ECOSYSTEM SERVICES OF WATERSHED FOREST AFFECTING THE AGRICULTURAL AREAS IN DOK KHAMTAI, PHAYAO, THAILAND

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ABSTRACT

The aims of the present study were to determine trees diversity, water quantity and ecosystem services in watershed forest areas and assess the value of ecosystem production services that affect agriculture by quadrat method at forest waterhed of Huai Tat Sae, Huai Chomphu and Huai Pha Neab reservoir areas for exploring the structure of plant community and in-depth interview was used to survey production service datas for analyze the value of the production. The result found 116 species belonging to 36 families. Shanon-wiener's Index average was 3.21. Run-off form rainfall release water to the reservoir was 3,083,437.5 m^3/ year, this to support corns, longan, rice, sweet tamarind and shallots in Sun Khong sub-distrcit agricultural areas, and forest production. The economic value for ecosystem services was 5,540,431 bath/ year.

Keywords: Ecosystem Services, Forest Watershed, Agricultural Area, Phayao

INTRODUCTION

Most studies on the relationship between the forest area and the rainfall quantity and distribution in several large lowlands inside and outside the country use the meteorological data and annual reduction of the forest area. Most of these studies found that the quantity and rainfall distribution did not have direct relationship with the remaining forest area. According to the study of Yuwanon (1997), during 1973 – 1993, the forest areas in the Nan river basins reduced 44% in the upper area, 49% in the central area, and 36% in the lower area. At the same time, the average rainfall in the areas was 1,555 mm at the upper area, 1,203 mm in the central area, and 1,244 mm in the lower area (Yuwanon, 1997). Therefore, the reduction of the forest areas did not have relationship with the annual rainfall quantity in the same lowlands. Variation of rainfall might have been due to natural climate variability over time and space regarding temperature, slight increases (Lalika et al., 2015).

In addition, Tangtham & Sutthipibul (1988) reported that there was no relationship between the forest area diminishment and the annual rainfall amount and distribution in the northeastern part of the country during 1951 – 1984 (Tangtham & Sutthipibul, 1998). Similarly, another study of Alford (1992) studied the northern part of the country in the river basins of Ping, Wang, Yom, Nan, Mae-Ing and Mae-kok, and Mae Yuam – Salawin (Alford, 1992). That study concluded the analyzing results that the annual rainfall amount during the studied years in 1952 – 1988 in these areas did not change, but the forest areas in these lowlands reduced significantly during the studied period. Moreover, Bruijnzeel (1990) collected the research results in the tropical zones in many world regions. That study concluded that the rainfall quantity and distribution were not distinctive as the main causes of the forest area reduction in exception of the large forest areas such as in Amazon (Bruijnzeel, 1990). Large amount of water vapor from the forests was a partial factor in converting

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into rainfall in the forests and nearby areas. It was found that the annual stream flow volume was helpful in controlling the water flow and delaying the flood water in the rainy season. Yuwanon (1997) found that the forest area changes and loss did not have relationship with the water flow volume and the highest dry period flow in the upper, central, and lower Nan River basins during 1973 – 1993 (Yuwanon, 1997). Meanwhile, Susanpoonthong (1995) reported that land utilization changes from forests to be other area uses in Mae Yom River basins caused the increase of runoff stream, especially in the flooding season (Susanpoonthong, 1995). In the studied areas in the northern part of the country in all basins in the province of Chiang Mai, Chiang Rai, Mae Hong Son, Lampang, Phrae, and Nan (Ping, Kok-Ing, Pai-Salawin, Wang, Yom, and Nan basins); Alford (1992) concluded in his report that the water volume in the basins did not change according to the change of the forest areas during 1952 – 1988 (Alford, 1992). His study involved with the water cycle in the basin ecosystem and the results from land utilization changes from the previous forest areas to agricultural areas and other uses. Agriculture development", and "urban development" land cover changes for each site. These land cover changes represent plausible conversions in each watershed de pending on whether there is: 1) effort to restore forest for watershed services; 2) conversion of forest to agriculture in the watershed; or 3) development of urban land cover (Dennedy-Frank & Gorelick, 2019).

