Project Number: 46-WWF 0201

02D137I

Water Supply Usage in Vietnam

An Interactive Qualifying Project
Submitted to the Faculty
of the
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science
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Date: May 2002

Approved:

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Introduction

We are researching water usage and supply in Vietnam because they are a pressing technological issue in society, which is the main focus and idea of the Interactive Qualifying Project. It is a broad topic that deals with technological issues and their effect on humanity and society as a whole. Water is the basic sustenance of all living things and developing ways and methods of controlling and studying all aspects of consumption and usage of water will surely result in a connection with people and society. We also hope to suggest possible improvements as well as independent observations on what we have researched and learned as a closing to this paper discussion.

About 70 % of the earth's surface is covered by water. There are more than 330 cubic miles of ocean water on our whole planet. Therefore it is no surprise that water, being the most abundant substance on the planet has had such a strong role in creating or forming the shape of Vietnam. Therefore, it is not only technology but also time that plays a major factor in effecting Vietnam's irrigation systems, water supply fishing and farming. This is mainly because of erosion that as a result has greatly impacted the societies within Vietnam. It is universally accepted that an adequate supply of water for drinking, personal hygiene, and other domestic purposes, and an adequate means of waste disposal are essential to public health and well being. Unfortunately, a lot of people in Vietnam, most of them living in rural areas, do not have access to a safe and convenient source of water, and where they do, normally do not have satisfactory sewage disposal facilities.

Water research is essential to the viability of a living population. To say the very least, water research is necessary. Water research is the process of analyzing and implementing a working water system to a given surrounding. It is an important research given that all humans and their environment around them are dependent on water. Developing countries such as a Vietnam depend on the basics, and that is water for health concerns. Sanitation as well as proper usage is the backbone of health concerns in Vietnam, so we will share research and findings in the overall makeup of the water supply in this developing country. Moreover, we will also delve into how different aspects such as time and technology have affected this area. In order to learn of the usage of a particular source in the country, we must study the country and area itself also for a better understanding of the connection between technology and societal usage. We ultimately hope to achieve a working, yet thorough understanding and foundation of the history, causes and effects, and future consequences of Vietnam and its water technology in order to build a basis for creative sources and ideas that may be implemented in the irrigation and water systems presently in Vietnam.

Irrigation systems, potable water supply, basic sanitation services, fishing, and farming are important to every society. These five factors concerning the water systems of Vietnam are of paramount importance to the health of people living in developing countries such as Vietnam. Therefore, these factors have greatly affected and shaped the societies and economy within Vietnam. Moreover, they have affected and shaped societies in rural, village, and urban areas of Vietnam in very different ways (Coward 15).

Advances in technology and the passing of time have significantly evolved irrigation systems, water supply and basic sanitation services, fishing, and farming mostly in urban areas of Vietnam. The implementation of dams along the Mekong River is a great technological contribution to Vietnam's society but yet it also has negative side effects, as we will later see. When the term "evolved" is used to describe Vietnam's water situation, in some ways it does not necessarily mean a positive outcome has occurred. An example is the building of water dams. Most dams are designed to accomplish a variety of functions, which include flood control, flat water for transportation, and water supply. Although these seem like good reasons for the existence of dams, this type of construction bring greater negative effects than good ones. The "environment effects of dams include loss of land and biological resources to inundation, reservoir sedimentation and downstream erosion, and hydrological changes unfavorable to many native or desirable species."

In Vietnam, the majority of the Vietnamese were rice farmers. In order to survive, they need two successful rice crops a year to ensure an adequate food supply. But, too much or too little water can and often does devastate at least one of those crops, leaving villagers with little or nothing to eat for months at a time. Thus irrigation system came to be an important part in the rice farmer's life. The reason for the use of irrigation system is to provide water to the right places and at the right time. In this IQP paper, one will find a number of factors that are related to Vietnam's irrigation system. For example how technology on Mekong River influences Vietnam's society, how time influences Vietnam's society, irrigation's number of factors to be considered, water supply, how

irrigation system affect the people, how to improve water supply in Vietnam, how social and economic effects of future goals/plans in rural areas and lastly are the recommendations of how to improve Vietnam's irrigation system.

Technology on Mekong River Influences Vietnam's Society

Dams just strangle rivers, and the perfect example of the damage dams cause to rivers is what is happening to the Mekong River that runs through Vietnam. The Mekong River covers more than 4500 kilometers through 6 countries. It divides Thailand and Laos, cuts through Cambodia, passes through South Vietnam, and finally ends in the China Ocean. The Mekong sustains 100 million people, who not only depend on this river for their basic need of water, but also for irrigation, traveling, and sometimes just for recreation. The Vietnamese called it the "Mother "of rivers. Today like many rivers in the world, the Mekong is in danger. The reason is the massive and not well planned construction of dams. These constructions have started to threaten the ecosystem of the river. In 1982, the Vietnam government decided to build the dams in Mekong River, which would provide energy to southwest Vietnam. However like in many other places in the world, the constructions of dams in the Mekong has a great affect to the environment and the people. For example, the dams caused deforestation, stopped the natural migration of fishes, affects fish reproduction, and the dam also alters the level and quality of water. Some people who live around the river refer to the Mekong dams constructions as evil, and they say that they have destroyed the happiness of their family. In addition, it has destroyed the wild life and has caused the displacement of thousands of poor people who

live along the river. These types of damages are being re-evaluated to see if the benefits of these dams are superior to the environmental and social costs (Kroeber 22-26). The Commission of The Mekong river, an organization which normally defends development in Vietnam, said that "the ecosystem of the Mekong River was deteriorating" and added: "If the current random of damage continues, the forests, the biodiversity, the existence of fish and quality of the soil will all be damaged to the point were recuperation will be impossible (Figure 1).

For some years now, many Asian countries have looked at the Mekong River as an opportunity to generate electricity and with this be able to develop faster. Most of the regions around the river are poor. The government of Vietnam and some programs which willing to build the irrigation system had looked at the Mekong as a way to produce money. Vietnam in particular has argued about the potential the river can give it. Some people insist that the dams were created to give energy to cities in the province of Can Tho, and it won't damage the Mekong, the others insist that the dams will be of benefit to countries south of the dam because it will equilibrate the flow of the river by controlling the quantities of water to be flown during droughts and flowed seasons (Micklin 34).

Outside of Vietnam, the sentiment towards the dams has changed considerably. The experts all agree that the dams kill wild life and the habitat of the fish. The environmentalists say that once the costs for compensation of the land and financial damages to individuals are calculated having in mind the cost of construction of the damns, many of the plans of hydroelectric energy in the Mekong won't be successful.

Last year, the World Bank, an organization that has supported the building of dams, and the World Union of Conservation gave an important study of two years of the economic, ecologic, and social impacts of 45,000 big dams around the world. Although they recognized that the dams had made an important contribution to the development of these countries, the report also stated that in many cases an unacceptable and unnecessary price has been paid by displaced communities and by the natural environment. The experts estimate that more than 100,000 in China, Laos, Thailand and Vietnam have been obligated to leave their houses because of the dams. The report was particularly critical of the Pack Moon dam in Vietnam. This dam has prevented the free migration of fish around the river and because of this from 265 species of fish that used to live in the river 96 species are left and the majority without commercial value. As a consequence fishing has gone down by 80%. As a result most of the fishermen have moved to Bangkok to look for other jobs. The study stated that if the Moon project were to be evaluated for construction today it wouldn't be accepted. Thanks to this it is believed that constructions of dams in Vietnam will not be accepted for now (Kroeber 45-46).

According to a director from Terra, an environmental group who stated that the Mekong River and many rivers around the world are being strangled by dams. Although these rivers may seem as useful constructions to improve the economic development of countries, in the end the negative effects from them bring more cost than gains. Countries should make deeper studies of the impacts of dams in their ecosystem before jumping into the constructions.

Time Influences Vietnams Society

However, to every negative side there is also a positive side. Many dam constructors believe that the building of dams in Vietnam carries a positive effect in that it prevents erosion. Water is the most abundant and therefore most powerful resource on the planet. Although water creates landmarks the size of the Grand Canyon, people cannot see the process, they can only see the result. Rain erosion is a result of kinetic energy developed by water as it flows over the surface of the material. Material particles are detached from the mass and transported to another location. Although one raindrop has little effect on the earth, the accumulated effect of rainfall over long periods of time can accomplish large amounts of erosion. This is a major problem to a country such as Vietnam. This country receives a massive amount of rainfall every year. Erosion begins when rainfall hits materials traveling at a high velocity and forces the materials to crumble into small particles. This continues until the rain creates small grooves. Continuing rain causes these grooves to overflow with a combination of water and particles, which is called run-off. Continuous run-off breaks up the surface into smaller and smaller particles. Accumulating run-off on the surfaces moves down the slopes and causes sheet erosion. This down slope run-off detaches these particles and moves them with the water. These moving particles strike against other particles on the surface, which sets them into motion, this process is called abrasion. The velocity and turbulence of the run-off affect the degree of the sheet erosion, some materials are less abrasive than others as well, which affect the degree of sheet erosion. Matter can be transported in three different ways: heavier

particles will roll along the surface, these are called rolling matter. Smaller particles will bounce along at a faster rate than rolling matter, these are called bouncing matter. The smallest particles are completely suspended by the water and travel the fastest; these are called suspended matter (Micklin 38-42).

