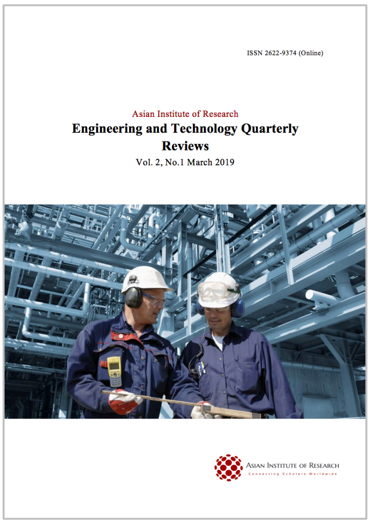

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Analysis of Relationship Between Ground Water Resources and Spatial Planning in Bali, Indonesia

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Abstract
Earth is the only planet in the solar system that has life. Almost 71% of the earth's surface is covered by water and all life on Earth is highly dependent on the presence of water. Conflicts of interest between life and water resources in space occur because of various interests. The purposes of this study is to investigate the potential and utilization of the Bali Ground Water Basin (CAT); and to analyze the strategy and policy directions in spatial planning of Ground Water Basin (CAT) in Bali Province, Indonesia. This research is conducted in Bali Province area, using data collecting technique is observation, literature study, and while data processing technique analyzed by analytic induction and comparative description. The findings of the study are ground water potential in Ground Water Basin (CAT) in Bali Province area is 1,577 Million M3/year (unconfined), 21 Million M3/year (confined) and ground water utilization of 8.4% or 134` M3/year. The strategy and policy direction can be formulated is to synchronize and harmonize between the organization of spatial planning, drilling permits and ground water monitoring.

Key Words: CAT (Ground Water Basin), Spatial Planning, Water Resources, Strategy and Policy Directions

1. Introduction

Water is a very important element for life, Earth is the only planet in the Solar System that has life (Parker, 2007). All life on Earth is highly dependent on water and according to Matthews (2005) nearly 71% of Earth's surface is covered by water in form of liquid, solid (ice), and water vapor/gas. Hydrological cycle is the journey of water from the sea, air, and land, this hydrological cycle is called water spatial plan. On land, water is the source of life.

Population growth will affect the increasing needs of primary and secondary human needs both in the economic, social, and environmental dimensions. This will result in uncontrolled changes in land use, increased utilization or use of water, which will affect the decrease in environmental carrying capacity. Population and industrial growth will affect the land use, which in turn change the land space. Changes that occur in land spatial planning will also affect the hydrological process (water spatial planning)

The final hydrological process is the flow of water back into the sea, it also seeps into the soil and is accommodated in the Basin of Ground water. Bali Province has eight Ground Water Basins, both local and cross-district. The most extensive ground water basin is the Denpasar-Tabanan Ground Water Basin covering nearly seven districts/cities. The research was conducted at the Denpasar-Tabanan Ground Water Basin covering the central part of Bali Province. The objectives to be achieved in this research are: (i) to analyze the potential and utilization of ground water in the central part of Bali Province; (ii) harmonization of water and land spatial planning in the central part of Bali Province.

2. Literature Review

Hydrological Cycle

The journey of water naturally always flows from the higher to the lower places and also flows both on the ground and below the soil surface. In accordance with the location and environmental conditions, water can change its shape. At 0˚C the water changes into ice; at a temperature of 100˚C, the water turns into gas (water vapor) and at a certain temperature, it will return to water. The water movement follows a hydrological cycle (Figure 1).

