

WATER RESOURCE MANAGEMENT UNDER CLIMATE CHANGE: IMPLICATIONS FOR SUSTAINABLE USE ON KARST TERRAIN

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ABSTRACT

The scarcity of freshwater is a critical issue that continuously is considered to be important around the world. The availability of freshwater steadily decreases because of growing population, high water demand and global climate change. Underground streams water and aquifers within karst terrain is assessed as an substantial factor of water supply systems in karst areas, and in the case that is assessed in this paper as well. Therefore, water management on karst area is essential to solve water deficiency problems, particularly during dry season. In this paper, management of karst spring water is discussed based on some cases from Citatah karst. Management of spring water is the main object of this paper that use mix method design, incorporating a qualitative and a quantitative approach. Result showed that inadequate human resource, infrastructure, database system; lack assertiveness, supervision and instrument of rules implementation; and low level of awareness and participation are found as the main factor of poor management of karst spring water at Citatah karst. However, better management could be attained by improving capacity building, strengthening monitoring capabilities, formulation of groundwater policy, implementing economic and financial instruments, improving participatory management and applying sustainable technology for agricultural and domestic water use.

Keywords: Citatah Karst, Karst Spring Water, Sustainable Use, Water Management

INTRODUCTION

Water management is a fundamental issue to humans and all living organisms to survive in the present era as water is a resource that is getting scarcer. Regardless of whether or not groundwater resources were karst aquifers, Bakalowicz (2011) stated that water resources have not been well managed. However, karst regions have varying potential to store water, though this depends on the condition of the catchment area and the rock structure. Ford and Williams (2007) assumed a close relationship between karst landforms (geomorphology) and the hydrogeological system, both above and below the surface because they are inter-related subsystems.

Approximately 70% of the water flowing gradually into underground river comes from epikarst. These karst landscapes are usually found in urbanized areas, where they face higher impacts from human activities. Destruction frequently occurred by mining activity that damaged the hills and endangered the whole karst system. Destruction of epikarst layer causes decreasing of water discharge in the dry season and flooding during the rainy season. According to van Beynen (2011), the most destructive practice for surface karst is large opencast mining that removes the entire subcutaneous zone, an important ground-water storage area and lowering the water table. Karst landscapes are thus very important because one cubic meter of limestone is capable of storing water about 165 up to 190 liters.

Related to the presence of Citatah karst in West Bandung Regency, West Java, this landscape is of special interest. As a field for study, karst which alleged to have been formed since 30 million years ago, store a variety of sources of knowledge that can be learned. In terms of environmental aspect, their presence greatly affects the survival of local communities especially as with regard to water provisioning. In 1950 there were still a lot of spring water at Citatah karst terrain. Bachtiar (2010), Geologist of Bandung, said that several water

resources in Citatah karst have gone due to open mining from generation to generation.

Nowadays the direction of Citatah karst management with regard to water resource management is still unclear. Water management at Citatah karst terrain becomes essential to be addressed with urgency and because improper management can cause at least two serious consequences which are lowering of water table and diffused pollution of groundwater mainly from agricultural activity or domestic waste water. So far, and with regard to mining activities that have harmed almost 70% of the area, local government has prohibited mining activities in some area of Citatah karst namely Pasir Pawon and Gunung masigit villages. According to a valuation report of West Java karst landscape, Gunungmasigit has been prepared to be an area of water protection, and it is strategic location to be studied.

Under proper management the balance between the necessity for development and preservation of nature will be sustainable. This is not apart from the institutional perspective, which is very important to increase the effectiveness and efficiency of water management. Havekes (2011) explained that there are some building blocks for good water governance specifically with regard to administrative organization, water law, adequate financing system and economic analyses of water measures, systematic approach, and participation of stakeholders.

All of those building blocks and their interrelations create the floor for good water governance; of course the specific details of the building blocks should fit the contextual characteristics of different countries, areas and administrative structures and culms. Hence, appropriate and balanced development in the fields of the mentioned building blocks is needed to identify at Gunungmasigit the approach routes and stepping stones to improve water source management in karst terrain properly in an orderly manner. The main aim of this study is to contribute to the development of proper water management in Citatah karst terrain, especially at Gunungmasigit village that has free from mining activities.

