

Impact of Rapid Tourism Growth on Water Scarcity in Bali, Indonesia

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Abstract

Despite Bali's dependency on tourism, concerns over the impact of tourism on water scarcity are increasing. The objective of this study is to analyze the clean water demand related to tourism growth and compare them with the available clean water supply. This study suggested that tourism water demand has increased by 20.8 million m³ (295%) from 1988 to 2013. Sixty-eight percent of the increase was concentrated in Badung Regency, where the tourism water demand ratio has increased from 31% to 46%. The study also suggested that rapid population growth has caused an increase in domestic water demand by 48.3 million m³ (48%). This study also shows that the capacity of clean water supply in Bali has increased significantly to meet these demands and the water supply coverage of domestic water demand has increased significantly from 13% in 1988 to 53% in 2013. The water supply coverage of tourism demand varies from year to year with an average of 28% in the study period. The increasing issues over water scarcity despite the improvement in the coverage of domestic water demand suggest further investigations. Yet, despite the large gap between supply and demand in the tourism sector the industry still can have undisrupted clean water throughout the year. This indicates the use of alternative clean water which can be obtained locally such as groundwater. Wise water management through the sharing of scientific data, including in the tourism sector is imperative in solving water scarcity in Bali.

Keywords: Badung Regency, clean water demand, water scarcity

INTRODUCTION

Rapid development and growth have predominantly positive impacts on people's lives. However, these also challenge society to better manage its resources in order to fulfill the needs of current and future generations. Freshwater is essential to sustaining life and ecosystems, and to many production activities, such as agriculture, tourism, and industry. The ability to manage freshwater resources in balance with development is necessary for sustainable growth (Grey & Sadoff, 2007).

According to a report by the World Travel and Tourism Council (2016a), tourism is a rapidly growing sector, and has outpaced growth in the wider global economy since 2009. The Southeast Asia region, in particular, has experienced the strongest growth in tourism, reaching 7.9% per year in 2015. In poorer countries, tourism is seen as an opportunity for economic development opportunity because it is a labor-intensive industry that does not require many specialized skills (Gössling *et al.*, 2015).

Tourism is well known for its over-use of freshwater, as well as being highly dependent on freshwater resources. In order to maintain their contributions to local economies, tourism industries need water for accommodation, gardens, swimming pools, spas, golf courses, snowmaking, and so on. However, tourism is often overlooked as a salient sector in global discussions, because water use in agriculture dwarfs that of tourism (Gössling *et al.*, 2012).

Bali is an island in a developing country (Indonesia) with high tourism growth. Therefore,

by focusing on Bali as an example, this study examines how a rapid increase in tourism demand and limitations in terms of the water infrastructure, policies, and management lead to water scarcity for the local population and environmental degradation.

Study Area

Located south of the equator, Bali Province is part of Indonesia and consists of two islands, Bali Island and Nusa Penida Island, with a total area of 5,634 km² (Figure 1).

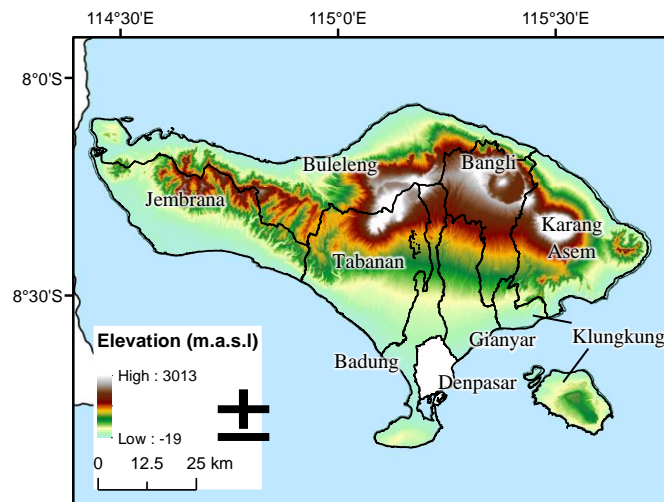


Figure 1. Map of Bali with its regencies and city

Administratively, the province consists of eight regencies (Jembrana, Buleleng, Tabanan, Badung, Gianyar, Klungkung, Bangli, and Karangasem) and one city (Denpasar). With the implementation of the decentralization laws in 2001, the regencies/cities became autonomous, and now play an important role in the quality of public services, such as providing a clean water supply.

The Balinese were traditionally an agrarian society, with their economy supported mainly by agriculture (43.5% in 1987) (BPS Provinsi Bali (Statistics of Bali Province), 1994). However, the tourism industry rapidly took over the economy, contributing 30.6% of the regional gross domestic product (RGDP) in 1994 (BPS Provinsi Bali (Statistics of Bali Province), 1994). Owing to the popularity of its tourism industry, Bali's RGDP increased almost tenfold in 16 years (1997–2013) (BPS Provinsi Bali (Statistics of Bali Province), 2000, 2014). Such rapid growth in the economy involved massive development of tourism

facilities, including accommodation, restaurants, spas, golf courses, and other tourist attractions, concentrated mainly in the south part of Bali Island. The period between 1983 and 2013 included the development of an additional 42,041 hotel rooms and an increase of 1.2 million tourist visits per year (BPS Provinsi Bali (Statistics of Bali Province), 1983, 2014). The industry has provided 481,000 direct jobs, making up 25% of the workforce in Bali (BPS Provinsi Bali (Statistics of Bali Province), 2009).

Water resources, infrastructure, and policy

With varied rainfall, from below 1,500 mm along the coastal zone to more than 3,000 mm in the mountainous areas, the total freshwater resources potential in Bali Province amounts to 6,587 million m³/year, of which 94% is surface water and 6% is groundwater. The freshwater is unevenly distributed across the island. The Buleleng and Tabanan Regencies contain 43% of these resources, while Denpasar City and the

Klungkung Regency (including Nusa Penida Island) have only 6% of the total water resources (JICA, Yachiyo Engineering Co. Ltd., & Nippon Koei Co. Ltd., 2006).

Traditionally, most Balinese would take clean water from shallow wells or springs and go to the river to bathe and wash their clothes. Today, only some people in the villages still use the river for bathing or washing. However, they are still highly dependent on shallow wells for clean water as an alternative water supply to the piped water (Cole, 2012). Clean water is supplied by nine PDAM (the regional drinking water company), which are owned and operated exclusively by the rency/city government (JICA *et al.*, 2006).