In Vietnam, river erosion is very common. Vietnam suffers from chemical erosion and hydraulic erosion. Chemical erosion occurs when chemicals in the water that were produced by urban industry, react with minerals in the surface materials and cause them to dissolve and break apart, the dissolution can cause chemical compounds to form such as salts. The salts are carried in the form of ions. For example, rock gypsum contains the compound calcium sulfate, when this is dissolved in water, it creates calcium ions and sulfate ions without several other salt compounds. However, it does not usually affect the taste of the water. Hydraulic erosion is based completely on the force of the moving water. A rapidly moving stream can widen cracks and break off large chunks of fractured rock. In 1983 a stream at flood stage in the Blue Mountains of northwestern Vietnam wrenched loose boulders weighing up to 90 tons and carried them over a mile downstream. Ever since the building of dams along the Mekong, there have been major improvements to this problem (Wilson and Bryant 78-79).

Oceans and shorelines are another factor caused erosion in Vietnam. This type of erosion takes place at the beaches of Vietnam in areas touching the South China Sea. The ocean can shape the shoreline, enlarge it, make it smaller, or smooth the cliffs above it. Irregular shoreline is a series of large coves along the shore. The bar of land between the

coves is called a headland. The irregular coastline is caused by waves beating against the shore, when waves reach shallow water, the waves begin to curve, and as they reach the shore they push the sand into the shape of the wave. The back flowing water drags the sand, which was not previously moved back out to sea. Arches are formed when waves hit headlands head on, due to the curving shape of the wave. The wave wraps around the headland and hits hardest against the sides, this action causes the waves to break away a large hole through the rock, creating the arch and if the roof of the arch breaks off, waves will cause the remainder to look like a tall cylinder sticking out of the water, this is called a sea stick. Retreating cliffs are cliffs along a shoreline where the waves continuously erode the rocks, this occurs in areas that are too deep. The rocks, sands, and gravel are pulled off the rocks directly out to sea. Beaches are formed when the rock, sand and gravel taken from the cliffs is pushed up onto the shallower surfaces. Under beaches are large terraces of loose rock, which waves have pushed up against the shore above. This layer is the gravel. When the gravel is pushed up by waves and is also pulled back, this forms bars, which keep the sand and gravel from slipping off the terrace. The final layer is the sand, which is the thinnest layer of all (Wilson and Bryant 98-103).

The valleys of Vietnam are usually a gully or ravine on a mountainside. These valleys are located more to the central part of Vietnam and away from the controversial water dams. The formations of these valleys throughout time has slowed erosion and in turn created more suitable fishing and farming conditions. As a result, it is safe to assume that in the villages of Da Nang and Hue, these valleys have created a healthy society.

Valleys will usually zigzag and have steep sides. The bottom is usually rock with potholes and boulders; the brooks have many waterfalls, rapids and pools. Downstream from a young valley there is usually an older, or mature valley. Due to many years of erosion, mature valleys streams are longer, straighter and wider. They have a smooth bottom eliminating rapids and pools. Down sloping is a term that describes when a piece of land become elevated due to nature. Down sloping in the valley has reduced the steepness of the slopes, therefore slowing down the flow of the stream and slowing also the process of erosion. So the bigger a valley gets, the longer it takes to get any bigger. Old valleys are extremely wide compared to their depth. The stream flows slowly through a winding channel on the valley floor, it is now so slow that erosion is scarce. The stream work consists mainly of transportation and deposition. An extremely old valley can be miles wide and only a few yards deep. The walls can still be as steep as they were in the young valley stage. If you were traveling through a valley you can sometimes see young, mature, and old valleys in order, in only a few miles. A valley can only go as deep as sea level or base level, which is the lowest point at which erosion can occur. There, are however, a variety of other natural occurrences, which can interfere with this process. A less productive village such as Nha Trang may illustrate this very well. Valley damage occurred in Nha Trang when a landslide dammed up the stream. This had created a lake where water found a way to escape. In turn seismic activity occurred in Nha Trang, and caused a portion of the valley to sink Much or all of the river's power had be lost. Years of erosion has occurred since then and in turn eroded most of the primary fishing areas for

fishermen in Nha Trang (Wilson and Bryant 60-68).

Irrigation: Number of Factors

There are several factors that must be known in order to begin planning an irrigation system for agricultural purposes. In some parts of southern Vietnam, the average rainfall during the growing season is too small and irrigation is necessary. A farmer contemplating irrigation will need to consider a number of factors. He will have to think about the climate, the soil, the availability of water, the crops to be grown and the amount of time and effort, which he is prepared to put into the operation. Even in the simple practice of irrigation by watering can, most of these factors must be considered, if only briefly. If the undertaking is likely to be more complex, involving the cost of developing or diverting a source of water, the purchase of equipment and materials and the employment of labor, then it will be more important to look carefully into the factors involved. To do this the farmer needs the best information he can get (Kroeber 5).

It is not always easy in remote areas to discover where the available information can be found or how to obtain it, but it is well worth a considerable amount of effort to find it. This may call for visits to the meteorological service, agricultural institutions, the water development and other organizations.

The climate is a very important factor in any sort of cultivation. In places where there are fertile soils and conditions are favorable for irrigation but there is no rainfall, the need for irrigation is obvious. In other places where there is some rainfall, but it is insufficient in quantity or badly distributed in time, crops might be very much improved

with irrigation. If rice is to be grown in paddies, then irrigation is a necessity. Whatever the circumstances it is important to obtain all possible information about the climate, the most useful data being rainfall, temperature, evaporation, humidity and the daily amounts of sunshine.

As climatic conditions vary with the time of year, and irrigation may involve growing crops during months when there is no traditional cultivation, climatic conditions throughout the year need to be carefully studied.

Most farmers understand soils, know where the better soils are to be found and how to use them for rain fed cultivation. The introduction of irrigation can sometimes produce unexpected results if the farmer does not know a few scientific facts about his soils.

The extra water of irrigation will bring about beneficial changes in most soils, increasing the amount of organic material, and by keeping the soil wet, facilitating growth and the movement of nutrients from the soil into plant systems. But, the more water in the soil, the less air, and as air is also needed for the processes, which maintain a soil's fertility; too much water can be harmful. Furthermore, some soils contain harmful soluble materials which irrigation water may bring up to the surface and subsequently precipitate, seriously affecting the crops.

Geography of the land is steep, however can be irrigated if it can be cultivated, depending upon the method of irrigation and the skill and resources of the farmer. But because it is important to control the water supply so that is will not be wasted, it is easier

to irrigate by surface methods if the land is not steeply sloping. If basin irrigation is planned, each basin must be as level as possible. One of the advantages of overhead irrigation is that proper control of the water is not so dependent on the slope and shape of the land. But if water is to be supplied in pipes under pressure, it is necessary to know the height or "head" for pumping. If water is to flow by gravity from one point to another, we must be certain that the starting point is higher than the delivery point. For a very small irrigation development, it may be possible to judge heights by eye, but this will be rare, and some topographical survey work is usually essential.

One of the commonest mistakes which people make when thinking about water for irrigation is to under estimate the quantity, which will be needed. In rural situations a good water supply for domestic and animal use may be very inadequate supply for irrigation. For example if the water consumed in a month by Krong Bong, a rural community of 2000 people with 250 cows and 500 buffalos were used for irrigation, this would provide two irrigations a month to an area of about a quarter of a hectare.

The amount of water needed for irrigation depends not only on climatic conditions and the total area to be irrigated but also on the crops to be grown. Tree crops and other perennial crops, which grow all the year round, need water throughout the year. Seasonal crops, which are cultivated from seed until they are harvested, need water only during the cultivation season. If irrigation water for seasonal crops is to be taken from a source that is liable to dry up during the dry season, the timing of the irrigation season will be an important consideration.

It is therefore important to know how much water will be needed for irritation in terms of the crops to be grown and the area of land to be irrigated, and how much is available to meet his need. As the capacity of many sources such as springs or streams will vary very much with the season of the year and from one year to another, great care must be taken in assessing the safe supply. On this question the Vietnam Government water development or water resources organization should be consulted. They would know if there are any records of the flow of a spring or stream and where these records may be found. If no records are available, then the farmer himself should start measuring the source, which he intends to use.

All natural surface waters and groundwater contain some dissolved salts. In some places water may contain so much salt that is unsuitable for irrigation. It is therefore wise to make sure that the water proposed for irrigation is not too salty. The degree of salinity of water can be determined by laboratory tests, and if there is any doubt about the quality of the water to be used, professional advice should be sought.

