Regional Environmental Change (2021) 21:115
https://doi.org/10.1007/s10113-021-01842-7

ORIGINAL ARTICLE

Wetland changes and their impacts on livelihoods in Chiang Saen Valley, Chiang Rai Province, Thailand

Nuttiga Hempattarasuwan[1] · Akarapong Untong[2] · George Christakos[3,4] · Jiaping Wu[4]

Received: 24 December 2020 / Accepted: 21 September 2021

Abstract

This study aims to classify and quantify the levels of change in the Wiang Nong Lom and Nong Luang wetlands (Chiang Saen Valley, Chiang Rai Province, Thailand) and their impact on local livelihoods. Primary data and key informant survey, group interviews, descriptive statistics, and *t*-tests were used. Importance-performance analysis was used to prioritize those issues that deserve most attention. The 448 households located in these wetland areas were surveyed and additional information was obtained through key informants and group interviews. Our results showed that both natural occurrences and human activity can cause wetland changes. Sedimentation is the main natural cause of wetland damage (62.2%). Use of agricultural technology (81.9%) is the most significant force driving wetland changes. More than 90% of the survey respondents agreed that during the last 30 years changes occurred in the community economy, socio-cultural tradition, and wetland ecology. More than 85% of the respondents reported that their livelihoods had been affected by those changes, whereas 94.2% of them claimed that the wetland ecology has changed. Changes that had a "high" impact on livelihoods included poor water quality, a decline in fishery and livestock grazing areas, an influx of immigrant workers, a decline in species, and number of fish and aquatic animals. There was a significant difference in the perceptions regarding the impact of changes in community economy and the wetland ecosystem of intensive and non-intensive users. It is recommended that volunteer monitoring programs can bring together communities with environmental and local government staff to monitor wetland quality.

Keywords Impact · Importance-performance analysis · Livelihoods · Perception · Wetlands · Wetland change

Introduction

Wetland ecosystems are significantly beneficial to humans, plants, and wildlife. For many generations, wetlands have provided important socio-cultural and spiritual benefits to local people (Mitsch and Gosselink 2007; Rodríguez et al. 2006; Chan et al. 2012; Vanessa et al. 2016). People depend directly and/or indirectly on wetland ecosystem resources and ecosystem services (Millennium Ecosystem Assessment 2005; Keddy et al. 2009; Qin et al. 2011). Most importantly, wetlands provide food and water necessary to satisfy the basic needs of people (MEA 2005). Schuyt and Brander (2004) have estimated that the economic value of global wetlands is about $3.4 billion/year due to the variety of services these ecosystems provide to human well-being. This fact seems to be neglected when it comes to decision-making concerning land use in wetlands, because these kinds of values do not appear in national financial accounts. Global wetlands have been altered significantly and continue to be destroyed by people (Keddy et al. 2009; Davidson 2014;

Communicated by Chinwe Ifejika Speranza

✉ Jiaping Wu
jw67@zju.edu.cn

Nuttiga Hempattarasuwan
nuttiga@hotmail.com

Akarapong Untong
akarapong_un@hotmail.com

George Christakos
gchrista@sdsu.edu

[1] Faculty of Fisheries, Kasetsart University, Bangkok 10900, Thailand

[2] School of Tourism Development, Maejo University, Chiang Mai 50290, Thailand

[3] Department of Geography, San Diego State University, California 92182, USA

[4] Institute of Coastal and Island Ecosystem, Zhejiang University, Zhoushan 316021, China

Published online: 29 October 2021

Nguyen et al. 2016). Therefore, during the last century, more than 50% of the global wetland ecosystem has become deteriorated or lost, with Asia being one of the most impacted regions worldwide (Davidson 2014). Particularly in developing countries, reducing poverty and maintaining the wetlands as a secure source of food are more important than conservation (Lamsal et al. 2015). As a result, it is difficult for local people to become aware of the different values of wetlands (Lannas and Turpie 2009; Mwakubo and Obare 2009; Lamsal et al. 2015).

Thailand's wetlands are also threatened by activities that encroach upon them such as agricultural and urban expansion, fisheries, and industrial development. In particular, the wetland areas in the North of Thailand make up roughly 7.7% of the country's total wetland areas (Thailand Institute of Scientific and Technological Research 2015). Although wetlands constitute a small percentage of the country's land area, they constitute a unique and important feature of the landscape that provides flood protection and water for local communities (TISTR 2011a). They are ecologically, socially, and economically consequential. The percentage of Northern Thailand wetland areas decreased by 62.4% between 2001 and 2009 as a result of conversion to farmland, grazing land, and to aqua-cultural uses (TISTR 2015). These activities can cause multifaceted wetland degradation that harms the ecosystem and generate water pollution (TISTR 2011a, 2015). They reduce water depth, which, combined with an over-abundance of aquatic weeds, leads to hydrologic alteration (Office of Natural Resources and Environment Policy and Planning 2004; Pingmoung et al. 2004). In the highlands of Northern Thailand, wetlands provide a vital and diverse range of ecosystem services that support local livelihoods. They act as holding areas for large quantities of surface water. They temporarily store runoff and serve as fresh markets; they are sources of food and other resources for local people. As a result, ethnic groups live in and near wetland areas (Pingmoung et al. 2004).

The Wiang Nong Lom and Nong Luang wetlands have been designated as sites of international importance to Thailand (TISTR 2015). They are a source of biodiversity and provide critical habitats for aquatic animals, edible plants, herbs, wildlife, and native and migratory birds from Southern China and Siberia (ONEP 2004; Pingmoung et al. 2004; TISTR 2011a). They are part of an ecological connectivity network which includes the Nong Bong Kai wetland which has been designed as a Ramsar site (ONEP 2004). Historically, there was an abundance of plants and aquatic animals in these two wetlands. This enabled local people to survive off the land without the necessity of migrating to larger urban areas, unlike other communities in Thailand. The final decades of the twentieth century saw livelihoods in the Chiang Saen Valley change from subsistence farming to commercial farming. This was a result of broad government policies that focused on stimulating economic growth and expanding technology (Pingmoung et al. 2004). Commercial farming and cash crops such as rice, cassava, maize, pineapple, para rubber, and palm oil expanded to meet domestic demand. Infrastructure developed to support agricultural production and community extension. Dredging for water storage, drainage, conversion to agricultural use, the introduction of invasive species (particularly *Mimosa pigra*), water pollution, overexploitation, and overharvesting (ONEP 2004; Trisurat 2006; TISTR 2011a, b) all increase the risk of degradation, whereas competition for and conflict in using wetland resources among stakeholders has risen. As a result of the extension of agricultural and cultivation land, these wetlands were impacted and experienced loss and degradation (Pingmoung et al. 2004; TISTR 2011a, b). Wetlands areas decreased significantly (30.5%) over the 30-year period (Hempattarasuwan et al. 2019).

These wetlands are connected with each other. They are particularly suitable for case studies concerned with the causes of change to community economy, socio-cultural traditions, and wetland ecology as well as with the impact these changes have on household livelihoods. Data (concerning the causes of change to community economy, socio-cultural traditions, and wetland ecology, as well as about the impact these changes have on household livelihoods) suggests that promoting participation in decision-making, in conservation and in the consideration of intelligent and effective use of the wetlands is a critical step. Awareness and knowledge of the problems are not sufficient to address conservation or to prompt wetland restoration efforts, in which case voluntary participation and community involvement turn out to be more important (Chun et al. 2012; Lamsal et al. 2015). Understanding the perceptions of the people is critical for promoting intelligent use, conservation and sustainability (Vanessa et al. 2016). Many countries, including Thailand, have adopted the Convention on Biological Diversity's ecosystem philosophy (CBD) (ONEP 2015). The CBD is based on an ecological approach (EA). An EA is a conceptual framework that offers a comprehensive theoretical base for achieving sustainable development premised on maintaining fully functional ecosystems. Under CBD, the EA is considered the main action framework as regards natural resources management; it emphasizes the need for management to interface with ecological, economic, social, cultural, and political factors within a single framework (Pardeck 1988; Maltby 2006).

