PRACTICE AND EVALUATION OF SCIENCE, TECHNOLOGY AND DISASTER PREVENTION EDUCATION USING EARTH OBSERVATION RESULTS

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KEY WORDS: Teaching guidance plan, Interferometric SAR, SNAP, Sentinel-1

ABSTRACT: Our experience with volcanic activity, earthquakes and other disasters resulting from crustal activity teaches that excellent technology is necessary for disaster prevention and reduction. Since the disasters caused by crustal activities generally occur in a wide area, Earth observation by artificial satellites is useful for disaster prevention. The purpose of this research is to develop science, technology and disaster prevention education in secondary schools using Earth observation results and to evaluate the learning effect of these programs. The aim of this education program is to use information technology to measure topographic change due to volcanic activity or an earthquake and analyze the results scientifically for disaster prevention. In this lesson, topographic change due to crustal activities is imaged with information technology. Analyzing the produced image deepens knowledge of disaster prevention. A learning guidance plan was drawn up as 8-unit hours. The SAR data used as teaching material was observed by Sentinel-1 SAR. The course employs SNAP provided by the European Space Agency with interferometric SAR processing function. As a result of teaching practice according to the developed teaching guidance plan, it was found that the students could perform the interferometric SAR processing using SNAP and the other application. Students also could interpret ripple images properly. The learning effects were clarified by analyzing pre- and post-questionnaire surveys.

1. INTRODUCTION

Our experience with volcanic activity, earthquakes and other disasters resulting from crustal activity teaches that excellent technology is necessary for disaster prevention and reduction. It is important to teach scientific and technological approaches to disaster prevention. Furthermore, Earth observation by artificial satellites has been continuously carried out in recent years, and considerable data has been accumulated. Disasters caused by crustal activities generally occur in a wide area, so the Earth observation results from the artificial satellites are useful for disaster prevention.

Earth observation satellites equipped with synthetic aperture radar (SAR) have operated continuously since 1991 (RSSJ, 2013). Recent SAR systems have observation modes such as strip, scan and polarization. Latest satellites have sophisticated orbital control techniques charting orbit within specific tubes. Precise orbit information can also be obtained by GPS. In addition, the repeat cycle is shortened by operating multiple satellites. Specific interference conditions must be satisfied to generate a ripple image showing the trend of the topographical deformation using the interferometric SAR technique. In recent years, with the progress of observation technology, the availability of SAR data sets satisfying these conditions has dramatically improved. Techniques capable of generating the ripple image showing fine surface change are almost established by processing of interferometric SAR data sets observed before and after the crustal activity.

Science and technology lessons for measuring terrain using the interferometric SAR has been developed focusing on cooperation between subjects that utilize the results obtained by the technology learning as a teaching material at classes of science learning (Ikemitsu et al., 2015; Ito et al., 2014). The effectiveness of learning was evaluated with the teaching practices in the education plan (Ito, et al., 2016). Here we propose to include further study contents on disaster prevention to improve the contrived science and technology education. The purpose of this research is to evaluate the learning effects of science, technology and disaster prevention education developed for secondary schools using Earth observation results from SAR. This paper presents a learning guidance plan for science, technology and disaster prevention education, and shows learning effects based on survey data obtained in classroom practices.

2. GOALS OF SCIENCE, TECHNOLOGY AND DISASTER PREVENTION EDUCATION

Science, technology and disaster prevention education in this research mainly covers secondary school. This education includes a part of the learning contents of “technology of information processing” in technology and “the
composition and changes of the Earth” in science. These contents were stipulated in 2008 as the Japanese curriculum standards for secondary education (MEXT, 2008a and 2008b). The former aims to teach basic knowledge about information and information processing technology, objectively judge and evaluate the processing result, and make it possible to utilize on its own. In the last of these, objectively capture the facts obtained from observations and experiments and cultivate scientific perspectives and ideas. Furthermore, the relationship between learning results and disaster prevention is considered with the aim to deepen knowledge of disaster prevention.

3. CLASSROOM PRACTICE OF SCIENCE, TECHNOLOGY AND DISASTER PREVENTION EDUCATION

3.1 Teaching Guidance Plan

In countries such as Japan that are located on plate boundaries, volcanic activities are rampant, and earthquakes occur frequently. The theme of this science, technology and disaster prevention education is “The use of information technology for disaster prevention in case of volcanic activity and earthquake.” In the present lesson, topographical deformation due to a huge earthquake is imaged using the information technology. The whole of the earthquake can be inferred by examining the image. Based on these results, knowledge of disaster prevention can be deepened. This education is carried out at the time of comprehensive learning. A teaching guidance plan was planned for a total of 8 units consisting of 4 consecutive, 50-minute classes of 2 units. This plan is shown in Table 1.

In recent years, Earth observation by artificial satellites has been continuously carried out, and the results have accumulated. Particularly, by interfering in the data set observed by SAR before and after the crustal activity, it is possible to generate the fine ground surface deformation as the ripple image. In general, understanding the principle of interferometric SAR technology requires knowledge of advanced mathematics and physics. However, in the final ripple image interpretation, it is easy to estimate the change of the ground surface along the sight direction from the shape and density of ripples and the number of repeating waves. Therefore, as teaching material, we employed SAR data sets that can perform interferometric SAR processing with Earth observation results.

During the first and second classes, understanding the basic principles and results of Earth observation technology and the interferometric SAR is deepened as the summary of learning contents of this study shows. Next, during the third and fourth classes, by operating the interferometric SAR processing software, the ripple image is generated showing topography change due to volcanic activity. During the fifth and sixth classes, the ripple image showing the topography change due to volcanic activity is interpreted, and the students consider disaster prevention for themselves. Subsequently, by operating the software in the same way, the ripple image showing the terrain change due to the earthquake is generated. Characteristics of ripples appearing in this image are also interpreted. During the seventh and eighth classes, the ripple image showing the topographical deformation due to the earthquake is interpreted and the class considers disaster prevention again. Finally, the usefulness of Earth observation and information technology is evaluated by referring to two kinds of ripple images showing topography change. Furthermore, information is provided as to how Earth observation technology can be used as a means of disaster prevention.

3.2 Teaching Materials

3.2.1 SAR Data and Analysis Software

The data used as teaching materials was observed by the C-band SAR that is equipped on Sentinel-1, operating under the European Space Agency (ESA). Its radar wavelength is about 5.5 cm. Since April 2016, two identical Sentinel-1s have been circling on the same orbital plane with a phase difference of 180° from each other. One of the implications is a high observation frequency and nominal repeat cycle of 12 days. The Sentinel-1 SAR has observation modes that include strip map, interferometric wide swath, extra wide swath and wave. In the observation by interferometric wide swath, TOPS (Terrain Observation with Progressive Scans) is employed. In principle, Sentinel-1 SAR data is delivered within 24 hours of observation and its immediacy is high. The SAR data can be obtained free of charge merely by registering an account in a delivery system called Copernicus Open Access Hub. In addition, no research proposal is necessary for acquiring the data, which is easy to for school teachers to use.

Additionally, ESA is developing free and open source software as part of the SEOM (Scientific Exploitation of Operational Missions) program. Through STEP (Science Toolbox Exploitation Platform), tool boxes and related materials are provided. In this research, remote sensing data analysis software called SNAP (Sentinel Application Platform), which ESA provides free of charge, is adopted as the teaching material for permanent use in school education (ESA, 2018). Tool boxes installed in SNAP can analyze observation data obtained during various missions.
SNAP's interferometric SAR processing is executed by the following steps. (1) Loading SAR data products. (2) TOPS coregistration after specifying polarization, scan number and burst range. (3) “Deburst” processing to fill gaps between bursts. (4) Repeating (2) and (3) in the case of multiple scans, integrating individual debursted scans. (5)

A teacher prepares teaching materials and worksheets that explain the above procedure in detail. Since the frequency of access to the file in SNAP’s analysis processing is quite high, a large capacity memory and an auxiliary storage device capable of high speed access are indispensable. Meanwhile, a PC equipped with a memory of 16 GB or more and a high-speed auxiliary storage device such as SSD of 500 GB or more is used in order to complete the interferometric SAR processing within a limited class time.

3.2.2 Crustal Activities

Regarding the crustal activity dealt with in this study, information on volcanic activities and earthquakes provided by institutions such as the meteorological agency and geographical survey institute are referenced. Considering students’ memory, volcanic activities and earthquakes selected as teaching material occurred in rapid succession within the past three years, and the distance between them is close. Furthermore, there are Sentinel-1 SAR data sets capable of generating a clear ripple image showing a topographical change.

As a result, the selected teaching materials include the volcanic activity in August 2015 of Minami-dake on Sakurajima in Kagoshima Prefecture and the Kumamoto earthquake (M7.3) that occurred in April 2016. The SAR data set (about 4 GB) from July 31 and August 24, 2015 were acquired in order to capture the topographical deformation of Sakurajima’s Northern mountain. Similarly, the SAR data set (about 5 GB) from April 8 and 20, 2016 was acquired to capture the topographical deformation due to the Kumamoto earthquake. The selected crustal activities are illustrated in Figure 2.

The final ripple image is displayed using drawing software (e.g. MS Paint), and the repetition of ripples, shape and topography change are estimated. In addition, the ripple images are superimposed on transportation networks; coastlines; and dense, high population regions. These images are displayed stereoscopically using digital globe software (e.g. Google Earth) in order to allow students to examine in depth the relationship between topographic change and disaster.
3.3 Teaching Practice

The teaching practice of this science, technology and disaster prevention lesson was performed for 11 students in Japanese secondary school in November 2017 according to the learning guidance plan shown in Table 1. These classes consisted of approximately two students a group. The group learning method was adopted. The computer for interferometric SAR processing was a notebook PC, and one computer was used for each group. Figure 3 shows how students operate SNAP. All the students were able to correctly operate SNAP, and topographical deformation could be generated as the ripple image. Each ripple image was displayed using the drawing software. In addition, the ripple image was stereoscopically displayed on the digital globe.

Using the worksheets to interpret the ripple image, it was possible to calculate whether the ground changed from the reference point in the direction of radar illumination. From the results shown in Figure 4, some students could determine that the southeast direction (Mt. Nabeyama) was rising from the top of the Ontake of Sakurajima and that the magma was erupting. Figure 5 shows superimposed ripple images showing the ground deformation on the Earth observation image. From this image it can be seen that the topography fluctuates largely at the active fault boundary and the north side has subsided from the active fault. Some students could determine that the south side was uplifted.

3.4 Evaluation of Learning Effect

A pre-questionnaire survey was conducted before the start of the first class, and a post-questionnaire survey was conducted after the last class, respectively. Both surveys consisted of 26 corresponding items and the questionnaires are listed in Table 2. Students’ answers ranged from 1 to 4. The larger the number, the more positive the response. Welch’s t-test was applied to examine the statistical significance for the pre- and post-questionnaire surveys.
The results of the t-test are shown in Figure 3. In 19 out of 26 items, significant improvement of learning effect was confirmed. In particular, the learning evaluation of items (f), (h) and (k) improved remarkably. These items pertain to the relevance of disaster prevention and learning outcome based on information technology and the science. Regarding the items (b), (d), (m), (n), (p), (s) and (t) for which no significant difference was observed, the average value of the pre-questionnaire surveys is close to 4. This means that many students already obtained the knowledge and had the experience. Furthermore, there was no item whose average value in post-questionnaire survey responses was lower than in pre-questionnaire survey responses. A learning effect for the developed science, technology and disaster prevention education was established.

Table 2. Learning evaluation items

<table>
<thead>
<tr>
<th>Item</th>
<th>Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Are you interested in learning about “land formations and changes” in science classes?</td>
</tr>
<tr>
<td>b</td>
<td>Are you interested in “information technology” that you learn about in technology classes?</td>
</tr>
<tr>
<td>c</td>
<td>Do you think that what you learned in science classes relates to what you learned in technology classes?</td>
</tr>
<tr>
<td>d</td>
<td>Are you interested in earthquakes?</td>
</tr>
<tr>
<td>e</td>
<td>Are you interested in volcanic activity?</td>
</tr>
<tr>
<td>f</td>
<td>Do you know the term “epicenter”?</td>
</tr>
<tr>
<td>g</td>
<td>Do you know the term “seismic intensity”?</td>
</tr>
<tr>
<td>h</td>
<td>Do you know the term “magnitude”?</td>
</tr>
<tr>
<td>i</td>
<td>Are you interested in “disaster prevention” intended to prevent disasters caused by earthquakes or volcanic activities?</td>
</tr>
<tr>
<td>j</td>
<td>Are you interested in studying “disaster prevention” by investigating the amount of the topography change due to volcanic activity or earthquake?</td>
</tr>
<tr>
<td>k</td>
<td>Are you interested in “disasters” caused by changes in terrain due to a volcanic activity or earthquake?</td>
</tr>
<tr>
<td>l</td>
<td>Do you know the term “latitude”?</td>
</tr>
<tr>
<td>m</td>
<td>Do you know the term “longitude”?</td>
</tr>
<tr>
<td>n</td>
<td>Are you interested in observing the Earth’s surface using artificial satellites?</td>
</tr>
<tr>
<td>o</td>
<td>Do you know the term “remote sensing”?</td>
</tr>
<tr>
<td>p</td>
<td>Do you know the term “radio waves”?</td>
</tr>
<tr>
<td>q</td>
<td>Do you know the term “radar”?</td>
</tr>
<tr>
<td>r</td>
<td>Do you know the term “synthetic aperture radar (SAR)”?</td>
</tr>
<tr>
<td>s</td>
<td>Are you interested in observation images of the Earth’s surface obtained by artificial satellites?</td>
</tr>
<tr>
<td>t</td>
<td>Have you ever used a map service via the Internet?</td>
</tr>
<tr>
<td>u</td>
<td>Have you ever displayed Earth observation images on the online map service?</td>
</tr>
<tr>
<td>v</td>
<td>Are you interested in a digital globe?</td>
</tr>
<tr>
<td>w</td>
<td>Have you ever used the digital globe to display an Earth observation image?</td>
</tr>
<tr>
<td>x</td>
<td>Have you displayed image data using drawing software?</td>
</tr>
<tr>
<td>y</td>
<td>Have you edited image data using drawing software?</td>
</tr>
<tr>
<td>z</td>
<td>Do you know the term “image data format,” also known as JPEG?</td>
</tr>
</tbody>
</table>

Figure 6. Comparison of pre- and post-questionnaire surveys shown in Table 2 where * indicates that it is significantly improved as a result of the t-test
4. CONCLUSION

We have presented the teaching guidance plan and materials to perform the science, technology and disaster prevention education using SAR data as the Earth observation results. As a result of practice classes conforming to the developed teaching guidance plan, it was revealed that secondary school students could execute interferometric SAR processing using professional software for remote sensing. They could read the produced the ripple images and correctly examine the topographic changes. They were also able to learn about disaster prevention through interpretation of processed results. Based on the results of statistical analysis of the pre- and post-questionnaire surveys, the learning effect was clarified. In the future, highly effective teaching materials will be developed, and the learning guidance plan and worksheets will be reviewed and improved.

ACKNOWLEDGMENT

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STUDY ON COUNTRY-BASED FLOOD RISK INDEX USING EARTH OBSERVATION DATA

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KEY WORDS: country-based, flood risk index, earth observation, satellite data

ABSTRACT:
The frequency and severity of flood disasters has been increasing around the globe. Therefore, it is needed to evaluate and compare the risks among different countries and regions and to use the results of such analysis as a guide in formulating policy and countermeasures to prevent disasters and mitigate their impact.

In this study, we categorized flood risk into four dimensions (exposure, basic vulnerability, soft countermeasures, and hard countermeasures) and used this categorization to calculate the flood risk for individual countries. We developed a methodology to compute Flood Risk Index by using global datasets combined with satellite remote sensing data, such as a Global Precipitation Measurement data and identified flood risk factors in different countries.

The examples of the study’s outcomes are as follows.
- Many of the countries with high flood risk are located near the equator in Southeast and South Asia. In these countries, the greatest contributing factor to high flood risk is increased hazard due to high precipitation.
- Although Japan has a high hazard score due to high precipitation, flood risk remains relatively low thanks to high coping capacity scores stemming from factors such as the country’s high literacy rate.

The significance of this study lies in the fact that we were able to collect, use, and analyze global monitoring data (from satellites and space-based radar) that contain flood-related data for developing countries, for which such information is scarce, as well as the fact that we were able to use these data to evaluate flood risk for different countries around the world by a consistent methodology. In addition, we demonstrated that the use of satellite data, which can be continuously collected, is an effective method for analyzing changes in flood risk over time. It is expected that the results of this study will be useful in the formulation of flood management policy.

