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THE EFFECT OF LANDUSE CHANGE ON RUNOFF IN THE NAN BASIN

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***ABSTRACT*:** Forest area in Nan river Basin was deteriorated due to the increased deforestation for agricultural purpose, resulting in natural resources change especially water flow in natural streams. Having been grown in the economic in NAN basin, the agricultural area had been increased. In the contrary, while the agricultural area increased, the forest area decreased. The forest area in NAN basin, which had been decreased, made the runoff coefficient increased. This study aim to investigate the relationship betweenthe land use change (decrease in forest area) and the runoff coefficient change andto determine the change of runoff in the Nan River basin, one of the important four river basins supplying water to the central plain area in Thailand. The collected data included rainfall, runoff, land use change (forest area change) in each sub basin boundaries. The land use data in the year 2000 and 2006 were used to analysis the runoff coefficient. The analyzed coefficients were then illustrated spatially by using GIS technology. The study found that the decreasing forest area in the basin affected the increase of runoff coefficient and decrease of total runoff. The study results can be used as a data to determine the balance of natural resource utilization and socio-economical development in the more sustainable manner in the future for the study area.

KEYWORDS: land use, change, runoff, sustainable development

1. INTRODUCTION

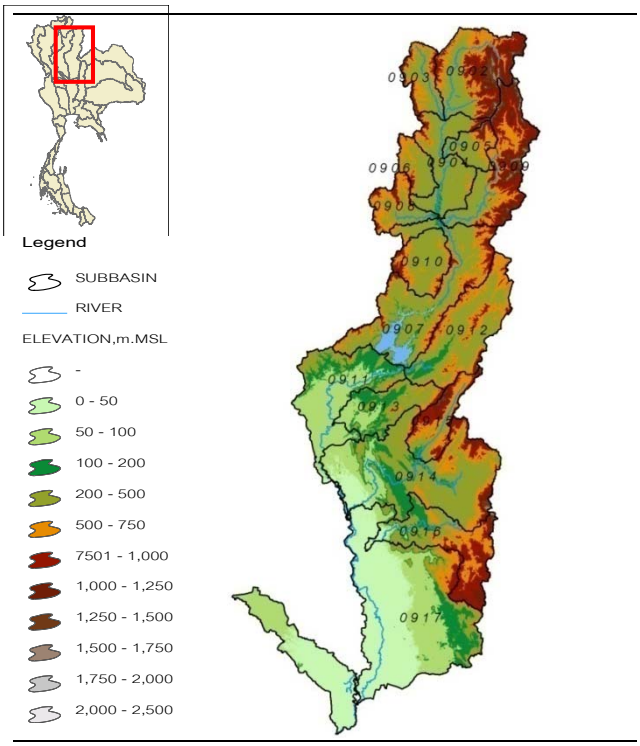
Historicallyland use had changed dramatically and the increasing population and economic growth,are the main causes. The increasing of natural resources usecreated the impact to the hydrologic and environmental conditions.The forest area decreased while the agricultural and urban area increased. After that the agricultural area was transformed to industrial, residential or recreational areas. The changeaffected the runoff.This study aim to investigate the effect the land use change to the runoff coefficient and to determine the change of runoff in the Nan River basin.

1.1 Study Area

The Nan river basin is located in the northern region of Thailand with the total catchment area of 34,682.04 sq.km.The basin originated from BorKlua district, Nan Province and is situated between Latitude 15o 42’ 12” to Latitude 19o 37’ 48” N and Longitude 99o 51’ 30” to Longitude 101o 21’ 48” E, The basin covers the area of 6 provinces namely Nan, Uttaradit, Phitsanulok, Pichit, Phetchabun and Nakhonsawan and can be divided into 16 sub-river basin as shown in Figure 1 and Table 1.

The total population in the Nan basin is 3,423,499 million in 2006 and 3,413,764 million in 2007. Socio-economically Phitsanulok Province has the highest economical development among 5 provinces in

the Nan river basin, while Nan Province has the lowest. The economic development status in the river basin is dependent on the country economics.