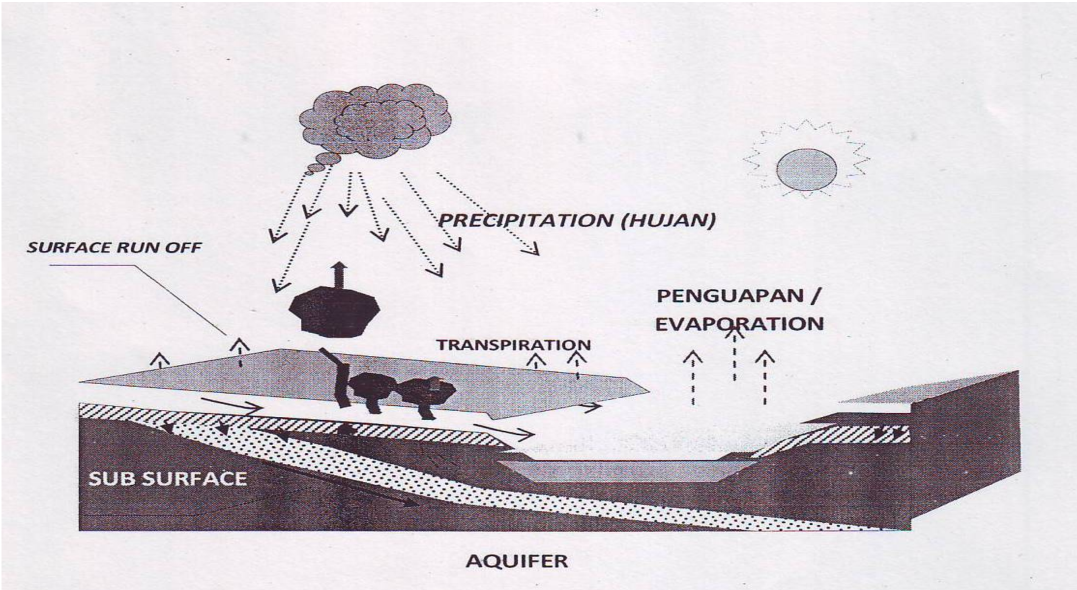

Figure 1. Hydrological Cycle
Source: Zoning Map of Ground Water Use, Bali Province (Public Works Office, 2014).

The Hydrological Cycle can be explained as follows: (1) Evaporation: occurs in areas that contain lots of water such as seas, lakes, rivers, reservoirs, lakes and others. Evaporation occurs because of the effects of sunlight; (2) Evapotranspiration: consists of two types of water flow i.e. evaporation and transpiration. Transpiration is the absorption of water by plant roots that are utilized for the plant's living needs. Because of the influence of sunlight there is evaporation. These two streams of water, which are absorption by plant roots and evaporation refer to evapotranspiration; (3) Rain Water: the water vapor caused by evaporation and evapotraspiration in the air will move. The process of condensing water vapor (cloud) into rainwater is called precipitation. The water vapor moves in the air and due to the difference in air temperature, the water vapor changes to a temperature below the freezing point then the moisture will turn into ice grains. Grains of water and ice grains due to the influence of gravity will fall down as rain. Rainwater is the main source of water either flowing in the soil surface or absorbing to the ground; (4) Rainwater Flow: (a) Run-off: is a flow above the ground level, flows from high to lower and empties into the ocean; (b) River flows: surface water will flow into catchment areas or often called watersheds, which then flow into the river system and last empties into the ocean; (c) Interflow: the water in the vadose zone (Fig. 2.2) then flows into the network system of rivers, reservoirs, lakes, and others; (d) Base Flow: ground water flow that fills the network system of rivers, reservoirs, lakes, etc.; (e) Run-out flow: ground water that flows directly into the ocean; (f) Infiltration: surface water not only flows on the surface but some are absorbed into the soil. Water that seeps into the soil refers to infiltration; (g) Capillaries: water that seeps into the soil and returns to soil moisture; and (h) Percolation: water derived from soil moisture in the vadose zone area that replenishes ground water flow.

Sub-Surface Water Formation

Basically ground water conditions are divided into two (Driscoll, 1987: in Kodoatie and Sjarief, 2010) as shown in Figure 2. Such as: (1) Vadoze Zone (Soil Water, Intermediate Zone Water adn Capillary Water); (2) Phreatic Zone adn (3) The two above zones are described in Fig. 2. In ground water zones, much of the ground water is used for agricultural purposes. Water will disappear in the ground water zone due to transpiration, evaporation and percolation. Capillarity power will fill the spaces between particles to full, then water will flow due to the force of gravity. Zone under ground water zone is middle zone, in this zone water will move down and some have retained. Capillary pipe is located in the zone below the middle zone, where water flows upward due to capillary force. Ground water is the boundary between the ground water zone with the capillary pipe, the ground water level provides a reference or approximation of ground water level.