METHODS

This study is a descriptive research which mix method design including qualitative and quantitative approaches were considered. The design that will be presented and is executed is a single case study analysis. In this research, both primary and secondary data sources were used. The secondary data are obtained from literature study that utilized journals, books, newspaper, web search, report and regulations Whereas primary data are obtained through survey method by means of semi-structured questionnaires and interviews. The management of water source at Citatah karst, especially at Gunungmasigit village is analyzed by SWOT analysis. Strengths, weaknesses, opportunities, and threats are used to assess five building block related criteria for water good governance. These criteria refer to administrative organization, water law, adequate financing system and economic analyses of water measures, systematic approach, and participation of stakeholders.

RESULTS AND DISCUSSION

Water Management at Gunungmasigit

Concept of good governance on the little scope area such as Gunungmasigit village (local scale) has not been implemented properly. According to Bucknall (2006) water resources management should take into account different scales, started from local, regional, national and then international across different time-frames. Historical, cultural and hydrological aspects of specific regions are influence water good governance on local scale. aspects of specific regions are influence water good governance on local scale. The five aspects of good water governance are described one by one as following subsections.

1. Administrative organization

According to 1945 Constitution of The Republic of Indonesia (section 33 article 3), earth, water and natural resources contained therein are controlled by the state and used for the greatest welfare of the people. Factor affecting its implementation is the capacity of state institutions in managing and distributing public goods that respects the rule of law. In fact, all water resources at Gunungmasigit village is managed by the community. Almost 35% of respondents said that they used to manage and control water supply personally for their own family.

Interviewing the local government suggests that there is no interaction between local and center government related to water management on Gunungmasigit village. The coherence between different administrative sectors only tied between agriculture organization (PPPT) and local interest groups such as farmers. According to Havekes (2011) coordination and collaboration of different government bodies is important in water management. Gunungmasigit village does not have collaboration or coordination between agricultural sector and irrigation sector or other related sector such as department of spatial planning and human settlements. Therefore, sometime the farmers did not get water flow to their rice fields, mainly the fields far from the water sources. PPPT institution cannot work optimally due to limited funds and multidisciplinary knowledge.

In term of water domestic needs, the villagers tend to use water from the karst spring freely due to the absence of an official regulator or regulations. It means no jurisdictions or responsibilities. Therefore, villagers seem not to consider and be aware of water safety especially of wastewater and water quantity on dry season. Several conflicts between villagers happen with regard to water shortage.

Although the findings suggest that the respondents are not aware of properly water management, this may not automatically reflect the picture of poor water management. Most subdivisions at Gunungmasigit village have a water manager called *pengandir cai* who is responsible for measuring the sustainability of water flow either from

storage or spring pool to the villagers houses. Spring water is distributed fairly and flowed alternately. Due to the bumpy road and long distance between villagers' house, secondary and primary storages, sometimes the water flows not smoothly, even frequently clogged. The water manager is supposed to be fixing the problem as soon as it is recognized. The villagers who use this service are charged as fifteen to twenty thousand rupiah (15.000 20.000 rupiah). Unfortunately, poor families cannot pay for this service and prefer to utilize water on public bathroom and carry water by buckets or jerry cans to fulfill household water need.

Lack of adequate information with regard to real conditions of distribution and contribution related to karst water utilization leads to indifference among government and other stakeholders. Without any role of the government, rural development is far from better conditioned. As explain in before, several spring points are not equipped with reservoir and public bathroom. Most of storage and public bathroom on study area was built by community initiatives. According to the chief of Gunungmasigit village, local government ever gave several rubber tubes only once and this almost happened 20 years ago when the village head election campaign was held. Unfortunately, he failed to officiate the village head position and his disappointment led to stop giving assistance. However, wherever in the world, the government (inevitably) plays an important role in water management (Havekes, 2011).

2. Water law

In Indonesia, water law is regulated in legislation No. 7 year 2004 about water resources. It stated clearly that in term of facing imbalance between water availability (which tends to decline) and increasing water needs, water resources must be managed while taking into account social, economy and environment functions. Moreover, groundwater regulation established by Government of West Bandung regency stated that groundwater management is done to realize the management of water resources in a balanced, sustainable and environmentally sound manner. However, the regulation seems not to be implemented on Gunungmasigit village. Related to the weakness of administrative organization above, the absence of a governmental role is affecting the existence of water law on local scale. Furthermore, the chief of each subdivision at Gunungmasigiti village admitted that they not implemented the regulation and even not recognize detailed rules with regard to water resources.