Where irrigation is used to extend an existing cropping season, this often means cultivating a second crop at a time of the year when the climatic conditions are markedly different from the rain fed crop season. New crops have to be considered in the light of possible new conditions. Grain, which can be grown under winter rain in DakLak will not thrive under irrigation in the summer because it is too hot (Kroeber 8-21).

If a farmer intends to grow vegetables under irrigation for sale, he must be sure that his produce will sell. Some years ago, a large dam was constructed in Bac Lieu to

enable the farmers to grow vegetables under irrigation during the dry season in addition to their traditional rain fed rice during the monsoon season. Little was done, either by the donor agency which provided the dam or by the government, to encourage the farmers to avail themselves of this new facility apart from a pilot project of a few hectares, on which some farmers were persuaded to grow irrigated cucumbers. At the end of the first irrigation season the farmers had several tons of cucumbers, which they could not sell. The only possible market for this produce would have been in a city 500 km away, and the cost of the transport could not possible have been recovered from sales.

Irrigation requires more labor than rain fed cultivation. In addition to the activities associated with dry land farming, the irrigation water supply has to be managed and controlled. On large projects much, and sometimes all of the water control may be mechanized, but this will not be the case with most small farm where the farmer may have to manage his water source, look after his supply line, and distribute the water on his land.

With rain cultivation it is possible to leave the farm from time to time to participate in other non-farming activities, as no great harm comes to the crops. Under irrigation, water must be applied when it is due, and under harsh climatic conditions a day or two of delay in watering may result in serious crop looses. The farmer is therefore much more tied to his land when it is irrigated. Irrigated rice is particularly labor intensive, and the dedicated commitment to cultivating successful paddy rice may not come easily to those not traditionally accustomed to this type of cultivation.

In Vietnam, it is necessary for a farmer to obtain a license to use a source of

water. The farmer should consult the responsible authority, which could be the Water Development or Water Resources Department, about his requirements. It may be that his needs are so small that they fall below the minimum for which licenses are required, but it is as well to have the legal position clearly understood before embarking on a development.

There may be other legal aspects to be considered, such as common rights to a source of water, or access to land for the conveyance of water from the source to the field. Where several farmers share in the development of a source, this will call for some co-operative agreement over the management and use of the supply (Asian Pacific Newsletter).

Water Supply for Agriculture

Agriculture is the norm and a way of life for the rural people in Vietnam. Agricultural work feeds the people and brings in much needed income to those hard working families. Mainly, every household has their own property on which they grow there own crops. They grow fruits, vegetables, and of course take care and maintain their rice crops, the most important of all crops. A consistent supply of water is obviously needed to produce these crops. It is therefore necessary to discuss water supply strictly used for agriculture.

Water reuse, spreading wastewater and municipal wastewater may have a great impact on the future usable water supply in Vietnam. Reuse of water has been practiced ever since people have taken water from rivers. Thus, in a sense, it is not new. Along

rivers such as the Mekong River, individuals, communities, and industry reuse the water much time over. There is no evidence that this causes harm. In addition, reusing water can greatly lower the overall demand for water resources. Wastewater can be used for irrigation, for industry, for recharge of groundwater; in special cases, properly treated wastewater has been used for public supply. With careful planning, various industrial and agricultural demands may be met by purified wastewater, thereby freeing freshwater for community, which require better water, suitable for human consumption. (Opy 41).

Spreading wastewater on marginal land to create new farmland may improve particularly important in Gia Lai and Ban Me Thuoc. In such areas reclaimed water will probably be used first for irrigation. Filtering wastewater through soil removes all particulate matter: most cations and some anions are strongly adsorbed, and organic matter is decomposed by soil bacteria.

Using municipal wastewater for irrigation is especially attractive where agricultural lands are located close to cities, because the plant nutrients in sewage would otherwise go to waste. Some biological treatment of sewage should precede land application, but for many crops the degree of treatment required is so low that little technology and capital investment are required. Dong Khanh City uses vast amount of untreated sewage as irrigation water.

Municipal wastewater from secondary treatment plants can be used for cooling, ore separation, and other purposes that do not have severe water quality requirements. Use as process water requires advanced treatment. The degree and kind of treatment depend on

demands and economics of the application. For pulp and paper production the use of wastewater after only limited advanced treatment has been found to be economically feasible.

The important advantage of water reuse is that it can, if properly managed, reduce by several folds the demand on water from natural sources. Continuously recycling 50 percent of the wastewater in effect doubles the water supply. Dong Nai, an arid location, had been using the water reuse technique. This technique is the method of reusing wastewater produce by the industry. It may provide additional water needed to permit industrialization that would not otherwise be feasible.

To reuse water without causing environmental disaster calls for good management and a good understanding of the user's requirements. Systems can easily be mishandled and cause serious disease or harm to the environment. If more than 50 percent of the water supply is wastewater, salt accumulation can cause serious problems whether the water is for agriculture, or industry use. The cost and difficulty of reusing water depend on the treatment processes needed. Some secondary and most tertiary treatments require large capital investment and trained, capable personnel. Operating costs are high, in many cases too high for water reuse to be feasible (Opy 45-63).

Therefore once rainwater runoff has been harvested from slopes, it can be used for crop production. The combination is known as runoff agriculture. In runoff agriculture the principles and practices depend on rainwater harvesting. The basic need is rainwater catchments that provide enough water to mature the crop. Obviously, the crops own water

requirements and general water conservation techniques are crucial to successful harvest. Poor crop yields in drought years are usually offset by production in good years.

The type of farming practiced must make the best use of the water. In general, perennial crops with deep root systems adapt better to runoff agriculture, because they can use runoff water stored deep in the soil, safe from evaporation. Some deep-rooted, drought resistant fruit trees can be very successful. Shorter-lived crops can also be grown; grains, such as pearl millet, that mature rapidly and require only one rainfall hold particular promise. Plants that become dormant during dry periods and begin growing when water becomes available are particularly suited to runoff agriculture.

The dry soils and climate of Vung Tau have been found suitable for a variety of crops under runoff agriculture. Excellent yields have been obtained from pasture plants, field crops, and orchards, well above those of dry land farming and comparable to yields in irrigated farming.

A form of runoff farming that utilizes water from small, deliberately built catchments has been practiced in Quang Ngai. The water is used on school vegetable gardens. The catchments have included school playgrounds, roads, etc. (Cedillo 23-34)

In Thua Thien Hue the limited rainfall usually falls during short, intense storms. The water swiftly drains away into gullies, and then flows, sometimes for many miles, toward the sea or an inland lake. Water is lost to the region, and floods caused by this sudden runoff can be devastating, often to areas otherwise untouched by the storm.

Water spreading is simple irrigation method for use in such situations: floodwaters

are deliberately diverted from their natural courses and spread over adjacent floodplains or detained on valley floors. The water is diverted or retarded by ditches, dikes, small dams, or brush fences. The wet floodplains or valley floors can then be used to grow crops. Water spreading is also frequently practiced on range and pasture lands.

Water spreading systems need a careful design and engineering layout to withstand floodwaters. Potential sites are often found in Hue, sometimes where floods are more common than rain. They must be selected with full consideration for topography, soil type, and vegetation. Two requirements are essential, first are the runoff water, which available for spreading, produced by an upstream drainage area that gives at least a few water flows each year, and floodplains or gently sloping areas where the soils are suitable for crop production. Inherently more risky than standard irrigation, the system depends on fairly regular rainfall and on soils that facilitate runoff. A constant concern is that sediment and gravel carried by floodwaters may adversely affect the cropland.

A plant can grow in a region with too little rainfall for its survival if a rainwater catchments basin is build around it, forcing rainfall from a larger than normal area to irrigate the plant. This practice is called micro-catchments farming (Cedillo 48-67).

In 1972 near the small town of Saigon, Thu Duc, West Vietnam, the farmers built a rock wall to capture floodwaters. The soils here absorb little moisture, and the rainfall runs away in flash floods. Using stones gathered from the fields, Thu Duc farmers build eight 1 m high walls across the plains so that rain is retained, and absorbed by the soil.

In the Thu Duc micro-catchments construction costs are very low, it is only from

$5 to $20 per ha, depending on the catchments size. The cash return from crops repays their construction costs within a few years.

Micro-catchments are efficient because conveyance losses are minimized. In light rains, they provide runoff water. It is much cheaper to convert a certain area into micro-catchments than to construct a runoff farm because micro-catchments do not need channels, conduits or terrace walls. Also, micro-catchments can be built on almost any slope, including almost level plains, enabling the farmer to use large, flat areas unsuited for runoff farms.

How Irrigation System Affect the People

As mentioned above, there are three simple irrigation methods that help the farmer to make the best use of the water, which are runoff farming, water spreading and micro-catchments farming. A large irrigation scheme imposes a major change on the community and may initiate a sequence of changes resulting from new affluence and a new way of life. Cam Luong village is a perfect example illustrating how irrigation affects the villagers. Like many Vietnamese villagers, there are nearly 3000 residents of Cam Luong need two successful rice crops a year to ensure an adequate food supply (Figure 2). But, too much or too little water can and often does devastate at least one of those crops, leaving villagers with little to nothing to eat for months at a time (Vietnam Irrigation System).