Water scarcity

Although the tourism industry has made a significant contribution to the betterment of livelihoods in Bali, increasing numbers of reports are blaming the industry for the water crisis and conflicts among water users in Bali (Cole, 2012; Mulyadi, 2011; Suriyani, 2015; Tarigan *et al.*, 2014; Trisnawati, 2012; Widiadana, 2012; Widyaswara, 2015). Local populations living in the vicinity of tourist areas have complained about difficulties in accessing clean water on a daily basis. The piped water, as the main clean water source of the community does not flow during certain hours of the day, or does not have sufficient pressure (PDAM Badung, 2014; PDAM Tirta Mangutama Kabupaten Badung, 2017). The alternative clean water source, mostly shallow wells, have become dry or, in some cases, salty (Cole, 2012; Muhajir, 2015; Widyaswara, 2015). The uncontrolled and rapid growth of tourism is blamed as the main cause of the water crisis in Bali.

Concerns over the future water crisis in Bali were addressed as a negative impact of the rapid growth in tourism. The media portrayal of the water crisis in Bali may influence the popularity of Bali as a tourism destination, which will limit future economic growth. It is therefore important to clarify the increase in clean water demand in Bali and to address the issues strategically.

This study quantifies clean water demand and compares it with the water supply for the local population surrounding the tourism industries. It aims to better understand the problems underpinning the water scarcity in Bali. In order to

achieve this objective, we perform the following steps:

- (1) Calculate the tourism water demand (inter-annual, spatial, and seasonal)
- (2) Calculate the domestic water demand (inter-annual and spatial)
- (3) Compare the water supply and demand before and after the rapid growth in tourism.

This study reviews the overall water resources condition in Bali, the significance of rapid tourism development and its demand, both in spatial-temporal perspectives, in causing water scarcity among the local population, and what solutions should be taken to address this issue strategically.

METHODS

In order to understand the impact of the rapid growth in tourism on the water scarcity in Bali, we first compare the water supply and demand in the past (before the development of tourism) with the situation as it is now (after the development of tourism). Before collecting data, we determined when tourism began to develop so rapidly by examining the increase in tourist visits using secondary data from 'Bali Dalam Angka' (Bali in Figures) periodicals, published by the Badan Pusat Statistik (BPS) Provinsi Bali (Statistics of Bali Province). Periodicals collected are from the year 1979 to 2016, the years of 1981, 1984, 1991, and 1992 missing.

After defining the period of rapid growth in tourism, secondary data were used from official publications to calculate the water supply and demand. Most of these publications are provided by the BPS Provinsi Bali. Some of the secondary data are not available on a monthly basis or at the rency/city level. In this section, we also explain methods and assumptions used to fill in the gaps.

Calculation of tourism water demand

The calculation of tourism water demand uses:

- (1) the number of rooms available, based on accommodation classification,
- (2) room occupancy rates, based on accommodation classification.

These data were obtained through surveys conducted by Badan Pusat Statistik Indonesia (Statistics Indonesia) using the VHT-S

questionnaire (monthly basis) and the VHT-L questionnaire (annual basis) (BPS Provinsi Bali, 2017).

Tourism water demand is calculated based on hotel/accommodation classifications because the consumption of water increases with the size of the hotel/accommodation (Gössling, 2001; JICA et al., 2006; Wiranatha, 2001). Furthermore, to understand the distribution of water demand according to spatial and temporal bases, we calculate the monthly tourism water demand for each regency. The demand for water is based on the number of occupied rooms in tourists' accommodations were calculated using the following equation.

$$TWD(m, c, r) = OR(m, c) \times NHR(m, c, r) \times RWD(c) \quad (1)$$

where *TWD* denotes tourism water demand, *OR* is the occupancy rate, *NHR* is the number of hotel rooms, *RWD* is the water demand per room, *m* denotes the month, *c* is the classification, and *r* is the regency.

The result is the amount of water used by tourist accommodations from January 1988 to December 2013. Note that the monthly *OR* data sets are only available at the provincial level and not for each regency. Thus, we assume that the occupancy rate at a particular month for all regencies is the same. Then, *RWD* is a constant representing the amount of water required for each occupied room, based on their accommodation classification. As described earlier, these constants were obtained based on previously published research on Bali. We compared research carried out by Wiranatha (2001) and JICA et al. (2006) to define the *RWD*. Although the constants provided in both studies were quite similar, we ultimately selected the constants based on Wiranatha (2001) because the constants are available for 3 categories (Non-classified (NC) accommodations, 1-3 stars hotels, and 4-5 stars hotels) while JICA et al. (2006) provided constants only for 2 categories (Non-classified and classified accommodations). The constants based on Wiranatha (2001) are as follows:

- (1) 4–5-star hotel = 1,424 m³/room/year
- (2) 1–3-star hotel = 949 m³/room/year
- (3) Non-classified hotel = 548 m³/room/year.

The calculation results are 2,808 figures (312 months in 9 regency/cities) thus calculated forms the base calculation for the inter-annual, spatial, and seasonal tourism water demand.

We calculated the monthly and yearly/inter-annual *TWD* at regency/city level (spatial water demand) and at the provincial level (inter-annual water demand). The monthly *TWD* is used to calculate the seasonal water demand described below.

Calculation of seasonal water demand

The seasonal water demand is calculated to see whether there is a significant difference in touristic water demand between high touristic and low touristic seasons at both provincial and regency/city levels. We also wish to understand whether the magnitude of difference has changed over time, i.e. in the early years of tourism development and in the recent years. For this purpose, we calculate the average monthly tourism water demand for the first ten years (1988-1997) and in the last ten years (2004-2013) for each month (January to December). Therefore, we know the average value of tourism water of every regency/city for twelve months in a year for two periods of tourism development. To calculate the seasonal tourism water demand for the whole Bali Province, we add up the value of all regencies.

Calculation of domestic water demand

Although the focus of this study is the impact of rapid tourism growth on the water situation in Bali, in order to understand its significance and its share in domestic water supply, we also calculate water demand required by the local population (domestic water demand).

The Bali Province Statistical Agency provides three types of population data sets: the population census (conducted by the central government every 10 years), the intercensal population survey (conducted by the central government every five years), and civil registration (obtained from administrative records of village authorities for each year). However, there are some discrepancies between the data sets of the central government and those obtained from the civil registration at the village level. This study views the data sets provided by the central government (i.e. the population census and intercensal population survey) as reliable. However, they are available

only in five-year increments, while we require yearly data. Thus, to estimate the yearly population we interpolated the five-year records into yearly records using trends identified from the civil registration data sets.

We calculate the annual domestic water demand per regency from 1988 to 2013 using the following equation:

$$DWD(y,r) = P(y,r) \times WDC \quad (2)$$

where *DWD* is domestic water demand, *P* is the population, *WDC* is water demand per capita, *y* is year, and *r* is regency. These primary data were obtained through surveys conducted by Badan Pusat Statistik using the VHT-S questionnaire (monthly) and the VHT-L questionnaire (annually) (BPS Provinsi Bali, 2017).

The value of *DWD* is calculated on a yearly basis (*y*) per regency (*r*) in Bali Province.

