et al.,1994; Rowe & Abel-Magid, 1995).

The tests were probably exposed to sunlight before the analyse. This could have killed some of the coliform bacteria exposed to the ultra-violet light and by it lowered the amounts of coliform

bacteria. However the exposure to sunlight can not increase the amount of the coliforme bacteria. This should be taken into account when analysing the coliform results (Jørgensen, 1998).

The method used for the coliform tests is the Most-Probable-Number (MPN) procedure. The colony counts pr. 100 ml water sample where as follows:

Table 2 Coliform and E.coli counts from the Department of Chemistry in Kota Kinabalu.

	Coliform (MPN/100ml)	E.coli (MPN/100ml)
Before treatment plant	50	20
After treatment plant	20	20
Household near Kundasang	80	50
Naradau river	5500	200

There are some standards or maximum allowances for coliform and E. coli in drinking water set by Malaysian Food and Food Regulations act in 1985.

Coliform in drinking water max: 10 MPN/100ml)
E.coli in drinking water: not dectable.

For the raw water, DOE Interim Water Quality Standards for Malaysia have the standards:

Coliform in raw water: less than 5000 MPN/100ml.
E.coli in raw water: less than 100 MPN/100ml.

There is a difference between raw water and drinking water in Kundasang. The *raw water* is water which is untreated. The *drinking water* in Kundasang has received a mechanical treatment at the intake as well as on the treatment plant.

The results in table 2 shows the different colony counts. The counts before the treatment plant are acceptable for raw water.

After the plant and at the household the counts are too high for drinking purposes and are therefore not acceptable. This will increase the risk for getting some of the above mentioned diseases. One of the ways to get rid of the water borne diseases is to chlorinate the water. The chlorinating of the water will kill the micro-organisms. The chlorine also neutralise many organic compounds by oxidising them (Brock et al., 1994). Previously this procedure was

carried out in KPD`s system. This procedure was problematic because they only had manual injections of chlorine and the water volume from the gravity driven system varied a lot. Therefore there were to large fluctuations in the chlorine concentration. Therefore there is no chlorinating at present in the KPD-system (Mr.Chung pers. comm.). The people in the Kundasang area compensate for the lack of treatment by boiling their water used for drinking purposes (farm interviews). By boiling the water the micro-organisms get killed. Some of the respondents also treat the drinking water in other ways in order to make the quality acceptable for drinking. For instance that can be filtration through a cloth on the tap. Some say the water is yellow or brownish in rainy season, one says that it is in the dry season, and some mention this as a reason for boiling. Two persons mention the fear of getting diarrhoea.

The counts at the Naradau river are too high even as a raw water resource. The area of Kundasang drains into the Naradau river so it could be expected that this would be the place with the highest colony numbers because of the human activity in the area. One explanation for the very high numbers could be the management of the sewage water in Kundasang. Most of the households have septic tanks or perhaps not even this. If septic tanks are not working or are not maintained they just led the sewage water drain directly out into the ground.

At present the hospital in Ranau do not have any cases of water borne diseases from the Ranau district. The health clinic in Kundasang which weekly sends reports to the hospital in Ranau have not reported any cases either. The raw water in Ranau is regularly examined for E.coli and coliform. For the Kundasang area the tests are only carried out twice a year by the Department of Health (Mr. Chung, pers. comm.). The reason for these rare testing is that the Kundasang area is lying right beneath the water catchment zone in Mt. Kinabalu Nationalpark and therefore the sources for polluting the water are very sparse according to the Department of Health in Ranau.

When considering these colony counts one must take into account that they only represent a snapshot of the concentrations in the river and they are therefore not representative as a generalisation for the four test places. But if the counts are so high in periods there are definitely a need for some kind of control of the water. There is probably also a need for a better treatment system if the water contains so high amounts of E.coli and coliform even if they only are high in periods.

5.3.2 The effect of fertilisers and pesticides on water quality

The agricultural practices have a major impact on the soils capability of holding the natural nutrients as well as fertilisers and organic matter. Kundasang is a high input system which means that the farmers only will be able to produce as much as they do because they apply a lot of fertiliser and pesticides. When the problems related to fertilisers are brought up it is very important to state that the use of fertilisers is not adding any type compounds which is not in the soil already. Of course there might be formed some residues and compounds which will not naturally be in the soil (Petersen, 1994).