Phayao has much degraded forest problems including forest invasion. San Khong Sub-district is one of the sub-districts which encounters with such problems. The forests in this sub-district are mixed forests and dipterocarp forests both of which are deciduous forests. These forests are affected from land utilization changes, and such changes causes less water volume at the watershed forests. In this study focus on the use of information on watershed forest areas, water quantity and land use change relationship to agricultural areas for planning decisions with water management. The use of basic hydrological concepts should be revised that can be applied directly to watershed management, including water supply-demand analysis in community level. Encourages farmers to see the importance of water management, zoning, and crop cultivation in accordance with soil conditions and the amount of water available in each area. Information management of relevant government agencies such as upstream forest information, soil layer and soil quality information effected to water quantity, weather information to be accurate, complete, up to date and disseminated in an appropriate format for farmers to use in decision making in cultivation.

The analysis of the literature was carried out according to the approach proposed by Alford (1992); Chaiyo, et al., (2012); Fan, et al., (2019)". These are the references of these papers that provide theoretical justification of the literature review process: Spatial priority areas for individual and multiple hydrological ecosystem services with economic costs across watershed.

MATERIAL AND METHOD

The Study Areas

The study area is the San Khong Subdistrict in Dok Khamtai District, Phayao Province. Shows the location of the reservoir, important stream gages, agricultural, urban and forest areas within the watershed (Figure 1). Major sources of water supply are surface water and ground water are in three reservoir included Huai Pha Naeb**,** Huai Chomphu, Huai Tat Sae**.**

Huai Pha Naeb reservoir: Coordinate N19° 9'43.84" E100° 5'50.08", height above the sea level: 529 meters.

Huai Chomphu reservoir: Coordinate N19°10'36.15" E100° 6'8.95", height above the sea level: 530 meters.

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Huai Tat Sae reservoir: Coordinate N19°12'2.06 E100° 5'59.91", height above the sea level: 504 meters.