Water demand per capita is a constant, used to define the amount of water required per person. The calculation uses values provided by Standar Nasional Indonesia (Indonesian National Standard) for domestic water use, which is 100 liters per capita per day (for areas with fewer than 1 million people) (BSN, 2002).

Similar to *TWD*, we also calculated the inter-annual water demand for regency/city level and for provincial level. However, since we do not consider the change in water use per capita due to seasonal changes, we do not calculate the seasonal water demand for *DWD*. Clean water supply data sets

As mentioned in the study context, clean water in Bali is supplied by the Regional Water Supply Company (PDAM). Each sub-provincial level (regencies or city) established its own water supply company and built the infrastructure. The capacity of water supply infrastructures was based on the varying demand and financial strength of each regency or city.

Datasets used in this study is the amount of water which were supplied to the customers by water supply companies. These datasets were obtained from Bali dalam Angka periodicals. These customers are categorized as trade company, households, tourist object and hotel (from year 2011, this category was renamed as “industry”),

social/public, government institutions, and others. The clean water supply datasets for Bali Province for each category are available from 1988 to 2013, while at regency/city level are only available for the year 1988, 2011, 2012, and 2013.

The total water supply in this study refers to the amount of water supplied to all categories of customers. The tourism water supply refers to the amount of water supplied to “tourism object and hotel” category and domestic water supply refers to the amount of water supplied to “households” category.

This study compares calculated demand explained above i.e. inter-annual tourism/domestic water demand and spatial tourism/domestic water demand. The comparison was carried out at the provincial level and regency/city level for year 1988 to 2013. In addition, the study compares the total domestic-tourism water demand with total water supply, domestic water demand with domestic water supply and tourism water demand with tourism water supply.

RESULTS

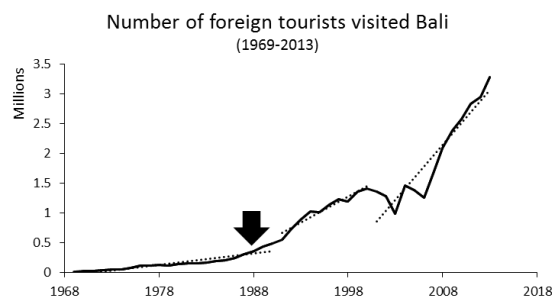


Figure 2. A rapid increase in tourism development (BPS Provinsi Bali (Statistics of Bali Province), 1979-2016).

Figure 2 shows the number of foreign tourist visits to Bali. Based on Figure 2, we determined that the rapid development of tourism in Bali began in 1988. Therefore, this year is the base year we use to compare the current situation to that before the rapid growth of tourism.

Inter-annual water supply and demand in Bali

The inter-annual tourism and domestic water demand are showed in Figure 3. It shows that tourism water demand increased from 7.0 million

m³ in 1988 to 27.8 million m³ in 2013 (295% increase), with an annual average increase of 0.8 million m³ (8.1% average increase every year). On the other hand, domestic water demand increased from 99.7 million m³ in 1988 to 148.0 million m³ in 2013 (48% increase), with an annual average increase of 2.1 million m³ (1.8% average increase every year). Thus, the demands of these two sectors increased from 106.7 million m³ to 175.8 million m³, at an average of 3 million m³ per year. Of the increase of 69.1 million m³ of water demand in 26 years, 30% resulted from tourism and 70% resulted from domestic water use.

Figure 3 also shows that at the provincial level, the domestic water demand is much larger than the tourism water demand, even after the rapid growth of tourism. This fact suggests that in general, the larger portion of the increase in water demand in Bali Province is still dominated by population growth. Nevertheless, the tourism share in the demand has increased from 6.59% in 1988 to 15.80% in 2013.

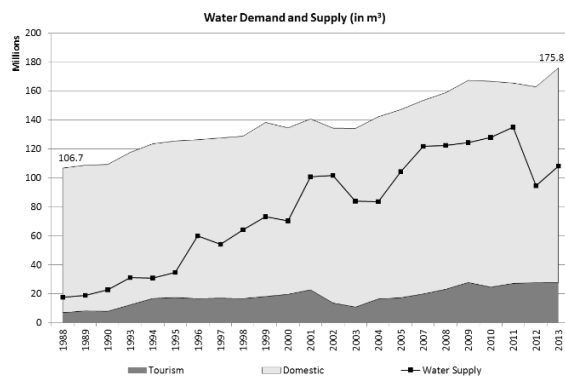


Figure 3. Water supply and demand in Bali

Figure 3 also shows the total clean water supply (including for other sectors) at the provincial level. The amount of clean water supply has increased significantly from 17.6 million m³ in 1988 to 102.2 million m³ in 2013 (a 480% increase).

Furthermore, we separate water supply and demand by sectors, i.e. domestic and tourism demand, and compare them as shown in Figure 4. The demand for tourism shows a sharp increase

This comparison shows that at the provincial level more Balinese have access to clean water supply after the rapid tourism development, despite of the high increase in tourism water demand. The rapid growth of tourism may not

from 1990 to 2001 and decreased by 40% in 2002 due to Bali Bombing in October 2002. The demand further decreased in 2003 by 52%. On the other hand, the domestic water demand increased constantly from 1988 to 2013.

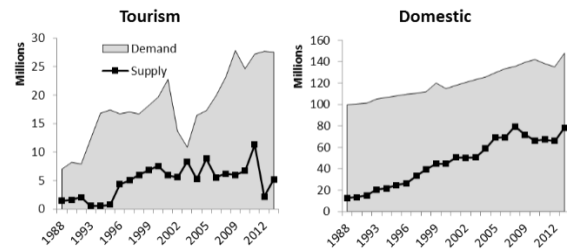


Figure 4. Water supply and demand for tourism and domestic in Bali (in m³)

The water supply for tourism varied throughout the years from 0.58 million m³ (in 1993) to 11.33 million m³ (in 2011) with the average supply of 4.96 million m³. The coverage for tourism water demand ranges from 3% (in 1994) to 77% (in 2003) with average coverage of 28%. The high coverage value in 2003 was due to low demand after 2002 Bali Bombing. Domestic water supply has increased constantly from 12.62 million m³ in 1988 to 78.32 million m³ in 2013 with average supply of 46.68 million m³. The coverage of domestic water demand increased from 13% in 1988 to 53% in 2013.

The comparison of supply and demand at the provincial level explains that, overall, the water supply condition is better after the rapid tourism growth for both sectors. The tourism share in the tourism-domestic water supply has decreased from 10% in 1988 to 6% in 2013. This fact is contradicting to tourism water demand share in tourism-domestic water demand (Figure 3). Even though the share in tourism water demand has increased, nevertheless, its share in tourism water supply has decreased. The average domestic water share in tourism-domestic water supply is about 90% and about 60% in the total water supply. The share in tourism-domestic water supply has slightly increased from 90% in 1988 to 94% in 2013.

affect water supply and demand at the provincial level since tourism developments are concentrated only in some areas in Bali. On the contrary, this study shows that at the provincial level tourism

development may give a positive impact on the development of infrastructures.

