

EXPLORING CAUSES OF WATER RESOURCE DEGRADATION:

Toward Theoretical Perspective and Its Relevance to Empirical Cases

Eva Rolia

The Lecturer of Civil Engineering Department, Muhammadiyah University Of Metro

Email: roliaeva@yahoo.com

ABSTRACT

Problems of water resource degradation are becoming more crucial nowadays. Since water is absolute necessity for human, the requirement of water will always increase in line with the increasing of population. However, the availability of water in the earth is obviously limited. Therefore the issue of water requirement and its availability is important to be discussed. This paper tries to discuss this issue by exploring hydrologic cycle that can be understood as a whole phases undergone by water. It is expected that a broader view in understanding problems related to water resource can be obtained by using this approach. After exploring theoretical perspective of water resource, its relevance to the real case will also be conducted. In this part, Lampung province is taken as a study case. It actually is a kind confirming theoretical views into reality. Causes of water resource degradation in Lampung province will be examined. Then, this paper will also discuss programmes and strategies that have been conducted by government institution in Lampung. In the last part, some possible alternatives will also be promoted in order to support environmental conservation, especially water resource.

I. Introduction

1.1 Background

Water is one of the most important necessities that have to be fulfilled by human in order to survive in life. In meeting this needs, not only is quantity considered, but quality also become an important matter. In terms of quantity, population growth seemingly cannot be served by existing water resources that is obviously limited. Meanwhile, quality of clean and consumable water tends to be worse. Many factors can be suspected for this condition. Many researchers have been done to examine causes of this deterioration. The results show that there is a strong relationship between human's behaviours and activities and this environmental degradation.

A similar situation also occurs in Lampung Province. Although water resources are abundant in this region, many residents have not been able to consume clean water in their daily life. Clean water supply provided by government likely can only serve residents in urban area, but a contrast situation has to be faced by residents living in remotes area. Factually, this province has five watersheds with total catchment area around 27,884.48

km² which is a significant water resource potential (Yudha, 2008). However, problems related to water consumption still occur.

This paper tries to elaborate this occurrence by examining causes of decreasing (quantity and quality) of water resources. Theoretical framework of hydrologic system in the earth will be explored in order to obtain a broader perspective. By this approach, it is expected that the root of environmental problems can be identified. Then, empirical case will also be taken. The aim of this part is to examine relevance of theoretical approach and the case in reality. In the next part, strategies that have been proposed will also be discussed.

1.2 Objectives

Objectives that will be achieved from the discussion in this paper are:

1. Exploring hydrologic system in the earth in order to give more understanding about water resource.
2. Identifying problems related to water resource and its consumption.
3. Identifying causes of water resource degradation.

4. Examining programmes that have been conducted either by government or community in dealing with conserving water resources. To be more specific, Lampung province is chosen as case study area.
5. Formulating possible alternatives that can support water resource improvement programmes.

II. Literature Review

2.1 Hydrology and Hydrologic Cycle

Terminology of hydrology comes from Greek language; hydro means water and logos means science. So, essentially hydrology can be explained as "a science that cover discussions related to the occurrence, distribution, and disposal of water in the earth planet" (Raghunath, 2006, p.11); whether on the surface or underground. It also covers physical and chemical aspects of water and its influence to human's daily life. In short, this branch of science discusses water within all its aspects, phases, forms and processes. Thus, by viewing this perspective, it can be concluded that hydrology substantially covers all aspects in the discussion on the formation process of water, movement and distribution of water, characteristics of water, and the relationship between water and human life.