1. INTRODUCTION

1.1 Background
Damage caused by flooding, drought, torrential rains, and other water-related disasters (in this paper, all calamities related to water—including flooding, drought, and coastal erosion—are collectively referred to as “water-related disasters”) has continued to increase in recent years, with countries in Asia and the Pacific witnessing a particular increase in the severity of such disasters (ICHARM, 2018). Of the thousand most severe natural disasters between 1900 and 2009, 88% were water-related, making water-related disasters the most common type of disaster in the 20th century (ICHARM, 2018). In response to the continuing increase in the frequency and severity of water-related disasters around the globe, much research is being conducted to evaluate and compare the risks among different countries and regions and to use the results of such analysis as a guide in formulating countermeasures to prevent disasters and mitigate their impact. As examples, a study reported in Asian Water Development Outlook (AWDO), a publication of the Asian Development Bank (ADB), develops and uses an indicator of water-related disaster risk to quantitatively evaluate the risk of water-related disasters in Asia Pacific countries (Imamura, 2013); another study shows the change over time (2005–2014) in risk of water-related disasters in Japan (Ito, 2017); and another study categorizes flood risk into four areas (exposure, basic vulnerability, soft countermeasures, and hard countermeasures) and uses this categorization to calculate the flood risk for individual countries.

1.2 Objectives
Although much research has been conducted on flood risk, the following limitations and challenges remain (Fujioka, 2017).
- Although research has been conducted on flood risk in specific regions (such as Asia and the Pacific) and countries, including the change over time of flood risk in specific countries, few studies have attempted to quantitatively evaluate flood risk in countries around the world using a consistent method.
- Some data needed to evaluate flood risk are not available for developing countries.
- All factors used for risk assessment are weighted equally. Few studies have attempted to assign appropriate
weights to different factors.

To address these limitations, in this study, we attempted to perform multifaceted flood risk assessment by introducing new sub-indicators derived from earth observation data. For example, we aggregated precipitation data acquired from a global precipitation measurement data product to generate weekly precipitation, number of days with precipitation in excess of 100 mm, and other data directly related to flooding. In addition, we calculated cumulative discharge from topography, which is a measure of water flow during precipitation events, and incorporated this into a Flood Risk Index (FRI).

2. METHODOLOGY

2.1 Calculation of the Flood Risk Index

The FRI used in this study is calculated by Equation (1) below to combine the five indicators listed in Table 1.

\[
\text{Flood Risk Index} = \frac{\text{Hazard} \times \text{Exposure} \times \text{Vulnerability}}{\text{Hard Coping Capacity} \times \text{Soft Coping Capacity}}
\]  

Table 1 The five indicators used to construct the Flood Risk Index

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard</td>
<td>Indicates the magnitude of natural phenomena that are the cause of water-related disasters based on precipitation, etc.</td>
</tr>
<tr>
<td>Exposure</td>
<td>Indicates the population and area affected by water-related disasters based on population growth rate, etc.</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Indicates vulnerability to water-related disasters based on the poverty rate, deforestation rate, etc.</td>
</tr>
<tr>
<td>Hard Coping Capacity</td>
<td>Indicates the ability to cope with water-related disasters through hard countermeasures based on gross reservoir capacity, etc.</td>
</tr>
<tr>
<td>Soft Coping Capacity</td>
<td>Indicates the ability to cope with water-related disasters through soft countermeasures based on literacy rate, school attendance rate, etc.</td>
</tr>
</tbody>
</table>

The indicators listed in Table 1 are constructed from subindicators that are normalized by expressing them as a percentage of the difference between maximum and minimum values, as shown in using Equation (2).

\[
(\text{Subindicator}(i)) = \frac{x_i - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}}
\]

Here, \(x_i\), \(x_{\text{min}}\), and \(x_{\text{max}}\) are, respectively, the subindicator value for a given country, the maximum across all countries of the subindicator, and the minimum across all countries of the subindicator. Principal component analysis (PCA) is performed on the normalized subindicators to assign a weight \(w_i\) to each subindicator. Indicators are calculated by summing the weighted subindicators as seen in Equation (3).

\[
(\text{Indicator}) = \sum_{i=1}^{n} w_i \times \text{Subindicator}(i)
\]

That is, the indicators are calculated using Equation (3) to sum the constituent subindicators, which are obtained using Equation (2) and weighted according to results of PCA. The FRI is calculated by inputting the values of these indicators into Equation (1).

2.2 Earth observation data sets

In this study, we obtained precipitation data for developing countries and other regions for which sufficient precipitation is unavailable by using GSMaP6) data product, which is global precipitation distribution data generated by multiple satellites. The data product contains global precipitation data between 60° latitude north and 60° south at a resolution of 0.1° × 0.1°. Each record item contains the latitude, longitude, and precipitation. Of the available GSMaP data, we used daily precipitation data generated from hourly precipitation re-analysis data corrected by surface rain-gauge data. Because the re-analysis data are updated irregularly, in this study, we used data for the 13-year period from January 2001 to February 2014, for which re-analysis data are currently available. From these data, we extracted daily precipitation data for individual countries, weekly maximum precipitation, number of days with precipitation in excess of 100 mm, and other data more likely to be directly related to water-related disaster risk, which we used to calculate the FRI.

2.2.2 New subindicators generated from earth observation datasets

Numerous global monitoring data sets are available from the United States National Aeronautics and Space Administration (NASA) and other space agencies. In this study, we selected data related to water-related disaster risk and included five sets of satellite or space-shuttle-borne radar as subindicators of water-related disaster risk (see Table 2).
### Table 2 New subindicators included in this study and reasons for their inclusion.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Subindicator</th>
<th>Reason for employing</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>Land share with slope (\leq 0.05^\circ) (%)</td>
<td>Water flowing into areas with low slope during precipitation events is not easily drained and readily causes flooding. A country’s water-related disaster risk increases with increasing share of land with low slope.</td>
<td>SRTM30 (NASA)</td>
</tr>
<tr>
<td>Population growth rate (%)</td>
<td>The number of people and amount of property exposed to hazard and subject to risk increases with increasing population growth rate.</td>
<td>SEDAC (NASA)</td>
<td></td>
</tr>
<tr>
<td>Land cover classification (score)</td>
<td>Land cover is classified (assigned a score) based on the magnitude of risk during flooding. The higher the score, the higher the risk of water-related disaster attributable to the country’s land cover.</td>
<td>ENVISAT (ESA)</td>
<td></td>
</tr>
<tr>
<td>Soil moisture (kg/m³)</td>
<td>Soil moisture level impacts the soil’s water retention function. The higher the moisture level, the faster and greater the magnitude of discharge (i.e., the greater the flood risk).</td>
<td>GLDAS (NASA)</td>
<td></td>
</tr>
<tr>
<td>Average cumulative discharge (number of cells)</td>
<td>Cumulative discharge reflects the topographic features of a given area and indicates the degree of concentration of water flow. Average cumulative discharge can be used to evaluate the degree to which flow is concentrated in a given country as a whole. The higher the number, the greater the concentration of flow, the greater the tendency for overflowing, and the greater the risk of flooding.</td>
<td>SRTM30 (NASA)</td>
<td></td>
</tr>
</tbody>
</table>

### 3. RESULTS AND DISCUSSION

#### 3.1 Countries assessed

Some countries were entirely or partially outside the area covered by the GSMaP data used in this study (60°N–60°S). Accordingly, we performed water-related disaster risk assessment for the 120 countries having at least 70% land area represented in GSMaP data.

In this study, we added new subindicators generated from earth observation data to existing subindicators, updated data sources, and assigned weights to subindicators according to the results of PCA to calculate the FRI.

Figure 3.1 is a map of FRI scores calculated in this study for countries around the world. It can be seen that there are many countries with high flood risk located near the equator in Asia, Central America, and South America. Among these, many countries with especially high flood risk are located in Southeast Asia or South Asia. The map also reveals that, overall, countries with high precipitation have high flood risk. Southeast Asia has been identified as a region in which damage from water-related hazards is increasing at a striking rate. The FRI developed in this study appears to reflect this trend. In contrast, countries in Europe and southern Africa have relatively little precipitation and, hence, are subject to few hazards. Flood risk in European countries is even lower due to their high coping capacities, both hard and soft. Further, although advanced countries such as Japan typically have higher hard coping capacity and soft coping capacity than developing countries, the map classifies some of these countries as having a relatively high FRI. This is because these countries have high precipitation and, thus, are subject to more frequent and more severe hazards.

![Figure 3.1 Map of Flood Risk Index](image)
After grouping the 120 countries for which flood risk was evaluated in this study into seven categories according to the regional classification scheme used by the World Bank (advanced countries, Africa, East Asia and the Pacific, East Europe and Central Asia, Latin America and the Caribbean, the Middle East and Northern Africa, and South Asia), we compared flood risk in these regions. Figure 3.2 presents the results of regional comparison for the 120 countries. In this study, the “advanced country” category is defined by membership in the Organization for Economic Cooperation and Development (OECD).

As can be seen in Fig. 3.2, South Asia, East Asia and the Pacific are regions with countries having especially high FRI values. This reflects the trend of increasing severity of water-related disaster damage observed, particularly in Asia.

Meanwhile, the average FRI value for Africa as a whole is very close to that of advanced countries. This is because countries in Africa are split into two dissimilar groups. One group, containing countries such as Kenya and Gabon, is located near the equator with high FRI scores due to high hazard or low coping capacity scores; the other, including countries such as South Africa and Swaziland, is located south of the equator and has low FRI scores.
The radar chart in Fig. 3.3 shows the normalized scores for indicators making up the FRI, averaged by region. According to Fig. 3.3, in advanced countries, although the hazard is slightly higher than other indicators, all five indicators are relatively low. The high coping capacity and low scores for other indicators result in low FRI scores. The chart also indicates that Africa has higher vulnerability and lower coping capacity than other regions. However, because precipitation is low in Africa as whole, the hazard is low, resulting in a low FRI score. Although exposure is high in the East Europe and Central Asia and Middle East and Northern Africa regions, the FRI score is quite low because the hazard score is especially low in these two regions. From this, it can be seen that the hazard score, which is constructed from subindicators such as 2-week maximum rainfall, has a substantial impact on the FRI.

Figure 3.4 above shows the relationship between the hazard and FRI scores for 120 countries. These scores are strongly correlated ($R^2 = 0.81$).

From Fig. 3.4, it can be seen that Japan, which exhibits the greatest residual with respect to the regression line among countries lying below the regression line, has a relatively low FRI score despite having a high hazard score. Japan’s low FRI score is the result of the high hazard score being offset by a high soft coping capacity score, reflecting factors such as the country’s high literacy rate, along with low exposure and vulnerability scores. In contrast, Pakistan and India lie above the regression line and have especially large residuals. These two countries have high exposure and vulnerability scores, with the exposure being particularly affected by the land cover class and soil moisture content and the vulnerability being substantially affected by the Corruption Perception Index (CPI).

Furthermore, although Mongolia should be expected to have a low FRI score due to its low precipitation and aridity, according to Fig. 3-4, the hazard score and, consequently, the FRI score are high. In fact, Mongolia experienced a massive flood in July of 2009 after a period of 40 years without one. This flood impacted over 2,000 households and caused 24 deaths. The study of Fujioka et al used biennial rainfall data and were not capable of capturing such a flood risk. However, the GSMaP data used in this study provided continuous rainfall data and proved to be well-suited for capturing such a flood risk.

Figure 3.5 below shows the relation between FRI score and the number of water disaster-related deaths per 10,000 population as well as per capita GDP. Mortality data were acquired from EM-DAT and covered the 20-year period from 1996 to 201622). Per capita GDP is indicated by the size of the circle. Mortality per 10,000 population was found to be not correlated with FRI score ($R^2 = 0.0648$).
The countries circled in yellow (dotted line) have both high FRI score and high water-related disaster mortality and are known for being substantially affected by flooding. Countries such as India and Bangladesh in South Asia have experienced increasingly severe damage due to floods caused by torrential rains during the monsoon season. The flood that occurred in August of 2017 caused over 1,400 deaths, making it one of the biggest water-related disasters in South Asia in the last two decades (Earth catastrophe review, 2018). It is also evident that countries with high FRI scores tend to have low per capita GDP. In such cases, the lack of funds to develop infrastructure and adequately implement disaster countermeasures is reflected in increased FRI score and increased water-related disaster mortality.

Many of the countries with low FRI scores circled in green (dotted line) are countries with high per capita GDP. It can be seen that countries with high per capita GDP also have low water-related disaster mortality. This indicates that countries with high income invest in infrastructure and education and thus tend to be able to implement effective disaster countermeasures.

At the same time, there are advanced countries, such as Japan and Australia, that have relatively high FRI scores despite having high per capita GDP. In these cases, the FRI scores are elevated by high hazard scores, which are a reflection of factors such as the 2-week maximum precipitation. Mortality is kept low in these countries by the high hard and soft coping capacity scores, which reflect these countries’ economic strength. However, the FRI results suggest that these countries could sustain substantial damage if a massive flood were to occur, even though they are advanced countries.

4. CONCLUSIONS
In this study, we improved the existing FRI by using earth observation data and to identify flood risk factors in different countries. The main outcomes of the study are as follows.

- Many of the countries with high flood risk are located near the equator in Southeast and South Asia. In these countries, the greatest contributing factor to high flood risk is increased hazard due to high precipitation.
- Although Japan has a high hazard score due to high precipitation, flood risk remains relatively low thanks to high coping capacity scores stemming from factors such as the country’s high literacy rate.

The significance of this study lies in the fact that we were able to collect, use, and analyze earth observation data (from satellites and space-based radar) that contain flood-related data for developing countries, for which such information is scarce, as well as the fact that we were able to use these data to evaluate flood risk for different countries around the world by a consistent methodology. It is my hope that the results of this study will be useful in the formulation of flood risk management and policy.

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PERMANENT AND TEMPORARY HAZARDS IN SYRIA AND ITS STUDY 
USING SPACE DATA

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KEY WORDS: Disasters, Desertification, Earthquakes, Pollution, Maps

ABSTRACT: The objective of this research aims to identifying the Hazards that are affected by the Syrian lands, which can lead to serious disasters. I have been classified it in to 2 types:1- permanent Hazards, as: - Earthquakes, associated with faults of Arabian Rift Zone, - Desertification and Land degradation, associated with Drought and Human activity, - water, air and soil Pollution, associated with industrial facilities, transportation, agricultural activity and oil pollution.

2-Temporary Hazards, as: -Dust and windstorms, -Forest Fires, -Snowstorms, -frost, -heavy rain, - extremes temperature, -Floods, -Landslides.

The research also focuses on "studying and monitoring these risks using space data and field Studies, we used in our research, data of next Satellites, Earth Observation Satellites - Navigations Satellites - Meteorological &weather satellites, for mitigation of these Hazards and disasters, As a result, we have prepared many maps of different scales, which illustrate the locations of these risks and determine their degree of seriousness, especially for Earthquakes, Desertification and Land degradation, pollution, Forest Fires.

Conclusions: This research confirms the permanent and temporary risks on Syrian lands and shows that the integration of space data and field investigations is the best way to study these phenomena, evaluate and mitigate their effects.

1-INTRODUCTION

A hazard is an event, or its potential, that threatens to cause damage and disruption for a particular area at a certain time threatening lives, livelihoods, property, infrastructure and the natural environment, as well as normal socio-Economic operations. An important distinction to note is that, whilst hazards act as catalysts for disasters, it is not inevitable that one should lead to the other.(Rukieh, 2016).

Hazards by their origins broadly divided in to tow main types, Natural and Technological or Industrial Hazards. The dynamics involved measures the two as either slow or rapid onset. Hazards can originate from a single source or a combination, and can gradually emerge in a sequential pattern of slow and fast phase. Over the past decades, the Hazards led to the frequency of natural disasters, which has grown significantly worldwide. In fact, many countries are vulnerable to a wide variety of natural, technological, and willful hazards and disasters. Syria is not isolated from the rest of the world and neighboring Countries, when it comes to the effects and impacts of these hazards and disasters.

Our studies classified Hazards in Syria in to 2 types: 1- permanent Hazards, as: - Earthquakes, associated with faults of Arabian Rift Zone, - Desertification, Land degradation, associated with Drought and Human activity, - water, air and soil Pollution, associated with industrial facilities, transportation, agricultural activity and oil pollution.

2-Temporary Hazards, as: -Dust storms, -Forest Fires, -Floods, -Snowstorms, -frost, -extremes temperature, -Landslides -heavy rain.