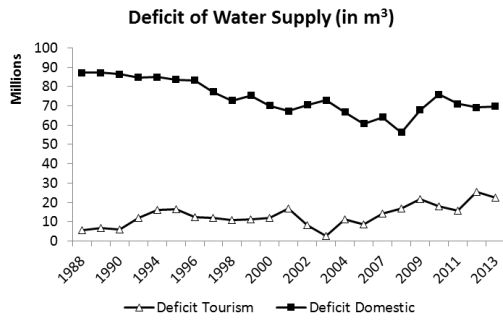


Figure 5. Deficit of water supply for tourism and domestic demands

The deficit of water supply in Figure 5 is obtained by subtracting water demand and water supply for the respective sectors, i.e. tourism and domestic which are shown in Figure 4. From Figure 5, we can see that in 1988, there was a deficit of 87. 1 million m³ in the domestic water supply, and in 2013, the deficit was reduced to 69.7 million m³. In the case of tourism water supply, the deficit increased from 5.6 million m³ in 1988 to 22.3 million m³ in 2013.

The fact that the deficit of domestic water supply decreasing and there are increasing

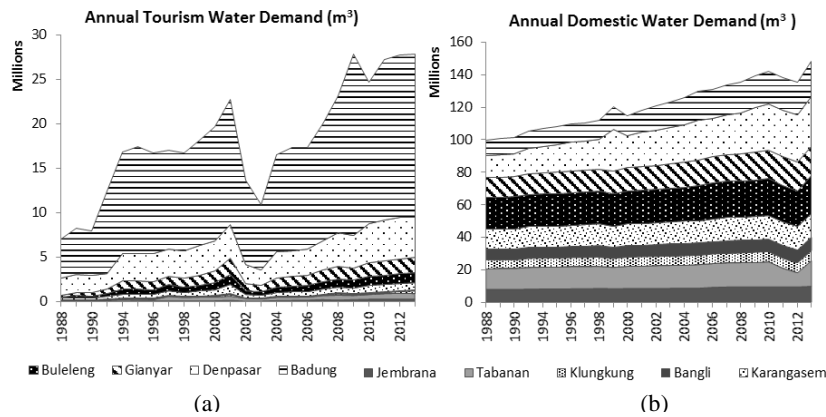


Figure 6. Trends of annual spatial water demand by regency in tourism and domestic sectors

Figure 6b shows the distribution of domestic water demand in Bali. In 1988, the regency with the highest domestic water demand is Buleleng (19% of Bali’s domestic water demand), followed by Denpasar City (13%) and Karangasem (13%). In 2013, the highest domestic water demand is in Denpasar City (21%) followed by Buleleng (16%) and Badung (15%) Regencies. The percentage of regencies’ domestic water demands are decreasing, except

concerns on water scarcity among the local population suggests further investigation. On the other hand, the increasing deficit in tourism water supply while there are no concerns on water scarcity among the tourism industries suggests further investigation on other water sources which are being used by tourism industries such as groundwater.

Spatial water demands and supply in Bali

Figure 6 shows the spatial distribution of water demand in Bali. In Figure 6a, we can see that most of the tourism water demand is concentrated in Badung Regency. Tourism water demand in Badung Regency, represents 62% of Bali’s tourism water demand in 1988 and it increased to 66% in 2013. Tourism water demand in Denpasar City, the capital of Bali Province, represents 28% of Bali’s tourism water demand in 1988 and it decreased to 18% in 2013. Tourism water demand in other regencies represents 9% of Bali’s tourism water demand in 1988, which almost doubled to 16% in 2013. The percentage of regencies’ tourism water demand are increasing since 1988, except for Denpasar City and Bangli Regency.

for Badung Regency and Denpasar City. They increased by 5% and 8% increase respectively.

The share of tourism water demand in tourism-domestic water demand increased from 0.33% (in Tabanan Regency) - 30.89% (in Badung Regency) in 1988 to 0.98% (in Bangli Regency) - 45.93% (in Badung Regency). Regencies with a high share of tourism water demand (>5%) increased from 2 regency/city

(Badung and Denpasar) to 4 regencies/city (Gianyar, Badung, Denpasar and Karangasem).

The estimation of spatial water demand suggests the following findings. The tourism water demand remains concentrated in Badung Regency, since the infancy of tourism development. The tourism water demand in Badung Regency is still increasing up to 2013. The increasing percentage (almost doubled) of tourism water demand outside Badung Regency and Denpasar City, suggests that the tourism area is started to grow equally in other regencies. The decreasing percentage of domestic water demand outside Badung Regency and Denpasar City suggests agglomeration of people near tourism concentrated area or capital city (urbanization) which may create increasing demand in these areas in the future.

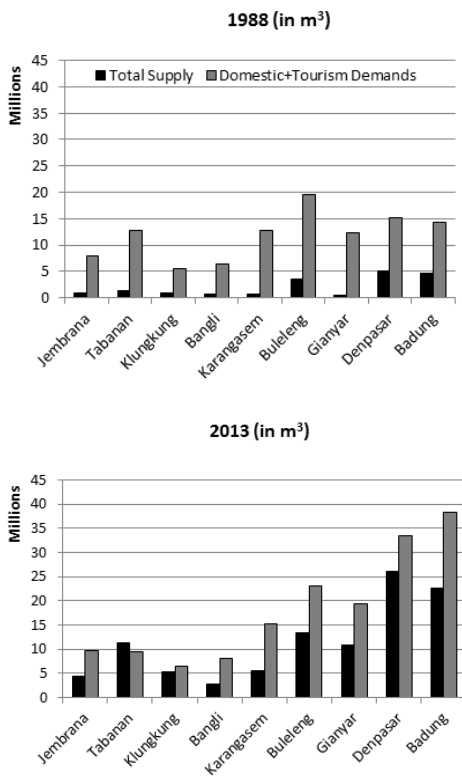


Figure 7. Comparison of water supply and demand by regency

Figure 7 compares the total water supply (including for other purposes) and tourism and domestic water demands by regency. In 1988, water supply coverage ranges from 3% (in Gianyar Regency) to 33% (in Denpasar Regency) and in 2013, water supply coverage was ranged from 33% (in Bangli Regency) to 100% (in

Tabanan Regency). In all regencies, water supply coverage improved by more than 20%.

Figure 8 compares the deficit in water supply before and after tourism development in domestic and tourism sectors. The figure shows that the deficit in tourism water supply is higher in 2013 compared to 1988. The deficit in tourism water supply ranges from 0.03 million m³ (in Klungkung Regency) to 3.39 million m³ (in Badung Regency) in 1988. The condition worsened in 2013 where the deficit ranges from 0.06 million m³ (in Bangli Regency) to 14.34 million m³ (in Badung Regency). The deficit in tourism water supply in Badung Regency increased more than 4 times since 1988.