Sources: Department of Water Resource

Figure1 Topography NAN Basin

2. METHODOLOGY

The analysis aimed to find the affect of land use change towards runoff coefficients. Thecollecteddata included rainfall, runoff, land use change (Forest area change) in each sub basin boundaries in the year 2000 and 2006.The analyzed runoff coefficients were then illustrated spatially by using GIS technology.

The data used in the study in the main basin and each sub basin of Nan basin are the land use in the year 2000 and 2006, rainfall and runoff time series.

The runoffcoefficient is defined as the Equation (1).

$$Q = CRA \qquad (1)$$

where***Q*** is runoff volume (MCM); ***C*** is the runoff coefficient; ***R*** is the rainfall (mm); and ***A*** is the sub-basin area (sq.m).

Table1 Catchment area of each sub basin in Nan Basin

CODE	SUB BASIN NAME	Area(km^2)
0902	UPPER PART OF MAE NAM NAN	2,222.34
0903	HUAI NAM YAO (1)	787.73
0904	SECOND PART OF MAE NAM NAN	2,200.39
0905	NAM YAO (2)	1,532.19
0906	NAM SAMUN	598.88
0907	THIRD PART OF MAE NAM NAN	589.57
0908	NAM SA	778.40
0909	NAM WA	3,375.80
0910	NAM HAENG	1,043.80
0911	FOURTH PART OF MAE NAM NAN	2,435.02
0912	NAM PAT	992.83
0913	KHLONG TRON	1,297.54
0914	MAE NAM KHWAE NOI	4,578.86
0915	NAM PHAK	2,008.04
0916	MAE NAM WANG THONG	2,470.50
0917	LOWER PART OF MAE NAM NAN	7,770.16
TOTAL		34,682.04

Sources: Department of Water Resources

In the study procedure is as follows:

1) prepare the land use map in the year 2000 and 2006,

2) classify land use type, i.e., forestry, agriculture,residential, irrigation, water resource and other, in each subbasin,

3) measure the area of each land use type in each watershed,

4) analyze the changes in land use (Forest area change)and runoff coefficient.

3.RESULTS

The difference of land use change and runoff coefficient in NAN basin in the year 2000 and 2006 was analyzed and the results are discussed as below.

3.1 Land Use Changes in NAN Basin

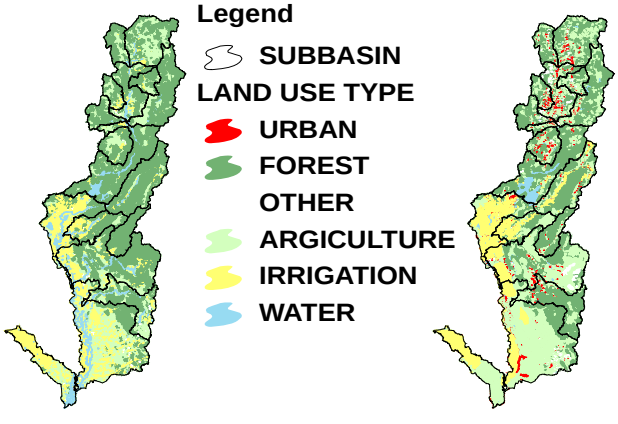
The land use in the study area, shown in Figure 2and Table 2,can be classified into 6 major groups, i.e., forestry area, agriculture area,irrigation area, residential area, water resources area and other.

Table2 Distribution ofland use type in Nan Basin

Type of Land Use	2000		2006	
	Areas (sq.km)	%	Areas (sq.km)	%
Residential	781.11	2.26	872.32	2.65
Agriculture	14,991.73	43.33	16,299.58	49.60
Irrigation	2,480.72	7.17	2,695.00	8.20
Forestry	15,745.15	45.51	13,798.86	41.99
Unclassified	130.29	0.38	535.10	1.63
Water Resources	471.12	1.36	399.23	1.21
Total	34,600.10	100	34,600.10	100

Sources: Land Development Department

Forest area is the top of land use type in Nan basin while water resource area had the lowest in 2000 and 2006 because NAN basin was less developed but rich in natural resource.