Discussing water cannot be conducted completely without explaining hydrologic cycle. It fundamentally can be defined as a cycle of water shifting process in terms of its formation and movement that occurs continuously in nature. Basically, there are three phases in this cycle. "There are: (1) evaporation and evapotranspiration, (2) precipitation, and (3) runoff" (Raghunath, 2006, p.12). To simplify, the process can be explain by this following diagram

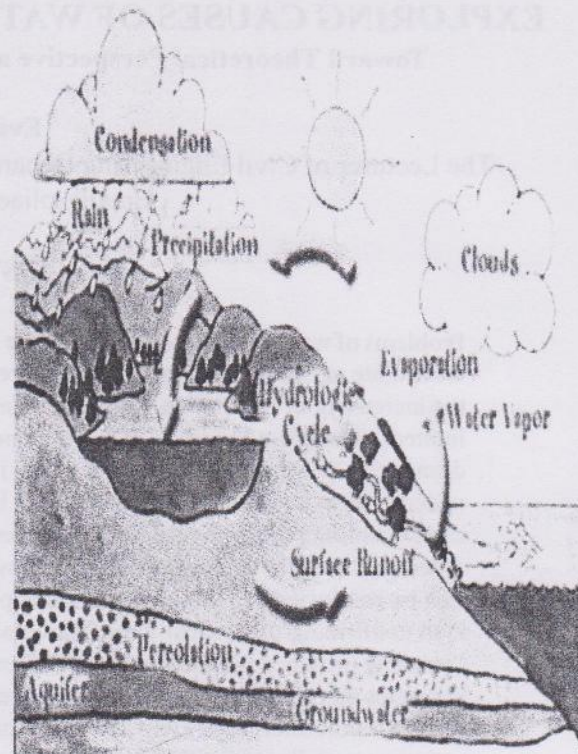


Figure 1 the Scheme of Hydrologic Cycle (source: www.physicalgeography.net) During hydrologic cycle, energy from sunlight causes evaporation process to surface of ponds, lakes, rivers, and oceans. Specifically, evaporation of vegetation is called transpiration. These vapours rise to the sky and are condensed at higher altitudes by condensation nuclei and form clouds. It then potentially generates precipitation. Some of precipitations are reached ground surface while others are intercepted at the surface of vegetation and evaporate again to the atmosphere. This process is called as interception loss. Rainfall that arrives to the earth, some of them infiltrate to underground while other flow on the ground surface as runoff. In infiltration process, water is stored as water reserve. On the other site, runoff flow to rivers then finally goes to the sea; and the evaporation process are repeated continuously (Asdak, 2002; Raghunath, 2006; Viessman Jr. et al, 1977).

2.2 Water Resource

In Indonesia, according Act Number 7 Year 2004 on Water Resource, water is defined as all forms of water located whether on the surface or sub-surface water; it also rainfall and sea water. Examples of surface water are rivers, lakes, irrigation, dams, drainage, ponds, etc. Meanwhile, "groundwater distribution is categorised into two main categories based on its zones.

They are zone of aeration and saturation. The former is the zone filled by partly water and partly air, the later is zone in which all voids are filled by water under hydrostatic pressure "(Viessmann Jr. et al, 1977, p.293).

By elaborating hydrologic cycle, it can be inferred that water resource can be categorised into two main categories; surface and underground water. Generally, "the amount of water volume in the earth, including fresh water and saline water, is approximately 1,385,984,610 km²" (data from UNESCO (1978) in Kodoatie and Sjarief, 2005, p.21). The detail proportion of this number can be figured as following table.

Table 1. The Amount of Water in the Earth

No	Location	Area (10 ⁶ km ²)	Volume (10 ³ km ³)	Percentage to total amount of water (%)	Percentage to total amount of fresh water (%)
1	Sea	361.3	1,388,000	96.579	
2	Groundwater	134.8			30.061
	a. Freshwater		10,530.00	0.7597	
	b. Saline water		12,870.00	0.9286	
3	Soil Mixture	82.0	16.50	0.0012	0.047
4	Ice in polar regions	16.0	24,023.50	1.7333	68.581
5	Other ices and snow	0.3	340.60	0.00246	0.972
6	Lakes				0.260
	a. Freshwater	1.2	91.00	0.0066	
	b. Saline water	0.8	85.40	0.0062	
7	Swamps	27	11.47	0.0008	0.033
8	Rivers	148.8	2.12	0.0002	0.006
9	Biological water	510.0	1.12	0.0001	0.003
10	Water in atmosphere	510.0	12.90	0.0009	0.037