I focused in this paper, also on "studying and monitoring these risks using space data and field Studies, especially, data of Earth Observation Satellites - Navigations Satellites and Meteorological &weather satellites, for mitigation of these Hazards and disasters,

As a result, we have prepared many maps of different scales, which illustrate the locations of these risks and determine their degree of seriousness, especially for Earthquakes, Desertification and Land degradation, pollution, Forest Fires.

2-SYRIAN HAZARDS

I classified Hazards in Syria in to types: 1- permanent hazards, its Includes, Earthquakes, associated, With faults of Arabian Rift Zone, and Collision Zone between the Arabian plate and the Eurasian plate - Desertification, Land degradation, associated with Drought and Human activity, - water, air and soil Pollution, associated with industrial facilities, transportation, agricultural activity and oil pollution.
2--Temporary Hazards, which include: -Dust storms, -Forest Fires, -Floods, -Snowstorms, -frost, -extremes temperature, -Landslides and - heavy rain.

3- RESULTS AND DISCUSSION

3-1 Earthquakes Hazards

Earthquakes Hazards in Syria related with: 1- risk of faults of Arabic rift zone, which starts from the red sea in the south, it extend to the north through the Gulf of Agaba, the Dead sea, Tabaraya lake and Lebanese Bekaa, consequently through the rift of Alghab in Syria, as far as Turkish bonders and Iskendarun regions along about 1100 km with branch of the Palmyride fold belt in Syria, the rift faults are considered left lateral displacement with vertical movement in different sites. (Rukieh 2016), 2-The Collision Zone between the Arabian plate to the south and the Eurasian plate (under the Anatolian plate-Tourous, Zagarous orogenic belt) from the north. (Rukieh 2009)

3-1-1 Active Faults: Neotectonic Map of Syria which prepared by us using space and remote sensing data, (Rukieh, et al 2005) shows that the active faults in Rift zone, Syria and adjacent territories are the main sources of seismic, volcanic and other geological hazards. Fig.1, demonstrates major active and weakly active faults in Syria and adjacent territories. We qualify as active faults those with the evident Late Quaternary offsets and qualify as weakly active faults those with the evident pre-Late Pleistocene offsets and weak and interrupted manifestations of the Late Pleistocene and/or Holocene activity. Majority of the faults of these two groups are situated in the rift Zone in west of Syria.


The main active Faults related with Hazards of Earthquakes in Syria are:
1- The Levant fault zone 2- The Rashayya and Serghaya faults
3-The St. Simeon fault 4-The Roum fault and its northern offshore continuation
5-The southwestern termination of the East Anatolian fault zone 6-Damascus fault
7-Latakia fault zone 8-Aafrin fault 9-Olab fault 10-Ein Qita fault
3-1-2. The link Between the Faults Determined From Space Images and Epicenters of Earthquakes in Syria and the Arabic Rift: The link between Tectonic scheme for Arabic Rift scale 1/4 million prepared by interpretation of space images (Rukieh, 2009) and Epicenters of earthquakes, which happened in the region, between 1910 and 2001, magnitude ranging between 3.5 and 6.5 degrees exceeded the number Hundreds, showing certain relationship between the centers of earthquakes and faults, as shown in Figure (2) and through this figure we can observe that the earthquakes that have occurred in the southern part of the Rift until the Hula Valley is an average and weak except one earthquake and mostly associated with Rift and its nearby branches, while in the northern part of the Rift (Syria), we note that some of these earthquakes associated with faults branching from the Rift towards the north-east and compatible with chains Palmyride (faults Rashayya, Serghaya, Damascus, North and South Palmyra and Alolab Fault) and other part associated with Rift himself and the third part with the extended faults in the like Roum fault, while the fourth part is interlinked with the Latakia- Kalles Fault and its continuity in the sea, and it has happened four basic earthquakes, which reaches about 5.5 degrees. Others are located within the volcanic rocks. We can notice also that the percentage of medium-intensity Earthquakes increases in the northern part, while in the far areas from the Rift Valley the earthquakes are absent.

Figure 2. Tectonic scheme for Arabic Rift system by interpretation of space Images and Epicenters Earthquakes, had happened 1910-2001 (Rukieh 2009)

3-2. Drought, Desertification and Land Degradation Hazards

Syria lies between latitudes 32° 19' and 37° 20’N, longitudes 35° 45’ and 42° 25’E; an Arab country in west Asia along the eastern Mediterranean, with a total area of 185100 km², and a population of around 23 million. The Badiya area in Syria is generally characterized by dry and harsh climatic conditions and limited natural resources including water, soil and the vegetative cover. The water resources are scarce and the rainfall is low and irregular. The region experiences frequent drought, Especially in the years of 2006-2011, drought that created one of the biggest humanitarian crisis Syria. The degradation of soil, vegetative cover (rangelands and forests) and biodiversity, together with the climatic changes, human interference and sand encroachment, lead to land degradation, spread of desertification and a decrease in agricultural productivity (ACSAD, 2004). According to the UN, 80 percent of Syria is susceptible to desertification, defined by FAO as "the sum of the geological, climatic, biological and human factors which lead to the degradation of the physical,
chemical and biological potential of lands in arid and semi-arid zones, and endanger biodiversity and the survival of human communities. Three years of drought have destroyed crops and livestock, ruining the livelihoods of thousands of farmers and displacing some 300,000 rural families to cities. (Irin, 2010) Desertification in the country is quite common, and several programs are being followed by the Government to face that, in addition to the local authorities, there are ACSAD and ICARDA, both institutes are world renown for their focused research works on desertification and land degradation.

Land degradation in Syria, a serious threat in the country affecting large areas and a high percentage of the population. Of course, climate is the main natural cause for land degradation with more frequent droughts, increased impacts of wind erosion in the dry arid areas, and water erosion with torrential rain leading to furthering desertification, wood cutting and overgrazing. Inappropriate land use and urbanization add to the above. (Mohamad R. Khawlie 2008). The salinity problem is becoming quite serious in several areas. In fact, soil Salinization stands alone as a major cause for land degradation in irrigated areas, due to over-irrigation by flooding and the absence of adequate drainage systems. In the Euphrates River basin, some 10000 ha near Rakka were classified as “severely-affected”. It has been estimated that 3000 – 5000 ha of the irrigated lands go out of the agricultural use every year in Syria due to extreme Salinization. Table 1 below shows the extent of soil degradation in the country; with a total of about 1.1 million ha are moderately – or severely – degraded (Hamdallah, 2005).

Table 1: Relative extent of human-induced soil degradation in Syria (1000 ha) (Hamdallah, 2005).

<table>
<thead>
<tr>
<th>Type</th>
<th>Degree</th>
<th>Slight</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water erosion</td>
<td></td>
<td>902</td>
<td>127</td>
<td>29</td>
</tr>
<tr>
<td>Wind erosion</td>
<td></td>
<td>1210</td>
<td>380</td>
<td>30</td>
</tr>
<tr>
<td>Over blowing</td>
<td></td>
<td>11</td>
<td>267</td>
<td>130</td>
</tr>
<tr>
<td>Salinization</td>
<td></td>
<td>15</td>
<td>20</td>
<td>90</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2138</td>
<td>794</td>
<td>297</td>
</tr>
</tbody>
</table>

Some quantitative estimates made on the soil loss showed that in the Latakia province, the maximum annual soil loss under forest conditions ranged from 10 to 60 kg/ha, from 200 to 2550 kg/ha under burned forest, and could reach 960 to 3280 kg/ha in agricultural lands. An overall assessment of Syria concluded that more than 50% of the soils are extremely accessible to erosion. This was highlighted by the estimate that about 570 million tons of soil was lost from a single dust storm in the summer of 1987 (Hamdallah, 2005). The steppe in Syria occupies 10.2 million ha, 55% of the country, and is badly degraded.

3-2-1- Role of space Technology in Desertification Monitoring and Management: One important key to the solution of the problem of desertification, in order to combat it we need to make continuous monitoring. The use of the space technology to monitor desertification play big role—through their unique specifications, various kinds and different resolutions of Space Images. Desertification monitoring includes activities which are aimed at:

1-Assessment of current states of Desertification 2- Analyses of land degradation process 3- Selection of basic indications of desertification 4- Mapping of degraded land and other related natural resources 5- Evaluating the impact of land use changes 6 -Monitor and assign geo-indicators for bright and hot spots. Satellites which used for monitoring of Desertification are:

1-Meteorological & weather satellites 2- Earth Observation Satellites 3-Space Shuttle 4-Navigations Satellites (Rukieh, 2009). Different Landsat satellite images of different acquisition dates were used for the Normalized Difference Vegetation Index (NDVI) in 1991, 1995, 2001. As shown in figure 3, we noticed green in 1991 & 1995 while 2001 it was drought (Bannari et al., 1995) (Eryan, 2006).
Figure 3: Normalized difference vegetation index (green biomass index) over Syria reflecting degradation in Badiya areas – notice green in 1991 & 1995 while 2001 is drought

Our Studies In General Organization of Remote Sensing (GORS -Syria) by cooperation with European Union Under Project Cold- Improving Coastal Land Degradation Monitoring in Lebanon and Syria "Using Remote Sensing data,( Abed M., Rukieh M. 2004), we prepared Many thematic Maps for Syrian coastal Region with scale 1/ 200000 – 1/ 25000. One of these maps, Erosion risk map as showing in fig.(4 ) for northern part of the Area.

Figure 4. Erosion risk map for northern part of Syrian Coastal area (Abed M., Rukieh M. 2004)
3-3- Environmental Pollution

The Environmental Pollution is a permanent hazard to production and public health, which infect various areas in Syria, especially large cities. The city of Homs (150 km north of Damascus), the third Syrian city after Damascus and Aleppo, is one of the most polluted cities in Syria. Its environment suffers from the pollution caused by the spread of many factories such as nitrogen fertilizer, sugar, cement and others, as well as the presence of the oldest and largest oil refinery in Syria in this city. The pollution divided in to 3 types: Air pollution, water pollution, and Soil pollution.

3-3-1 Air Pollution: The most important sources of air pollution in Syria are:
- Combustion of fossil fuels in transportation, domestic heating and industrial facilities,
- Rubbish burning, - Dust particles
Many Syrian cities are affected by gas emissions from different industries that do not take into account environmental considerations such as fertilizers, cement, thermal stations, oil industries, quarries, asphalt and others.
The measurements indicate that daily concentrations of total suspended particles exceed the World Health Organization limit (120 µg / m 3), ranging from 115 to 600 µg / m3 in most Syrian cities. It is very high in areas close to some industries, especially cement Factories.
Measurements conducted in some Syrian cities indicate a high concentration of sulfur, nitrogen and carbon oxides in some areas. The average SO2 concentrations in some locations in Damascus reached 0.245 parts per million, twice the allowable limit. And that the average concentration of (CO ) is between 2 and 20 ppm.
The daily average values of NO and NO2 in 2001 reached 0.3 and 1.2 ppm in Damascus and 0.5 ppm in Aleppo. As for the lead, measurements conducted in 2009 showed that the concentration of lead in Damascus air was 0.17 - 0.28 µg / m 3, while its concentrations were still high in some areas of Aleppo (1.5 µg / m3)., for other Metals such as copper, zinc and cadmium, their concentration in the population areas within the permissible limits (Ministry of environment 2012).
It is now known that there are many satellites that perform atmospheric monitoring for air pollution such as the Japanese GOSAT and the European ENVI SAT, the latest one is Sentinel-5P, which was launched in October 2017. It will provide measurements of: Ozone NO2 ,SO2 ,Formaldehyde , Aerosol .CO , (CH4) ,Clouds.
In recent years, spectrometric observations from satellites have been used to derive trends in troposphere NO2 (Lelieveld et al,2015). Strong upward NO2 trends have been reported for the Middle East, including the Eastern Mediterranean, coincident with very high levels of O3 especially in summer. The researchers used the Instrument (OMI), on Aura satellite program of the (NASA). Previous studies have derived significant upward NO2 trends from 2005 until about 2010 or 2011 over several cities in this region, for example, about 5 to 7%/year in Cairo, 2 to 8%/year in Tehran, 7 to 10%/year in Damascus, 10 to 20%/year in Baghdad, While, NO2 over Damascus and Aleppo decreased by 40 to 50% since 2011, (Lelieveld et al 2015) considered with the global war on Syria since that year.

3-3-2 Water Pollution: Water resources also face quality deterioration due to pollution coming from industries, over-irrigation, Agriculture activity, petroleum wastes, and untreated sewage water, Especially for Rivers, Lakes and some Sprigs.
The results of the monitoring campaigns carried out by some Ministries and Agrarian Reforms have proved the pollution of surface and groundwater with sewage, industrial and household water in many areas. In the Orontes River, the values of ammonia, suspended particles and POD exceeded the limits and standards for river water specifications in the lower part of the river,. In the Saguor River near Aleppo, exceed the concentrations of nitrates and ammonia Syrian Standard. (Shebli M. 2010)
For the groundwater in the coastal area, It has shown results Analysis of some surface wells used as a source of drinking water, High concentration of nitrates and ammonia due to contamination of sewage water and the use of fertilizers. Salinity in the water of some wells in Damsarho area is also due to sea water intrusion with fresh water.
Our Geoenvironmental studies for Damascus and Southern area of Syria using remote sensing data (Rukieh et al, 2000) shows, that the water of Barada River Highly polluted, Especially in the part that passes through Damascus city and in the Ghota of, Damascus. It has Two groups of contaminated organic elements and compounds were identified in surface water used for irrigation: Group 1: Phosphorus, nitrate, nitrite and ammonia. The source of this type of pollution is the dumping of
industrial and health waste. This creates conditions for the growth of microorganisms, including germs that can lead to infection. Group 2: Contains chlorite, hydrocarbons and calcium electrolytes, which exceeded standards in more than 80% of the samples, especially in the lower part of the Barada river. The concentrations of nitrates in some wells in the Damascus Gota exceed the permissible limits for drinking water. There are also Concentrations very high of heavy metals such as Cd, Pb, Zn, Cu, Cr, Sn, etc.. in the triple chromium They reached 10 mg per liter in the Dai'ani River and to a maximum of 10 times the permissible value in wells in the Zablatani area near Damascus.

Domestic wastewater is the main cause of pollution in villages and rural areas. Most Syrian cities have started to establish efficient systems for the collection and transportation of wastewater. The start of operation of treatment plants in Damascus, Aleppo, Homs and Salmiya cities, has alleviated the bacterial and chemical contamination of surface and groundwater in these areas. A new study (Mckernan 2017) has found that the civil war in Syria has had a drastic effect on rivers and fresh water resources in both Syria and neighboring Jordan.

3.3. Soil Pollution: Soil pollution in agricultural land is one of the major environmental problems. By non systematic observation, some major areas of pollution have been identified, including: Areas surrounding Homs: Soil contamination from chemical industry residues is a major problem because it occurs in an environmentally sensitive area, where soil permeability leads to the possibility of a spillover of pollutants into the shallow reservoir used as a source of drinking water. The areas near Aleppo: The results of the analysis of vegetables that irrigated with the water of the Quaiq River contaminated the presence of high concentrations of arsenic beyond the permissible limits. Our survey for areas around Damascus shows High concentrations of organic materials and heavy minerals in the soil and elements of Pb, Cd, Cr and As in the plantations at Al Ghota.

The integration between space data and field works gave optimal results to identified pollution in the Soil, as we applied in geoenvironmental mapping in Damascus and south Syria (Rukieh et al, 2000)

3.4-- Temporary Hazards

3.4---1. Dust Storms: Dust & sand storms are very dangerous phenomena which occur widely in the North East regions of Syria (Syrian Badiya), sometimes coming from other Countries, like Iraq, Egypt and Saudi Arabia . The dust storms impacted agriculture, disrupted transportation, and affected people's health and livelihoods. These storms can be easily monitored by satellite imagery, which includes those images collected by the Geostationary Operational Environmental Satellite (GOES), Land sat, TM Images, Sensor (WiFS), Sensor (SeaWiFS), (AVHRR) and (MODIS), (Pat S. Chavez, Jr., David J. et. all.2002, Rukieh M. 2009).

Dust activity increases in March and April, peaks in June and July and weakens in September (Shao, 2008). In 2015, an unprecedented dust storm hit Syria and Iraq. It is believed that this storm was caused by the increased erosion in Syria due to the civil war and the prolonged drought, or it is probably to be made by the great countries through a HARP project. The Figure (5) shows Dust storm Extend From Saudi Arabia to turkey and Cyprus , Through Jordan and Syria By MODIS-Aqua September(28, 2011) (left)

Fig.5, Dust storm Extend From Saudi Arabia to turkey and Cyprus , Through Jordan and Syria By MODIS-Aqua September(28, 2011) by NASA (Left). Dust over Syria and Iraq, The (MODIS) on NASA’s Terra satellite captured this image on June 18, 2010. (Right)
While in the right, shows the Dust from Syria blows along the course of the Euphrates River into Iraq in this natural-color image from June 18, 2010. The dust appears to be coming from salt pans or dry lakes in northern west Syria, west of the Euphrates River. Salt pans are among the most frequent sources of wind-blown dust in the world.