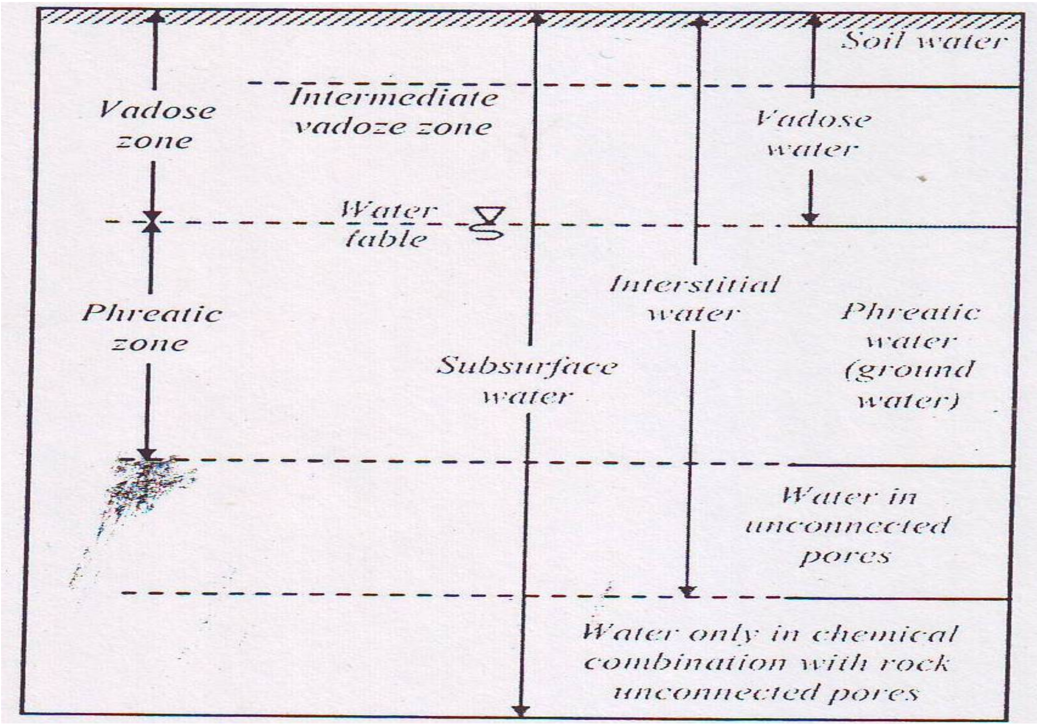

Figure 2. Sub surface water formation
Source: Kodoatie and Sjarief (2010).

Definition of Ground Water

Definition of ground water according to Government Regulation of the Republic of Indonesia Number 43 Year 2008 regarding Ground Water is water contained in a layer of soil or rocks located below the soil surface. Ground water or Phreatic Water which is the area that is restricted at the top is the water table and the lower limit is the initial boundary of water in unconnected pores. Soil Water is the starting area from the ground level to the beginning of the intermediate vadose zone.

3. Research Methods

Observations made to obtain data are empirical studies that are useful for measuring natural phenomena and/or real or grounded experiences. Empirical approach is done to gain knowledge through direct and indirect observation and also focus group discussion, which is then analyzed quantitatively and/or qualitatively. Quantitative analysis can also be transformed into qualitative by describing the existing data.

The study refers to the empirical approach because the research instrument tends to be designed more qualitatively to obtain data and information. This study tends to be "qualitative-verifying" in which the "triangulation-strategy" in obtaining data remains open. One of the qualitative-verifying qualities is the effort to reveal the facts behind the apparent data.

4. Results and Discussion

Potential and Water Utilization at Ground Water Basins of Denpasar-Tabanan

Based on the Government Regulation Number 43 Year 2008, it is stipulated that Ground Water Basins have hydrogeological boundaries that can be controlled by ground water hydraulic conditions. While the hydrological boundary is the physical boundary of the ground water management area that is limited by permeable and impermeable rocks, the limits of ground water separation, the slope of the rock layers, folds, and fractures. In addition, the water basin should also have an auxiliary area and a ground water release area in a ground water formation system. The ground water additive area is a ground water protected area which in principle ground water in the area is not to be utilized. While the release area is the ground water area to be utilized. The water basin must also have an aquifer system with a confined or unconfined impermeable layer underneath it.

