Climate change impacts on the coastal tourist resorts of Bali

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Abstract. This article will highlight several impacts on changes in Bali’s shoreline, especially on coastal tourist resorts. Climate change as a global issue is a fundamental factor in which the shoreline of Bali has significantly changed, although it was not only a single impact on the shoreline’s changes. Due to rising seawater in combination with other factors taking place in most parts of coastal areas have led to significant erosion on the coastal tourist resorts of Bali. Narrower spaces of the tourist beaches have gradually degraded the quality of the beach environment. Moreover, the rapid development of tourist facilities along the beach as a local issue has also led to rising microclimate on the coast, hence these global and local issues are the driving factors to change the local climate on the coastal regions. Kuta Beach Resort was selected as a case study to represent the recent condition of Bali coastal tourist resorts due to the most crowded tourist area. Through an empirical study in collecting data that was supported by theoretical approaches, data were, then, analysed into the descriptive analysis. Therefore, the article of this research is expected to become useful for academic purposes, urban planners and policymakers. Therefore, the purpose of the research is to clarify the significant negative impacts of climate change on the coastal tourist resorts of Bali and to evaluate the possible actions carried out by parties to mitigate the negative impacts.

1. Introduction
The world’s climate change is largely due to anthropogenic sources, whilst in 2011 the IPCC predicted that weather condition will be more extreme and acute unless local to global actions are taken to mitigate greenhouse emissions [1]. If no actions, global temperature could rise from between 1.4° and 5.8°C by 2100. Since humans’ activities produced various gas emissions destructing the ozone such as CO₂, CFCs HFCs, CH₄ and other gases, they become a key driver in the current raising temperature leading to a significant impact on humanity and other species in future decades [1,2]. Some predictions on risks of climate change are precipitation and wind speed became less consistent and significant changes, as a consequence risks to human health would arise through a variety of mechanisms [3].

Sea level rise, for instance, is one of the negative impacts of climate change deriving from ice melting in the Arctic pole. Due to this, most parts of the coast in the world were taken by seawater. Hence, erosion or abrasion has become a serious threat to most parts of the world’s coastal areas. Meanwhile, extreme weather events will bring about widespread damage to infrastructure, and loss of life and livelihoods [4]. Furthermore, climate change on coastal regions would be serious threats especially for the coral triangle and aquatic species. Indonesia having an abundance of coral reefs would be suffered from the negative impacts of coastal climate change. Whilst, coral reefs are one of the interesting tourist sites besides white sandy beaches on the coast. Ibnu Sofyan as a researcher from Maps and Survey Coordination Board of Indonesia argues that every 1°C of the temperature rise, sea level would be higher around 20-40cm [5].
Bali is one of the thousands of islands in Indonesia that has 593 km of shoreline whereby most parts of the coast were eroded. Based on the survey result carried out by Bali Beach Conservation Project Team in 2007 [6], pointed out that coastal erosion on this island can be categorised into three levels; hard, moderate, and minor erosion. Most hard erosion took place on the southern coast of Bali whereby these areas were developed as famous tourist resorts such as Seminyak, Legian, Kuta, Nusa Dua, and Sanur Beaches. Besides sea level rise, other factors were indicated to lead the erosion on the coast of Bali. The factors are coral mining, hotel wastewater disposals, boat activities and chemical waste from the rivers which caused coral destruction, and this destruction led the vulnerability of the coast to stand from wave and current. Meanwhile, the rapid growth of tourist facility development in the coastal areas of Bali by losing green open spaces has also contributed to the increasing temperature.

The rise of temperature in coastal tourist resorts of Bali inevitably caused by the tourist facility development has contributed to change microclimate. The conversion of green open spaces into the built environment has brought a significant change of outdoor thermal comfort, whilst the rapid growth of population due to people migration and tourist arrivals in the tourist resorts has also influenced the change of microclimate of the coast. Building and people densities in the coastal resorts have stimulated the rise of the outdoor temperature. Form this point, the negative impacts of global and local climate change are beach erosion and higher outdoor temperature. Therefore, the main purpose of the research is to clarify the significant negative impacts of climate change on the coastal tourist resorts of Bali and to evaluate the possible actions carried out by parties to mitigate the negative impacts.