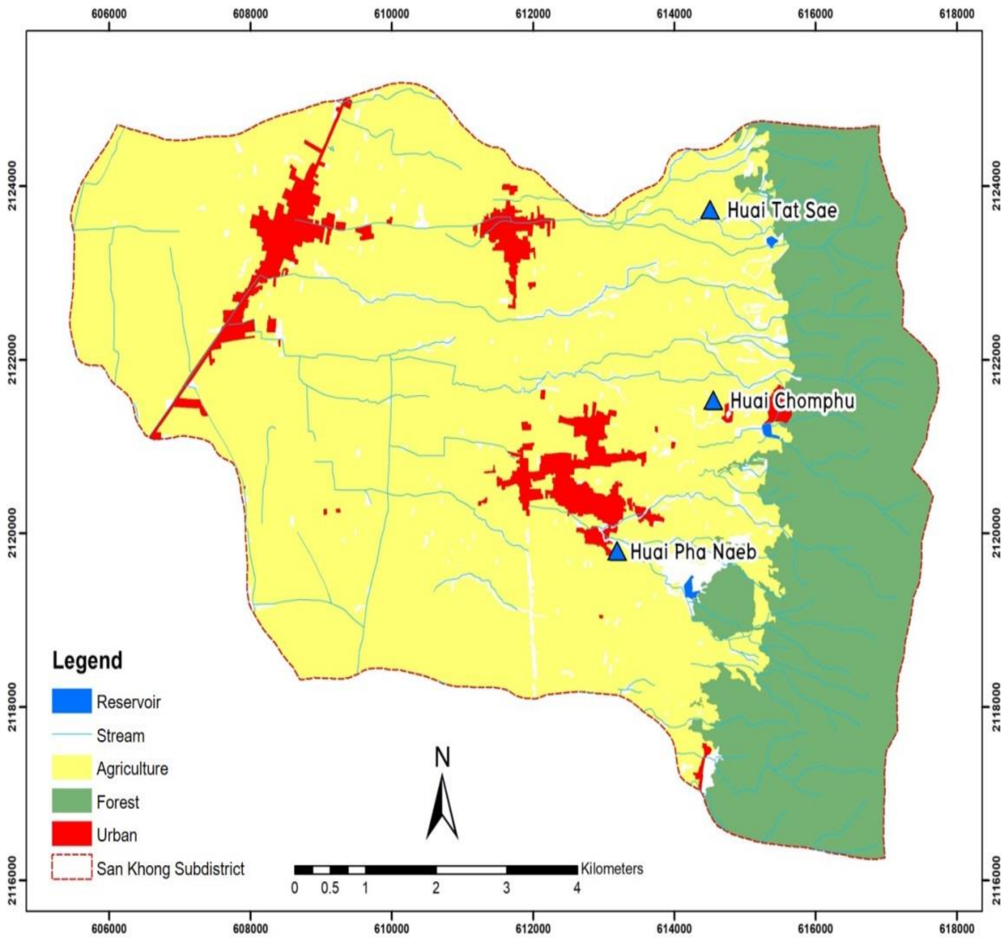

FIGURE 1
LAND USE MAP, WATER BODIES AND VEGETATION IN THE STUDY AREA OF WATERSHED FOREST AREA AND LOCATION OF THE RESERVOIR IN SAN KHONG DISTRICT, DOK KHAMTAI, PHAYAO, THAILAND.

The Plant Biodiversity Survey in the Watershed Forests

The suitable representative areas were selected by determining 4 plots of 20 m x 50 m. The survey was on the perennial species with the stems with the circumferences of over 13.5 cm and the breast height from the ground. These data were recorded in the plant diversity survey form. Then, the factor analysis and the important value index (IVI) were performed.

The biomasses were analyzed by using the equations of [6] Ogawa, et al., (1965) as follows.

Stem biomass (WS) = $0.0396\ (dbh^2h)^{0.9326}$

Branch biomass (WB) = $0.003487\ (dbh^2h)^{1.0270}$

Leaf biomass (WL) = $(WL) = (28.0/Wtc+0.025)^{-1}$

Overall biomass = $WS + WB + WL$ (kg)

The volume of the water inflow to the reservoir was calculated from the annual average water inflow = C x R x A, where:

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C = Runoff coefficient
R = Annual average rainfall
A = Catchment area in square meters

After that, the resulting water inflow volume was multiplied by the number of the average raining days in 10 years (1981 – 2010) according to Meteorological Department (2013). The raining days were 114 days.

Table 1
RUNOFF COEFFICIENT VALUE

Catchment Area (km)^2	Average Runoff Coefficient (C)		
	A	B	C
Less than 1.0	0.40	0.325	0.225
1.0 – 5.0	0.375	0.275	0.225
5.0 – 10.0	0.325	0.225	0.20
More than 10.0	0.30	0.20	0.15

Where
A = Catchment area with steep slope (over 80% slope)
B = Catchment area with moderate to much slope (over 3 – 8% slope)
C = Catchment area with rather flat (0 – 8% slope)

The Analysis of Ecosystem Service Value

The forest value in one year was calculated from the questionnaire data by multiplying the number of the picking day, the average picking quantity per day, and the price per unit. The agricultural product value in one year was calculated from the questionnaire data by multiplying the number of the cultivated area of a particular plant type, the yield per rai, and the price per unit.

The Study Results

According to the survey of plant diversity, the line plot system was used in coverage of 3 forest areas: 8 plots in Huai Chomphu, 8 plots in Huai Pha Naeb, and 6 plots in Huai Tat Sae. Each line plot was in a 50 x 20 m size and 100 m apart from the other plots. There were 22 plots in total in the dipterocarp forests, the mixed forests, and the dry evergreen forests (Table 4). Most plant species were found in the mixed forests. There were 1,557 trees, 73 families, and 108 species, with the plant density at 70.77 per rai, average relative density at (RD) at 0.93, average species frequency (F) at 65.53, average relative frequency (RF) at 0.93, average dominance (Do) at 2.37, and average relative dominance (RDo) at 0.93 (Table 5).

The slope of the area was about 18%, the slope oriented to the west, and the height above the sea level was about 550 m. In general, the forests were the dipterocarp forests and the mixed forests. Most Diptereocarpaceae family grew densely at the upper slope whereas some *Tectona grandis* L.f. grew together at the lower slope but with less density. The lower canopies were mostly covered by the upper canopies. Fruits and trees mostly found at the lower area were Shorea siamensis (Miq.) Kurz. The number of plant species and diversity were different among forest plant societies. Regarding the species diversity index, the Shannon-Wiener Index (H’) in the sample plots was at

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5.26, and the distribution evenness index was at 14.53 from 108 species of 1,557 trees with the diversity of big trees.

