Effect of land use change on water resources of the Mae Chaem river basin, Thailand

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1. Introduction

In recent years water supply shortage has become an urgent issue in Southeast Asia. While on the water demand is heightening with rapid economic development and urbanization, surface water supplies are increasingly being menace by the derivable land use change (Chuan, 2003). Especially in the northern Thailand, which consists of highland, forest areas are declining while agricultural areas are increasing water demand is also increasing with conflicts between hill tribes and lowlanders. Water scarcity is occurring both in upstream and downstream. This is often attributed to increasing use and storage in the upstream (Ekasingh et.al 2005). The objective of this study was to assessment effect of land use change on water resources of the Mae Cheam River Basin.

2. Study Area

The Mae Cheam river basin is located in the northwest of Chiang Mai Province in northern Thailand. The watershed covers an area of 3,853 km^2. The catchment's shape is long and narrow (approximately 100 km in length, and up to 40 km in width). The catchment covers from latitudes 18° 12´ to 19° 8´ N and longitudes 98° 8´ to 98° 34´ E. The area is highly mountainous with elevation ranging from approximately 650 m above mean sea level (m.s.l.), near Mae Cheam city, to more than 2,500 m.s.l. on the slopes of Mt.Inthanon. The catchment has a strongly seasonal climate with approximately 95% of annual rainfall occurring during wet season. The average annual rainfall at the city of Mae Cheam is 973.3 mm. around 90 percent of the rainfall falls during the period of southwest monsoon, which runs from May to October. Most area of the catchment is forested with the dominant land use being agriculture.

3. Methodology

3.1 Hydrological model

The Hydrological model based on BTOPMC Model (Nawarathana et al., 2000). Raw input data for BTOPMC falls into three main categories :(1) topography ;(2) time-series of hydrological data; and (3) land surface characterization.

3.2 Crop water demand

The crop water demand of each crop are calculated on the basis of meeting the evapo-transpiration rate (ET_{crop}) of disease free crop, growing in large fields under optimal soil conditions including sufficient water and fertility and achieving full production potential under the given growing environment.

3.3 Water sufficiency Index (WSI)

For the assessment of water sufficient, an index was adopted based on the ratio of the difference of stream flow (available water) and crop water demand *(RD-WD)*, to the available water, (*RO)*. The water sufficient index is defined by

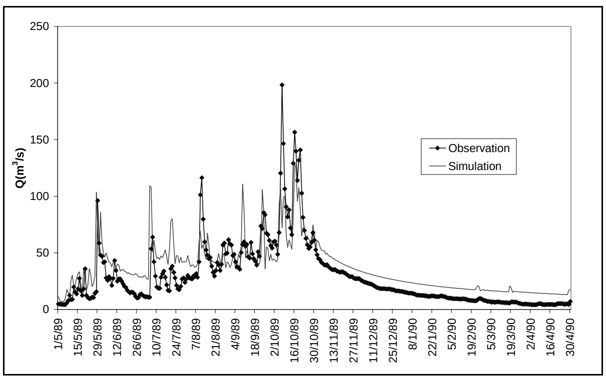
$$WSI = \frac{RO - WD}{RO} \tag{1}$$

where *RO* is stream flow the outlet of basin (m^3) and *WD* is water demand (m^3). The *WSI* constructed from the ratio of water withdrawals for crop water demand to available of surface runoff. *WSI* is an indicator of regional water status.

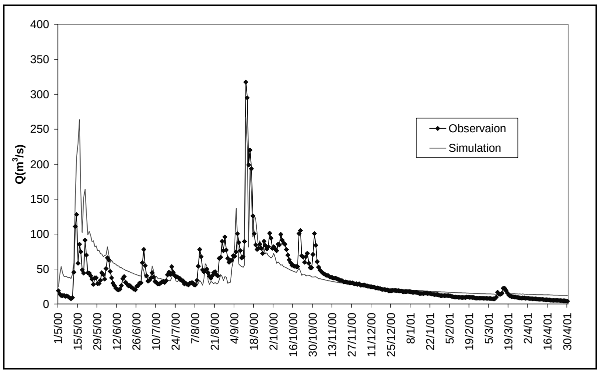
4. Results & Discussion

The BTOPMC model was modified as a distributed model in this application. Model performs calculation pixel-by-pixel basis. The result evaluation is based on the index of agreement (IOA). Fig 1 displays the comparison of observed and simulation hydrographs results were carried out for the years 1989 and 2000. The overall performance of the simulation seems satisfactory, as the IOA are 0.865 and 0.859 in 1989 and 2000. Model parameters obtained for the calibration were used to predict flow in 21 reference subbasins (Fig.2).

