MATRIX OVERLAY FOR DROUGHT ASSESSMENT IN THE NAM CHOEN WATERSHED, NE THAILAND.

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ABSTRACT: Drought is an insidious hazard of nature. It occurs almost everywhere in all climate zones, although its features vary from region to region with time, space as well as intensity. In a country like Thailand where almost agricultural land is rain-fed. It is a constant threat in one or another part of country especially in the Northeast region. The role of GIS technology can offer the ability to depict the spatial distribution of the extent and monitoring capability for natural disaster management. Matrix overlay function in ArcView GIS developed by Khon Kaen University is applied to assess the drought risk areas in the Nam Choen watershed which is in the Northeast of Thailand. Seven parameters involved in accordance to the impacts on drought are rainfall, surface water and irrigation, sub-surface water, stream density, slope, soil drainage, and finally, land use. The intensity of impact is represented by the value assigned to the entries of each matrix. The study result illustrates that 13.47 % of Nam Choen watershed are of very mild risk, 40.88 % are of mild risk, 37.87 % are of moderate risk and 7.78 % are of severe risk.

1. INTRODUCTION

Drought is an insidious hazard of nature. It occurs almost everywhere in all climate zones, although its features vary from region to region with time, space as well as intensity. Drought annually takes place in Thailand and spread over whole country especially in the Northeast region. Over 70% of the population is engaged in agriculture which is dominated by rain-fed production in the Northeastern part of Thailand which less than 6% of the cultivated land is irrigated (Rig, 1985). In addition, water shortage for domestic consumption is usually identified as the principal constraint for the people during the dry season. Lack of water or drought in the region has a profound impact that can be listed as economic, social and environmental.

Drought risk areas, by nature, are a result of a variety of factors. Drought in general originates from less precipitation over an extended period of time. These include occurrence of no rain in the rainy season, number and amount of rainfall events and other climatic anomalies. In an operational definition of drought it identifies drought from impact data. The drought pattern should be started with an assessment of rainfall. It is widely accepted that the combination of the physical nature of an area, amount of rainfall and water resource development leads to the identification of the drought pattern (Mongkolsawat et al, 2001). GIS technology can offer the ability to depict the spatial distribution of the extent and monitoring capability for natural

disaster management. The capability of GIS is to integrate multi disciplinary data that can be used to analyze drought risk area in time and space.

2. OBJECTIVE

The objective of this study is to assess drought risk area using GIS matrix overlay function.

3. STUDY AREA

The Nam Choen watershed which is located in the Northeast Thailand was selected to be a study area. It covers an area of about 5120 sq.km which lies between the latitudes of 16° and 17° N and the longitudes of 101° 24' and 102° 32' E (Figure 1). It is a portion of upper Chi basin that is the one of third main basin in Northeast region. It is consist of Nam Phom and Nam Choen catchment. Mountainous area with evergreen forest and dry dipterocarp forest, occurs in the west of the Nam Choen watershed, The flat area is in the east which main land use is paddy field in the rainy season and becomes second crop in the dry season. The foot hill area in the middle part is a rolling topography which is used for rubber plantation and mixed orchard. Geologically, it is underlain by thick sequence of Mesozoic rock which mainly consists of sandstone which gave sandy soil in this area and limestone. In the lower plain it is composed of alluvial deposits of sand, silt and clay.

The climate in this area is influenced by the northeast and southwest monsoon. The mean annual rainfall is about 1,116 mm. and the average annual temperature is about 27 ^{0}C.