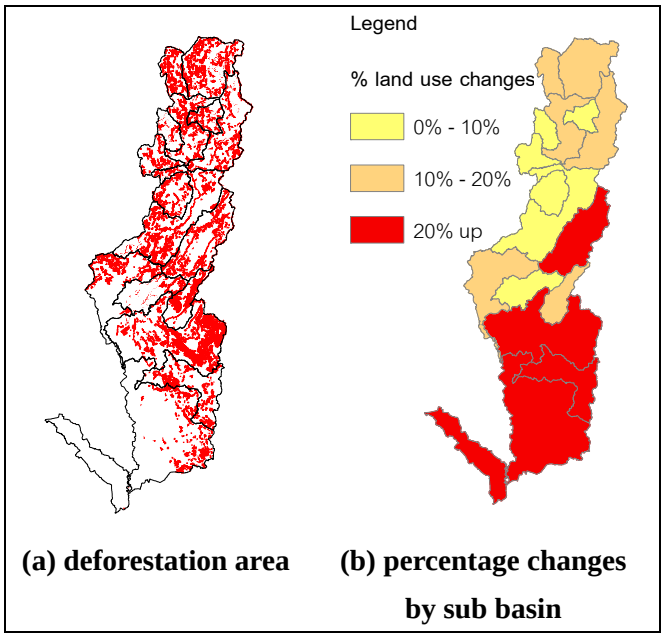


(a) Land Use 2000 **(b) Land Use 2006**

Sources: Land Development Department

Figure2 Land Use in NAN Basin

The differential land uses (forest area) by sub basin wereshown**F**igure 3 and Table 3. In 2006,the deforestation was greater than the 2000's because the economic in basin started to grow. The KhwaeNoi sub basin had the highest deforestation rate of 115.7 sq.km/year or 6.2% per year out of16 sub basin in NAN basinbecause Phisanulok Province, where the KhaeNoisubbasin is located, was highly developed.The SA sub basin had lowest rate of 6.5 sq.km/year or 1% per year.In average, forest area in Nan basin decreased about 386 sq.km/year or 16% per year.



(a) deforestation area **(b) percentage changes by sub basin**

Sources: Land Development Department

Figure3 Land Use Change (Forest area changes) in NAN Basin

3.2 Runoff Coefficient Changes in NAN Basin

The runoff coefficient, which indicatedwater release unit in each watershed, was calculated from the ratio of runoff and rainfall. The runoff coefficient had been calculated by annual rainfall and runoff data. The runoff coefficient was shown in Table 4 and Figure 4. The runoff coefficient values in 2000 is greater than 2006's becausethe forest area in 2006 was less than 2000. In Nan basin, runoff coefficient changedat the rate of 2.1% per year.

Table3 Forest area change in NAN Basin.

	2000		2006		differential	
Code	**A_F,km^2**	**%**	**A_F,km^2**	**%**	**A_F,km^2**	**%**
0902	1,205.2	54.2	1,012.8	45.6	192.4	16.0
0903	420.1	53.3	353.2	44.8	66.8	15.9
0904	770.2	50.3	660.9	43.1	109.4	14.2
0905	329.3	55.0	291.9	48.7	37.4	11.4
0906	364.2	61.8	328.3	55.7	35.9	9.9
0907	2,789.2	78.6	2,571.8	72.5	217.4	7.8
0908	630.5	81.0	585.0	75.2	45.4	7.2
0909	1,557.2	70.8	1,424.8	64.8	132.5	8.5
0910	615.2	58.9	555.5	53.2	59.7	9.7
0911	549.2	22.2	431.2	17.5	118.0	21.5
0912	1,657.8	68.1	1,481.0	60.8	176.8	10.7
0913	1,151.5	88.7	1,059.0	81.6	92.5	8.0
0914	1,860.0	40.6	1,049.6	22.9	810.4	43.6
0915	838.6	84.5	634.5	63.9	204.1	24.3
0916	932.4	46.4	768.9	38.3	163.5	17.5
0917	823.4	10.6	590.6	7.6	232.9	28.3
Total	16,493.94	47.3	13,798.86	39.6	2,695.1	16.3

