Community Based Educational Model on Water Conservation Program

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Abstract. The previous research showed that there were indicators of water crisis in the northern and eastern part of Denpasar city and most of coastal area experienced on seawater intrusion. The recommended water conservation programs were rainwater harvesting and educate the community to develop a water saving and environmentally conscious culture. This research was conducted to built the community based educational model on water conservation program through ergonomics SHIP approach which placed the human aspect as the first consideration, besides the economic and technically aspects. The stakeholders involved in the program started from the problem analyses to the implementation and the maintenance as well. The model was built through three main steps, included determination of accepted design; building the recharge wells by involving local communities; guidance and assistance in developing a water saving and environmentally conscious culture for early childhood, elementary and junior high school students, community and industry. The program was implemented based on the "TRIHITA KARANA” concept, which means the relationship between human to God, human-to-human, and human to environment. Through the development of the model, it is expected to grow a sense of belonging and awareness from the community to maintain the sustainability of the program.

1. Introduction

Groundwater is esssential for life and importance to human health and well-being. The ground water crisis has become the global issues in the 21st sencury, however, it is still hard to describe the character of the ground water crisis. Srivinasan et al [1] conducted a metaanalysis of 22 coupled human–water system case studies, using qualitative comparisonanalysis (QCA) to identify water resource system outcomes and the factors that drive them. The cases exhibited different outcomes for human wellbeing that could be grouped into a six “syndromes”: groundwater depletion, ecological destruction, drought-driven conflicts, unmet subsistence needs, resource capture by elite, and water reallocation to nature. These six syndromes are commonly felt in all major cities, especially in developing countries such as India, China, and Indonesia. Wyrwall [2] conducted the research on water crisis in India. The report stated that the first two months of the 2012 monsoon have seen remarkably weak rainfall, but existing groundwater bores in many areas can no longer be relied on as an alternative to surface water. It is exposing the simple fact that the India’s groundwater crisis water table has fallen too quickly due to over extraction. Udmale [3] also reported that that the availability of drinking water with acceptable quality is lacking. The drought that has occurred since 2011 has worsened in 2012 and led to a decrease in groundwater and to the failure of the public water supply systems in the Upper Bhima Catchment area. These data reinforced the results of local observations of annual water table decline exceeding 4 meter common throughout India [4]. Similarly India, China also faces an acute water crisis. China Water Crisis Risk [5] reported that some researchers have identified an indicator of water crisis since 1999, started with the water pollution. In 2005, World attention drawn to the notorious
Songhua River pollution incident; 100 tones of toxic benzene substances spilled into the river following an explosion at a petrochemical plant in Jilin Province. Four million people in the city of Harbin lost access to water for almost a week as a result. Since the Songhua River flows into the Amur River in Russia, Chinese and Russian authorities also worked to minimize the impact on the nearby towns of Komsomolsk-on-Amur and Khabarovsky. The issue of the water crisis in China continues to grow and in 2010 it was reported that a severe drought affects most of Southwest China. About 51 million people faced water shortages, economic damage to agriculture and failed electricity generation from hydroelectric dams is estimated to be at least RMB 24 billion (USD 3.5 billion). The drought also affected non-ferrous metal production in Guangxi, including of electrolytic zinc, with companies in Nandan County cutting production by 30%. The data describe that the water crisis has caused chain losses, not only losses from the economic aspect, but also threatens the health impairment and well being for both current and future generations. Indonesia with high population density also faces an acute water crisis. Changes from an agrarian country that is slowly moving towards an industrialized country has been accompanied by the increasing of urbanization, land use change lead to the decreasing of catchment area and exploitation of natural resources, including groundwater. In big cities like Bandung and Jogjakarta Indonesia, land use change has reached 2.3 to 7% per year. Data of the National Land Agency (BPN) in 2007, the area of rice fields in Java is 4.1 million hectares. However, based on an audit of the Ministry of Agriculture through Landsat image in 2010, only 3.5 million hectares remain, decreased for about 14.53% [6]. Meanwhile, Bogor Agricultural Socio Economic and Policy Analysis Center reported that the estimated conversion of irrigated rice field land in Indonesia from 2005 reached 42.20%. While in Bali, in the period 2000-2005 the average land conversion function reached 913.20 ha per year [7]. This change of land function is permanent and can not be returned as it was in its original condition. This is similar to what is conveyed by the Chairman of the Association of Indonesian Peasant Harmony (HKTI) Bali Nyoman Suparta said shrinkage reaches 800 to one thousand hectares per year, the largest depreciation occurred in Denpasar, Badung and Tabanan which is a strategic area in Bali with the tourism industry as one of its main economic pillars [8]. The high change of land use reduced the green area (catchment area), lack of water deposit, and finally led to the water crisis. Sudiajeng [9] reported that study on ground water in Denpasar City showed that there were indicators of water crisis in some strategic area, especially in Panjer, Peguyangan village (North Denpasar), and Penatih Village (East Denpasar) in which there is a deep wells with a depth of more than 100 m below ground level. This is consistent with the report of Liu et al [10] that the land conversion in China Alagan the period 1980-2000 has led to changes in flow and groundwater levels. Skyrocketing water demands, overuse and systemic inefficiencies, combined with persistent pollution of major water resources have resulted in depleted supplies of both ground and surface water, with devastating consequences. If current trends continue, the strain on water resources will be extraordinary, potentially threatening economic development and social stability. Many of water conservation programs have been implemented to prevent and minimize the effect of water crisis, but not a few who failed and did not reach the target. Problem of water crisis is very complicated. Not just technical issues, but more complex is precisely a social problem. Therefore, the approach in problem solving must also consider social aspect. One approach that can be done is to design a community-based water conservation program. This research was conducted to built the community based educational model on water conservation program through ergonomics SHIP approach which placed the human aspect as the first consideration, besides the economic and technically aspects. The program was implemented based on the "TRIHITA KARANA" concept, which means the relationship between human to God, human-to-human, and human to environment. Through the development of the model, it is expected to grow a sense of belonging and awareness from the community to maintain the sustainability of the water conservation program.

