SUPPORTING REPORT-B

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Chapter 1 Socio-economic Condition

1.1 National and Regional Economy

1.1.1 Social Condition and National Economy

The population of Vietnam was estimated at 76.3 million in 1999 (statistics in 1999), and 118 million in 2025 (World Development Report: 1996). The total area of Vietnam is 332,000 km2. The land is administratively divided into 57 provinces and 4 central control cities (Hanoi, Ho Chi Minh, Hyphone and Danang) in November 1996. The people of 20 % are living in urban area and the rest people are in rural area. More than 60 ethnic peoples are identified. They are Kinh (majority: 87 %), and the minorities of Thai, Muong, Taie, Nue, Meo and so on. The Zao, Ede and Bana minority peoples are living in the north. The Gia Lai people is in the Highland. The Cham and Khmel peoples are in the south.

Since 1986, Vietnam has experienced a transition from a centrally planned economy to a market economy called as "Doi-Noi". Over the last ten years, the economy has achieved a high growth rate at 9 % per year. Industry output growth has averaged 13.5 %. In spite of this significant growth, Vietnam remains still one of poor countries in the world, whose GNP per capita is estimated as US$ 250 (World Development Report 1996).

Vietnam is a poor, densely populated country that has had to recover from the ravages of war, the loss of financial support from the old Soviet Bloc, and the rigidity of a centrally planned economy. Substantial progress has been achieved over the past 10 years in moving forward from an extremely low starting point, though the regional downturn is now limiting that progress. GDP growth of 8.5 % in 1997 fell to 4 % in 1998. These numbers masked some major difficulties that are emerging in economic performance.

Since 1997, the economic situation in Vietnam was rather complicated due to the influence of the financial crisis in the Asian region and losses to agricultural production caused by floods in the central coast area. The GDP still increased at an average rate of 6.1 % for the period 1996-1999.

According to the Results of the household Living Standards and Economic Condition Survey in 1999, income increased for both the poor and the rich, but the results also indicated the gap between the poor and the rich is widening.

1.1.2 Social Condition and Regional Economy

Table 1.1 shows monthly income per capita by income source in seven regions.

North East South region contains Ho Chi Minh City and surrounding provinces and has achieved outstandingly in most sectors. Central Highlands has the second highest per capita income among the 7 regions. Agriculture sector in Central Highlands contributes the highest regional sector income in the country, and supports about 55 % of total income of the region. Central highlands are famous for industrial export crops, such as coffee and rubber. However, since the year 2000, the international price of coffee has dropped dramatically, and has effected coffee farmers in the region.

Table 1.1 Monthly Income per Capita by Income Source and Region in 1999

Unit: 1,000 VND

Region	Total	Salary & wage	Agriculture Forestry & Fishery	Industry & construction	Service activities	Others
North West and North East	210.00	34.70	117.00	12.00	24.20	22.10
Red River Delta	280.30	75.70	93.30	23.00	42.30	46.00
North Central Coast	212.40	40.40	88.10	21.20	29.50	33.20
South Central Coast	252.80	70.50	83.90	13.70	54.10	30.60
Central Highlands	344.70	54.50	189.20	15.90	59.60	25.50
North East South	527.80	191.60	111.40	54.40	117.70	52.70
Mekong River Delta	342.10	69.40	164.90	17.10	57.50	33.20

Source: Results of the Households' Living Standards and Economic Condition Survey in 1999

Table 1.2 Monthly Income per Capita by Income Source in the Central Highlands

Year	Total	Salary & wage	Agriculture, Forestry & Fishery	Industry & construction	Service activities	Others
1995	241.14	35.40	136.39	9.86	39.31	20.18
1996	265.60	39.20	146.50	13.00	45.60	21.30
1999	344.70	54.50	189.20	15.90	59.60	25.50

Source: Results of the households' Living Standards and Economic Condition Survey in 1999

Dac Lac province

Table 1.3 presents income per capita by income source in each province. Dac Lac is the richest of the three provinces. The main income source is agriculture, especially coffee production.

Table 1.3 Monthly Income per Capita by Income Source in Central Highlands

Unit: %

	Total (1000VND)	Salary & wage	Agriculture. Forestry & Fishery	Industry & construction	Service activities	Others
Dac Lac						
1996	309.52	10.84	59.69	3.68	17.03	8.76
1999	386.90	12.27	57.31	2.86	17.36	10.20

Source: Results of the households' Living Standards and Economic Condition Survey in 1999

Coffee is planted in about 250,000 ha in the province. Agriculture accounts for a high proportion of income, but the proportion has slightly decreased from 59.69% in 1996 to 57.31% in 1999, while salary and wages has increased.

1.2 Methodology of Social Survey

The survey on socio-economic condition was divided into three parts, secondary data collection (official statistics), household survey (questionnaire survey) and key informant survey (Rapid Rural Appraisal). Secondary data collection and household survey were conducted mainly for quantitative data collection, while key informant survey was carried out for qualitative data collection.

1.2.1 Rapid Rural Appraisal (RRA)

Purpose

Purpose of this RRA is better to understood the socio-economic condition in target communes in terms of present water sources, water use practice, poverty, electrification, etc. The team focused on

To collect general information of each commune, and

To share information among stakeholders on present condition of water use, problems and needs of villagers through the study.

Methods and Tools

(1) Key informant interview and semi-structured interviewing

The survey was carried out through key informant interview using a semi-structured checklist. In the survey, representatives from People's Committee, People's Council, villages, mass organization, Health Service and schoolteachers participated in interviews. Instead of formal, prepared questions, semi-structured interviewing uses a "checklist" to guide the interviewers through the topics the team wishes to address. Once the interviewers start interviewing on a certain topic, the issue is probed by asking related questions (sub-questions), in order to deepen the interviewers' understanding.

(2) Mapping

Mapping is one of the tools of RAA. The expert would draw a map, which showed roads, public facilities, dwelling location of each village, ethnic groups, number of households, population, poverty, water sources, power supply, etc. The map drawn by informants effectively introduced the team to the general spatial layout of the area. It is helpful to start RRA by mapping because it helps to break the ice as well as orienting the team to its surroundings.

(3) Historical profile

Historical profile shows not just what happens over one year, but what the important events in the life of the area, commune or village have been. Such items as disease outbreak and natural disasters, such as drought and flood, are important information for the planning.

(4) Seasonal calendar

In this study, the seasonal calendar was used for identifying rainfall pattern, the quality and quantity of water sources and disease patterns through the year. This can show correlation between rainfall and other items such as, quality and quantity of water sources, and disease incidence. It can be referred to more effective planning of disease prevention because the calendars show when and how long diseases break out in the area.

1.2.2 Household Survey

Questionnaire

Questionnaires were prepared by experts in charge of sanitary and environment, institution, operation and maintenance, and social and economic conditions. The questionnaires were also examined by an expert of DANIDA in charge of a water supply program in Dac Lac province. The questionnaire consisted of the following questions;

- on family structure: member, age, sex, education, occupation, income, and responsibility for family finance, education and health care
- on present water use practice: source, ownership, quality and quantity, consumption, O&M of facility and problems
- on future water supply: willingness and amount to pay, and responsibility on construction, management and O&M
- on living level: house type, commodities, electricity, expenditure
- Health and sanitation: personnel and organization concerned, health worker, mass media, sanitation practice, latrine, and disease, and
- on agriculture: land, crop, livestock, and yield and selling price.

Sampling Design

(1) Sampling size

Based on estimates of expected sampling errors, a sample size of 140 households was selected. Thirty households from each of 7 commune/towns were selected by a manner described as follows. Therefore, total number of households in Dak Lak province was 210 households.

(2) Selection methodology and sampling probability

The total number of households in the commune/town was divided by the number of households to be selected (30) to calculate the skip interval used in selection of households.

A random number is selected to start; succeeding site numbers are identified by formula: $X_i=X+i.k$; in which i=1,2,3… and the series is stopped when 30 samples are identified. The procedure is repeated for each commune.

Training of interviewers

All interviewers had previous experience conducting questionnaire surveys. For the purpose of confirming protocol and their skills, i.e. introduction and greetings, location/interview placement, interview management and time, two days training was held in Dac Lac province before starting the interview survey. One day was allocated to understanding all the questions and another day was allocated to a field trial. All interviewers experienced actual household survey with the questionnaire in the field trial. After the field trial, the interview team discussed the meaning of questions, ways of asking, revision of questions, etc.

Data input

Collected row data from all questionnaires was input and transformed into digital data by a sub-contracted company. The data was then checked and analyzed by the expert.

1.3 Results of Rapid Rural Appraisal

1.3.1 Population and Projection of Population

Population and growth rate data were collected as much as possible. However, as the growth rate in some communes is not available, the neighboring data was assumed for population projection for the year 2005, 2010, 2015 and 2020. Table 1.4 shows the estimated results.

Table 1.4 Projection of population

Commune	Total Villages	Number Household	Growth Rate(%)		Population 2000	Projection			
						2005	2010	2015	2020
Dac Lac province									
D1: Krong Nan	9	1998	**1.80**	**1.80**	10795	**10989**	**11802**	**12903**	**15423**
D2: Ea Hleo	13	2631	**2.20**	**2.20**	14853	**15180**	**16560**	**18464**	**22953**
D3-1: Krong Puk	7	1192	**2.60**	**2.60**	6619	**6791**	**7525**	**8556**	**11060**
D3-2: Krong Puk	5	640	**2.60**	**2.60**	3453	**3543**	**3926**	**4463**	**5770**
D3-3: Krong Puk	8	766	**2.60**	**2.60**	3494	**3585**	**3972**	**4516**	**5838**
D4-1: Ea Drong	6	1245	**1.20**	**1.20**	6901	**6984**	**7325**	**7775**	**8760**
D4-2: Ea Drong	4	431	**1.20**	**1.20**	1805	**1827**	**1916**	**2034**	**2291**
D5-1: Ea Wer	9	963	**10.00**	**2.10**	4992	**5491**	**8040**	**8920**	**10981**
D5-2: Ea Wer	1	64	**10.00**	**2.10**	313	**344**	**504**	**559**	**688**
D5-3: Ea Wer	1	46	**10.00**	**2.10**	197	**217**	**317**	**352**	**433**
D6: Kien Duc	8	2062	**2.10**	**2.10**	8626	**8807**	**9571**	**10619**	**13071**
D7:Krong Kmar	8	1169	**3.40**	**2.00**	5735	**5930**	**6779**	**7484**	**9123**

Population growth through migration was assumed only until the year 2005 due to unknown factors of political decisions for migration and limited land area.

Table 1.5 shows detailed numbers of villages/wards and households, population, average household size and population growth rate in each target commune/town. The total numbers of households and population at present in the target area are 13,207 and 67,783 persons. It shares more than half of the three provinces. Size of commune/town ranges from 1,073 households (5,502 people) in Ea War commune (D5) to 2,631 in Ea Drang town (D2).

Table 1.5 Detailed numbers of Villages, Households, Population in the Target Area

Town/ Commune	No. of village	No. of Household (household)	Population	Average householdsize (persons/household)	Population growth rate*)(%)
Dac Lac province					
D1:Krong Nang T.	9	1,998	10,795	5.4	1.8
D2:Ea Drang T.	13	2,631	14,853	5.6	2.2
D3:Krong Buk C.	20	2,598	13,566	5.2	2.6
D4:Ea Drong C.	10	1,676	8,706	5.2	1.2
D5:Ea Wer C.	11	1,073	5,502	5.1	10.0
D6:Kien Duc T.	8	2,062	8,626	4.2	2.1
D7:Krong Kmar T.	8	1,169	5,735	4.9	3.4
Province total	**79**	**13,207**	**67,783**	**5.1**	
Area total	**204**	**25,672**	**128,343**	**5.0**	**2.0**

Source: RRA results

*): Population growth rate consists of both natural and mechanical growth

1.3.2 Household Size

The RRA results show that the average household size in the target towns/communes varies from 4.2 persons per household to 5.6 persons. At the village/ward level, Ward No.8 in Krong Nang town (D1) has the biggest household size, 9.7 persons per household. In the target area, there are 210 villages/wards in total. Of which, 103 villages/wards are classified under 4.9 persons (average household size of target area), while 107 wards/villages are classified as 4.9 persons or more. Proportions of Kinh household in these wards/villages are 59% of 103 and 22% of 107 respectively. These figures show that the average household size is larger in villages/wards with a high proportion of ethnic minority (EM) groups. There are two reasons that influence the household size; number of children and adults who live together in one household. Household survey results also support this as mentioned below.

1.3.3 Ethnic Groups

Official figures show that there are in total 54 ethnic groups in Vietnam. The majority of the population in the country belongs to the Kinh group. In the target area, 20 ethnic groups were identified Ethnic minorities (EM) such as E De, Gia Rai, Ba Na, Xe Dang, Xo Dra, Ca Dong, Mnong, Gie, Mang, Brau and Romam originate from the central highland area.

According to the study results, E De is distributed in Dac Lac province. According to RRA results, proportions of Kinh households in the target area are estimated as 70% in Dac Lac province.

It is observed that the locations of most original EM communities are far from main road in communes/towns and close to mountainous area. They had practiced slash-and-burn cultivation, shifting cultivation, and relied on forest products, but most of them have stopped shifting cultivation, apart from a few minority groups. Some recently settled Kinh people live in remote area because they could not find land around the center of town/commune.

In general, each ethnic group, especially original EMs, tends to keep its own community, which often shaped village/ward.

1.3.4 Migration and Settlement

There are two kinds of migration pattern. One is government sponsored resettlement program (New Economic Zone). The Government has supported New Economic Zone program, in order to move people from high population density areas to sparsely populated areas. In this program, the Government prepares social and economic infrastructure and some institutional supporting systems for these settlers, so that migrants can start their lives smoothly.

Another is free migration where people move into unused area and start cultivation. Even though they are free migrants, they have a right to receive social services, such as education and health service just the same as legal dwellers. After several years, the town or commune where they live judges their behavior and, if there are no serious problems and troubles with them, they can be registered as a legal dweller. The considerable difference between legal dweller and illegal dweller is whether they have land use certification. It is necessary to borrow money from official banks. In case of free migration, seasonal migration was sometimes observed whereby those from another province come to the central highlands to reclaim forest area and cultivate cash crops every season. After selling the harvested crops they return to their main place of residence.

Capricious Migraqtion

Migration of Kinh and the other ethnic minorities peoples are sometime capriciously migrating without government control. The population growth ratio is included such capricious influences. The growth ratio of 2-3% in the Central Highlands is therefore, higher value than the average growth ratio of approximately 2% in the whole country.

1.3.5 Water Resource

Water resource map in all target communes were drawn with the help of key informants (Data Book Chapter 1, Figure K1-2 ~ 1-7). The water resources are classified into dug well, shallow borehole with a hand pump (UNICEF), deep well, river, stream, spring, and rain water (rainy season only). The same household often has several sources for different domestic purposes. They need to keep plural water sources which can be accessed through a year, even in the driest year.

Table 1.6 Water Source in Target Area

Province	Commune	Dug well	Spring	Borehole	River	Stream	Vendor
Dac Lac	Krong Nang	O	O				
	Ea Drang	O	O	O			O
	Krong Puk	O					
	Ea Drong	O	O				
	Ea Wer	O			O		
	Kien Duc	O		O			O
	Krong Kmar	O				O	

- Dug well includes UNICEF shallow borehole, Borehole: private use only

(1) Dug wells

Dug wells are the most popular water source in the target area. Most Kinh people and some EMs, who follow the Kinh practice, use dug well. The depth of a dug well varies from 5-6 m to 30 m and more. People use bucket with rope, bucket with pulley, hand pump or electric pump to lift water from well. Dug well water is used for drinking, cooking, bathing, washing and/or plant watering.

Most households using a dug well have their own dug well except EMs. If a household does not have a well or sufficient water in their well, water is collected from neighbors without payment. This is from mutual help custom. However, when a well is equipped with an electric pump, the owner charges a electricity fee to users who regularly use the pump.

Left: EM woman washing cloths and girls collecting water at Kong Yang commune in Gia Lai province.
Right: EM woman pouring water into a gourd at Kong Yang commune in Gia Lai province.

The Government has issued instructions to boil water for drinking purpose through local institutions such as health services and schools. At school level, when a school has a dug well and enough water, schools prepare drinking water tanks for children. If a school does not have a well or sufficient water in their well, teachers instruct children to bring boiled water from home.

(2) Springs, Streams and Rivers

Springs, streams and rivers have been used for a long time as water sources, mainly by EM in the area. Before rapid migration started in the central highlands, a large number of springs were located in mountainous area as well as rivers and streams. Mass migration caused deforestation for reclamation of agricultural and residential lands and pollution of these water resources by agricultural chemicals and human waste. Consequently, many springs have disappeared as water source or the quantity of water has decreased, and quality of these water sources has become worse.

Generally, water collection is done mainly by women including girls among ethnic minorities. Gourd bottles and plastic PET bottles are used for water collection. These bottles are carried by women in a bamboo basket on their back. Collected water is used for drinking and/or cooking. When women collect water from a spring, stream or river, they usually wash cloths and take baths as well, while men take baths during vacancy of women or at another water source. Most of these water collection points are kept a certain distance from the residential area, and cannot be seen from outside easily.

Left: Spring at Chu Hreng commune in Kon Tum province. Right: Spring at Krong Nang town in Dak Lak province

These water collection points have another important role. They provide a public space for communication, where women can exchange various kinds of information on their economic activities and lives.

(3) Deep boreholes

Deep boreholes are not popular in the residential area, but are observed at official facilities in some communes/towns. Water from those deep boreholes are for office use only and are not utilized within private households. In Ea Drang town and Kien Duc town in Dac Lac province, a few private deep boreholes are used. In Kien Duc town, two deep boreholes are used for to obtain water for selling.

