

Research Article

Land Use Changes after the Construction of the Xesalalong Reservoir: A Case Study of Three Villages in Thapangthong District, Savannakhet Province, Lao PDR

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ABSTRACT

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This study analyzed land use changes in three villages: Thongpang, Maiphosi, and Kouthi in Thapangthong District, Savannakhet Province, Lao PDR, following the construction of the Xesalalong Reservoir. Land use was classified into six categories: agricultural land (paddy fields and other agricultural land), water area, forest land, built-up land, roads, and cultural land, using Google Earth imagery combined with GIS analysis and field surveys. The total study area covered 6,653 ha. Between 2014 and 2024, agricultural land expanded substantially by 947.94 ha (+14.25%), driven primarily by paddy field expansion (+875.51 ha, +13.16%), which was the dominant form of land use change. Water area grew by 200.02 ha (+3.01%), built-up land by 40.36 ha (+0.61%), and cultural land by 7.74 ha (+0.12%). In contrast, forest land declined substantially by 1,193.65 ha (-17.94%), while roads decreased slightly by 2.41 ha (-0.04%). The overall classification accuracy was 81.5% with a Kappa coefficient of 0.76. The annual change rate indicated agricultural land expansion at +1.42% per year, contrasted with forest loss at -1.79% per year. These results demonstrate that reservoir construction and water management facilitated agricultural expansion, particularly paddy cultivation, while reducing forest cover. The findings highlight trade-offs between human land use and natural ecosystems and provide spatial evidence to support sustainable land and water management planning in rural Lao communities.

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1. Introduction

Land use reflects the relationship between human activities and ecosystems, particularly in rural areas where communities rely on agriculture and natural resources (Lambin *et al.*, 2001; Turner *et al.*, 2007). Land use changes are often influenced by economic, social, and infrastructural factors, such as water development projects, which can alter cropping patterns and expand cultivated areas (Hett *et al.*, 2012; Kamwi *et al.*, 2020). Therefore, studying land use changes is important for development planning, resource management, and sustainable land use (Loures, 2019; Gaur and Singh, 2023).

The study area includes three villages: Thongpang, Maiphosi, and Kouthi in Thapangthong District, Savannakhet Province, Lao PDR. These villages are adjacent and have

similar land use patterns. Originally, the communities mainly practiced subsistence agriculture using rainwater and natural water sources for cultivation. In 2014, the Xesalalong Reservoir was constructed near the communities, and water from the reservoir began to be used for agriculture around 2015 (China Daily, 2015; Lao News Agency, 2017).

The three villages were selected due to their geographical, lifestyle, and land use connections. Including all three villages allows for broader data coverage, enabling clearer and more comprehensive analysis of land use change patterns. Previous studies in the area focused on district-level land use change, emphasizing forest reduction and surrounding areas (Douangphachanh *et al.*, 2022). However, there remains a gap in understanding how village-level land use has changed in

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response to the Xesalong Reservoir, particularly with regard to the spatial patterns and rates of agricultural expansion versus forest loss at the local community scale. This study addresses this gap by analyzing land use changes between 2014 and 2024 in the three villages to examine spatial patterns and support local resource management, using Google Earth imagery as an accessible, high-resolution data source that effectively reflects land changes (Sheppard and Cizek, 2009; Yu and Gong, 2012). The results will provide insight into land use trends in rural Lao communities and support local development planning, water resource management, and sustainable land use.

2. Materials and Methods

This study is quantitative research combining secondary data from Google Earth imagery with field surveys to analyze land use changes in three villages: Thongpang, Maiphosi, and

Kouthi in Thapangthong District, Savannakhet Province, Lao PDR, located near the Xesalong Reservoir.

2.1 Study area

The study area includes Thongpang, Maiphosi, and Kouthi villages in Thapangthong District, Savannakhet Province, Lao PDR, situated near the Xesalong Reservoir, which was constructed in 2014 and started supplying water for agricultural use in 2015. The area ranges from 15°57'N to 16°04'N latitude and 105°46'E to 105°52'E longitude, covering a total of 6,653 ha. The three villages share similar geographic features, soil types, and environmental conditions. Their primary livelihood is rainfed agriculture, and local economic activities are closely tied to natural resources, making the area suitable for comparative analysis of land use changes following reservoir construction. As shown in Figure 1, the study area covers the three villages.