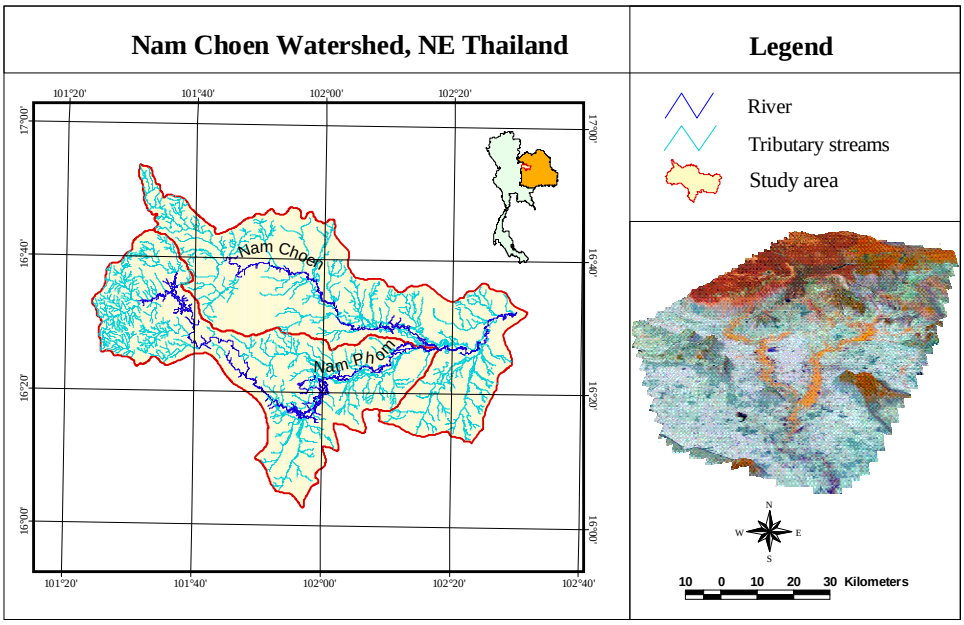


Figure 1 Location of study area

4. METHODOLOGY

4.1 Data collection

The data which are considered to cause drought risk area in this study, are rainfall, stream density, slope, soil drainage, surface water and irrigation, sub-surface water and land use. Those data are both of primary data that are obtained from Landsat -5 TM data and secondary data collected from other agencies as shown in Table 1.

Table 1 Data collection and source

Type of data	Layer	Sources
Primary data	Surface water Land use	Landsat-5 TM data acquired during December 2004-February 2005.
Secondary data	Rainfall Sub surface water Irrigated area Contour Soil Stream NRD2C	Meteorological Department Department of Mineral resource Royal Irrigation Department Topographic map at scale of 1:50,000; Royal Thai Survey Department Soil map at scale of 1:50000; Land Development Department Topographic map at scale of 1:50,000; Royal Thai Survey Department The National Economic and Social Development Board (NESDB) (National rural development in village level in 1994, 1996, 1999, 2003 and 2005)

4.2 Drought parameters analysis

To assess drought risk area, seven parameters which consider to impact on drought are rainfall, stream density, slope, soil drainage, surface water and irrigated area, sub-surface water and land use.

4.2.1 Rainfall analysis

Mean annual rainfall data collected from 42 stations in the study area and surrounding were compiled as a point database. Moving surface interpolation was performed to establish spatial rainfall (MAR) from point rainfall. The spatial rainfall was then identified using decile index to create the decile rainfall which have 10 classes. Ultimately, the 10 classes of decile rainfall were grouped into 4 classes of drought severity as shown in Table 2 and Table 3.

Table 2 Decile rainfall

Decile-Range	Decile Classifications	Rainfall range (mm.)	Drought severity class
1 (lowest 20%)	much below normal	< 934.7868	4
2 (lowest 20%)	much below normal	>934.7868-1045.966	4
3 (next lowest 20%)	below normal	>1045.966-1130.065	3
4 (next lowest 20%	below normal	>1130.065-1204.470	3
5 (middle 20%)	near normal	>1204.470-1276.133	3
6 (middle 20%)	near normal	>1276.133-1349.867	2
7 (next highest 20%)	above normal	>1349.867-1431.076	2
8 (next highest 20%)	above normal	>1431.076-1529.169	1
9 (highest 20%)	much above normal	>1529.169-1670.497	1
10 (highest 20%)	much above normal	> 1670.497	1

Drought Severity :1 = Very mild, 2 = Mild, 3 Moderate, 4 = Severe ; Source : modified from Gibbs and Maher, 1967.

4.2.2 Hydrological analysis

There are four parameters in hydrologic regime, surface water source, irrigated area, stream density in sub-watershed, and ground water yield and total dissolved solid. Surface water source was derived from 3 scenes of Landsat TM acquired during December 2004-February 2005 and irrigated area data collected by the project sites of the Royal Irrigation Department. Stream density was calculated from stream length within sub-watershed areas. Groundwater yield and total dissolved solid at a scale of 1:100,000 are surveyed by the Department of Mineral Resources. Those four parameters of hydrological data were categorized to drought severity class as illustrated in Table 3.

4.2.3 Physical terrain analysis

Slope, Soil drainage condition and land use are input variables in term of physical terrain. Land use map was carried out based on Landsat-5 TM data. The drainage condition of study area was

derived from soil properties. The slope layer was created from TIN made from contour line. Those maps were reclassified using conditions as shown in Table 3.