(4) Piped water

Piped water system is seen at D5, D6 and D7 in the target area. However, they are not properly operating at present by the reason of failure of water charge collection and very low house connection rate, etc.

At Krong Kmar town (D7) in Dac Lac province, UNICEF constructed a gravity type piped water supply system in 1998. The system supplied water from Krong Kmar head works to a public tank with a tap located in each village. After one-year of operation the system was destroyed by flood. People use dug wells now.

In Ea Wer commune (D5) of Dac Lac province, the province dug a deep borehole to serve water to six concrete tanks with a tap for two villages at the center of the commune.

Bamboo piped system was observed at Dak Ui commune in Kon Tum province. A spring is located at the middle of a mountain which is at a higher elevation than the villages. In the 1970's people started construction of a gravity type water supply piped system using bamboo from the forest. Recently they put

PVC pipe inside the bamboo pipe for reinforcement of the facility. Users purchase materials and maintain the facility by themselves.

Left: Public piped water supply system is made of bamboo and woods at Dac Ui commune in Kon Tum province. A board and a stone are used for washing cloths. PVC pipe is recently used for reinforcement. Right: Water intake at spring

1.3.6 Water Quality and Quantity

Change of water quality and quantity were also clarified in cooperation with key informant. It cannot be compared with other communes, because these figures were subjectively made by informants. The results, however, indicate changes of water quality and quantity through the year. It is necessary to combine these data with scientific examination conducted by the team, then the water condition in each communes/towns can be forecasted in detail.

The rainy season in the target area starts in March or April and ends in October to January. One or two months after the start of the rainy season, the quantity of water in all sources begins to increase, while quality begins to decrease. Meanwhile, there are areas, like Kong Tang town and Nonh Hoa commune in Gia Lai province, where it takes 5 months for the rain water to effect the water level of sources.

1.3.7 Poverty

Several definitions measuring poverty are available in Vietnam. The study team used the definition of Ministry of Labor, Invalids and Social Affairs (MOLISA), which is prevalent in rural administrative offices of target area. MOLISA uses rice as a measurement of income, and it can be converted to a money equivalent. Table 1.7 shows the poverty definition published by MOLISA in May 1997. The definition would be valid for 1998, but local administrations in the target area still use this definition.

Table 1.7 Classification and Definition of Poverty by MOLISA

Classification	Definition
-Very poor	• Income less than 13kg rice capita/month, equivalent to VND 45,000
-Poor in rural mountainous and islands	• Income less than 15kg rice capita/month, equivalent to VND 55,000
-Poor in rural, delta and midland areas	• Income less than 20kg rice capita/month, equivalent to VND 70,000
-Poor in urban areas	• Income less than 25kg rice capita/month, equivalent to VND 90,000

Source: Ministry of Labor, Invalids and Social Affairs

Poverty situation from the results of key informant interview is shown in Table 1.8. Of the three provinces it can be seen that Gia Rai province and Kon Tum province have rather high proportions of poverty. Towns commonly have less than 15% poverty rate, which is low compared to communes.

The poverty rate of these villages is remarkably high, 85% and 90%, even through their villages are sited on a main road. First priority of their needs is easier access to health service, second priority is clean water supply, followed by draught animals and electricity supply. According to key informants in these communes, the main reason of poverty is low agricultural production, especially cash crop production. Cash crops such as coffee, pepper and rubber, which are cultivated in other areas, cannot be grown in this area because of poor soil fertility. They grow cashew, maize, beans and sesame.

Meanwhile, in Ea Drang town, Kien Duc town and Krong Kamr town in Dac Lac province, the ratios of poor households are much lower than in other communes/towns. One characteristic common to these towns and communes is, the high proportion (over 90%) of Kinh households.

Among communes/towns, it tends that villages that are located in remote area have a high concentration of poor households. The situation of social and economic infrastructure is very poor.

Table 1.8 Poverty situation in the Target Area

Town/ Commune	No. of Household (household)	Population	Poverty[1)] (household)	Poverty (%)
Dac Lac province				
Krong Nang T.	1,998	10,795	300	15%
Ea Drang T.	2,631	14,853	228	9%
Krong Buk C.	2,598	13,566	370	14%
Ea Drong C.	1,676	8,706	316	19%
Ea Wer C.	1,073	5,502	207	19%
Kien Duc T.	2,062	8,626	107	5%
Krong Kmar T.	1,169	5,735	97[2)]	8%
Province total	**13,207**	**67,783**	**1,625**	**12%**
Area total	**24,191**	**118,617**	**4,430**	**18%**

Source: RRA results

1) Poverty includes very poor and poor households by MOLISA definition

2) There is no very poor households

According to the key informants, characteristics of poverty are;

- Households of illegal migrants
- Households with invalids by disease or accident
- Households with numerous children
- Households with insufficient land and capital to invest
- Households without modern cultivation technology

1.3.8 Gender

Among Kinh people (majority), male and female share the housework such as water lifting, cooking, cleaning, washing cloths and taking care of children. Among EM, some EM groups share the housework, but some do not. It is difficult to say that certain ethnic groups do one way or the other because even in the same ethnic group, various customs and traditions apply.

According to the results of household survey, responsibilities for finance, education and health in the family are shared between women and men, and there is no difference among different ethnic groups. Even though these responsibilities are shared among family members, final decision is prevalently made by men. When a family must make a decision on some important issues, the husband discusses it with his wife, and sometimes other family members or friends, then the husband makes the final decision after the discussion.

1.3.9 Mass Organization

In all target communes/towns, several community organizations are established, such as Farmer's Union, Women's Union, Youth Union, Elder's Union and Red Cross. Most of these organizations were established to spread government propaganda, but now they also have important roles of economical and social activity. All organizations take care of not only legal dwellers, but also illegal immigrant in their activities as the Government does. The main problem in all organizations is the shortage of budget for activities.

(1) Women's Union

Over 20-year-old women except elders can be a member of the Union. The union was originally established as a political organization to extend the Government propaganda and Party policies to members. Beside these main activities, social and economical activities are now a major role of the organization. The union is well organized by women from central level to community level. Budget is allocated by the commune/town People's Committee. However, since the budget is limited, some unions collect money from members to fund activities.

At the commune level, the Union is composed of the president, the vice president, board member and ordinary member. The board members hold a chief of a village at once. The president and the vice president are elected by the members directly. Following activities are common in all Women's Union.

- To introduce agricultural techniques for women, on garden planting and livestock breeding
- To extend primary health care, mother and child health care, family planning, and disease prevention in cooperation with public health services.

Some Unions have established a fund for individual economic activity. A member can borrow money from the fund at lower interest rate than from banks. The money is invested in economic activities such as agricultural input, but not for medical care and educational purpose. The purpose of the loan is to help women from poor households. Members contribute a small amount of money every year to expand the fund. They also support women to borrow money from VBARD (Vietnamese Bank for Agriculture and Rural Development) by providing a recommendation letter.

(2) Farmer's Union

All farmers, male and female, rich and poor, are members. They carry out agriculture extension service and introduction of new crop and livestock. The Union cooperates with Division of Agriculture and Rural Development of the District to carry out their activities. CPC or TPC allocates budget for the Union.

(3) Youth Union

The Union consists of teenagers (high school students and above), and young people in this 20's and 30's. The Main purpose of the Union is to educate the young generation on policies of the party. They carry out charitable activities and sports events. Besides these, they also coordinate with THS to promote environment and sanitation program. They work with WU, FU, VU and Red Cross in the same activities if needed. Awareness of people about sanitation in community has improved. TPC allocates budget for their activities. Some of their activities are sponsored by small entrepreneurs.

(4) Elder's Union

Over 60 years old people can be a member. Purposes of the union are to keep elders' life healthy and enjoyable. This is a kind of volunteer group.

(5) Red Cross

Members of Red Cross are selected from relatively wealthy households. They carry out charitable activities such as supporting victims of disasters, fire, and accidents with money and commodities (foods, furniture, blanket, mosquito net etc.). When the number of victims is small, members contribute money and/or commodities, but ask the Government in the case of large-scale disasters.

1.3.10 Rural Infrastructure

(1) Education

All communes/towns have primary schools. There is one primary school at the center of commune/town to teach from grades 1 to 5 as compulsory education. There are also many primary schools with one or two classrooms in remote areas which can teach from grade 1 to grade 2 or 4. Classes are carried out in two shifts, morning class and afternoon class, because of the shortage of classrooms. Towns usually have lower secondary and/or upper secondary school as well.

The drop out rate is quite low (less than 5%) according to teachers in all interviewed primary schools, while the household survey suggested it is higher. Teachers insisted that some students drop out in spite of their great effort. When a student almost drops out, or after the student dropped out, teachers visit the students and her/him parents to encourage them to stay or return to school.

(2) Health

The health service is located in all communes/towns, called Commune/Town Health Service (CHS and THS). More than two staff, at least physicians are stationed in each health service. Most health services are equipped with beds, treatment tools and medicines. CHS/THS is in charge of simple treatment for sickness and injury, delivery of babies, basic data collection and campaigns for improvement of health condition. Patients in serious cases are transferred to an upper level health service or hospital, such as District Health Service (DHS) and Provincial Hospital. Village health worker (VHW) system started in 2000. DHS appoints health workers and pays an allowance (about 40,000 VND/month). VHW have to inform the CHS/THS about disease cases and cooperate in campaigns organized by CHS/THS.

(3) Road and bridge

All communes/towns have or will soon have a main asphalt road passing through the center of the commune/town, but roads and bridges inside commune/town are in poor condition. Access to remote villages is difficult to even in the dry season.

(4) Electricity

Electricity distribution in each commune/town is shown in Table 1.9. Electricity is installed in all target communes/towns, but not to all villages and households. Villages in remote area and poor households cannot install electricity, because of economical difficulty. Users must contribute for installation of village power line as well as house connection. It costs between 1 million and 3 million VND depending on the distance from the main line, while a house connection costs 0.6-0.8 million VND per 100 m from the village line.

Electricity tariffs vary between 400 VND/kwh and 800 VND/kwh depending on commune/town. Tariff is categorized as private use, commercial use and official use, and agricultural use sometimes. The tariffs for official use and agricultural use are set about 100 VND/kwh higher than it of private use, and tariff of commercial use is set at almost twice that of private use.

CPC, TPC or DPC (in case of towns) have electricity management units for management, operation and maintenance. They usually have 3 or 4 staff for metering making bills, collection of charges and payment to the electric company. Before they pay the electric company, their salary and O&M cost are deducted.

Table 1.9 Household with Electrification

Dac Lac Province	Households (%)
Krong Nang T.	78%
Ea Drang T.	91%
Krong Buk C.	49%
Ea Drong C.	23%
Ea Wer C.	48%
Kien Duc T.	67%
Krong Kmar T.	99%

Source: RRA results

1.4 Results of Household Survey

1.4.1 Interviewee

To obtain accurate data from each household, an interviewer could speak to any family member. The interviewee means the person who mainly answered the questionnaire. Figure 1.1 shows sex ratio of the interviewees. Twenty percent (180) of the main interviewees were female in total. Thirty percent of the interviewees were female in Dac Lac province.

1.4.2 Household Size

The average household size in all provinces was 5.24 persons per household. There is little difference in average household sizes among provinces. Average household sizes in Dac Lac province are 5.18 persons per household. However, various distribution pattern of household size can be seen in each province in Figure 1.1.

Proportion of children (under 15 years) and adult by province and ethnic group is shown in Table 1.10 The number of children is not higher for EM than it is for Kinh, but the number of adults in EM is higher than it is for Kinh in whole area.

Table 1.10 Population of Children and Adults

• Unit: persons

Province		Children	Average per household	Adult	Average per household
Target area	All	1,174	1.96	1,967	3.28
	Kinh	657	1.77	1,186	3.19
	EMs	517	2.27	781	3.43
Dac Lac	All	423	2.01	665	3.17
	Kinh	262	1.83	414	2.90
	EMs	161	2.40	251	3.75

Source: Household survey results

1.4.3 Household Structure

The distribution of population by age and sex in each province is shown in Figure 1.3 – 1.5. As can be seen from these figures, in each province, the population of the 20-24 years age group is sharply lowers than the age group under 20 years. This may be considered to be due to the wars from 1946 to 1975. Regarding the number of children, it is high for the age group 15-19 years, but has tended to decline in the past five years. Overall the sex ratio is 51 percent female and 49 percent male, and there is no significant difference between provinces.

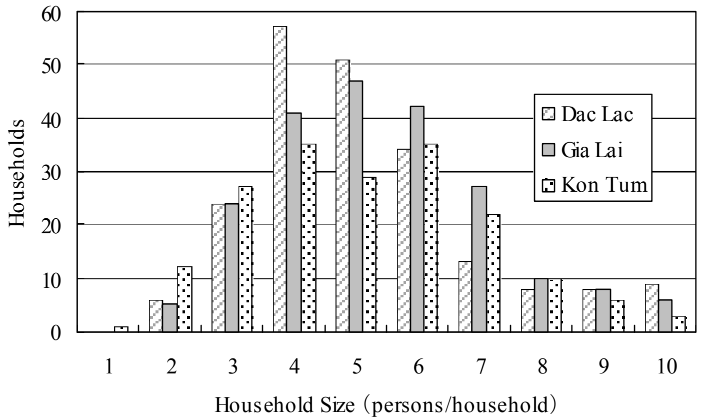


Figure 1.1 Housing Size

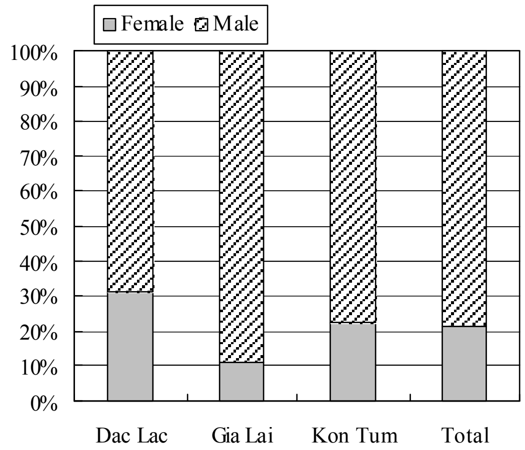


Figure 1.2 Main Interviewee by Sex

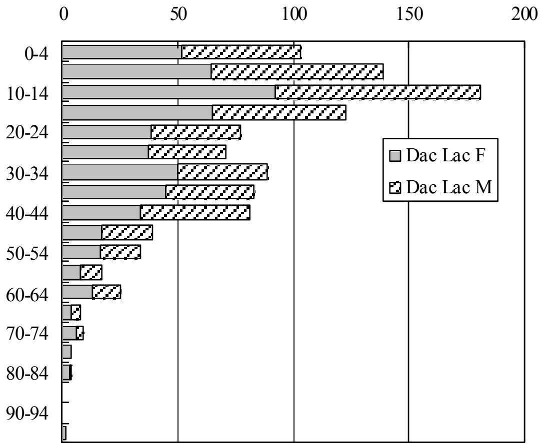


Figure 1.3 Population by Age and Sex in Dac Lac

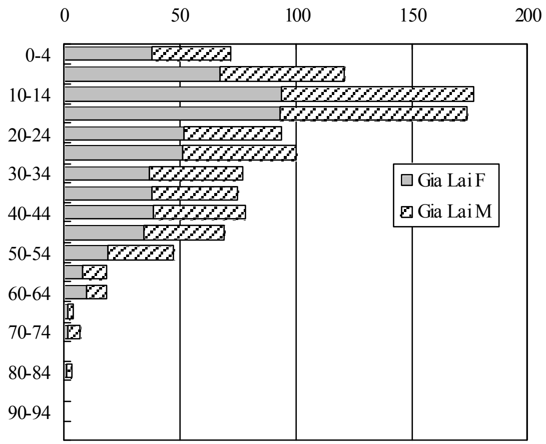


Figure 1.4 Population by Age and Sex in Gia Lai

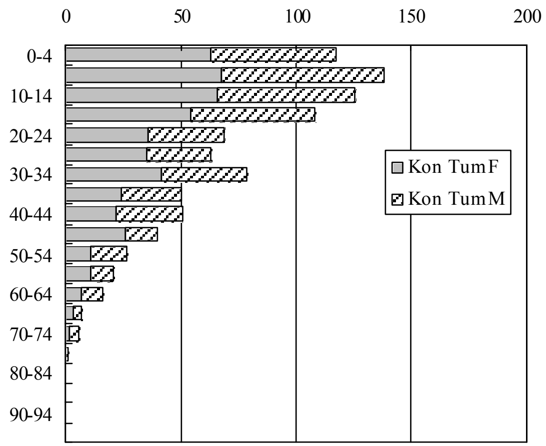


Figure 1.5 Population by Age and Sex in Kon Tum

1.4.4 Ethnic Group

Proportions of ethnic groups are shown in Figure 1.6. Total proportion of Kinh in households interviewed was 59 percent. Kinh is a major ethnic group in the country. The proportion of Kinh households in Dac Lac is 62 percent. There is a high ratio of E De in Dac Lac province.

1.4.5 Migration

Results of the household interview survey (Figure 1.7) shows that 64 percent of households interviewed were the migrants. Of these, 71 percent had settled in last two decades and 92 percent were Kinh. In Dac Lac province, 64 percent of households settled from out of the province, of which 76 percent of households came after 1980. In Dac Lac province, the proportion of migrants after 1990 is lower than in the 1980's.

1.4.6 Occupation

The occupation of family members by sex in the interviewed households is shown in Figure 1.8. As stated above, agriculture is a major income source in the central highlands. The occupation distribution also reflects this. The majority of workers are involved in agriculture. Beside agriculture, there are some small business, such as retail trading, restaurant, milling factory and workshops are observed in the area, but compared to Dac Lac and Gia Lai province only a small number of people are involved in non-farming jobs in Kon Tum province. The percentage of females working in retail trade or as teachers is higher than males.

