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Impacts of dam construction on livelihoods and utilization of riparian plant communities: A case study along the Mun River, Thailand

Phewphan, U.[1,2], Pattanakiat, S.[1] *, Phutthai, T.[1], Kongsombut, P.[2], Rakasachat, C.[3] and Rueangkitwat, I.[4]

[1]Faculty of Environment and Resource Studies, Mahidol University, Nakhon Pathom, 73170, Thailand; [2]Innovation for Social and Environmental Management, Mahidol University, Amnatcharoen Campus, Amnatcharoen 37000, Thailand; [3]Center of Research and Academic Services, Faculty of Environment, Kasetsart University, 50 Ngamwongwan road, Ladyao, Chatuchak Bangkok 10900, Thailand; [4]Geographic Information System Program, Faculty of Social Science, Chiang Rai Rajabhat University, Chiang Rai, 57100, Thailand.

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Abstract Land use and land cover (LULC) change in Mun River Basin between 2000 to 2020 has been classified. It was found that deciduous forest was declined by 57.9%, from 9,905.15 to 4,164.65 km², whereas evergreen forest was increased by 36.9%, from 3,177.57 to 4,349.76 km². Most of the utilization has been covered by agricultural and aquacultural land dominated more than doubling (+134%) and expanding of paddy fields, perennial crops, pasture, and farmhouses. Marsh and swamp areas was declined by 18.9% and indicating for continuously wetland pressure. For future scenarios, it was indicated the persistent agricultural dominance, reaching approximately 52,462.63 km² by 2030. The total forest cover was predicted to decline to 8,409.90 km². Urban and built-up land was expected to expand more than 9% growth in city, town, and commercial areas and nearly 15% growth in industrial land during 2025–2030. Based on the community survey, it was shown that 75.00% of respondents primarily depended on agriculture activities, seasonal flooding one to three months long, and flood shifted by about 15 days to one month compared with pre-dam conditions. Riparian forest remained important for household livelihoods, providing more than 70 useful plant species for food, medicine, fuelwood, and local tools. Unfortunately, resource availability and ecosystem services were reduced by agricultural encroachment, overharvesting, and dam-related hydrological alteration. These results are indicated intensifying socio-ecological trade-offs and the need to predict for appropriate riparian forest and wetlands management.

Keywords: Dam construction, Land use change, Livelihoods, CA-markov model, Mun river basin

* **Corresponding Author:** Pattanakiat, S.; **Email:** sura.pat@mahidol.ac.th

Introduction

The purposes of dam's construction are mainly for hydropower generation, water management for agricultural activities, and also for flood protection. It is very crucial for economic development. However, the impacts of this construction for watershed ecosystem and local communities' livelihood have been clearly emerged. It has been affected to alter natural river flow regimes, sediment transport disruption, nutrient cycles changes, which transforming from upstream and downstream ecosystems (Grumbine and Xu, 2011; Winemiller *et al*., 2016).

The Mun River Basin is located in northeastern Thailand and covering about 71,076 km². It is the largest tributary of the Mekong River in Thailand. It is highly supported and interconnected through an agricultural, ecological, and cultural systems (Mekong River Commission or MRC, 2018). The 12 dams have been constructed across different tributaries in the Mun River Basin. The 6 major dams were located directly along the mainstream of the Mun River. They were significantly altered for hydrological regime and patterns, for instance, the Sirindhorn Dam displaced over 20,000 households and inundated approximately 180,000 rai (28,800 ha) of forest land (Phommachanh *et al*., 2020).

The riparian forest has been located along riverbanks and floodplains of the Mun River. It is playing an important role and function as biodiversity hotspots, nutrient buffers, and natural flood regulators. It is also providing critical ecosystem services such as sediment trapping, water purification, and habitat connectivity for both aquatic and terrestrial species (Naiman *et al*., 2005; González *et al*., 2015). Therefore, it is absolutely sensitive to such a hydrological change. In the Mun River Basin, riparian forest consists of more than 70 plant species, which supported and integral to local diets, traditional medicine, and household energy needs (Killingbeck, 2006; Department of National Parks, Wildlife and Plant Conservation, 2018). Beyond their ecological functions, these forests sustain cultural practices and act as safety nets for rural livelihoods, particularly in communities with limited alternative income sources.

The dam-induced flow regulation has disrupted the seasonal flooding regimes that maintain riparian vegetation structure and composition. The reduction of flood frequency and altered inundation timing have promoted the encroachment of terrestrial species and diminishing flood tolerant vegetation, which led to habitat fragmentation and biodiversity loss (Soukhaphon *et al*., 2021; Yi *et al*., 2019). In addition, hydrological shifts, in Mekong and Yangtze River, cause the diminishing of productivity within floodplain area, reducing fish migration, and weakening the resilience of riparian ecosystems (Yang *et al*., 2019).

Dam construction is also visible affected to land use and land cover (LULC) change. Between 2000 and 2020, an agricultural area in the Mun River Basin has been expanded exceeding 1,100 km², meanwhile, the forest cover has been lost for more than 1,600 km² (Office of the National Water Resources (ONWR), 2020). These changes are influencing from both direct and indirect hydrological impacts. Similar case has been also reported for Ethiopia's Nashe watershed, where deforestation and wetland degradation after dam construction have undermined local livelihoods and reduced riparian habitat quality (Fikadu and Olika, 2023).

For the socio-economic impact's perspective, altered hydrology and land degradation might cause the reduction in abundance and diversity of riparian resources. This could be forcing communities to adapt their own livelihoods through crop diversification, increased dependence on market-purchased food, and community-based forest conservation. Similar adaptations have been documented in Ghana's Bui region and Indonesia's Upper Cisokan project, where dam-affected populations experienced economic displacement and resource loss (Obour *et al*., 2016).