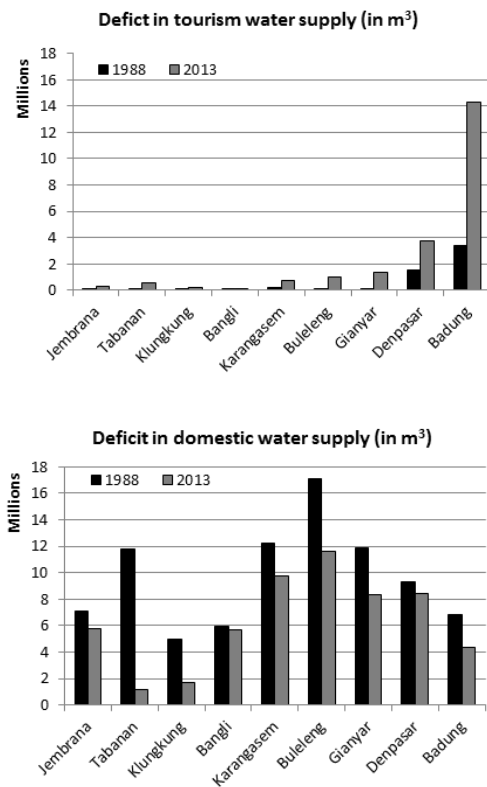


Figure 8. Comparison of deficit in water supply before and after tourism development

Figure 8 also shows that the deficit in domestic water supply was reduced in 2013 compare to 1988. The deficit ranges from 4.94 million m³ (in Klungkung Regency) to 17.11 million m³ (in Buleleng Regency) in 1988. The condition was improved in 2013 where the deficit ranges from 1.20 million m³ (in Tabanan Regency) to 11.63 million m³ (in Buleleng Regency).

Finally, tourism water supply share in the tourism-domestic water supply is much lower than tourism water demand share in tourism-domestic water demand. In 1988, the share ranges from 0% (in Tabanan and Klungkung regencies) to 21.48% (in Badung Regency. In 2013, the share reduced to a range between 0% (in Bangli Regency) and 17.39% (in Badung Regency).

The comparison between supply and demand at regency/city level suggests that deficit in tourism-domestic water supply decreased in most of the regencies, except for Denpasar City and Badung Regency where the deficit increased by 1.4 million m³ (13%) and 8.5 million m³ (83%) respectively. The deficit in tourism water supply are increased in all regencies and the deficit in domestic water supply are decreased in all regencies. Similar to the conclusion in previous sub-chapter, the high deficit in tourism water supply in Badung Regency suggests that the tourism industries depend mainly to other water supply such as from the groundwater.

Moreover, even though the deficit in domestic water supply has decreased significantly, there are still about 1.56 million people not connected to water supply in Bali in 2013. In Badung Regency, there are about 120 thousand people who have to find alternative water source. With the urbanization and environmental change, an alternative water source such as clean water from the river or shallow groundwater is more difficult to find, particularly in Badung Regency. Therefore, concerns about water scarcity may be increasing.

Water demands and supply in Badung Regency

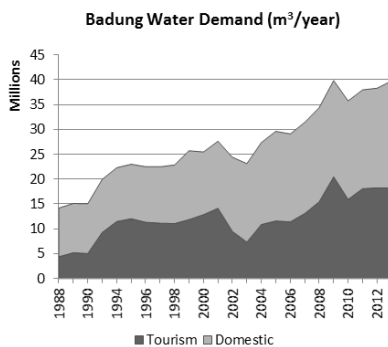


Figure 9. Comparison between Tourism and Domestic Water Demand in the Badung Regency

Figure 9 shows the tourism and domestic water demands in the Badung Regency. Here, tourism water demand increased from 4.4 million m³ in 1988 to 18.3 million m³ in 2013 (317%). In 1988, 62% of tourism water demand in Bali was concentrated in the regency and this value increased in 2013 to 66%. Tourism water demand in the regency is still increasing even though the annual growth rate between 2004 and 2013 is less than between 1988 and 1997. The domestic water demand in the regency increased from 9.80 million m³ in 1988 to 21.50 million m³ in 2013, accounting for about 15% of the total domestic water demand in Bali. Thus, the share of tourism water demand in tourism-domestic water demand in Badung Regency has increased from 31% in 1988 to 46% in 2013. In other regencies, the ratios in 2013 are less than 13%. Moreover, in Badung Regency, the increase in tourism water demand accounted for a larger portion (54%) of tourism-domestic water demand increase.

Figure 10 shows the water supply in Badung Regency for tourism and domestic sectors. Tourism water supply in Badung Regency increased from 0.99 million m³ in 1988 to 3.92 million m³ in 2013. The tourism water supply coverage is slightly decreased from 22.59% in 1988 to 21.45% in 2013. On the other hand, the domestic water supply in Badung Regency increased from 9.80 million m³ in 1988 to 21.50 million m³ in 2013. Thus, the domestic water supply coverage increased from 29.98% in 1988 to 72.89% in 2013.

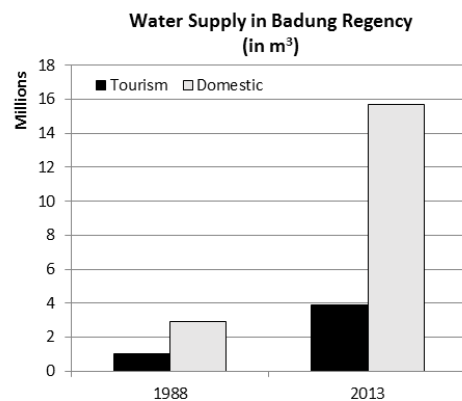


Figure 10. Water Supply in Badung Regency

The calculation of water demand in Badung Regency confirms that rapid tourism growth is concentrated in this regency, where the increase in tourism water demand takes a larger portion (54%) of the tourism-domestic water demand increase. With such an increase, in 2013, the tourists consume almost the same amount of water as the local population living in the regency.

The study also suggests particular attention should be placed in monitoring and demand management for the use of water by hotels in the area since most of these hotels are not using water supplied by PDAM. The difference between tourism water supply and demand is being taken from other sources and probably obtained locally.

Domestic water demand, on the other hand, shows better condition compare to before tourism development. However, the deficit in water supply indicates there are some people who do not have access to clean water supply in Badung Regency. Thus, concern on water scarcity may happen due to unavailability or degradation of alternative water source such as dry and saline shallow wells.