Assessment for water use focus on crop water demand that dominates the amounts for the other demands. The crop model was applied to the crop irrigation campaigns of 1989 and 2000. The model uses the FAO approach to calculate crop water requirements on a daily basis; crop water requirements in millimeter are calculated. The estimated monthly crop water use of Mae Chaem River Basin figures show in Fig 3. The amount of annual crop water demand is 11.37 x10^6 m^3 in 1989 and 7.48x10^6 m^3 in the year 2000. It indicates that the annual crop water demand had obviously reduced since 1989 to 2000. Considering the land use in Mae Chaem River basin, some agriculture area had become forest by afforestion program, which had been promoted in the study area.



(a)1989



(b) 2000

Fig.1 Comparison of observed and simulation hydrographs at P.14 station

Fig.2 Subbasin of Mae Chaem river basin

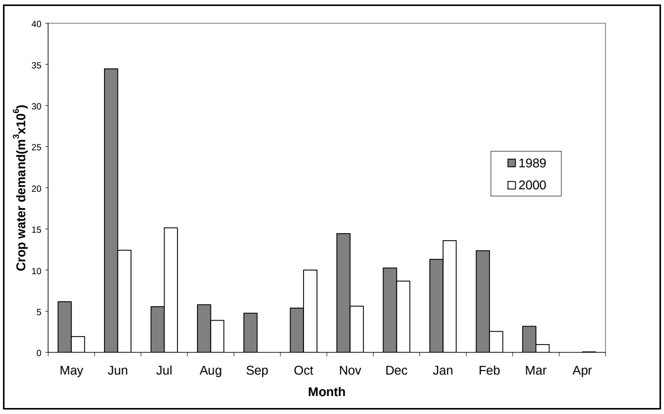
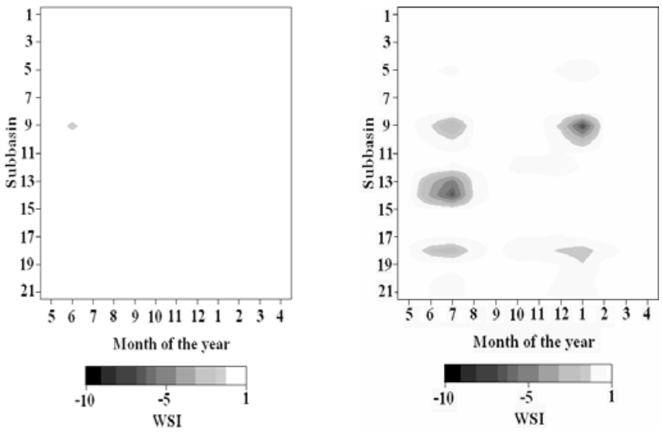


Fig.3 Monthly crop water demand in for Mae Chaem river basin 1989 and 2000

Fig. 4 presents the monthly values for *WSI* in each subbasin in 1989 and in 2000. It clearly shows that water deficit occurs in the early of the wet season in 1989 in subbasin 5, but it has been recovered in 2000. Table 1 present land use class with the water deficit subbasin, it shows the reason because some agriculture area had become forest by afforestion program. Conversely, in subbasin 9, the result show a serious water deficit occurred in early wet season and early dry season in 2000, but did not occur in dry season in 1989. Similar situation can be observed for subbasin 14. In subbasin 18 water deficits occur in both of wet season and dry season in 2000. The main reason of water deficit is deforestation in subbasin 9. Whereas subbasin 14 and 18, forest area much higher than last decade but the farmer changed agricultural type from maize to soybean and shallot for cultivate in wet and dry season. The serious situation is in subbasin 9 in dry season and wet season and in subbasin 14 only in wet season. For the water use conflict, it intense in dry season more than wet season because in wet season there is enough rainfall.



(a) 1989 (b) 2000

Fig.4 Monthly values for WSI in subbasin

Table1. Land use type in category of sub basin that serious water deficit occurs in 1989 and 2000

Land use class	Land use (%)							
	Year1989				Year 2000			
	subbasin				subbasin			
	5	9	14	18	5	9	14	18
Paddy	0.54	0.36	10.66	1.59	0.91	0.01	6.19	1.94
Agriculture	14.86	15.86	9.77	9.65	1.25	5.87	5.09	7.18
Cabbage	0	0	0	0	4.32	17.08	0	0
Forest	84.36	83.78	78.95	88.47	93.25	77.04	88.10	90.89
Urban	0.24	0	0.62	0	0.27	0	0.62	0
Other	0	0	0	0.29	0	0	0	0.01

References

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3) Nawarathna N.B., Kazama S., Sawamoto M. 2002. Improvement of calibration procedure of the block wise TOP model with Muskingum-Cunge routing method using sub basins simulated results: application to part of the lower Mekong River basin. In Proceedings of 13th Congress the APD/IAHR(1): 540-545.