COMMUNITY'S WATER RESOURCE MANAGEMENT IN UPSTREAM CATCHMENTS OF LARGE RIVER BASIN : A CASE STUDY IN PUA WATERSHED, THAILAND

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***ABSTRACT*:** The Pua Watershed locates in the Upper Nan River Basin upstream of the Sirikit Dam's reservoir in Nan province, Thailand. The typical problems are often seen such as water shortage with not cope for all utilization of agriculture, consuming, water supply during dry season. Moreover, flood and mudslides often overflow and destroy severely erosion of the river banks and flooding in urban areas and agriculture lands during wet season as well as water quality degradation and poor efficiency management of their irrigation systems. Even though the government already constructed with some small to medium scale water resources development project and alarm systems installation in some risk area of flood and drought based on top-down policy with lack of people participation. The problem still occurs, because those systems could not resolve their needs from local people in their communities. Thus, research for integrated water resources management for local communities in the upstream catchments of large river basin such as Pua watershed has been carried out based on their needs and participation from those local peoples as bottom-up policy. The learning processes of data collection of local watercourses were conducted at firstly as for use to balance of demands and supplies water resources in Pua watershed. The results show 626 watercourses with annual storage capacity of water of 4.8 million cubic meters which could be served for their own agricultural area of 5074 ha and population of 45173 people. Moreover, the watershed produces outflow not only Pua itself but also to downstream watershed as for other users in Nan Province too. Therefore, the strategic planning to manage water resources based on balancing of natural resources and environment were assigned with 6 strategic plans, 19 target active plans, and 71 projects within various periods i.e. short, medium, and long terms, respectively. There were 37 members as for the management council establishment as the aim for efficiently driven those plans and look after as the integrated water resources management in Pua watershed.

KEYWORDS: water resource management, flash flood, local communities, Pua watershed.

1. INTRODUCTION

The Pua Watershed situated in the Upper Nan River Basin in Nan province, Thailand. Nan River originated in Nan province that comprises of many tributary streams to produce as inflow to the Sirikit dam provided huge reservoir with the storage capacity of 9510 million cubic meters. The Upper Watershed of Nan Basin specified by location at upstream of the Sirikit Dam's reservoir in the Nan province which comprises of tributary source of water include Pua shown in figure 1. The typical problems of the upper Nan basin are often seen such as water shortage with not cope for all utilization of agriculture, consuming, water supply during dry season. Moreover, flood and debris flow include mudslides are often seen which cause to severely damage of the river banks and residential areas including agriculture lands during wet season. Moreover, water quality degradation and poor efficiency management of their irrigation systems were reported (DWR, 2005; and RID, 2006).

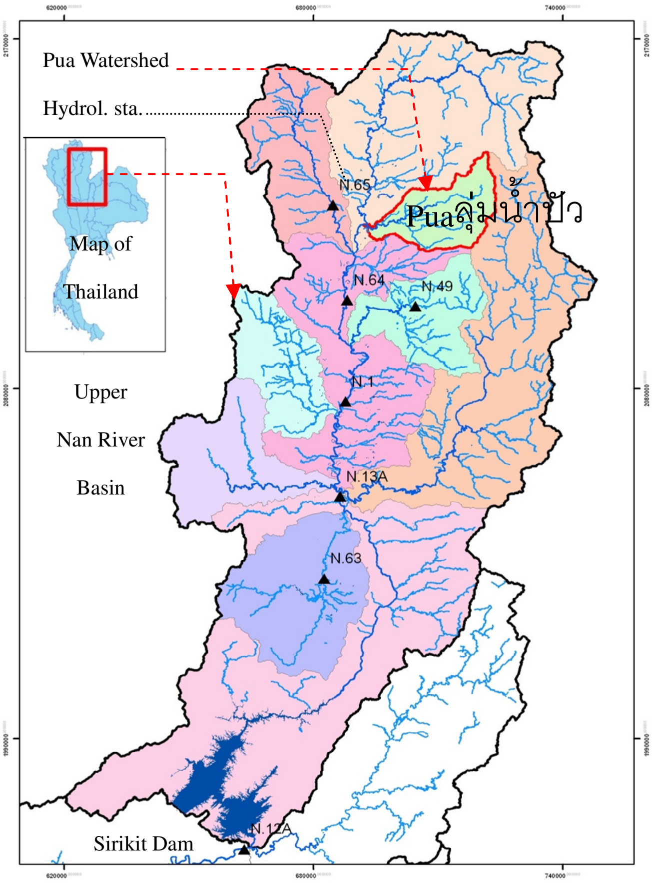

Fig. 1 Map of study area in the Upper Nan River Basin and hydrological observation stations upstream of Sirikit Dam

Even though there were already some water resources development projects and installation of alarm systems in some areas which constructed by the government mainly in medium to large sub-basins or tributaries of Nan river by the Royal Irrigation Department (RID) and other related agencies as top-down policies. The common problem still occurs particularly in the smaller catchments which almost are responded by each local administration office (LAO)'s community. Those top-down project plans cannot be covered all needs from their own LAO's area.