In an effort to determine the implication for sustainability of wetland management and livelihoods, several researchers in other countries, such as Bolivia, India, and Columbia, have attempted to ascertain local community perceptions and opinions by means of interviews and workshops regarding the impact of wetland change (Ricaurte et al. 2014; Bhatta et al. 2016; Vanessa

et al. 2016). A considerable part of the existing research addresses the engagement of local users in wetland services, conservation, and management (Lannas and Turpie 2009; Lamsal et al. 2015). Previous studies have classified wetland users based on different criteria. In one study, respondents were divided into groups classified as financially "better off," "intermediate," and "poor" (Rebelo et al. 2010). In another work, a household's social status was determined by assets owned and was used to categorize user-households as in a "higher class of wealth," "landless," or "labor" class (Das et al. 2015). A common finding is that most low-income households rely heavily on wetlands (Kipkemboi et al. 2007; Das et al. 2015).

Assessing the local community's opinions, regarding the impact of wetland changes, is the starting point to enhancing community participation in the design of wetland management policies that are sensitive to their needs. In this context, this study will address the main question: How can governments determine policy and ascertain priorities in order to motivate people to participate in wetland restoration and management? As such, the following research objectives were considered:

(1) To assess the perception of local residents regarding the economic, socio-cultural, and ecological changes in the wetlands and the impact these changes have had on their livelihoods during the 30-year period (1988 to 2017).
(2) To record the opinion of the local populace regarding the primary causes of wetland change.
(3) To ascertain what those who use the wetlands view as the primary causes of wetland change and the impact of these changes.

It is worth-noticing that objective #1 is related to two of our three study hypotheses (outlined in the Methods section below), in particular, to hypothesis H1 (local people experienced ecological wetland degradation and the negative impacts on their livelihoods), and to hypothesis H3 (respondents give high priority to the need to increase the diversity of species and the number of fish and aquatic animals for wetland management purposes). Moreover, objectives #2 and 3 are related to hypothesis H2 (users' perceptions regarding the causes of wetland changes and their impact on users' livelihoods may differ considerably).

Below, we begin with a description of the study area and certain aspects of the conceptual framework. We then describe the methods used, and we present and discuss findings obtained by data analysis. Finally, a critical summary of these findings can be found in the "Conclusions."

Study area

The Wiang Nong Lom and Nong Luang wetlands are adjacent to each other and include marshes and swamps. They cover an area of roughly 3100 ha and have been designated as wetlands of international importance (TISTR 2011a). They serve to store rainfall and water runoff from the highlands. These wetland areas are particularly valuable in providing flood protection to the Mae Chan and Chiang Saen Districts (ONEP 2004; Pingmoung et al. 2004; TISTR 2011a). These wetlands encompass areas in the Chan Chawa, Chan Chawa Tai, Takhaopleuk, and Jomsawan subdistricts of Mae Chan District, as well as areas in the Yonok sub-district of Chiang Saen District in Chiang Rai Province in the North of Thailand (20° 9′ 55″–20° 14′ 0″ N, 99° 57′ 57″–100° 2′ 16″ E; Fig. 1) at an elevation range of 358–372 m above mean sea level. They experience extended periods of warm weather because of their inland nature and tropical latitude zone. The hottest period of the year extends from April to June with a mean temperature of roughly 28°C, while July through September receives the most rainfall with a range of 287 mm/month (September) to 355 mm/month (August). The cool period occurs between December and January with mean temperature below 21°C (Hempattarasuwan et al. 2019). The parent materials of the soil were from residuum and local colluvium, and from alluvium. As happens in similar soil cases (ONEP 2004), soil texture is a mixture of clay and sand/loam. There were 311 and 376 plant species found within the Wiang Nong Lom and Nong Luang wetlands, respectively (TISTR 2011a, b). Rare plant species, such as *Cephalanthus tetrandra* (Roxb.) Ridsdale & Bakh. f and *Burmania coelestis* D. Don, were found in this wetland area (TISTR 2011a).

The discovery and analysis of historical settlements of ethnic groups and archeological sites indicate that people have lived in the wetlands of Chiang Saen Valley since the eighteenth century (Phuwanatwichit and Srirat 2014). This further raises the possibility that additional archeological remains could be unearthed in the area (Phuwanatwichit and Srirat 2014). The ethnic groups include Tai Yuan, Tai Lue, Tai Yong, and Isan (Pingmoung et al. 2004; Phuwanatwichit and Srirat 2014). Due to the unique topographic conditions, people live in small flat surrounding valleys. As such, the rural livelihood is largely dependent on these wetlands and the crucial role they play in providing water and food. The four major occupations related to household utilization of wetland resources are farmers, fishermen, buffalo raisers, and the households who regularly utilize wetland resources (including medicinal material and herb, wild edible vegetables, wild fruits, lotus plants, and honeybee; Phuwanatwichit and Srirat 2014). Approximately 21 % of the population of the Mae Chan and Chiang Saen Districts rely on the Chiang Saen Valley wetlands. The wetlands are most heavily relied

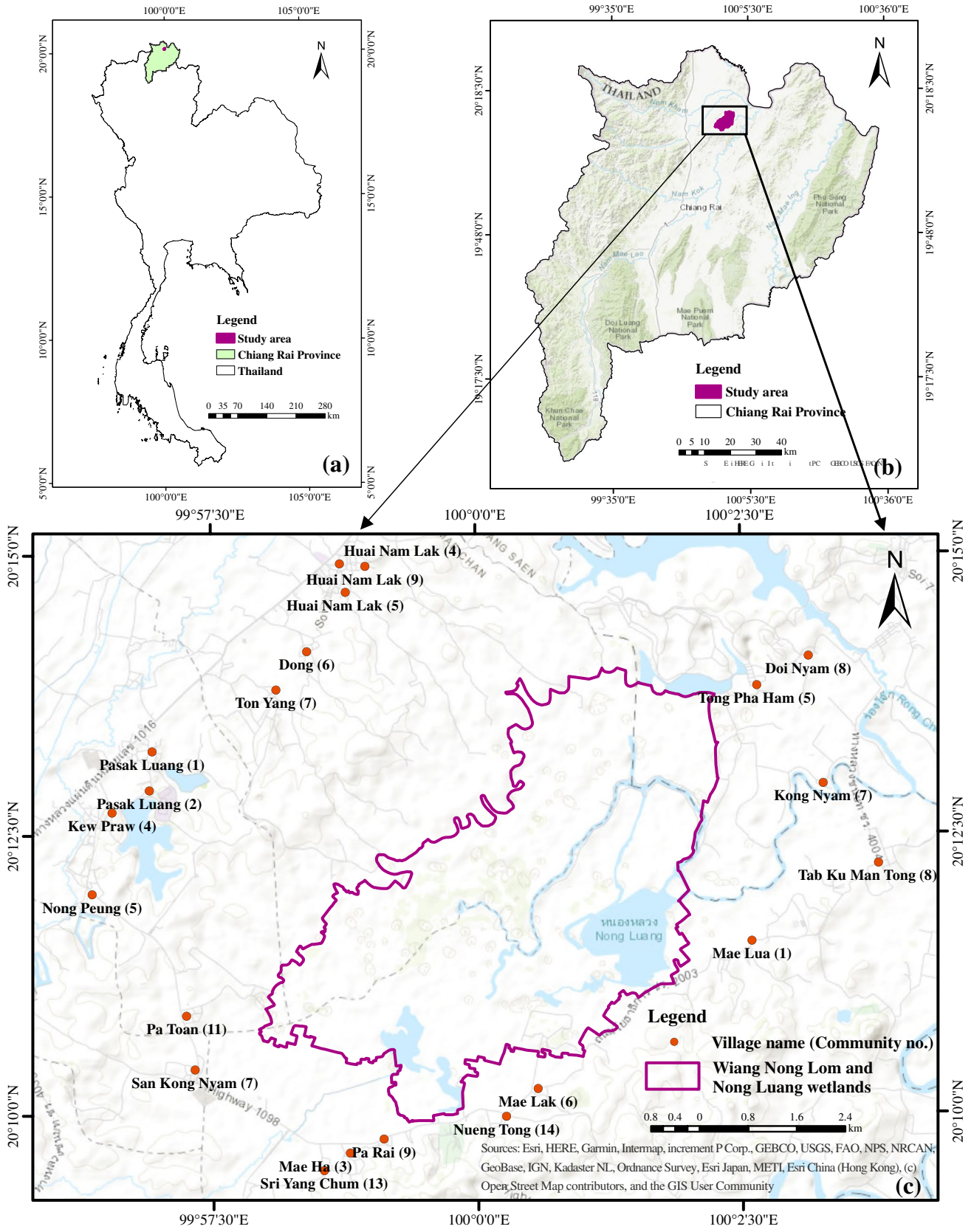

Fig. 1 Map of Thailand showing Chiang Rai Province (**a**) and the study area (**b**). The villages surrounding the Wiang Nong Lom and Nong Luang wetlands in the Chiang Saen Valley of Chiang Rai Province in Northern Thailand (**c**)