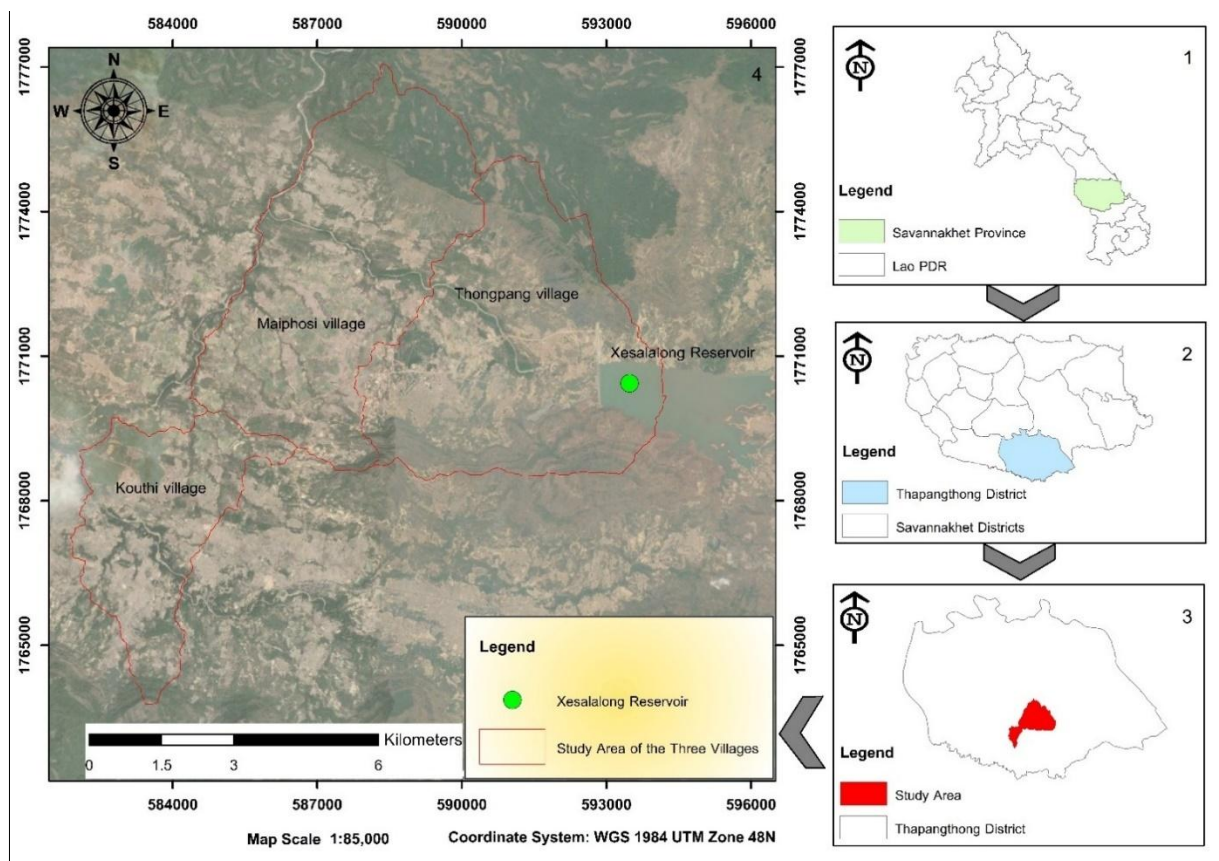


Figure 1 The study area covering the three villages.

