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ENVIRONMENT

An overview and assessment of two wetlands in Eastern Thailand: Kung krabaen bay and welu wetlands in chanthaburi province

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Abstract

Climate change as occasioned by environmental degradation has led to innovative thought on how to preserve natural resources while also deriving benefits. Mangrove destruction, saline water intrusion, decline in fish stock and reduced livelihoods were factors that led to the establishment of Kung Krabaen Bay development study centre and the Welu wetland both in Chanthaburi province. The two wetlands provide important benefits to the people that live around it as well as tourists. Through the absorption and processing of wastes, these wetlands help maintain environmental quality and safety while also maintaining a biological balance of carbon IV oxide and other green house gases. Shrimp farm waste is treated in Kung Krabaen bay. A synthesis of Provisioning, Regulating, Cultural and Supportive benefits of the two wetlands is presented. Management regime involves integrated approach (Kung Krabaen Bay) and a co-management approach (Welu wetland). Direct and indirect drivers of change are analysed with management capacity to effectively manage these drivers being examined. The rational use of the resources provided by wetlands is a key factor in their conservation. Recovery from overexploitation may take time but these wetlands are showing resilience and there is need to improve management regimes via international cooperation.

Highlights

- Ramsar classification: KKW - Class I, WW between Class F and I.
- Functions: sustainability, conservation, recreation
- Strengthen management to ensure sustainability.

Keywords: Environmental, Kung Krabaen, Welu wetland, Resources, Management

Kung-Krabaen Wetland

Located in Chanthaburi Province on the East of Thailand, the Kung Krabaen wetland, is a bay with an estimated water surface area of about 15 x 106 m^2 and average depth of 1.85m measuring about 5 km in length and 3 km in breadth (Tookwinas 1998) with a single narrow water entrance of 656 meters (Hambrey *et al.*, 1999). It had served as a major source of livelihood for the people in the local community and even beyond with the bubble burst of shrimp farming which led to destruction of the mangrove forests to make way for shrimp farms as well as the reliance on the forest products by the locals. Serious environmental degradation followed the intensive shrimp culture activities as well as agricultural activities that thrived in the area.

It is a bay that has served the locals in many ways, but human destructive and exploitative tendencies towards the environment has rendered the bay almost worthless. The Kung Krabaen Bay Royal Development Study Centre (2011) reported several causes of degradation in the bay including over-exploitation of the fishery, clearing of mangroves, and inland salinization which rendered the resource users helpless and unproductive surprisingly due to their own activities. According to Sangrungruang *et al.*, (1999), shrimp farming activities led to accumulation of nutrient rich sediments along the bay with the resultant effect of an unsightly shore line.

The need for scientific based studies, research and initiation of development activities that are best suited for the coastal area of Chanthaburi, led to the establishment of the Kung Krabaen Royal Development Project in December 1981 (Royal Development Study Centre and the Philosophy of Sufficiency Economy 2004). Tookwinas (1998) pointed out that the centre aims to conserve the mangrove forest, address the problem of declining wild fish stock along the coastline, and stem the tide of salinization of agricultural land that all have negative impacts on the environment as well as livelihoods. The Kung Krabaen Development Study Centre is expected to cover the management of about 13,090 ha of land that comprises a central area of 640 ha and 8,559 ha around the central area with an extension to cover another 33 villages over an area of 3,891 ha.

Welu Wetlands

The Welu estuary which lies on the western coast of Chanthaburi Province, is characterized by a shallow, elongated and semi-enclosed water shed with a distance of about 20km between the river head and the mouth of the estuary (Limsakul 2007). The Welu wetland, an estuary, is essentially a carbon sequestration project with a Project Design Document (PDD) that was put together by the Japanese International Cooperation Agency (JICA) in association with the local government in Chanthaburi province. Fish farms and shrimp farms dominate the area which spans about 19,000 ha and is characterized by fragmentation and minute strips of natural mangrove forest (Steel 2010).

The area was gazetted as a forest reserve in October 1962 and was supposed to legally stop all economic and exploitative activities as well as anthropogenic habitation (Steel 2010). However, the mangrove forest was cut down for shrimp production between 1980 and 1990 (UN-REDD 2013). In its natural state, the Welu wetland comprises mangrove forested areas and untouched or virgin wetland (Steel 2010).