In 1995, the American Friends Service Committee (AFSC) helped provide a pumping station, dam, and a series of canals that irrigate approximately 260 acres of land

in Cam Luong . As a result, villagers harvested twice as much rice as before from their fields. The Cam Luong irrigation system is just one of 18 such projects that AFSC has undertaken in Vietnam. Quite literally, each project helps put food in the mouths of rural Vietnamese villagers (Vietnam hydrology).

AFSC began its first irrigation project in Vietnam in 1989 by replacing a dam in Son La province that had been washed out by floods. Since then, thousand of villagers like those in Cam Luong have reaped the benefits of these projects. The irrigation systems allow many farmers to harvest two rice crops on their tiny plots of land one during the rainy season, the other during the dry season plus an additional crop of vegetables. If the second rice crop is successful enough, part of it might be sold or stored as insurance against future shortfalls.

Yet, these projects are built on a modest scale. Some dams are less than ten feet high with feeder canals two feet wide and one foot deep. And an observer might not see much water in those canals since some carry water only a few critical times a year. But regardless of their size, these projects help deliver the goods; namely, water at the right place and at the right time.

In addition to increasing the food supply, these projects often have beneficial side effects. In Cam Luong, for example, AFSC provided an electrical transformer to connect the pump to nearby power lines. As a result, Cam Luong villagers now have access to electricity despite their remote location. Many of AFSC's projects have produced similar benefits.

The system in Dong Muc irrigates more than 150 acres of land. The reservoir serves two communities with a total population of 1400 people. Prior to the completion of the irrigation system, the food shortage was so severe that some thought they would have to more. Now, people are staying.

The Trieu Duong project was designed to irrigate more than 650 acres of land. In 1991, the government built a pumping and electrical station, but there were no funds left for the canals. As a result, the system was never used. AFSC worked with villagers to build the missing canals, making a second crop possible for 16000 people in the Trieu Duong and Hai Ninh communes.

In Dong Lach, villagers only had 30 acres of land to plant rice, and one harvest was the norm. AFSC recently built a dam nearby, which increased crop area to nearly 90 acres during the rainy season and more than 30 acres during the dry season.

AFSC works in close partnership with Vietnamese engineers, as well as local villagers and officials, to complete these projects. In order to place an irrigation system, the AFSC first used survey to find out what village is mostly in need of the irrigation system, the next part is consulting with villagers to determine if they want the system, and then sign contract with Vietnamese to design the dam and canal systems. The villagers also help to complete the project by providing labor, and locally available raw materials, such as gravel and the sand that is mixed with cement to make the dams and canals.

The Dong Cam irrigation system is the biggest irrigation project of Phu Yen province has been build since September 1992. According to its design it is capable of

supplying more than 19000 hectares of rice with water. After 6 years of operation the project has been degraded and the ability to supply water has decreased compared with the earlier time. The content of the project is to repair and restore the irrigation system, restoring and consolidating two main canals dredging irrigation and sewage canals building stone embankments and dams which prevent damage from erosion of the canal banks gradually completing irrigation systems and roads which belong to the irrigation system and widening irrigation zones with a capacity of 19800 hectares. The irrigation system cost nine million dollars, the government use long-term loan with low interest rate for this project. The Dong Cam irrigation system helped the villagers increasing productivity of food output. For example, the Dong Cam villagers produce more vegetables and increasing the output of rice (Vietnam Hydrology).

Irrigation can bring wealth and prosperity to a community but it can also bring sickness and sometimes death. Many of the most important diseases in the tropics are related to water in some way. When a new dam or an irrigation scheme is built it can lead to an increase in the prevalence of diseases such as malaria or schistosomiasis. Young children often die if there is no medical care. Older people may suffer greatly and are unable to work and live their normal lives.

In Vietnam, there are not enough attention is being given to these health problems and so as more irrigation schemes are constructed more people may become sick. Those involved in irrigation might think that diseases are a problem only for the health workers. However, there are ways in which irrigators can help to reduce the risks of infection by the

irrigation practices they use and the way in which they operate and maintain their irrigation systems.

Schistosomiasis is sometime called Bilharzia and is found mostly in rural part of Vietnam. It is estimated that more than two thousand people are suffering form this disease. In its early stages victims sometimes have a skin rash shortly after infection and two or three months later have diarrhea with blood in their stools and urine. They feel very tired and are unable to work properly. Eventually the disease destroys vital organs in their bodies and this results in death. This does not usually happen suddenly. It can take many years (Wilson and Bryant 154-157).

The disease is caused by small parasitic worms that live in the human blood stream near the bowel and bladder of an infected person. They lay eggs and some find their way into the bowel and bladder and leave the body in stools and urine. In places where sanitation is poor, people tend to use canals and drains for their toilet, particularly if they are full of reeds and weeds in which they can be private. The eggs hatch in the water and they are free swim to look for suitable fresh water snails in which they can live and develop. The snails are called hosts as they house the eggs like a hotel for four to eight weeks. Sometimes they are called vectors because they help to transmit the disease. Each egg can produce thousands of larvae. These are very small and swim around in water. They can easily penetrate the skin of any person who happens to be standing in the water. They find their way through the blood stream to the bowel and bladder and the whole cycle starts again (Asian Pacific Newsletter).

Malaria is perhaps the most well known of all the water related diseases in the tropics and affects more than five thousand in urban and rural areas. It is a disease that produces high fevers from which many young children die. Those who survive can have continuing attacks. These tend to leave people weak and open to other kinds of infection.

The disease is linked to water because it is carried by Anopheles mosquitoes. These like to breed in pools to standing water. Undrained fields, badly maintained canals and drains and borrow pits filled with water provide ideal breeding places. A mosquito picks up the infection when seeking a blood meal and bites a person who is already suffering from malaria. It passes on disease to an uninfected person when it takes another blood meal. If people can be cured of diseases they cannot pass on any infection to others. Drugs are available to cure schistosomiasis and malaria. However, they are very expensive and not always available in the rural areas in the tropics.

The irrigation can help the victim by getting rid of the vectors. If the snails and mosquitoes are kills the diseases they carry cannot survive. Snail like to live in shallow, still or slow moving water in canals, drains or irrigated fields. One method of killing the snails is to use chemical called molluscicides in the irrigation water. However, like the drugs they are very expensive and difficult to obtain. Another method is to change the conditions in the channels and fields so that the snails do not like them. They then stop breeding the either move away or die.

Mosquitoes like to live in very similar conditions to snails. However they prefer to come in the house at night and tend to rest on the walls after a blood meal. One method of

killing mosquitoes is to spray house wall with DDT. Some mosquitoes are now resistant to this and so Malathion is used. This is regarded as a very safe insecticide. Like the molluscicides these chemical are expensive and not always available when they are needed. Changing their living conditions so that they can no longer breed can also kill mosquitoes.

Another way to prevent malaria and Schistosomiasis is to separating people from water. If people do not come in contact with infested water they cannot be infected with Schistosomiasis. If they are some distance from water the mosquitoes cannot reach them and so they may not get malaria.

Fighting disease is a very difficult task. Each of the methods described will help but they are of limited value on their own. The best results can only be obtained by using all the methods available at the same time (Asian Pacific Newsletter).

Improving the Drinking Water Supply in Vietnam

Vietnam's drinking water supply comes from basically everything. This includes a sophisticated pumping, storage, treatment, or modern-day distribution system. Sanitation facilities include public sewerage. However, this is rarely present in rural areas of Vietnam where simple springs or wells with no storage, treatment, or extensive distribution system, cesspools, pit privies, and soak-away pits are usually the type of technology that represent waste management and water removal in rural areas of Vietnam. As of December 31, 1975, 68 percent of the urban population and only 29 percent of the rural population were adequately served. The term "adequately served" here is defined as receiving clean

potable water in a convenient fashion. However, the relative mixture of rural and urban supplies differs among regions of Vietnam. Rural water supply programs lag behind urban programs in all parts of this country but progress has been made in all rural regions to this date. However, this is partly because of the inability of urban public services to keep up with the rapid migration of population from rural to urban areas.

Hand dug wells have been used for thousand of years but have become less popular with the advent of tube wells. Today, interest in dug wells is reviving, and they still hold much promise for Binh Duong, where people consider as an arid land. Modern materials, tools, and equipment may transform crude holes in the ground, hosts for parasitic and bacterial diseases, into more safe and reliable sources of water. Dug wells are inexpensive and easy to construct and maintain by fairly unskilled labor. They provide storage for water, as well as a source.

In most cases dug wells will be superseded by tube wells, but they provided an important transition step, and in some cases, dug wells will always be best for some villages in Vietnam, where transporting drilling equipment is difficult.