Generally there are two different types of fertilisers: Organic and inorganic. The organic fertiliser consists of animal residues and /or plant residues which primarily is organic matter and organic compounds. (Petersen, 1994; Taiz & Zeiger, 1991). Before the nutrients can be absorbed by the plants, they must be mineralised (Petersen, 1994). Therefore the nutrients will become slower available to the plants (Taiz & Zeiger, 1991). On the other hand the use of organic fertiliser do not give the farmers any chance for predicting the potential leaching that the organic fertiliser could provide the surroundings (Taiz & Zeiger, 1991).

Even after comprehensive analysis is carried out on the organic fertilisers the chances for any forecasts to be reliable will be limited. Another important aspect of using organic fertilisers is that they will improve the soils physical structure. By adding organic matter to a soil its water retention capacity during drought will increase and its drainage capacity during wet weather will increase as well (Taiz & Zeiger, 1991).

The inorganic/chemical fertilisers are salts which are usually produced in easily distributed granules. These granules will dissolve fairly easy and the salts will penetrate the soil (Dupriez &Leener, 1992). If too much is applied this will be subjected to direct run off if applied prior to a heavy rainfall. In the Kundasang area heavy rainfalls occur quite often. When the plant roots have fixed the amount of salts they need and the soil colloids have bound the salts the rest will accumulate in deeper situated soil layers (Dupriez & Leener, 1992; Petersen, 1994). Eventually these mineral salts will reach the water table which will mean that the ground water, eventually, will be unfit for consumption. On the other hand if managed correctly the inorganic fertilisers may not be contributing to leaching of nutrients to the soil water.

The three macro nutrients Nitrogen, Phosphorous and Potassium have differing mobility in the soil (Ahn, 1993). Analyses were carried out on Nitrogen and Phosphorous compounds. Nitrogen is a mobile nutrient which means that it will fairly easy be subjected to leaching (

Ahn, 1993; Petersen 1994). Phosphorous is a nutrient which is characterised as an immobile compound, and thereby its capability to be leaching into lower situated soil layers is low. One of the reasons for the immobility can be found in the fact that phosphorous is often found on insoluble forms (Ahn, 1993; Petersen, 1994). Potassium has a mobility which is situated somewhere in between the two previous described. Unfortunately no tests were conducted on this nutrient. The more mobile the compound is, the bigger the risk is for the compound to pollute the water. Nitrogen (in constitution such as nitrate and nitrite) is a potential health hazard for humans.

As an example could be mentioned the health risk for infants to get "methaemoblobinaemia", which is affecting the bloods capacity to carry oxygen (OECD, 1986).

Many countries experiences problems of high nitrate concentrations in the consumption water in areas of horticultural activity. This type of agriculture is often found at the edge of cities where the catchment areas may very well be located. Therefore, although the areas affected may not be very large, the water resource implications can be serious (OECD, 1986). Which is why it is found necessary to investigate the water resource in the Kundasang area.

In the Kundasang area the farmers used both kinds of fertilisers. The organic fertiliser used was mainly chicken residues. The process of releasing the nutrients will be slower than in chemical fertilisers. Poultry dung do have a high contents of Nitrogen, Phosphorous and Calcium Oxide compared to cow and pig manure (OECD, 1986).

The use of different pesticides are massive in the Kundasang area according to our interviews (farm interview). The need for pesticides and fungicides should be seen in the perspective of the cultivating practices. Many farmers were cultivating their crops as mono-cultures, but it is not unseen that the farmers use different kinds of intercropping techniques. Due to the Kundasang area being a highly productive area for vegetables, pests and fungi have relatively easy conditions for spreading. This is one of the main reasons for the large use of pesticides and fungicides.