Thus, the integrated water resource management plan for project development to solve their needs in the small catchments of Nan River Basin such as Pua watershed was conducted based on people participation in their communities as bottom-up policy.

1.1 Objectives

The main theme is to show and formulate the learning processes for the leaderships of local community people on how to use their own collected data i.e. watercourses surveying, situation, and capability for project development planning using water budget techniques with balancing demands and supplies in Pua watershed based on people participation as integrated water resources management (IWRM).

2. METHODOLOGY

Learning processes of the collection of all local watercourses information, situations, and capable for LAO officers and leader peoples to perform water budget balance of demands and supplies for their own area were conducted. The conception of IWRM (GWP-TAC, 2000) was applied as people participation for performing master plan of water resources management by concerning balance of natural resources and environment in Pua watershed.

The field survey of water courses in the learning process was started by using the Google Earth Map (maps.google.co.th) in order to understand their own topography in each community's catchment as well as watercourse systems surveying by global position system tool: GPS to record the coordinates of those existing watercourses. The Pua watershed's commanded area is 404 km^2 shown in figure 2. The Pua river is major stream of its watershed that produces streamflow for all year round, with the length of 56.3 km, and rather steep slope with range between 0.2 to 2.9 percent. The Pua watershed coves with 9 sub-districts of Pua district name: Phuka, Sakad, Silalang, Woranakhon, Satan, Pua, Ngang, Chaiwatana, and Chedichai. A diversion weir was bound the plain and mountainous areas with a rather steep slope of the riverbed of 2.9% and drainage area of 149 km^2 as upstream watershed while a milder slope of 0.2% found in a downstream river reach approx. 20 km of this weir, which considered as a gauged basin. However, the major branch streams of the Pua are ungauged catchments name: Kwang, and Koon with the drainage area of 86, and 35 km^2, respectively. These upstream watersheds produce runoff to the 3-streams downstream of Pua weir (Pua river), Jao weir (Kwang river or Namkwang), and Kang weir (Koon river or Namkoon) in figure 2, respectively, with a mean annual runoff of 578 million cubic meters (MCM or 10^6 m^3) as outflow to the downstream area in Nan province. The Royal Irrigation Department (RID) has been taken care management of the Pua weir and its irrigation area since the completion of construction to the operation and maintenance scheme with full annual budget according to medium scale project was specified. However, the small scale irrigation projects (SSIP) must to transfer to the LAO for maintenance and extension work after finished construction.

The hydrologic modeling system: HEC-HMS was applied to estimate river flow hydrograph from each rainfall storm over the ungauged catchments based on Snyder's synthetic hydrograph which produce input data to the river analysis system: HEC-RAS (USACE, 2008) as for awareness of water surface profiles and its hydraulic phenomenon along the Pua and branch rivers were modeled by the author and results were delivered to their communities particular during flood period (Chuen-chooklin, 2012). The model is shown in figure 2, whereas Pua1, Kwang1, Kwang, Koon, HuaiLa -Pood, and Pua-Ngang are local inflows to the Pua via streams name: Pua r1, Pua r2, Pua r3, Namkwang1, Namkoon1; and junction name: Bankaem, Tonlang, and Outlet in figure 2.

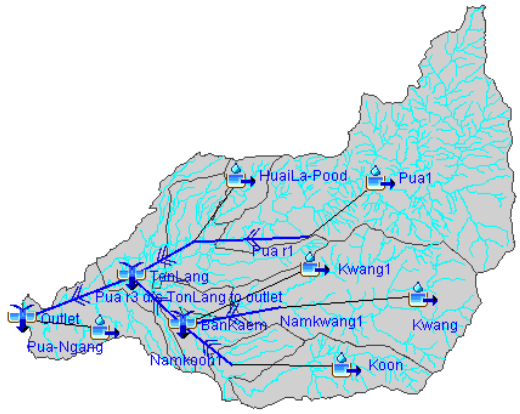

Fig. 2 Schematic of river networks in Pua watershed and its catchments was used in HEC-HMS.