Legal awareness of Gunungmasigit villagers seem to be poor due to low education. According to Besri (2011), legal awareness of community is influenced by level of education. He stated that education is the effective and efficient method to increasing public awareness. While based on research by Aminah (2012) dissemination of information has become the important factor since level of education has no significant influence to legal awareness. These findings indicate why some people can do whatever he wants relating to spring water utilization. The absence or lack of supervision by law enforcement officials may decline the public awareness. Without legal awareness, the prohibitions, commands, obligation, enforcement, compliance and protection of rights related to water management will lead to nowhere.

Nevertheless, Gunungmasigit villagers are really concerned and motivated to protect area around the springs. Trees that grow around the springs should not be felled. They believe preservation on spring area could sustain the water and this has been done from generation to generation. It is as such an unwritten rule to be obeyed by all villagers, but they named it as a culture instead of a rule. Another custom is about water diversion on dry season. According to the villagers, although karst spring water flows continuous all year round, the water on dry season is not as much as on wet season. Therefore, they seem to have their own policy to prioritize water stream to household instead to farm field.

Limited water supply has forced the community to advance public interest.

According to Department of Energy and Mineral Resources, since regent rule about mining prohibition has enforced at Gunungmasigit, the village prepared to be an area of water protection. However, in depth interview with chief subdivision indicated some small mining activity is still active on several subdivisions. The chief has known this but did not reprimand or report to the authorities. Lack of public knowledge regarding the potential karst as water storage may be one cause of less protection of the public against the karst region. Earlier research by Marheningtyas (2011), shows that lack of society knowledge influences their involvement on conservation program. Moreover, most of local community lives from mining and this since generations.

Regulation that was imposed suddenly caused many miners who lived at Gunungmasigit village to become jobless, because some limestone factories were forced to close down. The worst thing is that alternatives offered by the government were considered as just nonsense. Moreover, Government of West Bandung regency suggested that Gunungmasigit villagers should be more creative in creating jobs. The underpinning and logic of the mining regulation are not clear to Gunungmasigit villagers, hence they did not have confidence that the legislation serves their interests. Consequently, they go back to the mines without any respect to the regulations and water conservation status. Furthermore, close supervisions are not being done well and the instrument for sanction is not clear. Havekes (2011) stated that it is naturally essential that the regulation matches the culture otherwise the society compliance level might be poor and loses its function.

3. Adequate financing system and economic analyses of water measures

In Indonesia, infrastructure fund of water resources is budgeted at the central government level through Anggaran Pendapatan dan Belanja Negara (APBN) and at the regional level through Anggaran Pendapatan dan Belanja Daerah (APBD). Budgeting at the national level is performed through coordination between institutions that involve the National Development Planning Agency to develop annual government work plan. The state budget can be sourced from local currency, loans, and grants from donor countries or agencies. While local budget can come from local revenue and loans or grants allocated by the state budget. The budget for local government may come from the General Allocation Fund, Special Allocation Fund, and Revenue Sharing Fund that were carried out under the law (Rullihandia, 2008).

Previous research regarding to agricultural water need has shown rice cultivation on second period have water shortage hence resulting low yields (Yustikasari, 2014). Hence, the department of agriculture and irrigation should have good collaboration to provide funds and create water supply project. However, economic analysis is needed to attain efficient and effective financing system on karst water management.

Unfortunately, systematic approach on water management at Gunungmasigit village tends to be weak. Roles and responsibilities of each local institutions related to the water management functions are unclear. Besides, institutional agreements and coordination between different administrative sectors to carry out all water management functions are inadequate. Interview with local government official indicates that mining and tourism department dominates regional development. Agricultural department is focused on how to increase the yields without understand water issues on Gunungmasigit village. Each institutional perspective seems not support other institution or organization to perform its functions related to water management. In his writing, Havekes (2011) stated that awareness of systematic approach in Indonesia is necessary, which equalizing and awarding function are becomes an important part of systematic approach.

Lack of information on real conditions and data about karst spring water on Gunungmasigit village (such as the availability of ground water, approximate estimate supplies needed by water users, water discharge of spring water and roles and responsibilities of local government, institution, society and everything that is connected with karst spring water management) lead to management that only concerned with self-interest. When one party only holds the responsibility of domestic water needs, while water irrigation addressed by others, and the other water needs held by the party, the lack of inter-sector relationships can lead to uncoordinated development and management of water resources, ineffective system, unsustain and lead to conflict.

4. Participation of stakeholder

Many stakeholder groups are supposed to be involved in water management at Gunungmasigit village. As described before, government and other several institutions are not coordinated well, hence participation level of stakeholders on karst water management as a whole can be categorized as weak. In the field, the villagers play roles in water management especially regarding to water distribution and infrastructure. Based on legislation No. 7 year 2004, the communities need to be given a role in resource management water indeed. However, it is not mean the government and other institutions do not participate fully in the water management, particularly on financial.