2.2 Data collection

Google Earth Imagery: High-resolution Google Earth images from November 2014 (before reservoir utilization) and November 2024 (10 years after reservoir utilization) were used. November was selected because it represents the post-rainy season when agricultural land is fully utilized and cloud-free conditions are more frequent, ensuring clear imagery and comparability between years. Prior to analysis, the images were visually inspected for cloud cover, geometric distortion, and color consistency. Only cloud-free images with comparable color

balance and spatial resolution were selected for both time periods to minimize interpretation errors.

Field Surveys: Ground truth data were collected in 2024 to validate land use classification, including agricultural land, water area, forest land, built-up land, roads, and cultural land. GPS coordinates of sample points were recorded to support the accuracy assessment.

GIS Analysis: The imagery was georeferenced and re-projected to UTM WGS 1984 Zone 48N to align with actual coordinates. Land use boundaries were delineated through on-

screen visual interpretation and manual digitization in ArcGIS, using color, texture, shape, and pattern as the primary identification criteria. A minimum mapping unit of approximately 0.1 ha was applied to avoid excessive fragmentation of small features. In areas where land use types were ambiguous or transitional (e.g., forest-agricultural boundaries), field verification data and local knowledge were used to assign the most appropriate classification. Digitized areas were calculated in hectares. Land use change detection between 2014 and 2024 was carried out in terms of both absolute area and percentage. Change detection maps were then produced to illustrate spatial distribution patterns across the three villages.

2.3 Land use classification

Land use was classified into six main categories according to the Lao PDR National Land Law (National Assembly of Lao PDR, 2019):

- 1) Agricultural land: subdivided into paddy fields and other agricultural land, such as upland crops, cassava plantations, and pasture.
- 2) Water area: including reservoirs, rivers, and other water bodies.
- 3) Forest land: encompassing natural forest, secondary forest, and areas covered by trees.
- 4) Built-up land: including residential, commercial, and other constructed areas.
- 5) Roads: including main and secondary roads within the villages.
- 6) Cultural land: used for religious, traditional, or heritage purposes.

2.4 Accuracy assessment

To evaluate the accuracy of land use classification, 200 sample points were randomly selected across all six categories. A confusion matrix compared Google Earth classifications with field survey data. Overall Accuracy and Kappa coefficient were calculated. The classification achieved an Overall Accuracy of 81.5% and a Kappa coefficient of 0.76, which is considered acceptable for analyzing land use changes at this scale (Congalton and Green, 2019). Potential sources of classification error included seasonal variation in vegetation appearance, mixed pixels in transitional zones between forest and agricultural land, and differences in image quality between the two time periods. These limitations were mitigated through field verification and cross-referencing with local land use records.

2.5 Annual change rate

The annual change rate for each land use type was calculated using the formula:

$$\text{Annual Rate (\%/year)} = \frac{\text{Changes\%}}{\text{Number of Year}} \quad (1)$$

Where Change (%) is the percentage of land use change between 2014 and 2024, calculated as the difference in area divided by the total study area and multiplied by 100, and Number of Years = 10 (i.e., the period from 2014 to 2024). This formula assumes a linear rate of change over the study period and allows for standardized comparison of the speed and direction of change for each land use category, such as the expansion of agricultural land and the reduction of forest land.

3. Results and Discussion

3.1 Overall land use change in three villages

Comparison of land use before and after the utilization of the Xesalong Reservoir revealed a total change of 2,392.12 ha, accounting for 35.96%. Agricultural land increased by 947.94 ha (+14.25%), of which paddy fields contributed 875.51 ha (+13.16%) and other agricultural land (including upland crops, cassava plantations, and pastures) increased by 72.43 ha (+1.09%). Water area expanded by 200.02 ha (+3.01%), built-up land increased by 40.36 ha (+0.61%), and cultural land increased by 7.74 ha (+0.12%). In contrast, forest land decreased by 1,193.65 ha (-17.94%), and roads declined slightly by 2.41 ha (-0.04%).

Accuracy assessment indicated an Overall Accuracy of approximately 81.5% and a Kappa coefficient of 0.76, which is considered acceptable to good. The highest classification accuracy was observed for agricultural land and paddy fields, while forest and built-up land were moderately accurate but still sufficient for land use change analysis.