Seasonal tourism water demand in Bali

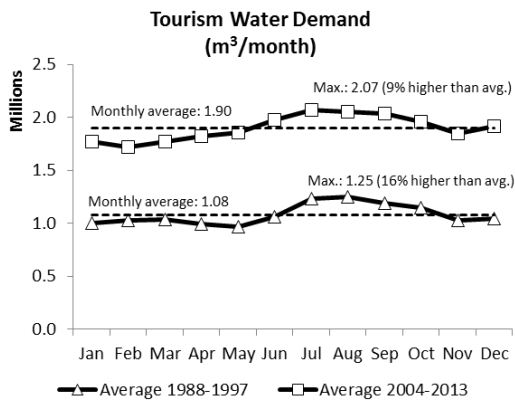


Figure 11. Seasonal variation in tourism water demand in Bali

We also calculate the seasonal demand variation, focusing particularly on the high touristic season for whole Bali and for Badung Regency as tourism dense area. Here, we compare the seasonal variation of the average monthly water demand in the first 10 years of rapid development (1988–1997) to the most recent 10 years (2004–2013). Figure 11 shows that the seasonal variation is higher now than it

was when tourism was in its infancy. During high season the tourism water demand is higher by 16% during 1988-1997 and by 9% during 2004-2014. Figure 11 also shows that the high season period (the month when water demand is higher than average) is longer in 2004-2013. In 1988-1997, the high season period is between July and October while in 2004-2013 the high season period is not only between June and October but also includes December.

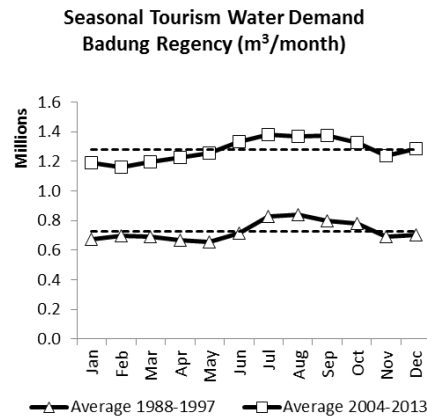


Figure 12. Seasonal tourism water demand in Badung Regency

In the Badung Regency, water demand is higher by 15.5% during high season for the period of 1988-1997 and by 7.58% for the period 2004-2013. Similar to the seasonal pattern at the provincial level, the high season period in Badung Regency is longer during 2004-2013 (June to October and December) compares to during 1988-1997 (July to October) with 9% higher-than-average tourism water demand.

DISCUSSION

Bali’s economy increased rapidly, owing to its beautiful nature and rich culture. The development of tourism has significantly improved the livelihood in Bali, thus its sustainability in supporting the economy should be managed wisely. Tourism uses a substantial amount of water in Bali (Gössling et al., 2012) and there are increasing concerns blaming the industry to cause water scarcity among the local population. The media portrayal on the water crisis may damage the image of Bali as a tourism destination. Thus, clarifying the impact of rapid tourism growth in Bali on water scarcity among the local population is essential.

Unlike Malta and Barbados, which have less than 80 million m³/year of renewable water resources (WTO (World Tourism Organization), 2001), Bali is blessed with 6,587 million m³/year freshwater resources potential (JICA *et al.*, 2006). Total water uses for tourism in Bali in 2013 is 27.8 million m³ and it is about 0.4% of the freshwater potential. The total domestic-tourism water demand requires only 2.7% of its freshwater resources. This shows that the water scarcity in Bali is not caused by physical scarcity (limited water resources), but rather by economic scarcity (i.e. lack of infrastructure, poor water governance, and a lack of demand management) (Tapper *et al.*, 2011).

Does tourism cause water crisis in Bali?

At provincial level, the total share of tourism water demand in domestic-tourism water demand was considerably high since 1988 (6.59%), and further increased to 15.7% in 2013, indicating more competition to the local population. Such a high share in domestic water use also happened in Malta (14.24%) and Barbados (12.46%), where tourism plays an important role in the regional economies (Gössling *et al.*, 2012).

The inter-annual water demand calculation suggests that the rapid tourism growth increased the tourism water demand in Bali by 20.8 million m³ (295%). At the provincial level, tourism growth contributes to 30% of tourism-domestic water demand increase and the larger portion (70%) is due to population growth. However, the spatial water demand calculation indicates that 67% of the tourism water demand increase is concentrated in Badung Regency. In the regency, the increase of tourism water demand was larger (54%) than the increase in domestic water demand. Moreover, the seasonal tourism water demand calculation indicates that after tourism development the high season period is longer (June - October and December) and in Badung Regency in 2013 the maximum monthly tourism water demand is higher by 9% than the average. The above results indicate the uneven distribution in tourism development – spatially and temporally. Thus, the impact on the water scarcity in Bali due to the rapid growth of tourism is likely to be concentrated in Badung Regency during June to October and December.

The comparison between tourism water supply and demand indicates that the large part of tourism water demand, both at provincial and regency/city level, is not supplied by PDAM. The share of water supply for the tourism industry in tourism-domestic water supply is much lower than the demand share. The big gap between supply and demand in tourism water use and the fact the tourism industries still can enjoy undisrupted water signifies the importance of further investigation on the sustainable use of alternative water sources that are currently being used to fulfill the needs of tourism industries. Particular attention should be placed in Badung Regency during June to October. The same concern was addressed by JICA *et al.* (2006) that indicates numerous numbers of hotels using boreholes and there is a need to manage boreholes along the seashore to avoid further seawater intrusion. Further in the report, JICA *et al.* (2006) suggested to increase the use of pipe water instead of boreholes among the hotels from 20% to 70% in 2025.

The water demand calculation at the provincial level also shows a higher amount of increase in domestic water use (70%). With the exception of Badung Regency, water scarcity in Bali may not merely the result of competition between the local population and tourism industries, but also among themselves. The comparison between domestic water supply and demand shows there is a significant improvement in the demand coverage after tourism development which indicates that more people have access to A clean water supply. Despite this improvement there are still rising concerns on the water scarcity among the local community which needs further study. One of the reasons may be the unstable supply of piped water and unavailability of alternative water supply such as river water and shallow groundwater. The environmental change due to anthropogenic activities, not only tourism but also industry and agriculture, may have – to some extent – reduced the availability of alternative clean water supply.

Tourism is one of the most important sectors for Bali's economy, thus it is necessary to keep positive portrayals to the image of Bali as tourist destinations. The above findings show that tourism water demand increased significantly in

Badung Regency and is higher than average during June to October. However, at the same time, the access to clean water among the community is better even in tourism concentrated areas. It is important to address the main cause of water scarcity among the population.

Underpinning problems

The rapid growths in tourism and population are uneven in Bali and so does the development of infrastructures. In most of the regencies/city in Bali, water demand is increasing mostly due to population growth. Only in Badung Regency, the tourism and domestic water demands are almost the same. Badung Regency is a highly concentrated tourism spot where more than half of the hotel rooms are located.