The potential of ground water basin is highly dependent on the recharge area, which in the land spatial planning is designated as a strategic area that serves as a conservation. Based on Decree of the President of the Republic of Indonesia Number 26 Year 2011 concerning Stipulation of ground water basins in Bali Province, where in the decision, Bali Province consists of 8 ground water basins. The ground water basins are: (i) across district-ground water basins, which consist of: Denpasar-Tabanan; Singaraja; Negara; Gilimanuk, Tejakula and (ii) the local ones (within one district) consisting of: Amlapura; Nusa Penida; and Nusa Dua.

Ground water Basin in Bali Province covers an area of 4,382.33 km² or 77.75% of Bali Province area. The potential for unconfined ground water is 1,577 million m³/year, while the potential for confined ground water is 21 million m³/year. From the above data, it can be seen that the Province of Bali has 77.75% of the ground water potential (according to Table 1), while the small amount or 22.25% (non-water basin area) does not have the ground water potential.

Ground water basin of Denpasar-Tabanan is located in the central part of Bali Province. It is the largest ground water basin covering 47.46% of all existing ground water basin covering seven districts/cities. Ground water basin of covers Tabanan, Bangli, Karangasem, Klungkung, Gianyar, Badung and Denpasar districts. In the north bordering Abiansemal and Nyelati, Ambengan in the south and Sanur in the southeast, while in the east bordering Paksebali and Gubug in the west. (See Figure 3).

The ground water basin of Denpasar-Tabanan has shallow ground water potential in unconfined aquifers of 894 million m³/year, while the potential for confined aquifer has a potential of 8 million m³/year (Table 1). The height of the topography of this basin is 0-2.000 m above sea level, with rainfall of 1,000-3,500 mm/year. This basin has a flow pattern as a trellis river flow, i.e. flow in the direction of the slope.

Table 1. Potential of ground water at ground water basins in Bali Province

Num.	Ground water basin	Size (Ha)	Precipitation (mm)	Unconfined (million m3/tahun)	Confined (million m3/year)
1	Denpasar-Tabanan	208.000	1000-3500	894	8
2	Gilimanuk	13.130	1000-1500	30	1
3	Negara	41.850	1500-2000	73	4
4	Singaraja	50.520	1000-2500	215	3
5	Tejakula	75.050	500-2000	188	3
6	Amlapura	19.982	1000-2000	60	2
7	Nusa Dua	9.911	1500-2000	38	
8	Nusa Penida	19.790	500-1000	79	
	Total	438.233		1.577	21
	% of Bali area	77,75			

Source: Ministry of Energy and Mineral Resources, 2005

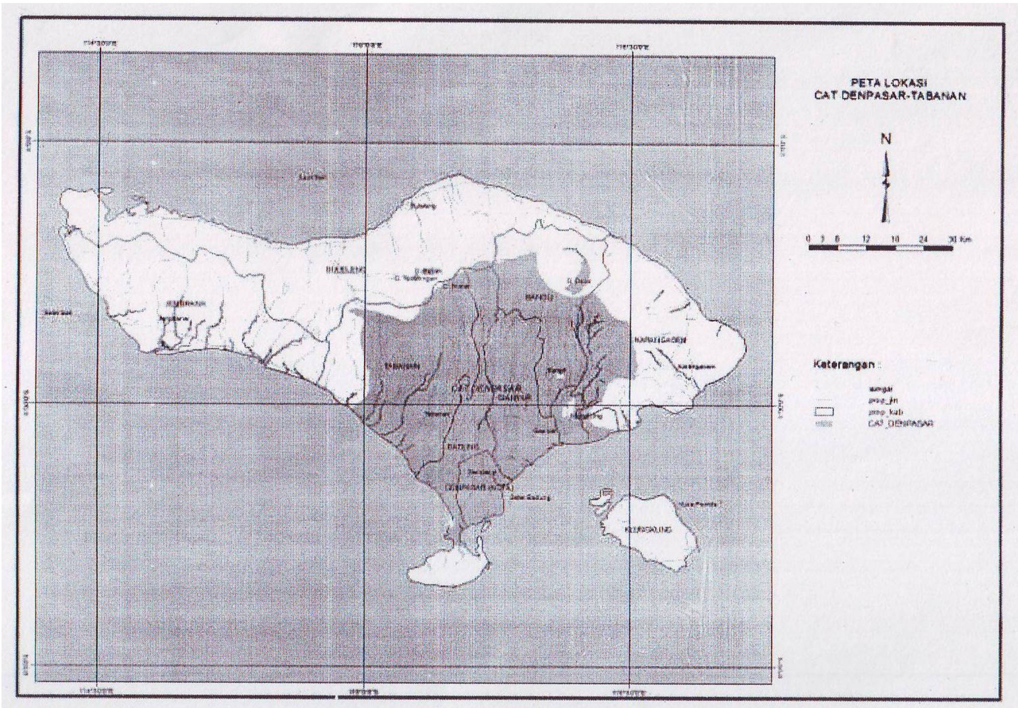

Figure 3. Ground water basins of Denpasar-Tabanan
Source: Map of Ground Water Utilization Zone (2014)