2. Materials and Method
The research was conducted in the northern and eastern part of Denpasar City. The location was taken based on the hydrological data of the water flow direction and recharge area. Water flow starts from the north to the eastsoutheast, south, and southwest [11]. Inline with the water flow direction, the recharge
area is in the northern part of Denpasar City with the highest permeability about 1.10 to 2.81 mm/hour [9].

It is a multi-years research started on 2013. The output of the research in 2013 to 2016 were the hydrogeology maps included the flow direction, the water table, Electrical Conductivity both for shallow and deep ground water (aquifer), and the water conservation map. Besides, two types of shallow recharge wells were designed based on those hydrogeological data. This research period (2017) was conducted to built the community based educational model on water conservation program through ergonomics SHIP approach which placed the human aspect as the first consideration, besides the economic and technically aspects as describe in Figure 1.

Figure 1. Total Ergonomics SHIP Approach for Sustainable Development Program [12]

Enclosed with the process in building the Community Based Educational Model (CBEM) on water conservation program, the important step is examine the existing condition; including identifying the problems, doing SWOT analyses of the local potencies as the consideration for the solution, building work system, analysing appropriate technology, building work plan, and evaluation and maintenance system. On-site observation was done by visiting and interview stakeholders, started with the local community, community leaders, customary leaders, village officials and government officials to obtain an overview of the availability and quality of water from the perceptions of users and stakeholders. In addition, the study is also to determine the extent to which people's understanding and awareness of environmental sustainability management.
Based on technical data obtained from the study period 2013-2016 and interview results, subsequently designed a community-based ground water conservation education model.