On the other hand, in 2013, Badung Regency contributed 24% to Bali's economy and tourism industry in Badung Regency contributed to 72% of the regency's economy. Thus, sustaining tourism industry in Badung Regency is essential for development in Bali. In order to understand the impact of rapid tourism development on water scarcity in Bali, this article further concentrated on discussing domestic-tourism water supply and demand in Badung Regency.

Looking at its water resources, the regency has 548.2 million m³/year (mean discharge) of water resources potential (9% of Bali's) (JICA *et al.*, 2006). PDAM Badung owned water treatment plant with clean water production capacity (potential) of 51 million m³ (BPS Provinsi Bali (Statistics of Bali Province), 2013). Furthermore, the clean water infrastructure in PDAM is high enough to accommodate both domestic and tourism demands (39.8 million m³). However, only 22.5 million m³ of clean water is being sold to customers (households, tourism, commercials, etc.) (44% of production capacity) and thus there were 21.7 million m³ of tourism-domestic water demand left uncovered. Further investigation in maximizing the use of existing infrastructure and increasing efficiency in water supply both from social and engineering perspectives should be carried out.

Concerns on water scarcity among local communities in tourism concentrated areas, among others, is due to the discontinuity in the piped water supply (only flows in the morning or

a few days in a week) (Cole, 2012; PDAM Tirta Mangutama Kabupaten Badung, 2017). The unavailability of water during certain hours or days among the community may be perceived as water scarcity among the local population, especially when tourists in hotels are still able to enjoy an abundant amount of water.

The unreliable water supply and unavailability of alternative water sources (dry and saline wells) have created water scarcity among the local population. Particularly in tourism dense areas, such as the Badung Regency, the fact that a much smaller number of tourists enjoy approximately the same amount of water as the much larger local population may trigger conflict. The tourists in this area use 16 times more water than the local population.

As mentioned in the previous sub-chapters, the tourism industries are not using water from PDAM. Based on this study, the amount of water being taken from other water sources by tourism industries in Badung Regency was 14.3 million m³ in 2013. According to Cole (2012), most of the accommodations in the Canggu Area (Badung Regency) have boreholes with 60 m depth and most of them are neither registered/metered nor paid for the water they abstracted. This situation may be one of the causes that cone of depressions, in shallow and deep groundwater, were found in some of the tourism spots in Badung Regency (Tirtomihardjo & Setiawan, 2011). There is a need to understand the impact of abstraction of deep groundwater (owned by hotels) to the shallow groundwater (owned by local populations) for understanding the impact of tourism development on the unavailability of alternative water sources. Furthermore, there is a need to monitor and manage the sustainable use of deep groundwater sources in Badung Regency, in particular for districts with a high number of tourism industries.

Solutions

The impact of rapid tourism growth on water scarcity in Bali is a sensitive matter which needs to be addressed strategically. A negative image of tourist destinations, in particular on their water resources may influence its popularity. Undoubtedly, the tourism industry is using Bali's clean water resources but its negative impact on

Bali's water resources can be avoided thus its positive impact on people's livelihood can be sustained.

Similar to other touristic destinations in the world, tourism water demand in Bali is concentrated in particular places at a particular time in a year. As such clean water allocation for domestic and industrial purposes is different if we compare it to other regencies or provinces. Thus, it is necessary to understand the distribution of demands for clean water based on its administrative boundaries and seasonal economic activities. Spatio-temporal calculations based on open statistical datasets on water supply and demand, such as being done in this study, may help to understand in a simple way the consequences of economic growth and the current practices in the clean water supply. Such calculations can be used to review the current water supply strategy as well as monitor the impact of the water deficit on other freshwater resources such as groundwater. The results of this study can be simply used by the government or clean water company that is working and managing its financial resources based on administrative boundaries.

Reviewing the impact of rapid tourism growth on water scarcity among the local population in Bali, this study suggests the followings:

(1) The high increase of tourism water demand is concentrated in Badung Regency during June to October. As such, with regard to planning in allocation for the tourism and domestic purposes, this study agrees with suggestions by (JICA *et al.*, 2006), to increase water supply coverage for tourism industry in order to avoid overuse of deep groundwater in particular in the coastal area. It is therefore important to encourage tourism industry to use public water supply as to avoid further degradation in groundwater supply. Such practice should be supported by a firm water use policy.

(2) Further investigations should be conducted to analyze underpinning reasons of discontinuity of water supply to households, in particular for an urbanized area such as Badung Regency and Denpasar City. Moreover, more study should be done to understand how to maximize the capacity of clean water treatment

plants in these areas, in order to improve the coverage in domestic water demand as well as to cover the needs of tourism industries.

(3) It is important to share public information on the current situation of water resources facilities and constraints in order to avoid negative portrayal of the tourism industry, which is important to the livelihood of people in Bali. Study results from an open statistical database can be easily shared with public to allow a fair perspective on the water scarcity situation in Bali. Through this information, public may have an active role in encouraging the government to provide better public services as well as monitor the impact of tourism industries to the environment.

(4) Tourism industries should also play an active role in reducing the disparity of water use between tourists and local communities. This study suggests that rather than concentrating on increasing efficiencies in their operations and water use systems, the tourism industries should widen their perspective to reduce water disparities to the adjacent community. Building public facilities that allow communities to enjoy greenery and water is one of the examples to reduce disparities between tourists and local communities.

CONCLUSION

Based on trends in tourist visits, the rapid increase in tourism began in 1988. Our results show that at the provincial level water tourism demand increased from 7 million m³ in 1988 to 27.8 million m³ in 2013 (295% increase) and domestic water demand from 99.7 million m³ in 1988 to 148 million m³ in 2013 (48% increase). Even though the tourism water demand increased rapidly, the larger portion of the increase in water demand in Bali Province is still dominated by population growth.

The high increase in domestic and tourism water demand is followed by improvement in the water supply. The water supply coverage for domestic water demand increased from 13% in 1988 to 53% in 2013 while for tourism water demand the values vary with an average of 28%. The increasing concerns in water scarcity despite significant improvement in domestic coverage

suggests further investigations. On the other hand, the large gap in the tourism water coverage and the fact that the industry still can have an undisrupted clean water supply suggests that the industry may use alternative water sources such as groundwater.

The rapid growths in tourism and population are uneven. In most of the regencies/city in Bali, water demand is increasing mostly due to population growth. Only in Badung Regency, the tourism and domestic water demands are almost the same. Badung Regency is a highly concentrated tourism spot where more than half of the hotel rooms are located. The spatial water demand calculation shows that in Badung Regency, the increase of tourism water demand increased from 4.4 million m³ in 1988 to 18.3 million m³ in 2013 (317%). In this regency, the increase in tourism water demand dominates the increase in tourism-domestic water demand (54%) and in 2013, the hotels are using almost the same amount of water as a population in the regency

Similar to other regions, there is improvement in domestic water coverage in Badung Regency. However, the unreliable water supply and unavailability of alternative water sources (dry and saline wells) may have created water scarcity among the local population. Particularly in such tourism-dense areas, the fact that a much smaller number of tourists enjoy undisrupted clean water with approximately the same amount of water as the much larger local population may trigger conflict. The tourists in this area use 16 times more water than the local population.