The annual change rate showed that overall agricultural land expanded at an average of +1.42% per year, particularly paddy fields at +1.31% per year. Other agricultural land and water area increased slightly at +0.10% and +0.30% per year, respectively. In contrast, forest land declined significantly at an average rate of -1.79% per year, indicating a clear trend of agricultural expansion, especially paddy cultivation, alongside continuous forest reduction. Table 1 summarizes the overall land use change in the three villages between 2014 and 2024, while Figure 2 presents the spatial distribution of land use change over the study period.

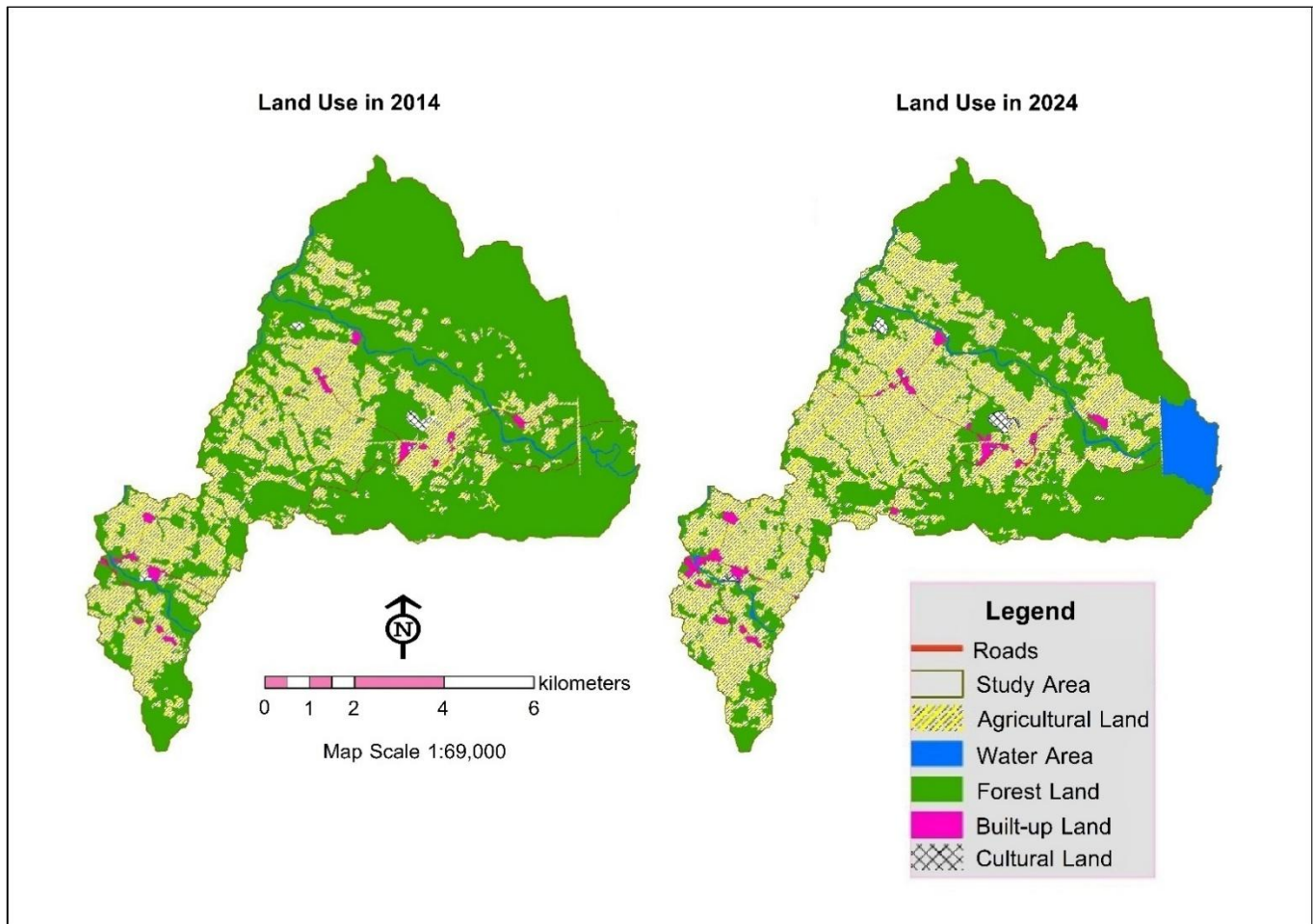
3.2 Land use change in individual villages