(Adopted from UNESCO (1978) in Kodoatie and Sjarief, 2005, p.21)

This table illustrates the total amount of water in the earth, forms and its proportion respectively. Among hydrologists, there is a strong belief that the total quantity of water is considered as constant; it is also obviously limited. However, the proportion shifts dynamically; and problems arise in line with this dynamics. For instance, ice melting in Polar Regions as an effect of climate change will increase sea level implicating environmental problems particularly at coastal zones. Another example is excessive ground water exploitation will reduce significantly underground water storage, and then it shifts into surface water. Problems may come into both underground and surface wa-

ter. The decreasing of underground water storage will endanger the availability of water either in a long or short term. In addition, waste disposed after consuming water will also give serious problems to surface water. It leads to degrade water resource in terms of both quantity and quality.

2.3. The Degradation of Water Resources

By viewing table 1, it can be concluded that groundwater has a significant portion in terms of fresh water availability. More than 30 % of fresh water actually is groundwater. However, over exploitation of groundwater without considering environmental and hydrological aspects affects to the deterioration of ground water either in terms of quantity or quality. To identify what the effects are, it is very helpful to see this following diagram.

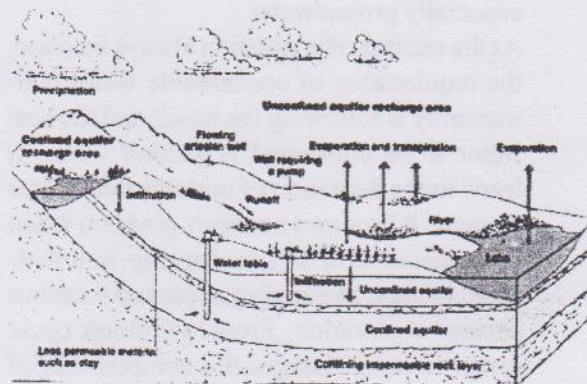


Figure 2 ground water recharge mechanism (source: www.mcdaniel.edu)

This picture shows an undividable relationship and interaction in exploration and recharging process of groundwater. The recharge process starts at catchment area. In this stage, rainfalls are caught at catchment area, partly become run-off while others infiltrate into ground recharging underground water storage. This process is able to prevent or even increase water table. However, over exploitation of groundwater can decrease this water table. Consequently, voids that previously are filled by water change into air. Then loading from upper structures pull it down. "It is called as land subsidence which potentially can disturb construction stability" (Asdak, 2002, p.269-271). In terms of quality, this process can also cause saline water intrusion especially at coastal zones. It is because empty voids resulting from exploitation is filled by saline water. Obviously, the quality of water will also decrease.

Let us explore what happen into surface water. As a result of ground water exploitation, surface water may also infiltrate into the ground because of emptiness of the voids. It essentially also reduces the quantity of surface water as well as contaminates groundwater. Then it is worsened by humans' behaviour that avoids environmental aspects in their activities. Littering rivers, for instance, obviously affect to quality deterioration of water. Not only that, it basically is responsible for the cause of flood and other disasters. Ironically, people now rely very much on rivers to fulfil their necessity, although they frequently deteriorate it.

To summarise, there are some causes of water degradation can be identified theoretically by considering hydrologic cycle and recharging process of ground water. They are:

1. Over exploration of groundwater resource; especially groundwater.

As the number of population always increase, the requirement of consumable water consequently is following the trend; and the best water to be consumed is ground water. It leads to the depletion of underground water storage. It becomes a serious problem when the consumption and recharging is imbalance. In fact, recharging apparently cannot balance exploration. From hydrologic cycle perspective, it changes the composition of water formations. Groundwater decrease dramatically while the amount surface water that actually is waste water after consumption increase proportionally.