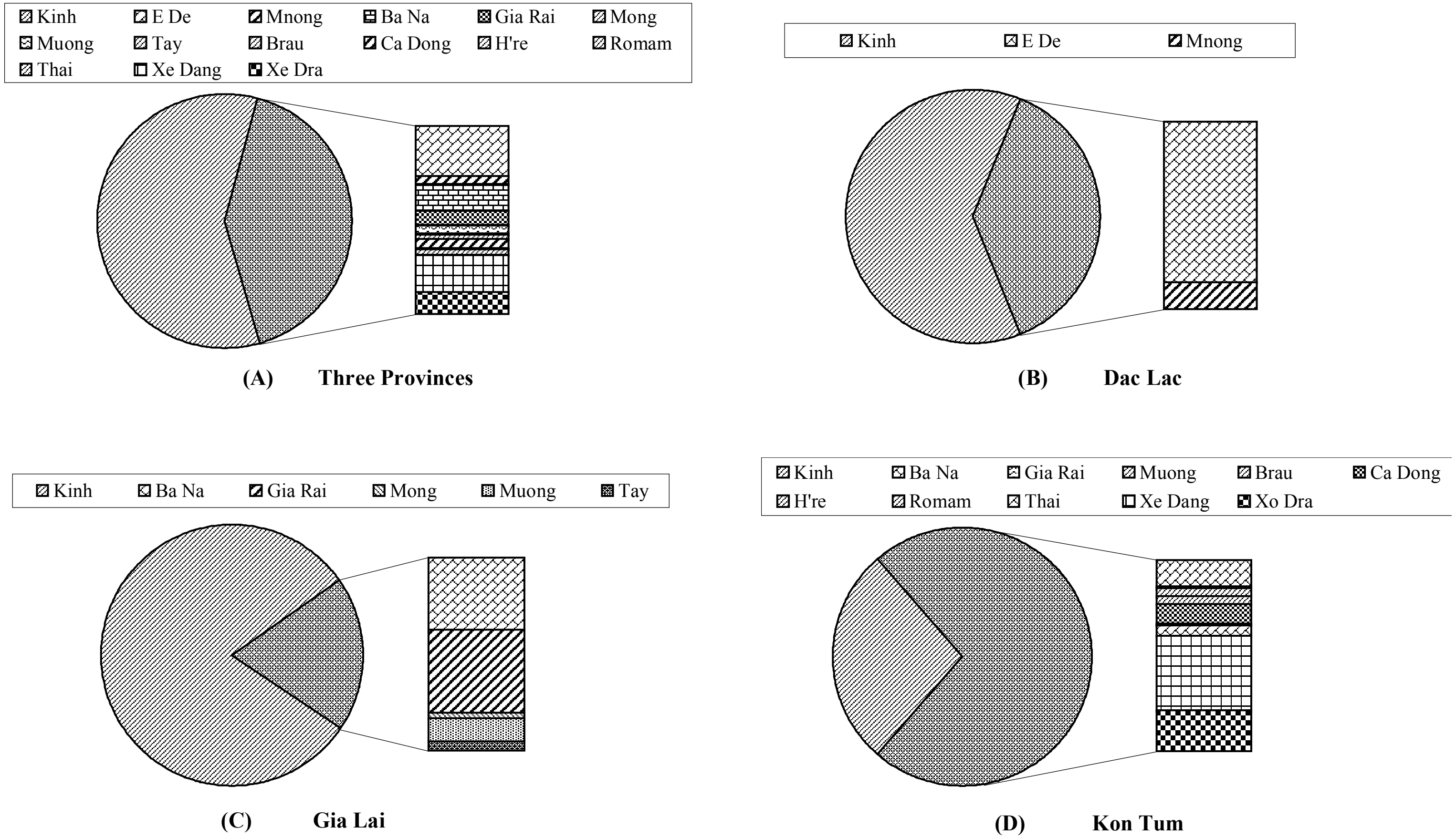


Figure 1.6 Distribution of Ethnic Minority

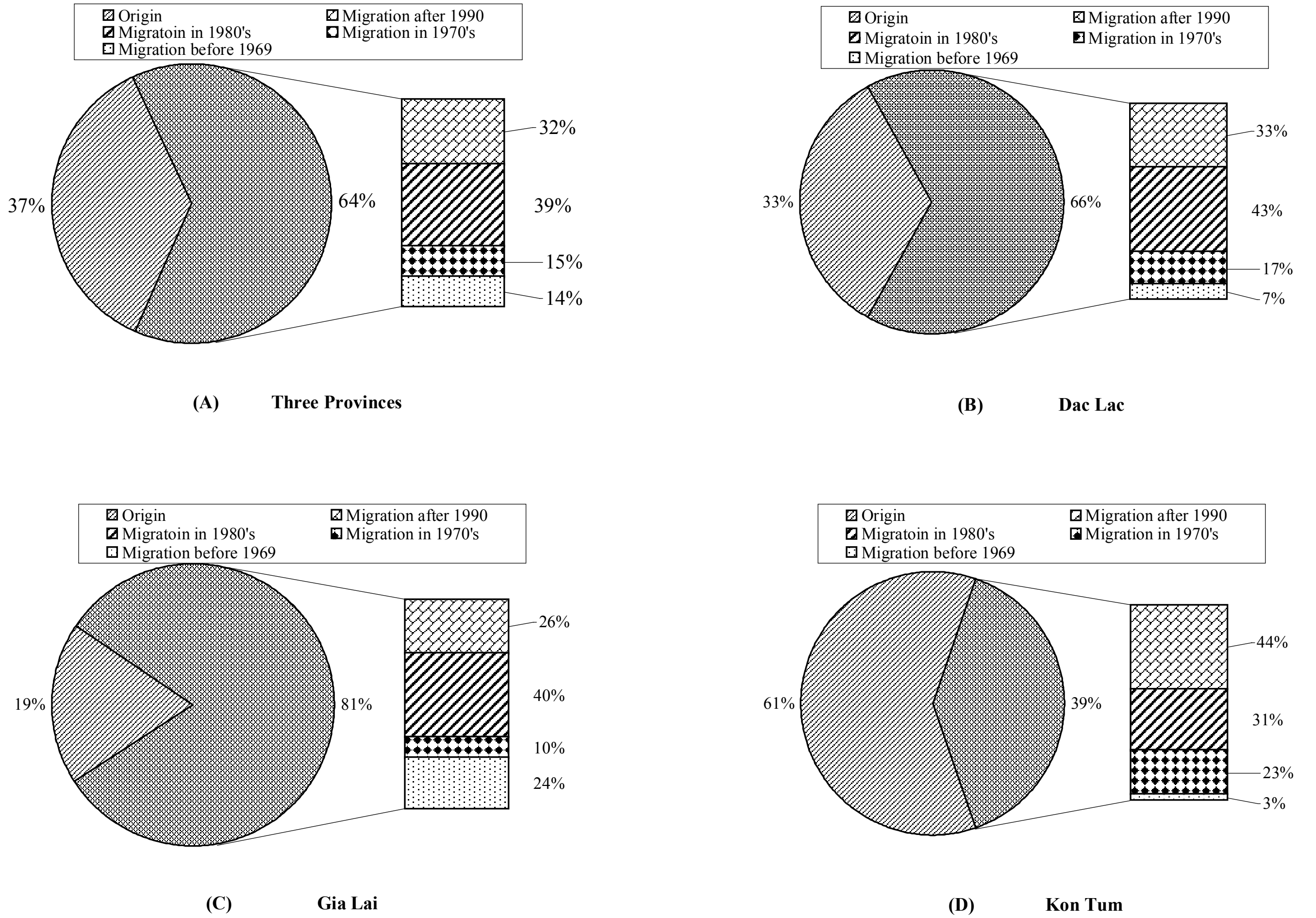
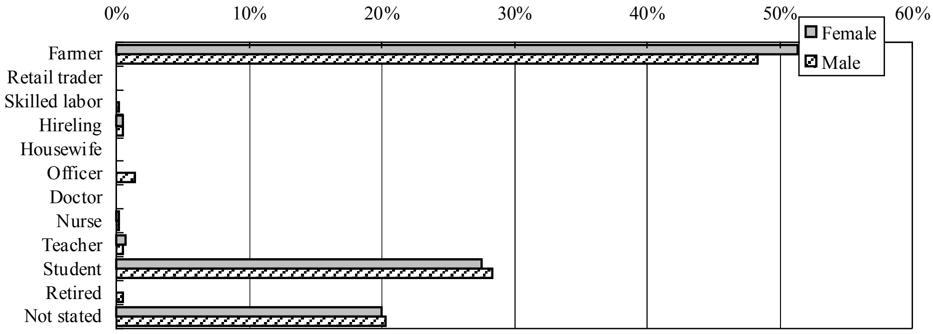
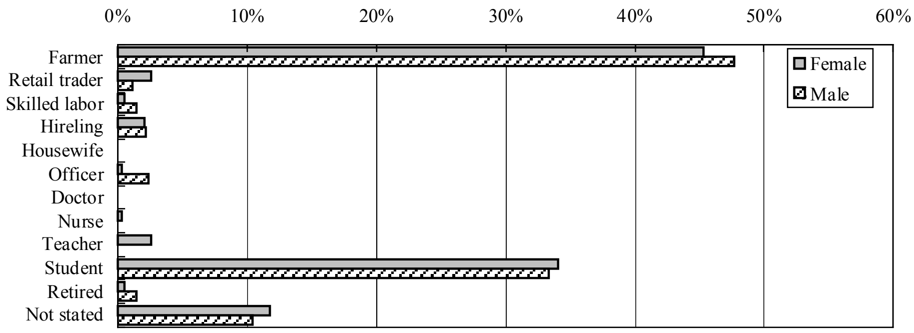


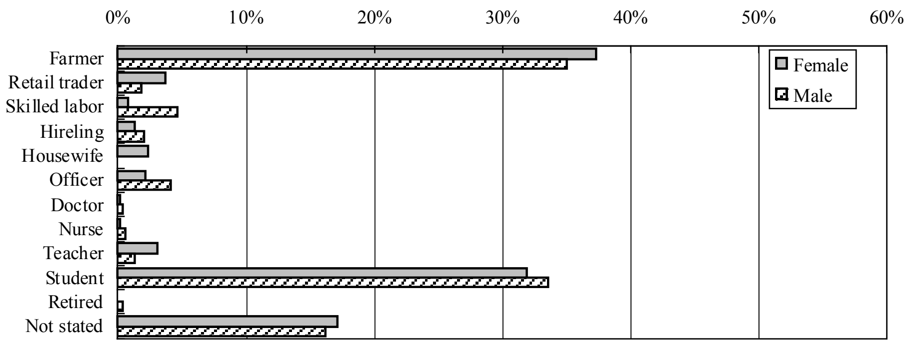
Figure 1.7 Migration



(A) Kon Tum



(B) Gia Lai



(C) Dac Lac

Figure 1.8 Occupation by Sex

1.4.7 Responsibility in Family

Table 1.11 shows the sex ratio for responsibility for family issues. Issues selected were family finance, education of children and health of family members. Female's responsibility for education and health is relatively high in Dac Lac province. Besides, there is no difference between female and male in responsibilities for the family. As mentioned earlier, the final decision is generally made by the male rather than female, even though responsibilities are shared between female and male.

Table 1.11 Responsibility on Family Issue by Sex

Unit: persons (%)

	Finance	Education	Health
Dac Lac province			
Female	213(48 %)	193(58 %)	190(60 %)
Male	227(52 %)	139(42 %)	128(40 %)

Source: Household survey results

1.4.8 Education

Figure 1.9 presents the proportion of uneducated population by age group in the interviewed households. The percentage of population that is uneducated decreases as the age group becomes younger. Difference between female and male has been improved as well.

Education system in Vietnam is shown in Figure 1.9. Compulsory education period is 5 years from grade 1 to grade 5 in primary school.

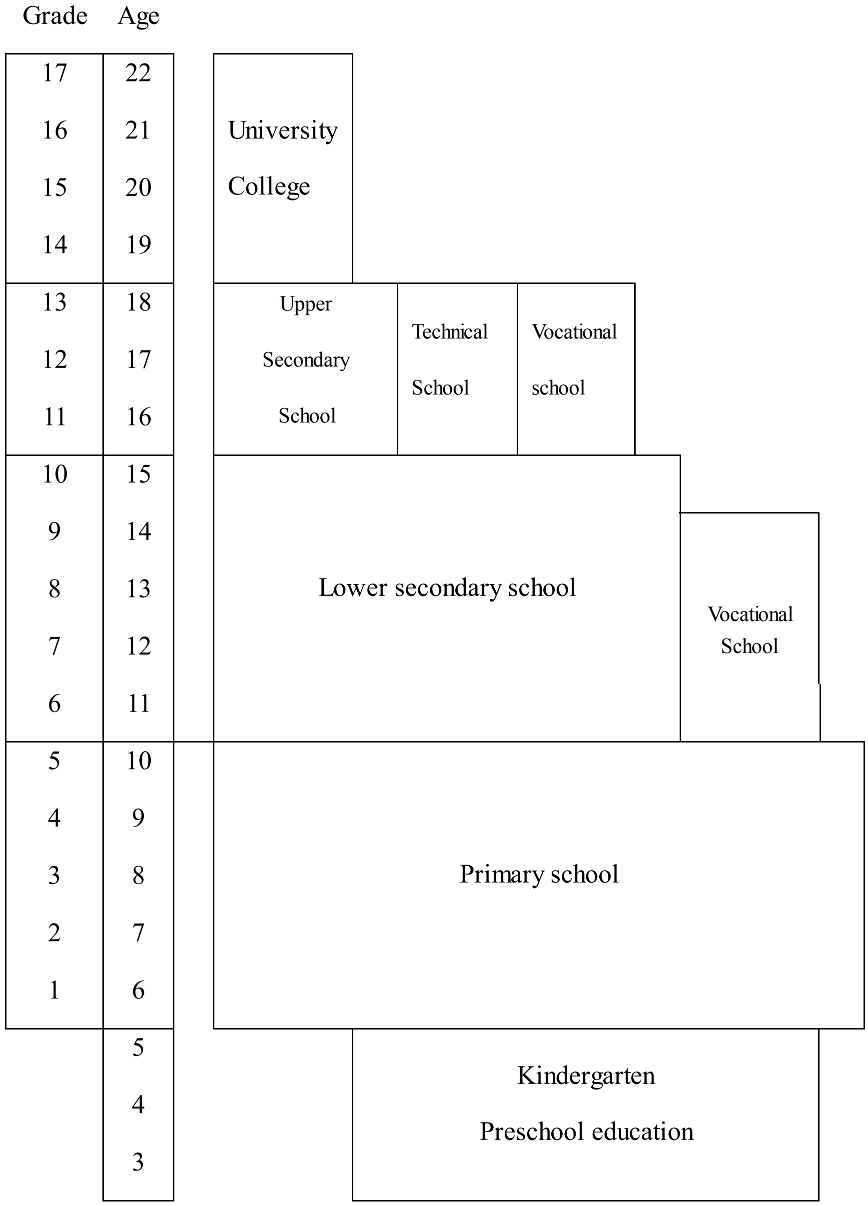


Figure 1.9 Educational System in Vietnam

Highest education level by sex and each age group is shown in Figure 1.10. Highest education level increase as age group becomes younger. However, many people dropped out in both primary and secondary education at present. A difference between female and male can be seen even for primary level education. Females tend to stop studying at an early stage of education.

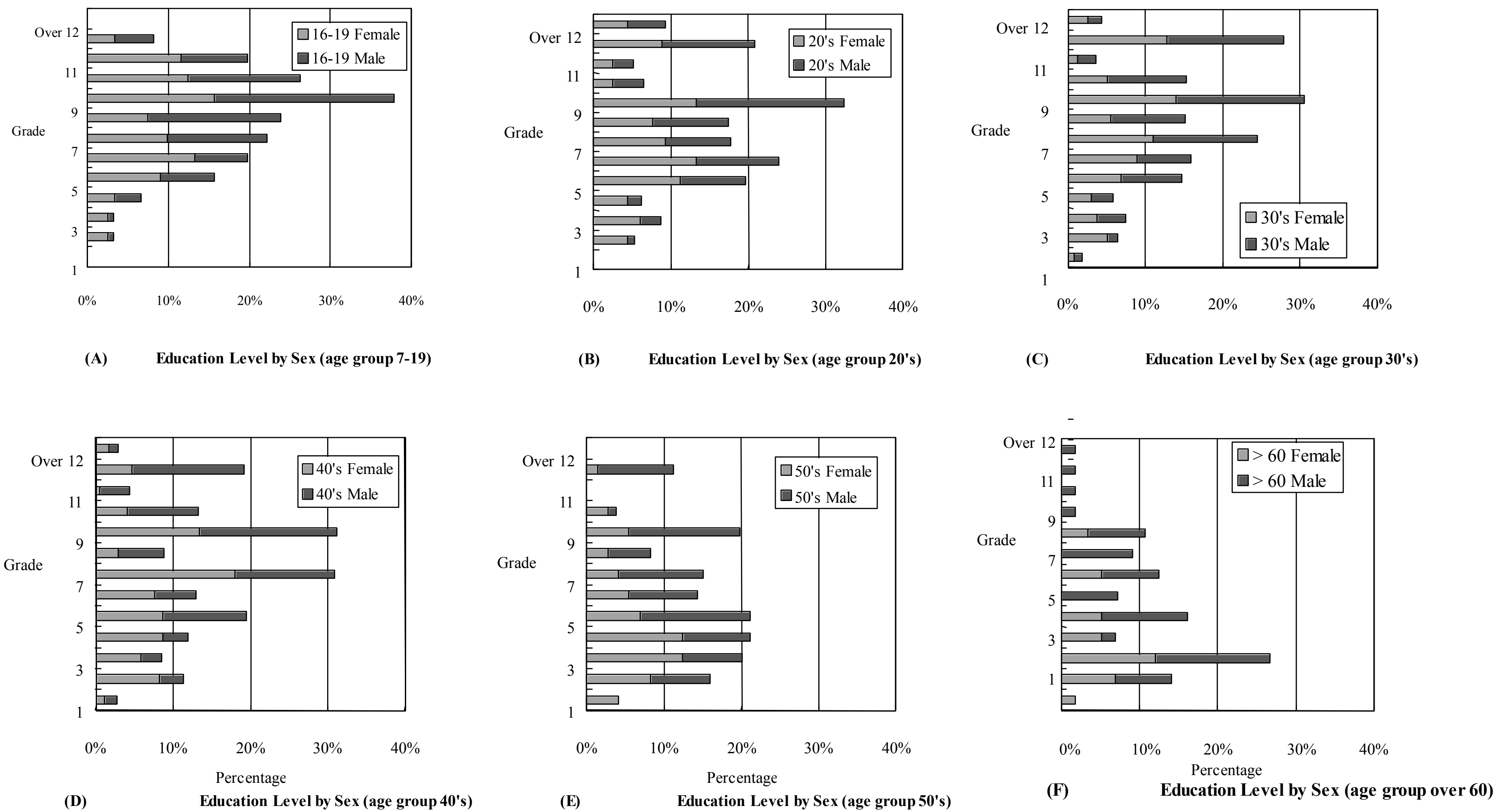


Figure 1.10 Education Level

1.4.9 Water Related Issues

(1) Water source

Main water sources of interviewed households are presented in Figure 1.11. Dug well, borehole, spring and river are used for water sources. Dug well is common in interviewed households of all communes/towns except three communes, Ea Wer commune in Dac Lac province. Ea Wer commune has a public water supply facility with deep borehole, and one village located by Srepok river relies on river water.