According to Rondinelli (1990), water supply system is basically a component of a region and forms of public service provision that should be implemented by the government for community benefit and the construction of public utilities is one of the duties and responsibilities that must be implemented by the government. Interview with some villagers suggest that they tend not to believe in government, moreover after the failure of a government official in village head elections. Each subdivision has to manage their "own" water resource, without any assistance and fund from government or stakeholders, which actually have responsibility in karst water manage. According to Pretty (1995), it can be categorized self- mobilization and connectedness level of participation, which the community participate by taking initiatives independently.

Generally, stakeholder participation on karst water management at Gunungmasigit village has been hindered by several constraints. In Indonesia, as a large country with many remote areas, limited financial resources and difficulty of involving representatives of all stakeholder admitted by the local government as influence factor of low level of participation. The government actually has a primacy to balance every stakeholder's interest. However, the absence of institutional agreements and coordination between different administrative sectors related to karst water management are leading to low-level participation. Other factor that becomes a problem at Gunungmasigit village is a lack of commitment to sustainable development in mining sectors.

Recommendations Regarding Water Management

The recommendations as described below are based on SWOT analysis. The SWOT analysis presents the strengths (S), weaknesses (W), opportunities (O) and threats (T) of the karst spring water management. Based on the findings of existing water management at Gunungmasigit village that compared to water good governance, the driving factors are categorized as an element of strength and opportunities, while limiting factors are categorized as an element of weakness and threats. By using SWOT analysis, driving and limiting factors are grouped as external factor (opportunity and threats) and internal factor (strength and weakness). The results of the assessment for each element and each factor are listed on Table 1.

There are too many weaknesses to allow for a sustainable water resources management system to be secured at this moment in Gunungmasigit village. However, the strengths and opportunities can be

used to overcome as much as possible the difficulties posed by weaknesses and threats, while promoting principles of good water governance. According to Danca (2000) weaknesses should be converted into strengths, while threats should be converted into opportunities. In addition, strengths and opportunities should be matched to optimize the water resources of Gunungmasigit village. The result of internal and external factors analysis of existing water management on Gunungmasigit village is used to identify strategic alternative to improve the management based on water good governance. Those strategies are improving of capacity building, strengthening monitoring capabilities, enforcing economic and financial instruments and managing stakeholders participation.

Table 1. Analysis of internal and external factors of existing water management at Gunungmasigit village

Internal factors	
S	1. Most karst spring water have high flow rate
	2. Karst spring water meet the drinking water criteria
	3. Total water discharge of spring water meet the domestic water needs
	4. The availability of surface water during the wet period
	5. Presence of the collaboration between PPPT institution and group farmers
	6. Presence of water manager (<i>tpenganfir cci</i>) who responsible measuring the sustainability of water flow
W	1. Inadequate infrastructure leading to excessive losses
	2. Total water discharge can not meet rice fields water needs properly during dry period
	3. Lack assertiveness and supervision of rules implementation
	4. The absence of a complete and accurate database system
	5. Lack of instrument (incentive or disincentive) for efficient water use
	6. Lack of skilled professional to monitoring and control of spring water management
	7. Insufficient level of awareness and knowledge of best management practices in agriculture
External factors	
O	1. Many stakeholder have the same interest on water needs
	2. Water resources legislation on national and local scale
	3. Regent Rule of West Bandung about mining prohibition
	4. Water has a high economic value
	5. The community have high initiative to manage water source
	6. High possibility of collaboration with college or university related to environmental and natural resources management
T	1. Higher water demand due to increasing population
	2. Climatic change
	3. Land alteration of recharge area due to mining activity
	4. Conflicts of interest between sectors
	5. Low public participation due to limited financial resources and multidisciplinary knowledge

Source: Author (2013)

1. Improving of capacity building

Based on Sessions (1993) definition, "Capacity building usually is understood to mean helping governments, communities and individuals to develop the skills and expertise needed to achieve their goals. Capacity building program, often designed to strengthen participant's abilities to evaluate their policy choices and implement decisions effectively, may include education and training, institutional and legal reforms, as well as scientific, technological and financial assistance".