2. The changes of land use especially at catchment area.

Soil and vegetation play an important role in hydrologic cycle, especially on the infiltration phase. Changes in land use, of course, will bring significant effects to this process. Deforestation, for instance, will lessen the amount of infiltration significantly; and amount of runoff will increase. As a consequence, the amount of water storage will also decrease. On the other hand, runoff that flows to rivers will also potentially bring terrible effects. Flood will occur when the amount of runoff excessively exceed the capacity of rivers. Not only that, runoff usually brings solid deposits if there is no vegetation in catchment areas. It causes sedimentation in the rivers that is finally will cause flood.

3. Humans' behaviour that is environmentally unfriendly.

Human as an actor in treating environment determine what kind of environment is going to be. Unfortunately, many people do not consider, or even do not care, about environment aspects of their activities; from small into large scale. Thus, human have a large responsibility in the degradation of environment; in this case we discuss about water resources. Littering rivers with domestic solid waste, using environmentally unfriendly chemical pesticides and fertilisers for agriculture, and polluting rivers in industrial activities are some examples that can be taken to support this hypothesis.

After examining causes of environment degradation, overcoming the problems is likely something obvious. The next section of this paper will elaborate approaches that possibly can be taken to overcome these problems.

2.4 Approaches in Overcoming Water Resources Problems

Water exploration and its interaction with environmental sustainability is a dilemmatic problem. On one side, water requirement constantly increase in line with increasing number of population. On the other hand, water resources is limited and urgently to be conserved. Indeed, it needs to involve many parties to overcome this problem.

There are some approaches that can be taken to deal with water resource conservation. Generally it can be viewed from technical and non technical perspectives (Wardana, 2001). From technical perspective, hydrologic cycle can be a helpful guidance to formulate the solution. Of course, examining the whole process will give an integrated point of view. Firstly, it can be started from catchment area. This location is closely related to infiltration process. Deforestation might be the most responsible for the decreasing of water storage. Not only does it reduce the amount of infiltration causing the lack of water, but also it generates more runoff that means give more burdens to rivers. If the condition in downstream is also destroyed, flood is likely inevitable.

Therefore, deforestation should be stopped to prevent worse situation. It can be done from very small unit until national scale. Starting

from neighbourhood scale, it can be started by planting one tree on every single household. So every house has a small catchment area that cumulatively become a considerable number. It actually a simple action, but it needs a huge awareness from every single person. On higher scale, municipality or province level for example, it needs a strong political to conserve catchment area. Nevertheless, only government has an authority to regulate whatever needed. One policy that can be taken is zoning regulation. If government very much concern on environmental degradation, appropriate zoning regulation is something inescapable.

From non technical perspective, it can be viewed from either government or community point of view. Government can prevent more serious problem or even make a better environment by using its authority. Providing adequate and reliable piped water supply, for instance, can reduce individual groundwater exploitation. The most important is a political will. If government has a strong commitment to conserve water resource, of course regulation that is produced will always considers environment concerns. Not only that, government also has budget and political power to promote programmes encouraging communities in environment conservation.

Finally, communities as users also give a significant portion in succeeding environment conservation. Awareness on environmental issues has to be promoted intensively in order to build environmental sensitiveness among societies. It essentially can be started from trivial daily activities e.g. consuming water as it is needed, minimising groundwater well construction, planting tree, no littering rivers, etc. The most difficult thing to do is likely encouraging the awareness. In this situation, government and other parties who concern on environmental degradation issues has to work hard and involve actively in sobering the society up about future catastrophe if it is not prevented from the very beginning.

III. Study Case

3.1 Study Area Overview

Previous discussion has explored environment degradation especially that is related to water resource theoretically. Now let us move to empirical problems that occur in reality. The case will be taken in Lampung province; the south

end province in Sumatera Island.

Topographically, Lampung varies from hilly and mountainous in the western part until lowland and swamp area in the middle to the east. To be more specific in water resources, Lampung has several rivers categorised as five major watersheds that are very important to local people.