3. Results and Discussion

3.1. Ground Water Conservation Program in North Denpasar Sub-district

North Denpasar Sub-District Geographically located on the north side of Denpasar with area of 3,302,148 Ha, consisting of rice field (765 Ha), dry land (1,342,668 Ha), land for public facilities (Office, field and others: 327.91 Ha) and others. The geographical altitude is <500 above sea level, and is largely agricultural, residential and industrial (trade services). The population reached 127,628 people, with their livelihood as farmers, craftsmen, traders, services, civil servants, blue colour workers and others. Based on hydrogeological data, North Denpasar is a recharge area with the highest rainfall between 1500 - 1750 mm / year and 4 wet months / year. The highest water passing rate (K) is 0.0434 m / day, ground water level 0.80 - 16.10 m under soil surface and the maximum infiltration rate 0.00000054 mm / second [9]. As the implementation of research results for the period of 2014-2016, the ground water conservation program has been conducted in this region. There has been built 2 recharge wells of 100 cm diameter concrete with a depth of 6 m and 6 recharge wells of 4 pcs HDPe pipe diameter 12 "with a depth of 4 m for rainwater harvesting. The local people involved in building these wells as a means of technology transfer, so that in the future, communities with local government can continue the program independently. To ensure the sustainability of the program, education and dissemination of ground water conservation programs has been conducted for local communities, from early childhood, community and industry, through lectures, educational video and activity-based education with the main theme of "Save Ground Water". Community-based groundwater conservation programs starting from designing recharge wells, recharge wells development sites, maintenance and sustainability programs are very effective. Through the "Tri Hita Karana" approach which prioritizes the harmonious relationship between Human and God, Human to Human, and Human Being with Environment, has succeeded in developing the sense of belonging, caring, and responsibility to maintain the sustainability of the program both for the current and future generations. This Community-Based Program is inline with A Report by University of Utah address to University Neighbourhood Partners [13]. Researchers have often plan their research, find appropriate settings to collect data, then analyse and publish data with focuses toward scholarly publications. This research method has limited impact and leaves communities feeling exploited as “research subjects” who never benefit from the potential good inherent in research. Settings such as the University Neighbourhood Partners can provide a way to incubate new ways of conducting research and new perspectives on how to integrate research with reciprocal action, learning, and benefit in society. Collaboration-oriented and issue-oriented partnerships have been shown to be successful. Collaboration-oriented involve substantial stakeholders input, a broad set of goals, and action goals that are focused on community improvements. Moreover, Demange et all [14] stated that the community-based approach refers both to the determination of individuals who mobilize themselves to defend common interests inadequately addressed by society as a whole and to their desire to “act together”. Community-Based program mobilized stakeholders with the same interests and needs and the idea is not for the community, but for, by, and with the community.

Refers to the result of the practical experiences in implemented the Community-Based Water Conservation Program in North Denpasar Sub-District, then the Community-Based Educational Model on Water Conservation Program has been created that can be implemented for similar program.

3.2. Community-Based Educational Model on Water Conservation Program

The Community-Based Educational Model, which has been created for, by, and with the community is describes in Figure 2. It showed that the involvement of substantial stakeholders both governments and communities were in all process of the groundwater conservation program.

The conservation program in the developing countries such as Indonesia is not as simple as in the developed countries. The understanding and awareness of people on environmental conservation is still
relatively low. Behaviours of people who dispose of garbage in any place including in rivers and drainage channels, the use of green area for housing or industry, and the excessive use of natural resources without feeling guilty are still widely found. To change the behaviour is not easy, because it has been rooted for years. Therefore, one effective way is by providing facilities and better conditions, which is strengthening by community-based Educations. With better facilities and conditions as well as the better understanding, people will feel the positive impact, for example can make life more healthy, comfortable, and more prosperous. Thus, people will unknowingly gradually behave better and ultimately bad behaviours will turn into unconscious good behaviour, and eventually will grow awareness to participate in its sustainability. Nelsson et al [15] identified three main mechanisms that best explain the reasoning of individuals to engage in conservation behaviours: i) conservation livelihood provides economic value; ii) conservation provides benefits that outweigh losses of curtailing previous behaviour, and iii) giving local authority over resources creates empowerment. The success of each mechanism was affected by various context factors, including the proportion of income generated for the family, capacity to engage in livelihood, cultural acceptability of livelihood and the livelihood being logistically achievable to partake in.

![Diagram]

Figure 2. The community-based educational model on groundwater conservation
Regarding the community-based on groundwater conservation program in North Denpasar Sub-District, it was succeeded. Site observation, which has been done soon after stop raining, showed that the wells were effective in rainwater harvesting and there were not any paddles surrounding all the 8 recharge wells. The results of interviews with local communities indicate that they are very satisfied with the success of ground water conservation programs in the region, including the principals of State Elementary School - 5 and State Junior High School - 12, where recharge wells was built. They stated that the puddles that have been causing the muddy and dirty are gone and the schoolyard as well as classrooms is dry and clean. Moreover, the head of Facilities and Infrastructure proudly reported that Junior High School - 12 won the environmental competition and represented Bali Province for national competition. This achievement of course, makes all teachers and students happy and fully aware that the groundwater conservation program in their schools has brought great benefits and makes the environment clean and healthy, and finally built a sense of awareness and feels responsible for the sustainability.