In Quang Tri village and Dong Ha village, dug wells are being seriously reconsidered. Since about 1954, when the use of air compressors and rock drills became common, many existing dug well in these villages have been deepened by digging through lava flows that blocked previous equipment. In the last 10 years Vietnam has also improved many dug wells solely by adding pumps. Powered by internal combustion engines or electric motors, inexpensive pumps, installed on platforms 1-2m above the

water level, boost the water up to ground level. Suitable pumps are now made in many developing countries, including Vietnam.

Dug wells, however, do have distinct limitations, they cannot be used to reach groundwater deeper than 20-30 m and their water production is usually low. Well digging technology is used in most digging project, but the art of lining wells has regressed, and there is an important need for improved linings. The liner protects against caving and collapse and prevents polluted surface water from entering the well. The main problem is lining the walls below the level of the water table. Another need is for safer, more rapid, more efficient digging techniques.

In the development of water supplies, small springs are often neglected. Yet in Da Nang, Hoi An, and Tuy Hoa, springs are the safest and most dependable source of water for domestic use. The horizontal well system, an improved spring development process, as great potential for providing an conserving sanitary water in geologically appropriate areas. A horizontal well is a spring. A horizontal boring rig is used to drill a hole and install a steel pipe casing into a mountain or hillside to tap a trapped water supply. In order to tapping water from springs, when a spring is located, it is either dug to expose the water bearing rock. Results are erratic and always carry a risk of damaging the natural barrier that dams the underground reservoir. If the flow is very low, a storage tank can be added to accumulate water during the night or off-season. With adequate storage, spring sites that flow only during a few weeks in the year may be useful.

During the last 20 years about 800 successful horizontal wells have been drilled in

arid areas of the southwestern Vietnam. Horizontal drilling equipment is currently manufactured; it is simple, portable, and dependable. The drilling process involves a rotary, wet boring horizontal drill stem rig, a carbide tipped, a small water pump, a cement pressure tank, a drill water supply, and a few standard plumbing tools and supplies (Coward 67-68).

Improving Water Supply in Vietnam

There are many successful horizontal wells and spring wells. However, Vietnam's government still has not stopped reduction of poverty in both rural and urban areas. They have a long way to go in terms of modernizing their water system and sanitation service. In 1978, the Vietnamese government has set a minimum target or goals that will help improve water supply and sewage disposal. These targets or goals include the supply of 60 percent of the urban population through house connections; the supply of 40 percent of the urban population through public stand posts; and the supply of 25 percent of the rural population with easy access to safe clean water. Even though it is very expensive to carry out these goals, Vietnam is making serious efforts to achieve them, like many other third world countries, they are giving greater attention than ever before to rural supply and sanitation. Rural development in general, and village water supply and sanitation in particular, are increasingly important objectives in all developing countries, not just in Vietnam.

At any one time the basic goal is to serve the largest possible population with a given quantity of investment. It is generally accepted that, holding constant the quality of

service, geological factors, and climate, it is cheaper per person to provide water in urban areas with relatively high population densities than in rural areas with thinly settled, spatially separated populations (Bergmann and Boussard 34-36).

According to the officials, who are in charge of water supply and sanitation investment in rural areas of Vietnam argue that, in many cases, it is not necessary to provide to residents of rural areas the same quality of water service as that provided to residents of more densely populated and sometimes more wealthy urban areas. Residents of large urban areas generally consider it desirable to have house connections, some houses with multiple taps, or, at the very minimum, convenient neighborhood stand-posts. On the other hand, the protection of an existing water source, the provision of several protected wells with hand pumps, or the provision of a larger well, or an earth dam with a stand-post distribution system may be a relatively major improvement in many rural areas of developing countries. Often this lower quality of service, but quite safe, rural system can be constructed at a lower per capita cost than a higher quality of service urban system. It is in our opinion that rural areas should start out with this solution as a temporary starting post. As technology becomes more affordable and available, only then should they start to upgrade.

It is also generally true lower income consumers using the lower quality of service consume a smaller amount of water daily. In addition, therefore, to smaller per capita investment in the distribution system, investment in the water source will not have to be as large on a per capita basis, because lower income rural users do not generally have water-

using appliances, flush toilets, or kitchen sinks. Furthermore, rural dwellers use smaller amounts when they have to carry water to their houses instead of having it piped to the house (Saigon Website).

Whereas specific cost figures relating to differences in quality of service between urban and rural areas are difficult to the find, some evidence supports the argument that per capita costs in rural areas can be lower. When comparing and interpreting financial cost figures, care must be taken to make sure that the figures include all the costs, such as planning, engineering, central administration, personnel training, and continuing technical assistance. Finally, in some cases, rural construction costs can be lowered because rural populations are supposedly more willing than urban populations to work and contribute free labor to the project.

Investment in rural areas can also be cheaper on a per consumer basis in the short run where readily available sources of water are being used to the fullest capacity around the developing country's big urban areas. Because a massive investment would be required to increase the available water supply to these areas, it might be cheaper on a per person basis to develop low volume, relatively cheap sources of water supply for the rural population. However, water supply investment in rural areas would not generally lead to an efficient resource distribution unless the growth of the urban areas were to be completely stopped, an unlikely and undesirable event in most developing countries.

In the more developed urban areas where all big cities and intermediate size villages have some form of functioning water supply system, it is sometimes argued that greater health

and economic benefits would be seen if water were improved in rural "bad water" areas rather then urban ones. Although urban areas may need additional investments to reach the set goals, the argument is that there would be a small change in health and economic activity from urban water supply improvement relative to the change to be expected from setting up a series of new water supply systems in rural areas or smaller villages lacking any clean water systems at all. Additional investment in urban areas may show slow improvements, while initial investment in rural areas would not immediately do so to a significant extent. Because there is very little evidence available on which to base this argument, any investment towards these grounds would have to be carefully thought through on a case-by-case basis (Coward 42-48).

The situation with regard to sewage disposal is slightly worse than that of the water supply. Although the investment in the construction of community water supplies and sewage disposal facilities amounts to nearly 500 million dollars invested in water supply and 200 million dollars in sewage disposal a year. By the end of 1970 only 25% of the population had access to adequate sewage collection and disposal facilities. In rural areas, an average of only 8 percent had access to adequate disposal facilities, with the southeast region is as low as at 3 percent.

When rural or village water supply systems are discussed, one issue that always arises is what constitutes a "rural" area and what exactly is a village. There are many ways to define rural or village target areas but usually, there is not a clear line that distinguishes between a large rural village system and a small urban system. Village systems may

expand into urban systems; and little manpower, limited financial resources, and the geography of the area in many cases lead to dealing with the entire water supply and wastes sector as a whole region rather then separately as each sub sector. Dealing with rural water supply in sub sectors alone can lead to failure in the development of economic and social growth and in programs for dealing with the country's water supply as a whole. National and water supply and sanitation sector surveys are usually a necessity if plans are to be developed which will permit the establishment of the most beneficial programs for dealing with Vietnam's total urban and rural needs.

The reason for having different sets of conditions for supplying water in urban and rural areas is that there tend to be different problems to overcome and different goals to be met, needing the creation of water supply and sanitation programs having different policies for urban and rural areas. There clearly are differences: as communities become smaller or more less densely populated, the nature of the water supply and sanitation problem changes. To financially afford this change, we find that it is important to try to distinguish urban from village water supply and sanitation operations. Generally, financial feasibility gives us an idea as to the economic explanation of investments, and therefore removes the need to try the impossible: to trace the exact impact of improved facilities on health, or to attempt to compute and measure other benefits. Furthermore, bad record on the physical operation and maintenance of rural systems in other developing countries appears to be closely associated with not being able to collect sufficient revenues from citizens. This shortage sometimes reflects inability to pay, but more often implies bad

management and institutional arrangements, and a lack on the part of consumers of appreciation of the value of filtered water. These are important mistakes that should be learned from if a rural area in Vietnam decides to implement a clean running convenient water system.

There are many reasons to continue on improving the water supply systems in the bigger cities of Vietnam. In some cases, it is argued that, meeting the demands imposed by the increasing population pressure in larger cities should be the priority; otherwise, irregular supply and emptying of pipes where there is wastewater infiltration would turn the water distribution system into a way of carrying many of the very diseases water supply systems are designed to prevent (Figure 6).

Furthermore, the water supply and sanitation needs of many rural dwellers are often less severe than those of the urban areas of Vietnam. The rural and poor part of Vietnam usually have some source of water available to them, even if it is unsafe and at a considerable distance from the house. On the other hand, the residences of densely populated poor urban areas usually have no alternative for water supply other than a public system. This water source is not potable and is not suitable for drinking. Often private vendors act as the distributors of clean drinking water. Cities such as Ca Mau suffer from this problem.

In addition low-income urban regions will probably not be able to pay the total financial costs of their water supply systems. For example, rural systems were defined as those supplying water to communities with populations of 10,000 and below because a

population less then 10,000 was thought to be generally unable to provide the financial support for urban levels of service. Therefore not all urban areas are lucky enough to obtain a clean running water supply and waste management system. Even though they are urban areas, these regions often lack the basic needs of water and are generally considered behind in living conditions compared to that of some rural areas and villages.