It has been confirmed by remote sensing interpretation that vegetation loss was mostly occurred nearby dam reservoirs and areas subjected to intensive human activity (Zaimes *et al*., 2019). Furthermore, geomorphological studies reveal that dam operations could be altering downstream sediment regimes which leading to sediment starvation, channel narrowing, and reduced habitat complexity (Annys *et al*., 2020).

The cumulative impacts of dam construction on riparian zones, ecosystems, and livelihoods have been convincing the urgent needs for integrated watershed management approaches. The study aimed to investigate the dynamics along the Mun River by combining geographic information system, remote sensing, and socio-economic surveys to evaluate the dam construction affected to livelihoods and the utilization of riparian plant communities.

Materials and methods

Study area

The Mun River Basin is the largest watershed of the country, which located in the northeastern Thailand (as shown in Figure 1). It covers the area about 71,000 km². The geographically coordinates are positioned between 102°00′–105°00′ E longitude and 14°00′–16°00′ N latitude. It is surrounding by the Phu Phan and Dangrek mountain ranges. The Mun River originates in Khao Yai National Park and flows eastward for 726 km before merging with the Chi River

and eventually joining the Mekong River at Ubon Ratchathani Province (Office of the National Water Resources (ONWR), 2020).

The watershed encompasses with diverse landscapes, including flood plains, non-flood plains, and hilly regions. Influenced by the Southeast Asian monsoon, the Mun River Basin is dominated as a tropical savanna climate with bimodal rainfall. Approximately 90% of the annual precipitation occurs during the wet season from May to October, while the remaining 10% occurs in the dry season. Annual rainfall ranges from 1,300 to 1,500 mm, increasing from west to east due to topographical variations. The average temperature is 27°C annually, with high seasonal in April and low seasonal in January (Office of the National Water Resources(ONWR), 2020; Soukhaphon *et al*., 2021).

The land use in the Mun River Basin is mainly dominated by an agricultural activity. It is including rain-fed rice cultivation accounting for 75% of agricultural activities and 55% of the total area. Other crops, such as cassava and sugarcane, are cultivated in upland regions. The land use change was recently included the expansion of cash crops and industrial-scale agriculture, accompanied by increased of using chemical fertilizers and pesticides. These practices have intensed the watershed's vulnerability to climatic variability, such as floods and droughts, contributing to environmental challenges (Akter and Babel, 2012).

The Mun River plays an important role for the hydrological function of the Lower Mekong Basin. It is contributing approximately 32,280 MCM of water annually, accounting about 10% of the Mekong River's total flow at Pakse, Laos. However, extensive dam construction, including Pak Mun and Sirindhorn dams, has significantly altered the river's natural flow, disrupting sediment transport, aquatic biodiversity, and riparian ecosystems (Office of the National Water Resources (ONWR), 2020).

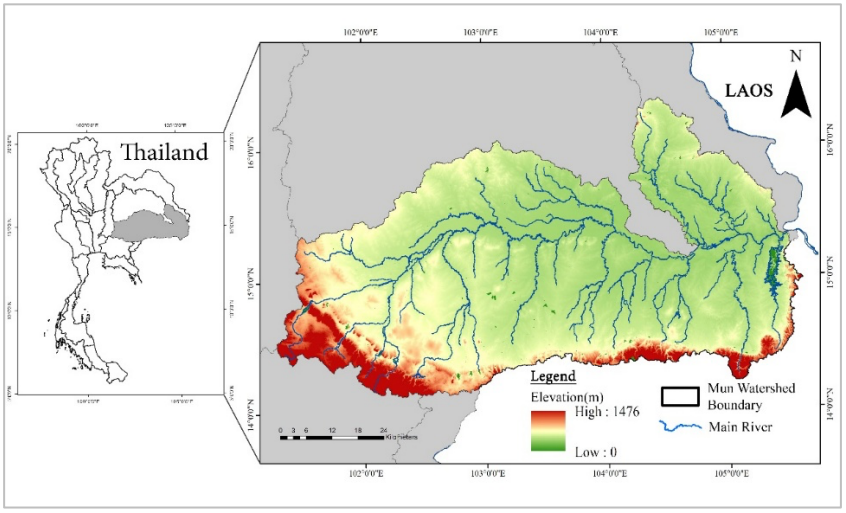


Figure 1. The study area in Mun River Basin, Northeastern Thailand

Data collection

This study was identified the variation in riparian plant communities affected before and after dam construction over the past 40 years. The LULC change was classified to explicit change from the past to the present. The GIS and satellite imagery interpretation were applied to differentiate land use change before and after dam construction. The first dam constructed in the Mun River Basin was the Phimai Dam, built in 1939 and practical operation in 1956. Meanwhile the latest, Kut Chum Saeng Dam, was constructed in 2016 and practical operation in 2018. The analysis of vegetation indices in the Mun River was employed to the riparian areas to reveal variations in riparian plant communities. The hybrid interpretation using LANDSAT series data (MSS, TM, ETM+, OLI+TIRS) were used to classify LULC within five different years including 2000, 2005, 2010, 2015, and 2020. Satellite imagery prior to 2000 was excluded due to its lower quality and limited spatial resolution, which hindered accurate land use classification compared to higher-resolution datasets.

The process of dataset preparation and analysis were proposed as follows:

1. Pre-processing: The atmospheric, radiometric, and geometric corrections of satellite imageries were applied to collect distortions and enhance image quality to be ready for the interpretation.

2. Nomenclature Definition: The land use and land cover patterns were established based on the level 1 from Land Development Department regulation.

3. Image Classification: The supervised classification using the Maximum Likelihood Classifier (MLC) was employed for each year. The categorizing of

LCLU classes was including agricultural land, forest land, miscellaneous land, urban and built-up land, and water bodies.