Shrimp farming activities have been indicted in this estuary for the loss of the mangrove forest due to conversion to shrimp farms. According to Hinrichsen (1998), the Chanthaburi Province lost about 90% of the areas dominated by mangroves to shrimp farms in just a space of two years, 1986 to 1988. About 95% of the forested area is covered by shrimp or fish ponds (TGO/JICA 2011).

The Welu Wetland Conservation Project is divided into nine areas: Office zone, Camping zone, Tourist centre, Broodstock zone, Fire fly zone, Water fall zone, Mangrove forest, Walk way, and Botany study zone.

Ecological Character of KKW and WW (Processes, Functions, Benefits and Values)

Kung-Krabaen Wetland

Tookwinas (1998) reported that water at the bay rises between 70 to 300 m from the substrate, but within the channels can vary between 0.6 to 1.5 m and is characterized by a fringe of mangrove forest in the inner parts that stretches for about 500 to 800 m from the land towards the edge of the sea and covering an area of about 160ha. Behind the mangrove fringe, are a large number of shrimp farms operating on a small scale with rice fields and fruit orchards littering the high lands that lie between the bay and hill while the uplands have a mixed forest character comprising orchards and rubber trees (Humbrey *et al.*, 1999). Essentially, it falls under class I (Intertidal forested wetland) of the Ramsar classification as well as class A (Permanent shallow marine waters). There is an extensive Seagrass bed at Kung Krabaen Bay in Chanthaburi province (Janekitkosol *et al.*, 2003).

Welu Wetland

With an estimated water volume of 8.1 x 10^7 m^3 and a diurnal system of tides with amplitudes ranging between 0.7m (neap) to 1.9m (spring), the water depth is usually between <1 to 10m at the mouth of the bay (mean depth being 3m) while the shallow inner estuary is dominated by fringing mangrove communities along the extensive mudflats that have organic matter of allochthonous origin (Limsakul 2007). Being an estuary, it falls under class F of the Ramsar classification as well as class I with its mangrove swamp and tidal regime.

Processes

(a) **Decomposition:** The presence of dark hued soil in the two wetlands suggested high organic matter content. This implies the presence of hydric soils in the wetlands. These wetlands have a very high soil moisture regime hence the characteristic inundation that was observed at the time of visit.

(b) **Water Movement:** In these coastal wetlands, water inundation is permanent with daily fluctuations occasioned by tidal variations. The balance of the water inflows and outflows from these wetlands seems to be positive hence all year round inundation. Water Inflow into these wetlands occurs via precipitation, surface run-off, ground water inflow and most importantly tidal inflows. Water outflow naturally occurs through evapotranspiration, groundwater outflow and surface water outflows. The Welu estuary gets its freshwater inflow from surface runoff emanating from the Welu River (Limsakul 2007).

(c) **Nutrient Cycling:** The process of decomposition as seen through the soil texture and color suggests that Nitrogen and phosphorous cycling occurs although the stoichiometric values were not determined. The Welu wetland on the other hand is designed specifically for the purpose of carbon sequestration. It is meant to be a huge carbon sink for the enormous amount of green house gas that is emitted as a result of anthropogenic activities. According to Limsakul (2007), dissolved nitrogen is dominant and make up a large portion (about 80%) of the nitrogen in the Welu wetland while phosphorus is partitioned into about 70% particulate or suspended solids.

Functions

There is a vast expanse of Seagrass covering about 160ha in the central area of the Kung Krabaen bay with an ecological importance in terms of water quality improvement via nutrient absorption while also serving as cover for breeding aquatic organisms. The Kung Krabaen bay is to serve as a conservation site while also ensuring the sustainable use of the mangrove zone for shrimp aquaculture through the sea water irrigation project. The blend of research, commercial exploitation, restocking programmes and tourism forms the basic objective of the management of the bay. The rich coastal resources of the Welu wetland placed it in a position to support coastal aquaculture activities with resulting environmental degradation as a result of overexploitation of the wetland area through mangrove deforestation to make way for shrimp aquaculture. Intensive aquaculture in this area without regards for sustainability led to decreasing harvests occasioned by heavy water pollution as a result of high nutrient loading hence fishermen were forced to abandon their original ponds and develop new ones, a situation which led to greater deforestation of the wetland (TGO/JICA 2011).

(a) **Water quality improvement:** These wetlands provide a very important function of filtration. They serve as sink sources for nutrients that flow from inland sources as well as coastal aquaculture operations.

(b) **Nurseries:** The two wetlands provide nursery grounds for fish as well as other aquatic organisms and even terrestrial organisms that breed on the coasts.