The main lithology of this check is coastal and lake sediments that function as an aquifer with a depth of 60-210 m (local subsurface). The sediment is gravel, sand and gravel with medium soluble, while the rock is volcanic rock group of Lesong-Pohen-Sanghyang, rocks of Mount Batukau, Mount Agung, and volcano group of Buyan-Beratan and Batur.

Emerging springs on Ground water Basin of Denpasar and Tabanan amounted to 425 units with the largest flow of 500 L/sec. and the discharge of 14512.50 L/sec. (See Figure 4 and Table 2). From the analysis, the utilization of ground water taken from 188 drills and 441 deep wells for both household and industrial needs. Total ground water usage is 134 million m^3/year (8.40% of ground water basin of Bali Province) or 15% of ground water basin of Denpasar-Tabanan.

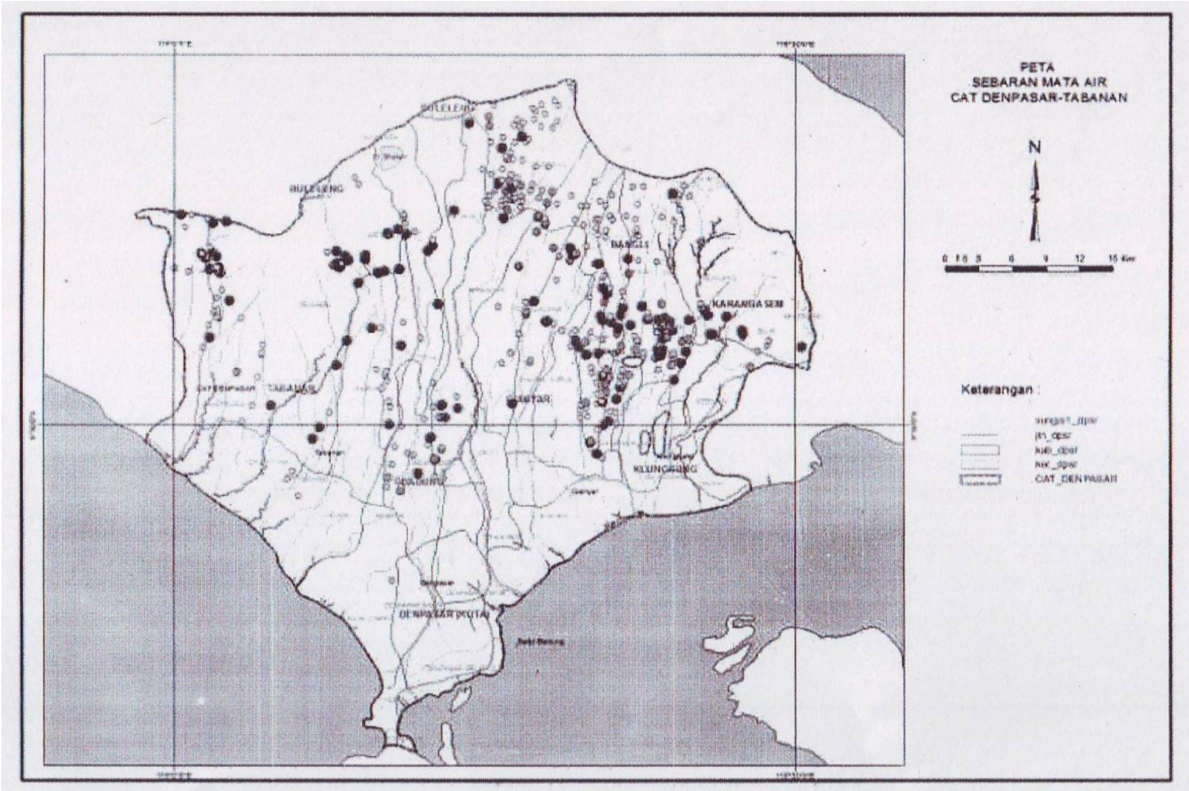

Figure 4. Ground water usage of ground water basins of Denpasar-Tabanan
Source: Map of Ground Water Utilization Zone (2014)