Here is the list of rivers in Lampung, Table 2. the list of rivers in Lampung province

No	The name of the river	Length (km)	Catchment area (km ²)	Estimated quantity (m ³ /s)
1	Way Sekampung	256	4.795	216.0
2	Way Semangka	90	985	67.5
3	Way Seputih	190	7.149	26.0
4	Way Tulang Bawang	136	1.285	200.0
5	Way Mesuji	220	2.053	155.0

(Source: modified from Manik, 2008,p.4-12)

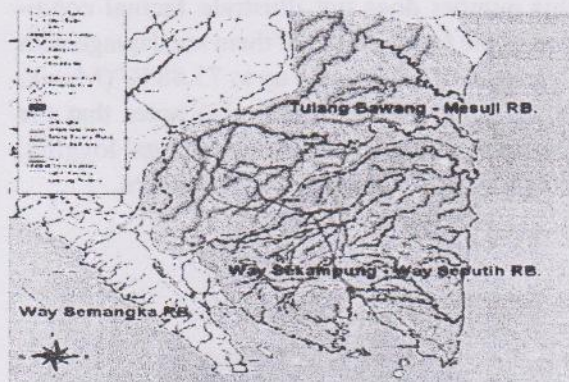


Figure 3. Map of watershed in Lampung province (source: www.lampung.go.id).

By looking at table 1, actually Lampung has a big potential of water resource. Those rivers are very important for supporting local people's basic needs. Most water company (PDAM) rely very much on these rivers as water resource. Besides, rivers are also used to support economic activities such as irrigation and fresh water fisheries. As an evidence, it is estimated that 20 -100 kg/hectare per year of fresh water fish is produced by Way Tulang Bawang river. Besides, potential of groundwater is also significant. "Mining office of Lampung Province calculates that Lampung has 8,474 million m³per year of potential groundwater" (Yudha, 2008, p.9). However, this number recently tends to decrease because condition fish habitat is becoming worse. The next section of this paper will reveal environmental problems emerging in Lampung, especially regarding water resource, and the causes of those problems.

3.2. Water Resources Problems in Lampung

Since problems of water resources are too complex to be revealed entirely, the discussion will be more focus on two arenas. They are problems at upstream (as catchment area) as well as problems on rivers and coastal zones.

Firstly, a major problem that occurs at catchment area in Lampung is deforestation. Many forest shift into agricultural land and settlement. Indeed, it looks like a dilemmatic problem when environment conservation has to combat with economic necessity. Total area of forest in Lampung annually decreases and changes into plantation and/or settlement. "It was recorded 2006 that the area of forest in Lampung is 1,004,735 hectares or 28.4 per cent of total area of Lampung province" (data of Dinas Kehutanan Provinsi Lampung/2006 in Manik, 2008, p.6). However, study from Manik (2008) shows that this number does not illustrate factual condition of the forest. Many of them are damage with "the level of the damage up to 73.88 %" (Manik, 2008, p.7). This research also notes that the causes of this circumstance are illegal logging, illegal forest occupiers, and forest fire.

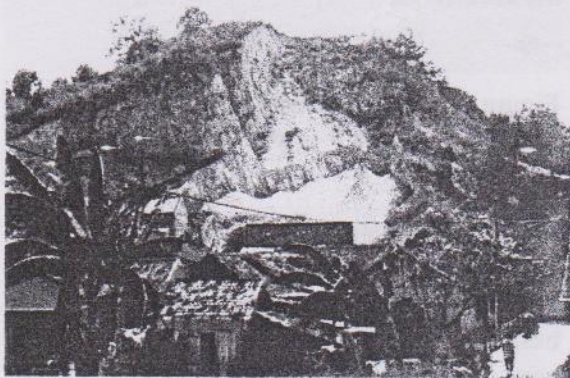


Figure 4. Gunung Kunyiit, one of catchment areas in Bandar Lampung where shifts into settlement (source: www.lampungpost.com)

The damage of forest basically also brings many bad implications. It endangers biodiversity and decrease hydrologic function of forest itself. The decreasing of hydrologic function implicates to quantity fluctuation of watershed, increasing the amount of runoff, and decreasing infiltration rate. It generates derivative problems such as flood and landslide in rainy season as well as drought in dry season.