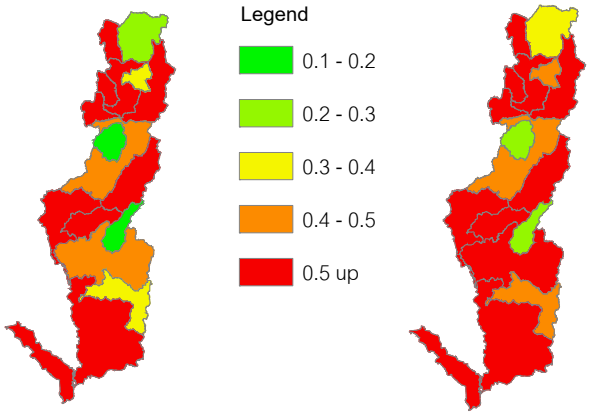
Remark: A_F is forest area

Table 4 Annual runoff coefficient in each sub basin

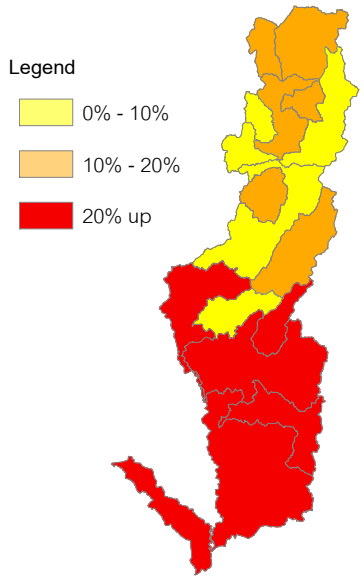
Code	2000	2006	% diff
0902	0.29	0.32	10.4
0903	0.68	0.76	11.5
0904	0.51	0.58	13.4
0905	0.39	0.44	11.5
0906	0.61	0.66	8.4
0907	0.46	0.50	8.6
0908	0.68	0.73	7.1
0909	0.54	0.59	8.1
0910	0.25	0.28	10.2
0911	0.62	0.75	21.9
0912	0.61	0.68	10.9
0913	0.57	0.61	7.3
0914	0.49	0.69	40.8

Table 4 Annual runoff coefficient in sub basin (cont.)

Code	2000	2006	% diff
0915	0.21	0.27	27.3
0916	0.36	0.44	20.9
0917	0.59	0.77	30.6
Avg.	**0.49**	**0.57**	**15.08**



(a) runoff coefficient in 2000 **(b) runoff coefficient in 2006**



(c) the distribution of runoff coefficient

Figure4Runoff coefficient and Runoff coefficient change in NAN Basin

4.CONCLUSIONS AND RECOMMENDATION

The study concluded that land use change affected runoff volume. The change in forests area influenced the runoff change which can be described by the increase of runoff coefficient from the year 2000 to 2006.Runoff coefficient in the wet season were higher than those in the dry season.the deforestation was effected from the growth of the economic in basin which caused the increase in the agriculture area. The decreasing forest area in the basin affected the increase of runoff coefficientand decrease of total runoff as shown as an impact chain in Figure 5. There is a need to find a balance between developing area and forest area.The study can be used as a data to determine the balance of natural resource utilization and socio-economical development in the more sustainable manner in the future for the study area.

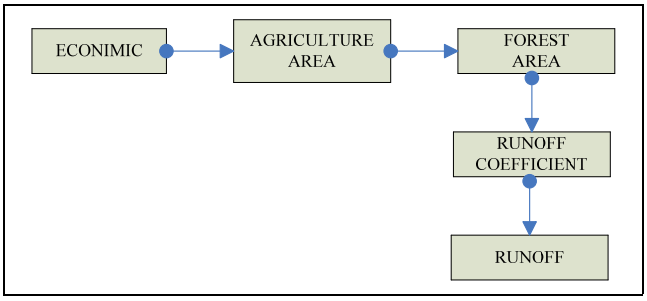


Figure5summary of the impact chain

The present study used monthlyhydrological data of each subbasin for analysis with two year of land use data as available. In future if more landuse data is available, the trend and rate of land use change can be determined more properly which will make the study morepreciselly.

5. ACKNOWLEDGMENT

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