3.2.1 Thongpang village

The total land use change was 1,016.06 ha (37.62%). Agricultural land increased by 295.56 ha (+10.94%), of which paddy fields expanded by 282.41 ha (+10.46%) and other agricultural land increased by 13.15 ha (+0.49%). Water area increased by 197.83 ha (+7.33%), built-up land by 11.98 ha (+0.44%), and cultural land by 2.66 ha (+0.10%). Forest land showed the largest decrease of 504.97 ha (-18.70%), and roads declined slightly by 3.06 ha (-0.11%). Table 2 shows land use change in Thongpang village between 2014 and 2024.

Table 1 Summary of land use change in the three villages between 2014 and 2024.

No.	Type of land	2014 Area (ha)	2014 (%)	2024 Area (ha)	2024 (%)	Change area (ha)	Change (%)
1	Agricultural land	2,088.10	31.39	3,036.04	45.63	+947.94	+14.25
1.1	Paddy fields	2,056.16	30.91	2,931.67	44.07	+875.51	+13.16
1.2	Other agricultural land	31.94	0.48	104.37	1.57	+72.43	+1.09
2	Water area	65.58	0.99	265.60	3.99	+200.02	+3.01
3	Forest land	4,392.32	66.02	3,198.67	48.08	-1,193.65	-17.94
4	Built-up land	60.18	0.90	100.54	1.51	+40.36	+0.61
5	Roads	23.73	0.36	21.32	0.32	-2.41	-0.04
6	Cultural land	23.09	0.35	30.83	0.46	+7.74	+0.12
Total		6,653.00	100.00	6,653.00	100.00	2,392.12	35.96

**Figure 2** Land use change map of the three villages between 2014 and 2024.

3.2.2 Maiphosi village

The total land use change was 960.92 ha (36.08%). Agricultural land increased the most, by 467.94 ha (+17.57%), of which paddy fields increased by 447.86 ha (+16.82%) and other agricultural land by 20.08 ha (+0.75%). Built-up land increased by 7.60 ha (+0.29%), cultural land by 4.33 ha (+0.16%), roads by 0.31 ha (+0.01%), and water area by 0.28

ha (+0.01%). Forest land decreased the most, by 480.46 ha (-18.04%). Table 3 presents land use change in Maiphosi village between 2014 and 2024.

3.2.3 Kouthi village

The total land use change was 416.44 ha (32.30%). Agricultural land increased by 184.44 ha (+14.30%), including paddy fields (+145.24 ha, +11.26%) and other agricultural land

(+39.20 ha, +3.04%). Built-up land increased by 20.78 ha (+1.61%), reflecting residential expansion as the community grew in response to improved agricultural productivity. Water area increased slightly by 1.91 ha (+0.15%), as Kouthi Village is located farther from the main reservoir compared to Thongpang Village. Cultural land increased by 0.75 ha

(+0.06%), and roads by 0.34 ha (+0.03%), indicating modest infrastructure development. Forest land declined by 208.22 ha (-16.15%), primarily due to conversion to paddy fields and other agricultural uses driven by increased water availability from the reservoir. Table 4 shows land use change in Kouthi village between 2014 and 2024.

Table 2 Land use change in Thongpang village between 2014 and 2024.

