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Title of paper

Construction of Detection and Alert System for Wild Fire

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Abstract

We accomplished modeling and visualization of the wild fire hotspots in Arc Map®. Also, we developed an alert system, which can present estimations on risk and danger, thus which will become an effective tool for policy makers.

1. Introduction

In Siberia, Mongol, China, Thailand and Indonesia, large-scale forest fires have frequently occurred. It is extremely important to minimize the damage, in order to maintain and increase the timber resource and the forest environment in the Asia-Pacific region. Wild fire has three different characteristics compared to usual fire that occur in urban area.

1. Disappearance of function of forest as CO2 absorption source, from the aspect of correspondence to global warming,
2. Continuance for a long time
3. Scale of consequences given to forest ecosystem

Considering these characteristics, wild fire is more important than usual fire. Wild fire also causes damage beyond national boundaries, thus information sharing is essential. In addition, as objective, rapid and highly reliable information needs to be provided.

We constructed a better system, which can overlay layers that are considered prospective damage like lives and properties, and factors which expanding damage like the land's undulation and local weather. While existing alert system merely shows only where the wild fire has occurred, our system provides "risk information", which means objective degree of impact for the risk of each hotspot.

Table.1 System comparison table

	GDACS	Sentinel Asia	Our alert system
Objective	International platform creation to provide near real-time alerts about natural disasters around the world	Disaster information is shared among Asia Pacific region, and it effectively manages the disaster in Asia Pacific region.	The risk of a wild fire that occurs in various places can be objectively understood.
Data source	Public information compiled from information provided by GDACS partners	MODIS data from TERRA/Aqua	MODIS data from TERRA/Aqua that is provided by AIT and Yasuoka laboratory from The University of Tokyo
Target area	World	Asia Pacific region	Thailand
User, Stakeholder	Country where disaster occurs, Aid group, Research laboratories	decision-maker	risk manager, Aid group
Manager	Joint Research Center	Japan Aerospace Exploration Agency	Hiromichi Fukui laboratory

2. Research Methods

2-1. Information provided by our system

The risk of wild fire means how fire could effect to individuals or society. Thus, information concerning human lives or resources, which may be lost by a disaster, is crucial. On the other hand, the linked effects can occur when the goods are lost; for instance, if the forest is lost it damages the ecosystem, when the cultural heritage is lost the attractiveness as sightseeing place reduces, or we would lose the opportunities to investigate historical facts. In order to contain these liked effect, we define the effects by disaster as the lost value and function, whose endpoint has importance economically, culturally, or environmentally. These goods are considered to be “lost indirectly.” Those risk information was interpreted as spatial geographic information.

Therefore, there are three kinds of data we used in our system, (a) the data on the location of the wild fire, (b) “the data on vulnerability, and (c) the data on prospective damage. The data is described in Chapter 2-3 in detail.

The indirect losses and inter-linked effects can be schematized as follows (Fig.1):