The seasonal tourism water demand calculation shows that, in Badung Regency, the monthly maximum tourism water demand is 9% more than average water use. The high season for tourist visits is from June to October.

In the areas that depend on the tourism industry, tourism water demand should be addressed as a water-consuming sector. It is required to avoid water scarcity among the local population as well as overuse in local water resources such as groundwater. Therefore, water resources assessment and planning should highlight the importance of analyzing tourism water demand on a temporal and spatial scale.

REFERENCES

- Becken S. 2014. Water equity – Contrasting tourism water use with that of the local community. *Water Resources and Industry*, 7-8, 9-22. doi: 10.1016/j.wri.2014.09.002
- BPS Provinsi Bali (Statistics of Bali Province). 1983. *Bali Province in Figures*. Bali.
- BPS Provinsi Bali (Statistics of Bali Province). 2000. *Bali Province in Figures*. Bali.
- BPS Provinsi Bali (Statistics of Bali Province). 2014. *Statistik Air Bersih Provinsi Bali 2014*. Bali.
- BPS Provinsi Bali (Statistics of Bali Province). 2016. *Bali Province in Figures*. Bali.
- Cole S. 2012. A political ecology of water equity and tourism. *Annals of Tourism Research*, 39(2), 1221-1241. doi: 10.1016/j.annals.2012.01.003
- Gössling S, Hall CM and Scott D. 2015. *Tourism and Water*. Bristol: Channel View Publications.
- Gössling S, Peeters P, Hall CM, Ceron JP, Dubois G, Lehmann LV and Scott D. 2012. Tourism and water use: Supply, demand, and security. An international review. *Tourism Management*, 33(1), 1-15. doi: 10.1016/j.tourman.2011.03.015
- Gössling S. 2001. The consequences of tourism for sustainable water use on a tropical island: Zanzibar, Tanzania. *Journal of Environmental Management*, 61(2), 179-191. doi: 10.1006/jema.2000.0403
- Grey D and Sadoff CW. 2007. Sink or Swim? Water security for growth and development. *Water Policy*, 9(6), 545. doi: 10.2166/wp.2007.021
- JICA, Yachiyo Engineering Co. Ltd. and Nippon Koei Co. Ltd. 2006. *The comprehensive study on water resources development and management in Bali Province in the Republic of Indonesia final report: main report*. Bali
- Leng RA, Stambolie JH and Bell R. 1995. Duckweed - a potential high-protein feed resource for domestic animals and fish. *Livestock Research for Rural Development*, 7(1), 7. <http://www.cipav.org.co/lrrd/lrrd7/1/3.htm>
- Lukman, Ridwansyah I, Nomosatryo S, Badjoeri M, Nasution SH and Dina R. 2012. Pertimbangan dalam pengembangan budidaya ikan pada karamba jaring apung di Danau Toba. *Prosiding Seminar Nasional Limnologi V*, Bogor, 65-78.

- Muhajir A. 2015, 22 April 2015. *Pariwisata lahirkan ancaman krisis air di Bali*. Retrieved from <http://www.rappler.com/world/regions/asia-pacific/indonesia/90735-pariwisata-ancam-krisis-air-bali>
- Mulyadi A. 2011, 4 May 2015. Bali Krisis Air Bersih, *Online Article, Kompas.com*. Retrieved from <http://nasional.kompas.com/read/2011/05/04/19321775/2015.Bali.Krisis.Air.Bersih>
- Osman KM, Mohamed LA, Abdel Rahman EH and Soliman WS. 2009. Trials for vaccination of *tilapia* fish against aeromonas and pseudomonas infections using monovalent, bivalent and polyvalent vaccines. *World Journal of Fish and Marine Sciences*, 1(4), 297-304.
- PDAM Tirta Mangutama Kabupaten Badung. 2017, 24 February 2017. *Tanggapan, Keluhan, Kritik & Saran Dari Pelanggan*. Retrieved from <http://www.pdam-badung-bali.co.id/tanggapan-pelanggan-s-32.html>
- Shakeela A. 2015. Water Crisis Management in a Tourism Dependent Community *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, 9(12), 4082-4086.
- Sulastrri and Nomosatrio S. 2005. Perubahan komposisi dan kelimpahan fitoplankton Situ Cibuntu, Cibinong, Jawa Barat. *Limnotek Perairan Darat Tropis di Indonesia*, 12 (2), 92 – 101.
- Suriyani LD. 2015, 15 April 2015. *Bali terancam krisis air, mengapa?* Retrieved from <http://www.mongabay.co.id/2015/04/15/bali-terancam-krisis-air-mengapa/>
- Tapper R, Hadjikakou M, Noble R and Jenkinson J. 2011. *The impact of the tourism industry on freshwater resources in countries in the Caribbean, Mediterranean, North Africa and other regions*. London.
- Tarigan H., Dharmawan AH, Tjondronegoro SMP and Suradisastra K. 2014. Conflict of water resources and marginalization subak: case studies in Tabanan Bali. *International Journal of Research In Social Sciences*, 4(4), 96-106.
- Tirtomihardjo H and Setiawan T. 2011. Simulasi Aliran Air Tanah: Cekungan Air Tanah Denpasar-Tabanan, Provinsi Bali. [imulation of Groundwater Flow: Denpasar-Tabanan Groundwater Basin, Bali Province]. *Jurnal Geologi Indonesia (Indonesian Journal on Geoscience)*, 6(3), 145-163. doi: 10.17014/ijog.v6i3.123
- Trisnawati H. 2012. Dampak perkembangan infrastruktur pariwisata terhadap konflik air di Kabupaten Badung dan Tabanan. *Jurnal Ilmiah Pariwisata*, 2(1), 109-222.
- Widiadana RA. 2012, 5 September 2012. Tourism Industry Responsible for Water Crisis in Bali, The Jakarta Post. Retrieved from <http://www.thejakartapost.com/news/2012/09/05/tourism-industry-responsible-water-crisis-bali-expert.html>
- Widyaswara IWE. 2015. Krisis air di Denpasar makin jadi, Made Nyemplong beli 8 galon per hari.
- Wiranatha AS. 2001. A systems model for regional planning towards sustainable development in Bali, Indonesia. *Doctor of Philosophy Case-study Dissertation*, The University of Queensland, Queensland.
- World Travel and Tourism Council. 2016a. *Economic Impact 2016: Annual Update Summary*. London.
- World Travel and Tourism Council. 2016b. *League Table Summary 2016*. London.