4. Ground Truthing: The ground reference points were obtained through GPS-based field surveys and cross-checked with high-resolution imagery from Google Earth Pro.

5. Accuracy Assessment: The accuracy assessment for the classification was evaluated using overall accuracy and the kappa coefficient performance.

The previous research has demonstrated the effectiveness of integrating remote sensing and GIS techniques in assessing the environmental impacts of dam construction, enabling the accurate monitoring of land use and vegetation dynamics over time (Zhao *et al*., 2018). It is providing a detailed understanding of ecological transformations and inform sustainable management strategies for riparian ecosystems influenced by human activities.

Data processing

LULC change analysis

Change detection analysis was conducted using classified images from 2000, 2005, 2010, 2015, and 2020 to identify patterns of LULC change. For long-term trend assessment, three key reference years were selected based on the principle of representing distinct temporal stages: 2000 as the starting point of analysis, 2010 as the midpoint, and 2020 as the most recent year. This selection ensures sufficient temporal spacing to capture both gradual and substantial changes while avoiding redundancy from closely spaced datasets.

Accordingly, the analysis was structured into three main comparison periods:

- **2000–2010** – representing long-term changes from the early to middle stage;
- **2010–2020** – representing long-term changes from the middle to recent stages; and
- **2000–2020** – representing cumulative changes over the entire 20-year period.

The percentage of change (Hassen and Assen, 2018) and the rate of change (Abate, 2011; Temesgen *et al*., 2014) were calculated for each comparison period using Equations (1) and (2):

$$\text{Percentage of Change} = \frac{\text{LULU}_{\text{final}} - \text{LULC}_{\text{initial}}}{\text{LULC}_{\text{initial}}} \text{x}100 \quad (1)$$

$$\text{Rate of Change} = \frac{\text{LULU}_{\text{final}} - \text{LULC}_{\text{initial}}}{\text{Number of proposed years}} \text{ x100} \quad (2)$$

Prediction of LULC for 2025 and 2030

The prediction of land use and land cover for the years 2025 and 2030 in the Mun River Basin was analyzed using the Cellular Automata–Markov (CA–Markov) model. The spatial simulation capabilities of Cellular Automata (CA) integrated with the temporal transition probabilities derived from Markov chain analysis was employed to enable the simulation of complex spatiotemporal dynamics. The incorporation of historical land use dataset and probabilistic transition matrices was utilized to identify the possibilty of future scenarios.

This prediction model was defined LULC over extended periods, capturing processes such as agricultural transformation, urban expansion, and changes in natural habitats.

The Markov chain component operates as a stochastic process in which the future state depends solely on the current state, independent of preceding historical states. It is characterized by discrete intervals in both time and events. The mathematical representation of the Markov chain used in this study is provided in Equation (3) (Pontius and Malanson, 2005; Eastman, 2009).

$$V_t+1=V_t \times P_{ij}$$

$$P_{ij}\begin{bmatrix} P_{11} & P_{12} & \dots & P_{1n} \\ P_{21} & P_{22} & \dots & P_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ P_{n1} & P_{n2} & \dots & P_{nn} \end{bmatrix} (0 \le P_{ij} \le 1) \quad (3)$$

where V_t and V_{t+1} denote the system state at time t and t+1, respectively. Meanwhile, P_{ij} is the probability of transitioning from state i to state j in the subsequent time.

Accuracy assessment for evaluating classifications

Following the completion of the classification process, the subsequent step involved evaluating the classification accuracy to determine the degree of correspondence between the results and actual ground conditions. In this study, the accuracy assessment was performed using ground control points (GCPs) collected during field surveys with GPS devices. These reference data, commonly referred to as ground truth, were randomly selected and applied in the calculation using Formula 1.

Overall accuracy

The classification accuracy was evaluated using 597 GPS-based ground truth points collected during field surveys. Overall accuracy (OA), producer's accuracy (PA), user's accuracy (UA), and the kappa coefficient were computed from confusion matrices derived by comparing classified maps with the reference data of Congalton (1991), Foody (2002), and Lillesand and Kiefer (2015). The overall accuracy equation was used in this study as shown in Formula 1. According to Stehman (1997), this assessment ensures the reliability and validity of the classification results, which are essential for subsequent spatial analysis aspect.

$$\text{Overall Accuracy} = \frac{\text{Correct Classifications}}{\text{Total Observations}} \text{ x100} \quad (1)$$

Kappa coefficient analyses

The kappa coefficient was proposed to measure the agreement between classified data and the actual ground truthing to consider the possibility of chance agreement (Singh and Tyagi, 2021). It compares observed accuracy to expected accuracy under random classification conditions as shown in Formula 2 as follow.

$$K = \frac{(P_o - P_e)}{(1 - P_e)} \quad (2)$$

Where:

- P_o is the observed agreement, measuring as the proportion of correctly classified points.
- P_e is the expected agreement, representing the agreement that could occur purely by chance.

Community surveys process

To understand the socio-economic impacts of dam construction, the data collection was operated directly from affected communities which located in the riparian zones of the Mun River. The population and comprised households including individual's livelihoods were proposed depend on agriculture, fisheries, or other river-based activities.

The purposive sampling was employed to ensure that participants should be represented diverse livelihood groups and held relevant experiences regarding the impacts of dam construction. The selected criteria was included as: (1) residence in the study area for at least 10 years, (2) direct involvement in river-dependent occupations, and (3) willingness to participate in interviews or

discussions. The sample size was proportionally distributed across the six study sites to capture local socio-economic and ecological contexts.