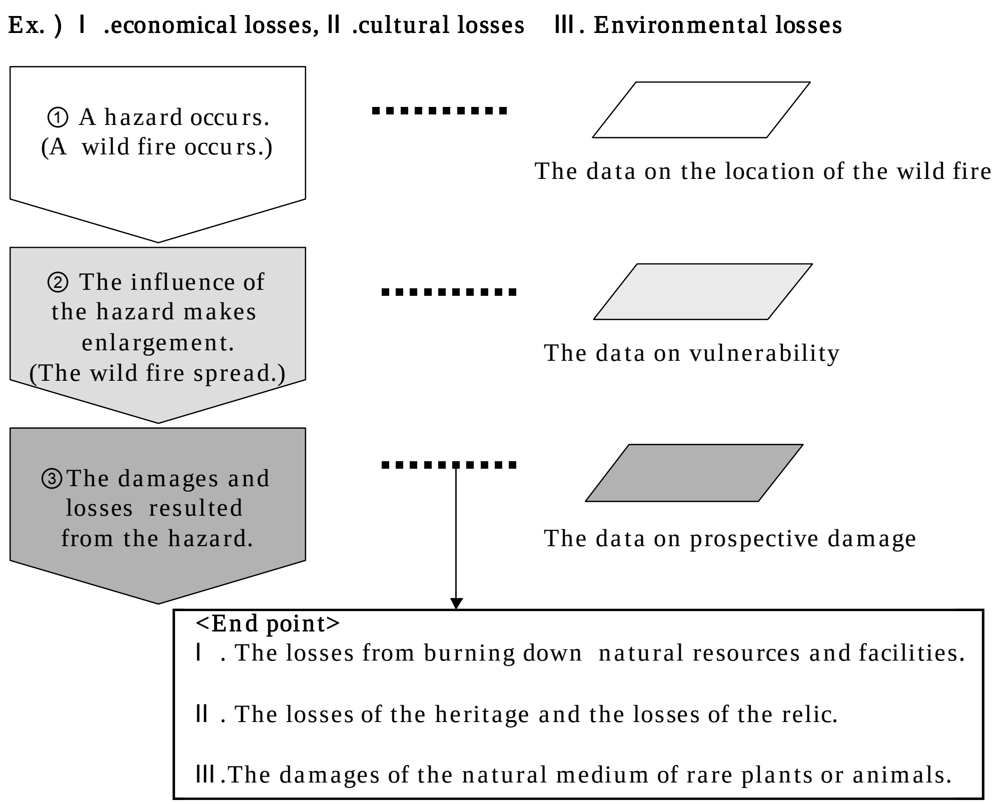

Fig.1 The indirect losses and inter-linked effects

The risk of wild fire can be judged respectively. The users are of this system alerted after examination the index of the data. Therefore, the users watch the data and judge the risk.

We overlaid three data on the Web-GIS, which can express the changing data. Thus we use Arc IMS® on account of easy operation and simple construction.

2-2 The framework of the Alert System

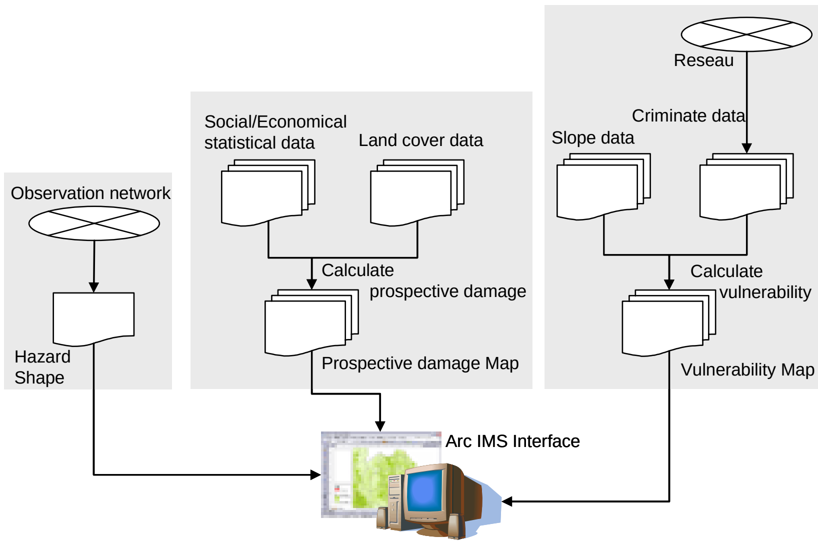

Fig.2 The framework of alert system

We proposed a framework of the alert system (Fig.2) which supports response to wild fire.

2-3 Study Area

Fig.3 Thailand

The issue of wild fire has grown into a serious problem for tropical rain forests in Southeast Asia, in arid areas in Australia and Africa, and in coniferous forest zone in Arctic Circle. Because Thailand was selected as the study area since it organizes the geographic information relatively well.

2-3.1 wild fire point

Wild fire frequently occurs in mountain-ringed region far from human habitation. Therefore a satellite remotely sensed imagery is effective for monitoring wild fire. MODIS image is typically used detect wild fire[1]. MODIS data can be acquired through the Internet. Fig.4 shows the procedure of our alert system. Our system can detect wild fire and construct a shape file automatically. As the input data, the MODIS Level 1B data from the Institute of Industrial Science, University of Tokyo[2] was used. As the processing algorithm, the algorithm from Research & Development Center ScanEx[3] was used. Using the method, ncdump[4] that the National Center for Supercomputing Applications has developed, and using the output data of MOD14, the list of latitude and longitude was extracted, and to process into the Shape file, shapefiles Library of R[5] was used.