(c) **Wildlife habitat:** Fish, birds and other life forms typically call these two wetlands home. The Welu wetlands is of crucial importance in this regard as it houses the Brahminy kite (*Haliastur indus*) which is listed as least concern with a declining population on the IUCN red list of threatened species. The mangroves present in these wetlands fall under several genera but the Rhizophora and related genera are most common and particularly members of the family Rhizophoraceae represented mainly by *R. mucronata* and *R. apiculata*.

(d) **Flood buffers:** These wetlands help to hold water in large quantities so as to prevent inland flooding.

(e) **Erosion control:** The reforestation of the Welu wetlands with mangroves has mitigated erosion problems along the coast hence effects of storms and ocean surges are effectively absorbed.

(f) **Recreation:** These wetlands provide areas for fishing, aquaculture, hunting, bird-watching, boating, kayaking and other forms of recreation for holiday makers.

Table 1. Ecosystem Services and Benefits of the Kung Krabaen bay and Welu Wetlands in Chanthaburi Province of Thailand

Wetland Service		Benefits for man (Well-being)
Provisioning	Food	Fish, fish products (Fish sauce), vegetables, fruits, Tea from Pluchea indica and sweets from Bruguiera gymnorrhiza and Someratia orata
	Fibre and Fuel	Logs, fuel wood, peat and animal fodder.
	Biochemical	Soap making
Regulating	Climate Regulation	The Welu wetland is designed specially to sequester the green house gas, CO_2.
	Water Flow and Regulation	These wetlands help to maintain equilibrium in the hydrologic cycle by maintaining the groundwater discharge and recharge rates.
	Water Purification and waste treatment	The Kung krabaen bay is designed to specifically treat waste water from shrimp farms and return same to the ocean without loading the immediate environment.
	Erosion control	The presence of mangroves and other emergent plants help to hold soil particles together and prevent coastal erosion hence retention of soil, soil nutrients and sediments.
	Flood Mitigation	The water holding capacity of the vast area covered by the two wetlands helps to prevent inland floods.
	Pollination	Insects and birds that act as plant pollinators are abundant in the two wetlands.
Cultural	Recreational	The two wetlands provide opportunities for recreation. The Welu wetland attracts tourists interested in watching the Brahminy kite as well as fire flies. It provides kayaking facilities.
	Aesthetic	The Kung Krabaen bay produces flowers which are of aesthetic value.
	Educational	Both wetlands serve as centres for research and training of people as well as centres for schools to send students to study through visits.
Supporting	Soil Formation	With the retention and accumulation of sediments in these wetlands, the process of soil formation is triggered.
	Nutrient cycling	Sources of sink for nutrients such as nitrogen and phosphorous as well as recycling.

Benefits

The two wetlands provide important benefits to the people that live around it as well as visitors that come to savour the recreational function of the wetlands. The benefits (Table 1) derivable from these ecosystems with regard to man can be grouped to include: Provisioning, Regulating, Cultural and Supportive benefits. These Wetland ecosystems provide many benefits that bring about improved livelihoods hence the wellbeing of the people. Fish, wood, fiber, water, water purification, climate regulation, flood mitigation, recreation, erosion control, and tourism all fall under these categories.

Current Management Regime

Kung Krabaen Bay

Through the absorption and processing of wastes, these wetlands help maintain environmental quality and safety while also maintaining a biological balance of carbon IV oxide and other green house gases. The treatment of low nutrient wastes from shrimp farms in Kung Krabaen bay involves the use of four mangrove species: *Ceriops tagal, Rhizophora apiculata, Avicennia alba* and *Bruguiera gymnorrhiza*. The rich biodiversity that thrives within these wetlands is a vital storage for genetic material and the diverse flora and fauna are vital to the ecological process in these wetlands.

The Kung Krabaen bay is currently being managed through an integrated system that involves many government agencies working together to create an inter-disciplinary cohesion for the management of the coastal resources. The management encompasses the mountainous areas and runs down the cultivated agricultural lands to the coast and the adjoining ocean. Management activities dwell on the preservation of the natural resources and the ecosystem that supports them while also considering the socio-economic aspects of livelihoods. Management of the various activities involves integration so as to create awareness in the local population for sustainable exploitation alongside improved livelihoods while maintaining ecosystem integrity to foster eco-tourism.