- **In-depth Interview (IDI)**: The semi structured interview was conducted from 72 participants, including farmers, fishermen, and local officials. The interview was focusing on livelihood changes, ecological challenges, and community responses to dam construction.
- **Focus Group Discussion (FGD)**: The FGD was organized within six study area defining 5–8 participants per group. The discussion was emphasized based on shared challenges and strategies for adaptation.
- **Field Observations (FO)**: The field observation was conducted during daily activities such as fishing and farming to capture contextual data and validate interview finding.

Ethical consideration approach

The study was approved by the Institutional Review Board at Mahidol University (COA. No. 2020/01-019). All participants were informed about the study objectives and detail information as needed. Their consent was obtained before data collection. The data confidentiality was maintained throughout the research based upon the Personal Data Protection Act (2022).

Results

Changes in LULC

The LULC changes within the Mun River Basin between 2000 and 2020 was included for 4 nomenclatures as forest area, agricultural production zone, aquaculture, and wetland. The deciduous forest was continuously declined from 9,905.15 km² in 2000 to 4,164.65 km² in 2020, representing a loss of about 57.9%. The evergreen forest was increased from 3,177.57 km² to 4,349.76 km², reflecting an overall gain of 36.9%. It could be possibly linked to reforestation and conservation measures. The orchard area was fluctuated which shown highly peak at 39,593.21 km² in 2005 and then declining to 37,396.37 km² in 2020. The suggestion for market-driven changes in perennial crop cultivation was provided. The aquacultural land was expanded from 40.13 km² in 2000 to 93.89 km² in 2020. It was more than doubling of its area size (an increase of 134%) The marsh and swamp area was decreased from 850.75 km² to 690.17 km² with a reduction of 18.9%. It was likely due to land reclamation for agriculture and infrastructure (Table 1 and Figure 2).

Table 1. LULC changes between 2000 - 2020

LULC		Years of Land Use (km²)				
Level 1	Level 2	2000	2005	2010	2015	2020
Agricultural land	Aquacultural land	40.13	64.15	80.29	90.33	93.89
	Aquatic plants	9,640.58	10,661.46	8,562.58	9,345.75	9,353.20
	Field crops	110.30	131.30	113.96	120.54	126.54
	Horticulture	58.36	33.34	25.00	25.43	28.53
	Integrated farms/Diversified farms	672.56	519.41	536.96	479.01	476.82
	Orchards	37,659.67	39,593.21	38,348.39	37,299.19	37,396.37
	Paddy fields	123.23	217.82	362.14	312.76	318.66
	Pasture and farmhouses	2,725.79	3,364.86	3,751.42	4,378.39	4,419.97
	Perennial crop	9,640.58	10,661.46	8,562.58	9,345.75	9,353.20
Forest land	Deciduous forest	9,905.15	4,529.96	4,414.80	4,334.71	4,164.65
	Evergreen forest	3,177.57	4,085.24	4,517.44	4,344.34	4,349.76
	Forest plantations	330.66	547.57	631.32	631.17	606.55
Miscellaneous land	Garbage dump	7.48	7.49	7.82	8.50	8.14
	Marsh and Swamp	850.75	708.83	693.28	680.24	690.17
	Mines, pits	39.44	35.24	87.87	90.07	93.13
	Other miscellaneous land	135.52	162.58	273.21	256.43	260.12
	Rangeland	1,372.64	1,638.03	2,192.46	2,125.42	2,115.05
	Salt flat	21.25	20.46	20.95	22.25	22.46
Urban and built-up land	City, town, commercial	279.74	300.85	385.19	389.05	393.98
	Communication and utility	53.61	88.55	78.27	84.20	86.13
	Industrial land	116.37	158.23	156.29	176.53	182.89
	Institutional land	216.59	301.44	585.59	615.61	629.29
	Other built-up land	124.62	148.06	150.63	156.22	162.12
	Village	1,688.01	1,948.72	2,915.68	2,947.01	3,025.12
Water body	Artificial water bodies	817.03	954.71	1,174.56	1,220.40	1,125.57
	Natural water bodies	888.66	834.29	989.71	922.24	926.68
	Summary area	**71,076.00**	**71,076.00**	**71,076.00**	**71,076.00**	**71,076.00**

Note: LULC change were assessed using three LANDSAT series (MSS, TM, ETM+, OLT+TIRS)

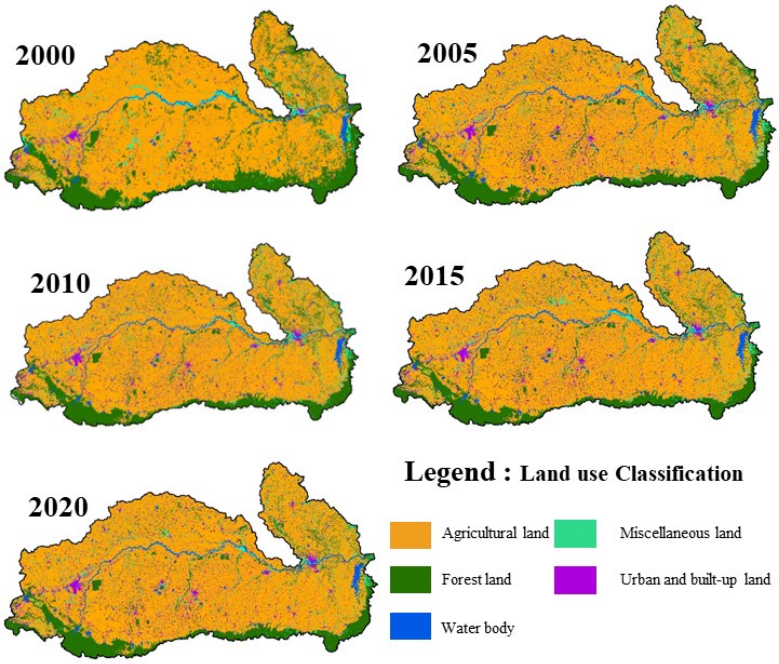


Figure 2. LULC changes of the Mun River Basin

The change comparation was performed upon the three selected reference periods as 2000–2010, 2010–2020, and 2000–2020 showed that between 2000 and 2010. The deciduous forest loss was shown as the most severe change accompanied by an expansion in perennial crop area and urban settlement. Between 2010 and 2020, urban and built-up area was continuously expanded. Meanwhile, further encroaching on agricultural and natural landscapes was also scattered. For the cumulative change over 2000–2020, the basin exhibited persistent agricultural intensification, urban expansion, and progressive alteration of natural habitats. These trends to be increasing in economic and social pressures. The expansion of cultivated and developed land met the needs of local communities but accelerated biodiversity loss and degraded vital ecosystem services.