(2) Ownership of water source

Spring, stream and river are public water sources. Only wells can be owned privately. Table 1.12 shows the proportion of dug wells as water source and ownership status. There is quite a low percentage people that own a dug well in Kon Tum province. This is related to income because construction of the dug well costs money and owners must incur O&M cost every year for the well.

The only private borehole was identified in Ea Wer commune in Dac Lac province.

Table 1.12 Ownership of dug well

	Proportion of dug well user	Of which, own well
Dac Lac	82 %	90 %

Source: Household survey results

(3) Quality

Figure 1.12 shows the quality of water by use and season. Fifty percent of households in Ea Wer commune in Dac Lac province are not satisfied with water quality in dry season.

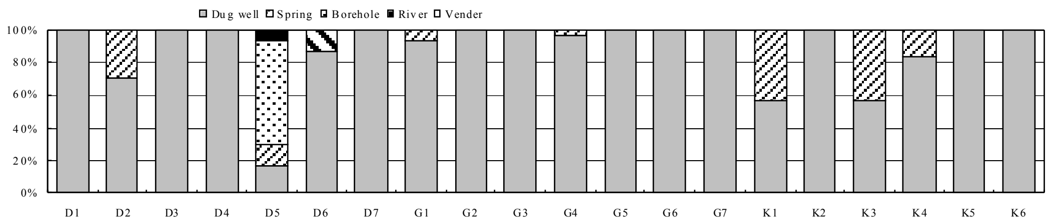
A few households answered “dissatisfied” with water quality through the year in Krong Nang town and Krong Kmar town in Dac Lac province.

(4) Quantity

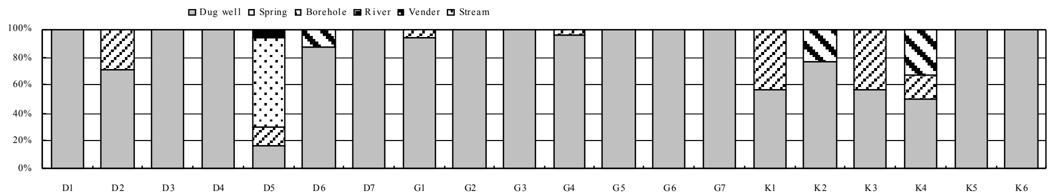
Figure 1.12 shows the quantity of water by use and season. In Dac Lac province, the quantity is little change throughout the year.

(5) Request for present water condition

Table 1.13 shows points of dissatisfaction with the present water supply. Interviewees answered “Distance” do not have their own water source.

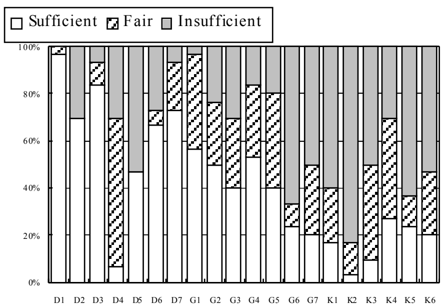


(A) Present Water Source for Drinking

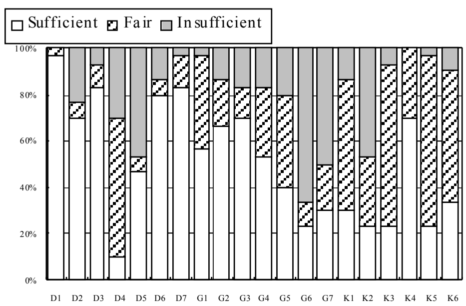


(B) Present Water Source for Domestic

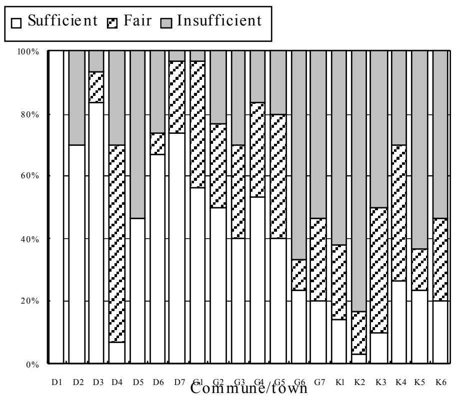
Figure 1.11 Present Water Sources



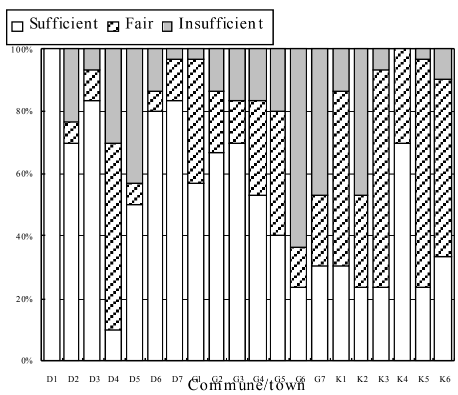
(A) Quantity of domestic water in dry season



(B) Quantity of domestic water in rain season



(C) Quality of drinking water in dry season



(D) Quality of drinking water in rain season

Figure 1.12 Satisfaction Ratio for Present Water Sources

Fifty-five percent of interviewed households answered “Equipment” as a dissatisfied point. Of these 54% use a bucket for lifting water. Households that use a bucket generally seek to upgrade to a motor pump. Some people that presently use a motor pump also responded “Equipment”. It is not clear whether they want a higher quality or quantity pump.

Households that answered “Quantity” account for 48% of total interviewed households. It is observed in all kinds of water source users.

Table 1.13 Requests for Improvement to the Present Water Supply

	Distance	Equipment	Quantity	Quality
Dac Lac	17%	44%	33%	60%
Total	25%	55%	48%	60%

Source: Household survey results

Sixty percent of those interviewed answered “Quality” to be improved.

(6) Operation and maintenance

At present, people, who own a dug well maintain (i.e. dredging mud in the bottom of a well) the well by themselves. When a dug well needs to be deepened, however, an owner asks a specialist. Most households responded that they want CPC or DPC to manage the water supply system as well as the electricity supply system (Table 1.14). It is considered that this is because most have never experienced using a borehole before. Even though people have used water from the borehole, they have never operated the borehole because CPC or DPC has carried out all O&M and paid for them.

Table 1.14 House Holder Expectations on Organizational responsibility for water supply O&M

		Activitiy				
		Construction of Facility	O&M Of Facility	Money collection	Management auditing	Tariff setting
Dac Lac	CPC	88 %	89 %	96 %	93 %	92 %
	DPC	10 %	8 %	3 %	3 %	4 %
	PCERWASS	0 %	1 %	0 %	0 %	0 %
	Village	0 %	0 %	0 %	0 %	0 %
	User	1 %	1 %	0 %	3 %	3 %

Source: Household survey results

(7) Ability and Willingness to Pay

Willingness to Pay (WTP) for individual piped system is similar to or exceeds that for public water supply system in all communes/towns (Figure 1.13).

WTP in Dac Lac province are 84%. Average WTP for individual piped system are quite high in all provinces, 85% in Dac Lac province.

According to National Rural Potable Water Supply and Sanitation Strategy to 2020, an average household spends less than 1 percent of its annual income on water supply and sanitation, and the strategy assumes that an average rural household could pay between 3 percent and 5 percent of its total annual income for potable water and sanitation in the future.

Table 1.15 is a rough estimation of WTP (payment) and Ability to Pay (ATP) calculated from present income. At present, people are ready to pay more than 1% of their income for piped water supply in all communes/towns. Table 1.15 also describes ATP calculated by percentage in accordance with NRWSS. If income stays at present levels the, amount stated in Table 1.15 can be spent by users for both water supply and sanitation. The difference between the present WTP and ATP should be reduced through the Information, Education and Communication activity of the project.

Table 1.15 Willingness to Pay and Ability to Pay

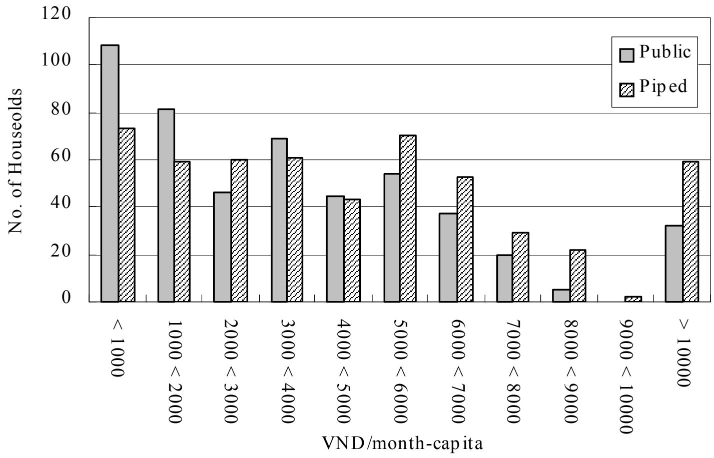
Unit VND

Town/ Commune	Average annual income per capita	Willingness To Pay for piped system (VND, %)		3% of income	5% of income
Dac Lac province					
Krong Nang T.	4,075,111	60,500	1.5%	122,253	203,756
Ea Drang T.	3,015,873	53,600	1.8%	90,476	150,794
Krong Buk C.	2,855,897	51,300	1.8%	85,677	142,795
Ea Drong C.	3,026,693	55,700	1.8%	90,801	151,335
Ea Wer C.	1,295,899	32,300	2.5%	38,877	64,795
Kien Duc T.	4,668,492	209,500	4.5%	140,055	233,425
Krong Kmar T.	3,287,566	62,900	1.9%	98,627	164,378

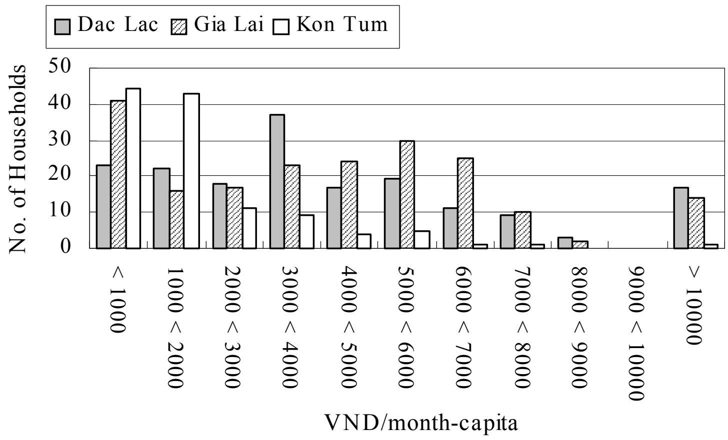
Source: Household survey results

(8) Future water needs

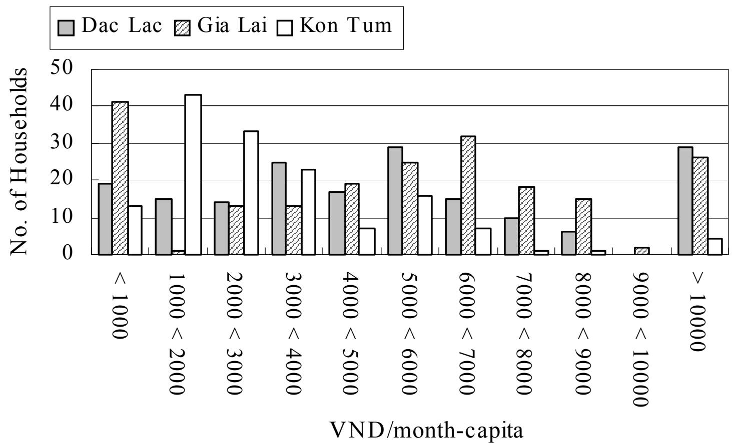
Future water needs for domestic use, gardening, and livestock are presented in Figure 1.14. For domestic use including drinking, 80 percent of households respond that they need from 20 to 120 liters per day per person. Households that answered from 40 to 60 liters per day-person are 32 percent of total households. Meanwhile, for gardening and livestock, 54 percent of households need less than 120 liters per day, while 22 percent answered that it is unnecessary.



(A) Willingness to Pay by Kinds of System



(B) Willingness to Pay for Public Water Supply by Province



(C) Willingness to Pay for Piped Water Supply by Province

Figure 1.13 Ability of Willingness to Pay

1.4.10 Living Condition

(1) Income and Expenditure

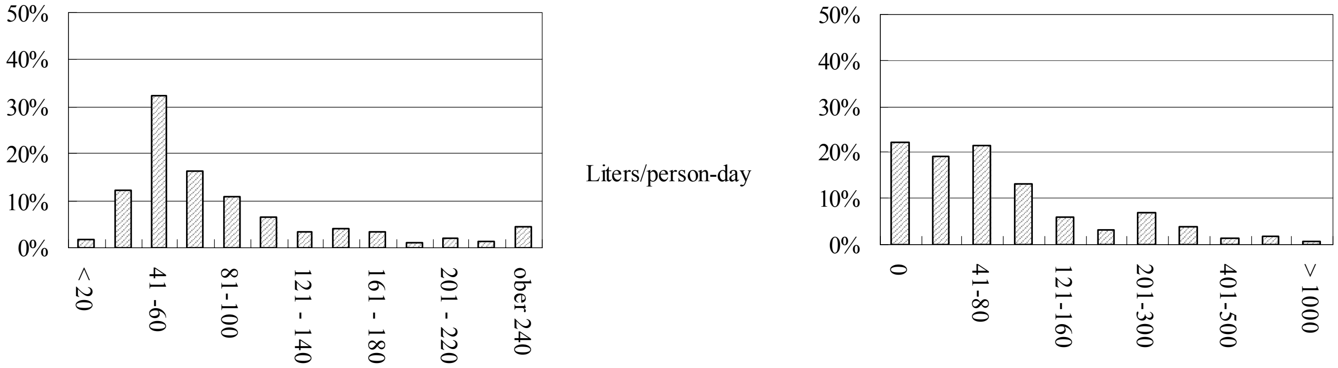
Figure 1.15 shows monthly income per capita.

Table 1.16 Average Expenditure by Expenses Items

	Food	Cloths	House	Water	Electricity	Fuel	Education	Medical service	Agriculture	Other	Total
Dac Lac	5,249,148	574,082	132,864	55,560	559,692	298,740	1,180,000	477,273	1,845,856	154,796	10,528,011

Source: Household survey results

Table 1.16 shows expenditure by expenses items in interviewed households. Average expenditure of interviewed households is 10,373,000 VND/year in Dac Lac. Figure 1.16 shows proportion of each item against total expenditure. Expenses for water is only 0.5% in Dac Lac. Expenses for electricity in Dac Lac province is the highest of the three provinces because of the high proportion of households who have electric products such as TV, video and electric fans.