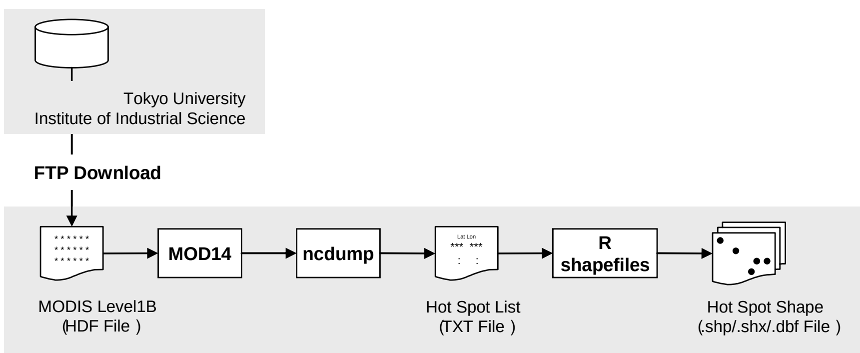

Fig.4 Flowchart of wild fire detection

2-3.2 Factors that induces damage to expand

We considered factors that induce to expand damage such as urging spreading fire. The spreading wild fire is seriously influenced by the land's undulation and climate. Its speed and the direction change because of those factors. Therefore, data related to the land's undulation and climate conditions are extremely important to take accurate measures.

For example, the land's undulation is known that fire spreads faster on slopes compared to flat land, and spreads upward towards the top of the hill[6]. There is a research which shows that a slope with an angle of 45 degrees spreads a fire 27 times faster than flat land[7]. Thus, we used a 90 meter mesh DEM data[8] prepared by the SRTM (Shuttle Radar Topography Mission) and process it into a slope degree data by Surface Analysis of Arc Map®.

Likewise, from the point of view of damage expansion, accessibility to fire stations and traffic network were considered vulnerable to wild fire.

2-3.3 Prospective damages of wild fire

There are different kinds of prospective damages of wild fire; economic or cultural loss, and impairment of abilities which support human society or ecological system. Therefore, the spatial distribution of the properties can be interpreted as a hazard map concerning such values and functions by overlaying the distributions of wild fire with these layers. We prepared data on land use, population distribution, and cultural legacies whose values and functions may be threatened due to wild fire.

The damage by wild fire we can imagine easily is economic damage due to disappearance of forest and farmland. We used satellite remotely sensed data to classify forest area and farmland since it is widely known. According to Global Land cover 2000[9] prepared by Joint Research Center, forest and farmland occupy the most part of Thailand and artificial facility areas are only Bangkok City and a part of Chiang Mai. Therefore, such artificial area is not quite effective for comparing impacts of wild fire in Thailand, but it is important to estimate damages.

Likewise, the damage of wild fire also contains loss of life or threatened lives. Generally, wild fire occurs in the mountains, but it sometimes threatens human lives due to spreading fire. These examples suggest that there is significantly important in displaying detected wild fire and distribution of population on Web-GIS. We used a Gridded Population of the World[10] prepared by The Earth Institute at Columbia University which was maintained population distribution grid data in world level.

The damage of wild fire contains not only economic loss but also cultural loss. For example, if a historic site under investigation is ruined, the history that should be solved would remain unknown. However, it is difficult to calculate impact on culture of all facilities existing on the ground. Therefore, we prepared distribution of World Heritage appointed by UNESCO[11] which is registering in Geography Network as typical cultural heritage layer. When a wild fire is detected near these points, we should consider the risk of ruining cultural values.

3. Result

Our system can display maps like following Fig.5-8. We prepare three scales, whole of Thailand (Fig.5), provincial region in Thailand (Fig.6 and 7), and local area in Thailand (Fig.8). We prepared layers for each scale, whole Thailand, provincial region, local area at present (Table.2).