3-4-2- Forest Fire: The area of forests in Syria is about 520 thousand hectares, of which 230 thousand hectares are natural forests and the rest are artificial forests most of them located in coastal mountains.

3-4-2-1 Causes of fires in Syria - The climate is the main factor in Mediterranean forest fires in general, with long summers, low humidity and high temperatures. In addition to, wind, under these conditions, fires can start from any cause (cigarette, lightning, matchstick, etc.).

- Animal herders are an important cause of fires
- Farmers' use of fire to remove crop residues and reduce forest areas for agricultural expansion is one of the main causes of forest fires, where fires extend from farmland to neighboring forests.
- The indifference of smokers and holidaymakers who set fire to forests for food preparation accounts for about a third of forest fires.

- Other causes of fire include: coal and lime industries, children, use of equipment, fishing spark. In short, the causes of forest fires in Syria are the result of human action.

Total burned forest areas in Syria (ha) 3802.226, (Latakia) 566.951, (Alghab), 1218.298 (Hama), 1096.45 (Idlib), 1184.50 (Tartous) (Ali M. 2008). In 2014, 1,200 fires were recorded in these forests and surrounding farmland, while the number of fires since the beginning of 2001 until the end of 2011 amounted to 1039 fires.

3-4-2-2 Remote Sensing Importance: Space borne remote sensing technologies have improved the capability to identify fire activities at local, regional and global scales by using visible and infrared sensors on existing platforms for detecting temperature anomalies, active fires, and smoke plumes. Geosynchronous satellites such as GOES and polar orbiting sensors such as NOAA AVHRR have been used successfully to establish calendars of vegetation state (fire hazard) and fire activities. Other satellites with longer temporal sampling intervals, but with higher resolution, Such as Landsat, Ikonos, Quick bird, Geo-eye and SPOT, Indian, Russian Chinese satellites and space borne radar sensors, deliver accurate maps of active fires, vegetation state and areas affected by fire. As we see in fig. 6, Quick bird Space Images which show forest land in Syrian basset area before and after forest fire in this area in 28/10/ 2004, which excess of 30 km2

Providing an effective response to wild land fires requires four stages of analysis and assessment (P.S.Roy 2004)
1- Determining fire potential risk
2- Detecting fire starts
3- Monitoring active fires
4- Conducting post-fire degradation assessment, Space techniques are used at all these stages.

Fig. 6, Quick bird Space image shows situation of Basset forest in Syria before and after fire happened in 28/10/2004. (30 km2)

3-4-3 Floods: Floods in Syria are rare, often occurring in winter or spring in low places, after heavy rains, this year, floods occurred in several cities and rivers of Syria on 17 February and a major flood occurred in Damascus on 26 April as a result of heavy rains in a short time. On 10 May, a flood hit the streets of Banias city. Like these floods can observing by satellite images. The most important crisis happened in Syria, it was collapse Zayzoun dam in 03.06.2002, which we studied by space images. The (Fig.7 left) shows TM space Image to the Zayzoun dam before its collapse in 03.06.2002, where the right side, shows TM space image taken in 4-6-2002 after collapse the Dam, which has been identified clearly the submarine areas and affected land as a result of the collapse of the dam, which reached more than nine thousand hectares.
Fig. (7) TM Space Image of Zayzoun Dam Break in Syria – black in center (3 June 2002 before collapse, (left) TM image in 4-6-2002 after collapse, (right) show affected land reached more than 9000 hectares. Rukieh 2002

3-4-4 Snowstorms: Snowstorms happen usually in winter (12, 1, 2, months), sometimes in March and November, one time in the year or more, some years no one storms. One of the most important snowstorms in Syria over the last hundred years was the Great Storm of February 11, 1911, which lasted 40 days. The thickness of snow it was more than 2 m in streets of Cities and the temperature dropped to 10-27 degrees below zero and the water Euphrates River froze. It has even extended to Iraq, Jordan and Palestine, and many people died of hunger and cold.

The second major snow storm occurred on February 4, 1950, lasted 3 days, temperature was between 3 to 9 degrees below zero. The snow reached the Mediterranean, where the thickness of snow in Aka city on the sea was 55 cm.

We refer to some of the storms that have taken place in the last twenty years:

Storm in 25 February 2003, It was the strongest storm since 1950, according to historians. The thickness of the snow in the streets reached half a meter, accompanied by winds of up to 80 kilometers/hour, which led to the uprooting of some trees and the destruction of many protected agricultural houses, causing damage to most of its inhabitants.


3-4-5 Frost: Usually accompanied by snowstorms, before it or after, sometimes “frost can occur without snow in the winter months, especially at night and can last for 15 days and lead to a lot of losses, especially for farmers.

3-4-6 Extremes Temperature: Syria's continental and dry climate, in the inside of the country, moderate on the coast and in the western mountains; it is very hot in summer and in the day and cold in winter and night. In the heat waves, which happen in June, July and August, the temperature in Damascus exceeds 40 degrees and can reach 48 degrees in the north-eastern regions of Syria (the cities of Deir al-Zour, Hasakeh and Raqqa). Most related with global climate change.

3-4-7 Landslides: The landslides in Syria are a few and usually occur in the coastal mountains after heavy rains or heavy snow, and we find them most possible in the Basset region of Northwest Syria, we can monitor these slides by satellite images.

4- Conclusion

In Syria there are three major hazards (earthquakes, desertification and land degradation, and Environmental pollution). They must be studied by Space technologies, determined their location and
how to deal with them to avoid their disasters, which caused big losses in the economy and human development. In order to avoid the risk of earthquakes, must be designed an earthquake-resistant Buildings and kept away from the active faults in the construction of housing and economic facilities. There are also a number of temporary risks known as time of occurrence often, such as forest fires, dust storms, snowstorms, etc.. The integration of space data and field investigations is the best way to study these phenomena, evaluate and mitigate their effects and disasters.

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FLOOD HAZARD MAPPING IN THE FLOODPLAIN OF MALINGON RIVER, VALENCIA CITY, MINDANAO, PHILIPPINES

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KEYWORDS: flood hazard, mapping, modeling, GIS, LiDAR

ABSTRACT: Flooding becomes one of the most challenging natural calamities in the Philippines today risking the lives and properties of the affected communities. Loss of lives and livelihoods due to flood hazards made the government to consider the need of research aiming to mitigate flood impacts and to increase the level of awareness thereby creating more adaptive and resilient communities. This study involved the combined technologies of Geographic Information System (GIS), Light Detection and Ranging (LiDAR)-derived digital elevation model (DEM) and the families of hydrologic models like Hydrologic Engineering Center-Hydrologic Modeling System and -River Analysis System (HEC-HMS and HEC-RAS). The aim was to determine the amount and timing of precipitation-runoff relationships in the upstream watershed, and performing two-dimensional hydraulic calculation in the floodplain of Malingon River in Valencia City, Mindanao, Philippines. Models were calibrated and the generated flood hazard maps were validated using actual datasets gathered from the field. Maps for different scenarios like 2-year, 5-year, 10-year, 25-year, 50-year and 100-year return periods were generated. Statistical analysis of features like buildings and other infrastructures exposed to different level of flood hazards was likewise conducted. Output of the study served as important basis to a more informed decision and a science-based recommendations in formulating local and regional policies statements for more effective and cost-efficient management strategies relative to flood hazards.

1. INTRODUCTION

The Philippines is considered natural hazard hotspot with approximately 50.3% of its total area and 81.3% of its population vulnerable to natural disaster (Senate Economic Planning Office, 2013). There are 20 tropical cyclones entering the Philippine Area of Responsibility (PAR) per year which have the largest impact (ECHO, 2017; JICA, 2015). In the last two decades, losses and damages caused by flooding have drastically increased (Acosta et al., 2016). Typhoons Bopha in 2012, Haiyan in 2013, Hagupit in 2014, Koppu in 2015, and Tembin in 2017 are among of the worst and deadliest storms that hit the country losing thousands of lives, damaging millions of houses, and destroying multimillion agricultural areas and properties (Ellis and Gray, 2014; Hodal, 2014; Hanna, 2015; Acosta et al., 2016; Masters, 2017; Villamor, 2017).

With the dire need of mitigating the impact of rainfall-induced flooding, research efforts had been conducted as a response to urgent needs of assessing environmental risks in flood-prone areas. Flood risks and effects assessment is fundamental in identifying hazard-prone areas that need immediate measure for mitigation to prevent worse case scenarios to happen in the future. It can also help communities and local government units to be more effective in their attempts to identify adaptation strategies so that impacts of flooding can be minimized (Makinano-Santillan et al., 2015; Few, 2003). One of the most common techniques in assessing flood hazard and vulnerability is through numerical modeling and use of geospatial technologies (Costas et al., 2017). Flood damages may be quantified by intersecting flood layers with exposed population and land cover which was also done by several studies (Santillan et al., 2016). The utilization of this technologies and approaches using model simulation and satellite imagery made a faster-detailed monitoring and flood mapping (Yoshimoto and Amarnath, 2017; Jung et al., 2014; Huizinga et al., 2005).

Reliable numerical methods and innovative topographic survey techniques such as the use of LiDAR technology made modeling popular in flood hazard mapping (FEMA, 2012; McDougall and Temple-Watts, 2012). Numerical modeling in flood hazard mapping involves two components: the hydrologic simulation which determines the amount, duration and occurrence of flooding event; and the hydraulic simulation which determines the behavior of flood water in the floodplains utilized in flood mapping (USACE, 2008; USACE, 2015). The use of 2-dimensional (2D) approach in flood modeling which gives detailed description of the hydraulic behavior of the river’s flow dynamics is vital in understanding flood flow and provide detailed hazard mapping in the floodplains (Costabile and Macchione, 2015). In this study, the utilization of high spatial terrain and feature data from LiDAR technology
coupled with the medium-resolution land-cover information from Sentinel-2 images and 2D flood modeling approach were applied in flood hazard mapping of Malingon River. Simulation of different rainfall scenarios in 2-year, 5-year, 10-year, 25-year, 50-year and 100-year return periods were conducted and its flood impact to exposed ground features and land cover classes was determined.

2. METHODOLOGY

2.1. Location Map

Malingon River is located in Valencia City, Bukidnon in the island of Mindanao, Philippines (Figure 1). It lies between the coordinates of 7° 55’ 36.95” to 7° 59’ 20.67” north latitudes and 124° 56’ 0.61” to 125° 7’ 12.4” east longitudes with an average elevation of 673.37 meters above sea level and a total drainage area of 71.67 km². The climate is characterized by high relative humidity with rainy season lasting five to six months in a year (Rola et al., 2004). Flooding incidents due to overflowing of Malingon River and its tributaries occur almost every year, especially during the rainy seasons from the month of September to January. In 2011 and 2012, Valencia City was flooded due to typhoons Bopha (locally known as Pablo) and Washi (locally known as Sendong) which traversed the Bukidnon Province, respectively (NDRRMC, 2012).

2.2. Flow Chart

Hydrologic and hydraulic models were parameterized using satellite image of land cover and elevation models. The hydrologic model determines the amount of discharge or the rainfall-runoff relationship within the river basin while 2D hydraulic model simulates the behavior of water flows and precipitation into the river system and floodplain areas. The actual hydrologic data like rainfall and discharge were used to calibrate the hydrologic model. The accuracy of the hydrologic model was also examined. 2D hydraulic simulation was conducted using the calibrated hydrologic model which will create the flood depth grid. Depth grid was validated using validation points for accuracy test of the 2D hydraulic model in predicting floods. Flood simulations were then conducted for different rainfall scenarios. The flood depth grids were classified ranging from <0.5m, 0.50m to 1.50m, and >1.50m for low, medium, and high hazards, respectively. Overlay analysis were done using the extracted features from the digital surface model (DSM) to determine the number of exposed features. The process flowchart is shown in Figure 2.

Figure 1. Location map Malingon River

Figure 2. Process flow of flood hazard mapping
2.3. Land Cover Classification

The land cover data of Malingon Basin was derived through object-based classification of Sentinel-2 Level 1C satellite images downloaded from the USGS Earth Explorer. The satellite image was acquired last July 16, 2016. The image was preprocessed using “Sen2Cor” plugin in Sentinel Application Platform (SNAP) version 6.0, a tool which process the atmospheric-, terrain and cirrus correction of Top-Of-Atmosphere (TOA) Level 1C input data and converts TOA to Bottom-Of-Atmosphere (BOA) Level 2A products ready for image classification. SNAP is an application ideal for Sentinel-based data processing and analysis with improved extensibility, portability, modular rich client platform, generic data abstraction, tiled memory management, and a graph processing framework (STEP-ESA, 2018). The land cover classes were classified using object-based classification where the classes are segmented according to the color, texture, shape and Normalized Difference Vegetation Index (NDVI). The classified land cover classes underwent visual inspection to identify obvious misclassification and subjected to manual editing. Accuracy assessment of the classified land cover classes were applied using error matrix. The land cover map was converted to Curve Number (CN) grid for hydrologic model parameters and Manning’s n coefficient map for hydraulic model parameters.

2.4. Hydrologic Model Development and Model Calibration

The hydrologic model of Malingon River basin was created using Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) Version 4.0, an application which simulates the rainfall-runoff relationship in the watershed with existing condition. The HEC HMS model is composed of three components: the basin model which is the physical representation of the watershed, the meteorological model for the weather data, and a set of control specification indicating the time step and simulation period.

The basin model was developed using the 10-m Synthetic Aperture Radar Digital Elevation Model (SAR DEM) and predefined river networks for the delineation of watersheds; and was parameterized using the generated land cover map from Sentinel-2 image and soil information from the Bureau of Soils and Water Management (BSWM). The hydrologic data such as discharge data and rainfall data are primary inputs and necessary for the model simulation. The discharge data was gathered using automatic water level and velocity meter together with the river cross-section data at the Malingon Bridge; and the rainfall data from the pre-installed automatic rain gauge at the Barangay Lurugan, Valencia City which is an upstream of the Malingon River. The parameters of the hydrologic model were calibrated by fitting the simulated discharge hydrographs to the actual measured discharge. The actual hydrologic data gathered from December 10, 2017, 00:00 to December 14, 2017, 18:40 were utilized for the model calibration. The model calibration was evaluated using three measures of accuracy namely the Nash-Sutcliffe Coefficient of Model Efficiency (NSE), Percentage Bias (PBIAS), and the root-mean-square error (RMSE) – observations standard deviation ratio (RSR). These measures were computed by comparing the observed and the simulated hydrographs in accordance with existing evaluation guidelines for systematic quantification of accuracy in hydrological simulations (Moriasi et al., 2007). The hypothetical rainfall event simulations were applied using the Rainfall Intensity Duration Frequency (RIDF) data from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), shown in Table 1. RIDF is a set of information on the likelihood of an event to occur or referred as return periods with different rainfall amount and the duration. The RIDF of the Malaybalay PAGASA Weather Station was used for the hydrologic simulation of hypothetical scenarios in Malingon River.