In order for a developing country to advance, it is a necessity to slowly and carefully change unproductive rural areas and villages into a productive urban society. A priority in this change includes implementing a clean convenient running water supply. It must be carefully done or else it may end up as those urban areas such as Ca Mau, as mentioned above. Villages under Vietnam's program that are supplied with water should be able to generate local leadership support and a general population enthusiasm necessary to use and maintain a water system properly (investment may easily be wasted without local support) It is common for example, to find statements about existing rural supply programs such as: "It has been observed that greater numbers of those supposedly served by the wells are not using them during seasons when a nearby pond, canal, or backyard dug well has plenty of water at shorter carrying distance, or are not using the water at all because of taste or high iron content". Even the most undeveloped technologies may be too much for some communities to deal with in the absence of appropriate leadership, education, or community enthusiasm (Cedillo 80-85) .

The level of education and skills existing among the rural population is one of the major factors to consider in determining whether or not the operation and maintenance

phase of the program should have a national, regional, or local administrative base. When village systems are turned over to low income, relatively uneducated local authorities to operate, the probability of system failure is high." Many failures, however, have been caused by unwillingness on the part of central water authorities to use their best men for the highly important function of training village-operating personnel. In cases where it is decided that system operation and maintenance must be handled on a highly centralized basis, it is required to at least set up local village advisory committees so that local populations feel the water systems are their own and will take pride in seeing the systems operate properly.

Since the heart of rural development in Vietnam depends on agricultural productivity, a community where agriculture is the primary employment could be classified as a rural community that should be first in line for a clean water supply and sanitation investment. Some good candidate rural areas include Phong Dien, Nha Trang, and Nam Can.

Population migration to the larger urban areas is creating a problem in Vietnam and therefore those villages or areas with the most rapid population departure are the villages or regions that should receive priority water supply. It is obvious that, when choosing the types of villages to be served under a particular water supply program, there will be considerable overlap in the villages or geographic areas. An eligible village with a population between 500 and 4000 can also be a source of out-migration to urban areas, they have a predominantly agricultural economy and a strong and supportive local

government, and they are close to several other smaller clusters of population that could also be served efficiently from a central water supply system.

In the country's rural, it is generally not possible to provide clean water near all dwellings when the target population is relatively isolated. In the case of isolated or dispersed population, which is not concentrated in clusters or in villages with more then the equivalent of 50 to 100 single family dwellings, the best that can probably be done is to sponsor a program of occasional protected springs or dug wells with hand pumps, each of which serves a particular geographic area. A more technically complicated system for a dispersed population would generally be very costly on a per consumer basis and would be almost impossible to maintain (Figure 5). A program designed to serve the non-clustered population could simply be called a "dispersed population water supply program," or some similar name describing the target, which is the focus of the program. If differences in the cost of obtaining water from different sources are ignored and only more sophisticated piped water supply systems for clusters of population in rural areas are considered, the average cost of a system tends to be less for larger villages and they tend to be better able to financially contribute to the support of a piped system and also in some villages of Vietnam, are more likely to contain a population able to be trained to help maintain a piped system (Bergmann and Boussard 23-28).

Social and Economic Effects of Future Goals/Plans in Rural Areas

Clean water supply systems in rural areas of Vietnam affects local, regional, and

national economic and social growth. The economic and social effects of investing in rural water supply and sanitation will only be discussed in this paper since most urban regions are already well established socially and economically. This is in contrast to most of the rural regions of Vietnam. The kinds of effects are macroeconomic effects, long run and short run social, income, and improve health.

The macroeconomic effects of a rural water supply program on the national economy of a developing country such as Vietnam are clearly not worth considering if the program is smaller in relation to total national economic output. Individual village pilot projects or other local projects, which are not part of a large national program, would not affect the national economy significantly.

Vietnam would also experience an increase in overall economic activity as a result of the water supply program if funds were obtained from sources outside the country. This may be possible on two conditions. First, if the funds would flow into the country especially for the rural water supply program, and, second, if the country is not already fully employing all of its resources. At a minimum, the increase in Vietnam's economic activity or output will be equal to that proportion of the increase in direct program spending financed by outside sources, plus the increase in indirect spending made by those newly employed in the program and those directly or indirectly supplying services, equipment, and material to the program (Saigon Website).

Similarly, if the country finances a portion of the rural water program through increased taxes or user fees, and if this additional government revenue is composed partly

of money which the population would otherwise have saved, then the government would immediately put the money back into the economy, increasing a mass demand, resulting in a net increase in overall economic activity or output. Although a clean efficient water supply for residents of a village may be a necessary condition for significant economic development, it is clearly not enough as a means to achieve this objective. There are many other factors that must be considered into the formula of decent economic and social development as well.

Concentrating water supply and sanitation investment in rural growth points will tend to increase the long run economic development impact of the investment. A strategy of assigning the highest priority for improved water supply and sanitation to the smaller, poorer, and least educated rural villages is a high cost and extremely risky. These villages generally have higher per capita construction costs, and have difficulty contributing financial resources to construction, or levying charges adequate to cover even operation and maintenance expenses. Rural areas such as Long Xuyen should be avoided first since they have all characteristics of being last in priority. They have major changes and improvements to make in order to become a worthy candidate for a modern water supply and sanitation system (Coward 22-25).

Investing in complementary programs will increase the probability that the water supply and sanitation program will have an economic and social development impact on an area. If in semiarid regions or in areas with a dry season a village water supply system is designed to include the provision that livestock can be watered and small crops

irrigated, the probability that the system will have a significant economic impact is increased.

Finally, a water supply system is both consumption and an investment good. It is consumption good in that people begin using it immediately upon its completion. It is an investment good in that it is part of the local infrastructure and can indirectly generate additional, future economic activity by attracting local business and village industry. Also, it generates improved health of local human resources and in turn can increase production. To the extent that village water supply systems are investment goods partly financed out of revenue from new taxes and user charges, which would have been spent on consumption, then the result is a net shift from short run consumption to investment. This shift could have a net positive effect on long run economic growth in the regional or national economy.

If the Vietnamese government bears at least part of the cost of the water supply program, and if it raises its revenues by taxing economic output or income, then a rural water supply program will generally result in a redistribution of income within the country from urban to rural and from higher to lower income population. This happens because of the fact that per capita economic output and income are almost always higher in urban areas than in rural areas. A water supply program will produce a flow of resources into non-urban areas and financed at least partly by countrywide taxes on output or income, would redistribute resources. Income would be redistributed from higher income urban areas to non-urban areas and generally from higher income population to lower income

population. This will in turn create an overall balance within the country and give Vietnam a good start in improving its society as a whole (Cedillo 29-31).

There are several direct and long run effects on the economic and social outcome of a community or region that can result from introducing potable water supply systems designed to provide water for human consumption. Direct economic benefits to the population is created from encouraging fish farming in a reservoir constructed for the local potable water supply, or in a drainage pool. A drainage pool collects water after the village has used it. A reservoir fish farming operation is most beneficial where a large, open-air reservoir must be constructed and where the water must be filtered or otherwise treated prior to human consumption. Under these conditions, and depending on local costs of feeding the fish, Vietnam could gain an extra food source and increase its water system revenue through a fish farming operation requiring little additional capital investment in the water supply system. The city of Cam Thanh is a good example of how this works.

In areas, where climate and local technology allow the growing and storage of food during a wetter growing season, it is possible that water troughs for animals might make beef cattle, hog or poultry feeder operations possible at an initial water investment cost not much greater than the cost of the village potable water system for human consumption. If possible, any of the small garden irrigation, fish farming, or livestock watering efforts described could generate additional direct economic benefits to a rural community in a relatively short time, by increasing community income and output.

One possible negative, short run economic effect of a village water supply system might be a financially poorer population in terms of disposable income, or funds which low income people have to spend. With the possible exception relating to crops, livestock, and fish, it is difficult to show that potable water for human consumption will directly increase the income of a population in the short run. This is particularly true of rural areas where water is not at present purchased from vendors, where there is general underemployment so that improvement in health will not increase earnings, and where regional health services are free or at least heavily subsidized by the central government. In cases such as these, in the short run, the necessity of paying from 1 to 5 percent of yearly income as a water tariff in exchange for potable water, which does not immediately increase earnings or output, actually reduces the disposable income of each family and in a way, will make them poorer.

A common economic argument made for rural potable water supply systems is that "over the long run, a system is a necessary part of a community's infrastructure." Without one, it will not attract industry or generate an expanding commercial and village industry sector. There are two observations that can be made about this argument. First it is probably true in the sense that a potable water system is necessary for most forms of local economic development. As local businesses grow and village industry develops, the lack of a potable water supply system could slow down the rate of local economic and social growth. Although, however, a potable water supply system is at some point usually necessary for long run overall development, it is definitely not always enough to generate

development. If there are several villages in a given region of Vietnam, and if they all obtain water supply systems at approximately the same times, there is no reason to assume that all, or even most of them, will increase their rate of economic growth as a result. "Given existing migration, marketing, and growth patterns, some of the villages may grow and develop. But the odds are that many will not."