1) The dipterocarp forests included 23 species, 439 trees with the density of 19.95 trees per rai. The dominant species were Shorea siamensis (Miq.) Kurz, Shorea obtusa Wall. ex Blume, and Dalbergia assamica Benth. etc., respectively. The plant societies in the sample plots had the species diversity index (SWI) at 4.32, the total cross-sectional area (SBA) at 4.21 square meters per rai, forest condition indicator index (FCI) at 24.36, plant biomass in the plots at 35.28 tons per rai, and carbon storage in the forest ecosystem at 27.30 tons per rai, divided into biomass at 12.02 tons per rai and in soil at 5.68 tons per rai.
2) The mixed forests consisted of 55 species, 951 trees with the density of 43.22 trees per rai. The dominant species were Tectona grandis, Xylia xylocarpa (Roxb.) Taub., and Pterocarpus macrocarpus Kurz. etc., respectively. The plant societies in the sample plots had the species diversity index (SWI) at 3.98, the total cross-sectional area (SBA) at 4.85 square meters per rai, forest condition indicator index (FCI) at 38.19, plant biomass in the plots at 34.20 tons per rai, and carbon storage in the forest ecosystem at 19.67 tons per rai, divided into biomass at 16.28 tons per rai and in soil at 10.25 tons per rai.
3) The dry evergreen forest contained 30 species, 187 trees with the density of 8.5 trees per rai. The dominant species were Castanopsis echinocarpa Miq., Castanopsis tribuloides, Afzelia xylocarpa (Kurz) Craib. T, Lagerstroemia floribunda Jack, and Shorea roxburghii G.Don etc., respectively. The plant societies in the sample plots had the species diversity index (SWI) at 2.46, the total cross-sectional area (SBA) at 4.09 square meters per rai, forest condition indicator index (FCI) at 25.30, plant biomass in the plots at 19.24 tons per rai, and carbon storage in the forest ecosystem at 58.21 tons per rai, divided into biomass at 14.85 tons per rai and in soil at 54.87 tons per rai.

According to the biomass analysis of the surveyed forest area, the survey point with the highest biomass was Huai Chomphu with the total biomass at 8,174.62 tons. The species with the highest biomass was Xylia xylocarpa (Roxb.) Taub. at 6,601.82 tons, followed by Schleichera oleosa (Lour.) Merr, At 363.69 tons, and Shorea obtusa Wall. ex Blume at 251.99 tons, respectively.

The survey point with the second rank of biomass was Huai Tat Sae with the total biomass at 3,658.95 tons. The species with the highest biomass was Shorea siamensis (Miq.) Kurz at 1,872.02 tons, followed by Shorea obtusa Wall. ex Blume at 1,146.35 tons, and Albizia lebbeck (L.) Benth. at 258.20 tons, respectively.

The survey point with the lowest biomass is Huai Pha Naeb with the total biomass at 1,729.78 tons. The species with the highest biomass was Lagerstroemia duperreana Pierre ex Gagnep. At 718.09 tons, followed by Schleichera oleosa (Lour.) Merr. at 357.73 tons, and Leucaena leucocephala (Lam.) de Wit at 272.45 tons, respectively.

The water loss of each forest types was at the range of 52 – 55 rainfall deducted by the water vapor amount in the research at 50% of the runoff (Bruijnzeel, 1990).

According to the utilization survey from 3 reservoirs, water was mostly used for planting horticultures such as shallots, corns, tapiocas, and rubber trees. For rice farming, the community used rain water.

1) Huai Pha Naeb had the catchment areas of 7.7 km^2, average rainfall at 1,100 mm/year, and the water inflow at 1,376,375 m^3/year.
2) Huai Chomphu had the catchment areas of 4.55 km^2, average rainfall at 1,100 mm/year, runoff coefficient at 0.325 and the water inflow at 813,312.5 m^3/year.
3) Huai Tat Sae had the catchment areas of 5 km^2, average rainfall at 1,100 mm/year, and the water inflow at 893,750 m^3/year.