<table>
<thead>
<tr>
<th>Return Periods (Year)</th>
<th>5 mins</th>
<th>15 mins</th>
<th>1 hr</th>
<th>2 hrs</th>
<th>3 hrs</th>
<th>6 hrs</th>
<th>12 hrs</th>
<th>24 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>9</td>
<td>21.4</td>
<td>47.8</td>
<td>63.7</td>
<td>73.5</td>
<td>90.2</td>
<td>103.4</td>
<td>112.8</td>
</tr>
<tr>
<td>5</td>
<td>13.4</td>
<td>34</td>
<td>78.4</td>
<td>100.8</td>
<td>114.3</td>
<td>130.2</td>
<td>143.2</td>
<td>153.6</td>
</tr>
<tr>
<td>10</td>
<td>16.3</td>
<td>42.4</td>
<td>98.6</td>
<td>125.3</td>
<td>141.4</td>
<td>156.7</td>
<td>169.6</td>
<td>180.7</td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td>52.9</td>
<td>124.1</td>
<td>156.3</td>
<td>175.5</td>
<td>190.1</td>
<td>202.8</td>
<td>214.8</td>
</tr>
<tr>
<td>50</td>
<td>22.7</td>
<td>60.8</td>
<td>143</td>
<td>179.3</td>
<td>200.9</td>
<td>214.9</td>
<td>227.5</td>
<td>240.2</td>
</tr>
<tr>
<td>100</td>
<td>25.4</td>
<td>68.6</td>
<td>161.8</td>
<td>202.2</td>
<td>226</td>
<td>239.5</td>
<td>252</td>
<td>265.3</td>
</tr>
</tbody>
</table>

Table 1: Values of the different hypothetical rainfall events based on local RIDF data.
2.5. Hydraulic Model Development

The 2D hydraulic model of Malingon River basin was created using the Hydrologic Engineering Center River Analysis System (HEC RAS) version 5.0, which is designed to perform one-dimensional (1D), two-dimensional (2D), or combined 1D and 2D hydraulic calculations for a full network of natural and constructed channels (USACE, 2016 as cited by Santillan et al., 2016). For this study, 2D modeling was performed. The 2D HEC RAS model was developed by creating a 2D flow area or domain representing the entire floodplain of the river basin, shown in Figure 3. The 2D flow area mesh of Malingon River basin has an approximate area of 39.84 km² and was computed using a 20-m by 20-m cell size with a total of 99,039 cells. The model consisted of four boundary conditions in which two are inflows representing the discharge from upstream rivers (J530 and J467 obtained from the HEC-HMS model), one as the normal depth condition near the outlet (a slope value for discharge distribution), and one boundary condition for the precipitation that falls to the 2D area as inputs into the HEC-RAS 2D hydraulic model to predict or estimate flood depths and extents. With the use of break lines or the abrupt changes in elevation which represents the roads and river banks, the 2D flow area was computed to create the computational mesh or cells. The 1-m resolution terrain model was used as the primary source of elevation data. Parameterization of the HEC RAS model utilized the land cover information by extracting the Manning’s roughness coefficients, and these values were used to calculate the hydraulic table properties of flood simulation area.

Figure 3. 2D model domain (floodplain) of Malingon River for HEC RAS

2.6. Flood Depth Generation and Hazard Classification

Each hydrograph represents the flow of water entering the 2D model domain, i.e., at the 2 inflow boundary condition locations. These simulated flow hydrographs together with the rainfall data were used by the unsteady flow analysis module of HEC RAS to dynamically simulate depth and extent of flooding. For each extreme rainfall event flood simulation, a spatially-distributed grid of maximum flood depths was created. The depth grid was then exported as a raster file in the GIS software and converted into flood hazards by categorizing depths to its corresponding flood hazard levels (Low Hazard: less than 0.50m, Medium Hazard: 0.50m to 1.50m, and High Hazard: greater than 1.50m).

2.7. Flood Validation Survey and Error Analysis

Flood validation survey was conducted to obtain flooding information from the local people through personal interview within the river basin whether they were flooded or not flooded in a certain typhoon event. For this study, Tropical Storm Sendong (international name Tropical Storm Washi) flooding information was gathered. It was also conducted to assess the accuracy of the Malingon HMS-RAS model in generating flood hazard maps by rebuilding historical events. Interpolated historical rainfall data of Tropical Storm Sendong in 2011 gathered from Butuan, Lumbia, Malaybalay, Cotabato, Davao and General Santos PAGASA station was utilized, since there were no available rainfall data within the basin at that time. The generated flood map from Tropical Storm Sendong was compared to the validation points gathered within the Malingon River basin.

The accuracy computation used the confusion matrix approach which compares model result against actual collected data (Marfai, 2003). Another accuracy measure used is the F-measure known as harmonic mean which determines the fitness of the simulated flood extent to the actual setting on the ground (Aronica, et al., 2002;
Horritt, 2006 as cited by Santillan et al., 2016). The root mean square error (RMSE) was also calculated to determine the error difference from the simulated flood depth and the actual gathered flood height in the field.

### 2.8. Feature Extraction

The ground features in Malingon River basin were extracted from the 1-meter spatial resolution LIDAR-derived DSM acquired by the University of the Philippines-Diliman (UPD) last 2016. These features refer to ground structures which consist of buildings or houses only. A total of 7,184 buildings were extracted within the 2D model domain of Malingon River floodplain shown in Figure 4. The extraction was aided with high-resolution satellite images from Google Earth and Google Street View, and validated using geo-tagged photos. Extracted buildings were utilized as a primary input for flood exposure assessment.

![Figure 4. Extracted building features within the 2D model domain of Malingon River](image)

### 2.9. Scenario Flood Simulation and Flood Exposure Assessment

Output hydrographs from calibrated HMS model of Malingon River using different rainfall scenarios were utilized as an input for the validated 2D RAS model together with land cover map for roughness coefficient. The generated flood depth grids were classified according to different flood hazards which repeat the process. The extracted features from the DSM and the flood hazard maps of different rainfall scenarios were utilized to flood exposure assessment. Overlay analysis were applied to determine the number of buildings exposed to flood hazards.

### 3. RESULTS AND DISCUSSION

#### 3.1. Land Cover Map

The land cover map of Malingon River was created using Sentinel 2 satellite image and classified into 6 categories: agricultural land, bare land, built-up area, forest, grassland and water (Figure 5). It has an overall accuracy of 96.7% and Kappa coefficient of 96.3%. The agricultural land is the dominant land cover within Malingon Watershed with 60.92% and followed by bare land or fallow area with 11.76%. This means that the watershed is agriculturally active of which the economy is more on agricultural production. Shown in Table 2, the area in square kilometers and percentage of each land cover class.

<table>
<thead>
<tr>
<th>Land Cover Name</th>
<th>Area (km²)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Land</td>
<td>43.66</td>
<td>60.92</td>
</tr>
<tr>
<td>Bare Land</td>
<td>8.43</td>
<td>11.76</td>
</tr>
<tr>
<td>Built-up Area</td>
<td>1.86</td>
<td>2.60</td>
</tr>
<tr>
<td>Forest</td>
<td>13.29</td>
<td>18.55</td>
</tr>
<tr>
<td>Grassland</td>
<td>4.40</td>
<td>6.14</td>
</tr>
<tr>
<td>Water</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>71.68</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>
3.2. Calibration of Hydrologic Model and Simulation of Rainfall Scenarios

Discharge data collected in Malingon Bridge and the rainfall data in Barangay Lurugan were utilized to calibrate the model. Calibration results of Malingon HEC HMS model is shown in Figure 6. The overall performance of the model was determined to be very good, with an NSE = 0.78, PBIAS = -8.62, and RSR = 0.46 based on the Moriasi et al. (2007)’s evaluation guidelines and model performance. This implies that the HEC HMS model of Malingon River can be used in simulating hydrographs using extreme rainfall scenarios. Shown in Figure 7, the resulting 24-hours simulated hydrographs within the inflows of J530 and J467 using the calibrated HEC HMS model and the different rainfall scenarios. The peak flow of the J530 is larger than the peak flow of J467, since the catchment area of J530 is larger than J467. This simulated hydrographs were utilized for flood simulation in HEC RAS model of Malingon River. The amount of rainfall return period is directly proportional to the amount of discharge within the two inflows with increasing trend.
3.3. Flood Validation and Error Analysis

Reconstruction of flooding extent during Tropical Storm Sendong was applied and utilizing the flooding information and validation points of the same event within the floodplain of Malingon River to determine the accuracy of the Malingon 2D HEC RAS model in generating flood hazard maps (Figure 8). Based on the confusion matrix analysis, the accuracy of the Malingon 2D HEC RAS model in simulating flood extent and depth is 80.5%, which implies that the model can generate any flood event from any rainfall event can be 80.5% accurate. The result in F measure analysis was 0.56, which means that the flood map generated by the models is an intermediate fit. The calculated root mean square error is 0.47 meters, indicates that the model over predict the flood depth estimation by 0.47 meters which is a good fit.

Figure 8. Flood validation points of Malingon River in Tropical Storm Sendong flood hazard map

3.4. Generated Flood Hazard Maps

After the Malingon 2D HEC RAS model passed the flood error analysis, the model utilized the simulated hydrographs and extreme rainfall values from the Malingon HEC HMS model to generate flood hazard maps in different return periods shown in Figure 9. The resulting flood extent increases as the return period also increases. The total area of the 2D model domain of Malingon River is 39.84 km$^2$. The 2-year return period has the smallest flooded area with 28.3% and accounts to 11.28 km$^2$. In addition, the 100-year return period, 60.67% of the 2D model domain total area was flooded which accounts to 24.17 km$^2$ and the largest area flooded (Figure 10). This means that the return periods (amount of rainfall) are directly proportional to the flood extents. All of the generated flood hazard maps are assumed to be an 80.5% accurate based on the error analysis of the flood map validation using Tropical Storm Sendong flood information.

Figure 9. Flood hazard maps of Malingon River in different return periods
3.5. Exposure Assessment

Results show that the number of flooded buildings increases with the increase of rainfall amount as modelled using different return periods. (Figure 11). The total number of buildings sampled in Malingon River floodplain is 7,184. The 100-year return period has the most number of flooded buildings with 81.03% which account to 5,821 buildings. This implies that in extreme scenarios with 1% chance probability every year, more than 80% of the buildings will be flooded. For smallest number of flooded buildings was in 2-year return period accounting to 3,799 buildings with 52.88% from the total number of building sampled. This means that more than half of the sampled buildings will be flooded in 50% chance probability every year. Most of them located near the downstream portion and near the river banks. The results of assessing the exposed buildings to flooding per hazard level per return periods in Malingon River floodplain is shown in Figure 12.

Figure 10. Area flooded of Malingon River in different return periods

![Figure 10. Area flooded of Malingon River in different return periods](image)

Figure 11. Total number of flooded buildings and percentage in different return periods

![Figure 11. Total number of flooded buildings and percentage in different return periods](image)

Figure 12. Number of flooded buildings per hazard level per return period

![Figure 12. Number of flooded buildings per hazard level per return period](image)
The graph shows an inverted proportion of not flooded buildings and the number of flooded buildings in low hazard areas. On the other hand, an increasing trend was observed in the number of flooded buildings in medium and high hazard level in orange and red colors, respectively. For 2-year and 100-year return period scenarios, an increase of 46% and 68% flooded buildings for medium and high hazard level, respectively, were observed. Expectedly, assessment showed that exposed features have been increased with the extent of flooding in the area. All of the flooded and not flooded buildings per hazard level in different return periods are assumed to be 80.5% accurate based on the error analysis of the flood map validation using tropical storm Sendong flood information.

4. CONCLUSION

The study has generated important geospatial datasets and information to include land cover, soil, elevation models, rainfall, and discharge, among others, as primary inputs in flood modeling. The overall model performance was fitted showing acceptable accuracy both for the hydrologic model calibration and hydraulic models validation. Hydrologic model performance was tested using NSE, PBIAS, and RSR statistics with values of 0.78, -8.62, and 0.46, respectively. The respective increasing trends in the amount of discharge, flood extents and number of buildings exposed to flood with the increasing amount of extreme rainfall events (return periods) were described in this study. Highly detailed flood hazard maps at different return period scenarios were generated which will be made available to target beneficiaries like LGUs and other agencies. The generated hazard maps and flood simulations help local community to understand the dissimilarities of the impacts of different rainfall amount occurring in the floodplains. Output of the study served as valuable input in the formulation of a science-based policy recommendations that shall be integrated into the local and regional policies on Disaster Risk Reduction Management (DRRM) Plans and actions. This initiative is believed to contribute in building disaster-resilient communities towards sustainable development not only in the floodplain of Malingon but for the entire Island of Mindanao.

5. ACKNOWLEDGMENT

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6. REFERENCES


DISASTER SITUATION REPORT BASED ON GENERAL PUBLIC RESPONSE: a STANDARDIZATION PERSPECTIVE

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KEY WORDS: social media, situation reports, EDXL

ABSTRACT: Taiwan is located in an area often struck by natural disasters like typhoon or earthquake. To enable the general public aware of the coming threats of hazards, the disaster relief agencies are required to monitor the continuously changing situations and provide prompt warnings and immediate help to the disaster sites. The source of hazard information may widely include individual agencies’ own systems, sensor web, IoT devices, exchange with other agencies or even social media (e.g., Facebook) and citizens. The content may be as simple as a photo with a few words or as complex as integrated reports about the hazard information of a region. The past practices often require a tremendous volume of manual operations to overcome the heterogeneity barriers, and even extra edition to make the acquired data (e.g., geotagging the photo) good for response decision making. An effective mechanism is therefore desperately necessary for improving the efficiency for automatically handling the variety types of hazard information from different resources in a timely manner. Social media has become an increasingly important source for collecting and updating the real-time disaster situations. This paper examines the requirement and processing strategies of hazard information collected from the general public and compare the results with the governments’ hazard information. We summarize the feasibility of distributing parsed information according to the framework in the EDXL Situation Report standard. As the EDXL SitRep standard can suffice the needs for further exchanging information between different agencies, the results can contribute to expand the capability of taking advantages of the extraordinary valuable information from the general public for better emergency response and recovery.

1. INTRODUCTION

Taiwan is located in an area often struck by natural disasters like typhoon or earthquake. Whenever disaster occurs, it is the responsibility of the government to provide prompt warnings and immediate help to the citizens to avoid further damages. The various resources that can aid the collection of information about disaster situations in the territory is therefore a mandatory task to the governments. Chen (2008) identifies five challenges for the operations of emergency response systems: (1) work flow, including human training before the emergency, the distribution of the man power and the tracking of work; (2) resource, including standardization and distribution mechanism; (3) information, including information integration, format of information and standardized the exchanging information; (4) decision making and (5) responsible agencies, including collaboration between agencies and organizations. An effective information sharing between responsible agencies clearly plays a critical and indispensable role in the successful operation of emergency response systems. If a variety of authorized agencies can exchange their own domain hazard information, the aggregated information will help the commanders in the EOC to build better understanding before making decisions. Nevertheless, if no prior agreement on how disaster situation information is recorded and distributed, then the huge volume of aggregated report information may on the contrary become a huge burden to the responsible agencies. This paper focuses on the information sharing during the phase of disaster responses. When disasters occur, the authorized agencies must continuously monitor the changing disaster situations and take necessary actions for the best welfares of the citizens. In addition to the vast amount of observations current sensor technology can provide, responses from the general public are also valuable information that cannot be ignored. Unlike sensor observations that are largely presented by quantitative numbers, free-text information from the general public may require further parsing and interpretation for obtaining the required information. Meanwhile, because the available time and resource is often limited during disaster response, the time pressure is often tremendous. To further enable the sharing of disaster information between different agencies, a standardization approach is necessary. McGarry et al. (2016) discusses an emergency response system named IC.NET, which can make the disaster responses standardized to enable the successful exchange of data between agencies. IC.NET is a prototype of an EDXL based messaging platform designed for the exchange of Emergency Data. The messages from agencies or crowd would be standardized by this platform.

This paper aims to discuss the standardized disaster information exchange based on the input of the social media.

2. CHARACTERISTICS OF DISASTER SITUATION INFORMATION
2.1 The characteristic of disaster report from social media

2.1.1 The characteristic of social media in disasters

According to the Global Digital Report 2018 posted by Internet research agencies (https://wearesocial.com), there are as many as 2.17 billion active users on Facebook and 330 million active users on Twitter in 2017. The fast growth of social media no doubt has a tremendous impact on how information between human beings is shared and used in their daily lives. Before the disaster, the government agencies can publicly broadcast the information about the hazard to the public via social media in a location-based manner. Citizens may call for help or report what they see using social media after the disaster occurs. The emergence of social media has revolutionized the collection and transmission of information and even becomes a special taskforce in the emergency response. For example, when Typhoon Morakot hit Taiwan in 2009, a number of disaster information sharing platforms based on social media was launched by volunteers, e.g., Morakot Typhoon Disaster Support Network, Morakot Typhoon Disaster Information Map, etc. The Morakot Typhoon Disaster Information Map was continuously updated with new information feeds for disaster response and relief references. Other platforms like PTT, Plurk, Twitter were also used for collecting the disaster information (Wang, 2015). The ideal emergency communication system should have the characteristic of low cost, easy usable, scalable, fast network connection, one to many communication, GIS and visualization (Mills, 2009). In addition to the above-mentioned features, social media also has better performance than traditional media in terms of information flow, information control, relevance to local people, cost, accessibility and instant (Keim, 2011). The inclusion of general public as disaster information source is advantageous, as the capacity of government certainly has its limitation. Nevertheless, many issues must be considered before the information from social media can be correctly used.