The government holds the first key to improve capacity building. Not only for water good governance on Gunungmasigit village but also on twenty three other villages. All this time, the government has been assigned the responsibility of water resources management to the local

community because they have a better knowledge of the water condition and their socio-economic situation, also because they are the most exposed to the influence of the decisions on how to manage those resources. In this case, the local government of Gunungmasigit village have trouble to allocate and manage spring water because they do not understand the interests and priorities of the local community and other related stakeholders.

With reference to the existing regulations, the local government can begin to exploit the strengths and opportunities to improve water management on Gunungmasigit village. Priority to improve the capacity building on Gunungmasigit village is by improving technical capabilities of human resources of water authorities that are directly responsible for the execution and monitoring of water management. Collaborations between stakeholders and college or university can be used to formulate water management programs as form of execution of water resource and water management legislation (on national and local scale) integrated with regent Rule about mining prohibition on Gunungmasigit village. The goal of water management, time or period of the program, role, function and responsibility of each stakeholder and other related institution should be clearly spelled out by considering the specific conditions of Gunungmasigit village and resources (including human resources and financial capacity) of each stakeholder.

In term of water shortage, especially on rice field water needs, improvement of technical knowledge of farmers is also important factor on capacity building, especially on irrigation water pattern. As explain before, irrigation system on Gunungmasigit is using spring water continuously because farmers do not have a reliable source of information with respect to the quantities of water actually needed to irrigate paddy and certain climatic conditions. According to Kalsiin (2011), periodic irrigation pattern is more efficient than continuous irrigation. The role of non-departmental institution such as PPPT, financed by local government and agricultural department, can be optimized for giving training to the farmer group. Rainwater utilization program is also enable to implemented to meet agricultural water needs, especially on dry period. Therefore the second period of rice cultivation (May August) will not be short of water again.

2. Strengthening monitoring capabilities

Monitoring toward water resources, water quality, water use and disposal system is essential for effective management of karst spring water on Gunungmasigit village. Although monitoring is not given as a direct regulatory responsibility, all stakeholders need to make the monitoring of waterspring as one of their basic functions to carry out the management of water resources. Compliance monitoring and data acceptance is difficult without the involvement of interested parties. Similarly, financial management instruments such as water price and polluter pay principle is important for financial sources, encourage water savings and valuable for self- motivation monitoring of each stakeholder.

According to Australian Water Department (2011), monitoring on local scale should not only consider the findings of regional and district monitoring but also address existing site characteristics. Economically, it is impossible for the local government to carry out all types of monitoring. By cooperated with the concerned water authorities, the funding needs can be shared. Beside, cooperative arrangements between stakeholders for sharing water resources data and provide adequate access to data by the public can be established. The local government even can facilitate college student who doing some research or study tour on Gunungmasigit village. As explained before, karst landscape has education functions, which store a variety of sources of knowledge that can be learned.

The role of college is very constituted by Tridharma College include education, research, and community service. Understanding of

education is in order to transfer of knowledge that has been developed through research by students in college. Data generated by student research is valuable for the government to support or complement the existing data. Other proponents may be required to conduct more detailed monitoring to ensure adequate baseline data is collected. Non-official water manager (*pengandir cai*) that has existed on Gunungmasigit village can be contributing to spring water management through monitoring of domestic water needs. Meanwhile, the government also can take advantage indirectly to farmer group that has been trained to monitor periodic irrigation systems.

3. Economic and financial instruments

Associated with better management of water resources and a new management structure, the local government of Gunungmasigit village must increase attention to water management system with an adequate financing system. Basically, economic instruments are levies to encourage people changing their behavior in a particular direction. In this case is changing the way of domestic and agricultural water use. Economic instruments such as tariff; subsidies; cross-subsidies; and other businesses based incentive such as water trading; and waste disposal costs, can be used to promote the efficient allocation and use of water resources (demand-side management). It can also be used to achieve broader objectives, which is justice water allocation and sustainable use of spring water. The pricing authority is not given to the market because the price is very important for the poor people. However, the pricing of water on Gunungmasigit village must consider the scarcity of the resource and its true value.

From supply-side management, it keep water safe from contamination due to mining activity, which somehow still operating illegally around Gunungmasigit village, through policy based on a polluter pay principle. Income received has flexibility in use and may be used as an investment for poor community service or to address inequities in water issues. In addition, financial instrument can create a mechanism to increase the amount of money to fund the activities, both operational as well as for capital. Financial instruments focus on income generating money and its relationship with the cost of activities that should be funded. By strong monitoring and application of polluter pay principle, the management and development of water resources on Gunungmasigit village can be sustainable. According to Cordato (2001), enforcement to the polluters to bear the costs of their activities is also meant to improve economic efficiency. However, policy based on a polluter pay principle should enable the government to manage water source sustain without sacrificing the efficiency of a free market economic system.

