An Analysis of the 2010 Flood in Nakhon Ratchasima Municipality, Nakhon Ratchasima Province, Thailand
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ABSTRACT
Nakhon Ratchasima municipality and nearby areas are prone to severe and non-severe floods because they situate in the old floodplain terrace that occupies up to 45% of its total area. Severe damage from floods can be alleviated if the Nakhon Ratchasima municipality has a proper land-use planning together with well-constructed drainage system. This study focuses on geomorphology and environmental geology in an attempt to confirm physical limitations and the environment that constraint the expansion of the Nakhon Ratchasima municipality. To predict future flood-risk areas, data on geomorphology, physical properties of landforms and soils, temperatures, and rainfalls were collected, revised and analyzed before they were used to reconstruct flood-risk areas map. There is a potential for a repeat of the 2010 severe flood if the city is expanded to the north without efficient drainage system. The monthly record of temperatures over 35-year period shows stable maximum temperatures, while they show a rise in minimum temperatures. Annual rainfall also shows a gradual rise. The concomitant rises in minimum temperature and annual rainfall appear to reflect the significance of global warming.

Keywords: 2010 flood in Nakhon Ratchasima municipality, Korat City, geomorphologic map, land-use planning, global warming.

1. INTRODUCTION
To achieve the best benefits and the highest suitability, planning of land use requires the consideration of three major components, including society (people), economics and environments. The importance of each component can be weighed varyingly because each individual component contains several elements. For example the environmental component consists of geological, geotechnical, geo-environmental and natural hazards elements. A weight of the importance of each element is also variable. Thus, planning of land use involves thorough analysis of each individual element in all three components. Moreover, the planning of land use needs to be revised in accordance with the front-time-to-time dynamic changes of the three major components.

Nakhon Ratchasima municipality (so called Korat City or Nakhonratchasima City) of the Nakhon Ratchasima province is the fifth largest municipality in Thailand after Bangkok, Nonthaburi, Pak Kret and Hat Yai municipalities. It covers an area in an approximate of 37.5 square kilometers (Figure 1). A land-use plan for the growth of the Nakhon Ratchasima municipality and nearby has been studied and documented since 1981 as part of the plan of Thai government to decentralize the development from the capital city to regional provinces. Nakhon Ratchasima province has been chosen to serve as the growth pole of the Northeastern region. Several studies have been conducted to provide necessary and critical information for use in the planning of land use (e.g.; Srisatjalertvaja; 1981; Sinclair Knight & Partner, 1983; Satarugsa, 1987; Department of Public Works and Town and Country Planning (DPWTCP), 2013; Nakhon Ratchasima Municipality, 2013). About a half of the Nakhon Ratchasima municipality situates in old floodplain terrace, where floods occur commonly. The Department of Town and City Planning (DTCP) has thus constructed flood-prone area map, showing the areas in the Nakhon Ratchasima municipality with high, moderate and low possibility of flood threat (Figure 2).

Based on the data from Figure 2 and other previous studies (e.g. Satarugsa, 1987), flood is not an unexpected event in Nakhon Ratchasima municipal area and nearby. Indeed, a severe flood did occur in October 2010, causing severe damage to hospital, school, commercial and residential areas, especially in the first three days (October 18-20, 2010). Much of the damage was due to a lack of prior preparation for severe flood event. Several areas were not declared as flood zone in advance, but they were submerged for more than three days. The majority of residents in the Nakhon Ratchasima municipal area was unaware and was not informed about flood possibility. In fact, the 2010 flood did occur mostly in the areas mapped as high possibility and in some parts of areas mapped as moderate and low possibilities (flood potential map, Figure 2). The residents of the high possibility flood zone had only experienced the flood that occurred in a short time (few hours) with less amount of water. Hence, the damage from 2010 appeared to be due to underestimation of flood event.

The 2010 flood incident raised many questions; was the 2010 flood due to the extraordinary amount of rainfalls, resulted from climate change?, what were the primary causes of the 2010 flood?, will the similar flood occur again in the future?, how to lessen the damage from severe flood should it repeat . To shed some light to some of these questions, this paper provides the results, obtained from an analysis of rainwater and temperatures over the period of 35 years (1977-2011) together with available data that can be archived. In addition, this paper provides an update of potential flood map together with the information on physical properties of the landform of the Nakhon Ratchasima municipality and nearby, obtained from the review and reproduction of the geomorphologic map constructed by Satarugsa (1987).
Figure 1. Map of Nakhon Ratchasima municipality and nearby; outline in circle is the study area (source: topographic map 1:50,000, L7018 series 5439 III and 5438 IV).