2.1.2 The case study of social media in disaster response

In addition to the information exchange system launched after disaster occurs, the use of social media also receives great attentions in recent years. Maceachren et al. (2011) discuss the approach to parse the Tweeter content for identifying the disaster incident and determining its location, then make the information visualized on the SensePlace2 platform. Because Tweeters has 140 words limitation for each Tweet, the way of making posts may largely depend on users’ background, knowledge and culture. The challenge is how to parse the required information about the incident and its location from the short post. Although the location information may be available from users’ GPS, but this cannot be seen as a default assumption. So the location information has to depend on the use of hashtag, like #position, then use the Twitter API to crawl the information about a particular place. Since the data from social media data is unstructured, SensePlace 2 is designed to structure tweets and visualize the data on the map according to parsed temporal and spatial information. The spatial and temporal clustering from the messages can be used for assessing the urgency of the incidents. Adam et al. (2012) develop the SMART-C platform, which can receive the data from various resources, and in the meantime also can achieve two-way communication between the official and the public in terms of the information about incidents. Various modules are developed to address different needs, for example, DynaSpeak is used to recognize the voice message. After receiving and pre-processing the various data, they would make the initial semantic analysis, compare multi-reports to make the classification, then delete the noise to achieve more accurate semantic analysis.

2.1.3 The challenges of using social media in disaster response

The advantage of crowdsourcing is to make good use of the huge number of citizens locating at difference places as the information sources to accomplish the mission. This characteristic perfectly meets the demands of disaster response. However, some concerns regarding the use of social media in disaster responses still remain. Table 1 lists the issues and summarizes the proposed solutions from previous researches.

<table>
<thead>
<tr>
<th>Issues</th>
<th>Existing solutions</th>
<th>Discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data credibility</td>
<td>(1) Time and spatial clustering (Adam et al, 2012)</td>
<td>Validation of the parsed content is necessary.</td>
</tr>
<tr>
<td></td>
<td>(2) Data visualization (Maceachren et al, 2011)</td>
<td>Users’ credibility.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The same incident reported by a number of users during a short period of time.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standardized the content to simplify the parsing works.</td>
</tr>
<tr>
<td>Heterogeneous data</td>
<td>Using customized or standardized tools to process the data. Ex. Twitter API</td>
<td>Using customized module to extract the disaster information from various resources. The ontology, semantic Web</td>
</tr>
</tbody>
</table>
A component, organization coordination component interact with each other to overcome the problem of heterogeneous data integration.

Position information

1. GPS data
2. word description
3. hashtag
4. photo and video

(Adam et al, 2012) (MacEachren et al, 2011) It would be convenient if we have GPS enabled data. For photos, we can extract their coordinates, or perform image processing to geo-locate the photo. As for the hashtag analysis, we have to build a complete geographical database in advance.

Duplicated reports

Using volunteers to manually check the duplications. (Gao et al, 2011) Need more efficient and accurate results by automatic techniques. Characteristic of time and spatial clustering can be used for reference.

Mechanism of collaboration between organizations and agencies

Standardization (McGarry et al, 2011) Standardization is necessary. Designing standards widely accepted by different domains is a challenge. All resources have to follow the same standards or specifications.

Lost internet connection

Make a prediction model. (Gao et al, 2011) The disaster will be repeated. In addition to using the reports, the historical data also can be added to predict the potential disaster areas.

2.2 The characteristic of situation information collected by responsible agencies

In addition to the information collected from social media, every responsible agency is required to collect data related to their given duties when disasters occur. Table 2 shows the design of flooding incident data from the Water Resources Agency, Ministry of Economic Affairs. Different from social media, the agencies have the professional capability and instruments to collect and manage the required observations, e.g., time, position, and description of the incident. Since the responsible agencies can develop dedicated systems following domain specifications, they are capable of continuously monitoring the changing situations and exchanging the real-time situation if necessary. Therefore, the sharing of disaster situations from related responsible agencies based on a common standard can facilitate an effective mechanism for all stakeholders to gain a complete control of different types of hazards. The fundamental requirements are the designed standards must include all essential and required type of information and must have a standardized schema to simplify the data exchange processing.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Explanation</th>
<th>Attribute</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial number</td>
<td>The serial number of each reports.</td>
<td>River bureau</td>
<td>The reports belong to which river bureau.</td>
</tr>
<tr>
<td>Data source</td>
<td>The source of the reports</td>
<td>Report number</td>
<td>The report number of the reports. Used to identify the incidents.</td>
</tr>
<tr>
<td>County</td>
<td>The county where the disaster occurred.</td>
<td>Town</td>
<td>The town where the disaster occurred.</td>
</tr>
<tr>
<td>The categories of incidents</td>
<td>The incidents belong to which categories like road.</td>
<td>Time</td>
<td>The reporting time.</td>
</tr>
<tr>
<td>Location</td>
<td>The detailed location where the disaster occurred.</td>
<td>Disaster description</td>
<td>The description of the disaster situation.</td>
</tr>
<tr>
<td>Severity of the flood(cm)</td>
<td>The depth of the flooded.</td>
<td>Flood recede or not</td>
<td>The situation of the flood which can used for the disaster tracking.</td>
</tr>
<tr>
<td>Flood receding time</td>
<td>The time of the flood changing which can used for the disaster tracking.</td>
<td>The updating situation of disasters</td>
<td>The management of disaster situation.</td>
</tr>
<tr>
<td>Contact information</td>
<td>Contact information of the related agencies.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Although disaster situation reports from the government agencies and social media have their respective distinguished characteristics, both of them are valuable to the successful operation of disaster response, a comprehensive approach to integrate these two sources of information is necessary. The next section introduces a standardization framework proposed by OASIS for standardizing the situation report for disasters.

3. EDXL-SitRep

Due to the heterogeneity of the disaster information resources, standardization is an effective approach to resolve the differences and enable the successful interactions between different stakeholders. The Emergency Data Exchange Language (EDXL) proposed by OASIS (Organization for the Advancement of Structured Information Standards) is standards dedicated to facilitating the exchange of emergency information across the local, state, tribal, national and non-governmental organizations of different professions that provide emergency response and management services (Organization for the Advancement of Structured Information Standards, 2016). As a family of standards, the EDXL includes a number of standards designed for exchanging different types of disaster-related information and make the respective domain applications possible. For example, the alerting system in Taiwan follows the CAP standard for exchanging the emergency alerts and public warnings issued by responsible agencies. Under a collaborated framework including all responsible agencies, this system can now distribute alert information via web, social media and cellular broadcasting, such that citizens under hazard threat can receive alerts to avoid damages. The merits of using standardization technology to remove the originally heterogeneous alert information from different resources prove to be extremely advantageous.

The Emergency Data Exchange Language Situation Reporting (EDXL-SitRep) is the standard dedicated to the exchange of timely situation reports produced by different agencies. Similar to the challenges of introducing CAP, the situation reports from responsible agencies are very different because of the domain-specific design and the lack of collaborated communications. The use of EDXL-SitRep serves as the foundation for resolving such differences and facilitate the sharing of emergency data. Figure 1 shows the UML diagram of the scheme of EDXL-SitRep. Every situation report must include fundamental information defined by class of SitRepType. Depending on the tasks at hands, the reporter must additionally one of the report types defined by report. The former mainly addresses the needs for managing the reports coming from different resources, e.g., the title of the report, the people who prepare the report, the ID of the report, etc. This class is commonly used by all situation reports, regardless of what type of report is chosen. Table 3 shows the major categories and the designed items of SitRepType. Based on the requirement of handling individual situation report, the class of SitRepType records information about who, what, when and where. As the situation in reality may continuously change overtime, the class of SitRepType includes the element to record the previous report, such that the changing status can be traced. This, however, apparently require the authorized agencies to design rules for giving ID or naming the incidents.

The EDXL-SitRep includes five types of report. The type of FieldObservation is mainly used for human observers to provide information about what they see in reality. The designed elements include observation location, immediate need, immediate needs category and the observation text. It is a brief and simple format to provide the basic information in disaster. If the agencies need a detail information about the incident which the message is concerned, the SituationInformation report type would be the ideal one. Using the incident name, incident kind, incident start date time, geographic size, etc. to report the information about the incident and disaster. The type of ResponseResourcesTotals is mainly used for responsible agencies to provide information about the resource name, resource required count, date time ordered, etc., so that the EOC commanders can deliver requested resources to the disaster sites. The type of CasualtyAndIllnessSummary is used by local governments or responsible agencies to report the situations regarding casualty and illness. Finally, the type of SituationSummaryType is a comprehensive record of all the information about disaster including incident cause, damage assessment information, transportation systems etc. The schema of EDXL-SitRep has the advantages of addressing the description needs of different types of scenarios in emergency response. Since the participants may widely include governments, private sectors, and NGO, the standardization of situation reports is certainly helpful to facilitate their communications.
Table 3. Major categories and the designed items of EDXL-SitRep

<table>
<thead>
<tr>
<th>Classification</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unified code</td>
<td>messageID, reportNumber, reportTitle, incidentID</td>
</tr>
<tr>
<td>Origin tracing</td>
<td>preparedBy, authorizedBy</td>
</tr>
<tr>
<td>Report content</td>
<td>reportPurpose, actionPlan</td>
</tr>
<tr>
<td>Time</td>
<td>forTimePeriod</td>
</tr>
<tr>
<td>Position</td>
<td>reportingLocation</td>
</tr>
<tr>
<td>Incident progress tracing</td>
<td>reportVersion, originatingMessageID, precedingMessageID</td>
</tr>
<tr>
<td>Incident emergency</td>
<td>urgency, reportConfidence, severity, nextContact</td>
</tr>
<tr>
<td>Report</td>
<td>report</td>
</tr>
<tr>
<td>Others</td>
<td>incidentLifecyclePhase</td>
</tr>
</tbody>
</table>

4. ANALYSIS

As discussed in previous sections, the information of social media, regardless from volunteered group or not, come from citizens’ observations. Therefore, the type of FieldObservation appears to be the natural selection. Figure 2 shows the posts collected from the Facebook group (台南市淹水) during the torrential rain incident in August 24, 2018 in Tainan. Users’ information typically includes photos and free text descriptions. Although users for all these three cases include information about where the photo is taken, all of them are referenced by the name of either place (administrative units) or roads. Only one mentions “flood”. Out of the three mandatory elements of FieldObservation, the observationLocation and observationText can be parsed if parsing mechanisms and geographic databases are available. However, users may not have sufficient professional skill to give precise descriptions about the situations, so additional efforts (e.g., interpretation from photos) are still necessary. Without GPS coordinate, the pinpoint of these three reports on the maps are difficult, so additional mechanism of geotagging the photos are definitely necessary. As for the required elements from the class of SitRepType, rules of issuing ID, determining the time and authorized people must be created. To avoid unverified false news or rumors floating in internet to cause panics, the collected social media information is better managed and verified by a specific responsible agency, and only this agency is authorized to publish or share disaster information collected from social media.

Figure 2. Situation reports from the Facebook group
Table 4. Information parsed from the Facebook situation reports

<table>
<thead>
<tr>
<th>What (observationText)</th>
<th>Flooded to knee. (Interpreted from the photo.)</th>
<th>Flooded to calves. (Interpreted from the photo.)</th>
<th>Flooded 20 cm. (Interpreted from the photo.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where (observationLocation)</td>
<td>Anding port</td>
<td>Qingshui Rd., Yanshui Dist., Tainan City</td>
<td>Matou</td>
</tr>
</tbody>
</table>

There are three required elements in FieldObservation: observationLocation, immediateNeeds and observationText. So after the data processing it can provide the two elements.

Table 5 shows the preliminary attempt to generate situation report according to the information from social media. The simulated scenario is the local fire department reports to the EOC about the situations it collects from the local social media group and has verified the reported situation is correct.

Table 5. Preliminary analyzed results

<table>
<thead>
<tr>
<th>Element</th>
<th>Correspond to the social media data</th>
<th>Recorded content</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>messageID</td>
<td>DPFTNC_Flood_0824_0001</td>
<td>Message ID is given to uniquely identify an individual message. The ID can be a sequential number. Message ID is given by the authorized agency.</td>
<td></td>
</tr>
<tr>
<td>originatingMessageID</td>
<td>DPFTNC_Flood_0824_0001</td>
<td>Unique message ID to indicate the first message of a series of reports. Can only be given by authorized agency.</td>
<td></td>
</tr>
<tr>
<td>precedingMessageID</td>
<td></td>
<td>Can only be given by authorized agency.</td>
<td></td>
</tr>
<tr>
<td>incidentID</td>
<td>Tainan Anding district _ 0824 _ flooding _0001</td>
<td>Incident ID given by the authorized agencies. May need to follow particular rules.</td>
<td></td>
</tr>
<tr>
<td>reportNumber</td>
<td>DPFTNC_Flood_0824_0001</td>
<td>The serial number given by the system.</td>
<td></td>
</tr>
<tr>
<td>reportTitle</td>
<td>Flooding at Anding district of the Tainan city at 0824</td>
<td>Informative content to describe the major content of the report for easier interpretation. The title should be unique for management purpose.</td>
<td></td>
</tr>
<tr>
<td>reportVersion</td>
<td>Initial</td>
<td>Determine the content according to the status of the report.</td>
<td></td>
</tr>
<tr>
<td>preparedBy</td>
<td>Ann</td>
<td>The name of the responsible person for the report.</td>
<td></td>
</tr>
<tr>
<td>authorizedBy</td>
<td>Fire department of the Tainan city government</td>
<td>The name of the responsible agency.</td>
<td></td>
</tr>
<tr>
<td>reportPurpose</td>
<td>Purpose: Because of the flooding, some people are trapped inside the house. Needs: The Relief agencies and lifeboat.</td>
<td>The content is dependent on the reported situations.</td>
<td></td>
</tr>
</tbody>
</table>
| forTimePeriod      | 2018/08/24 12:00                    | 2018-08-24T12:00:00+08:00 | The temporal information can be referenced to the time when the information is posted in social media, the
<table>
<thead>
<tr>
<th><strong>Field</strong></th>
<th><strong>Value</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>reportingLocation</td>
<td>Anding</td>
<td>The location can directly refer to the reported location in social media (GPS coordinates or textual description), or the location or coordinates after manual interpretation or image processing.</td>
</tr>
<tr>
<td>urgency</td>
<td>Immediate</td>
<td>This element should be verified by the responsible agencies. The information from other agencies or sensors can be used to validate the urgency of the incidents.</td>
</tr>
<tr>
<td>reportConfidence</td>
<td>HighlyConfident</td>
<td>This element should be verified by the responsible agencies. There should be clear differences between reports that have been validated and not validated.</td>
</tr>
<tr>
<td>severity</td>
<td>Severe</td>
<td>Information given by the responsible agency's professional judgments.</td>
</tr>
<tr>
<td>immediateNeedsCategory</td>
<td></td>
<td>Optional element.</td>
</tr>
<tr>
<td>immediateNeeds</td>
<td>Need lifeboats.</td>
<td>Description by users.</td>
</tr>
<tr>
<td>immediateNeedsCategory</td>
<td></td>
<td>Optional element.</td>
</tr>
<tr>
<td>observationLocation</td>
<td>Anding port (As same as reportingLocation.)</td>
<td>The geographical location database can be established first. When users who fulfill the reports would be asked to open the GPS service. After geolocating, the geodatabase can give the location tag which is similar to the mechanism of “check in”.</td>
</tr>
<tr>
<td>observationText</td>
<td>Flooded to the knee (The information should parse from the photo which means it need more data processing.)</td>
<td>It is flooded to the knees here, and the elderly are trapped and need rescue boat assistance.</td>
</tr>
</tbody>
</table>

From table 4 and table 5, we can see the information provided by people in social media can basically fulfill the requirements of the class of FieldObservation, but additional help from human operators, processing mechanisms and databases are necessary. The content of many elements from the class of SitRepType can only be given, determined or validated by the responsible agencies. Following the common rules of EDXL-SitRep, every responsible agency must develop a specific mechanism for its domain situation reports. Especially for the agencies responsible for collecting and managing information from social media, the validation and management of the huge volume of disaster information would be a tremendous challenge in the future. While we are welcome to the input from the general public, the handling of duplicated, invalidated, inaccurate or even fake reports certainly demands smarter algorithms to improve the quality of the situation reports.
Following the EDXL-SitRep standard, the standardized situation report information is encoded in XML for further exchange. The standardized XML schema thus enables the stakeholders to develop parsing mechanism to acquire necessary information to meet their application demands.

![XML schema](image)

**5. CONCLUSIONS & DISCUSSIONS**

During disaster response phase, it is a big challenge for relief agencies to grasp the continuously changing status and take immediate actions. This ultimate goal cannot be achieved without the collaboration of all related stakeholders, including all the citizens. This paper examines the possibility of including the social media as an information source for disaster situation information and exchange the collected data following the EDXL-SitRep standard. After comparing the data characteristics from social media and responsible agencies, it is clear that government agencies have superior capability to cope with the requirement of standardized data exchange, while information collected from social media obviously require guidelines, training, customized application programs and knowledge-based mechanism to parse necessary information and encode standardized SitRep information. An ideal emergency response system must be able to take advantages of all the available situation reports for better decision making, so a collaborated and standardized framework involving all stakeholders, regardless government, private sectors and social media, must be given the highest priority in the future disaster management plan.