Table 3 Drought parameters and severity

Drought Component	Variables	Class	Drought severity
Meteorological data (Rainfall data)	Mean annual rainfall (Decile range)	< 1045.966 mm.	4
		> 1045.966 - 1276.133 mm	3
		> 1276.133 - 1431.076 mm.	2
		> 1431.076	1
Hydrological Data	Water source	Water source area of 0 - 0.5 km^2	
		Area beyond water source >0.75 km.	4
		Area beyond water source >0.5 - 0.75 km.	3
		Area beyond water source .0.25 - 0.5 km.	2
		Area beyond water source 0 - 0.25 km.	1
		Water source area of 0.5 - 5 km^2	
		Area beyond water source >1.5 km.	4
		Area beyond water source >1 – 1.5 km.	3
		Area beyond water source >0.5 – 1 km.	2
		Area beyond water source 0 - 0.5 km.	1
		Water source area of 5 –10 km^2	
		Area beyond water source >2.25 km.	4
		Area beyond water source >1.5 – 2.25 km.	3
		Area beyond water source >0.75 – 1.5 km.	2
		Area beyond water source 0 - 0.75 km.	1
		Area beyond water source 0 - 1 km.	1
	Irrigated Area	Area within irrigated area	1
	Groundwater yield and TDS. (TDS : Total dissolved solid)	3 m^3 / hr. & TDS. > 1500 mg/l	4
		2 - 10 m^3 / hr. & TDS. > 750 - 1500 mg/l	3
		10 –20 m^3 / hr. & TDS. <750 mg/l	2
		>20 m^3 / hr. & TDS. <750 mg/l	1
	Stream density	0.1 – 0.35 km/ km^2	4
		0.36 – 0.70 km/ km^2	3
		0.71 – 1 km/ km^2	2
		> 1 km/ km^2	1
Physical Terrain	Land use	Field crop / Deciduous forest / Village	4
		Mixed field crop / Forest and mixed crop	4
		Grass land / Shrub / non-use	3
		Mixed paddy / Mixed ever green forest	3
		Tree / Fruit tree / Swamp and other	2
		Paddy / Mixed fruit tree / ever green forest	2
		Water source / Riparian / Swamp	1
	Drainage condition	Excessively drained	4
		Moderately drained, Well drained	3
		Poorly drained, Somewhat poorly drained	2
		Very poorly drained	1
	Slope	> 30 %	4
		17-30 %	3
		2-17 %	2
		0-2 %	1

Drought Severity :1 = Very mild, 2 = Mild, 3 = Moderate, 4 = Severe ; Source : Modified from Mongkolsawat et al, 2001.

5. DROUGHT RISK AREA ANALYSIS

The integration of drought components was analyzed using the matrix overlay function in Overlay Analyst Extension on ArcView GIS program to analyze the drought risk area.. The output map was created by using a selective ranking table as shown in Table 4. Several trial analysis were carried out to identified the appropriated rating of each parameter. The procedure of analysis is shown in Figure 3.

Table 4 Selective ranking table for matrix overlay

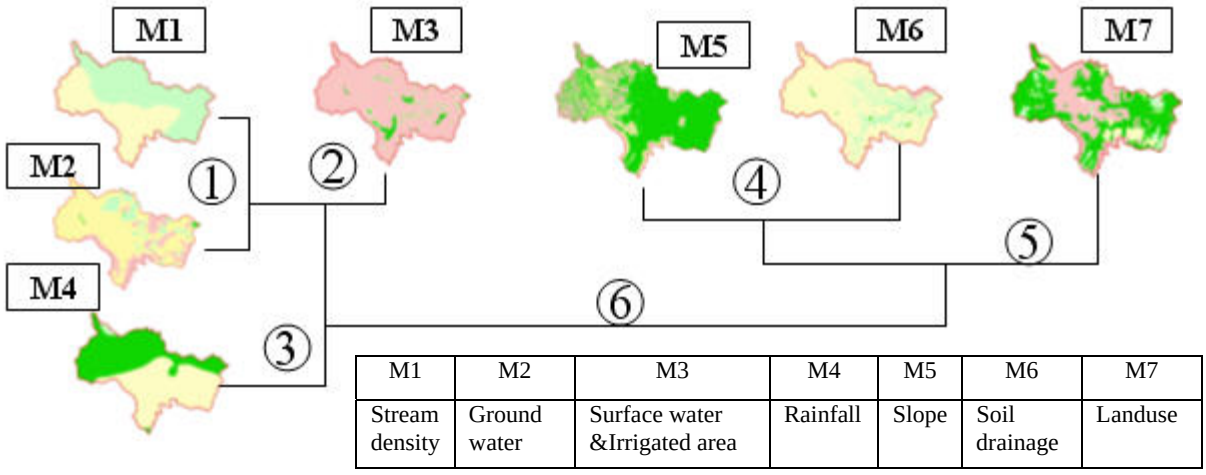
Matrix Overlay		**MAP 1**			
		1	**2**	**3**	**4**
MAP2	**1**	1	2	2	3
	2	1	2	3	3
	3	2	2	3	4
	4	2	3	3	4

MAP 3

Where MAP 1 and MAP2 are input maps.
MAP 3 is output map.

And when MAP 1 > MAP 2

Source : Modified from Mongkolsawat, et al, 2001.