Figure 2. Flood-risk map of Nakhon Ratchasima municipality and nearby mapped by DPWTCP (2013).
2. GEOMORPHOLOGY AND GEOLOGY

In the study of Satatrugsa (1987), the geomorphology and geology of the Nakhon Ratchasima municipal area and nearby consists of an old floodplain terrace (alluvial terrace), recent floodplain, undulated terrain and landfilled. The old floodplain terrace was dried up due to climatic change during Quaternary period. About 55%, 40% and 5% of the area, mapped as undulated terrain, is covered by loess like deposit (eolian deposit), recent floodplain plus old floodplain terrace and the remnant of oxbow lakes, swamps, Lam Takhong and Lam Boribun creeks and theirs tributaries, respectively. Geology of the Nakhon Ratchasima municipal area and nearby is located on the edge of Khorat Basin and composed of Khok Krut, Maha Sarakham and Phu Khao Thong formations and unconsolidated sediments, consisting of gravel bed, laterite, alluvium and loessial soil. The Khok Krut and Phu Khao Thong formations are located in the southern part of the area. Beneath alluvial sediments is Maha Sarakham formation that is located in the northern part of the area. For land use recommendations, Satatrugsa (1987) divided into 4 zones, extremely high, high, moderate and low geotechnical limitation zones. The recent floodplain and old floodplain terrace including oxbow lakes and swamps were classified as extremely high and high geotechnical limitation zones. Floods occur frequently in this area in wet seasons. Consideration should thus be given to dewatering and special foundation designs. In addition, saline soil and saline groundwater exist, especially at the area locates at the North. Low geotechnical limitation zone locates in the South, which is covered by the loessial soil (undulated terrain), while the remainder falls in moderate geotechnical limitation zone. The loessial soils are very hard at a dry condition and very soft at a wet condition. These properties do not provide good structural foundation for high-rise buildings.

3. METHOD OF STUDY

This study used pre-existing data on the physical properties of landforms and soils in the Nakhon Ratchasima municipal area and nearby along with data on temperatures, and rainfalls. These data were evaluated and analyzed before they were used in the reconstruction of geomorphologic map. The reconstructed map was then used to outline predictive future flood-risk areas (Figure 3). The geomorphologic map from the study by Satatrugsa (1987) was extended northward and southward.

4. RESULTS

Figure 4 shows the amount of rainfall in the Nakhon Ratchasima municipal area and nearby between 1977 and 2011 (Meteorological Department, 2013), which indicate a clear trend for an increase the amount of rainfalls. However, this trend does not imply the amount of rainfall to rise every year, but it suggests yearly fluctuation in rainfall quantity as it occurred in the past, when there may be less or plentiful rainfall in some years. The amount of rainwater in 2010 is reported to be 1,386 mm and this is not the maximum amount, recorded in a 35-year period. The maximum amount of rainwater record of 1,446 mm is in 1988. This highest amount of rainfall, however, did not produce severe flood. Figure 5 shows patterns of monthly rainfall in 2010, 2005, 1988 and 1986. The patterns of rainfall differ slightly in each year. In the 2010 flood, it rained from May until October. The rainfall data indicate that patterns of rainfall appear to play a role for the 2010 flood. There was progressive accumulation of rainwater since May. Groundwater level in the potential flood area is about 0.5-1.0 m. The soils in the potential flood area thus become fully saturated with only small amounts of rainwater. The pattern of the rainfall in 2010 indicates poor drainage system in the Nakhon Ratchasima municipality and nearby. Hence, construction of an efficient drainage system is needed to alleviate the flood, caused by such frequent heavy rainfall as in 2010.

Figure 6 shows the trend of maximum and minimum temperatures of the Nakhon Ratchasima municipality and nearby over the 35-year period between 1977 and 2011. The minimum temperatures increase significantly over time, but there is no evidence for a rise or fall in maximum temperatures. In other word, the temperature data in Figure 6 could be interpret to suggest that the temperature in winter time will increase and thus it will be warmer in winter time, compared with the winters in the past. Conversely, the temperature in summer time will remain as hot as in the past. The rising minimum temperature appears to support the effects of global warming in the planet earth.

Figure 3 outlines the areas with flood potential. Geomorphology of the area was used as a basis for delineation of the potential for flood. To prevent the flood of the same magnitude and damage as the one occurred in 2010, the drainage system in this flood prone area must be improved. The southern area, shown in Figure 3, has low potential for flood, but it is not suitable for high-rise buildings. This low-flood risk area is covered by loessial soils, which become very hard and very soft in dry and wet conditions, and thus they do not provide good structural foundation for high-rise buildings, unless proper foundation design and treatment has been carried out.

5. CONCLUSIONS

The Nakhon Ratchasima municipality and nearby situate in old floodplain terrace (alluvial terrace), recent floodplain, undulated terrain and landfilled. An approximate of 55% of the area, mapped as undulated terrain and landfilled. An approximate of 55% of the area, mapped as undulated terrain, is covered by the loess like deposit, while the remainder 45% is covered by recent floodplain, old floodplain terrace, remnant of oxbow lakes, swamps, Lam Takhong and Lam Boribun creeks and theirs tributaries. The latter area of 45% and about 5% from the undulated terrain and landfilled area have the potential of flood threat of similar extent to that of 2010 flood. The amount of rainwater and minimum temperatures both show an upward trend.

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Figure 3 Geomorphologic map of the Nakhon Ratchasima municipality and nearby (modified from Satarugsa, 1987) and outline of potential flood areas superimposed on geomorphic map.
Figure 4. Graphical illustration of total rainfalls between 1977 and 2012 (source: Meteorological Department, 2013).

Figure 5. Patterns of rainfalls in (a) 2011, (b) 2005, (c) 1988 and (d) 1986 (source: Meteorological Department, 2013).
REFERENCES


Figure 6. Graphical illustration of minimum and maximum temperatures between 1977 and 2012 (source: Meteorological Department, 2013).