Another very crucial reason is that the farmers do not have any monitor system, to tell them when to spray. Instead they spray regularly according to a table. This practice is not sustainable and will increase the possibilities for pesticides and fungicides to infiltrate the soil and contaminate the ground water. Being concerned about the pesticides contaminating the water resource, focus should also be put on the oxidation products which may be more hazardous than the pesticide itself because of their persistence or higher toxicity (OECD, 1986). Due to

the above stated cultivation practices it was believed that the raw water in the area was contaminated with different of the above mentioned compounds, especially regarding the run-off water from the area. As the areas above the KPD intakes were not cultivated it was believed that the amounts (if detectable) would be very low.

The only parameter which was expected be to high for human consumption was BOD_5, due to the low amount of purification taking place in the KPD system. It could be argued that the BOD_5 could not be that high, taking the low amount of suspended solids (turbidity) into consideration.

Table 3 (consists of 5 separate water analysis)

Results from Kumawanan

	date11.10.98	date 13.10.98	date 17.10.98
Hardness (EDTA)mg/l	very soft	very soft	very soft
Carbonate hardness	71.2	71.2	71.2
NH_4^+ Mg/l	Nd	Nd	nd
NO_2 Mg/l	Nd	Nd	nd
NO_3^- Mg/l	Nd	Nd	nd
PO_4^- Mg/l	0.25	0.50	0.50
Conductivityμms(in situ)	0.025	0.025	0.021
Conductivityμms (in lab)	0.03	-	-
Turbidity (JTU) (in situ)	23	-	21
Turbidity(NTU) (in lab)	1.36	2.84	1.29
DO_0 (diss. ox.)mg/l	7.59	7.33	7.28
$DO_{after\ 5\ days}$ mg/l	6.97	-	-
BOD_5 mg/l	0.62	-	-
pH (in situ)	6.96	6.40	6.83
temp in celsius	17.1	17.9	16.9

nd - not detected.

- - not measured.

Results from Mantaki

	Day of test 11.10.98	Day of test 13.10.98	Day of test 17.10.98
Hardness (EDTA)mg/l	very soft	very soft	very soft
Carbonate hardness	71.2	71.2	71.2
NH_4^+ Mg/l	Nd	Nd	nd
NO_2 Mg/l	Nd	Nd	nd
NO_3^- Mg/l	Nd	Nd	nd
PO_4^- Mg/l	0.25	0.50	0.50
Conductivityμms(in situ)	0.061	0.063	0.064
Conductivityμms (in lab)	-	-	-
turbidity (JTU) (in situ)	104	-	144
Turbidity (NTU) (in lab)	-	0.86	-
DO_0 (diss. ox.)mg/l	7.08	6.94	6.17
$DO_{after\ 5\ days}$ mg/l	7.01	-	-
BOD_5 mg/l	0.07	-	-
pH (in situ)	7.10	6.31	6.73
temp in celsius	15.3	16.0	15.8

Results from Mesilau East

	Day of test 11.10.98	Day of test 13.10.98	Day of test 17.10.98
Hardness (EDTA)mg/l	very soft	very soft	very soft
Carbonate hardness	71.2	71.2	71.2
NH_4^+ Mg/l	Nd	Nd	nd
NO_2 Mg/l	Nd	Nd	nd
NO_3^- Mg/l	Nd	Nd	nd
PO_4^- Mg/l	0.50	0.50	0.50
Conductivityμms(in situ)	0.033	0.071	0.034
Conductivityμms(in lab)	-	-	-
turbidity (JTU) (in situ)	43	-	90
turbidity(NTU) (in lab)	-	0.63	-
DO_0 (diss. ox.)mg/l	6.78	6.91	7.01
$DO_{after\ 5\ days}$ mg/l	6.96	-	-
BOD_5 mg/l	-0.18	-	-
pH (in situ)	6.60	7.22	6.41
temp in celsius	15.8	16.8	16.0