upon as a food source, as fisheries, for water storage and daily water supply, for agricultural purposes, as fish ponds, and for serving as grazing areas (Pingmoung et al. 2004; TISTR 2011a, b). These wetlands also encompass the most expansive grazing area in the North of Thailand (Phuwanatwichit and Srirat 2014).

Methods

Conceptual framework

The Convention on Biological Diversity (CBD) is an international legally binding treaty that balances the three key objectives of achieving environmental sustainability, economic prosperity, and social well-being (Convention on Biological Diversity 2003; Maltby 2006). The global CBD is fundamentally based on this premise that considers the ecosystem approach (EA) as an integrated strategy for management of resources, thus offering the action framework under the CBD (Maltby 2006). Accordingly, this EA-based conceptual framework was applied in this study.

The flow chart diagram presented in Fig. 2 outlines the overall research approach of this study. A conceptual framework is built using variables described in the literature. The research problem statement serves as a reference for constructing this conceptual framework. The research instruments consist of questionnaire, surveys, and interviews used to obtain, measure, and analyze data. Key informants, group interviews, and one individual interview were conducted. Finally, the interview data was collected and analyzed and insights were drawn from the results to support policy.

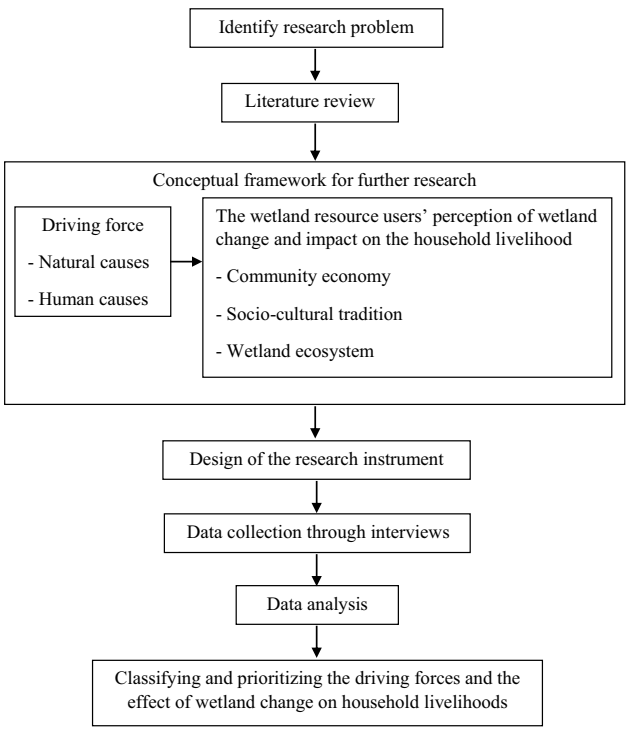

Fig. 2 Flow chart of research process

As can be seen in Fig. 2, the conceptual framework identifies the potential of driving forces of wetland degradation and loss and classifies the levels at which local people (wetland resource users) have experienced the wetland changes (particularly at the levels of community economy, socio-cultural tradition, and ecology of wetlands), as well as the impact of these changes on their livelihoods. Data collected by the users of wetland resources on wetland changes and their impact on household livelihoods (including driving forces generate a clear picture of how certain elements) are important and constitute the priorities of wetland management policies and planning.

There are three elements for consideration in this study, as described next.

The perception of wetland changes and their impact on livelihoods

We have designed questionnaires to effectively identify how the local communities perceived that they are affected by wetland changes. These questionnaires assessed three dimensions: community economy, socio-cultural tradition, and ecology. Community economy defined a set of economic practices that explicitly foreground community and environmental well-being. Community economy comprises data on wetland resources, the household economy, occupations, community employment, and the business investment of households (Rebelo et al. 2010; Lamsal et al. 2015). The socio-cultural tradition focuses on social interactions rather than individual characteristics through a process of communicating in groups, society, and cultures. Data was also collected on social, cultural, and traditional benefits. These benefits include resources for household subsistence, socially conscious wetland conservation and restoration efforts, sustainable livelihoods through conservation of wetland resources, and use of the wetlands for cultural events and religious activities (Baral and Heinen 2007; Chun et al. 2012; Lamsal et al. 2015). Additionally, the ecology of wetland ecosystems emphasizes the diversity of the hydrological and ecological functions of wetland. Services such as access to water, its quality, the wetlands' role in providing a natural habitat for aquatic animals, wildlife, fish, birds, wild animals, plants, and its role in promoting and developing wetland tourism were analyzed (Rebelo et al. 2010; Rahman et al. 2012; Lamsal et al. 2015; Vanessa et al. 2016).

Forces driving wetland changes

Driving forces on wetland ecosystems are someone or something that has the power to make things happen. The relationship between wetlands and human society has changed significantly overtime (MEA 2005). Since 1900, 50% of global wetlands have been altered or lost (Davidson 2014). Natural occurrences and human activities both impact wetland ecosystem functioning and services (Maltby 2006). Erosion and sedimentation are natural occurrences. Human activity can directly and indirectly contribute to the degradation and loss of wetlands. Primary direct forces include the development of infrastructure, conversion of land, withdrawal of water, pollution, overharvesting and overexploitation, expanding agricultural production, and the concomitant use of more fertilizer, invasive alien species, climate variability, and increased temperatures (MEA 2005; Gopal 2012).

Users of wetland resources

Many studies have applied an income- or other financial-based analysis and they have generally divided users into two groups: the first group consists of users who rely heavily on wetlands' contribution to their household income and as a stable food source, whereas the second group consists of users who access and use wetland resources but depend on the wetlands as their main source of food or income to a lesser degree than the first group. This second group generally includes farmers, those who are better educated, financially better off, and households who are members of a wetland conservation group (Lannas and Turpie 2009; Lamsal et al. 2015).

Based on the conceptual framework above, three hypotheses were introduced in this study, as discussed earlier:

(H1) Local people witnessed and experienced the degradation of ecological wetland changes as well as the generalized consequences and the negative impacts on their livelihoods (such as a reduction in the number of species and aquatic animal population as well as a decline in the amount of fodder that occurred during the relevant 30-year time frame).

(H2) The perceptions of intensive and non-intensive users regarding the impact of wetland changes on their livelihoods differ as do their opinions as to the causes of wetland change.

(H3) Respondents give high priority to the need to increase the diversity of species and the number of fish and aquatic animals for wetland management purposes.