Another possible cause of water resource degradation is augmenting of dry land agriculture that ignores land conservation. "In Lampung, the area of dry land agriculture is about 1,854,184 hectares or equal to 52.41 % of total area of Lampung province where is mostly located at upstream zones of watershed" (Manik, 2008, p.10). Cultivation is done either by individual farmers or big farming companies. Individual farmers usually cultivate vegetables, cassava, corn, and other short term harvested commodities. Meanwhile, long term harvested commodities such as: coffee, cacao, rubber, sugarcane, and palm are mostly cultivated by big farming companies.

"Theoretically, land conservation is suggested for areas with slope more than 8 per cent. And mostly dry land agriculture especially coffee plantation is located at areas where the slope is more than 15 per cent. However, either individual farmers or companies have not done yet land conservation" (Manik, 2008, p.10-11). As a consequence, it increases the amount of runoff that erodes fertile top soil. It actually generates disadvantages to both upstream and downstream areas. At upstream it reduces soil fertility that finally affect to productivity. On the other hand, sedimentation occurs at downstream decreasing the depth of rivers that potentially causes flood in rainy season.

Besides facing water resource problems as mentioned previously, quality of water in Lampung also tend to decrease. Study of Yudha (2008) notes that based on pollution measurement conducted during April to June 2008, pollution level of rivers that is taken as samples in Lampung is moderate to high polluted. It mostly is caused by industrial, agricultural, and domestic waste. Local newspapers frequently reported pollution cases caused by industries. In 2008, for example, there were at least three demonstrations triggered by river pollution that is caused by industries. This occurrence happens in Tulang Bawang (January 2008), in Sungkai, Lampung Utara (February), and in Pesawaran (July 2008) when rivers in each regency was polluted by cassava flour factories. (Yudha, 2008, p.16-17).

3.3 Strategies Done by Government to Overcome the Problems

Undeniably, it is not easy to overcome problem related to water resource. It should consider many aspects and involve many stakeholders.

In addition, the approach used has to be integrated and comprehensive. So solutions that are promoted can effectively be implemented due to optimise the results. Here are solutions or strategies that have been implemented by government in Lampung:

1. In 2006, Lampung Provincial Government relocated 1.399 household that had occupied conservation land in Taman Nasional Bukit Barisan Selatan (TNBBS) and 624 households from conservation land in Lampung Barat. By doing this, it is expected that these conservation lands can function as it is supposed to be. If it is assumed that every household occupied at least a half hectares of land, it means about a thousand hectares have been saved.
2. Promoting forest rehabilitation programme (Gerakan Rehabilitasi Hutan dan Lahan/GERHAN) that is done simultaneously every year since 2003 in all regencies/municipalities.

Table 3 shows the result of this programme.

no	institutions	Implementation of GERHAN (hectares)				
		2003	2004	2005	2006	2007
1	Dshut Provinsi Lampung	1388	1000	1000	200	2000
2	Dshut dan PSDA Lampung Barat	4450	1900	3550	-	6350
3	Dshut Lampung Utara	4880	800	2500	200	2500
4	Dshut Lampung Selatan	1662	1200	2380	980	6280
5	Dshutan Tanggamus	6100	4775	1425	650	6200
6	Dshutan Lampung Tengah	3000	1600	2000	325	5500
7	Dshutan Way Kanan	3750	1180	1850	200	2250
8	Dshutan Lampung Timur	450	675	2350	225	2200
9	Dshutan Tulang Bawang	1000	1500	2900	150	1650
10	Balai Taman Nasional Way Kambas	4521	1000	1000	-	-
11	Balai Besar TNBBS	-	1000	100	-	-
12	Dshutan Bandar Lampung	-	100	100	124	-
13	Dshutan Metro	-	100	100	-	-
TOTAL		31201	16900	21305	3154	39350

(source: data of BPDAS Way Seputih Way Sekampung (2007) in Manik, 2008, p.15)

By looking at this figure, it can be inferred that there is a significant effort from government institution to rehabilitate land especially that function as catchment area. It is expected that there will be a significant betterment in land conservation. And finally, catchment areas act properly as it ideally should be.