Results from Mesilau West

	Day of test 12.10.98	Day of test 13.10.98	Day of test 17.10.98
Hardness (EDTA)mg/l	very soft	very soft	very soft
Carbonate hardness	71.2	71.2	71.2
NH_4^+ Mg/l	Nd	Nd	nd
NO_2 Mg/l	Nd	Nd	nd
NO_3^- Mg/l	Nd	Nd	nd
PO_4^- Mg/l	0.25	0.50	0.25
Conductivityμms(in situ)	0.025	0.063	0.019
Conductivityμms (in lab)	-	-	-
Turbidity (JTU)(in situ)	581	-	16
Turbidity(NTU) (in lab)	-	0.86	-
DO_0 (diss. ox.)mg/l	7.03	6.94	7.10
$DO_{after\ 5\ days}$ mg/l	6.96	-	-
BOD_5 mg/l	0.07	-	-
pH (in situ)	6.87	7.10	6.31
Temp in celsius	16.3	16.0	15.7

Results from Naradaw

	Day of test 12.10.98	Day of test 15.10.98	Day of test 17.10.98
Hardness (EDTA)mg/l	very soft	very soft	very soft
Carbonate hardness	71.2	71.2	71.2
NH_4^+ Mg/l	Nd	Nd	nd
NO_2 Mg/l	Nd	Nd	nd
NO_3^- Mg/l	Nd	Nd	nd
PO_4^- Mg/l	0.50	0.25	0.25
Conductivityμms(in situ)	0.071	-	0.038
Conductivity μms(in lab)	-	0.11	-
Turbidity (in situ)	92	-	305
Turbidity(NTU) (in lab)	25.46	10.7	-
DO_0 (diss. ox.)mg/l	7.51	-	7.73
$DO_{after\ 5\ days}$ mg/l	6.85	-	-
BOD_5 mg/l	0.66	-	-
pH (in situ)	7.53	7.30	6.64
Temp in celsius	20.60	-	19.30

The tests indicate that the consumption water do have a very low amount of BOD_5 which shows that the water do contain a low amount of bacteria. Furthermore, the tests indicate that the fertilisers are not affecting the water resource seriously. All the above measured parameters are below the WHO standards. To be able to test the water for pesticides, heavy metals and cross check the parameters measured in the field, samples were send to a laboratory in Kota Kinabalu.

Which ?
State authorised ?

Water Test Results

(Samples collected on 14 Oct 1998 and submitted for analysis on 15 Oct 1998)

Parameters	Mesilau East	Mesilau West	Mantaki	Kamowanan	Naradaw
Hardness (EDTA) mg/L	20.8	14.9	38.6	24.8	36.6
Calcium (EDTA) mg/L	6.7	4.0	9.1	3.2	13.1
Magnesium (EDTA) mg/L	1.0	1.2	3.9	4.1	1.0
Chloride, mg/L	<1	<1	<1	<1	<1
Ammoniacal-N, mg/L	0.12	0.14	0.08	0.12	0.13
Nitrate-N, mg/L	8.53	1.46	1.00	1.16	1.53
Total Phosphate, mg/L	0.27	0.27	0.26	0.25	0.28
Cadmium, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Iron, mg/L	<0.1	<0.1	<0.1	<0.1	0.1
Lead, mg/L	<0.06	<0.06	<0.06	<0.06	<0.06
Manganese, mg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, mg/L	<0.04	0.06	0.08	0.08	0.05
Zinc, mg/L	<0.01	0.01	0.01	0.04	0.01
Aldrin, mg/L	nd	Nd	Nd	nd	nd
Dieldrin, mg/L	nd	Nd	Nd	nd	nd
Total DDT, mg/L	nd	Nd	Nd	nd	nd
Heptachlor, mg/L	nd	Nd	Nd	nd	nd
Endrin, mg/L	nd	Nd	Nd	nd	nd
Methoxychlor, mg/L	nd	Nd	Nd	nd	nd

nd – not detected

Why test only for banned organo-chlorines? and not other pesticides (fungicide, herbicide) organo-phosphorus

DUBIOUS STATEMENT NOT REPRESENTATIVE

The results from the laboratory shows that all parameters tested is acceptable according to the WHO guidelines to water quality. It should be noted that there is no traces of pesticides in the water. All the measurements found in the field is supported by these data, because they correspond very well with measurements made by the laboratory. Regarding heavy metals, the only parameter that could be questioned is Cadmium. The WHO guideline are 0,005 mg Cadmium/ litre sample water and it seems that the accuracy of the laboratory equipment is not fine

enough to detect if the water contains more Cadmium than "allowed" according to the guidelines

5.3.3 The users view on the quality of water

All most everybody thinks that the water has a good quality both for irrigation and drinking. Even though they think its good quality they always boil the water with a few exceptions. The users boil it mostly for safety reason, but many not even consider this reason, because it has been a tradition to boil the water. A farmer explained that he boiled the water to kill the little germs (bacteria) and sometimes he strains it as well (JKKK, pers.comm.).