Table 1 Sampled communities and corresponding sample sizes

Sub-district	No. of Communities	Total number of households	Household percentage	Number of households sampled
Chan Chawa	5	1620	30.0	133
Chan Chawa Tai	5	1781	33.0	144
Takhaopleuk	7	1576	29.2	129
Jomsawan	1	16	0.3	5
Yonok	3	404	7.5	37
Total	21	5397	100.0	448

Research design

Both quantitative and qualitative research approaches were implemented in this work. The household survey was a quantitative research approach that took the form of questionnaires and structured interviews. A context-specific quantitative approach was used to evaluate the perceptions of local residents regarding economic, socio-cultural traditional, and wetland ecological changes and their impact on livelihoods through an ecological approach. It also attempted to determine what people believe were the primary causes of those changes. The qualitative approach used structured interviews and semi-structured face-to-face interviews with key informant and groups interviewees. Participant observation was used in this study by living in the local communities to observe behavior, livelihoods, culture, events, and wetland-related activities. The study used methodological triangulation that facilitated data cross-validation based on the relevant data sources to develop a comprehensive understanding of the relationship between wetlands and livelihoods.

Sources of data

Primary data was collected by survey of households near the wetlands and by key informant and group interviews. The 27 key informants were community and municipal leaders, career group leaders, a local NGO leader, government agencies, senior monks, and a teacher who provided information helpful to understanding the general changes in the wetlands and the impact those changes have on livelihoods. Group interviews of community members were conducted to gather information about local knowledge, community and career group leaders, and wetland resource users.

Population, sample, and sampling

"Population" is defined as the number of households within a 4-km radius of the Chiang Saen Valley wetlands. A multistage sampling procedure was employed to identify sample

households for this study. There were 5397 households identified in 21 communities in 18 villages ("moo bahn") within the administrative boundaries of 5 sub-districts (Table 1). This list served as the framework for a stratified random sampling. To get a sample size from the community population, the Taro Yamane formula was applied at a 95% confidence level and a margin of error of 5% (Yamane 1973). The sample size of the study was 372 households. However, in order to reduce sampling error, it was decided that the subject households of this study would be increased to 448. In each community, households were purposively chosen; specifically, those households chosen that access and used wetland resources and live around wetlands, whereas the selected household representatives were an adult and the most senior members of the households who could provide sound information regarding their utilization of wetland resources and informed perceptions regarding the wetland changes that occurred between 1988 and 2017. The survey was conducted during the months of April and July of 2017.

Wetland resource users are divided into two groups (Lannas and Turpie 2009; Lamsal et al. 2015): (1) intensive users who accessed and utilized wetland resources at least once a week and (2) non-intensive users who accessed and used wetland resources less than once a week. Utilization took the form of fishing, use for agriculture, edible plant collection, use of fodder, collection of fuelwood, and use of other natural materials in the household (Lannas and Turpie 2009; Lamsal et al. 2015).

Research instrument

The household questionnaire was developed and used to collect the necessary information. In this respect, scale validity and reliability are important issues, i.e., the items should measure what it is supposed to measure in the content domain and according to the objective of the scale. The validity of the questionnaire was established using a panel of experts and a test questionnaire to determine scale reliability. The Cronbach's alpha was used to assess the reliability of the tests (Cronbach 1970). The Cronbach's alpha values ranged from 0.77 to 0.97, which was greater than the recommended level of 0.7 (Bates and Clark 2019). Close-ended questions with a Likert-scale were asked. Three main areas of opinion regarding wetland change were explored:

(1) The causes of wetland change which could be assessed as having an impact ranging from level 1 (very low) to level 5 (very high)
(2) Seven degrees of change in the community economy, socio-cultural tradition, and ecology on services or resources of the wetlands ranging from "−3" (significant decrease) to "3" (significant increase) with a midland "0" meaning "no change"
(3) The degree of impact on the household livelihood from "0" (no impact) and 1 (very low) to 5 (very high).

Data analysis

The statistical analysis of the household survey included (i) descriptive statistics of mean, standard deviation, and frequency; (ii) statistical tests (*t*-tests) were used to test the hypotheses. An independent samples *t*-test was conducted to compare the perceptions and opinions concerning the impact of wetland changes and the opinion of intensive and non-intensive users regarding the primary causes (the natural causes and the human causes) of wetland change. The importance-performance analysis (IPA) has been widely used to examine the relationship between importance and performance (Obonyo et al. 2013; Deng and Pierskalla 2018). Importance and performance ratings are displayed on a two-dimensional grid, and fall into one of four quadrants (Wong et al. 2011; Obonyo et al. 2013). Attributes located in Quadrant I represent key areas whose improvement need to be given top priority. Quadrant II represents attributes that need to maintain the same performance levels to sustain organizational growth. Not all attributes that fall into Quadrant III are important and pose no threat to the organizations. Quadrant IV rates both performance and importance of attributes as low. Therefore, management needs not to take further action on those attributes. Therefore, the IPA was applied (Wong et al. 2011; Obonyo et al. 2013; Deng and Pierskalla 2018) to classify the levels of changes in wetlands and their impact on local livelihoods. The frequencies of respondents who indicated the specified levels of changes in wetlands and the levels of their impact on local livelihoods were used to determine the position of the crosshairs in the importance-performance grid and the priority implication of each quadrant. Quadrant I itemizes changes with negative (non-beneficial) increases in the wetland ecosystem, the community economy, and socio-cultural traditions change that had a high impact on livelihoods. Attributes located in Quadrant II are rated a decrease in the level of changes and a high impact on the livelihoods. Quadrant III represented an increase in the level of changes and a low impact on livelihoods. Quadrant IV denoted a decrease in the level of changes and a low impact on livelihoods. Content analysis (Morgan 1988) was used to analyze the key informant survey and group interviews data.

Results

Household socio-economic demographics

The respondents were 58.5% male. Their ages ranged from 21 to 82 years old ($M = 53.5$, $SD = 10.7$). Overall, 63.8% of

the respondents attended primary school and 13.6% had no formal education. The results showed the most commonly reported occupations were farmer (57.4%) and laborer (26.8%). Of the respondent households, 38.8% reported gross monthly income of US$163–325/month, and 29.7% earned less than US$163/month. The majority of households (52.9%) had monthly expenses of US$163–325/month. The interviewed households averaged about 0.85 hectares of land holdings and about 0.24 ha of wetland area holdings.

Forces driving wetland changes

The surveyed households believed that both natural occurrences (58.2%) and human activity (60.2%) can cause changes in wetlands. Sedimentation is the main natural cause of damage to wetlands according to the highest percentage of total respondents (62.2%). The primary human activities that cause damage to wetlands are the use of advanced science and technology, particularly agricultural technology such as tractors, crawler backhoes, and water pumping machines (81.9%), and an increase in invasive species such as giant sensitive plants (*Mimosa pigra*) and golden apple snails (67.1%). Additionally, 64.4% of respondents believed that climate change and climate variations also had a high impact on wetlands. However, this study showed that economic growth did not have a high impact on wetlands. Production-related economic growth is related to the production of goods and services such as growing cash crops, land use changes, soil and water pollutants, a large number of wetland resource users, land owned by private investors and outsiders, wetland encroachment, and deforestation. Construction-related economic growth is related to wetlands being converted by drainage and dredging for agricultural purposes and infrastructure development (Table 2). It was found that construction-related economic growth also did not have a significant impact on wetlands compared to other reported causes of wetland degradation.

Changes and the impact of those changes on household livelihoods

More than 90% of respondents agreed that changes occurred in the community economy, the socio-cultural tradition, and ecology of the wetlands in the previous 30 years. More than 85% of respondents reported that their livelihoods had been affected by those changes. Of the respondents, 94.2% reported that the ecology of the wetlands changed; most (55.1%) of the respondents indicated that the change manifested itself as a decrease in ecosystem productivity (Table 3). This is because the majority of local people were dependent directly on wetland resources.