The Evaluation on the Economic Values of the Provisioning Ecosystem Service

During 2009 – 2020, the forest area of San Khong Sub-district increased about 4.14 rai (3.53%) due to the forest rehabilitation. One type of land utilization was changed into an ecosystem

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service useful for human. It included wood yield of the forests, control of soil absorption, water drainage from soil layers to the streams, control of soil erosion, and alleviation of weather severity. In this research, the economic values of the provisioning ecosystem service were evaluated, and the results are illustrated in the following table.

Table 2
THE NUMBER OF PICKING DAYS, AVERAGE PICKING QUANTITY, AND PRICE OF THE PROVISIONING ECOSYSTEM SERVICE AT THE HUAI CHOMPHU WATERSHED FOREST

Items	Number of picking days	Average picking (kg)	Price/unit	Total (baht/year)
Pak-wan	22	5.2	80	2,400
Red ant eggs	24	3.8	500	12,400
Puff ball mushrooms	40	6.8	500	41,000
Bamboo shoots	32	22.2	20	3,856
Total				59,656

According to the survey at the Huai Chomphu watershed forest, the highest economic value of the provisioning ecosystem service was in puff ball mushrooms at 103,700 baht / household / year, followed by red ant eggs at 57,700 baht / household / year.

Table 3
THE NUMBER OF PICKING DAYS, AVERAGE PICKING QUANTITY, AND PRICE OF THE PROVISIONING ECOSYSTEM SERVICE AT THE HUAI TAT SAE WATERSHED FOREST

Items	Number of picking days	Average picking (kg)	Price/unit	Total (baht/year)
Pak-wan	18	2.6	80	1,280
Red ant eggs	24	3.2	500	11,200
Puff ball mushrooms	40	7.6	500	38,500
Bamboo shoots	40	21.2	20	3,464
Total				54,444

According to the survey at the Huai Tat Sae watershed forest, the highest economic value of the provisioning ecosystem service was in puff ball mushrooms at 88,000 baht / household / year, followed by red ant eggs at 48,400 baht / household / year.

Table 4
THE NUMBER OF PICKING DAYS, AVERAGE PICKING QUANTITY, AND PRICE OF THE PROVISIONING ECOSYSTEM SERVICE AT THE HUAI PHA NAEB WATERSHED FOREST

Items	Number of picking days	Average picking (kg)	Price/unit	Total (baht/year)
Pak-wan	22	6.6	80	3,008
Red ant eggs	24	3.4	500	13,200

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Puff ball mushrooms	40	7.6	500	46,000
Bamboo shoots	44	24.4	20	4,136
Total				66,344

According to the survey at the Huai Pha Naeb watershed forest, the highest economic value of the provisioning ecosystem service was in puff ball mushrooms at 115,900 baht / household / year, followed by red ant eggs at 52,100 baht / household / year.

Table 5
THE PLANT TYPES, AREA SIZES, PRICES, AND AGRICULTURAL YIELD AT THE HUAI CHOMPHU WATERSHED FOREST

Plant Types	Area sizes (rai)	Yield/Rai (kg.)	Total Yield (kg.)	Prices/kg.	Total (baht/year)
Corns	90	699	62,910	7	440,370
Longan	30	308	9,240	23	212,520
Rice	4	479	1,916	10	19,160
Sweet Tamarinds	48	498	23,904	50	1,195,200
Shallots	4	1,331	5,324	30	159,720
Total					**2,026,970**

The total value of the agricultural yield at the Huai Chomphu watershed forest was at 2,026,970 baht/year. The highest total plant value was in sweet tamarinds at 1,195,200 baht/ years, followed by corns at 440, 370 baht/year.

Table 6
THE PLANT TYPES, AREA SIZES, PRICES, AND AGRICULTURAL YIELD AT THE HUAI TAT SAE WATERSHED FOREST

Plant Types	Area sizes (rai)	Yield/Rai (kg.)	Total Yield (kg.)	Prices/kg.	Total (baht/year)
Corns	92	699	64,308	7	450,156
Longan	17	308	5,236	23	120,428
Rice	17	479	8,143	10	81,430
Sweet Tamarinds	14	498	6,972	50	348,600
Garlics	18	694	12,492	14	174,888
Total					**1,175,502**

The total value of the agricultural yield at the Huai Tat Sae watershed forest was at 1,175,502 baht/year. The highest total plant value was in corns at 450,156 baht/ years, followed by sweet tamarinds at 348,600 baht/year.