The simple equation using water budget balance model in each catchment included rainfall, runoff, and storage capacity applied as supply to watershed whilst water uses for crops, people consumer, industries, tourists, and etc. were considered as demand from this watershed.

Crop water requirement: *CWR* (mainly paddy field with few cash crops: upland and vegetables) in both wet and dry seasons (excluded mountainous area) was estimated based on crops evapotranspiration from local climatological data and crop coefficients: K_c for crop stage (FAO, 1998) in eq. (1).

$$CWR_i = A*1.6*d_i*(K_{ci}*ET_i+L-P_{ei})/\eta \qquad (1)$$

whereas $_i$ stage or growing, A is growing area in rai (1rai=0.16ha), ET is evapotranspiration in mm/ day (table 1), L is percolation loss in paddy field 1.5-2.0 mm/day, P_e is effective rainfall in mm, d is number of day, CWR in m^3, and η is irrigation efficiency. The effective rainfall approx. based on monthly rainfall, crops, and bund height (paddy field). The water demand for paddy field's land preparation is normally higher than crop water use which depended period of practice (normally 200-250 mm per 3-4 weeks, and 50-80 mm/season within 1-2 weeks for upland crops). K_c is crop coefficients (table 2).

Table 1 Potential evapotranspiration in Pua

Month	Temp.(ºC)	Humid.(%)	ET (mm)
Jan	20.6	78	71.3
Feb	22.2	71	81.2
Mar	25.9	67	108.5
Apr	28.3	69	120
May	28.1	78	117.8
Jun	27.8	81	102
Jul	27.1	84	93
Aug	26.9	85	93
Sep	26.7	85	90
Oct	25.7	83	86.8
Nov	23	80	72
Dec	20.2	78	62

Table 2 Monthly K_c for various crops (pan method)

Month no.	1	2	3	4
HYV Rice	1.32	1.79	1.48	0.28
Maize	0.85	1.5	1.35	0.32
Soybeans	0.83	1.46	1.18	0.42
Mungbean	0.68	0.8	0.36	-
Groundnut	0.71	1.16	0.86	0.36
Tobacco	0.6	1.25	1.14	0.23

The demand included water for human drinking and consumer purposes approx. 110 liter/day/person, for tourist use based on number of accommodations, for industrial use based on sizing and purpose approx. 5-30 m^3/ha/day for small factory. If all total water demand is greater than water availability from the sources, therefore shortage water problem would be occurs with need more water sources to be solved. However, if too much water caused by heavy rainfall in wet season, flood and debris flow problems might be occurred. Therefore, efficiently drainage systems i.e. well re-dredging of main and lateral channels include by pass channels, early warning systems, flood protection dike, and reforestation at upstream watershed management should be considered.

The IWRM committees for managing the Pua watershed has been established by the representative persons whom come from each local communities in this watershed i.e. head of village, head of sub-district, sub-district prime, parish mayor, and supervisors from the local government and district offices include local administrator, agriculture extension officer, and irrigation district officers. Therefore, the strategic planning to manage water resources concerning natural resources and environment were brain-stormed and built up as the active plans for well look after the Pua watershed.

3. RESULTS

The results showed mean annual rainfall in Pua watershed of 1891 mm, rainy day of 110 days which produces outflow runoff from this watershed with volume of 578 $x10^6$ m^3 approx. 5% of inflow to the Sirikit dam. But in dry season river flow is only 5% and causes to shortage water in some part (figure 3).

There were existing 626 watercourses in 2010 with ponded area of 97.6 ha and storage capacity of 4.8 $x10^6$ m^3, which can serve enough for existing cultivated area of 5074 ha (table 3 and figure 4) and water use for 45173 people from 10 sub-districts in each LAO in the Pua watershed.

Most of irrigation schemes in this area are gravitational water supply systems and manage by each farmer user group. Only 8% of total landuses are agricultural lands including paddy (7%), upland crops & vegetable (1%), the remaining are shifting cultivation (maize, upland rice, and etc.) and forest in highland and mountainous area (figure 4).

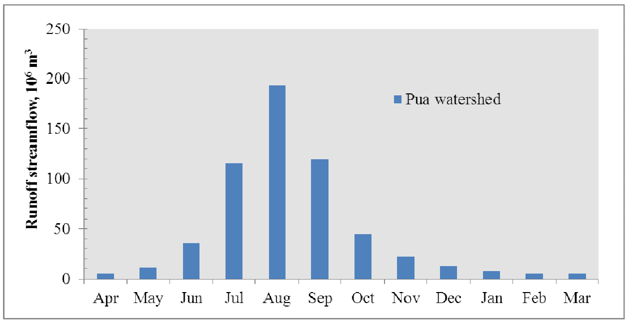

Fig. 3 Monthly streamflow produced from Pua river.