Table 2 Combined percentage of responses indicating opinion that the causes of wetland change in the last 30 years were "high" or "very high"

Possible causes of wetland change	Opinion as to the causes of wetland change as 'high' and 'very high' combined %
1. Natural causes	58.2
• Sedimentation	62.2
• Soil erosion	54.1
2. Human activities	60.2
• Advanced science and technology	81.9
• Invasive alien species	67.1
• Climate change	64.4
• Population growth	55.7
• Wetland management	55.0
• Economic growth – Production	52.1
• Economic growth – Construction	44.7

Table 3 Perspectives as to changes and the level of impact of those changes

	Respondents (%)					
	Nature of change			Level of impact on the household livelihood		
	Decrease	Increase	Total	Low	High	Total
1. Community economy	28.1	63.0	91.1	70.5	15.0	85.5
2. Socio-cultural tradition	8.7	84.4	93.1	64.7	21.4	86.2
3. Ecosystem	55.1	39.1	94.2	66.3	18.8	85.0

Changes in community economy

The vast majority of respondents (nearly 73%) reported a change in fishery and livestock grazing areas, and in the regularity in purchase of land in villages and around wetlands by investors (50.9% noted this change as a decline, and 48.7% said that this had a high impact on their livelihood). Similarly, 57.8% reported an increase in the purchase of land by private investors which 44.4% of the respondents indicated had a high impact on their livelihoods. These private investors purchased villagers' land to cultivate cash crops such as rice, para rubber, and palm oil leading to agricultural expansion and encroachment onto the wetlands. Of the 64.1% reporting changes in the conflict in wetland resource allocation, 49.3% of the respondents reported an increase in conflicts and 41.6% said that this had a high impact on their livelihood (Table 4).

Changes in socio-cultural tradition

The majority of the sampled households (77%) perceived substantial change in community development activities (such as construction, reconstruction, rehabilitation or installation of housing and buildings, public facilities, and improvements); 75.9% of respondents indicated a change in the number of immigrant workers in the community with 67% indicating that the number of immigrants increased. Directly competing with local people for jobs, the influx of immigrants adversely affected the locals and 46.7% of the households indicated this had a high impact on their

Table 4 Perspectives on changes and the level of impact of those changes 1988–2017

	Respondents (%)					
	Nature of change			Level of impact on the household livelihood		
	Decrease	Increase	No change	Low	Medium	High
1. Community economy						
1.1 Areas of fisheries and grazing livestock	50.9	21.7	27.4	18.0	22.4	48.7
1.2 Private investors buy lands in villages or areas around wetlands	14.7	57.8	27.5	15.8	30.1	44.4
1.3 Community employment	32.4	36.2	31.4	21.0	30.9	26.5
1.4 Land price and purchase land for profit	14.5	53.4	32.1	19.7	32.2	34.3
1.5 Income can be derived from wetlands	39.5	27.9	32.6	31.2	31.2	16.0
1.6 Income disparity and inequality of households	19.6	46.4	34.0	15.9	44.7	31.3
1.7 Conflict in wetland resource allocation	14.7	49.3	36.0	11.8	34.4	41.6
1.8 Public utilities in the community	17.4	44.6	38.0	14.5	36.0	31.0
1.9 Occupational diversity in community	17.6	43.3	39.1	24.7	27.8	29.4
2. Socio-cultural tradition						
2.1 Community development activities	7.4	69.6	23.0	16.4	30.8	36.9
2.2 Immigrant workers have a higher inflow in community	8.9	67.0	24.1	15.0	29.7	46.7
2.3 Wetland conservation and restoration with a social consciousness and awareness	8.7	64.7	26.6	17.2	30.7	34.8
2.4 The wetlands are used for household subsistence	15.6	57.6	26.8	12.4	31.0	39.5
3. Ecosystem						
3.1 Species and number of birds, wild animals	48.9	36.8	14.3	22.8	37.4	30.1
3.2 Species and number of fish, aquatic animals	46.9	33.0	20.1	21.4	24.3	44.8
3.3 Natural habitat for aquatic animals, wildlife	51.1	28.6	20.3	18.8	34.1	34.1
3.4 The diversity and abundance of wild food plants	51.1	23.4	25.5	21.8	32.8	37.1
3.5 Poor water quality because of additional nutrients and/or pollutants	22.5	50.5	27.0	14.6	17.7	57.5
3.6 The size of wetland	42.2	29.9	27.9	16.4	31.8	34.4
3.7 Species and number of lotus plant	46.9	25.0	28.1	27.1	32.9	29.1
3.8 Amount of fuel wood and raw materials used for handcrafts such as bamboos, reeds	55.1	15.2	29.7	24.7	29.6	30.4
3.9 Water level in marshes, swamps, rivers in wetlands	42.4	27.2	30.4	20.5	37.4	27.9
3.10 An amount of fodder	50.9	18.5	30.6	25.4	26.3	34.7
3.11 Promoting and developing wetland tourism	15.2	53.4	31.4	26.5	36.8	14.7
3.12 Water scarcity-problem of not enough water for crops and fisheries	41.1	24.8	34.1	21.7	28.8	32.1

livelihood. The wetlands were used more for household subsistence according to 57.6% of the households of which 39.5% indicated that this had a "high" impact on their livelihoods (Table 4).

Changes in wetland ecosystem

The sum and substance of the changes reported by the households reflects overall wetland degradation. Respondents reported that the number of birds and wild animals in the wetlands was altered (85.7% of respondents) with a decrease of 48.9%; the number of species and fish and aquatic animal population were affected (79.9%), there were changes in the natural habitat of aquatic animals and wildlife (79.7%). Respondents reported that all of these changes were negative as 48.9% (number of birds and wild animals), 46.9% (species and number of fish, aquatic animals), 51.1% (natural habitat for aquatic animals, wildlife), and 51.1% (the diversity and abundance of wild food plants, including fruits, vegetables) of the respondents reported a decline in each (Table 4).

Nearly 45% of respondents indicated that the decline in the species and number of fish and other aquatic animals had a "high" impact on rural livelihoods. The decline in diversity and abundance of wild food plants was considered to have a "high" impact by 37.1% of the respondents (Table 4). These results indicated that local people depend more on fish, aquatic animals, and wild food plants than on birds and wild animals.

Additional nutrients and/or pollutants entering the water supply from non-point sources was very concerning to the respondents as 50.5% believed that this would result in an increase in the poor water quality problem and 57.5% reported that this had a "high" impact on their livelihoods (Table 4). They were concerned about the effects of the extensive use of agrochemicals in pineapple plantations and their flow into wetland areas (Fig. 3).

Classifying the effects of wetland changes on household livelihoods

The result of applying IPA was to classify the levels of the effect of wetland changes on rural livelihoods. The IPA grid describes levels of wetland change in the community economy, socio-cultural tradition, and wetland ecology and the level of impact on the household livelihood. The grid consists of four quadrants; only negative impacts on livelihoods are displayed in Fig. 2.

The attributes of the changes placed in Quadrant I are (1) the highest increase in the levels of changes and (2) the highest impact on livelihoods. Improving upon the items that fall into this quadrant is a top priority. This study concludes

Fig. 3 Classification of changes in wetland and the impacts on the household livelihood attributes

		Level of impact on the household livelihood	
		High	Low
The changes in the community economy, socio-cultural tradition, and wetland ecology	Increase	Quadrant I: The highest increase in the levels of change and the highest impact on livelihoods. i. Poor water quality ii. Influx of immigrant workers into the community iii. The purchase of land in the villages or areas around wetlands by private investors iv. Conflict in wetland resource allocation v. Use of wetlands for household subsistence vi. Land price and the purchase of land for profit	Quadrant III: An increase in the level of change and a low impact on livelihoods. i. Income disparity and inequality of households
	Decrease	Quadrant II: A decrease in the level of changes and a high impact on the livelihoods. i. Areas for fisheries and livestock grazing ii. Species and number of fish, aquatic animals iii. The diversity and abundance of wild food plants iv. The amount of fodder v. The size of wetland vi. The amount of fuel wood and raw materials used for handcrafts vii. Natural habitat for aquatic animals, wildlife	Quadrant IV: A decrease in the level of changes and a low impact on livelihoods. i. Species and number of birds, wild animals ii. Water level in marshes, swamps, rivers in wetlands iii. Species and number of lotus plants iv. Water scarcity-problem of not enough water for crops and fisheries v. Income can be derived from wetlands

that these are key areas that policy makers and environment agencies should pay attention to urgently. The problems of poor water quality, influx of immigrant workers, private investors buying land in villages and areas around the wetlands, the conflict in wetland resource allocation, the use of wetlands for household subsistence, the price of land, and purchase of land for profit were identified as of local concern. As these issues are of local concern and can affect the local residents, the residents should be involved in the problem-solving and decision-making processes.