M1	M2	M3	M4	M5	M6	M7
Stream density	Ground water	Surface water &Irrigated area	Rainfall	Slope	Soil drainage	Landuse

Figure 2 The procedure of drought risk analysis

6. DROUGHT RISK AREA ASSESSMENT

To assess the reliability of the resultant map the test areas were checked against NRD2C survey data surveyed by The National Economic and Social Development Board (NESDB). This survey is based on the shortage of water in villages for agricultural use. These data were used to identify the weighting of each drought parameter by matching the level of the shortage water and the class of drought risk.

7. RESULT

The study result illustrates that 13.47 % of Nam Choen watershed are of very mild risk, 40.88 % are of mild risk, 37.87 % are of moderate risk and 7.78 % are of severe risk as shown in Figure 3 and Table 5.

Table 5 Drought Risk Area in Nam Choen Watershed.

Drought class	Drought risk area (sq.km.)	Drought risk area (%)	% of matching with water shortage for agriculture in village
Very mild	689.800	13.47	55.65
Mild	2093.599	40.88	36.00
Moderate	1939.455	37.87	33.60
Severe	398.661	7.78	-
Total	5121.515	100.00	

8. CONCLUSION AND RECOMMENDATION

In conclusion, the result obtained from matrix overlay do not give much satisfy for drought risk analysis in the Nam Choen watershed. Because the percentage of matching between drought risk level and the level of the shortage water is low. Therefore, to increase more accuracy of the result, some parameter should be improved the ranking as well as the rating of each parameter.

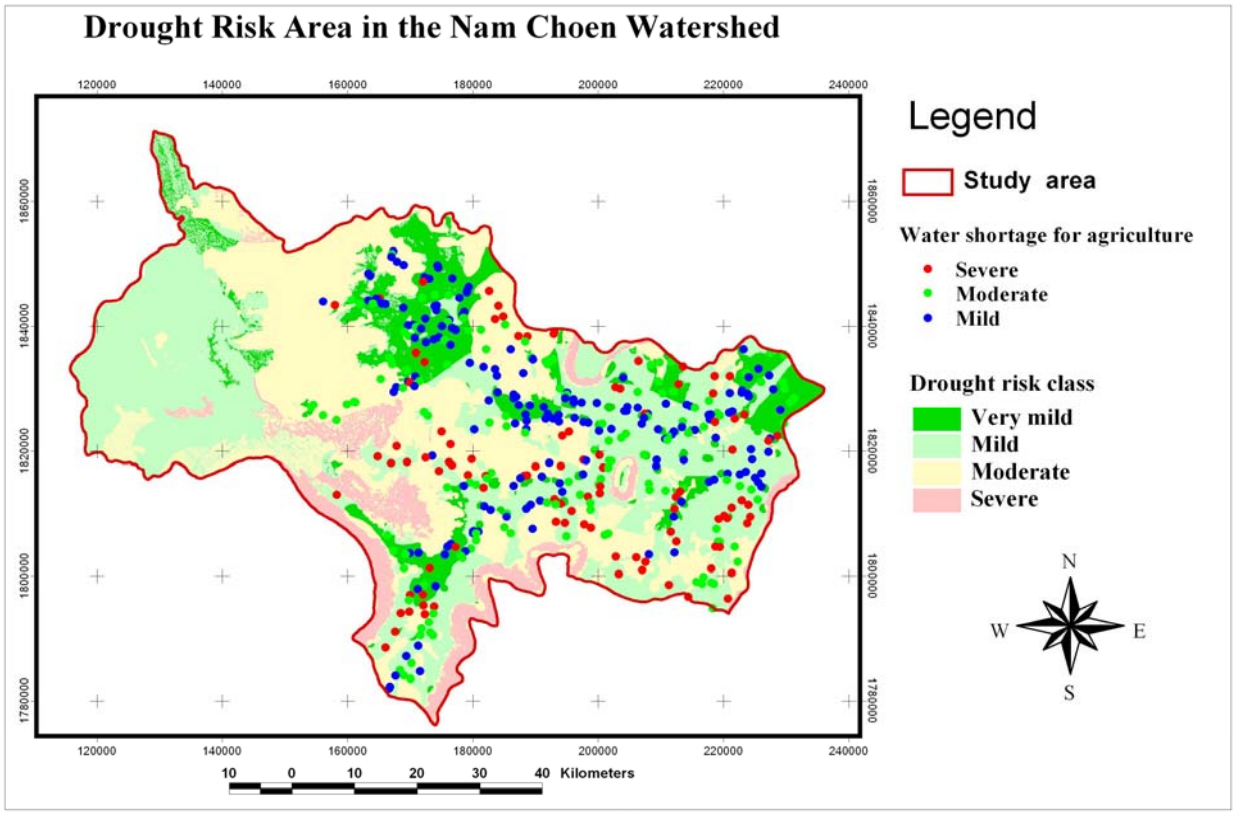


Figure 3. Drought risk area in the Nam Choen watershed based on matrix overlay method.

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