4. Conclusions
This article highlighted successes of the implementation of the Community-Based Educational Model (CBEM) on Groundwater conservation program both from the technical and the socio-culturally perspectives. The recharge wells which have been built in the properly recharge area with involve substantial stakeholders input were effective in harvesting rainwater and eliminated the puddles surrounding. This method has a broad impact and is protected from people who feel exploited as "research subjects"; instead they feel that they are as a team in planning, implementing and solving the existing problems. The real achievement supported by understanding gained through dissemination, socialization and education made communities are fully aware of the benefits of groundwater conservation programs, especially in improving cleanliness and environmental comfort that finally built a sense of responsibility for sustainability.

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References
[1] Srinivasan V, Lambin E F, Gorelick S M, Thompson B H, and Rozelle S 2012. The nature and causes of the global water crisis: Syndromes from a meta-analysis of coupled human-water studies. Water resources research, Vol. 48, W10516, doi:10.1029/2011WR011087
[2] GoI 2010, Groundwater Scenario of India 2009. Central Ground Water Board, Ministry of Water Resources: http://www.cgwb.gov.in/documents/Ground Water Year Book%2 020 09-10.pdf.
[3] Udmale P, Ichikawa Y, Nakamura T, Shaowei N, Ishidaira H and Kazama F 2016. Rural drinking water issues in India’s drought-prone area: a case of Maharashtra state. Environ. Res. Lett. 11 074013, doi:10.1088/1748-9326/11/7/074013
[4] Wywoll P 2012, ‘India’s groundwater crisis, GWF Discussion Paper 1228, Global Water Forum, Canberra, Australia.
[5] China Water Risk. 2010. China’s Water Crisis Part I. http://chinawaterrisk.org/wp-content/uploads/2011/06/Chinas-Water-Crisis-Part-1.pdf
[6] Prihatin RB 2016. Urban Land Misuse: (A Case Study of Bandung City and Yogyakarta City) Pusat Pengkajian, Pengolahan Data dan Informasi (P3DI) Sekretariat Jenderal DPR RI. Access from https://jurnal.dpr.go.id/index.php/aspiras/article/view/507/403
[7] Iqbal M 2007. Fenomena dan Strategi Kebijakan Pemerintah Daerah Dalam Pengendalian Konversi Lahan Sawah di Provinsi Bali dan Nusa Tenggara Barat. Phenomenon and Strategy of Local Government Policy in Controlling Conversion of Rice Fields in Bali and West Nusa Tenggara Provinces. Pusat Analisis Sosial Ekonomi Dan Kebijakan Pertanian Bogor.

[8] KBR Denpasar 2017. Lahan Sawah di Bali Menyusut Seribu Hektar per Tahun. Rice Fields in Bali Shrinking Thousand Hectares per Year. Access from: http://kbr.id/berita/03-2017/lahan_sawah_di_bali_menyusut_seribu_hektar_per_tahun/9284.html.

[9] Sudiajeng L, Wiraga I W, Parwita I G L, and Santosa G 2017. Domestic Recharge Wells for Rainwater-Harvesting in Denpasar City, Bali-Indonesia. International Journal of GEOMATE, 13 (36), 50-57.

[10] Liu H L, Bao A M, Pan X L; & Chen X 2013. Effect of Land-Use Change and Artificial Recharge on the Groundwater in an Arid Inland River Basin. Water Resour Management, 27:3775–3790. DOI 10.1007/s11269-013-0380-6

[11] Sudiajeng L, Wiraga I W, Parwita, I L; Andayani, W K 2014. Analysis of recharge area as an effort of groundwater conservation in Denpasar City. Proceedings of National Seminar on Vocational Engineering II, Badung, 18 - 19 September 2014.

[12] Sudiajeng, L, Sumetri W, Rumini I, Paramita P (2007). Total ergonomics approach in developing sustainable mangrove forest action in Bali. Proceedings of Agriculture Ergonomics Development Conference.

[13] The University of UTAH 2007. Facilitating Mutually Beneficial Community-Based Research: A Report to University Neighborhood Partners.

[14] Demange E, Henry E, Préau M 2012. From collaborative research to community-based research. A methodological toolkit. ANRS/Coalition PLUS. Coll. Sciences sociales et sida.

[15] Nilsson D, Baxter G J, Butlerb R A, McAlpinea C A. How do community-based conservation programs in developing countries change human behaviour? A realist synthesis (Abstract). Biological Conservation Volume 200 : 70, 93-103