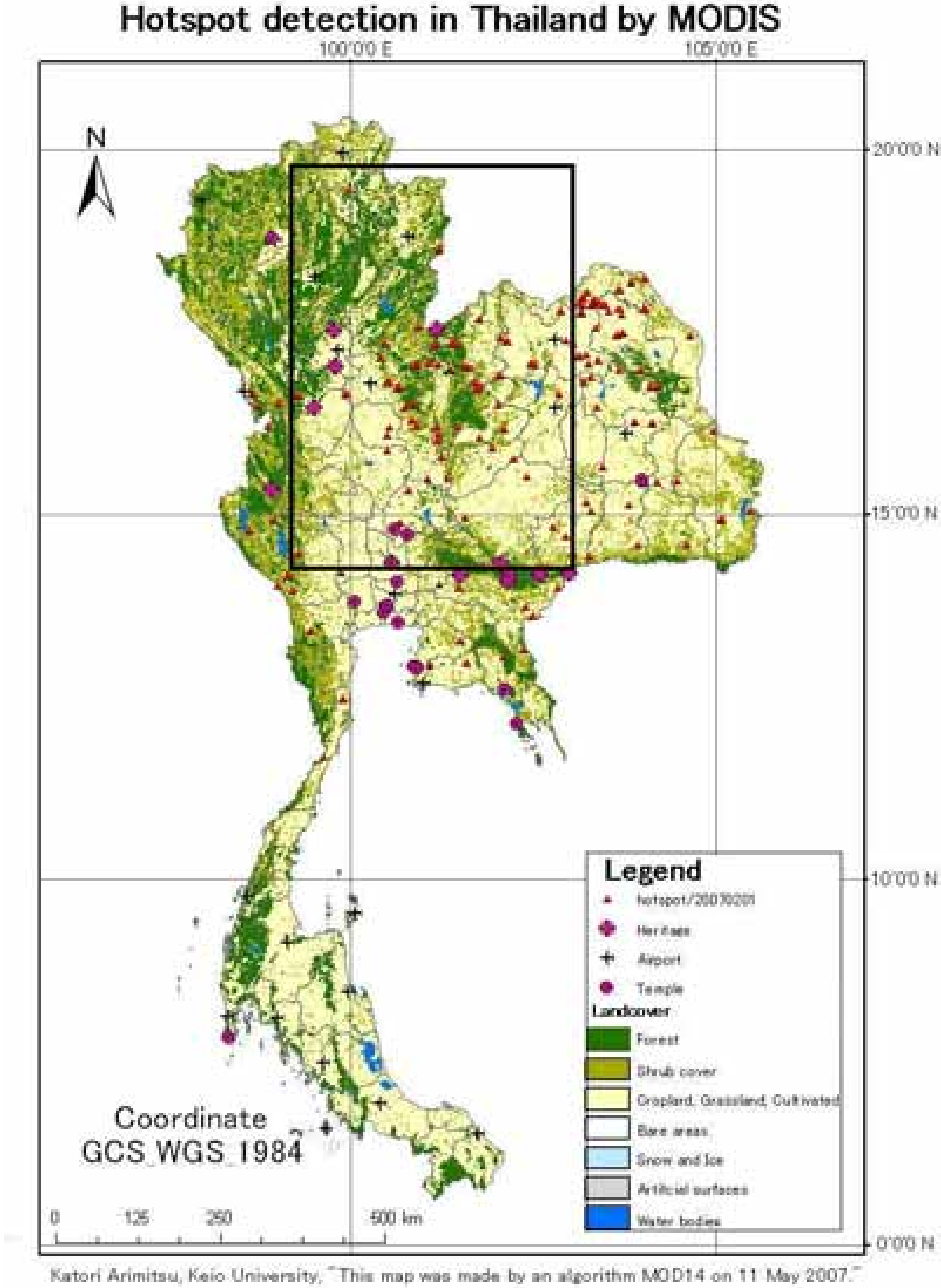

Fig.5 Hotspot detection in Thailand by MODIS

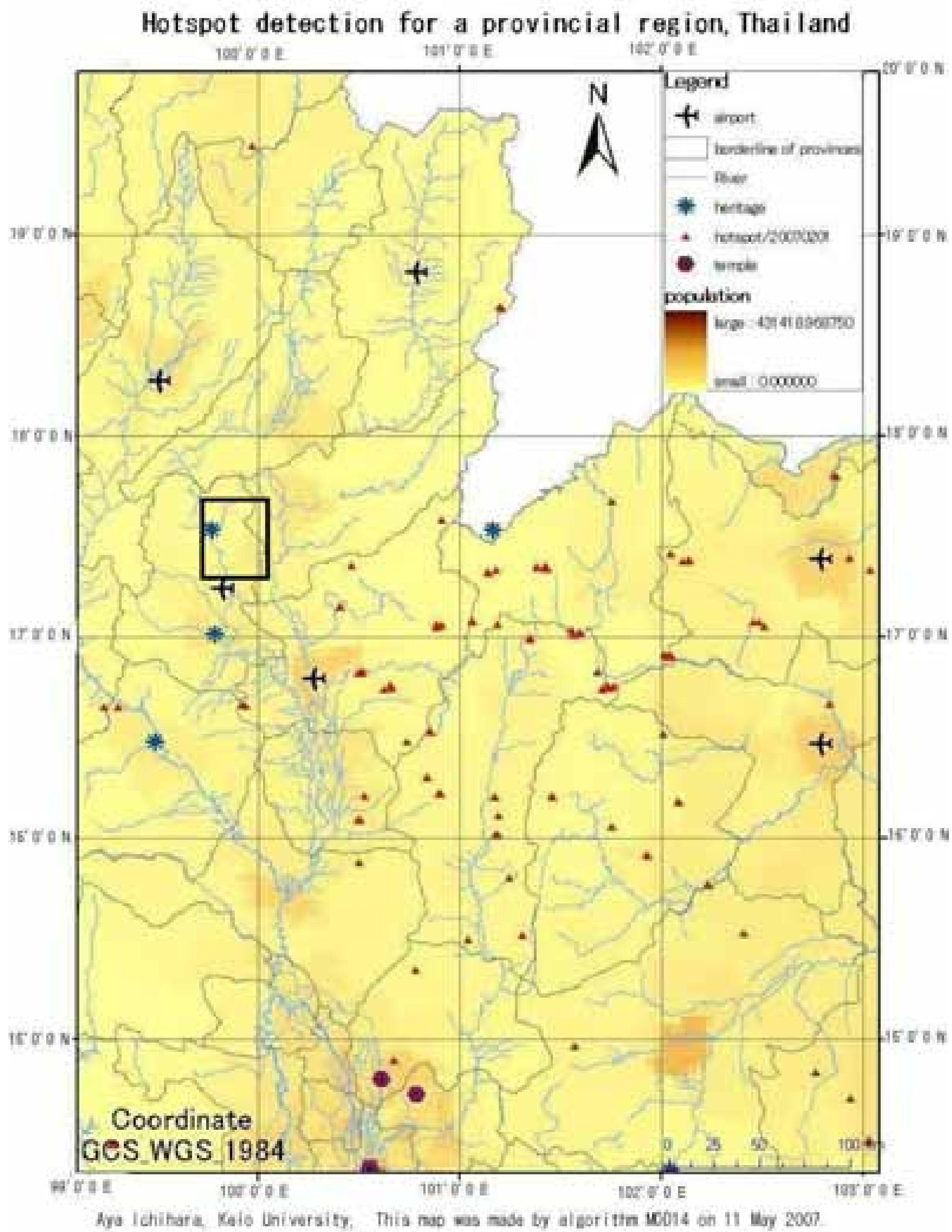

Fig.6 Hotspot detection for a provincial region, Thailand

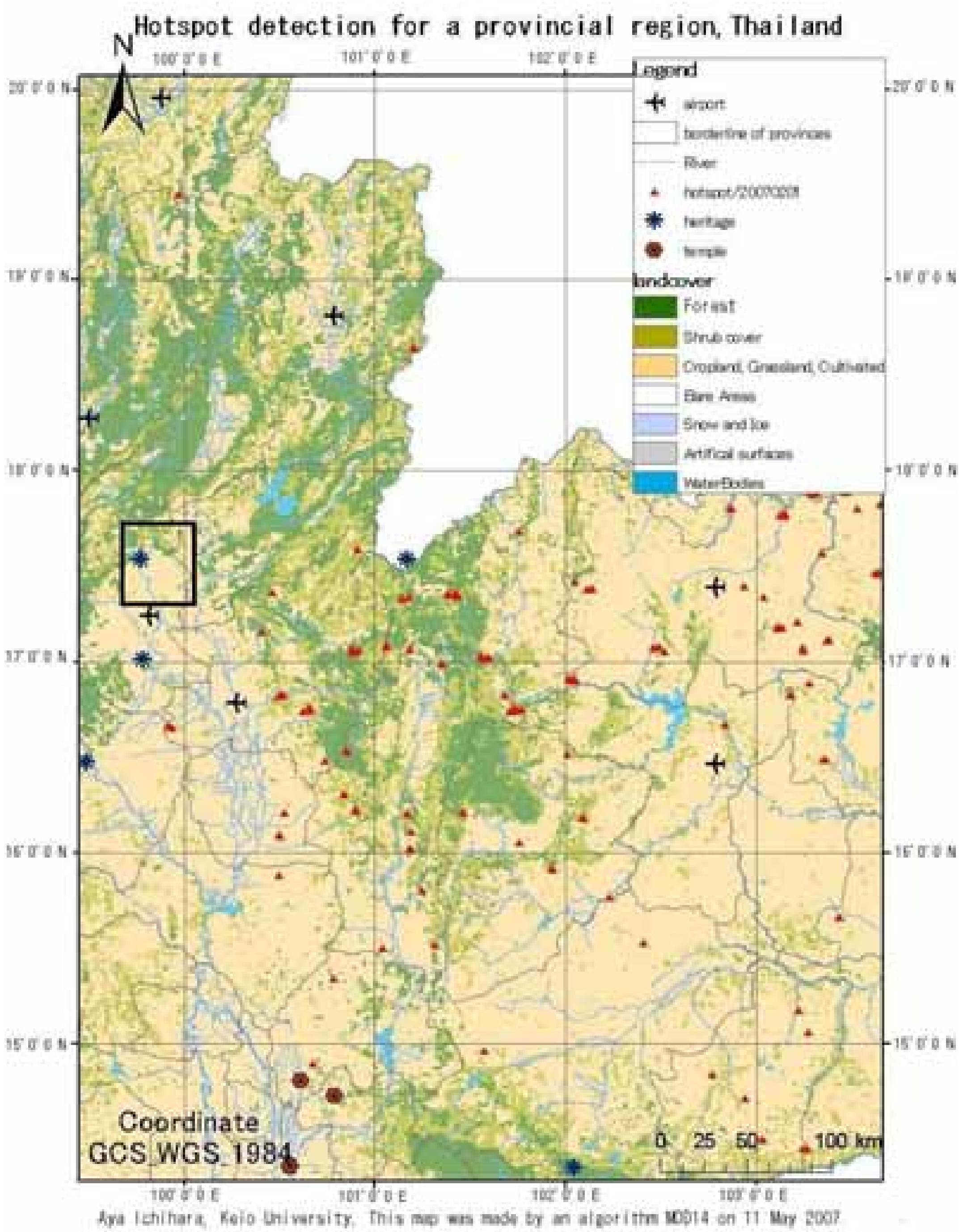

Fig.7 Hotspot detection for a provincial region, Thailand

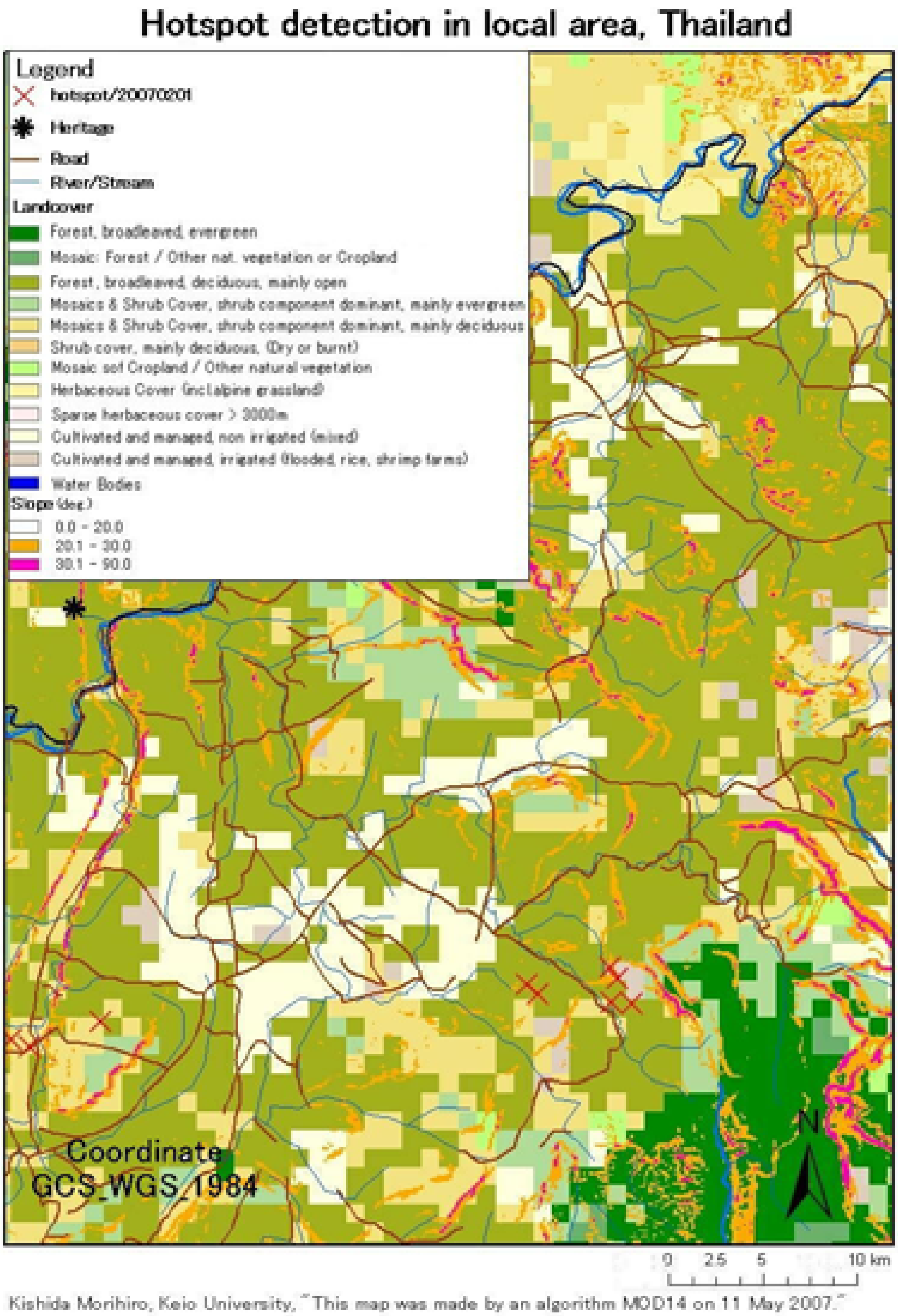

Fig.8 Hotspot detection in local area, Thailand