Some issues require further examinations in the future:
1. Difficult to get the updating data:
   People in social media are not required to provide updated situations, so further actions must be taken for monitoring the changing status. Nearby sensors may provide auxiliary information when needed.
2. Location information:
   The quality of location information from social media cannot be precisely controlled. The availability of reference maps, GPS coordinates, as well as the image processing technology all help to improve the location determination of disasters, but a complete and accurate solution is still under development.
3. Education training:
   With well-prepared manuals, examples and application programs, the training of volunteers on social media becomes possible, but there will always be demands for naive users who do not have any knowledge, but are willing to provide information. So the working interface must continue to improve its knowledge and friendliness to interact with users while collecting information.

**6. References**


A FRAMEWORK OF CLIMATE DISASTER RESILIENCE INDEX (CDRI) FOR ENVIRONMENTAL COMPONENTS IN KUKUP-TANJUNG PIAI, JOHOR

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3 Department of Science, Management and Design, Razak School of Engineering and Advanced Technology, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, Kuala Lumpur.

Email: zainora@iium.edu.my; i_ibrahim@iium.edu.my, epgplanning@gmail.com, wnurul.kl@utm.my

KEYWORDS: resilience, environmental components, disaster, coastal erosion, land use.

ABSTRACT: Over the time, Malaysia has been experienced environmental related disasters in relation to the impact of climate change and its associated phenomena. Disasters such as monsoon flood, erosion and landslide are amongst the most common ones hit Malaysia. In this regards, Malaysia highly emphasises the need for having an appropriate management system for disaster risk strategies in its 11th Malaysia Plan (2016-2020), which is parallel with the aspiration of Sendai Framework for Disaster Risk Reduction (2015-2030). The issue of coastal erosion concerning sea level rise has merged significantly in Kukup-Tanjung Piai, Johor. Hence, this research was initiated to develop a framework of the Climate Disaster Resilience Index (CDRI) for environmental components, reflecting the importance of environmental dimensions within the context of land use planning. The analysis is based on a comprehensive review of the literature and used the international directive in developing the proposed framework. This paper presents the GIS-based process in developing a framework of CDRI for environmental components. There are five geographical settings namely built-up areas, forest reserve, erosion, coastal areas, and rivers applied as GIS database for generating the spatial risks areas of coastal erosion. The result for CDRI was obtained via conducting a Focus Group Discussion (FGD) session with 22 participants of various government technical officials. The findings of CDRI indicate that the average score of resilience is relatively moderate with a score of 3.52. The frequency of hazard records the highest score at 3.87 and ecosystem has the lowest score of 3.20. These findings are of particular importance to Pontian District Council and other technical agencies to strengthen their ability and capacity as responding to the risk of coastal erosion in Kukup-Tanjong Piai.
1. INTRODUCTION

Globally, there is a serious concern on the environmental and social disturbances relating to the globalisation and climate change resulted from both anthropogenic and natural process (Urry, 2011 and Pelling, 2011). The climate change is undeniably a global issue that influence significant implications for many countries including Malaysia. The country is generally located geographically outside the seismic source zone of Sumatera fault that is partially of Pacific Ring of Fire and is relatively considered safe from any severe damages and destruction caused by natural disasters (Centre, 2016; Hendriyawan and Irsyam, 2002). It is noticeable that there is a growing trend in research on natural disasters due to the historical evidences (Marto, Soon, Kasim and Mohd Yunus, 2013).

In the local context, historical records show that Malaysia is now exposed to some common natural hazards including floods, tsunami, landslides, seismic activity and haze. Amongst the major disaster events faced by Malaysia are tropical storm Greg in Sabah (1996), tsunami in several states in the western coasts of Peninsular Malaysia (2004), enormous monsoon flood in Kelantan (2014), and earthquake in Sabah (2015). These disaster occurrences claimed many lives apart from economic loss to the country. In this regards, Malaysia highly emphasises the need for having an appropriate management system for disaster risk strategies in its 11th Malaysia Plan (2016-2020), which is parallel with the aspiration of Sendai Framework for Disaster Risk Reduction (2015-2030) (United Nations, 2015). It is timely for the country to have its mechanism to handle and manage any disaster that is accordance to the global standard of operation. As such, this research aims to develop a framework of the Climate Disaster Resilience Index (CDRI) for environmental components, reflecting the importance of environmental dimensions within the context of land use planning. This purpose contributes to the objectives which are to identify the criteria that leads to the formation of CDRI for environmental component; and thus to examine the status of the level of environmental resilient of coastal erosion occurrence in Kukup-Tanjung Piai, Johor.

2. STUDY AREA OF KUKUP-TANJUNG PIAI

Kukup-Tanjung Piai is located at the southern part of District of Pontian, Johor (Figure 1). The locality administrative areas include Mukim Ayer Masin, Mukim Sungai Karang and Mukim Serkat. Generally, Kukup-Tanjung Piai is dominantly covered by agricultural and fisheries areas (Figure 2). According to the report of National Physical Plan 3, the shoreline of Kukup-Tg Piai is severely threatened by coastal erosion level 4 (highly eroded) and level 5 (critically eroded). As a result, it affects the economy and property of the people within the area. Tanjung Piai which is recognised as a Ramsar site, located in the permanent forest reserve (PFR) of Sungai Pulai, a well-known eco-tourism product in Johor. Both Kukup and Tanjung Piai are
considered as National Parks with distinctive importance of flora and fauna. The site profile indicates that this area is exposed to the convergence of currents in the waters of the Straits of Malacca and the Straits of Johor, in which the shipping activities produce powerful waves heading to the beach. Over the time, this process disturbs the sandy coastal mangrove trees on the muddy land. Presently, it is discovered that several structures in the Ramsar site Tg Piai has collapsed and consequently, changed the landform and geographical profile of the area.

Figure 1: Location of Kukup-Tanjung Piai, Pontian District, Johor

Figure 2: Land Use of Pontian District, Johor
3. **RESEARCH METHODOLOGY**

The research applied three methods, covering literature review, GIS analysis and conducting focus group discussion (FGD) session with the relevant technical agencies. Firstly, the theoretical framework was deemed necessary as it provided the fundamental basis of the employment of the appropriate research methodology in data collection and data analysis. Referring to the manual of Planning Guidelines for Environmental Sensitive Areas by PlanMalaysia, coastal areas are considered as ESA. The nature of coastal areas is complicated and tends to change depending on its characteristics of geophysical, morphology, geology, littoral transport, sediments, wind and waves (Misra and Balaji, 2015). According to Paiman, Asmawi and Mohamed (2016), coastal areas are considered as one of the most complex areas for traditional planning system. As a result, this leads to the coastal erosion as the common environmental issue, creating other related consequences such as displacement of settlement and the loss of mangroves. The rate of coastal erosion is obviously influenced by the global change. At the global context, the frameworks to address the disaster management were endorsed via consensus of members of United Nations. Sendai Framework for Disaster Risk Reduction (2015-2030) has been accepted on the 3rd United Nations World Conference on Disaster Risk Reduction which took place on 14 to 18 March 2015 in Sendai, Japan, following the implementation of Hyogo Framework for Action 2005-2015 as the pioneer in combating disaster globally. In the local context, some initiatives at the local level indicate the disaster management, for instance, National Physical Plan 3 addresses the resilience in the context of environmental planning within the town planning field.

Secondly, it is evident from the literature of Misra and Balaji (2015), they stated that GIS can be applied to determine the coastal physical changes. In this research, the dataset for relevant GIS layers were conducted for spatial mapping, showing the visual of possible disaster in the geographical setting of any town. The study produced spatial mapping on the potential hazards that could take place in Kukup-Tanjung Piai, taking the consideration of its geographical and environmental settings. Therefore, this study highly employed the series collection of secondary information regarding textual and statistical data in the form of Geographic Information System (GIS)/MapInfo format to assemble the relevant data for mapping purpose (Table 1). The fundamental technique used was the sieving plan, whereby several pre-determined environmental parameters were selected and arranged accordingly.
Table 1: Selected GIS data used for spatial

<table>
<thead>
<tr>
<th>Data</th>
<th>Vector Data</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contour</td>
<td>Contour map</td>
<td>2010</td>
</tr>
<tr>
<td>River network</td>
<td>Natural drainage system</td>
<td>2015</td>
</tr>
<tr>
<td>Land use</td>
<td>Land use map</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>Cadastral map (Land Lot)</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>Geology map</td>
<td>2013</td>
</tr>
<tr>
<td>Forestry</td>
<td>Johor Permanent Forest Reserve map</td>
<td>2015</td>
</tr>
<tr>
<td>Wetland areas</td>
<td>Johor Permanent Forest Reserve map</td>
<td>2105</td>
</tr>
</tbody>
</table>

Thirdly, in-depth interviews were conducted for the purposes of data gathering from key stakeholders in a session of Focus Group Discussion (FGD) in Melaka. A total of 22 government officers participated in the FGD sharing their opinions and views related to the environmental related matters. Among the officials came from Department of Irrigation and Drainage, Department of Forestry, Department of Minerals and Geoscience, Department of Agriculture and Meteorology Malaysia. A specific tool, known as Climate and Disaster Resilience Initiative (CDRI) was adopted. Basically, there are five CDRI components, i.e. physical, economy, environment, infrastructure/utilities and governance. This paper explores specifically on the environmental components that cover: the hazard intensity; frequency of hazard; ecosystem services; land use; and policy on environment. Each of these aspect has its own detailed sub-component.

4. RESULTS AND DISCUSSIONS

In the FGD, the participants were asked to give their responds on the pre-selected indicators involved in disasters, as follows:

i. Intensity of hazards: scale of the impacts and the level of severity.

ii. Frequency of hazards: the occurrence in any reasonable time period.

iii. Ecosystem services: quality of urban biodiversity, soil, air, water and humidity of the city.

iv. Land use planning: vulnerable areas to weather related condition, the morphology of the city, the settlements located in potential danger areas, the availability of green area and the loss of green spaces.

v. Policies on environment: compliance with environmental policy, the existence of a policy of preservation of the environment, waste management system, deterioration of air quality and food security.
The results in shown in Table 2 and Figure 3, indicating that frequency of hazards achieved the highest score of 3.87 (satisfactory). Meanwhile all the indicators only set for moderate scores (3.00-3.50). Of the five indicators, the FGD participants opted for frequency of hazards as the most reliable indicator, meaning that they confident the tendency of hazards to happen in Kukup-Tanjung Piai is very low. This result is good for long term planning and management of Kukup-Tanjung Piai. The mean for the five indicators demonstrates that it has a score of 3.52, a satisfactory condition. Generally, the environmental resilience is satisfactory for natural protection. The assistance from governance and operation of environmental protection will enhance the level of resilience in fighting natural disasters coming to these places.

Table 2: CDRI for environmental components

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity of hazards</td>
<td>3.60 (satisfactory)</td>
</tr>
<tr>
<td>Frequency of hazards</td>
<td>3.87 (satisfactory)</td>
</tr>
<tr>
<td>Ecosystem services</td>
<td>3.20 (moderate)</td>
</tr>
<tr>
<td>Land use planning</td>
<td>3.64 (satisfactory)</td>
</tr>
<tr>
<td>Policies on environment</td>
<td>3.33 (moderate)</td>
</tr>
<tr>
<td>Mean</td>
<td>3.52 (satisfactory)</td>
</tr>
</tbody>
</table>

![Figure 3: Result of CDRI for environmental component for Kukup-Tanjung Piai](image-url)
Meanwhile, Figure 4 shows the potential hazards areas for Kukup-Tanjung Piai spatially, generated via GIS based on the per-selected environmental related data as discussed in Table 1. A long stretch of coastal areas facing Strait of Malacca and Strait of Johor are severely affected by erosion (level 5). This situation clearly threatens the population and their property. The physical and environmental factors make the areas prone to coastal erosion incident. Lacking of mangrove, wind direction and strong current further encourage these areas for easily eroded. The CDRI analysis for environmental component successfully contribute to the objective of study, i.e. identify the resilience level of environmental indicators for Kukup-Tanjung Piai.

Figure 4: Environmental Characteristics of Pontian District, Johor

5. CONCLUSION

It this research, the team has successfully developed the selection of essential indicators in DCRI for environmental components. The indicators cover the intensity of hazards, the frequency of hazards, ecosystem services, land use planning and policies on environment. The results obtained via collective responds from 22 participants of FGD, coming from various
technical departments. Of the five indicators, the frequency of hazards shows the highest score of 3.87. The spatial mapping that the severity of coastal erosion is located along the coasts of Kukup-Tanjung Piai. The analysis of CRDI could be further improve based on series of relevant environmental and geographical data of Kukup-Tanjung Piai, so that the numerical and spatial results could be generated for many purposes. The resilience of environmental component is crucial particularly in the uncertain condition of global climate that affect the quality of lives of coastal community.

ACKNOWLEDGEMENTS
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REFERENCES


Applying MODIS and Landsat Images for Evaluating Urban Cool Island Effect

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KEY WORDS: MODIS, Landsat 8, Land Surface Temperature (LST), Urban Cool Island (UCI)

Abstract: Both MODIS and Landsat 8 provide the land surface temperature (LST) images, but their images are slightly different both in the spatial resolution and in the calculation of LST. The MODIS retrieves LST from thermal infrared response at the spatial resolution of 1 kilometer, whereas the Landsat 8 images retrieve LST from band 10 and 11 thermal infrared response with the spatial resolution of 30 meters. These differences are the focus of this paper and are evaluated in the process of finding urban cool islands (UCI). Taipei City is selected as our research area. The heat generated from high-rise buildings and artificial impervious surfaces in Taipei results in the urban heat islands. Yet, there are also several urban parks with high-density vegetation coverage where can cool down the surface temperature of the city. Thus, we expect to acquire large-scale LST by multi-temporal MODIS and Landsat 8 images, considering the relationship between the green area in downtown and the spatial resolution of images, and assessing how large the green area may result in the UCI. Finally, we also use the temperature actually measured by the ground weather station for validation, analyzing whether both of two images can be used to evaluate the UCI effect.

1. INTRODUCTION

Dense Buildings and artificial impervious surfaces in the cities result in the warmer air than their surrounding rural area, the phenomenon known as the Urban Heat Island (UHI) effect. The difference between the urban temperature and their surrounding rural temperature defines the Urban Heat Island Intensity (UHII) (Oke, 1987). In Contrast, due to evaporation cooling and less impervious surfaces, the green space and water bodies isolated in the cities usually leads to the cooler air than their urban surroundings, known as the Urban Cool Island (UCI) effect (Oke, 1987). The Urban Cool Island Intensity (UCII) is defined as the difference between the temperature in cool island and the temperature of surrounding urban area.

Both Landsat and MODIS satellites images can be used to retrieve large scale Land Surface Temperature (LST), which can be further detected the distribution of UHI/UCI. Many UHI/UCI studies have been conducted using remote sensing data. For example, Stathopoulou et al. (2007) used the LST obtained from Landsat 7 ETM+ to observe the UHI effect and to assess the relationship between LST and urban land cover in the major cities in Greece. Li et al. (2011) used Landsat TM images to evaluate the relationship between spatio-temporal pattern of UCII and the land use in Chang-Zhu-Tan Urban Agglomeration. Rasul et al. (2015) used Landsat 8 images to examine the spatial variation of the daytime surface UCI effect of Erbil City in Iraq.
Most studies assess the UCII between large scale urban and rural areas. Few investigations of the UCII of the specific urban parks or green spaces detected by remote sensing data have been published and few studies analysed the seasonal variations of the UHII/UCII. Therefore, in this study, we collected four Landsat 8 and MODIS images separately with clear-sky that were available from 2014 to 2016 in Taipei City from the Earth Explorer (https://earthexplorer.usgs.gov/). Then we used the temperature actually measured by the ground weather station for validation, analysing whether both Landsat 8 and MODIS images can be used to evaluate the LST directly. Finally, we used the LST to calculate the UCII of several main parks of four seasons in Taipei City, evaluating the correlation between the UCII and the area of urban parks.

According to the above, the objective of this study is to use the LST retrieved from the satellite images to quantify the UCII of several main urban parks in downtown Taipei. Based on this objective, the three issues of this study is:

- Comparison of the LST from Landsat 8/MODIS images with temperature measured by weather stations
- Evaluating the spatial distribution of LST in Taipei City
- Calculation of the UCII of urban parks in four seasons

2. METHODS

2.1 Study area

Taipei City is the capital city of Taiwan, locating in the north of the island. Its total area is about 271.80 km² (ranging from 24°57’ N to 25°12’ N, and 121°27’ E to 121°39’ E). The population of Taipei is about 2.67 million with the density of population is about 9800 persons per km².