2. Materials and method

Most coastal areas as coastal cities or coastal suburban have risks from climate change especially changes in means, and in extreme, even in exposure, because of anthropogenic effect. Whilst, coastal areas at the same time faced a variety of risks associated with sea-level rise such as coastal flooding, storm, constraints on water supplies, higher temperatures, and heat waves, as well as health risks [7].

2.1 Flooding

Flooding risks in coastal areas are potentially caused by climate change through three distinct ways; sea level and storm surges; rainfall leading to higher volumes/longer wet seasons; and from the increased river flows. The heavy amount of precipitation on the surface added with the increase in frequency will add to flood risks. In addition to flood hazards, the risk of landslides easily takes place in regions that have more extreme rainfall events associated with climate change. Whilst, in a settlement, flooding often damages a sanitation system as septic tanks which may cause contaminated by water overflow. The lack of infrastructure sanitation becomes a determinant factor of coastal contamination in which faecal material carries a substantial threat of diseases [8].

2.2 Storms, sea-level rise and coastal populations

Storm with force winds is to become more frequent and intense, with easily shifting coastal areas. The urban population settled in coastal zones is at risk from storm and sea level rise. Even though coastal areas are at risk from these hazards, the number of people who settled on the coast has significantly increased. There are two-thirds of the world’s populations over five million inhabited in the coastal areas and the proportion of the urban population in developing countries who settled in coastal areas is nearly twice compared to urban residents in high-income countries [9]. One estimate has assumed that millions of people at the moment are affected by coastal flooding every year and are bound to increase, though any scenario for climate change is created [10].

2.3 Higher temperatures and heatwaves

Due to climate change, most cities in particular Asia in the future are estimated more frequent heat waves whereby the larger and higher density of coastal areas the higher temperatures to take place. The coastal ‘heat island’ having higher temperatures than in surrounding areas will affect human health, labour productivity, and leisure activities in the coastal areas. According to a research, it was found that
the impact of heatwaves is associated with a market short-term increase in mortality [11]. Moreover, high temperatures and heatwaves in the coastal areas will bring a significant impact on financial post, especially for energy usage. The additional cost for climate control such as air conditioning in buildings and environmental effects as smog increased concentrations of some air pollutants and deterioration of green spaces.

2.4 Coral bleaching

A combination of climate change impacts resulted in the destruction of coral reefs, mangrove conversion, loss of fish nursery areas, destructive fishing methods, pollution of water bodies, and other excessive aquaculture. The threats of the fishery sector for sustainability may increase in the future although it remains to be further assessed [12]. In addition, the warming of seawater interfere with nutrient-rich waters, inhibits the development of plankton and lacks nutrition supply in the food chain, whereby this means that it is limited fish to catch for human consumption. Whilst, beautiful natural scenery of coral reefs under seawater is at risk to be damaged.

2.5 Research method

The southern coast of the island such as Kuta, Legian, and Seminyak Beaches was selected to be propounded as the research objects. The selected objects were backed up by several reasons; famous resorts in this region, the first coastal resort, high population, and building densities. In relation to the research study, it uses a qualitative approach with a case study researh. It intended to clarify the impacts of climate change taking place in Kuta, Legian and Seminyak Beaches. This research began by tracing sources of data which were possible to be collected. Besides observation on the field, in-depth interviews with local authorities were very important sources of information since they kept institutional data relating to the initial growth of resort development and monitoring results carried out by them. Therefore, the research question proposed is what are the impacts of climate change in the coastal tourist resorts and how to possibly mitigate and adapt from climate change by reducing the outdoor temperature.

3. Results and discussion

3.1 Results

From observation, institutional and mapping studies, data collected are divided into several subsections based on its characteristics, although most sources of data collected were from the physical environment.