Socio-ecological implications

It was found that the increased LULC patterns were included pasture and farmhouse area, industrial zone, and village settlement (as shown in Table 2). The communication and utility infrastructure has been expanded alongside an industrial and residential growth, particularly near urban centres.

The increasing economic and social pressure should be influenced for land use decisions in the Mun River Basin. The steady growth of agricultural land is reflected to the rising demand for cultivated area to meet the food and agricultural needs of local communities. However, this expansion has been affected to the cost of forest loss. It has been posed as a significant risk to biodiversity, disrupts ecological function, and reduced the resilience of critical ecosystem services. The observed trends are underscored the urgent need for integrated land use planning that can balance economic development with the conservation of riparian and upland habitats.

Future land use prediction for 2025 and 2030

The future land use scenarios for the Mun River Basin have been generated using the CA–Markov modelling framework. It is indicated that a persistent trend of agricultural should be dominance with moderate fluctuation over the study period (as shown in Table 3). The prediction output suggests that an agricultural land would slightly contract to 51,698.66 km² by 2025 and increasing again to 52,462.63 km² by 2030. This reflect was shown the continued prioritization of cultivated land to meet agricultural production demands. The minor expansion is also predicted for aquacultural area, from 103.33 km² in 2025 to 107.41 km² in 2030, alongside an incremental growth in selected commercial crop zone.

The forest area has been decreased from 9,120.96 km² in 2020 to 8,409.90 km² by 2030. The deciduous forest has been decreased from 4,733.47 km² to 4,582.42 km². Meanwhile, the evergreen forest has been decreased from 4,086.98 km² to 3,235.02 km².

The urban and built-up area was definitely expanded. Whereas, the city/town/commercial was increased from 395.44 km² in 2025 to 431.98 km² in 2030. The industrial land was also increased from 228.75 km² to 262.71 km² over the same period. It was indicated the ongoing urbanization and industrial development across the basin.

Additionally, water bodies have been defined within minor changes. The artificial water bodies slightly decreasing from 1,252.71 km² in 2025 to 1,235.56 km² in 2030. The natural water bodies are expected to increase modestly from 923.54 km² to 935.13 km². These variations reflect ongoing adjustments in water management and land use practices (as shown in Table 2).

Table 2. Summary of future land use for 2025 and 2030

Land Use/Land Cover	Classified LULC Predicted (km^2)		Land Use/Land Cover	Classified LULC Predicted (km^2)	
	2025	2030		2025	2030
Agricultural land			Miscellaneous land		
Aquacultural land	103.33	107.41	Garbage dumps	8.15	8.16
Aquatic plants	20.23	20.33	Marshes and Swamp	656.37	654.14
Field crops	10,467.81	11,023.71	Mines, pits	97.69	100.11
Horticulture	118.04	121.20	Other miscellaneous land	109.03	107.16
Integrated farms/Diversified farms	31.33	32.21	Rangeland	2,215.62	2,225.54
Orchard	418.32	412.84	Salt flat	24.13	24.45
Paddy fields	35,527.93	35,705.11	**Urban and built-up land**		
Pasture and farmhouses	318.17	320.78	City, town, commercial	395.44	431.98
Perennial crops	4,693.50	4,719.04	Communications and utilities	87.68	89.85
Forest land			Industrial land	228.75	262.71
Deciduous forest	4,733.47	4,582.42	Institutional land	638.69	691.64
Evergreen forest	4,086.98	3,235.02	Other built-up land	164.02	170.98
Forest plantations	582.78	592.46	Villages	3,172.29	3,266.06
			Water body		
			Artificial water bodies	1,252.71	1,235.56
			Natural water bodies	923.54	935.13

The prediction of land use trends is defined as agricultural expansion and urban growth accompanied by declining in forested area. It could be emphasized that the urgent activities for balancing and sustainable land management strategies should be important and needed. The biodiversity conservation needs to be maintained for ecosystem services and ensure long-term environmental resilience in the Mun River Basin.

Accuracy assessment for LULC

Erdas Imagine in conjunction with Google Earth Pro was employed to conduct an accuracy assessment of LULC classification output. This assessment incorporated a total of 597 sample points for each assessed year: 2000, 2005, 2010, 2015, and 2020 respectively. A stratified random sampling approach was also applied to ensure that a minimum of 60 points were selected for each land

use patterns. Each sample point was subsequently verified using Google Earth Pro to match the respective time periods of the LULC output.

The verification process and accuracy reports were generated for each year using Erdas Imagine. It was indicated that the OA values ranged from 80.31% to 94.48%. In 2000, the highest OA was observed for agricultural land (93.62%) with a kappa coefficient of 0.82. The lowest was fallen to forest land (82.98%) with a kappa coefficient of 0.60. In 2005, OA value was ranged between 80.31% and 89.18% with kappa coefficients ranging from 0.63 to 0.84. In 2010, OA varied from 80.98% to 92.49% meanwhile kappa coefficients were ranged from 0.64 to 0.84. In 2015, it was recorded the highest OA of 94.48% for water bodies and the lowest OA of 80.87% for forest land. In 2020, OA value was ranged from 83.00% to 91.49% with kappa coefficients ranging between 0.62 and 0.78 (as shown in Table 3).