The quality of water is not only considered upon the health matters, but also very much at the taste of it. Many users think that it taste good, especially better than the water in Ranau which is brownish and taste like fish (JKKK, pers.comm.). Some people think it taste sweet while others boil the water to avoid the taste of chlorine which is not in the water. All in all the users are satisfied with the quality, though it might less good in the dry season.

5.3.4 The use of alienated ground over the KPD intakes

There is an area over the KPD intakes which the State recently has planned to sell. The KPD sees a problem in utilizing the area above their intakes, because it may influence the quality and to a limited extend the quantity of water they are supplying their consumers (Philip Chung and Group Manager at KPD). The areas has not yet been sold, but the KPD is afraid that either some farmers or some hotel owners will buy the ground and thereby create a negative impact on the water. The farmers will certainly use pesticides and fertilizers which will affect the quality and if they construct their own pipelines then it will affect the amount of water KPD can use to supply their consumers. Also if hotels are built above the current intakes of KPD it will have an affect on the resource. KPD sees two solutions to the state's plan of selling this area; either the area is protected against use or KPD receives some extra funding to remove their currently intakes above the alienated area (Philip Chung and Group Manager at KPD), but that will be within the national park. KPD has applied for the latter, and they are still waiting for a positive answer. If they do not receive the funding then KPD may not be able to fulfil their own standards.

5.4 Quantity

When you have agriculture based on irrigation the quantity of water can be a limiting factor on your production. When there at the same time is an increase in the population and in the tourism, it could be expected that the quantity of water could be a problem.

At each of the four intakes and at Naradau river we made some measures on the water quantity in the rivers. In the following a theoretical example on how to calculate the water flow is given.

As mentioned in the methods (section 4) the river profile and the water velocity is needed to calculate the flow in the river. Figure 1 shows the intervals the river is divided into (a_1-a_6). To get an estimate for the areas a_1 and a_6 we used the equation for an perpendicular triangle:

$a_1 = ½\ d_1\ (w/6)$,
where d_1 is the depth and (w/6) is the width of the river interval.

The rest of the intervals were estimated to be squares and calculated as a_2.

$a_2 = (d_1+d_2)/2 * (w/6)$
The depth used is the mean value of the two depths in the interval.

The water velocity is measured with a propeller. The velocity was measured in the middle of each interval. To calibrate rounds pr. minute (or rounds pr second, rps) into water velocity (V, m^2/s) a certificate of calibration is used (see appendix 6, certificate of calibration). The chart gives an number (n) instead of rps. The number you get from the chart is put into an equation to get the water velocity.

The equation used is:

$V= (0.0681 * n + 0.0155) m/s.$

This equation can be used only when $n< 1{,}34$. There were no examples were this was not the case.

Naradaw river is here given as an example on the raw data from the water flow results .

Table 3a: water flow from Naradaw

	a1	a2	a3	a4	a5	a6
$A(m^2)$	0.449	0.936	1.024	1.097	0.902	0.341
Rps	0.242	1.83	2.46	2.54	2.93	1.25
N	0.032	0.135	0.172	0.176	0.199	0.101
$V(^m/_s)$	0.018	0.025	0.027	0.027	0.029	0.022
$A*V(m^3/s)$	0.008	0.023	0.028	0.03	0.026	0.008

Total water flow: (0,008+0,023+0,028+0,030+0,026+0,008) m^3/s = **0,123 m^3/s**

The results from Naradaw and the other stations are shown in table 3a. The raw data from the other stations are in appendix 7.