Annual crop water demand and human utilization with 90.9 and 2.1 x10^6 m^3/year were estimated based on monthly uses shown in table 4.

Table 3 Existing watercourses in Pua in 2010

sub-district	no.	Cap., m^3	Irr.Area, ha
Chedichai	48	1348494	496
Chaiwatana	128	702856	56
Ngang	22	28795	-
Pua	139	1050503	512
Paklang	5	85987	-
Satan	104	579300	1936
Sakad	3	53020	-
Silalang	57	600588	1200
Woranakhon	59	337573	528
Phuka	61	11742	346

Note watercourses are a number of farm pond, weir, reservoir, groundwater well, pumping st., and wetland or swamp area.

Table 4 showed monthly water needs in the Pua watershed. There is lack of water supply occurred in some areas due to larger water needs because larger residential and cultivated areas were reported. The demands during wet season (June to November) are less than streamflow. Therefore, the Pua produces outflow to the downstream users. However, the demands in dry season (December to May) are greater than amount of streamflow in figure 3.

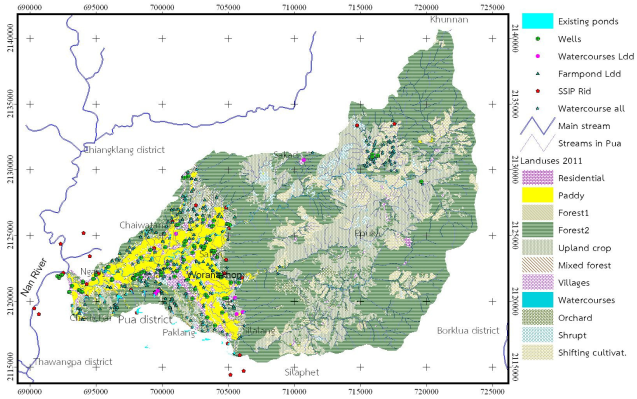

Fig. 4 Landuse types & watercourses in Pua.

Table 4 Overall water uses in Pua (x 10^6 m^3) in 2010

Month	Crop-water	Human	Indus.	Ecology
Jan	4.56	0.18	0.03	1.34
Feb	3.29	0.17	0.03	1.21
Mar	2.23	0.18	0.03	1.34
Apr	1.71	0.18	0.03	1.30
May	5.28	0.18	0.03	1.34
Jun	20.22	0.18	0.03	1.30
Jul	15.70	0.18	0.03	1.34
Aug	15.20	0.18	0.03	1.34
Sep	11.19	0.18	0.03	1.30
Oct	4.80	0.18	0.03	1.34
Nov	3.59	0.18	0.03	1.30
Dec	3.16	0.18	0.03	1.34

The trend of water shortage problem is tended to be increased in near future due to higher need of water for more growing crops in low land area and higher landuses change in upland area to get higher farm’s income i.e. orchard or rubber tree plantations. Therefore, each LAO in Pua should well manage their watercourses based on balancing the demands and supplies for the development plan combination of traditional knowledge based. Best vision and strategic planning to manage water resources with natural resources and environment concerned were assigned with 6 strategic plans, 19 target active plans, and 71 projects within various periods i.e. short (<1 years), medium (1-3 years), and long terms (>3 years), and categorized based on their topographies: upstream, midstream, and downstream watersheds, respectively. Those 6 strategic plans included water resources, organic agriculture, watershed management, environmental management, land resource management, and renewable energy plans. All 19 target active plans and 71 projects were contributed to 6 strategies. The Pua Watershed Council with 37 members representative come from each LAO was established with aim to efficient driven those plans management and taken care as the integrated Pua watershed development.

4. CONCLUSION & RECOMMENDATION

The Pua watershed produces streamflow not only Pua itself but also share river flow as outflow to the downstream of the Nan River Basin and Sirikit Dam's reservoir too. However, midstream and downstream areas in the Pua could be easily damage by flood after continuing heavy rainfall because its upstream watershed is less vegetative cover due to more deforestation with shifting cultivated area and landuses changed cause to faster speed of runoff flow, and its effect from backwater phenomena from the junction to the Nan River too (Chuenchooklin, 2013, 2012b). Furthermore, rapidly growth in economics will need more water in future especially for food and human consumer. Therefore, more strengthening of the water users involve in IWRM should be emphasized as taken care for their own watersheds and all project developments.

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