Quadrant II lists ecosystem changes that decreased and had a high impact on the livelihoods. The decrease in the areas for fisheries and for livestock grazing, the nature of the species and number of fish and aquatic animals, the diversity and abundance of wild food plants, the amount of fodder, the size of wetland, the amount of fuel wood and raw materials, and the damage to the natural habitat for aquatic animals and wildlife are key issues to be monitored. It is recommended that such wetland monitoring needs to provide some focus on these items because they are more likely to further decrease. Without action, livelihoods will be adversely affected.

Quadrant III lists items with a high increase in the level of ecosystem changes that had a low impact on livelihoods.

Quadrant IV itemizes changes in the ecosystem and community economy with a slight decrease that had a low impact on livelihoods. Although these items did not have a significant effect on livelihoods, it is recommended that local governments and environmental agencies should be aware of the negative impact. They can have serious consequences in the near future due to the cumulative effects over time.

Differences in perceptions of wetland users

The study found that 48.7% of the respondents were intensive users and 51.3% were non-intensive users. There was a significant difference in the perceptions regarding (i) the impact of changes in community economy of intensive users ($M = 3.59$, $SD = 1.30$) and non-intensive users ($M = 3.34$, $SD = 1.34$); $t(446) = -1.989$, $P = 0.047$ and (ii) the impact of changes in the wetland ecosystem of intensive users ($M = 3.83$, $SD = 2.05$) and non-intensive users ($M = 3.37$, $SD = 1.65$); $t(446) = -2.624$, $P = 0.009$. However, no evidence exists that the impact of changes in the socio-cultural tradition has an effect on the perceptions of intensive users ($M = 3.71$, $SD = 1.76$) and non-intensive users ($M = 3.66$, $SD = 2.86$); $t(446) = -0.241$, $P = 0.809$.

This study found evidence that the opinions of intensive users ($M = 3.56$, $SD = 0.56$) and non-intensive users ($M = 3.35$, $SD = 0.69$); $t(445) = -3.516$, $P = 0.000$ differ as to the human causes of wetland changes. On the contrary, there was no significant difference in perspective regarding the natural causes of wetland changes between intensive users ($M = 3.55$, $SD = 0.78$) and non-intensive users ($M = 3.40$, $SD = 1.07$); $t(445) = -1.642$, $P = 0.101$.

Discussion

Forces driving wetland changes

The findings of this study reflect that local residents indicated concerns about the increase in the use of advanced science and technology as it was reported as the primary force driving wetland change. The use of modern technology, particularly advanced agricultural equipment (e.g., tractors, crawler backhoes, water pumping machines), contributed to the reduction in time and labor costs and contributed to the yield growth that underpinned the increase in agricultural production. This increased production also led to a conversion of wetlands to rice cultivation fields and to a higher demand on wetland water. It is clear that wetlands near agricultural lands are at risk and have suffered losses because of expanding cultivation and concomitant encroachment. An easily defensible argument could be made that this is linked to governmental agricultural policy. This is in line with previous studies (Dawe 2010) in which it was reported that since 1986, the Thai government attempted to improve technology, rural infrastructure, and facilities in efforts specifically focused on raising agricultural productivity. Hence, more people turned to raising cash crops. As the respondents have suggested, the expansion of cash crop production in the Chiang Saen Valley has influenced wetland changes. Cash crop price incentives for the production of rice, para rubber, palm oil, pineapple cultivation, and farm ponds provided by the government since 2003 has led to land use changes inside and outside wetlands. This has had a significant impact and has resulted in encroachment upon wetland areas.

Invasive alien species such as the golden apple snails and giant sensitive trees have regularly been found in the wetlands. Giant sensitive plant (*Mimosa pigra*) is an invasive prickly shrub originating from tropical America that can grow very well spread throughout large areas of Thailand (Lonsdale 1988). Local people reported that these alien species destroy the habitat of other indigenous plants and animals. This is clearly in line with the evidence that the greatest threat to biodiversity is directly related to the loss of habitat. Other wetland studies have generated similar findings (Richardson and van Wilgen 2004; Holmes et al. 2012).

Wetlands appear to be vulnerable to agricultural activities and climatic variability. They play a critical role as a source of water storage, especially during the summer season. Irrigated rice cultivation, orchards, and grazing animals depend directly on wetlands where many local people (nearly 61%) face water scarcity problems, i.e., not enough water exists

for their crops and fisheries. In particular, the wetlands suffered from extreme drought in 2015, which affected rice yields and caused a decline in fodder for buffalo and cattle, accordingly, led to changes in resource allocations. Of the respondents, 49.3% reported an increase in conflicts concerning wetland resource allocation that had a high impact of their livelihood (41.6%). Conflicts with surrounding land use in terms of water level and water quality often hamper wetland restoration and biodiversity conservation projects (Decleer et al. 2016). The findings are directly in line with previous findings that climate change is related to land use change, as both significantly affect wetland productivity (Gell et al. 2012; Rashford et al. 2015; Sutcliffe et al. 2016) particularly, the impact of climate change on wetland farming operation has affected a significant proportion of local communities and poor farmers whose livelihoods depend on subsistence and small-scale farming operation (Emmanuel and Gabriel 2021).

Changes and their impact on household livelihoods

Our findings confirm that local people (more than 90%) experienced wetland changes and other events that have impacted their livelihoods (more than 85%), such as a reduction in the number of species and aquatic animal population as well as a decline in the amount of fodder during the time frame, which is consistent with earlier findings (Lamsal et al. 2015; Vanessa et al. 2016). Notice that the entire livelihood of many households depends on what the wetland ecosystem provides.

According to the IPA concept and the main research question ("How can governments determine policy and ascertain priorities in order to motivate people to participate in wetland restoration and management?"), we suggested that high priority should be given to the increase of the species and number of fish and aquatic animals for wetland management purposes. Nevertheless, our results showed that improving poor water quality is often a top wetland management priority. The respondents (50.5%) believed that soil and water pollutants impacted wetlands. These took the form of additional sediment, nutrients and other pollutants entering from non-point sources. They feared the effects of the overuse of chemical fertilizers and pesticides in agriculture and their eventual flow into wetland areas. The resulting change in wetland water quality negatively impacted their livelihoods. Nearly 60% of the respondents said the decreased water quality had a high impact on their livelihoods. It is clear that monitoring water quality is essential for the wetland ecosystem and human health. Our results concur with earlier studies (Kleppel et al. 2004; Delgado et al. 2009). Land use changes appear to strongly influence water quality and ecosystem function (Kleppel et al. 2004). Regarding the community surrounding the wetland, 93% of individuals perceived that the wetland had suffered significant changes in turbid water flows that are clearly visible (Delgado et al. 2009).

Many cultures have lived and depended on wetlands (Mitsch and Gosselink 2007) resulting in a diverse make-up of immigrants and ethnicity in the communities (Lamsal et al. 2015). This study found that local residents and key informant and group interviewees raised concerns about the purchase of lands in villages and in areas around wetlands by private investors. This resulted in the encroachment onto the wetlands to create new agricultural areas. In some areas, the private investors allowed farmers to rent out their land. These factors led to nearly 60% of the respondents reporting an increase in the purchase of land for profit and eventual higher land prices. Private investment to grow and cultivate rice, para rubber, palm oil, and pineapples flowed into the Chiang Saen Valley agribusiness sector. Immigrants and/or local resident laborers were hired to harvest the crops. Respondents reported that the influx of immigrant labor had a high impact on livelihoods because they competed directly with local people for jobs. In relation to wetlands, this is a concerning and complicated economic problem in the Chiang Saen Valley.