(A) Need for Drinking and Domestic Use

(B) Need for Gardening and Livestock

Figure 1.14 Needs for Water Quantity

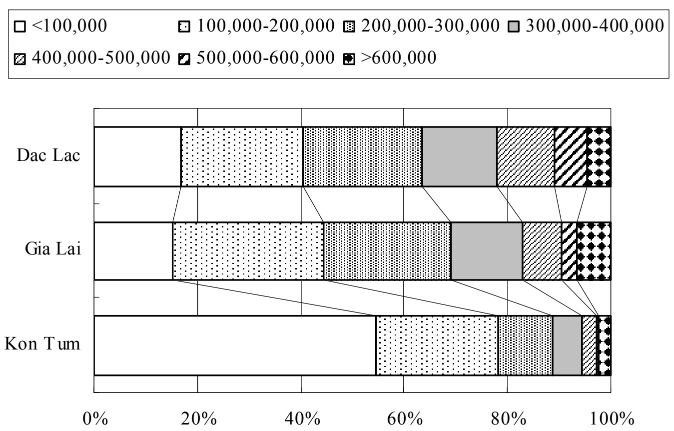
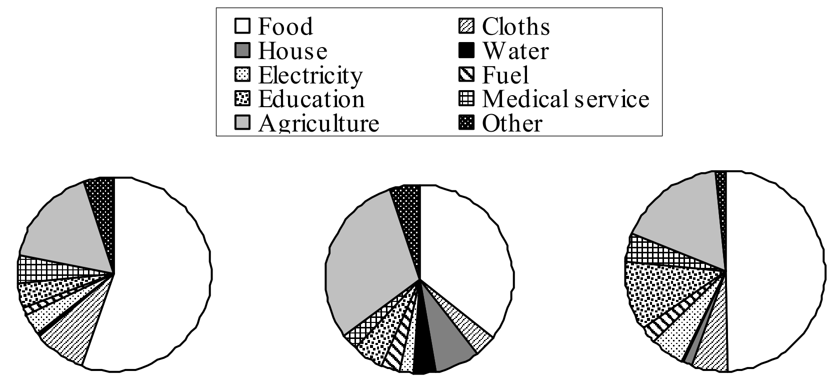


Figure 1.15 Monthly Income per Capita



(A) Kon Tum (B) Gia Lai (C) Dac Lac

Figure 1.16 Expenditures by Expense Items

(2) Electricity

Eighty-eight percent of total interviewed households use electricity (including batteries). Most users access the power line, while a few households in Dac Lac province use batteries. More details about access to the electricity in whole area are described in the result of RRA.

Table 1.17 Power Source for Domestic Use

	Power line	Battery	Generator	None
Dac Lac	87%	3%	0%	10%
Total	86%	2%	0%	12%

Source: Household survey results

As Figure 1.17 shows, wood and charcoal are still the dominant source of heat for cooking, even in electrified area. Communes/towns in Dac Lac province relatively use gas for cooking compared to the other two provinces. About 80 percent of household that use gas for cooking are not farm households.

(3) Type of Housing

In the household survey, definitions of house type are shown in Table 1.18 and were obtained from the 1999 Population and Housing Census. Figure 1.18 shows a relationship between type of house and income.

Table 1.18 Definitions of House Type

Classification	Definition
- Permanent type	Brick wall, ceramic roof and cement floor
- Semi-permanent type	Wood wall, ceramic roof, and cement floor or ground
- Temporary type	Any type other than above

Permanent and semi-permanent houses are common in the high-income group, while temporary types are common for the low-income group. Because people must buy housing materials in case of permanent and semi-permanent type houses, these results are directly linked to income level. It is not clear whether the difference between rates of permanent type and semi-permanent type house is related to income.

(4) Commodity Ownership

Figure 1.19 presents commodity ownership in the interviewed households.

Private transportation methods are important in terms of accessing information and interacting with people in other areas. More than half of the households interviewed have a motorcycle in Dac Lac province. Households that do not have either a bicycle or motorcycle account for 26% in Dac Lac province.

Having electric products is related not only to income level, but also to the situation of power supply in the residential area concerned.

Watching TV program or video is a common source of enjoyment in the lives of householders. Televisions account for the highest rate of ownership among electric products. TVs also have an important role as an information source in terms of activities of campaign and promotion. The number of households having a TV set in Dac Lac province is two times higher than Kon Tum province.

Telephone is not yet prevalent in the interviewed households. This is also condition of infrastructure is related to expansion of user.

1.4.11 Agriculture

Agriculture is the main income source in the central highlands. Following Table 1.19 shows cultivated area and number of farmers in the interviewed households. As can be seen, households have about 1.1 - 1.4 ha in Dac Lac province. Main cash crops are coffee, pepper and cashew.

Table 1.19 Cultivated Area in Interviewed Households

	Total farmland (Ha)	Farm households (Households)	Average farmland per household (Ha/household)	Number of farmers (Persons)	Average farmland per farmer (Ha/farmer)
Dac Lac	241.63	176	1.37	394	0.61

Source: Household survey result

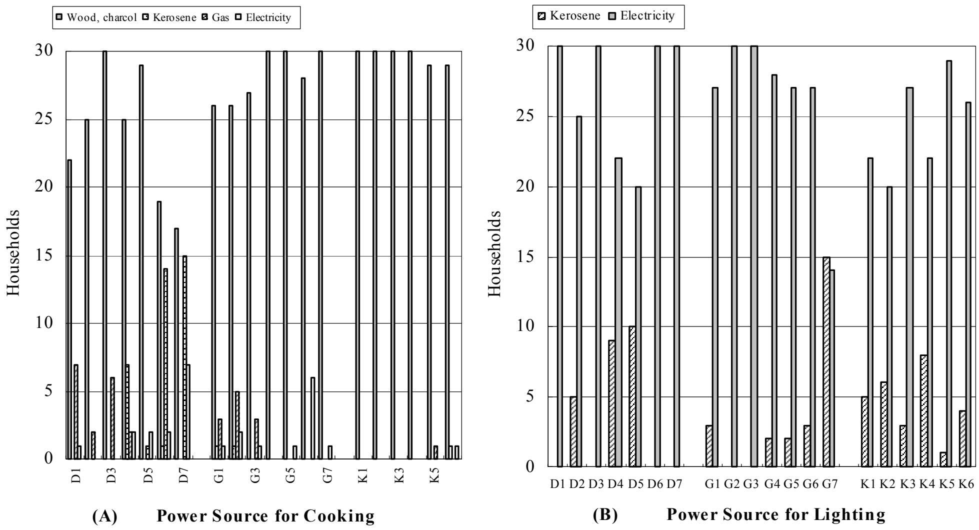


Figure 1.17 Power Sources

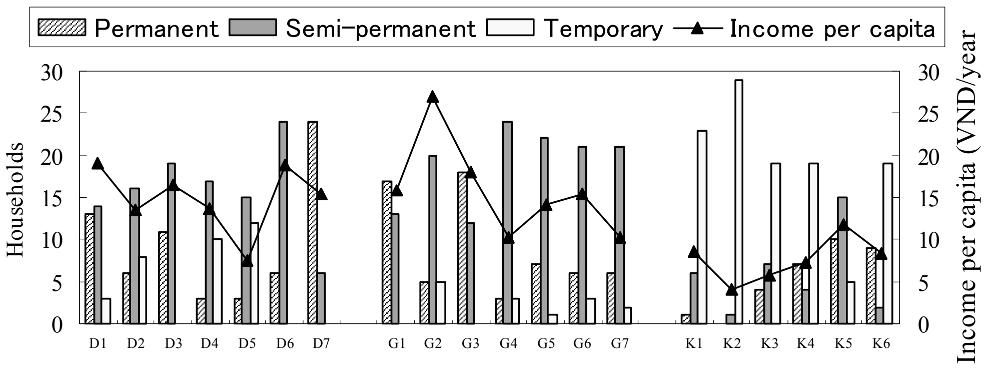


Figure 1.18 Type of House and Income

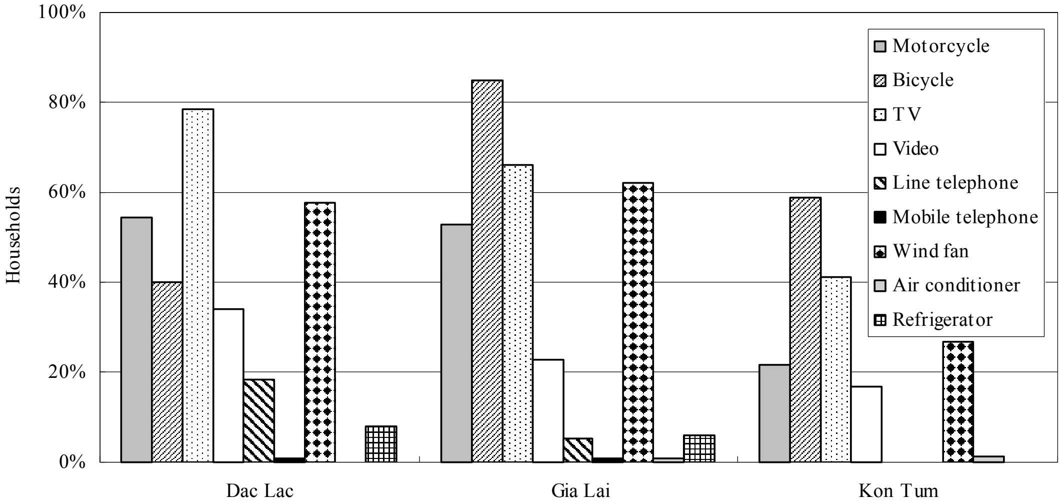


Figure 1.19 Owned Commodity

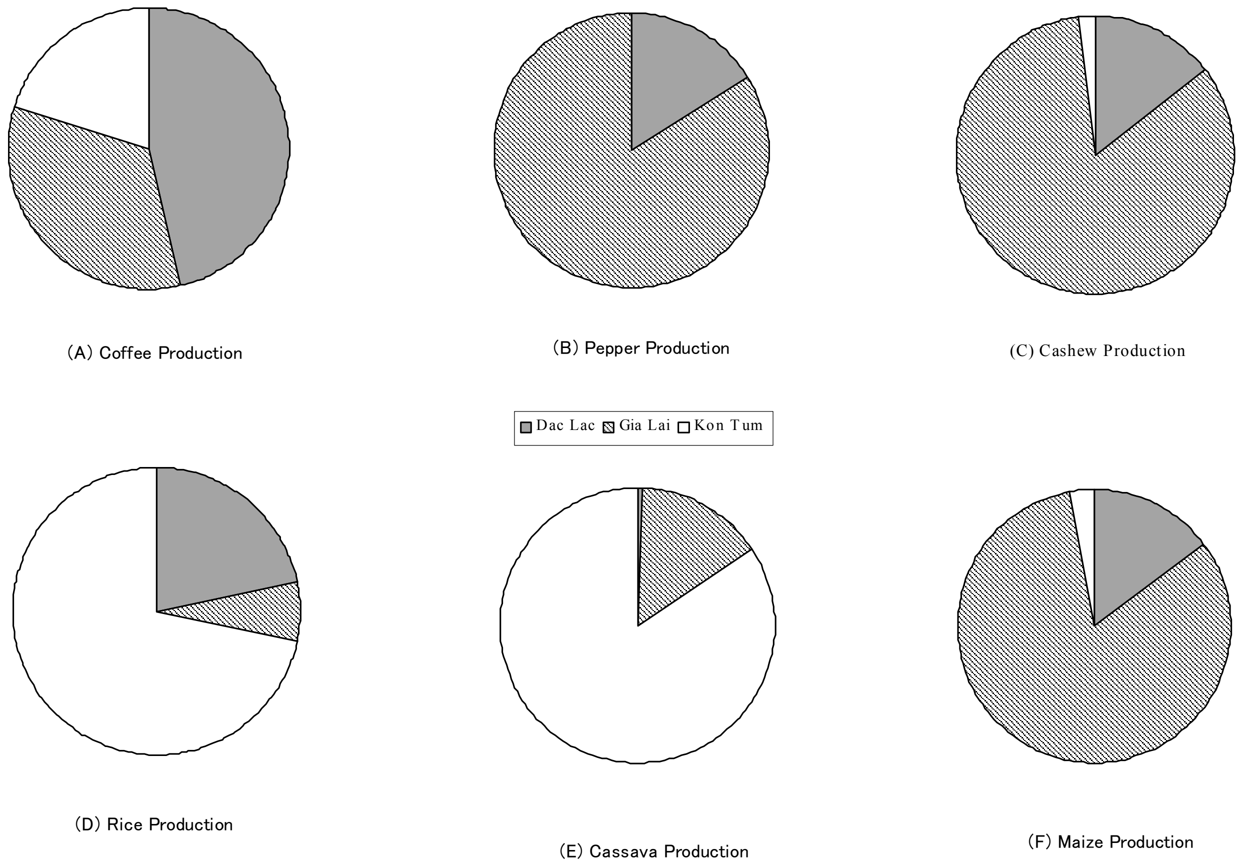


Figure 1.20 Main Agriculture Products

Chapter 2 Design of Water Supply System

2.1 Framework of Water Supply Master Plan

2.1.1 Purposes

The purposes of water supply master plan is the find the best solutions for rural water supply in the study area in accordance with the National Rural Clean Water Supply and Sanitation Strategy up to year 2020 (NRWSS). As a result the selected 21 priority water supply out of all the 46 systems were planned by a centralized piped water supply network. The 21 systems are recommended to implement in the earliest stage.

The water supply master plan was updated during the F/S phase for the following items:

- ♦ projections of population and water demand in every system in the study area,
- ♦ groundwater development plan,
- ♦ identification of necessary treatment systems for the priority systems,
- ♦ preliminary drawings for the priority systems,
- ♦ hydraulic calculations to check pressures in the piped systems,
- ♦ standard designs of water supply facilities that can be used with detailed design, and
- ♦ cost estimates for the piped supply systems.

2.1.2 Strategy

The NRWSS gives clear targets to be achieved up to the year **2010 (phase 1)** and the year **2020 (phase 2)**, and this study follows the same targets of the NRWSS. The NRWSS emphasizes the need for the demand responsible approaches with applying appropriate technological options, and for enabling the users to make an informed choice for the selection of the water supply system.

The present study aims a groundwater development which points towards a **centralized piped water supply system for the prioritized systems**. Alternative options are given for the systems, where piped water supply method is insuitable.

In this study the three options of water supply system are identified by the rural condition of Central Highlands. Each option was examined advantages and disadvantages. This is based on the effectiveness of each system for bringing clean drinking water to users, capital cost, cost and complexity of operation and maintenance, appropriate level of operation and maintenance, availability of spare parts, and economic evaluation with taking into account of the social equity and political situations.

2.1.3 Level of Service

According to the NRWSS, the users should decide the "level of service". Service items mean:

- method of supply,
- user demand,
- service hours, and
- service pressure.

Level of service is described as follows:

Service item	Level of Service
Supply method	A: **House connection** by piped supply B: **Public taps** by piped supply C: Individual household systems such as private dug well.
Water demand	NRWSS is described the demand of **60 l/c/d** for years 2010 and 2020.
Service hours	Basically **24 hours**.
Service pressure	40 m head (4 bar) at maximum, and more than 4 m head in peak hours.

The centralized piped water supply systems will provide the opportunity for local residents to choose house connections (supply method A) and public taps (supply method B). Individual households shall be taken the simplest method for the improvement of the existing dug wells (supply method C) with the help of the user's contribution, UNICEF and the local governments.

2.2 Water Demand Projections and Choice of Technology

2.2.1 Projection of Populations

The population was projected for the years 2005, 2010, 2015 and 2020 for all 46 systems in the study area to cover the all villages and hamlets. The population and population growth rates were collected from the 20 target communes with breakdown for each village so as to make the best planning by grouping for systems. It was collected during the 1st field investigation period, and updated at the F/S stage. When population growth rate is not certain by various reasons, the population growth rate is assumed to be the same as nearby commune/village.

The population growth rates of D5 (Ea Wer commune) are higher than 10% because these communes received huge numbers of migration at once by the policy of the central government. The growth rates of D7 (Krong Kmar commune) are relatively high (3.4%) because that the local economy is rapidly developing and increase migration. As the abnormally high growth rates of these communes will be terminated soon by the limited land space to receive migration. They are expected to continue up to 2005 and falling down to the regional average (about 2.0%) after probably 2006.

Table 2.1 Projected Populations

Commune	No. of Villages	No. of Household	Growth Rate (%)*	Growth Rate (%)*	Population	Projection			
			2001-2005	2006-2020	2000	2001	2005	2010	2020
Dac Lac province									
D1: Krong Nan	9	1998	**1.80**	**1.80**	10795	**10989**	**11802**	**12903**	**15423**
D2: Ea Hleo	13	2631	**2.20**	**2.20**	14853	**15180**	**16560**	**18464**	**22953**
D3-1: Krong Puk	7	1192	**2.60**	**2.60**	6619	**6791**	**7525**	**8556**	**11060**
D3-2: Krong Puk	5	640	**2.60**	**2.60**	3453	**3543**	**3926**	**4463**	**5770**
D3-3: Krong Puk	8	766	**2.60**	**2.60**	3494	**3585**	**3972**	**4516**	**5838**
D4-1: Ea Drong	6	1245	**1.20**	**1.20**	6901	**6984**	**7325**	**7775**	**8760**
D4-2: Ea Drong	4	431	**1.20**	**1.20**	1805	**1827**	**1916**	**2034**	**2291**
D5-1: Ea Wer	9	963	**10.00**	**2.10**	4992	**5491**	**8040**	**8920**	**10981**
D5-2: Ea Wer	1	64	**10.00**	**2.10**	313	**344**	**504**	**559**	**688**
D5-3: Ea Wer	1	46	**10.00**	**2.10**	197	**217**	**317**	**352**	**433**
D6: Kien Duc	8	2062	**2.10**	**2.10**	8626	**8807**	**9571**	**10619**	**13071**
D7:Krong Kmar	8	1169	**3.40**	**2.00**	5735	**5930**	**6779**	**7484**	**9123**

*The shaded parts in the table show that rapid population growth will follow the development plan up to 2005, and will scale down (about 2.0%) after 2006 through 2020. The population projections for the other communes/towns apply the same growth rates.

2.2.2 Projection of Water Demands

The water demand projections were made based on the projected population, coverage and demand per capita (q) as followings:

Year	2001	2005	2010**	2020**
Coverage (%)*1	25	50	85	100
Demand (q) (l/c/d)*2	30	30	60	60

*1: Coverage means population served as percentage of total population
*2: l/c/d means litter per capita per day
** NRWSS targets

The necessary water supply quantities are calculated for setting of design factors such as, 1) daverage day demand (Q_{av}), 2) maximum daily demand (Q_{max}), and 3) maximum hourly demand (q_{max}). The formula to calculate necessary water supply quantity are shown in the following tables. These calculated results are to be used for the design of the water supply facilities in each system.