The climate of Taipei City is humid sub-tropical, with an annually average temperature of 23°C. The coldest month is January (16.1°C), and warmest month is July (29.6°C). Previous studies of the urban heat island effect in Taiwan have indicated that unlike other metropolises in the world with the same population whose urban heat maximum occurs during the winter, Taipei’s urban heat maximum occurs during summer, with a heat island intensity of 4.5°C at mid-night (Chang et al., 1999).

Taipei City has a total of 804 municipal parks, including 46 thematic parks. In this study, we choose the top 10 thematic parks as our study region (Figure 1), excluding the parks which are besides mountain. The data of these urban thematic parks are extracted from the land use data of Taipei.

2.2 Data collection

2.2.1 Landsat 8

The Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) are instruments onboard the Landsat 8 satellite, which was launched in February of 2013. The satellite collects images of the Earth with a 16-day repeat cycle, referenced to the Worldwide Reference System-2. Landsat 8 passes over Taipei at around 10:30 every 16 days, covered by the image of Path 117/Row 43.
Figure 1. Top 10 parks and 13 ground weather stations of Taipei City

Landsat 8 images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. The resolution for Band 8 (panchromatic) is 15 meters. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are acquired at 100-meter resolution, but are resampled to 30 meter in delivered data product. In this study, Band 10 and 11 of Landsat 8 OLI/TIRS Collection 1 Level-1 is used to retrieve LST which is further compared with the LST from Terra MODIS.

The acquisition date of the four Landsat 8 images used in this study with clear-sky in Taipei are 2014/12/31, 2015/04/06, 2016/07/29, and 2015/11/16, which represent the four seasons respectively.

2.2.2 MODIS

The Terra MODIS satellite was launched in 1999, and began collecting data in 2000. MODIS has a polar orbit covering all of the Earth every one or two days. Terra MODIS passes over Taipei City at around 10:30 local time every day, acquiring data in 36 spectral bands, ranging in wavelength from 0.4 µm to 14.4 µm. The LST retrieved from MODIS has a spatial resolution of 1 km x 1 km, and is at approximately the same time as Landsat 8. In this study, LST from MODIS/Terra Land Surface Temperature/Emissivity Daily L3 Global 1 km SIN Grid V006 (MOD11A1) is selected to compare with the LST from Landsat 8. The acquisition date of the four MODIS images used in this study are 2014/12/30, 2015/04/05, 2016/07/28, and 2015/11/17, a day apart from the acquisition date of four Landsat 8 images respectively because of the cloud coverage over Taipei.

2.2.3 Temperature from ground weather stations

There are 13 ground weather stations in Taipei City, including Anbu, Taipei, Zhuzihu, Shezih, Dazhi, Shipai, Tianmu, Shihlin, Neihu, Datunshan, Xinyi, Wenshan, Pingdeng. (Figure 1). Each weather station records the temperature at the hour. Thus, we use a linear interpolation of two temperature values of 10 and 11 to get a temperature
of the acquisition time of the satellite images. We took the temperature from interpolation as ground truth data to evaluate the correlation with LST obtained from the satellite thermal images for validation.

2.3 Retrieval of land surface temperature from the Landsat 8 images

Landsat 8 data is composed by 11 bands, with the Band 10 and 11 are thermal infrared bands. To obtain the LST form Landsat 8 data, we have to covert the digital number of Band 10/11 to at-sensor spectral radiance by Eq. (1) (USGS, 2016).

\[ L_\lambda = M_L \cdot Q_{cal} + A_L \]  

Where:
- \( L_\lambda \) is at-sensor spectral radiance (Watts/(\( m^2 \times \text{srad} \times \mu m \)))
- \( M_L = 0.0003342 \) (Radiance multiplicative scaling factor for the band from metadata)
- \( Q_{cal} \) is L1 pixel value in digital number
- \( A_L = 0.1 \) (Radiance additive scaling factor for the band from metadata)

The spectral radiance value was subsequently converted to top of atmosphere (TOA) brightness temperature with Eq. (2) (USGS, 2016):

\[ T_B = \frac{K^2}{\ln(K_1 L_\lambda + 1)} - 273.15 \]  

Where:
- \( T_B \) = TOA brightness temperature, in Celsius
- \( L_\lambda \) = At-sensor spectral radiance (Watts/(\( m^2 \times \text{srad} \times \mu m \)))
- \( K_1 \) = Thermal conversion constant for the band (Band 10 = 774.8853, Band 11 = 480.8883)
- \( K_1 \) = Thermal conversion constant for the band (Band 10 = 1321.0789, Band 11 = 1201.1442)

An emissivity correction is required to accurately obtain LST from Landsat images. There are several methods sorted out to convert brightness temperature to LST. Giannini et al. (2015) compared 5 methods to retrieve LST for emissivity correction. Most studies applied emissivity corrected method to retrieve LST successfully from Landsat images (Li et al. 2011, Rasul et al. 2015). In this method, NDVI (Normalized difference vegetation index) is taken into account to calculate the surface emissivity. \( P_V \) is the vegetation proportion obtained, calculates by Eq. (3)

\[ P_V = \left( \frac{NDVI - NDVI_{\text{min}}}{NDVI_{\text{max}} - NDVI_{\text{min}}} \right)^2 \]  

Where:
- \( NDVI = \frac{(NIR - \text{Red})}{NIR + \text{Red}} \) NIR is Band 5, Red is Band 4 in Landsat 8.
Then, the expression of emissivity ($\varepsilon$) is given by Eq. (4)

$$\varepsilon = 0.004P_V + 0.986$$ (4)

The land surface temperatures corrected for emissivity ($\varepsilon$) is computed by the follow Eq. (5)

$$\text{LST} = \frac{T_B}{1 + (\frac{\lambda T_B}{\rho}) \ln(\varepsilon)}$$ (5)

Where:
- $\text{LST}$ is land surface temperature, in Celsius
- $T_B$ is TOA brightness temperature, in Celsius
- $\lambda$ is the band wavelength (Band 10 = 10.895\,\mu m, Band 11 = 12.005\,\mu m)
- $\rho = 1.438 \times 10^{-2}\,mK$
- $\varepsilon$ is emissivity

2.4 Retrieval of land surface temperature from the Terre MODIS images

The collection 6 and Level 3 of MOD11A1 daily LST product is selected (Wan et al., 2015), which provides LST values at 1 km spatial resolution gridded in the Sinusoidal projection. The exact grid size at 1km spatial resolution is 0.928 km by 0.928 km. The C6 daily MOD11A1 LST product is generated by the generalized split-window LST algorithm under clear-sky conditions (Wan et al., 1996; Wan, 2013; Simó et al., 2016).

2.5 Calculation of UCI intensity

Urban Cool Island Intensity (UCII) is used to quantify the UCI effect. UCI is the surface temperature differences between the different urban regions. (Stathopoulou et al., 2007). Previous studies have discussed the relationship between UCI and land cover. Some UHI indicators for LSTs have been sorted out (Schwarz et al. 2012, Sheng et al. 2017). For example, the UHI indicator for urban-agriculture is defined as “mean LST (all urban land cover) – mean LST (pixels with agriculture)” (Jin et al. 2005). The UHI indicators for urban-rural is defined as “mean LST (pixels within buffer urban weather station) – mean LST (pixels within buffer rural weather station)” (Sheng et al. 2017).

In this study, the UCII is defined as the difference between the mean LST (pixels of urban parks) and the mean LST (pixels of surrounding urban areas). A 300-meter buffer zone around the park excluding the park is used here to define urban area. Therefore, the magnitude of UCII is calculated by Eq. 6. (Li et al., 2011; Rasul et al., 2015).

$$\text{UCII} = -(\text{LST}_p - \text{LST}_u)$$ (6)

Where UCII is Urban Cool Island Intensity, $\text{LST}_p$ is mean LST of urban parks, $\text{LST}_u$ is the mean LST of surrounding urban areas. We let the UCII to be positive value so we added a minus in front of the difference.
3. RESULTS AND DISCUSSION

3.1 Validation of Land Surface Temperature

Before the further applying of the LST obtained from Landsat 8 and MODIS images, a validation by the temperature measured by ground weather station is necessary. In this study, we calculate the correlation between the temperature from the 13 weather stations and the LST value of the corresponding pixel. The results are shown below: (Figure 2)

![Figure 2. The correlation between LST and temperature from weather stations](image)

We put the temperature of four seasons together to calculate the correlation. The result shows that LST retrieved from both Landsat 8 and MODIS images have a high correlation with the temperature measured by ground weather stations, with the R square is 0.9164 and 0.9497 respectively. If we consider the four seasons separately, the LST from MODIS still has a high correlation with the temperature from weather stations, with the minimum R square is 0.88 in summer. However, as for Landsat 8, the R square is 0.265 in 2014/12/31, unusually small compared with other days, probably because of a piece of thin cloud above Taipei. But overall, the correlation is still very high, so we can directly use the LST obtained from Landsat 8 and MODIS images in further applications.

3.2 The spatial distribution of LST

We use both Landsat 8 and MODIS images to retrieve the LST of Taipei City. The spatial distribution of LST in four dates are shown below (Figure 3, Figure 4). The results of MODIS LST show that the north and south-east of Taipei have relatively lower temperature than central Taipei mainly due to elevation. Actually, the relatively lower temperature in northern Taipei is the situation of Yang Ming Mountain, and the south-eastern Taipei is situated Nangang Hills. The distribution of LST in summer shows that the temperature in pixels of central Taipei are all very high, and relatively higher than the surrounding area, compared with the LST in spring. We can probably speculate that the UHI effect in central Taipei is more intense in summer. However, due to the limitation of spatial resolution, we cannot evaluate the detailed LST of urban parks. The cell size of the MODIS data is $928 \times 928$ m$^2$, but the largest urbans park in Taipei City is Da’an Forest Park with an area of $263832$ m$^2$. Therefore, we can only use the LST from Landsat 8 to evaluate the UCII of urban parks in Taipei City.
The distribution of LST obtained from Landsat 8 in the four dates are shown below (Figure 3). LST in most places can be successfully retrieved from the data, but it is showed that some of the pixels have irregular values compared with surrounding areas. These places such as two small blocks in western and western south of Taipei in 2016/07/29 and a piece that extends from northeast to southwest are covered by very thin cloud. It is not easy to find images with clear-sky in four seasons respectively due to the lower temporal resolution of Landsat 8.

In contrast, because of the higher spatial resolution, the more detailed distribution of LST in downtown Taipei can be detected. We can preliminarily find out some places with relatively lower temperature in downtown Taipei. Such places like Keelung Rivers, Renai Road, Dunhua South Road, Da'an Forest Park and Youth Park, as the two largest parks in Taipei City, have significantly lower temperatures than the surrounding areas in spring and summer.
These places can be considered as urban cool islands in Taipei. In the next part, we are going to calculate the urban cool island intensity (UCII) of the main urban parks in Taipei City.

![Figure 4. The spatial distribution of LST obtained from Landsat 8 in Taipei City](image)

### 3.3 Calculation of the UCII of urban parks

As mentioned above, the spatial resolution of MODIS is too low to evaluate the UCII of the urban parks in Taipei. The LST from Landsat 8 has a spatial resolution of 100 meter, but are resampled to 30 meter in delivered data product, and the size of top 10 parks in Taipei ranges from 48037 to 263832 m$^2$. Therefore, we can use the LST from Landsat 8 to calculate the UCII of the top 10 thematic parks theoretically. Besides the ten parks, we also take Taipei Botanical Garden into account because it is also a significant large green space in downtown Taipei. The results of the UCII of parks in four seasons are shown below (Table 1)
Table 1. UCII of main urban parks of Taipei City in four seasons (Units: °C)

<table>
<thead>
<tr>
<th>Parks</th>
<th>Area (m²)</th>
<th>2015/04/06 (Spring)</th>
<th>2016/07/29 (Summer)</th>
<th>2015/11/16 (Autumn)</th>
<th>2014/12/31 (Winter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Da’an Forest Park</td>
<td>263832</td>
<td>1.92</td>
<td>1.72</td>
<td>0.8</td>
<td>0.16</td>
</tr>
<tr>
<td>Youth Park</td>
<td>207863</td>
<td>1.36</td>
<td>1.28</td>
<td>0.87</td>
<td>0.34</td>
</tr>
<tr>
<td>Nangang Park</td>
<td>183215</td>
<td>1.44</td>
<td>1.31</td>
<td>0.8</td>
<td>0.51</td>
</tr>
<tr>
<td>Bihu Park</td>
<td>160489</td>
<td>1.65</td>
<td>1.56</td>
<td>0.94</td>
<td>1.01</td>
</tr>
<tr>
<td>Xinheng Park</td>
<td>160247</td>
<td>0.62</td>
<td>0.77</td>
<td>0.28</td>
<td>-0.27</td>
</tr>
<tr>
<td>Dahu Park</td>
<td>143664</td>
<td>0.75</td>
<td>0.42</td>
<td>0.37</td>
<td>0.72</td>
</tr>
<tr>
<td>Zhishan Park</td>
<td>107870</td>
<td>1.51</td>
<td>1.77</td>
<td>0.97</td>
<td>0.43</td>
</tr>
<tr>
<td>Taipei Botanical Garden</td>
<td>93704</td>
<td>1.73</td>
<td>1.78</td>
<td>0.99</td>
<td>0.55</td>
</tr>
<tr>
<td>228 Peace Memorial Park</td>
<td>76373</td>
<td>0.9</td>
<td>0.95</td>
<td>0.37</td>
<td>0.05</td>
</tr>
<tr>
<td>Art Park</td>
<td>59249</td>
<td>-0.20</td>
<td>-0.04</td>
<td>-0.39</td>
<td>-0.18</td>
</tr>
<tr>
<td>Yuanshan Park</td>
<td>48037</td>
<td>-0.44</td>
<td>-0.43</td>
<td>-0.59</td>
<td>-0.72</td>
</tr>
</tbody>
</table>

The result shows that the UCII of urban parks in downtown Taipei is higher in spring and winter than in autumn and summer. The highest magnitude of UCII is 1.92°C in Da’an Forest Park in 2015/04/06, spring. The UCII of top 4 parks in spring is more intense than in summer, which is very different from the general imagination.

On the other hand, the UCII of Art Park and Yuanshan Park have negative values in all four seasons, probably because both of two parks are very close to each other and the Keelung River. The mean LST around the two parks is relatively cool due to the distribution of water bodies.

Generally speaking, it seems like to be a positive correlation between the area of parks and the UCII. However, the heterogeneity of the surrounding area of the parks will affect the value of UCII. More indicators, such as different land use/land cover or the buffer zone, have to be taken into consideration in future studies.

4. CONCLUSION

In this study, we successfully used Landsat 8 and MODIS images to retrieve land surface temperature of Taipei. First, we used the temperature actually measured by the ground weather station for validation. Result shows that the R square value between LST from Landsat 8 and temperature from weather station is 0.9164. The R square value between LST from MODIS and temperature from weather station is 0.9497. Both LSTs from Landsat 8 and MODIS also have very high correlation with temperature from weather station in four seasons respectively. Thus, according to the result of validation, we can directly use the LST from Landsat 8 and MODIS images for further applications.

Through the spatial distribution of LST from MODIS data, we found that downtown Taipei is warmer than the surrounding mountain areas, but not able to evaluate more detailed LST of urban parks due to the limitation of spatial resolution. Conversely, we can preliminarily find out some places, such as Keelung River and the two largest parks, with relatively lower temperature in downtown Taipei. According to the above, it is concluded that MODIS is suitable for analysing a larger-scale temporal distribution because of the lower spatial resolution (1000 m) but higher temporal resolution (daily). In Contrast, it is not easy to find images with clear-sky due to the lower temporal resolution of...
Landsat 8 (16-days), but the higher spatial resolution (100 m) makes it possible to detect the urban cool islands in downtown Taipei.

Therefore, we finally use the LST retrieved from Landsat 8 to evaluate the UCII of urban parks in Taipei in four seasons. Results showed that the UCII is higher in spring and summer, with a magnitude up to 1.92°C in spring in Da’an Forest Park, the largest park in Taipei City. However, we also found that the mean LST is possibly affected by the heterogeneity of the surrounding area such as water bodies. Therefore, it is necessary to develop other indicators, taking different land use or buffer zone into consideration for evaluating UCII of the urban parks in future studies.

5. REFERENCE