Migration from rural to urban is a growing problem in Vietnam. It is considered to be long-term negative effect. Two of the main reasons for migration are a lack of educational opportunities for children and a lack of employment and income generation opportunities for the total family. Because a village water system can at best generate only limited direct employment and income opportunities and has no effect on the amount of formal education available, it is unrealistic to expect a water supply system, by itself, to produce significant changes in long run economic growth, social development, and migration patterns in most rural villages.

Evidence shows that the relationship through time between economic development and village water supply systems for human consumption in Vietnam is difficult to find and even more difficult to evaluate for the reasons that most rural water supply programs in other developing countries have been in existence for less than ten years. It is risky to model Vietnam's future under such short-term examples. Also many villages that received water in the early stages of the older programs have also received a number of other infrastructure and development investments through the years. As a result, it is very difficult to point out an increase in local economic activity to any one

particular government investment. It can either be in health care, village industry, or agriculture. Not just investments in a potable water system.

Another observation on the long run economic effects of a water supply system is that firms or industries of a significant size are not generally attracted to small villages solely because a water system exists. Large companies, or even small water using firms, will generally be able to develop their own water source in rural areas. They choose a specific location for a variety of economic reasons, most of them unrelated to whether or not the local village has a potable water supply system.

Property tax revenue, which makes up a large portion of local revenue in Vietnam, would also increase if property values were to increase. Such increases could occur in the following ways: first, new businesses and village industry might develop new property or might expand existing establishments; second, as the desirability of potable water becomes more widely recognized, property with on-premises water service or convenient access to potable water becomes more attractive to population from areas without water, which in turn helps to increase the price of the property.

Nevertheless, if a potable village water supply system does create long run economic activity in an area, the taxable stock of private investment, both commercial and residential, should increase along with the taxable flow of income and sales. This would allow other different approaches in financing the system. This includes using the additional public sector revenue to help pay off water system debt, or further expanding and improving the system without resorting to higher future water rates.

A link between economic output and improved health is obvious but is sometimes difficult to demonstrate. Experimental studies do exist establishing a link between health factors and economic output on an international level. One attempt to find the effects of schistosomiasis and malaria on labor productivity. The study compared health and economic output across twenty-two different Asian countries. They found that the influence of health factors on economic output appears to be large compared to the influence of other factors. These factors include agricultural inputs such as labor and commercial fertilizer. This study went so far as to conclude that health inputs are associated with variations in economic output beyond those usually attributed to labor and capital. These findings, of course, could be subject to considerable errors in data (Asian Pacific Newsletter).

When death rates in Vietnam decline as a result of better drinking water or improved sanitation facilities, the final calculated value of the economic and social impact depends on whether or not a person's consumption is viewed as a cost to society or as an objective of society. When a person dies prematurely, society loses the amount of output, which he would have produced over an extended lifetime. What is generally debatable is whether or not this loss to society should be calculated on a net basis or on a gross basis. If one were interested only in what the effect is on others, then the net basis would be an acceptable way to calculate society's economic loss. Alternatively, however, one could consider consumption to be an objective of society and therefore argue that the portion of a person's output which he would have consumed would have increased the total welfare

of society and therefore should not be subtracted form total output. In this case the gross output calculation would be better to use.

It has been pointed out that from an economic and social resource point of view, society loses more if a twelve year old dies than if an infant dies because, while neither has started contributing earnings to society, more of society's resources have been invested in the twelve year old. From a program of project evaluation point of view, however, any costs incurred up to the time when the water project is initiated are sunk costs - costs that have been incurred but cannot be recovered. The impact of a water supply project relates only to earnings and consumption in the future.

It is true that in Vietnam and as well as any other third world country, if the same amount of earnings is attributed to both a twelve year old and a one year old, the twelve year old will have a greater present value in society because the twelve year old earnings are realized years earlier. If it is assumed, though, that there will be some economic growth resulting in increases in the productivity of labor, the one year old during his working years may be more productive, in real terms, than the twelve year old.

Observation has shown, in many instances, that the greatest number of deaths from water related diseases in developing countries occurs among children less than two or three years of age. As a result, a benefit survey exercise attempted to attach a "standardized" discounted earnings stream to probable changes in water related deaths. Regardless in age distribution, this would probably overvalue the short run economic benefits of a reduction in death rates through improved water supply.

An obvious positive short-term social and economic effect is on women. Irrigation and drainage have played a critical role in the development of agriculture and food supply in Vietnam. A potable water supply system makes obtaining the water needed for drinking, washing, and preparing food more convenient for the local population. Those who must fetch and carry water for family use will have more time, therefore, to devote to other things. The provision of water for the family in the rural areas of most developing countries is the primary responsibility of women. Depending on season, location, and terrain, water carriers in many parts of Vietnam could be expected to spend more than one hour each day carrying water. Furthermore, again depending on location, terrain, and season, the distance between dwellings, and a usable source of water is generally less than a mile.

After the introduction of a potable water supply system, women would be able to spend that time formerly used in carrying water in more directly productive activities to increase economic output and earnings. Again, the opportunity to increase earnings and output may be relegated to those seasons, if any, in which planting, cultivation, and harvesting make labor a resource temporarily in short supply. During those limited periods of time, the additional woman hours of labor, and perhaps the additional availability of water carrying animal, may make it possible for the village to engage in a more intensive or extensive cultivation of land and thereby to utilize better existing land and agriculture related capital.

Aside from seasonal factors, whether or not women would spend more time at

measurable productive activities would depend on the opportunities for such work and on the personal and cultural factors affecting the inclination of the former water carriers to engage in such work. In a study of nine Dong Thanh villages where agricultural work occupied the largest share of time of a majority of married women, when asked what they would do if they had more time available, less than half said they would spend it on agricultural work.

In another study carried out of the small village of Tinh Li in southeast Ha Noi, women were asked how they would allocate their time if a new water supply system saved them about twelve hours per week. Their responses were

Activity	*Hours*	*Percent*
Directly Productive Work	6.8	57
Household Jobs	4.2	35
Leisure	0.9	8
Total	11.9	100

The interesting thing about this situation is that the women did in fact have the opportunity to engage in productive work, that is, in cassava and charcoal production. As a result, an estimate of the value of the time which would not have to be used fetching water was made by multiplying the average returns to labor from cassava and charcoal production times 0.57 times the time saved fetching water. In this exercise it was assumed

that the returns to women were approximately equal to the returns to men, and that the returns to labor were constant. (Ostrom 313)

To the extent that women spend a portion of their newly acquired free time on domestic chores such as washing clothes or tidying up their dwellings, there generally would be no directly measurable short run economic benefit, except perhaps, possible increases in property values.

We have learned that irrigation systems and water supply in general, are vital to the growth and prosperity of Vietnam's society. We have discussed that water dams along the Mekong river plays a large role in carrying out and distributing much of Vietnam's water supply. There were negative factors introduced as well as positive factors in the effects of these dams. This paper researched in detail how irrigation systems, water supply, and basic sanitation services affected society in rural areas. Rural regions of Vietnam were extensively discussed because urban regions of Vietnam are already well established compared to that of rural areas. Health and the well being of the people along with Vietnam's economy had a relation in these three factors. Goals and possible improvements to Vietnam's water systems were also offered in attempt to improve and develop society within Vietnam.

There are many factors that should be considered in choosing who should benefit from a rural water supply and sanitation program. The program may have many objectives, such as improved health, economic development, income redistribution, and influencing migration patterns. Water supply and sanitation development for a region

should be determined based on these objectives. It is in our opinion that each rural area should be analyzed individually based on their needs of all of these objectives, not just based on one or two of these objectives. The rural area with the overall greatest needs should be first in line for obtaining a water system and or sanitation service. We believe this is an effective way to start improvement on Vietnam's society: to start from the bottom and work upwards.

However, it is also in our opinion that some areas should not be included in the line for a water supply or sanitation service, no matter how great the needs are for those certain people. Those areas or regions should be dealt with later or rather put on the side. These areas or regions we are speaking of are the ones with a dispersed population. The more dispersed the population to be served, the less likely is a water supply system to be financially viable, and properly maintained, not only because of lower per capita village income but also because average system costs, for a given standard of service, will be higher. Investing in these regions would be a waste of time and would be like throwing away a good portion of Vietnam's much needed income.

It is possible that water supply systems together with improved sanitation and other complementary investment programs could slow rural to urban migration rates. There is little evidence, however, that, in the short run, a rural water supply program, by itself, will have any effect on migration. In fact, in the long run, if the water supply program resulted in a healthier, more potentially productive rural population, the lack of rural employment opportunities could cause an increase in the flow of population into

urban areas; an unwanted effect that Vietnam is leaning away from.