Necessary water supply quantity	Definitions
Average Day Demand (Q_{av})	• Q_{av} = capita * q * 1.2 • 20% is added here for leakage. This will require a very efficient O&M planning, otherwise the leakage will be higher.
Maximum daily Demand (Q_{max})	• $Q_{max} = Q_{av}$ * 1.3 • coefficient value (1.3) is applied referring Japanese standard of 1.28. • Q_{max} is used to determine: Number of required wells (depending on yield), Dimensions of raw water pipes, Dimensions of treatment plants, Dimensions of elevated tanks, and Dimensions of reservoir tanks.
Maximum Hourly Demand (q_{max})	• $q_{max} = Q_{max}$ *2.0/24 =1.3 *2.0 Q_{av} /24 • coefficient value (2.0) is applied referring Japanese standard for rather small piped system in rural area. q_{max} is used to determine dimensions of transmission and distribution pipes.

Table 2.2 Calculation of necessary water supply quantity: Dac Lac Province

Qav: Daily average supply (m^3/day)
Qmax: Daily maximum supply (m^3/day)
qmax: Daily maximum hourly supply (m^3/hour)

Year	2001			2005			2010			2020		
Community	Qav	Qmax	qmax	Qav	Qmax	qmax	Qav	Qmax	qmax	Qav	Qmax	qmax
D1: Krong Nan	98.9	**128.6**	**10.71**	212.4	**276.2**	**23.01**	789.7	**1026.6**	**85.55**	1110.5	**1443.6**	**120.30**
D2: Ea Hleo	136.6	**177.6**	**14.80**	298.1	**387.5**	**32.29**	1130.0	**1469.0**	**122.42**	1652.6	**2148.4**	**179.03**
D3-1: Krong Puk	61.1	**79.5**	**6.62**	135.5	**176.1**	**14.67**	523.6	**680.7**	**56.73**	796.3	**1035.2**	**86.26**
D3-2: Krong Puk	31.9	**41.5**	**3.45**	70.7	**91.9**	**7.66**	273.2	**355.1**	**29.59**	415.4	**540.0**	**45.00**
D3-3: Krong Puk	32.3	**41.9**	**3.50**	71.5	**93.0**	**7.75**	276.4	**359.3**	**29.94**	420.3	**546.4**	**45.54**
D4-1: Ea Drong	62.9	**81.7**	**6.81**	131.9	**171.4**	**14.28**	475.8	**618.6**	**51.55**	630.7	**820.0**	**68.33**
D4-2: Ea Drong	16.4	**21.4**	**1.78**	34.5	**44.8**	**3.74**	124.5	**161.8**	**13.48**	165.0	**214.5**	**17.87**
D5-1: Ea Wer	49.4	**64.2**	**5.35**	144.7	**188.1**	**15.68**	545.9	**709.7**	**59.14**	790.6	**1027.8**	**85.65**
D5-2: Ea Wer	3.1	**4.0**	**0.34**	9.1	**11.8**	**0.98**	34.2	**44.5**	**3.71**	49.6	**64.4**	**5.37**
D5-3: Ea Wer	2.0	**2.5**	**0.21**	5.7	**7.4**	**0.62**	21.5	**28.0**	**2.33**	31.2	**40.6**	**3.38**
D6: Kien Duc	79.3	**103.0**	**8.59**	172.3	**224.0**	**18.66**	649.9	**844.8**	**70.40**	941.1	**1223.5**	**101.96**
D7:Krong Kmar	53.4	**69.4**	**5.78**	122.0	**158.6**	**13.22**	458.0	**595.4**	**49.62**	656.9	**853.9**	**1.16**

2.2.3 Choice of Technology

The NRWSS stresses the need for appropriate technology, easy operation and maintenance, low cost and sustainability. This section is described the three main technical options that may be suitable for the selection of the system in the study area: 1) centralized piped network, 2) small piped network, and 3) household system.

(1) Option 1: Centralized Piped Network

Centralized piped supply is applicable for the 21 systems prioritized in the previous chapter to meet immediate catch up the NRWSS target by its large size water supply. A piped system enables all (or most) of households to be connected to a piped water supply system. General descriptions of this option is as follows:

- Densely populated areas are feasible for this solution.
- The water source will be a deep well for most communities, although some communities may be supplied from a surface water source.
- This option can centralize more complicated processes such as water treatment and pump operation.
- A single operation and maintenance organization will be needed.
- Relatively long supply pipelines will be needed if the housing density is not high enough (e.g. as the systems in Kon Tum province). Long lines place a higher demand on maintenance in order to avoid high leakage rates (up to 50 % or more).
- As the users will have to pay for the connection themselves, it may be a problem for poor households.
- In areas with high poverty rates there could also be a number of public taps. Public taps are furthermore included for kindergartens, schools, health clinics, hospitals and other public utilities.

Photo 1 shows the central of D6 (Kien Duc town). This is a semi-urban area with little resemblance to a rural area. A centralized piped water supply system is feasible.

(2) Option 2: Small Scale Piped Network

In the small scale piped network option, each (or a few) village has its own small piped network. General descriptions of this option are as follows:

- This option is suitable for small communities/hamlets located in remote areas far from the main communities and with small number of households (from 2-100).
- A shallow well with a sufficient yield is needed to use for this option for all the communities.
- A treatment plant have to be constructed in each community (if needed).
- The construction cost per capita of this option may become high.

Photo 2 shows a remote area in G4-2, with long distance between houses in the villages. This option will actually appoints after examining the location of water sources and the degree of treatment requirement.

(3) Option 3: Household System

Dug wells often get polluted and they have risk for drying up in the dry season. The polluted water of the dug wells can be solved by improvement of the shallow wells e.g. covering apron, installation of hand pump and possibly lining of the well. General descriptions of this option are as follows:

- Simple filters to remove iron and to some extent bacteriologic contamination may be needed.
- This option is relatively inexpensive and requires little operation and maintenance.
- Improved sanitary and hygienic practices are important.

Photo 3 shows a dug well in D3-3. It is well constructed with apron and raised side. It might be improved with a hand pump or possibly a small electric pump, thereby reducing the risk of contamination and making operation easier.

Photo 1 Semi-urban area (D6). Well suited for piped water supply (Option1)

Photo 2 Thinly populated area (G4). Long pipelines increase cost and risk of leakage (Option 2)

Photo 3 Dug well. Well constructed with apron and raised sides.

This type could be improved with a handpump or small electric pump (Option 3)

The plan includes two phases (phases 1 and 2) in accordance with the NRWSS. The following shows the consequences of each phase:

Phase	Water supply
Phase 1: 2002 –2010:	Supply by centralized piped water network is implemented in larger, densely populated 21 systems prioritized for piped supply systems. Water supply is improved in other areas by improving household systems, mostly shallow dug wells.
Phase 2: 2011 - 2020:	Extending the distribution pipes of the already established network continues the improvement of the supply. New piped networks are constructed in such systems for high population growth areas.

The summary of the selection of the options is shown in the table below, and the water supply plan to be used option for a total of 46 systems is shown in Table 2.3.

<table>
<tr><th>Phase</th><th>Option</th><th>Number of systems</th><th>Total</th><th>Remarks</th></tr>
<tr><td rowspan="7">Phase 1</td><td rowspan="3">Option 1</td><td>Kon Tum:5</td><td rowspan="3">21 systems</td><td rowspan="3">• Priority projects for option 1 were further investigated at the F/S stage and described herewith.</td></tr>
<tr><td>Gia Lai: 7</td></tr>
<tr><td>DacLac: 9</td></tr>
<tr><td>Option 2</td><td>No system</td><td>-</td><td>• No system is recommended for a small piped system at phase 1.</td></tr>
<tr><td rowspan="3">Option 3</td><td>Kon Tum:13</td><td rowspan="3">25 systems</td><td rowspan="3">• Improvement of the existing dug wells, and construction of dug wells are realistic for remote areas. No groundwater sources were identified in K5 and K6.</td></tr>
<tr><td>Gia Lai:9</td></tr>
<tr><td>Dac Lac: 3</td></tr>
<tr><td rowspan="9">Phase 2</td><td rowspan="3">Option 1</td><td>Kon Tum:9</td><td rowspan="3">26 systems</td><td rowspan="3">• Distribution pipes of the firstly prioritized systems will be extended, and connected to some neighboring systems.
• Systems in K4-3, K4-4, K5, K6, D3-3 may be included in piped network if enough financial and water resources are promised.</td></tr>
<tr><td>Gia Lai: 7</td></tr>
<tr><td>DacLac: 10</td></tr>
<tr><td rowspan="3">Option 2</td><td>Kon Tum:3</td><td rowspan="3">3 systems</td><td rowspan="3">• 3 systems with a population more than 1,000 may be appropriate for small piped systems at phase 2 if fund is available.</td></tr>
<tr><td>Gia Lai: 0</td></tr>
<tr><td>DacLac: 0</td></tr>
<tr><td rowspan="3">Option 3</td><td>Kon Tum:6</td><td rowspan="3">17 systems</td><td rowspan="3">• Systems with a population less than 1,000 even at phase 2 are not suitable for piped systems.</td></tr>
<tr><td>Gia Lai: 9</td></tr>
<tr><td>DacLac: 2</td></tr>
</table>

Note: Phase 1 means the period of 2003 – 2010, and Phase 2 means the period of 2010 –2020.

Table 2.3 Water Supply Plan

System	Population			Phase 1 (2003-2010)	Phase 2 (2010-2020)
	2000	2010	2020		
DAC LAC					
D1 Krong Nang	10795	12903	15423	Option 1	Extension of distribution pipes
D2 Ea H´Leo	14853	18464	22953	Option 1	Extension of distribution pipes
D3-1 Krong Puk	6619	8556	11060	Option 1	Extension of distribution pipes
D3-2	3453	4463	5770	Option 1	Extension of distribution pipes
D3-3	3494	4516	5838	Option 3	Option 2
D4-1 Ea Drong	6901	7775	8760	Option 1	Extension of distribution pipes
D4-2	1805	2034	2291	Option 1	Extension of distribution pipes
D5-1 Ea Wer	4992	8920	10981	Option 1	Extension of distribution system
D5-2	313	559	688	Option 3	Option 3
D5-3	197	352	433	Option 3	Option 3
D6 Kien Duc	8626	10619	13071	Option 1	Extension of distribution pipes
D7 Krong Mar	5735	7484	9123	Option 1	Extension of distribution pipes

Note: The areas with shaded mark are correspondent with the priority systems.

2.3 Groundwater Development Plan

2.3.1 Present Groundwater Resources

Out of the 21 priority systems, the water sources have been identified for 19 systems: the groundwater resources for 17 systems. The remaining 2 systems (D3-2 and D4-2) need to explore wells as their initial water sources.

The safe well yields for the 9 wells explored by the study team and the 2 existing wells to be integrated are shown below.

Table 2.4 Safe Well Yields of Explored Wells

Prioritized System		**Safe well yield (m^3/day)**	**(liter/sec)**	**Geology**	**Remarks**
Dac Lac province					
D1	Krong Nang	**346**	4.0	Basalt (β N_2-Q_1)	**Confined aquifer**
D2	Ea Drang	**225***	2.6	Basalt (βQ_{2-4})	**Existing boreholes will be used.**
D3-1	Krong Buk	**415**	4.8	Basalt (β N_2-Q_1)	**Confined aquifer**
D3-2	Krong Buk	**-**	-	Basalt (β N_2-Q_1)	**Not yet drilled**
D4-1	Ea Drong	**268**	3.1	Basalt (β N_2-Q_1)	**Confined aquifer**
D4-2	Ea Drong	**-**	-	Basalt (β N_2-Q_1)	**Not yet drilled**
D5-1	Ea Wer	**320**	3.7	Basalt (β), Jurassic sandstone (J)	**Unconfined aquifer**
D6	Kien Duc	**259***	3.0	Basalt (β N_2-Q_1)	**Existing boreholes will be used.**
D7	Krong Kmar	**518**	6.4	Sand (Q), Jurassic sandstone (J)	**Unconfined aquifer**

* Based on the pumping test of the existing boreholes for D2 and D6

Basalt covers most of the communes/towns in Gai Lai and Dac Lac provinces, except for the target communes of Kon Tum province, D-7 (Krong Kmar town). The 9 wells explored by the study team have enough quantity of water for the initiation of the piped supply systems. However, in a number of systems the quantity of water will be insufficient. The two wells explored by the study team in D2 and D6 did not have enough quantities, so the existing wells are integrated to the piped supply systems.

2.3.2 Necessary Groundwater Development

The following table shows the numbers of wells which will be required by 2010 and 2020 based on the water supply plans and safe well yields of the wells used for piped supply. The number of necessary wells in 2010 and 2020 were calculated based on the before described maximum daily demand (Q_{max}) and safe well yield obtained by groundwater investigation. The present quantity of water in the wells of K1-1, G2, and D2 will not satisfy the future water demand even in 2005. In K1-1 there is a need to explore 7 more wells up to 2010, and 6 more in D2, 5 more in G2 and 3 more in D6. The explored wells in K2-1, K3-1, G6-1, and G7-1, have enough water for water supply plans and will not require any additional wells up to 2010.

Table 2.5 Number of Required Wells

Prioritized system	Safe well yield (m^3/day)	Water supply plan (m^3/day)				Required wells	
		2001	2005	2010	2020	2010	2020
D1: Krong Nan	346	128.6	276.2	1026.6	1443.6	2	2
D2: Ea Hleo	225	177.6	387.5	1469.0	2148.4	6	3
D3-1: Krong Puk	415	79.5	176.1	680.7	1035.2	1	1
D3-2: Krong Puk	415	41.5	91.9	355.1	540.0	1	1
D4-1: Ea Drong	268	81.7	171.4	618.6	820.0	2	1
D4-2: Ea Drong	268	21.4	44.8	161.8	214.5	1	0
D5-1: Ea Wer	320	64.2	188.1	709.7	1027.8	2	1
D6: Kien Duc	259	103.0	224.0	844.8	1223.5	3	1
D7:Krong Kmar	518	69.4	158.6	595.4	853.9	1	0

The necessary drilling points in future are shown with the shadow zones in the figures in the Supporting Report-A labeled "Groundwater potential and the most promising drilling area". The exact locations shall be decided through the discussion with the people's committee and PCERWASS to avoid private land. The location of well to be constructed shall also be decided considering well interval of 300m or over, distance from latrine (shall be 50m apart from latrine) or to prevent noise pollution (shall be 20m apart from house).

For the purpose of selecting of potential groundwater areas in the study area, geophysical prospecting by electrical and electromagnetic sounding was carried out in the first field investigation stage The resistivity of weathered or fractured saturated rocks and sedimentary rocks becomes lower. Water along faults and fractures in the rock will demonstrate low resistivity anomalies against the compact and fresh rock. Very low resistivity - less than 10 ohm-m - possibly indicates existence of a high content of clay.

The resistivity of promising zones, that could be an aquifer, ranges from 30 to 100 ohm-m, reflecting the drilling experience of this study. The successful ratio by the 20 drilling was 90% (17 wells were constructed). The sites for the future production wells could be close to the successed exploratory wells because the hydrogeological data and the results from the electrical sounding and electro-magnetic survey in the first investigation are available to analyze the suitable location for drilling. In this case, further geological and hydrogeological investigations can be avoided.

2.3.3 Drilling Method

After identifying potential groundwater areas, drilling will be carried out by the following order:

1) drilling work,
2) geophysical logging,
3) reaming of holes,
4) installation of casing and screen pipes, and
5) gravel packing and grout sealing.

(1) Drilling Work

Core drilling was performed by a hydraulic driven rotary machine in the first field work. Considering the difficulty of drilling and enormous time for reaming work by old rotary machines in Vietnam for hard basalt layers, it is recommendable to employ down-the-hole (DTH) method which is the latest type of drilling rig to be provided. Typical well design is shown in Appendix 1.

Water level shall be measured and recorded during drilling work. When a portion of outstanding loss of drilling water or spring-up of groundwater is encountered, the depth of the portion shall be recorded with the discharge rate.

(2) Geophysical Logging

Immediately after the completion of drilling work, electrical logging will be made using logging devices of the latest model of real time recording system at site to be provided. The logging record will be used in the casing and screen program to be installed in the drilled hole.

(3) Reaming of the Pilot Hole

After completion of geophysical logging, reaming work is conducted to make a hole wider, if the old type of drilling machine is employed in future work. The latest drilling rig will not require such reaming work when the procurement of machine is possible. Enormous amounts of time can be saved by deducting the reaming work by the latest rig.

(4) Installation of Casing and Screen Pipes

The following table shows the specifications of the necessary casing and screen pipes for future well construction. The following pipes which were provided by JICA remain at the sites after drilling and constructing the 20 exploratory wells. It is recommended that the remaining pipes be used to minimize the construction cost with high quality wells. In total, 1,188m of the remaining pipes shall be approximately equivalent to 12 wells 100 m deep on average. However, the material of pipes may not be Fiber Reinforced Polymer (FRP) for the local construction when the remaining pipes are thoroughly consumed.

Table 2.6 Casing and Screen Pipes

Type of Pipes	Material of Pipes	Size of Pipe	Remaining Q'ty
Screen	FRP	150mm (dia.) x 4m (L)	1,096m
	FRP	150mm (dia.) x 2m (L)	476m
Casing	FRP	150mm (dia.) x 4m (L)	380m
	FRP	150mm (dia.) x 2m (L)	4m
Bottom Plug	FRP	150mm (dia.)	74 pieces
Centerizer	Made by copper	150mm (dia.)	39 pieces
Screen	FRPM	150mm (dia.) x 2m (L)	4m
	FRPM	150mm (dia.) x 4m (L)	52m
Casing	FRPM	150mm (dia.) x 4m (L)	340m
	FRPM	150mm (dia.) x 2m (L)	4m
Bottom Plug	FRPM	150mm (dia.)	1 piece
Centerizer	Made by copper	150mm (dia.)	53 pieces

The drilled hole shall be vertical and straight enough to install the casing and screen pipes, and to allow the packing of the homogeneous gravel in the space between the casing and screen pipes and the drilled hole.