Financial instruments help the local authorities making decisions on specific investments. One way to improve the efficiency of water is to invest and improve the infrastructure (Copeland and Tiemann, 2010). By this, more attention will also be given to the operation and maintenance. More attention will also be given to reduce the amount of losses in the system. Even so, any investment must be rational and consider the necessary resources (capital, labor, raw materials, etc.) to ensure the use of water resources optimally. Supported by Havekes (2011) argument, described that economic analyses are part of adequately financing water management. Instruments, which can be developed in Gunungmasigit village for this purpose is the cost benefit analysis, cost assessment system during life economic and multi-criteria analysis.

4. Participatory management

Major destination of participatory management is to prepare a framework, which can minimize conflicts and maximize consensus between different water users. In order to implement an effective management plan of karst spring water, participation of all stakeholders is necessary to reach highest level of efficiency. Low level of

participation and poor systemic approach on Gunungmasigit case can be dealt with either through local forums of discussion and representatives of the governmental agencies. The local forums could consist of various local types of consumers such as farmers, water manager (*pengandir cai*) private sector, local institutions, and other representatives that connected to water management.

The involvement of stakeholders is more than just a public hearing to get feedback on the instructions or government legislation. It is to identify the problem and the value of public concern and develop a broad consensus on design and new reforms. Involvement of stakeholders also means utilizing the interested parties with their broad information and knowledge in order to obtain a reasonable way out, efficient and sustainable in water resource management. Coordination should be a concern in the participation of the interested parties. Therefore, roles and responsibilities of stakeholders in the structure of water resources management process should be made clear from the outset to facilitate communication on a local scale.

Organizing parties concerned on water source management at Gunungmasigit village is long and difficult process. However, the biggest challenge for karst water management is to maintain the active participation of the interested parties. The key is to ensure that interested parties see the benefits of their participation. For some stakeholders, for example mining industries, the management of karst water resources could be seen negatively because they are suddenly faced with new policy based on a polluter pay principle. In this point of view, local government as a great responsibility to provide and present the real benefits from their involvement in the management of karst water resources at Gunungmasigit village.

According to guidance on public participation proposed by UNECE (2000), information is the most important in order to remain interested parties concern in water resources management. Information can also create a sense of local ownership of the process of being implemented. One of its activities is to ensure that interested parties are kept informed of the status of water resources management through regular reports. By providing information to all stakeholders, it promotes to dialogue between stakeholders and brings greater transparency, openness and alternative to decision maker. Workshops, flyers, websites, field visits and consultations are various information instruments that can be implemented at Gunungmasigit village.

CONCLUSION

The research discovers that water management based on water good governance is not implemented properly on Gunungmasigit village. Most is handled by the community, ranging from built storages, public bathrooms, drainage and septic tank; provided water pass, pipe and water tube; to distributing and controlling water flow for domestic and agricultural water needs. Sometimes conflict within community and between communities happen due to poor monitoring. The role of local government is very small, especially with regard to the needed systematic approach aspect there is ample space to improve. This is exacerbated by the lack of data and information on the field, lack of assertiveness and supervision of rules implementation, inadequate of human resource and financing system, and low level on public awareness and stakeholder participation.

SWOT analysis has found some alternative for better management of karst spring water on Gunungmasigit village. Improving capacity building through development of human resources of water authorities that directly responsible for the execution and monitoring water management is the first step for the government to established sustainable water management. Collaboration with existing non-official organization, college or university and other stakeholders that interested on water management must be tightened with clear role, function and responsibility of each party. The stakeholders need to make the

monitoring of spring water as one of their basic functions. Therefore, adequate data and information system are needed because reliable water information is a basic tool for effective water management and better use of our water resources.

Regarding to low financing system, local government of Gunungmasigit village must implement economic and financial instruments. At least two functions can be achieved, namely promoting the efficient allocation and water use and keeping the water safe from contamination, particularly from mining activity. Revenue from implementation of economic and financial instrument can be used for funding water management activity, improving and maintaining the infrastructure.

Participation of all stakeholders is also necessary to reach highest level of efficiency on water management at Gunungmasigit village. The parties have to be sure that they get the benefit of their participation. Local government is the key who has responsibility to provide and present the real benefit of their involvement in karst water management. Therefore, interested parties must be kept informed through regular reports, which lead to greater transparency, openness and alternative to decision maker.

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