Table 2. Average Potency of Spring on Ground water Basin of Denpasar-Tabanan

Num.	Debit (L/sec)	Average Debit (L/sec)	Number of spring	Total (L/sec)
1	5,0	5,00	253	1.265,00
2	5,0-10,0	7,50	59	442,50
3	10,0-25,0	17,50	56	980,00
4	25,0-50,0	37,50	26	975,00
5	50,0-100,0	75,00	19	1.425,00
6	100,0-250,0	175,00	6	7.050,00
7	250,0-500,0	375,00	5	1.875,00
8	500,0	500,00	1	500,00
		Total	425	14.512,50

Source: Analysis (2015)

Harmonization of Spatial Planning

Each law uses different terminologies with different meanings too. To find the relevance of the differences in those terminologies, it will be compared between Law Number 7 of 2004 on Water Resources (PSDA) and Law Number 26 of 2007 on Spatial Planning, as per Table 3.

Table 3. Relevance of Law Number 7 of 2004 with Law Number 26 of 2007

No.	Law Number 7 of 2004	Law Number 26 of 2007
1	Conservation of water resources	Protected areas
2	Water resources management pattern of the river basin	Regional Spatial Plan (National, Province, and District/City)
3	Technical boundaries are Watersheds, Ground water Basins, River Basins	Administrative boundaries (National, Province, and District/City)

From Table 3 it can be concluded that Law Number 7 of 2004 emphasizes the river area which is the responsibility of the local river area (vertical institution), while Law Number 26 of 2007 emphasizes the administrative area which is the responsibility of the regional head. In the Spatial Planning as stipulated in Bali Provincial Regulation Number 16 of 2009 covers protected areas and cultivation areas. Protected areas include areas that protect their subordinate areas (protected forest areas and water catchment areas). The catchment area covers all forest areas and upstream watershed areas in Bali Province.

The determination of the Ground water Basin in Bali Province is based on Presidential Decree Number 26 of 2011 with the recent discharge compared to Regional Regulation No. 16 of 2009. Therefore, the regulation of the Regional Regulation has not regulated in detail about the Ground water Basin. For that we need further detailed arrangement of Ground water Basin.

5. Conclusions and Recommendation

Based on the research results, it can be concluded:

1. Ground water basin of Denpasar-Tabanan is located in the central part of Bali Province and it is an inter-district ground water basin. It is the largest ground water basin covering seven districts/cities : Tabanan, Bangli, Karangasem, Klungkung, Gianyar, Badung and City of Denpasar. In the north bordering Abiansemal and Nyelati, Ambengan in the south and Sanur in the southeast, while in the east bordering Paksebali and Gubug in the west.
2. The ground water basin of Denpasar-Tabanan has shallow ground water potential in unconfined aquifers of 894 million m^3/year, while the potential for confined aquifer has a potential of 8 million m^3/year (Table 1). The height of the topography of this basin is 0-2.000 m above sea level, with rainfall of 1,000-3,500 mm/year. This basin has a flow pattern as a trellis river flow, i.e. flow in the direction of the slope;
3. Dependence on the ground water usage mainly for both household and industrial or commercial needs. The total ground water usage is 134 million m^3/year (8.40% of ground water basin of Bali Province) or 15% of ground water basin of Denpasar-Tabanan. The ground water usage is taken from 188 drills and 441 deep wells.
4. It needs harmonization between Law Number 7 of 2011 on Water Resources and Law Number 26 of 2007 on Spatial Planning along with all its derivatives that concerns about Ground water Basins in Bali Province

Some recommendation and suggestion can be formulated as below:

1. Although the use of ground water in terms of percentage is still small in number (conclusion 3), ground water levels have decreased due to drilling density and different ground water productivity levels. It is therefore necessary to draw attention to areas prone to decreasing ground water levels and periodically control the decrease of ground water levels;
2. There should be restrictions on drilling permits, especially areas where drilling density is high enough, especially that may affect the decrease of ground water level.

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