Although the short run migration effects of a rural water supply and sanitation program are doubtful, it is a little more likely that potable water supply systems can be used to encourage, over a period of time, the grouping of dispersed populations into more economically viable village units. However, We still believe that the gamble of investing in water supply is much too great. Implementing a water supply in hopes of a reverse in a population migration drift is just not worth the gamble. Reverse of population migration drift should be a bonus, not the focus of the project.

Economic development is extremely important in building a better society in Vietnam. In fact, economic development tends to go hand in hand with social developments in any country. Although a potable water supply for residents of a village in Vietnam may be a necessary condition for significant economic development, it is clearly not sufficient enough alone to achieve this objective of economic prosperity.

Concentrating water supply and sanitation investment in rural growth points will tend to increase the long run economic development impact of the investment.

A strategy of assigning the highest priority for improved water supply and sanitation to the smaller, poorer, and least educated rural villages is a high cost and extremely risky venture. These villages generally have higher construction costs, and have difficulty contributing financial resources to construction, or even the heightening of taxes in order to adequately cover operation and maintenance expenses.

It is also believed to be a good idea for Vietnam to invest in complementary

programs. Investing in complementary programs such as health education, crop improvement, marketing information, and so on will increase the probability that the water supply and sanitation program will have an economic development impact on an area.

We also feel that in semiarid regions or in areas with a dry season, a village water supply system should be designed to include the condition that livestock can be watered and small gardens and crops can be irrigated. With this condition in mind, the probability that the system will have a significant economic impact is greatly increased.

Health related benefits are also an important factor to Vietnam's society. Based on the review of many major studies, there is evidence that suggests better water and better sanitary facilities are associated with better health. These studies examine the relation between the quantity and quality of water consumed, sanitary facilities, and the level of various water and sanitation associated diseases.

The health studies also suggest that the degree of improvement in health to be expected in any given population depends on the level of health in the first place, the economic state, cultural habits, educational level, the general physical environment including adequate means of waste disposal, and income level. Because of these factors, two different villages with identical water supply improvements can have significantly different results. Therefore, it is in our opinion that factors that could possibly be improved such as education level should definitely be raised to a higher bar in the future.

In many rural areas of Vietnam, unskilled labor is abundant and is greatly under-employed. A rural water supply and sanitation program, designed solely to improve the

health of the labor force, may therefore increase the extent to which there is an oversupply of labor but have very little impact on economic output and earnings. From a government point of view, improvement in health for these citizens in these particular areas may not be such a wise investment for the country as a whole.

There is some evidence, with regard to waterborne diseases such as typhoid and cholera, that improved sanitation is, in the long run, more effective and less expensive than vaccination. In a more general sense, preventive medicine is usually more cost effective than curative medicine, and water supply and sanitation are key elements of preventive medicine.

Factors that affect benefits also affect costs of a project. One approach to the cost health improvement problem is to put it in terms of a question: what amount of improvement in the major disease rates would it take to make a given investment worthwhile?

The major problem associated with providing water supplies in rural areas of developing countries relates to the operation and maintenance of systems. It is difficult to find villages where the systems are working precisely as planned, and it is common to find even relatively new systems, which are not functioning at all.

Assigning a high priority of water service to villages able to pay a user fee at least sufficient to cover operation and maintenance expenses, and enthusiastic about receiving improved water, increases the probability that the water supply systems will remain operational for a significant period of time.

There is some evidence that villages tend to value their water systems more highly, make better use of the systems, and operate and maintain them more efficiently when they have contributed resources to help cover construction costs, and are paying user fees which at least cover operation and maintenance expenses.

Encouraging villages to contribute free labor to the construction of their piped water supply systems is a good idea and can lower both the economic and financial costs of the systems and can stimulate the rural population to take pride in their systems. There is some evidence that a community water supply and sanitation program that requires a contribution (labor or money) from village populations may be used as a catalyst to stimulate a community organizational infrastructure which will continue to function after the water supply project has been completed.

The level of education and skills existing among the rural population is one of the major factors to consider in determining whether or not the operation and maintenance phase of the program should have a national, regional, or local administrative base. When village systems are turned over to low income, relatively uneducated local authorities to operate, the probability of system failure is high. Many failures, however, have been accompanied by reluctance on the part of central water authorities to use their best men for the highly important function of training village-operating personnel. In cases where it is decided that system operation and maintenance must be handled on a highly centralized basis, it is desirable at least to set up local village advisory committees so that local populations feel the water systems are their own and will take pride in seeing the systems

operate properly.

To increase the probability that permanent health and economic benefits will occur, the water supply and sanitation program should provide for the training of pump or system operators, bill collectors, and community promoters. An educational program for villagers focusing on good sanitation and water use habits and on any village gardening or livestock watering potential of the system should also be provided.

An output oriented, bonus incentive system for local and regional employees of the water supply program might be of value in increasing the probability that the continuing goals of the program are met at the local level. All these factors discussed, especially concerning technology and leadership, are all vital factors in the improvement of Vietnam's society and are major steps in bringing this prospective country into a modern-day, high tech 21th century.

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Mekong River Fact sheet

Length	4,200 km (2,610 mi)
Countries	China, Myanmar (Burma), Thailand, Laos, Cambodia and Vietnam
Basin population	60 Million
Country population total	242 Million
Per Capita GDP	Varies from US$ 2,565 (Thailand) to US$ 265 (Cambodia)
Uses	Irrigation, fisheries, power generation, transportation, industrial and domestic supply
Primary Legal Agreement	Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin, Chiang Rai, Thailand, 5 April 1995 - (Thailand, Laos, Cambodia and Vietnam)
Institutional arrangements	Mekong River Commission (Thailand, Laos, Cambodia and Vietnam)

Figure 1. Mekong River

Figure 2. Water irrigation is provided in most cases by human power

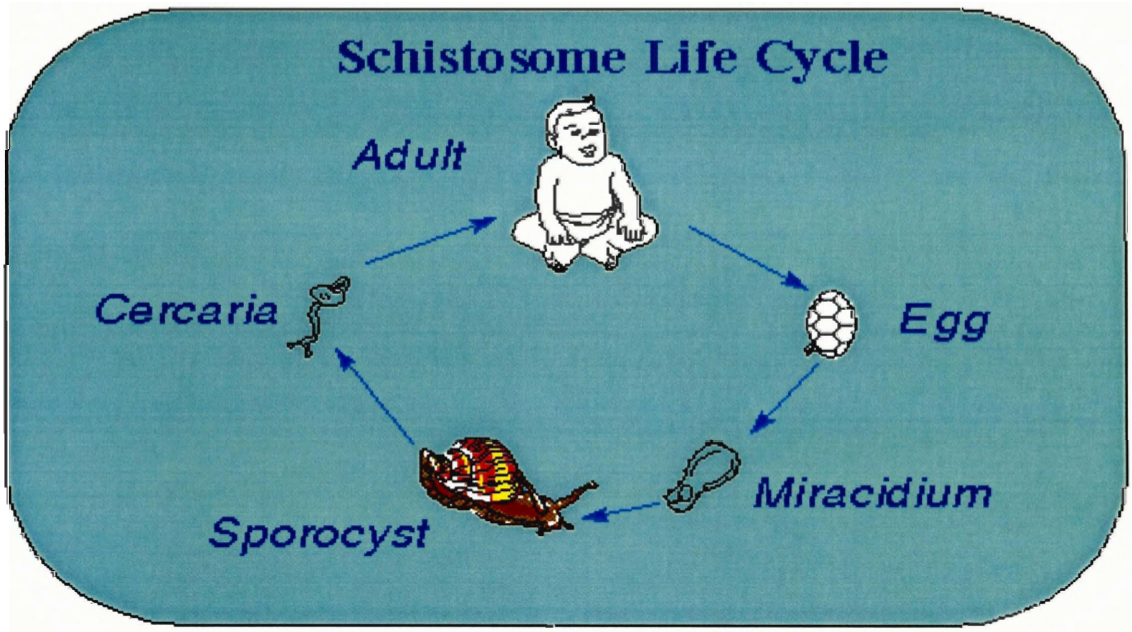

Figure 3. Schistosome Life Cycle

Figure 5. Dug Well

Figure 6. A pipe network for drinking water

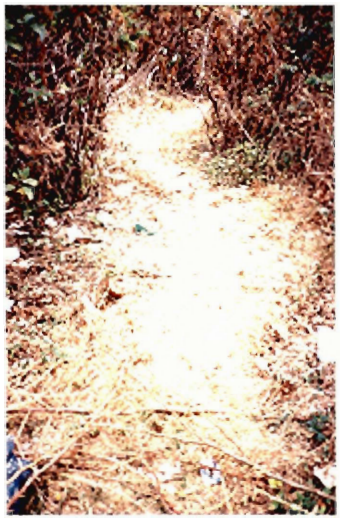

Figure 7. Many rural people use the bushes for a bathroom.