3.1.1 Location, climate, and topography. District of Kuta comprises five villages; Kuta, Legian, Seminyak, Tuban, and Kedonganan, which is part of the Badung Regency. Only Kuta, Legian, and Seminyak have become tourist resorts, located in the southern coast of Bali (figure 1). With a total area of 1,752 ha, the length of the shoreline of the Kuta District in the western part is 13.11 km and 5.6 km in the eastern part. In addition, the topography of the Kuta District is 0-27m from above sea level which means that it is relatively low from the sea level. Nevertheless, with 3.3 km of white sandy beach in the western part, Kuta is known as the best favourite coastal tourist resort in this region according to a survey result conducted by Bali Tourism Board in 2001 [13].

Meanwhile, the climate of Kuta is between 22°-34°C with 70-90% of relative humidity. Whilst, the temperature in Kuta District by 2001-2010 has indicated that there was fluctuated especially from 2001 to 2008, however, two years later (2009-2010) the temperature at Kuta rapidly increased [14]. Moreover, the mean temperature in ten years (2001-2010) was 26.995 or 0.34°C of temperature raised in ten years (figure 2). If the increase of 0.34°C is required to assume the Kuta’s temperature in the years of 2030, the Kuta’s temperature will reach of 0.68°C higher than the mean temperature in 2010. It means that Kuta’s mean temperature in 2030 will be 27.675°C

3.1.2 Wind direction, waste transport, and eroded beach. At Kuta Beach, wind direction is mostly influenced by west and east monsoon seasons. Kuta Beach, however, suffers from the west monsoon
periods particularly taking place in the period of November-January since this period, tons of annual rubbish from other islands come to the coast of Kuta Beach causing dirty beach. Even after the storm occurred in 2011, the high volume of rubbish covered the beach from the south to the north. As a consequence, Kuta leaders supported by the local government of Badung Regency worked hard to clean the beach by using heavy tools. In addition, according to the Completion Report of Bali Beach Conservation Project /BBCP (2009), wind direction at Kuta beach has changed since the development of International Ngurah Rai Airport’s runway. Besides the change of wind direction, erosion also has taken place at Kuta Beach. According to Tjokorda Lahrini as ME Manager of Patra Bali Hotel in 2005 stated that approximately 75m of our land ownership in front of our hotel has become the sea. (figure 3) shows a calculation of sand loss from 1972 to 2001.

Figure 1. Location of Kuta, Legian, and Seminyak Resorts [6]

Figure 2. Graphic of mean temperature at Kuta by 2001-2010 [14]
3.1.3 Population and development of built environment. Based on the statistical data of Kuta District in figure 2018, the total population of the Kuta District in 2017 was 54,914 people, with a population density of 3,134/km². If compared to each village, Tuban Village with 21,561 of the number of population, is the highest density due to its small area, followed by Kedonganan Village is the second density. Kuta, even though the population was 17,149 as the second largest of inhabitants, the population density was only 2,372 as the third position. The population density in each village in 2017 was above 1,000 people/km² or 3,314 people/km² in average [16]. This people density excluded the number of tourists visited/stayed in Kuta’s tourist accommodation.

Based on the Badung Tourism Agency, the number of tourism visited Badung Regency in 2009 was 2,229,294 with 0.23% of the average increase. If 50% of tourist number who stayed in Kuta, it means that the total tourist number is about 1,115,000/year or 3,055/day, causing the increasing number of the population density. Meanwhile, the highest percentage of population growth in Kuta took place in the year of 2000 – 2010 was up to 5.93%, whilst Bali and national growth was 2.15% and 1.47% respectively (figure 4). Hence, it can be said that the population growth of Kuta is almost four times than the national population growth. But in the last three years, it was 1.94% according to Kuta District in Figures 2018.

3.2 Discussion
Based on the data that are highlighted on the result of the survey whereby it has already emerged the impacts of climate in the Kuta tourist resort, however, the particular impacts on tourist resorts need to
clarify it into more depth. For this purpose, the impacts of climate change on the Bali coastal tourist resorts particularly in the Kuta beach tourist resort are able to be analysed according to the climate change’s issues in the local context.