As a result of wetland degradation, local people were forced to consider and pursue alternate livelihood measures such as raising water crops (i.e., water morning glory, water mimosa, lotus plants), fish, chickens, individual household crop farming for household consumption, making handicrafts, and non-farm day labor. In relation to the purchase of lands by private investors and the encroachment onto the wetlands to create new agricultural areas, at the Yonok subdistrict boundaries located near the wetlands, the local governments designated lands for landless households (about 0.04–0.32 ha per household; Hempattarasuwan et al. 2019) for agricultural use, such as fish ponds and rice cultivation that alleviate the effects of problems of landlessness and food production.

Household utilization of wetland resources

There was a significant difference in the perceptions regarding the impact of changes in community economy and ecosystem between intensive and non-intensive users, with a 95% confidence interval. The intensive users perceived a higher impact on their livelihoods than non-intensive users of changes in the community economy and ecosystem. However, there was no significant difference in the perception of the impact caused by changes in socio-cultural tradition on livelihoods. Yet, there was significant difference in the opinions as to the human causes of wetland changes between these two user groups. These findings are in accordance with other studies (Boafo et al. 2014). Ninety percent of the households collected and used fuelwood, fodder, and forage

and wild plants. Most women perceived the declining supply and scarcity over the last 15–30 years as the result of commercial charcoal production and poverty (Boafo et al. 2014).

The findings of this study confirm that wetland resources were economically important and provided a valuable component to the livelihood of the local residents, especially low-income households. Other studies have generated similar findings (Lamsal et al. 2015; Vanessa et al. 2016). These findings confirm that the difference in the dependency on wetland resources can have a significant impact on the opinions and perspectives as to the causes of wetland change and as to the degree of impact on the livelihoods of local residents of the changes in the community economy and the ecology. In sum, these findings could improve the understanding of overall notions and approach concerning the economic value of wetlands, while, at the same time raising awareness and aid decision-making.

The methodological approach of this work may be valuable in the study of wetland areas. Differences in cultural, social, economic, and ecological/environmental aspects should be taken into consideration when applying this approach for wetland restoration purposes. In this setting, our approach provides a starting point for future research concerning the implementation of the analytic hierarchy process (AHP) approach to organize and analyze complex decisions on wetland development and use.

Conclusions

This paper investigated the classification of the levels of changes in wetlands and their impact on local livelihoods. Primary data and key informant survey, group interviews, descriptive statistics, and statistical test were used to this study. IPA was applied and it generated a clear picture of how certain study elements can be important priorities in wetland management policies and planning.

Our findings indicated that the application of advanced science and technology, particularly agricultural technology, such as tractors, crawler backhoes, and water pumping machines, was the most impactful cause of wetland change. Other significant causes such as the introduction of invasive species and climate change and variability had a high impact on the wetland ecosystems.

The wetland ecology experienced the highest level of change, most notably a reduction in productivity. Changes in the water quality, the nature of the inhabiting species and the number of fish and aquatic animals in the wetlands were characterized as having a high impact on livelihoods. Impacting livelihoods to a lesser degree were the decline in the diversity and abundance of wild food plants. The purchase of village land and land near the wetlands by private investors resulting in an influx of immigrant workers, a decline in fishery and livestock grazing areas, and the conflict in wetland resource allocation were found be the most impactful on community livelihoods. Therefore, the selected land use policy, relevant regulation, and/or legislation are critical components of any effort to achieve wetland sustainability.

The information provided by this research is urgently needed moving forward. The problems of water quality, the influx of immigrant workers, private investors buying nearby land, the ongoing conflict in wetland resource allocation, wetlands use for household subsistence, land prices, and purchasing land for profit were identified as issues of local concern. Impacting and interesting to the local people, these problems should be addressed by involving the local people in the problem-solving and decision-making process.

The IPA provides useful insights that future emphasis should be placed on monitoring the reduction of fisheries and livestock grazing areas, the impact on species and the number of fish and aquatic animals, the diversity and abundance of wild food plants, the amount of available fodder, the size of wetlands, the amount of fuel wood and raw materials, and the natural habitat for aquatic animals and wildlife. As government and environmental agencies will continue monitoring these events very closely, it is critical to be able to assess the existing status and quality of remaining wetlands for ongoing comparison and monitoring.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10113-021-01842-7.

Acknowledgements We would like to thank each of the 21 communities that were involved to varying degrees in this study and the Thai government agencies that provided research information. The authors are very grateful to the editor and the reviewers for their constructive comments.

Funding This work was supported in part by APN-Asia-Pacific Network for Global Change Research (ARCP2015-06CMY-Wu).

References

Baral N, Heinen JT (2007) Decentralization and people's participation in conservation: a comparative study from the Western Terai of Nepal. Int J Sust Dev World 14(5):520–531. https://doi.org/10.1080/13504500709469751

Bates TA, Clark PC (2019) Reliability and validity of the simulation learning effectiveness inventory. J Prof Nurs. https://doi.org/10.1016/j.profnurs.2019.04.007

Bhatta LD, Chaudhary S, Pandit A, Baral H, Das PJ et al (2016) Ecosystem service changes and livelihood impacts in the Maguri-Motapung wetlands of Assam, India. Land 5(15). doi:https://doi.org/10.3390/land5020015

Boafo YA, Saito O, Takeuchi K (2014) Provisioning ecosystem services in rural savanna landscapes of Northern Ghana: an assessment of supply, utilization, and drivers of change. J Disaster Res 9(4):501–515. https://doi.org/10.20965/jdr.2014.p0501

CBD (2003) Ecosystem approach: further elaboration, guidelines for implementation and relationship with sustainable forest management. (UNEP/CBD/SBSTTA/9/INF14) UNEP, Montreal

Chan KMA, Guerry AD, Balvanera P, Klain S, Satterfield T et al (2012) Where are cultural and social in ecosystem services? A framework for constructive engagement. BioScience 62(8):744–756. https://doi.org/10.1525/bio.2012.62.8.7

Chun MH, Sulaimam WNA, Samah MAA (2012) A case study on public participation for the conservation of a tropical urban river. Pol J Environ Stud 21(4):821–829. http://www.pjoes.com/A-Case-Study-on-Public-Participation-r-nfor-the-Conservation-of-a-Tropical-Urban,88812,0,2.html

Cronbach LJ (1970) Essentials of psychological testing. Harper & Row, New York

Das S, Behera B, Mishra A (2015) Determinants of household use of wetland resources in West Bengal, India. Wetl Ecol Manag 23(5):803–816. https://doi.org/10.1007/s11273-015-9420-8

Davidson NC (2014) How much wetland has the world lost? Long-term and recent trends in global wetland area. Mar Freshwater Res 65(10):934–941. https://doi.org/10.1071/mf14173

Dawe D (2010) Rice crisis: markets, policies and food security. Earthscan Press with FAO, London

Decleer K, Wouters J, Jacobs S, Staes J, Spanhove T et al (2016) Mapping wetland loss and restoration potential in Flanders (Belgium): an ecosystem service perspective. Ecol Soc 21(4):46. https://doi.org/10.5751/ES-08964-210446

Delgado LE, Martin VH, Bachmann PL, Torres-Gomez M (2009) Conceptual models for ecosystem management through the participation of local social actors: the Rio Cruces wetland conflict. Ecol Soc 14(1):50. https://doi.org/10.5751/ES-02874-140150

Deng J, Pierskalla C (2018) Linking Importance–Performance Analysis, Satisfaction, and loyalty: a study of Savannah, GA. Sustainability 10(3):704. https://doi.org/10.3390/su10030704

Emmanuel MA, Gabriel SU (2021) The practical challenges of achieving sustainable wetland agriculture in Nigeria's Cross River basin. Water Int 46(1):83–97. https://doi.org/10.1080/02508060.2020.1863698

Gell P, Mills K, Grundell R (2012) A legacy of climate and catchment change: the real challenge for wetland management. Hydrobiologia 708(1):133–144. https://doi.org/10.1007/s10750-012-1163-4

Gopal B (2012) Future of wetlands in tropical and subtropical Asia, especially in the face of climate change. Aquat Sci 75(1):39–61. https://doi.org/10.1007/s00027-011-0247-y