These findings are demonstrated variations in classification accuracy across land use categories and years. The high accuracies were agricultural land and water bodies meanwhile the lower accuracies were recorded for forest land. The kappa statistic was substantial indicated to almost perfect agreement between the classified maps and reference data. The reliability of the classification results for subsequent spatial and temporal analyses.

Table 3. Accuracy assessments and kappa coefficients for the years 2000, 2005,2010,2015, and 2020

LULC Classes	2000		2005		2010		2015		2020	
	OA (%)	KC	OA (%)	KC	OA (%)	KC	OA (%)	KC	OA (%)	KC
Agricultural land	93.62	0.82	85.62	0.84	85.37	0.64	90.98	0.75	89.36	0.71
Forest land	82.98	0.60	82.34	0.64	87.23	0.66	80.87	0.82	91.49	0.78
Miscellaneous land	89.02	0.78	80.31	0.84	92.49	0.65	82.73	0.65	84.56	0.73
Urban and built-up land	86.48	0.67	89.18	0.63	84.38	0.69	86.84	0.80	83.00	0.73
Water bodies	88.89	0.61	89.11	0.64	80.98	0.84	94.48	0.80	84.57	0.62

OA = Overall accuracy (%), KC = kappa coefficient

Effect of dam construction and LULC on rural livelihoods

According to the demographic survey of 72 respondents, the majority were identified as male (76.39%) and 23.61% for female. The age average was 56 years which respondents ranging from 33 to 75 years old. Most of the primary occupation of respondents were farmers for 75.00%, followed by village leadership roles (16.67%), general labor (6.94%), and monastic duties (1.39%). In terms of secondary occupations, about 61.11% reported as none. Meanwhile,

22.22% were engaged in general labor and 16.67% in small-scale farming (as shown in Table 4).

Although most respondents reported that they were not directly displaced by dam construction. The seasonal flooding was still remained a recurrent phenomenon. Flooding typically occurred from the mid-rainy season to early winter and lasting for approximately one to three months which water depth was ranging from one to five meters. The timing of flood peaks had shifted by 15 days to one month earlier or later compared to pre-dam conditions. It was influenced to agricultural scheduling and seasonal resource availability.

Riparian forests continue to play a vital role in sustaining household economies. Direct uses include the collection of over 70 plant species for food, medicinal herbs for treating musculoskeletal ailments, and fuelwood or charcoal derived from shrubs and large vines. Wild fruits and aquatic fauna provide additional protein sources, while plant materials are used in crafting tools for fishing and daily activities. Indirect benefits of riparian ecosystems include serving as habitats for terrestrial and aquatic species, reducing current velocity, trapping sediments, and contributing to water quality regulation. However, agricultural expansion, overharvesting of forest resources, and hydrological changes caused by dam operation have led to reductions in riparian vegetation cover, shifts in species composition, and diminished ecosystem service provision.

Table 4. Demographic characteristics of respondents

Demography	Number	Percentage	Demography	Number	Percentage
1. Gender			2. Age		
Male	55	76.39	Oldest	75 years	
Female	17	23.61	Youngest	33 years	
Total	72	100.00	Average	56 years	
3. Main occupation			4. Additional occupation		
Agriculturist	54	75.00	No	44	61.11
Village headman	12	16.67	Yes - General worker	16	22.22
General worker	5	6.94	- Agriculturist	12	16.67
Monk	1	1.39	Total	72	100.00
Total	72	100.00			

Environmental and social impacts of hydropower development in the Mun River Basin

Hydropower development in the Mun River Basin is significantly affected to LULC changes. It was including the expansion of agricultural land, reduction in forested areas, and transformation of the riparian vegetation structure. The construction of large dams has prolonged inundation periods in downstream areas that causing the mortality of flood-intolerant plant species. They have been subsequently replaced by flood-tolerant vegetation. Sedimentation process has been intensified along riparian zones. The habitat fragmentation has adversely affected both terrestrial and aquatic species by reducing breeding and spawning grounds.

From a social perspective, modification in hydrological flow regimes have been altered the way of natural resources utilization within the communities. In certain areas, riparian forests have been designated as community conservation forests. It was providing for clearly demarcated boundaries, local management committees, and harvesting regulations. In other area, increased agricultural encroachment has been observed which leading to further habitat degradation.

These findings are demonstrated the dual nature of hydropower impacts in the Mun River Basin. On the one hand, reservoirs provide water security which enable to dry-season irrigation and support agricultural productivity. But on the other hand, ecological integrity has been compromised biodiversity reduction and traditional livelihoods disruption. This trade-off is underscored the need for balancing management strategies that can be simultaneously sustained an economic benefit and preserve critical ecological functions.

Discussion

The study revealed that the bidirectional relationship between dam construction, riparian ecosystem transformation, and rural livelihood dynamics in the Mun River Basin, Thailand were complex and intricated. The combined spatial, ecological and socio-economic analyses have shown that hydropower and water management infrastructure comprising 12 large-scale dams and numerous smaller projects has fundamentally altered the basin's hydrological regime. It was cascading effects on land use, vegetation patterns, and community well-being.

Ecological transformations of Riparian Zones

It was confirmed by remote sensing and field observation about a substantial decline in riparian forest cover and alongside notable shifts in species composition. The inundated zones have recently transitioned toward flood-tolerant vegetation and experiencing to reduce flood frequency which favor for terrestrial species. These changes were parallel to global patterns in regulated rivers. They were altered the flow regimes and disrupted sediment transport fragment habitats, diminish ecological connectivity, and reduce habitat heterogeneity(Nilsson and Berggren, 2000; Yi *et al*., 2019; Ziv *et al*., 2012).