3.2.1 Flooding impacts. The highest volume of the rainfall at Kuta Beach usually takes place in March-April and November-December. The flooding easily to take place at the Kuta resorts due to the low land and close to the sea. Based on the survey, most buildings along the coast did not follow the national regulation stipulating the setback line should be 100m from High Water Level (HWL) to the onshore. Moreover, the tourist resorts with unplanned development were pointed out by insufficient urban drain to collect and discharge rainwater through a certain place or a wastewater collector tank. Whilst the land surface seems difficult to absorb rainfall under the surface due to the highest building density. Lebak Bena River as a natural boundary between Legian and Kuta Village and rainwater drainage became a hotel building foundation; other rivers became narrower due to the construction of revetment and inaccurate position of the construction.

3.2.2 Storm, sea level rise impacts. Every storm occurring in Kuta Beach has pushed the sand beach through seawater to the onshore (to the street and tourist facilities along the coast), whilst sea level rise as a permanent impact took place the land/beach to become part of the sea. Both impacts have led to a significant decrease in beach space. Although sand nourishment with extending beach space approximately 50 m to the offshore had carried out in 2007-2008 for beach rehabilitation, erosion is still continuing to occur. The hard erosion took place at the southern side of the beach or the northern side of Ngurah Rai International Airport’s runway. Hard erosion was triggered by low land (topography) of Kuta Beach which is only less than 10 m above sea level. An effort to block sand to the onshore has been done by the local government along with the community through constructing a fence wall along the street of Jl. Pantai Kuta.

3.2.3 Higher local temperature impacts. The rapid growth of the population in the Kuta District is above Bali and national population which was over 3,000 people/km2 in 2017. Migration to Kuta District was inevitable to take place as it related to labour opportunities in the tourism sector. The high people density, of course, needs land, water, dwellings, foods, and other sources for their life. As a result, agricultural land, green open spaces, and other open spaces have converted to be built environments such as hotel accommodation, villas, dwellings and private commercial buildings leading to high building densities in this area. Green open spaces (mangrove forests and beaches) were less than 16% left, because of land conversion as well as possible beach encroachment. Moreover, the extension of building structures facing offshore by obeying setback line regulations led to the significant decrease of the beach as public spaces. This condition mainly resulted from an unplanned and uncontrolled tourist resort. As a result, the local temperature has increased.

3.2.4 Wind direction change and other environmental impacts. Due to the change of wind direction, annual waste transport from other island entering Kuta Beach has come to Kuta Beach since early 2000. The annual rubbish usually takes place from December to February. An extra budget is needed for cleaning the beach. Moreover, the change of wind direction has cause sand drift from the south to the north that leads to little erosion especially in the southern part of the beach or the north side of the runway. Meanwhile, to enhance the beach quality by installment of vegetation along the beach is unlikely to be implemented since the beach has limited space for its instalment.

4. Conclusion

Sea level rise has led to a serious impact on the coastal tourist resorts of Bali since the sea has taken part in the beaches or lands along the coast as erosion. However, other factors are also a key role in the eroded beaches, for instance: coral mining in the past and wastewater disposal discharged to the sea. The effect of the eroded beach has degraded the beach environment and the quality of the resorts. Since
the effect has a trickle-down, the damage of the resorts will bring about the decreasing number of tourists to visit the coastal resorts and then influencing the income and sales taxes. The decrease amount of income will cause the government to have less viability for developing Bali as a whole. As a consequence, the government should have the ability to maintain and preserve the coastal tourist resorts (beach and outdoor thermal comfort) by providing their budget.

Since sand nourishment work needs a huge budget, the regional and local governments were unable to carry out the work. Although they have the ability to clean their beaches in front of the resorts through regular cleaning, it is not sufficient enough to stop sand loss. As a result, the beach spaces became narrower in most parts of the coastal resorts. Although the central government rehabilitated the major coastal tourist resorts including Kuta Beach, erosion could not be stopped. In this sense, the government of Bali does not seem to have the ability to provide funds, whilst the central government is unlikely to rehabilitate it again. Because the beauty of the Bali beaches is one of the most important assets in Bali tourism besides the Balinese culture and traditions, all parties should take responsibility to maintain these assets well.

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