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Table 7
THE PLANT TYPES, AREA SIZES, PRICES, AND AGRICULTURAL YIELD AT THE HUAI PHA NAEB WATERSHED FOREST

Plant Types	Area sizes (rai)	Yield/Rai (kg.)	Total Yield (kg.)	Prices/kg.	Total (baht/year)
Corns	231	699	161,469	7	1,130,283
Longan	31	308	9,548	23	219,604
Rice	69	479	33,051	10	330,510
Sweet Tamarinds	10	1,331	13,310	30	399,300
Shallots	8	694	5,552	14	77,728
Total					**2,157,425**

The total value of the agricultural yield at the Huai Pha Naeb watershed forest was at 2,157,425 baht/year. The highest total plant value was in corns at 1,130,283 baht/ years, followed by sweet tamarinds at 399,300 baht/year.

The Survey Result Discussion

The study was on plant diversity and provisioning ecosystem service in the agricultural season which affected on the agricultural sector in San Khong Sub-district, Dok Khamtai District, Chiang Rai Province. In the study, the plant diversity were surveyed by using the 20 x 50 m line plots in 3 watershed forests: 8 plots in Huai Chomphu, 8 plots in Huai Pha Naeb, and 6 plots in Huai Tat Sae. The perennial plants were mostly found in 37 families and 116 species, and the forest conditions were mostly the mixed forest. The most plant species diversity was found in the Huai Pha Naeb forest at 3.40, followed by the Huai Chomphu forest at 3.26, and the Huai Tat Sae forest at 3.09. The plant family mostly found was FABACEAE with different important value index (IVI) in each area. The plant species with the highest important value index were Xylia xylocarpa (Roxb.) Taub. in Huai Chomphu at 97.15 IVI, Lagerstroemia duperreana Pierre ex Gagnep in Huai Pha Naeb at 64.12 IVI, and Pentacme siamensis (Miq.) Kurz in Huai Tat Sae at 71.33 IVI. Regarding biomass and carbon storage, the highest amount of biomass and carbon storage was found in Huai Chomphu i.e. biomass at 8,174.62 tons and carbon storage efficiency at 9,190.13 carbon tons/hectare/year.

According to the study on the ecosystem service, the communities received the provisioning services from the 3 watershed forests. At the Huai Chomphu watershed forest, the average water inflow to the reservoir was at 708,225 m^3/year; the value of the ecosystem service for the community was at 59,656 baht/year; and the value of the agricultural yield was at 2,026,970 baht/year. At the Huai Pha Naeb watershed forest, the average water inflow to the reservoir was at 696,255 m^3/year; the value of the ecosystem service for the community was at 66,344 baht/year; and the value of the agricultural yield was at 2,026,970 baht/year. At the Huai Tat Sae watershed forest, the average water inflow to the reservoir was at 402,876 m^3/year; the value of the ecosystem service for the community was at 54,444 baht/year; and the value of the agricultural yield was at 2,026,970 baht/year.

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The Research Result Discussion

According to the study was on plant diversity in San Khong Sub-district, Dok Khamtai District, Chiang Rai Province, the most forests were the mixed forests with perennial trees in 37 families and 116 species. The nearby areas of the stream were mixed with tropical rainforests and dry evergreen forests whereas the top areas of the mountains were changed from the mixed forests to the deciduous forests. The most plant diversity was found at Huai Pha Neab at 3.40, followed by Huai Chomphu at 3.26, and Huai Tat Sae at 3.09. The plant family of FABACEAE was mostly found. The surveyed area with the highest biomass and carbon storage was in Huai Chomphu with biomass at 8,174.62 tons, and storage carbon efficiency at 9,190.13 carbon tons/hectare/year. The findings are consistent to Chaiyo, et al., (2012) study on the plant society characteristics, biomass quantity, and carbon storage quantity. The study found that the plant societies were in the mixed forests with the sandy soil, a little height of the area, and the average rainfall at the range of 900 – 1200 mm/year (Chaiyo, Garivait & Wanthongchai, 2012) . These factors were suitable for the growth of the mixed forests, so the most surveyed areas were found in the form of the mixed forests. The species diversity index was found at 2.26 with the average biomass at 246.11 tons/hectare, and the carbon storage at 115.67 carbon tones/hectare. The species diversity were closely similar at 2.26 since the surveyed areas were similar. Construction of forest watershed is an ecohydrological and sustainable tool that not only traps nutrients and pollutants but also converts nutrients to plant biomass which can sustain bio-energy and livelihoods for society (Singh & Singh, 2020).