3. Promoting river rehabilitation programme (Program Kali Bersih/Prokasih). This programme aims to rehabilitate the quality of river. In addition, community participation is also encouraged in this programme. In 2007, it was recorded that Bandar Lampung Municipality Government had allocated a hundred million rupiahs to clean six rivers up that across this municipality. Then it was continued by allocating sixty six million rupiahs to follow up this programme in 2008 (Yudha, 2008). However, the result of this programme seemingly has not been satisfied yet. It needs more effort to campaign this programme and encourage communities to involve.

3.4 Possible Strategies that Can Be Promoted.

According to previous discussion, it cannot be ignored that government had tried to promote some strategies to cope problems of water resource. In order to develop those strategies, there are some possible alternatives can be proposed.

1. Keep functioning conservation forest and protected areas as a catchment areas. It may be needed to relocate illegal forest occupiers. Therefore, government also has to consider social economic effects of relocation action. Before relocating them, it should be guaranteed that occupiers will be given compensation such land for cultivation and settlement outside conservation areas.
2. Elucidating and giving assistance to communities or farmers that occupy land where the slope is 8 % or more to conserve their land by constructing terrace system. It may effectively prevent landslide. In addition, it also prevents top soil from to be brought by runoff. It is also important to build understanding within farmers that this action will be beneficial for them.
3. Promoting prokasih more intensively involving more stakeholders such as industries, farming companies, as well as government institution and communities. By this

approach, it can be expected that more actors involved will implicate to more significant result.

IV. Conclusions

From the discussion, there are some conclusion can be obtained. They are:

1. Water resource is a part of a complex hydrologic system in the earth. It includes many processes that cannot be viewed partially. Because of that, to deal with water resource problems, an integrated and comprehensive approach is something inevitable.
2. The degradation of water resource has strong relationship with human activities. Therefore, active participation of communities has a significant portion in improving quantity and quality of water resources.
3. Government as the party that has an authority has to initiate and/or accommodate programmes that environmentally friendly. In addition a strong commitment in conserving environment is obviously needed.

REFERENCES

- Asdak, Chay. 2006, Hidrologi dan Pengelolaan Daerah Aliran Sungai, Yogyakarta, Gadjah Mada University Press.
- Kodoatie, Robert J, Roestam Sjarief, 2005, Pengelolaan Sumber Daya Air Terpadu, Yogyakarta, Penerbit Andi.
- Manik, K.E.S, 2008, Kondisi Aktual dan Pengelolaan DAS di Provinsi Lampung, Bandar Lampung, Lembaga Penelitian Universitas Lampung.
- Mithcell, Bruce, B. Setiawan, Dwita Hadi Rahmi. 1997, Pengelolaan Sumberdaya dan Lingkungan, Yogyakarta, Gadjah Mada University Press.
- Raghunath, H.M. 2006, Hydrology: Principles, Analysis, and Design, New Delhi, New Age International Limited Publisher.
- Rahayu S, Widodo RH, van Noordwijk M, Suryadi I dan Verbist B. 2009. Monitoring Air di Daerah Aliran Sungai. Bogor, Indonesia. World Agroforestry Centre - Southeast Asia.

Viessman Jr. Warren, John W. Knapp, Gary L. Lewis, Terence E. Harbaugh. 1977, Introduction to Hydrology, New York, Harper and Row Publisher.

Wardhana, Wisnu A. 2001, Dampak Pencemaran Lingkungan, Yogyakarta, Penerbit Andi.

Yudha, Indra Gumay, 2008, Sumberdaya Air di Provinsi Lampung, Bandar Lampung, Lembaga Penelitian Universitas Lampung.

<http://www.lampung.go.id>

<http://www.lampungpost.com>

<http://www.physicalgeography.net>

<http://ga.water.usgs.gov>

<http://www.mcdaniel.edu>