No.	Type of land	2014 Area (ha)	2014 (%)	2024 Area (ha)	2024 (%)	Change area (ha)	Change (%)
1	Agricultural land	439.14	16.26	734.70	27.21	+295.56	+10.94
1.1	Paddy fields	436.84	16.18	719.25	26.63	+282.41	+10.46
1.2	Other agricultural land	2.30	0.09	15.45	0.57	+13.15	+0.49
2	Water area	27.79	1.03	225.62	8.35	+197.83	+7.33
3	Forest land	2,185.64	80.93	1,680.67	62.23	-504.97	-18.70
4	Built-up land	20.18	0.75	32.16	1.19	+11.98	+0.44
5	Roads	12.08	0.45	9.02	0.33	-3.06	-0.11
6	Cultural land	15.72	0.58	18.38	0.68	+2.66	+0.10
Total		2,700.55	100.00	2,700.55	100.00	1,016.06	37.62

Table 3 Land use change in Maiphosi village between 2014 and 2024.

No.	Type of land	2014 Area (ha)	2014 (%)	2024 Area (ha)	2024 (%)	Change area (ha)	Change (%)
1	Agricultural land	935.48	35.13	1403.42	52.70	+467.94	+17.57
1.1	Paddy fields	919.57	34.53	1367.43	51.35	+447.86	+16.82
1.2	Other agricultural land	15.91	0.60	35.99	1.35	+20.08	+0.75
2	Water area	25	0.94	25.28	0.95	+0.28	+0.01
3	Forest land	1,678.94	63.05	1,198.48	45.01	-480.46	-18.04
4	Built-up land	12.48	0.47	20.08	0.75	+7.60	+0.29
5	Roads	6	0.23	6.31	0.24	+0.31	+0.01
6	Cultural land	4.97	0.19	9.3	0.35	+4.33	+0.16
Total		2,662.87	100.00	2,662.87	100.00	960.92	36.08

Table 4 Land use change in Kouthi village between 2014 and 2024.

No.	Type of land	2014 Area (ha)	2014 (%)	2024 Area (ha)	2024 (%)	Change area (ha)	Change (%)
1	Agricultural land	713.48	55.33	897.92	69.63	+184.44	+14.30
1.1	Paddy fields	699.75	54.26	844.99	65.52	+145.24	+11.26
1.2	Other agricultural land	13.73	1.06	52.93	4.10	+39.20	+3.04
2	Water area	12.79	0.99	14.70	1.14	+1.91	+0.15
3	Forest land	527.74	40.92	319.52	24.78	-208.22	-16.15
4	Built-up land	27.52	2.13	48.30	3.75	+20.78	+1.61
5	Roads	5.65	0.44	5.99	0.46	+0.34	+0.03
6	Cultural land	2.40	0.19	3.15	0.24	+0.75	+0.06
Total		1,289.58	100.00	1,289.58	100.00	416.44	32.30

3.3 Discussion

In the comparison of land use change characteristics among the three villages, a consistent trend was observed. Agricultural land increased significantly in all villages, particularly paddy fields, which were the main driver of agricultural expansion. Simultaneously, forest land decreased the most across all villages, reflecting the direct impact of land use restructuring following the operation of the Xesalong Reservoir. In addition, water areas, built-up land, and cultural land showed slight increases in all villages, indicating community adaptation and increased utilization of land for human activities.

However, each village exhibited distinct characteristics. Maiphosi Village showed the highest increase in agricultural land, both in terms of area and proportion, whereas Thongpang Village experienced the greatest loss of forest land and the most substantial increase in water area. Notably, Thongpang was the only village where road areas decreased. In contrast, Kouthi Village, despite showing the lowest overall land use change, had a higher proportional increase in other agricultural land and built-up land compared to the other villages. Overall, land use changes in the three villages followed similar main trends but also reflected variations according to local context and resource utilization in each community.

The land use patterns of the three villages prior to the operation of the Xesalong Reservoir in 2014 are consistent with Chaikaew (2019), who studied land use structures in the Klong Kui Reservoir area in the same year. Chaikaew reported that forest land occupied the largest proportion (54.8%), followed by agricultural land (36.98%) and water areas (2.59%), with paddy fields being the dominant type of agricultural land (11.05%), while upland crops, cassava, and grasslands together accounted for 25.93%. However, these findings differ from those of Sribunkhum *et al.* (2021), who analysed land use in the Lam Dom Yai sub-watershed in 2014 and found that agricultural land had the highest proportion (72.86%), followed by forest land (16.74%), built-up areas (4.95%), miscellaneous land (3.43%), and water areas (2.01%). These differences likely reflect variations in socioeconomic conditions, which influence land use patterns, particularly the proportion of agricultural land closely related to community livelihoods and the role of agriculture in sustaining local life.