In terms of the provisioning ecosystem services of the 3 watershed forests, the most areas were the mixed forests. The average water inflow to the reservoirs was at 708,225 m^3/year at Huai Chomphu, at 696,255 m^3/year at Huai Pha Naeb, and at 402,876 m^3/year at Huai Tat Sae. Climate change derived extreme temperature and varied rainfall and flow conditions are affecting on ground runoff due to the rainfall quantity (Shrestha & Shrestha, 2019) . The area conditions were the mixed forests as well and the ecosystem services were utilized well in the rainy seasons. analysis indicates that increasing total forest cover does not necessarily increase basin ET. In these watersheds, increasing deciduous and mixed forest cover was associated with lower ET, while increasing evergreen forest cover was associated with higher ET. Regression analysis indicated that watersheds with more evergreen forest had higher ET and those with more deciduous forest had less (Younger, Jackson & Rasmussen, 2020).

This study found that the ground runoff varied according to the rainfall amount at the average flow of 640,452 m^3/year. Both studied areas were closely similar I (Arunyawat & Shrestha, 2016) n the forms of the mixed forests with the average rainfall at the range of 900 – 1200 mm/year. Run-off form rainfall release water to reservoir was 3,083,437.5 m^3/ year to support corns, longan, rice, sweet tamarind and shallots in Sun Khong sub-distrcit agricultural areas. Regarding the ecosystem service of the 3 watershed forests, the ecosystem service for forest product values were at 59,656 baht/year at Huai Chompu, at 66,344 baht/year at Huai Pha Naeb, and at 54,444 baht/year at Huai Tat Sae. According the studied on the economic and social factors affecting on the forest utilization of the nearby communities in Northern Thailand found that quantifying and mapping of water related ecosystem services for enhancing the security of the food-water-energy nexus in land use data–sparse catchment (Arunyawat & Shrestha, 2016). Impacts of climate change and water resources development on the declining inflow into reservoir. Automatic remotely sensed image classification in a grid environment based on the maximum likelihood method. Impact of climate extremes on hydrological ecosystem services (Daneshi, 2021). Ecosystem service value This analysis used absolute value of hydrological ecosystem service as a surrogate for biological diversity, the areas with higher ecosystem service value and lower economic value were involved into reserve network of ecosystem service in prior. Understanding tradeoffs among priority

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conservation areas of individual ecosystem services through Jaccard's index and correlation of selection times, which could promote to construct highly compact priority areas of watershed conservation system to satisfy ecological and economic targets (Fan, Ou & Chen, 2019).

The results could be summarized in 5 aspects. 1) In the water cycle, a lot of rainfall amount got the interception loss due to the forest coverage. 2) The amount of water seeping and absorbed in soil was used in the growing process and transpiration loss. 3) The water volume of the basins increased due to the reduced density of groundcovers due to land clearing, and changing plant species using much water to the species using less water. 4) Changes in land utilization for forests to other uses at some level did not have effects on the rainfall quantity and distribution, and runoff volume and flow in the dry season. And 5) the forest usefulness in other aspects apart from the water cycle should be necessarily considered for management in basin resources, forest preservation, and forestation particularly in the upstream areas which were the center of management with effects on water volume at the downstream and the whole water system.

A limitation of this study are average temperature and precipitation are the factors that affect watershed systems. Extreme climate conditions such as sustained droughts, extreme flooding, and intense rainfall events have major effects on hydrology and water quantity in the areas. Data with differences in the yield of water flowing into the reservoir affected to decision making in agriculture areas. The study areas is large, random data collecting is not possible to obtain information that covers the entire area.

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