Table.2 Layers for each scale

Scales	Layers
Whole Thailand	Hotspot, Land cover, Air port, Fire station. Heritage , Temple
Provincial Thailand	Hotspot, Land cover, Population, River, Heritage Street, Air port, Fire station, Heritage, Temple
Local of Thailand	Hotspot, Vegetation, Population, Slope, Stream, Street, Air port, Fire station. Heritage, Temple

Fig.9 provincial region in Thailand[12)]

4. Discussion

4-1. The data of "vulnerability" and "prospective damage" indicator

We consider the relationship between "vulnerability" and "prospective damage".

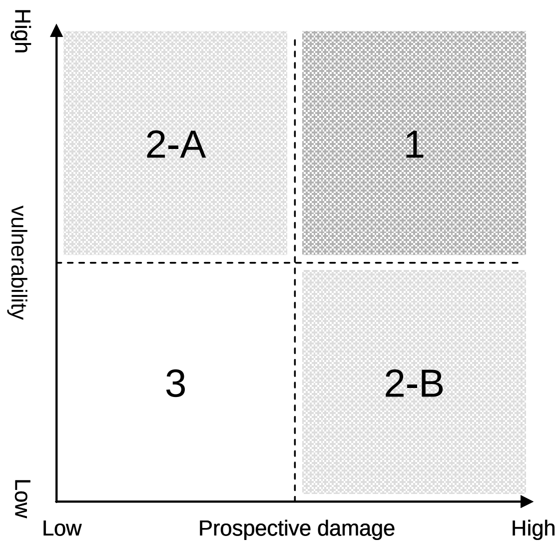

Fig.10 Divide the matrix into 4 groups

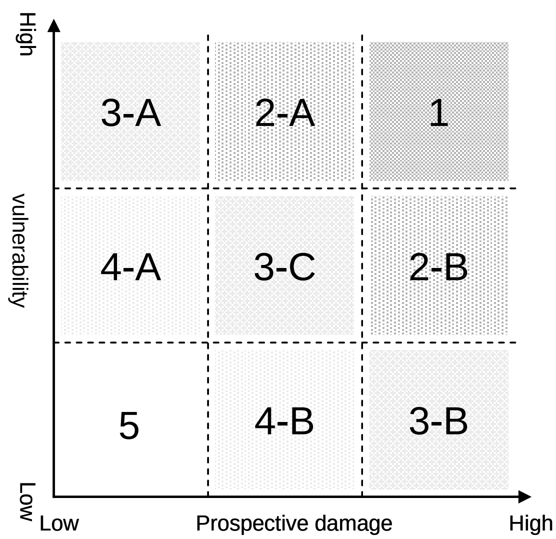

Fig.11 Divide the matrix into 9 groups

Fig.10 is a matrix to classify wild fire into four kinds by the number of "the data of vulnerability" as y-axis and "the data of prospective damage" as x-axis.

In the spots of "1 group", there are many property values and a possibility that the wild fire does widespread damages. It is necessary to deal with such a wild fire at once. Contrary to this, it is not necessary to deal with a wild fire in "3 group" at once as well as others groups.