On the basis of the lithological and logging records, the casing program shall be formulated for each well. In accordance with the casing program, bottom plug, screen and blank casings shall be installed in the center of the drilled hole. The centralizers shall be attached to the said pipes at every six (6) meters interval from the bottom.

(5) Gravel Packing and Grout Sealing

Immediately after the casing installation completed, gravel packing shall be carried out into the annular space between the pipes installed and the hole. The packing gravel shall be composed of round shaped siliceous materials and selected gradation.

Gravel shall be dropped at an equal rate, not so as to occur sticking and bridging of gravel at the space. Drill-cut or impervious materials may be packed at the blank casing portion near the surface.

Finally, the annular space between the hole and casing pipes at the upper-most ten (10) meter portion of all the holes shall be sealed perfectly by cement grouting to avoid the infiltration of surface water.

2.3.4 Water Quality and Necessary Treatment

(1) Review of Water Quality Analysis

Water quality analysis was carried out for 23 items shown in Chapter 2 in the first investigation and for 3 items (coliform, nitrate, and nitrite) in the F/S period.

Necessary treatment is decided based on the result of the water quality analysis of the exploratory wells and in accordance with Standard 505 of the MOH for separate systems and rural areas. The standard is somewhat more lenient than the WHO standard for some parameters, e.g. an iron content of 0.5 mg/l is allowed.

The following general observations are made:

- ♦ The iron content of groundwater was high in D4-1, D5-1, D6, and D7. Iron and manganese in the water do not pose a health risk, but they leave colored deposits in installations or stains on clothes, and unpleasant taste.
- ♦ Some manganese content is found in D5-1 and D7.
- ♦ pH is slightly low in some deep wells (D1, D2, D6, and D7). Low pH means that the water is corrosive and may corrode house installations and pipes made out of metal. Aeration facility is recommended to adjust pH value.
- ♦ The water is generally soft.
- ♦ Some of the groundwater samples have a certain level of coliform.
- ♦ No treatment is necessary for arsenic and fluoride.
- ♦ Dioxin was not detected in the 3 analyzed samples (D6).

(2) Recommendations for Treatment

The following preliminary recommendations on treatment can be made, and an overview is seen in the following table.

- **pH adjustment** can be done by neutralizing the corrosiveness by adding chemicals (usually lime). This complicates the operation of the systems and it will only be recommended for the larger systems, if the analysis from the deep wells shows that it is necessary. Level of pH could be adjusted by aeration, but this effect shall be checked through the monitoring of the pilot model plants.
- **Chlorination** may be avoided for small systems as it complicates the operation and maintenance with high cost of O&M. However it cannot totally be avoided if coliform is still found. For the larger systems, a chlorinator should principally be installed.
- **Iron removal** may be necessary in the systems of D4-1, D5-1, D6, and D7.
- **Manganese removal** may be required in the communes D5-1 and D7.
- For the system of K4-1, **surface (river) water** is often subject to bacteriological contamination. In the rainy season the water often becomes turbid, which complicates the treatment. In addition, the river water contains a high content of iron. The water should consequently be treated for removal of turbidity and the water should be disinfected. A simple technology option has been recommended for treatment of surface water.
- The need for treatment should be reconfirmed by repeated water quality analysis before the detailed design.

Table 2.7 Recommended Treatment

System	Source	Treatment			
		Problem	Filtration	pH adjust. Recommended	Disinfection
D1	Deep well	Low pH	No	Yes	Chlorination
D2	Deep well	Low pH	No	Yes	Chlorination
D3-1	Deep well	None	No	No	Chlorination
D4-1	Deep well	Iron	Aeration + Slow sand filter	No	Chlorination
D5-1	Deep well	Iron Mangan.	Aeration + Slow sand filter	No	Chlorination
D6	Deep well	Iron Low pH	Aeration + Slow sand filter	Yes	Chlorination
D7	Deep well	Iron Mangan. Low pH	Aeration + Slow sand filter	No	Chlorination Chlorinated lime No

2.4 Design for Piped Schemes

2.4.1 Design Principles

"Appropriate technology" or even "low technology" should not necessarily mean "low cost". Even though less advanced methods are recommended, the materials used should be good. The following are the basic recommendations for the design principles of the piped supply systems.

- **Simple (or manual) pump controls** are recommended.
- As far as possible **gravity** will be used for transport of water.
- **Local materials** should preferably be used for construction in order to ensure the availability of spare parts.
- **Pipe material and fittings should be of good quality** in order to minimize pipe bursts and leakage.
- **Water meters are delicate equipment and only good quality meters should be used**, otherwise they will quickly break down or the accuracy will degrade. Only dry-dial meters should be used, as even the allowed iron content of 0.5 mg/l may be harmful to wet-dial meters.
- Pumps with good efficiency should be used in order to save operating costs.
- Installations should be properly performed. Poor pipe work will certainly increase leakage rates.

2.4.2 Design Criteria

This section includes the Vietnamese design criteria "TCXD 33 (1985)" for water supply external networks and facilities design standard. This master plan follows this design criteria, and the following table shows the design items and design criteria.

Table 2.8 Design Criteria

Design Item	Design Criteria
Service hours	• Basically 24 hours.
Submersible Pumps	• Submersible pumps are dimensioned to deliver the maximum daily supply (Q_{max}) in 2020 around 20 hours pumping (4 hours is considered for sudden public power drop and maintenance).
Booster pumps	• Booster pumps pumping to elevated tanks should deliver the maximum hourly supply (q_{max}).
Distribution Pipe Dimensions	• The distribution pipe dimensions will be calculated so as to deliver the required service pressure in the maximum hourly supply (q_{max}) for 2020.
Treatment Plants	• Treatment plants will be dimensioned for delivering the maximum daily supply (Q_{max}) within 20 hours in 2010 and less (corresponding to the demand) before that.
Reservoirs	• Reservoir size will be constructed to balance the fluctuating demand from the distribution system against the output from the raw water supply, and to act as a safeguard for the continuation of the supply should there be any breakdown or stop by maintenance at the sources. The dimension is as 8 times the average hourly demand in the maximum daily supply (Q_{max}) for 2010.
Elevated Tanks	• Elevated tanks are set for the accumulation of water pressure, and usually are located at the highest locations close to reservoirs. Elevated tank size is determined by the consumption in the average hourly demand in the maximum daily supply (Q_{max}) for 2020.
Service Pressure	Pressure at user should be: • Maximum: 40 m (4 bar). Higher pressure (up to 6 bar) can be accepted in some areas if no other source is available. Pressure reducing installations should be considered. • Minimum: 6 m (0.6 bar). In the peak situation 4 m may be accepted in small areas if the achievement of higher pressure will be costly.
Public Taps	• Public taps will be installed at all public buildings, e.g. peoples committee offices, schools, kindergartens, health centers etc. The communities may decide on more public taps to be installed.
Bulk Water Meters	• Bulk water meters are to monitor water production and consequently unaccounted-for water, in various areas of the water supply system. • Bulk water meter shall be installed in the front of each village/hamlet and/or diverging point from main distribution pipeline to secondary pipeline.

2.4.3 Alternatives for the 21 Piped Schemes

The 21 prioritized systems are varying with regard to elevations and pressure, and the locations of the water supply facilities should be efficient. This section prepares the six main alternatives for economical centralized piped supply as described below:

(1) Alternative 1

This solution is proposed in systems with small variations in ground elevation. For example, where it is not possible to position a reservoir on high ground, and supply the distribution system by gravity. It can also be proposed in areas where there is no need for water treatment (excepting chlorination).

Water is pumped directly from a deep well submersible pump to a ground level reservoir for storage. From this reservoir, the booster pumps transfer water to an elevated tank (8 to 10 meters in height). From the elevated tank the water flows by gravity to the piped distribution network.

(2) Alternative 2

This solution is proposed where simple water treatment is necessary, which basically involves removal of excess contents of iron and manganese. Chlorination after slow sand filtration may require when a long retention time is expected by large scale reservoir.

The deep well submersible pumps transfer water through a treatment plant (aeration tower and slow sand filtration) to a ground level reservoir. Booster pumps then transfer water to an elevated tower, from where the water flows by gravity to the distribution network.

(3) Alternative 2a

This variation of Alternative 2 is proposed where the topography allows for a treatment plant and reservoir to be placed at relatively high ground. There is no need for booster pumps or an elevated tower (example: K3-1).

The main problem of this alternative is to locate a suitable position for the treatment plant at a relatively high ground level, while considering that there will also be the need for proper access to the treatment plant (the requirement for access to a reservoir only is less critical). Optional chlorination at filtration.

(4) Alternative 2b

This variation of alternative 2 is proposed where it is not possible to find a suitable location for a treatment plant for iron or manganese removal at a high position. Consequently, the treatment plant may be placed near the deep well, and the water boosted to a reservoir site. From the reservoir, the water flows by gravity to the distribution network.

This solution introduces the need for secondary booster pumps, however, an advantage is that the treatment plants can be more conveniently positioned with easy access.

(5) Alternative 3

This solution is proposed for the treatment of surface water. The intake consists of a concrete inlet chamber along river cource. Simple treatment plant which consists of a roughing filter (pre-filter) will be installed in front of raw water pipeline. The treatment facility and reservoir of slow sand filter and chlorination shall be planned by gravity system. From there the water pumps up to elevated tower reservoir.

In order to reduce the power cost a gravity system of the treatment plant, the topographic survey was carried out for the upstream of conceivable treatment plant. The intake is selected 1 km upstream of the treatment plant. Therefore, a raw water pipe of at least 1 km in length would be necessary.

(6) Alternative 4

This is the proposed simple solution in areas where there is no need for water treatment (apart from optional chlorination), and where the topography allows for a ground level reservoir to be placed at a site of high ground elevation. Direct pumping from a deep well to a reservoir located on a high ground.

Table 2.9 shows the overview of proposed water supply systems, summarized in.

Table 2.9 Overview of Proposed Water Supply Systems

Prioritized System	Alternative	Description and Comments
DAC LAC		
D1 Krong Nang	**1**	• Water is pumped directly from the deep well to the ground level reservoir. Water is boosted to an elevated tower from where the water gravitates to the villages.
D2 Ea H´Leo	**4**	• Water is pumped directly from deep wells to the ground level reservoir at high point above the town. More than one pressure zone will be necessary because of the topography of villages (differences in elevations are more than 100 meters). • The water quality is only known from one low-yielding well, but several wells will be needed. Consequently, the needs for treatment cannot be evaluated with certainty.
D3-1 Krong Puk	**1**	• Water is pumped directly from the deep well to the reservoir, from where it is boosted to the elevated tower. Water gravitates to the network.
D3-2	**1**	• The water quality is not known (no well was drilled during the first phase) and treatment may be necessary. In this case alternative 2 can apply.
D4-1 Ea Drong	**2**	• Water is pumped directly from deep wells through the treatment plant to the ground level reservoir. • Treatment: Iron and manganese removal by aeration and slow sand filtration. • Treated water is boosted to an elevated reservoir (placed at the highest point in the villages) and gravitates to the villages.
D4-2 Ea Drong	**1**	• The water quality is not known (no well was drilled during the first phase) and treatment may be necessary. In this case alternative 2 can apply.
D5-1 Ea Wer	**1**	• Water is pumped directly to the treatment plant nearby the proposed reservoir site. Water transfers to the reservoir, from where it is then boosted to the elevated tower. • Treatment: Iron and manganese removal by aeration and slow sand filtration.
D6 Kien Duc	**2a**	• Water is pumped directly to the treatment plant located nearby the proposed ground level reservoir site, at a high point above the villages Water gravitates to the villages. • Treatment: Iron removal by aeration and slow sand filtration.
D7 Krong Kmar	**2b**	• Water is pumped directly from deep wells to the treatment plant nearby the deep wells. Water is then boosted to the ground level reservoir at a high level location. • Water treatment: removal of iron and manganese by aeration and slow sand filtration.

2.4.4 Water Supply Drawings

The diagrams in attached in the last of this Chapter 2 ("Layout Drawings of Water Supply System") detail the final proposed water supply networks for each of the systems. This section provides a general description of the contents of the drawings as well as comments on particular details and restraints.

The layout drawings in attached in the last of this Chapter 2 have been updated where necessary, of which the changes and additions by the updated results are:

- ♦ Newly decided intake location and raw water pipe line route,

- ♦ Addition of some main distribution pipes,
- ♦ Change in pipe lengths and diameters of several main distribution pipes,
- ♦ The proposed location of water treatment plants,
- ♦ Change of location of elevated reservoirs (K4-1 and G4),
- ♦ Inclusion of water supply network diagram for D3-2.

(1) Deep Wells

The locations of the wells drilled by the study team are shown in the drawings. There are also existing deep wells in D2 and D6, which are planned to be incorporated into the water supply systems in future. Although more than one deep well is required for most systems in order to cover the user demand at phase 1, the final location of these wells shall be confirmed in detailed design phase.

(2) Target Area and Water Supply Plan

The layout drawings indicate the main areas proposed to be supplied with piped water, i.e. the names and locations of villages. Areas of future development are also shown in the drawings, where plans for such development were informed (e.g. for G1, D1, D6 and D7).

The maximum hourly supply for year 2020 is shown for all villages in the layout drawings. The maximum hourly supply for year 2000 is the basis for the design of pipelines.

(3) Raw Water Pipes

Proposed routing and diameters of raw water pipelines are shown in the drawings. The routing was chosen so that the pipelines would always run alongside roads for easy identification and maintenance, and simpler location.

For the raw water pipes from new deep wells, which have not been identified, a length of 1,500 meters for these raw water pipes has been conservatively estimated and included in the design and cost estimates considering the present conditions.

(4) Main Distribution Pipes

The main distribution pipes are shown in the drawings with diameter and approximate length indicated. The diameters of the pipes were designed for year 2020, based on hydraulic calculations described in the next section.

The main distribution pipes can supply all main areas with water at sufficient pressure, such that the secondary network (which will be designed during the detailed design phase) can supply all households. Main distribution pipes are normally of diameter 75 mm to 200 mm.

Distribution pipes should preferably be constructed along roadside shoulders for easy access and maintenance, however this installation may not always be possible.

The systems in D6 and D7 have an existing, limited, piped water network and these are included in the design.

(5) Secondary Distribution Pipelines

For most systems many of the houses were concentrated along the main roads. Thus, one main distribution pipeline along each side of the main road where the residential people request it could supply most of the households. There are some houses located away from the concentrated area along the roads, so several secondary pipes are necessary to enable water supply to these areas. Secondary pipelines are normally of diameter 25 to 65 mm.

Secondary pipes will be designed during the detailed design phase, such that water supply pipelines are located near all households and thereby enabling them to connect to the system. Secondary pipelines are generally not shown in the drawings of this report, however the required quantities to supply all houses in the villages have been estimated.

The quantity of secondary pipes needed was estimated following the criteria below:

- ♦ An estimate of the length of the village,
- ♦ The need for one or two pipes along the road to the village,
- ♦ Interconnection pipes were added.

(6) Proposed location of Treatment Plants and Reservoirs

The proposed location of treatment plants and reservoirs were determined taking into account the following:

- ♦ Water should be directly transferred by submersible pumps to treatment plants, and flow by gravity to the reservoirs, in order to avoid secondary pumping. This may not always be possible because the location of treatment plants (e.g. on hilltops) may be unfavorable, with regards to site access.
- ♦ If possible, reservoirs should be located at high locations, so that the water can gravitate to the system.

- Space for the construction of treatment plants and reservoirs should be readily available.
- The water works should preferably be placed on public ground, in order to avoid compensation to private landowners.

(7) Public Buildings

Public buildings (e.g. CPC, TPC, Schools, Kindergartens and health clinics) are shown in the drawings. Public taps should be installed in the vicinity of all public buildings.

2.4.5 Hydraulic Calculations

The proposed water supply schemes have been analyzed using a computer aided hydraulic calculation software package for piped networks, specifically "Epanet". The "Darcy-Weiss" equation was the basic calculation process for the analysis.

(1) Analysis Guidelines

The following guidelines were applied for the analysis:

- Pipe dimensions listed in the tables are internal diameters.
- The maximum hourly supply in year 2020 was used for dimensioning the pipes. This provided a conservative calculation for the design in all periods up to year 2020.
- A number of the systems were further analyzed in order to determine and view how flow and pressure varied during the course of an average day.
- A pipe roughness factor of 0.1 mm was used. This is a conservative value, which takes into account the possibility of deposits on the pipe wall over time (a typical value for new pipes is 0.01 to 0.05).
- All main distribution pipelines in the system were included in the analysis. Some secondary pipelines were also included for several systems.
- Pumping mains were generally not included in the analysis as the design of a single pumping pipe is relatively simple and does not require computer analysis. Design of pumping mains with multiple pumps networked together may be more complicated, however as the locations and details on future deep wells are not yet known, the multiple pump case cannot be analyzed at this stage.
- Water supply quantities were distributed amongst network nodes on the basis of water demands and knowledge gained from inspections during the field surveys. The supply quantities were distributed in a conservative

manner by, for example, placing half (or a third) of the consumption at the farthest point of the pipe.

- The criterion for minimum pipe pressure was 6 meters head at all locations, but preferably up to 7 meters, so as to take into account friction losses in secondary pipes.
- Alternatively, it is sound practice to maintain minimum flow velocities in the pipes (preferably above 0.2 m/s). This is in order to avoid stagnant water and to achieve a self-cleaning effect within the pipes.
- Accurate pipe invert levels are of high importance towards accurate results of the analysis. Surface levels have been obtained during the field visits with the use of altimeters and by the study of topographic maps (1:50.000). Several critical lines were subject to carry out a topographic survey, in order to confirm the levels of the main areas for supply. However, elevations of some secondary pipe routes may still not be sufficiently accurate and should be confirmed during detailed design.