The Mun River Basin findings were also consisted of the loss of ecosystem services integral to rural livelihoods. Over 70 riparian plant species were utilized for food, traditional medicine, artisanal tools, and fuel which remain important to household economies. However, overharvesting, agricultural encroachment, and hydrological alterations have reduced both diversity and seasonal availability. These outcomes align with evidence from other Southeast Asian riparian system, where hydropower development accelerates biodiversity decline and erodes provisioning, regulating, and cultural services (Baird and Barney, 2017; Phommachanh *et al*., 2020).

Livelihood adjustments and socio-economic trade-offs

Most of households were not permanently displaced by dam construction. The altered flood regimes have reshaped agricultural calendars, fisheries productivity and access to riparian resources. The communities have adopted various adaptation strategies, such as crop diversification, reliance on dry-season irrigation from stored water, and community-based forest management. However, these initiatives are unevenly distributed and face challenges including insecure tenure rights, inconsistent enforcement, and competing land-use pressures. The socio-economic trade-offs in many studies of other dam-affected context were also reported, such as the Mekong Basin and Ghana's Bui Dam. It was found that infrastructure development has generated both economic opportunities and heightened livelihood vulnerabilities (Obour *et al*., 2016; Soukhaphon *et al*., 2021).

Governance implications and sustainability pathways

It was clarified that the implementation of hydropower and irrigation projects could be provided for explicit consideration of environmental flows, sediment dynamics, and LULC impacts. The risk should be undermining the

ecological foundations that sustain rural livelihoods. The Thai-language provincial development reports emphasized that rapid economic expansion in Northeast Thailand, coupled with national-scale water infrastructure policies, has accelerated riparian habitat loss despite existing conservation frameworks (Kaewkandee *et al*., 2012).

Sustainable dam governance in the Mun River Basin would be required the hybrid approaches to integrate engineering solutions with community-led conservation and absolute adaptive management. The priority measurement should be included for environmental flow regulation, riparian habitat restoration, floodplain reconnection, participatory land-use zoning, and farm pond expansion to enhance climate resilience. Such strategies align with global recommendations advocating basin-wide, multi-stakeholder frameworks to balance energy production, water security, and biodiversity conservation (Grumbine and Xu, 2011; Richter *et al*., 2010).

For maintaining the ecological integrity of riparian zones, it is not solely an environmental goal but a socio-economic necessity. The sustainability of rural livelihoods in dam-influenced landscapes depends on preserving the dynamic equilibrium between engineered water management and the natural processes. It could be supported biodiversity, agricultural productivity, and cultural heritage. In the Mun River Basin, achieving this balance demands coordinated action among government agencies, local communities, and cross-basin stakeholders to ensure that future water infrastructure development aligns with both human and ecological well-being.

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Conflicts of interest

The authors declare no conflict of interest.

References

Abate, S. (2011). Evaluating the land use and land cover dynamics in Borena Woreda of South Wollo highlands, Ethiopia. Journal of Sustainable Development in Africa, 13:87-105.

Akter, A. and Babel, M. S. (2012). Hydrological modeling of the Mun River basin in Thailand. Journal of Hydrology, 452-453:232-246. https://doi.org/10.1016/j.jhydrol.2012.05.059

Annys, S., Ghebreyohannes, T. and Nyssen, J. (2020). Impact of Hydropower Dam Operation and Management on Downstream Hydrogeomorphology in Semi-Arid Environments (Tekeze, Northern Ethiopia). Water, 12:8. https://doi.org/10.3390/w12082237

Baird, I. G. and Barney, K. (2017). The political ecology of cross-sectoral cumulative impacts: Modern landscapes, large hydropower dams and industrial tree plantations in Laos and Cambodia. Journal of Peasant Studies, 44:769-795. https://doi.org/10.1080/03066150.2017.1289921

Congalton, R. G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. Remote Sensing of Environment, 37:35-46. https://doi.org/10.1016/0034-4257(91)90048-B

Department of National Parks, Wildlife and Plant Conservation (2018). Riparian forest – Northeastern Region. P 500.

Eastman, J. R. (2009). Idrisi Taiga, Guide to GIS and Image Processing, Manual Version 16.02. Clark University, Worcester.

Fikadu, G. and Olika, G. (2023). Impact of land use land cover change using remote sensing with integration of socio-economic data on rural livelihoods in the Nashe watershed, Ethiopia. Heliyon, 9:e13746. https://doi.org/10.1016/j.heliyon.2023.e13746

Foody, G. M. (2002). Status of land cover classification accuracy assessment. Remote Sensing of Environment, 80:185-201. https://doi.org/10.1016/S0034-4257(01)00295-4

González, E., Sher, A. A., Tabacchi, E., Masip, A. and Poulin, M. (2015). Restoration of riparian vegetation: A global review of implementation and evaluation approaches in the international, peer-reviewed literature. Journal of Environmental Management, 158:85-94. https://doi.org/10.1016/j.jenvman.2015.04.033

Grumbine, R. E. and Xu, J. (2011). Mekong hydropower development. Science, 332:178-179. https://doi.org/10.1126/science.1200990

Hassen, E. E. and Assen, M. (2018). Land use/cover dynamics and its drivers in Gelda catchment, Lake Tana watershed, Ethiopia. Environmental Systems Research, 6:4. https://doi.org/10.1186/s40068-017-0081-x

Kaewkandee, K., Chanthasomwong, A., Bunthun, N., Phumhinpheng, W., Boonphunthuek, P., Kreuangkaew, P., Srisuk, P., Suwanwet, S. and Yota, C. (2012). Community-based food security management: The analysis of communal management of seasonally flooded forest in the Northeast and mixed evergreen and deciduous seasonal forest in the West using Driver-Pressure-State-Impact-Response Model. Thailand Research Fund (TRF).