After the operation of the Xesalong Reservoir in 2024, land use patterns of the three villages were similar to those reported by Agumagu *et al.* (2025), who analysed land use and land cover in the Niger Delta, Nigeria, in the same year. They found that forest land occupied the largest proportion (50.5%), divided into tropical forest (27.6%) and mangrove forest (22.9%), followed by agricultural land (29.07%), built-up land (18.5%), and water areas (1.9%). Although the proportions differ, both cases indicate that forest and agricultural lands continue to dominate land use. Similarly, Faksomboon *et al.* (2022) reported that in the Pong Nam Ron sub-watershed, Kamphaeng Phet

Province in 2024, forest land accounted for 91.23%, followed by agricultural land (7.89%), built-up land (0.37%), water areas (0.32%), and miscellaneous land (0.10%), highlighting the continued importance of forest and agricultural lands despite differences in geographical and socioeconomic contexts.

The study of land use changes in the three villages between 2014 and 2024 revealed that agricultural land increased more than any other land type, with a total increase of 947.94 ha (+14.25%), particularly paddy fields, which increased by 875.51 ha (+13.16%). This trend was driven by the construction and operation of the Xesalong Reservoir, which provided sufficient water for double-cropping of rice (wet and dry seasons), enabling local communities to expand agricultural production to meet both consumption and market demands. Meanwhile, forest land decreased the most, losing 1,193.65 ha (-17.94%), mainly due to the conversion of forest areas to agricultural land, especially paddy fields and gardens, as well as partial conversion to the reservoir area, resulting in a clear reduction in forest cover.

These findings are consistent with previous studies. Toemton (2021), who analysed the Royal Initiative Project at Doi Bae Lae Highland Agriculture Development Station, Chiang Mai (2013–2020), reported a 34.62% increase in agricultural land, particularly paddy fields (+42.39%), while other agricultural lands decreased by 7.77% and built-up areas increased by 8.42%. Similarly, Ibrahim *et al.* (2025) found in the Black Belt region of Alabama, USA, that conversion from forest to agricultural land affected rainfall, temperature, and ecosystems, requiring adaptation in agriculture and environment. Zhang (2023) also noted that such land use changes impact biodiversity and natural resource utilization, reflecting potential effects in the study area.

However, some studies show contrasting trends. For example, Rakuasa and Achmadi (2024) reported that in Slawi Subdistrict, Tegal Regency (2014–2024), agricultural land decreased by 9.03%, while built-up areas increased by 9.21%. Toemton (2021) also observed that although paddy fields increased, other agricultural lands and water areas decreased significantly, differing from the Xesalong study area, where the reservoir supported agricultural expansion, leading to increases in water and other agricultural lands.

These comparisons illustrate that land use changes vary according to geographic, economic, water management policy, and community livelihood contexts. While some trends, such as the expansion of paddy fields, may be similar, overall land use change is strongly influenced by local factors.

4. Conclusion

Between 2014 and 2024, the total land use change in the three villages near Xesalong Reservoir reached 2,392.12 ha (35.96%) of 6,653 ha. Agricultural land increased by 947.94 ha (14.25%), mainly due to paddy fields expansion (+875.51 ha,

13.16%), corresponding to an annual change rate of +1.42% per year for agricultural land and +1.31% per year for paddy fields. Forest land decreased by 1,193.65 ha (-17.94%), with an annual decrease rate of -1.79% per year. Water areas, built-up land, roads, and cultural land changed at lower rates (+0.30%, +0.06%, -0.004%, and +0.01% per year, respectively). These results highlight the role of water management in promoting agricultural expansion while leading to forest loss. These land use change patterns are strongly influenced by local geography, socioeconomics, and community livelihoods.

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