(2) The Results of the Analysis

The results of the analysis is included in Dat aBook, together with print outs of the results in the form of network maps. The results are graphically shown on the maps, featuring pressures for the nodes and flow velocities for the pipes (values are shown underneath the respective nodes and pipes, with node numbers and pipe numbers also shown). Tables of the analysis results are included after each network map, detailing complete information on the water supply system flows and pressures.

Tables specify elevations, supply quantity and pressures for the nodes; and lengths, dimensions, velocities and head losses (per km) for the pipes.

The following significant results of the analysis can be seen:

- Generally, there were no problems in achieving the required pressures throughout most areas in the network. However, there were isolated areas where it was difficult to reach sufficient pressure during maximum hourly supply times. During times outside the maximum hourly supply periods (usually lasting only a few hours per day) there was no difficulty for all areas in obtaining sufficient pressure.
- A maximum height limit for elevated reservoirs of 10 meters was used in the analysis. Higher pressures can be achieved by increasing the height of these towers.

- Water Supply networks can be adjusted to optimal pressures and supply flows with the aid of computer software calculations. The resulting output often lists many different pipe dimensions and numerous changes in dimensions along pipes. Some such results are not desirable with regards to operations and maintenance, so repeated changes to pipe dimensions were subsequently avoided and the results altered accordingly.
- One particular result of the computer analysis was that the outskirts of systems only required very small pipe diameters. However, allowing for future water supply system expansion, these very small dimensions (below 65 mm) were avoided at pipe ends in most networks.
- The analysis results formed, in part, the basis for the estimation of pipe quantities. However, most secondary pipes will only be correctly evaluated after detailed survey maps are completed and detailed design has been performed. At this stage, lengths of such secondary pipes have been only approximately estimated from information gathered during site visits.

2.5 Standard Designs of Water Supply Facilities

The main components of each proposed network system are outlined in Appendix 2 ("Spreadsheet on Design of Water Supply Facilities"). Typical designs of the water supply works have been prepared and the drawings are included in Appendix 3 ("Standard Designs of Water Supply Facilities").

A general summary of specifications for water supply works is presented below. The designs have been detailed to an extent that they can easily be modified to the single communes with regard to dimensions.

The following Standard Drawings are included:

- Typical deep well structure,
- Typical design of well head and well house building,
- Typical iron and manganese removal plant (aeration tower, reaction tank, and slow sand filter),
- Typical surface water treatment plant (horizontal roughing filter and slow sand filter),
- Chlorination system,
- Sludge basins and sand washing basins,
- Typical reservoirs,
- Pumping stations,
- Pipelines,

- ♦ Typical public taps - Alternative 1 to 3, and
- ♦ Water meters.

2.5.1 Well Head

The proposed assembly of a wellhead consists of: air valve, pressure gauge (0 to 10 bar), non-return valve, gate valves, water meter, pipework, and anti-waterhammer protection (optional).

None of the wellheads included in the study required pipes greater than 100 mm in diameter, and most wells shall only require 80 mm diameter pipeworks. Pipework may be fabricated from galvanized iron.

Pump house should be equipped with a tripod with crane for the well house buildings for easy installation and removal of the submersible pumps.

Waterhammer analysis should be carried out on in detailed design stage all pumping mains and protection against waterhammer pressure surges should be installed at pump stations as needed.

2.5.2 Iron and Manganese Removal

The designs illustrate a typical Vietnamese standard design for iron removal plants, which is considered appropriate, considering the water quality test results in the study area. The following are the important points concerning iron and manganese removal:

- ♦ **Manganese removal can be performed by means of aeration and slow sand filtration.** This process requires very effective aeration and careful operation of the filter, which should never become dry and should preferably receive a constant flow of water.
- ♦ The purpose of aeration is to provide sufficient time for the iron and manganese oxidization reaction processes to complete. The hydraulic retention time should be approximately 40 minutes.
- ♦ The aeration system consists of a series of small water pipes (25 mm dia.) perforated with outlet holes (3 - 5 mm dia. at approximately 50 mm spacing), from where the outflow of water falls down upon a series of plates in turn, and finally on to the surface of the reaction tank. Some maintenance is necessary because the pipe outlet holes may become blocked with iron deposits over time.
- ♦ Proper ventilation is necessary to enable the supply of sufficient oxygen, as

well as assisting in the removal of possible dissolved gases in the water, such as hydrogen sulphide.

- Removing the products created during the iron and manganese oxidization processes is achieved by the use of a filter, consisting of several sand layers of differing particle size. The maximum hydraulic filter speed should be 5 m/day for slow sand filtration.
- Iron removal can be performed by means of aeration and slow sand filtration. The periodical washing or replace of the surface layer (10cm) in slow sand filter is approximately 3 to 6 months intervals, depending upon its water treated volume and size of sand filtration.

2.5.3 Surface Water Treatment

Treatment of surface water is more complicated than for groundwater for several reasons, such as rivers and streams becoming more turbid during the rainy season. More significantly, it is possible that upstream areas of river and stream intakes are used for bathing, washing clothes and defecating, and may therefore be biologically contaminated.

The following is the main points of surface water treatment:

- The process of surface water treatment follows roughing filter, followed by slow sand filter.
- Complete removal of turbidity may present a problem during the rainy season, however this can only be verified after testing the water quality following heavy rain.
- The water quality analysis showed that the surface water had high iron content. The roughing and slow sand filters are together able to remove the iron.
- The purpose of the roughing filter is to remove the bulk of the turbidity content and also some of the iron content contained in the raw water. The filter shall be equipped with drains. From the roughing filter the water flows by gravity to the slow sand filter.
- The slow sand filter is a simpler alternative to the slow sand filter, and contains very fine sand, requiring a larger filter area.
- Slow sand filters do not require backwashing or the operation of backwash pumps, however the filter sand needs to be periodically removed, washed and replaced. Washing of the filters should be performed every 3 months, however washing may need to be more frequent during the rainy season.

- In order to guarantee the fulfillment of all water supply quality standards, it may be necessary to employ flocculation, sedimentation and filtration processes followed by disinfection. Such full-scale treatment complicates the operation and maintenance procedures and increases the costs.

2.5.4 Chlorination

Deep groundwater does not normally require a disinfection process by chlorination, provided that the deep well and installation works were properly installed and constructed, and the required safety zone has been established around the deep well. The need for disinfection will also depend on how well the deep aquifer has been protected from possible seepage from upper aquifers. For several systems there exists this risk of contamination of the unconfined aquifer from above (e.g. K1-1, K3-1, D5, and D7).

However, there is always the risk of pollution of treated water, while stored in reservoirs for long retention time or through breaks in damaged pipes. The points to be highlighted for chlorination are as follows:

- As an option, the chlorination equipment of chlorine gas shall be installed where a large reservoir tank and long retention time are expecting and/or shallow groundwater sources. For smaller rural villages in case of a few hours retention time, chlorination can be installed later during phase 2 (2010 – 2020).
- Surface water that has been treated by roughing filter and slow sand filter normally also becomes bacteriological clean, however this cannot be guaranteed. Therefore, the water should, in theory, be disinfected by chlorination.
- The disadvantages of the chlorination process are that it complicates the treatment process; particularly in the way the chlorine should be continually and correctly dosed against measured water flow, and should be well mixed, which is sometimes difficult to achieve. The efficiency of disinfection also depends on the content of other substances in the water.
- The cost of delivering chlorine to the plant needs to be added to the overall operations and maintenance cost. Chlorine is also a dangerous chemical substance that requires careful handling and storage.
- An alternative chlorination system is presently being used in treatment plants for several water schemes in Vietnam. This particular disinfection process produces chlorine from salt (Na Cl) through electrolysis. This eliminates the

risk of handling and storing chlorine, however the risk of the system breaking down and requiring spare parts is increased.

2.5.5 Sand Washing Basins (Alternative 3 and K4.1)

The purpose of sand washing basins is to facilitate washing of the filter sand media to a clean efficient procedure. The basins are simple structures where the sand can be placed securely for washing, enabling the water to drain away, and all the sand remain for drying.

Following this settlement, the overlying water can be drained away to a stream or river.

The following points are highlighted for sludge basin and sand washing basins:

- ♦ The sand-washing basins can be constructed as simple concrete boxes. The size shall be decided in detailed design stage depending on the availability of land use condition.

2.5.6 Reservoirs

- ♦ The purpose of reservoirs is to balance the varying supply quantity (up to maximum hourly supply) against the relatively steady production flows of the water works, with the use of water storage.
- ♦ Reservoirs shall be constructed in reinforced concrete, and shall be equipped with overflows large enough to accommodate the maximum expected flows from inlet pipes.
- ♦ The reservoir shall be equipped with sufficient ventilation in order to empty the reservoir of air, when filling with water.
- ♦ The reservoir shall have a piped washout installed at its base.
- ♦ All openings shall be covered with screening in order to prevent birds, rats, etc. from entering the reservoirs.

2.5.7 Pumping Stations

Two kinds of pumps are used in the systems: submersible pumps and booster pumps

<u>Submersible pumps:</u>

- ♦ These are the most commonly used, for pumping from the deep wells to surface reservoirs or treatment plants.

- The submersible pumps proposed fall within a relatively narrow range for flow yields and lifting heads. The maximum proposed yields vary between 6 m3/hr and 22 m3/hr.
- The lifting heads vary between 60 and 110 meters.
- Most pumps could be operated from power supplied from a one-phase power grid.
- Only in perhaps 0 to 3 instances would 3 –phase power supply be required.

Booster Pumps:

- Where elevated tanks are constructed it becomes necessary to pump water from ground reservoirs to elevated tanks using booster pumps.
- Booster pumps are also necessary in the case of secondary pumping requirements from low elevation treatment plants to reservoirs located at higher levels.
- Booster pumping to elevated towers typically only provides small lift, e.g.15 to 20 m. Booster pumping from treatment plants to reservoirs may need to lift 40 to 50 m.
- Pumps should be carefully designed to operate near optimum efficiencies, based on the design parameters of flow and head.
- If the pump operates outside (above or below optimum flows) its optimum efficiency, this means that the power consumption becomes higher for each m3 lifted, resulting in increased costs to water production or distribution.

Control of Pumping:

- Control of pumping is proposed to be manual to the highest extent possible. For example, a pump may be started manually in order to fill up a reservoir, and stopped manually when full.
- A pumping schedule should be prepared from the experience gained during operation, and by considering the water consumption.
- Another simple way of controlling start and stop operations of pumps is by using float control switches in the reservoirs. When the reservoir is full, the float lever becomes horizontal and trips a switch that signals the pump to stop. After the water level drops, the float lever will hang vertically, tripping a switch that signals for the pump to start. This method may require the installation of cables over relatively long distances to carry signals from the float control switch to the deep well pump panel, which results in the risk of possible damage to cabling.

Motor Protection:

- Motor control panels, as recommended by the pump supplier, shall be included in the installation of pumps.
- Control panels shall include necessary pump protection devices to protect against, e.g.: dry running, voltage surge, under/over voltage, lightning transient surge protection, thermal overload protection, phase failure protection shall be included for three phase pumps.

2.5.8 Pipelines

Most of the proposed water supply schemes are relatively small and with pipe dimensions below 100 mm diameter. Only a few main distribution lines may be of larger diameters up to 125 mm, 150 mm or 200 mm. Detailed specifications for water supply pipes are included in Appendix 4 (Technical Specifications).

Raw Water Pipelines:

- Raw water mains are proposed to consist of galvanized iron pipes.
- Mains passing through farmland should principally be installed in trenches deep enough to cover the pipes with minimum 1000 mm of soil, in order to avoid damage resulting from the planting of coffee, and other crops, shrubs and trees.

Distribution Pipelines

- Galvanized iron (GI) pipes have traditionally been used for water distribution mains in Vietnam. In places where it may be necessary to construct the mains either above ground or at shallow depths, GI pipes should be used.
- However, high density polyethylene (HDPE) and unplasticized polyvinyl chloride (uPVC) pipes are now also widely used. Such plastic pipes are less costly and do not corrode, once buried.
- uPVC pipes may become brittle if they are subjected to sunlight, thus should be stored accordingly.
- It is proposed to use uPVC Class 6 bar pressure for pipes 100 mm diameter and above, and HDPE for pipes below 100 mm diameter. In areas where heavy external forces may be exerted on the pipe, e.g. road crossings, GI pipes should be used or the plastic pipe should be housed within a protective steel sleeving. Concrete encasement should not be used for plastic pipes.
- Several areas have large differences in elevation. In such cases, Class 10 bar pressure pipes should be used, or if hydraulic calculations result in maximum operating pressures exceeding 60 metres.

- ♦ A minimum soil cover of 600 mm is recommended for distribution pipes within footpath areas for protection against normal loads and to provide nominal protection towards obstructing access for illegally made connections. A minimum cover of 1000 mm is recommended in roads to avoid damage from vehicles, trucks, road works and other works.

Pressure Testing:

- ♦ All water supply mains shall be pressure tested with the pipe joints uncovered.
- ♦ The pipes should be tested to 1.5 times the working pressure, and the pressure loss should be measured at each end of the section of main being tested.

Disinfection:

- ♦ All mains shall be flushed with clean water, until the water emerging from the flushing operation is visibly clear. Following the flushing procedure, and before commissioning and handing over of water mains or plant, all parts that will be in contact with the water supply shall then be disinfected.
- ♦ The disinfection process provides that all such sections of the pipeline be immersed with a 50 mg/l chlorine solution for 24 hours. If the concentration of chlorine after the test is less than 25 mg/l, the testing shall be repeated based on international guideline.
- ♦ Following disinfection, the system shall be thoroughly flushed until the residual chlorine content is below 1 mg/l.

2.5.9 Valve Chambers

Isolation Valves

- ♦ The purpose of isolation valves is to provide the possibility of carrying out repairs on sections of the water supply network, without causing supply to be cut-off to other areas of the village.
- ♦ A number of valves have been included in the estimates in order to facilitate the above procedures. Isolation valves are proposed to be resilient wedge soft-seated gate valves.
- ♦ All gate valves should be installed in watertight lockable valve chambers.

Air Valves, Washouts and Thrust Blocks:

- ♦ Generally, it is not considered necessary to install air valves on distribution lines as house connections will act to release air. It was estimated that there will be a few points where air valves will be necessary along the raw water mains, which will be determined during the detailed design.

- ♦ Washouts should be installed on main distribution pipes at low points by installing a flanged branch off-take with valve.
- ♦ Thrust blocks should be constructed at all points of change in direction (bends and tees), changes in diameter and dead ends, on all raw water mains and distribution mains (100 mm diameter and larger). Thrust blocks consist of a concrete block with the pipe adequately embedded to transfer the forces. The surface area of the thrust block bearing against the undisturbed soil surface shall be sufficient for the particular type of soil to support such force.

2.5.10 Public Taps

Three types of public taps have been included as standard designs in the drawings:

- ♦ Alternative 1 uses a tap for dispensing water directly from the distribution main. The tap is installed on a concrete slab, with a slight slope for drainage.
- ♦ Alternative 2 uses 3 taps for dispensing water, and a small storage volume (1 m3) as a back-up supply, during periods of the maximum amount served, times of power failure or during reduced pumping times. There is a single tap on a sloping concrete slab.
- ♦ Alternative3 includes a small storage as a back-up supplying, bathing rooms for men and for women, with 3 taps for supplying water. This type is suited to very poor villages.
- ♦ Pipes and taps shall be manufactured from metal, such as GI or bronze. Plastic pipes must not be used to prevent damages by hunging the water vessels on the pipe.

2.5.11 Water Meters

Bulk Water Meters:

- ♦ Bulk water meters are important for monitoring overall water production and Unaccounted-For Water (UFW) through district meters throughout the water supply system.
- ♦ Location to be installed the meter are in front of each village/hamlet of the main distribution pipeline, and/or in front of branch (secondary) pipeline.
- ♦ Raw Water Meters: Equipped at all Deep wells in order to record water production.

- Clean Water Meters are recommended installed at all reservoir outlets.
- If necessary bulk water meters could be equipped together with an upstream screening filter in order to avoid larger particles in the water flow from damaging the meter rotor mechanism. If necessary, a by-pass could be installed at the meter in order to facilitate the cleaning of the screen and maintenance of the meter.
- The diameter of the water meter should be designed according to the range of flows and the manufacturer's specifications.

Household Meters:

- Household meters installed in house connections are for the accurate collection of water tariffs.
- The theoretical lifetime of a user household water meter should be at least 10 years, however, this depends on the quality of the meter, water quality and the general maintenance carried out on the meter. Unless the standards of these are high, the life span of the meter becomes much less.
- Meters should be calibrated regularly (internationally every 3 to 5 years depending on the meter quality and maintenance level). This requires that reliable meter calibrating facilities are available in the province (or neighboring provinces) and that spare parts are readily available.
- If users discover that the meters are inaccurate, they will eventually lose faith that they are paying a "fair" price for the water supplied. A common problem is that users will then attempt to "cheat" the meters, by manipulating them in various ways. The user may possibly go as far as sabotaging the meter.
- Metering each of the households increases the administrative workload. Meters need to be read and recorded regularly by trained staff. The recorded data needs to be processed, with water bills sent out to users and money collected.
- Policies for metering should be decided by water supply unit (WSU) and the board who are to operate the systems. Possible solutions should be presented to each village in order for them to make well-informed choices.
- The water meter installation is important for quantitative control for whole water supply to manage proper consumption and to establish fair water charge collection system.