Table 3b. The water flow at the different stations.

	Kumawanan	Mesilau east	Mesilau west	Mantaki	Naradau
Quantity(m^3/s)	0.034	0.043	0.02	0.009	0.123

The flow in the river is varying a lot over time so these figures should not be taken as representative for the rivers in general. They show the flow only at the time when they were taken. Futhermore the propeller was very unstable at the places were the current was slow.

5.4.1 The change in the payment from flat-rate to water meter

Most of the people whom KPD supply with water pay a flat-rate per month no matter the amount of water the use. That is the original way of paying, but KPD has recently introduced a meter-system to the new consumers where the consumer only pays for exactly the amount of water the use. In the present payment-system there is some differentiation as there are two levels in the flat-rate system.

The KPD's strategy is to install the meter-system to everyone, because then they have a much better view upon the real use of water (Philip Chung and Group Manager at KPD). Another essential reason is that over consumption may be avoided, because the users will get a much better feeling of their own consumption. Today it is often seen, that the tap in the households just keeps on running without any reason (Philip Chung and Group Manager at KPD).

But introducing the meter-system is not in everybody' favour. Most of the users think that getting the meter-system installed will imply a higher payment, because they currently use more water than they actually think they are paying for. Therefore they do not want this system

to be implemented, one farmer hopes that the government will stop KPD implementing this new system, though he thinks that paying by meter-system will imply a lower payment (farmer int). Another solution is to circumvent KPD by constructing their own pipelines (farmer int). But the solution, KPD is looking for when introducing the meter-system, is a change in behavior. Farmer Jasimin is a representative of this change in attitude, he will save the water by closing the tap and thereby get a much more optimal solution for both parts.

In opposition to the opinion that a change into the water meter is a bad solution, is bar manager Abu Bakar. He argues that using the water meter system will imply a more fair and better payment because of the same flat-rate all year is paid, even though the large differentiation in amount from the dry season to the wet season.

5.5 Summary of findings

The main catchment area for Kundasang is protected by the boundaries of the Mt. Kinabalu National Park. As long as the catchment area is protected against agricultural or commercial activities the quality of the water will be acceptable. The main supplier of water, KPD have their intakes situated just beneath the park boundaries so they will be able to deliver a good quality of raw water. At present there are some alienated land above the KPD intakes in the National Park. If this land will be used for any of the above mentioned activities it could affect the water quality. The KPD distribution system will not be able to cope with such changes with their present system. They do not have the prober treatment system for such changes.

The sewage water in the Kundasang area is a problem for the water quality. Because of leaking water pipes the sewage can get into the drinking water. There is an insufficient wastewater management in the area. The new Water Resource Council, which properly will be establish in 1999, will take the input as well as the output into consideration. By defining a waste water policy the politicians and managers will be provided with an instrument for a better management in the future.

The quality of the water is acceptable at present stage, but if the agricultural production expand it can influence the quality. The expansion will increase the use of pesticides and fertilizers, which can have a serious impact on the health conditions in the Kundasang area. An expansion in the tourist industry can also affect the quality due to human residuals impact on the water quality. The present treatment system is not geared for these effects and have to be incorporated in the system.

The users of the KPD-system do not consider the available amount of water as a present problem. However there have been identified some limitations of the present system. KPD has requested the hotel Fairy-Garden to supply themselves, and some of the users in the outer kampongs have mentioned that they did not receive enough water. The use of a timetable in the dry season by KPD limits the hours which the farmers can irrigate, is also a sign of limitations in the present system. Because KPD is not capable of supplying the farmers with sufficient amounts of water they have constructed their private pipelines in order to receive enough water, even though this is illegal.

The institutional arrangement and lack of extensive legislation give space for above mentioned illegality. KPD has not got the power to enforce their rules, and thereby be able to manage the resource properly. Another problem from KPD's point of view is that the use of the resource could be more optimal. Therefore they have introduced a change in the payment system from a flat rate system to a water meter system. This is supposed to reduce an over consumption by the users.

A Increased pressure from agriculture production and tourism will properly make the present system incapable of coping the distribution of the resource.