Killingbeck, K. T. (2006). A river runs through it: R. J. Naiman, H. Décamps, and M. E. McClain, Riparia: Ecology, Conservation, and Management of Streamside Communities, 430 pp. Landscape Ecology, 21:1377-1378. https://doi.org/10.1007/s10980-006-0026-7

Lillesand, T. M. and Kiefer, R. W. (2015). Remote sensing and image interpretation (7th ed.). Wiley.

Mekong River Commission (MRC). (2018). State of the Basin Report 2018. MRC Secretariat. https://www.mrcmekong.org/assets/publications/SOBR-2018-English.pdf

Naiman, R. J., Décamps, H. and McClain, M. E. (2005). Riparia: Ecology, conservation, and management of streamside communities. Academic Press. https://doi.org/10.1016/B978-0-12-663315-3.X5000-X

Nilsson, C. and Berggren, K. (2000). Alterations of riparian ecosystems caused by river regulation: Dam operations have caused global-scale ecological changes in riparian ecosystems. BioScience, 50:783-792. https://doi.org/10.1641/0006-3568(2000)050[0783:AORECB]2.0.CO;2

Obour, P. B., Owusu, K., Agyeman, E. A., Ahenkan, A. and Madrid, À. N. (2016). The impacts of dams on local livelihoods: A study of the Bui Hydroelectric Project in Ghana. International Journal of Water Resources Development, 32:286-300. https://doi.org/10.1080/07900627.2015.1022892

Office of the National Water Resources (ONWR). (2020). Basic information report of the Mun River Basin. Retrieved from https://ebook.onwr.go.th/book/140

Phommachanh, S., Baird, I. G. and Greig, L. (2020). The impacts of hydropower dams on riparian livelihoods in the Mekong Basin. Water, 12:2212. https://doi.org/10.3390/w12082212

Pontius, R. G. and Malanson, J. (2005). Comparison of the structure and accuracy of two land change models. International Journal of Geographical Information Science, 19:745-748. https://doi.org/10.1080/13658810512331389445

Richter, B. D., Warner, A. T., Meyer, J. L. and Lutz, K. (2010). A collaborative and adaptive process for developing environmental flow recommendations. River Research and Applications, 22:297-318. https://doi.org/10.1002/rra.892

Singh, M. and Tyagi, K. D. (2021). Pixel based classification for Landsat 8 OLI multispectral satellite images using deep learning neural network. Remote Sensing Applications: Society and Environment, 24:100645. https://doi.org/10.1016/j.rsase.2021.100645

Soukhaphon, A., Baird, I. G. and Hogan, Z. S. (2021). The impacts of hydropower dams in the Mekong River Basin: A review. Water, 13:3. https://doi.org/10.3390/w13030265

Stehman, S. V. (1997). Selecting and interpreting measures of thematic classification accuracy. Remote Sensing of Environment, 62:77-89. https://doi.org/10.1016/S0034-4257(97)00083-7

Temesgen, G., Amare, B. and Abraham, M. (2014). Evaluation of land use/land cover changes and land degradation in Dera District, Ethiopia: GIS and remote sensing-based analysis. International Journal of Scientific Research in Environmental Sciences, 2:199-208.

Winemiller, K. O., McIntyre, P. B., Castello, L., Fluet-Chouinard, E., Giarrizzo, T., Nam, S., Baird, I. G., Darwall, W., Lujan, N. K., Harrison, I., Stiassny, M. L. J., Silvano, R. A. M., Fitzgerald, D. B., Pelicice, F. M., Agostinho, A. A., Gomes, L. C., Albert, J. S., Baran, E., Petrere, M., Jr., Zarfl, C., Mulligan, M., Sullivan, J. P., Arantes, C. C., Sousa, L. M., Koning, A. A., Hoeinghaus, D. J., Sabaj, M., Lundberg, J. G., Armbruster, J., Thieme, M. L., Petry, P., Zuanon, J., Torrente Vilara, G., Snoeks, J., Ou, C., Rainboth, W., Pavanelli, C. S., Akama, A., van Soesbergen, A. and Sáenz, L. (2016). Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science, 351:128-129. https://doi.org/10.1126/science.aac7082

Yang, H., Rood, S. B. and Flanagan, L. B. (2019). Controls on ecosystem water-use and water-use efficiency: Insights from a comparison between grassland and riparian forest in the northern Great Plains. Agricultural and Forest Meteorology, 271:22-32. https://doi.org/10.1016/j.agrformet.2019.02.034

Yi, Y., Zhou, Y., Song, J., Zhang, S., Cai, Y., Yang, W. and Yang, Z. (2019). The effects of cascade dam construction and operation on riparian vegetation. Advances in Water Resources, 131:103206. https://doi.org/10.1016/j.advwatres.2018.09.015

Zaimes, G. N., Gounaridis, D. and Symenonakis, E. (2019). Assessing the impact of dams on riparian and deltaic vegetation using remotely-sensed vegetation indices and Random Forests modelling. Ecological Indicators, 103:630-641. https://doi.org/10.1016/j.ecolind.2019.04.047

Zhao, Z., Liu, G., Liu, Q., Huang, C., Li, H. and Wu, C. (2018). Distribution characteristics and seasonal variation of soil nutrients in the Mun River Basin, Thailand. International Journal of Environmental Research and Public Health, 15:1818. https://doi.org/10.3390/ijerph15091818

Ziv, G., Baran, E., Nam, S., Rodríguez-Iturbe, I. and Levin, S. A. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. Proceedings of the National Academy of Sciences, 109:5609-5614. https://doi.org/10.1073/pnas.1201423109

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