Therefore, in the spots of "2-A group" and "2-B group" a decision maker may take a different action depending on how a risk is recognized.

・ **In case the wild fire in "2-A group" correspond quickly mote than that in "2-B group"**

When you dislike the thing whether there is damage or not more than the thing any wild fire occurs, that is to say when you think whatever wild fire causes the large damage, "the data on prospective damage" is disregarded and "the data on vulnerability" is valued.

・ **In case the wild fire in "2-B group" correspond quickly more than that in "2-A group"**

When you are worried about the damage and the loss due to wild fire, and you do not care the spread of wild fire, "the data on vulnerability" is disregarded and "the data on prospective damage" is valued.

Fig.11 is a matrix classifying wild fire into nine kinds by the number of "the data of vulnerability" as y-axis and "the data of prospective damage" as x-axis.

There are two cases if a decision has to be made based on only one of "the data on vulnerability" or "the data on prospective damage".

First, we judge "1 group", "2-A group" and "3-A group" as equal risk. Therefore, wherever wild fire occur, for example, in the wasteland, the farmland, the mine, the heritage and the urban district, are corresponded alike.

Second, we judge "1 group", "2-B group" and "3-B group" as equal risk. Therefore, the wild fire where natural extinction cannot be expected, such as the wild fire surrounded by the combustible trees and the wild fire where natural extinction can be expected, such as the wild fire enclosed by rivers, lakes and protection forest against fire, will be equally treated.

The judgments enumerated in the examples are not rational estimates. That is why we consider it is important to use "the data on vulnerability" and "the data on prospective damage" when we consider the correspondence to wild fire.

4 - 2. Methods of using our alert system

Judging from existing systems, there is no system which risk manager can use when he decides what kind of action he should take to extinguish a wild fire. For example, GDACS[13] shows the layers such as population density, tectonic map, weather map, however it is not for wild fire. Then, there is no data needed for judging which fire must be extinguished at once or which fire may be dying out, although we can see where a wild fire is. For example, Sentinel Hotspots[14] is for wild fire and it shows many layers such as LANDSAT Mosaic, Topographic and so on, however it does not have data such as airports or heritages. Compared to them, our alert system can be used for judge-materials when a risk manager takes steps.

First, looking at the figure of whole Thailand (Fig.5), a risk manager can see in what province a wild fire occurs, and judge which airport or heliport is the nearest one for the spot ready to extinguish fire. In addition, because of land cover data, he can immediately understand the relation to a town at once.

Second, looking at the figure of provincial region in Thailand (Fig.6 and 7), a risk manager, mainly in central government, can see the hotspot in detail compared to the figure of whole Thailand. Then he can predict where is the densely populated area or where fire may be dying out, because of the layers of population, land cover and rivers. Thus, he may be able to judge that he needs immediate step in case wild fire occurs near the densely populated area and there are no rivers near the spot.

Third, looking at the figure of local of Thailand (Fig.8), a risk manager, mainly in a provincial government, can see the hotspot in more detail compared to the figure of provincial region in Thailand. Hence he can predict where is the densely populated area because of the data concerning slope, stream, and roads including the data used in provincial regional map.

He can also predict the possibility of spreading fire because of the slope data, and the possibility of restraint of spreading fire because of the stream data. Thus, he may be able to judge that he needs immediate step in case a wild fire occurs near the densely populated area, there are no rivers or streams and the slope is steep. Then, if they could go to the spot with fire engines, he can ask fire stations, and if they could not go by themselves, he can ask fire stations which have the helicopters or airplanes.

5. Conclusion

Our objective is to construct near real time alert system of wild fire as a decision support system for a risk manager with infrastructure of GIS. Our system can be evaluation terms of developing supporting system by preparing some prospective damage layers which existing systems do not have. However, in the study, we prepared only part of necessary layers.

For further investigation, we recommend collecting more data and advance to use it with participating Web-GIS. Not only showing slope or land cover data, we hope to provide a risk manager with layers of prospect of spreading fire, by which he can estimate which wild fire must be the most dangerous, layers of prospect of spreading fire which whether information of near real time is used for, layers of prospective damage, by which he can see the damage caused by wild fire, and the information for the citizens by mobile phones. This study area is limited only to Thailand this time, but we need to expand the target area to whole Asia countries. For practical use, the service of our system is insufficient. By collecting the information for example, what kind of function and system a risk manager may need and want to use, we hope to construct much convenient alert system. In the future, we hope to apply our alert system to other hazards not only wild fire.

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