Hempattarasuwan N, Christakos G, Wu J (2019) Changes of Wiang Nong Lom and Nong Luang Wetlands in Chiang Saen Valley (Chiang Rai Province, Thailand) during the period 1988-2017. IEEE J Sel Top Appl Earth Obs Remote Sens 12(12):1–15. https://doi.org/10.1109/JSTARS.2019.2937949

Holmes PM, Rebelo AG, Dorse C, Wood J (2012) Can Cape Town's unique biodiversity be saved? Balancing conservation imperatives and development needs. Ecol Soc 17(2):28. https://doi.org/10.5751/es-04552-170228

Keddy PA, Fraser LH, Solomeshch AL, Junk WJ, Campbell DR et al (2009) Wet and wonderful: the world's largest wetlands are conservation priorities. BioScience 59(1):39–51. https://doi.org/10.1525/bio.2009.59.1.8

Kipkemboi J, van Dam AA, Ikiara MM, Denny P (2007) Integration of smallholder wetland aquaculture–agriculture systems (fingerponds) into riparian farming systems on the shores of Lake Victoria,Kenya: socio-economics and livelihoods. Geogr J 173(3):257–272. https://doi.org/10.1111/j.1475-4959.2007.00246.x

Kleppel GS, Madewell SA, Hazzard SE (2004) Responses of emergent marsh wetlands in upstate New York to variations in urban typology. Ecol Soc 9(5):1. http://www.ecologyandsociety.org/vol9/iss5/art1/

Lamsal P, Pant KP, Kumar L, Atreya K (2015) Sustainable livelihoods through conservation of wetland resources: a case of economic benefits from Ghodaghodi Lake, western Nepal. Ecol Soc 20(1):10. https://doi.org/10.5751/es-07172-200110

Lannas KSM, Turpie JK (2009) Valuing the provisioning services of wetlands: contrasting a rural wetland in Lesotho with a peri-urban wetland in South Africa. Ecol Soc 14(2):18 http://www.ecologyandsociety.org/vol14/iss2/art18/

Lonsdale WM (1988) Litterfall in an Australia population of *Mimosa pigra*, and invasive tropical shrub. J Trop Ecol 4(4):381–392. https://doi.org/10.1017/S0266467400003035

Maltby E (2006) Wetland conservation and management: questions for science and society in applying the ecosystem approach. In: Bobbink R, Beltman B, JTA V, Whigham DF (eds) Wetlands: functioning, biodiversity conservation, and restoration. Springer, Heidelberg

MEA (2005) Ecosystems and human well-being: wetlands and water synthesis. World Resources Institute, Washington, DC

Mitsch WJ, Gosselink JG (2007) Wetlands. John Wiley and Sons, Hoboken

Morgan DL (1988) Focus group as qualitative research. Sage Publications, London

Mwakubo SM, Obare GA (2009) Vulnerability, livelihood assets and institutional dynamics in the management of wetlands in Lake Victoria watershed basin. Wetl Ecol Manag 17(6):613–626. https://doi.org/10.1007/s11273-009-9138-6

Nguyen HH, Dargusch P, Moss P, Tran DB (2016) A review of the drivers of 200 years of wetland degradation in the Mekong Delta of Vietnam. Reg Environ Change 16(8):2303–2315. https://doi.org/10.1007/s10113-016-0941-3

Obonyo GO, Ayieko MA, Kambona OO (2013) An importance-performance analysis of food service attributes in gastro-tourism development in Western Tourist Circuit, Kenya. Tour Hosp Res 12(4):188–200. https://doi.org/10.1177/1467358413491132

ONEP (2004) Nong Bong Kai strategic wetland management plan. Office of Natural Resources and Environmental Policy and Planning, Bangkok

ONEP (2015) Master plan for integrated biodiversity management 2015-2021. Ministry of Natural Resources and Environment, Bangkok

Pardeck JT (1988) An ecological approach for social work practice. J Sociol Soc Welf 15(2):133–142. https://scholarworks.wmich.edu/jssw/vol15/iss2/11

Phuwanatwichit T, Srirat S (2014) Sustainable tourism planning and management preparing for the ASEAN Economic Community (AEC): Wiang Nong Lom wetland, Chiang Rai province. Chiang Mai Univ J Soc Sci Human 15(2):132–164. http://journal.human.cmu.ac.th/ojs/index.php/human/article/view/96

Pingmoung R, Kanpinyo P, Viyaka P, Kongsuwan D, Yaso T et al (2004) A biodiversity and environment study towards sustainable management at Wiang Nong Lom wetland. Chiang Rai Rajabhat Univ, Chiang Rai

Qin Y, Yang Z, Wei Yang W (2011) Ecological risk assessment for water scarcity in China's YellowRiver Delta Wetland. Stoch Environ Res Risk Assess 25:697–711. https://doi.org/10.1007/s00477-011-0479-3

Rahman M, Tazim MF, Dey SC, Azam AKMS, Islam MR (2012) Alternative livelihood options of fishermen of Nijhum Dwip under Hatiya Upazila of Noakhali District in Bangladesh. Asian J Rural Dev 2(2):24–31. https://doi.org/10.3923/ajrd.2012.24.31

Rashford BS, Adams RM, Wu J, Voldseth RA, Guntenspergen GR et al (2015) Impacts of climate change on land-use and wetland productivity in the Prairie Pothole Region of North America. Reg Environ Change 16(2):515–526. https://doi.org/10.1007/s10113-015-0768-3

Rebelo LM, McCartney MP, Finlayson CM (2010) Wetlands of Sub-Saharan Africa: distribution and contribution of agriculture to livelihoods. Wetl Ecol Manag 18:557–572. https://doi.org/10.1007/s11273-009-9142-x

Ricaurte LF, Wantzen KM, Agudelo E, Betancourt B, Jokela J (2014) Participatory rural appraisal of ecosystem services of wetlands in the Amazonian Piedmont of Colombia: elements for a sustainable management concept. Wetl Ecol Manag 22:343–361. https://doi.org/10.1007/s11273-013-9333-3

Richardson DM, van Wilgen BW (2004) Invasive alien plants in South Africa: how well do we understand the ecological impacts? S Afr J Sci 100:45–52. http://hdl.handle.net/10204/2088

Rodríguez JP, Beard TD Jr, Bennett EM, Cumming GS, Cork SJ et al (2006) Trade-offs across space, time, and ecosystem services. Ecol Soc 11(1):28. http://www.ecologyandsociety.org/vol11/iss1/art28/

Schuyt K, Brander L (2004) The economic values of the world's wetlands. World Wide Fund (WWF), Gland

Sutcliffe C, Dougill AJ, Quinn CH (2016) Evidence and perceptions of rainfall change in Malawi: do maize cultivar choices enhance climate change adaptation in sub-Saharan Africa? Reg Environ Change 16(4):1215–1224. https://doi.org/10.1007/s10113-015-0842-x

TISTR (2011a) The status of wetlands in Thailand: inland wetlands. Office of Natural Resources and Environmental Policy and Planning, Bangkok

TISTR (2011b) The status of wetlands in Thailand: Wiang Nong Lom wetland. Office of Natural Resources and Environmental Policy and Planning, Bangkok

TISTR (2015) Promoting efficient wetland management in Thailand. Office of Natural Resources and Environmental Policy and Planning, Bangkok

Trisurat Y (2006) Community-based wetland management in northern Thailand. Int J Environ Cult Econ Soc Sustain 2(1):49–62. https://doi.org/10.18848/1832-2077/CGP/v02i01/54189

Vanessa GR, Jiang Y, Irvine K (2016) Assessing the services of high mountain wetlands in tropical Andes: a case study of Caripe wetlands at Bolivian Altiplano. Ecosyst Serv 19:51–64. https://doi.org/10.1016/j.ecoser.2016.04.006

Wong MS, Hideki N, George P (2011) The use of importance-performance analysis (IPA) in evaluating Japan's e-government services. J Theor Appl Electron Commer Res 6(2):5–6. https://doi.org/10.4067/s0718-18762011000200003

Yamane T (1973) Statistics: an introductory analysis. Harper and Row, New York