Aquaculture is used as a means for aquatic fauna conservation through hatchery bred restocking of the natural waters as well as the operation of crab banks to help conserve the crab population in the bay. More than 20 million seeds of tiger prawn, white shrimp, sea bass, grouper and swimming crab are being released into the Kung Krabaen Bay and the surrounding sea each year by visitors as part of the eco-tourism programme with the sole aim of increasing the fish biomass within the bay and its surrounding thus the integrity of the ecosystem is guaranteed (The Kung Krabaen Bay Royal Development Study Centre 2011). The feeding niches of fishes in the bay is given priority attention and maintained while indiscriminate use of antibiotics in shrimp culture is avoided with health management which involves research and diagnosis of diseases and viruses using advanced technology (Polymerase Chain Reaction -PCR). The bay also manages oysters that are cultured using raft hanging methods. The bay enforces a no hunting zone for conservation of wild life.

The aesthetic and recreational use of the bay also forms part of the management system. Flowers are produced as part of the economic benefits of the conservation of the bay while people are taught how to make a living using the forest products through a development based tourism programme.

Welu Wetland

The Welu wetland is managed through the co-management method that involves participation from all stakeholders in order to derive economic, social and environmental benefits while maintaining the ecological integrity of the area. The management of the area has resulted in the restoration of the mangrove area covering about 30,000 rai (4,800ha). There is also an ongoing research into the aquatic flora and fauna and so far, there have been 92 species of plants identified in the area. Restocking of the natural waters with hatchery produced seed of sea bass and the mud crab is also another management procedure in this wetland.

Commercial ventures that produce soap, baskets and fish sauce under the brand name Welu wetland is one of the steps aimed at showing the benefits of the ecosystem sustainability. The centre also uses eco-tourism as a method to ensure conservation. Tourists are opportune to watch the Brahminy kite in the day and fire flies at night (during their season). Furthermore, tourists and companies are allowed slots in the wetland to plat mangroves as part of environmental friendliness and awareness aimed at conservation. Co-management was achieved by the Department of Marine and Coastal Resources through dialogue with the leadership of the local communities. This was met with stiff resistance but there was a concession later after familiarization was achieved by the people. The local people were involved in tourist guidance and production of valuable goods from the forest's resources which found a ready market among tourists.

Presently, there are no penalties for illegal gaming and removal of mangroves but compliance is enforced by the DMCR. Enforcement is hampered by fear of attack from the local people hence the engagement of the leadership of the people to ensure compliance. This led to the establishment of the community conservation programme with leaders to supervise fellow locals and a management system that involves replanting 10 mangroves for every one that is cut down. However, there is lack of probity and transparency in the enforcement.

Drivers of Change (Direct and Indirect)

Direct Drivers

(*i*) **Land Cover Change:** Logging, urbanization, agriculture, human habitation has caused bio-diversity loss and impaired the delivery of vital ecosystem services such as water retention and flood mitigation capacity of the wetlands. The most dramatic changes to land cover occur on wetlands as reported by Kull (2012) and Awoniran *et al.*, (2013).

(*ii*) **Overexploitation/Inappropriate use of wetland resources:** overuse of the ecosystem services in these wetlands have led to reduction in fish stocks as well as other aquatic life. If renewable resources are exploited beyond sustainable limits, they will not be able to recover. Agriculture has been identified as the major culprit for overexploitation of wetlands (Montes and Bifani 2013).

(*iii*) **Pollution:** The discharge of shrimp farm sediments and sludge has contributed to the change in the ecosystem structure of the two wetlands hence the necessity for management interventions. The quality of water flowing out of the wetland is affected greatly by the inflow of polluted water (Mitsch and Gosselink 2015). Pollution Impairs human health, damages wetland ecosystems and adversely impairs environmental sustainability in the wetlands.

(*iv*) **Climate Change:** The presence of CO_2 in excessive amounts than the environment can handle tends to disrupt the natural balance of the wetland ecosystem and adversely affects development concerns. The Welu wetland is being used as a green house gas sink in order to stem the negative tide of climate change. Wetlands reduce the speed of decay of organic matter hence reduced rate of carbon emissions (Crooks *et al.,* 2011). The determination of impact of climate change on wetlands is not a straightforward process considering the diversity of the wetlands, geographical locations, limited knowledge on physical and biological ecology and effects of non-climatic factors (Flournoy and Fischman 2013).

Indirect Drivers

(a) **Demographic change:** Population around these wetlands increased with the surge in activities related to shrimp aquaculture. This led to the clearing of the mangroves to make way for farms. This is true for wetlands because they have multiple uses hence stakeholders are diverse and population using the resource increase (Rongoei *et al.,* 2013). In addition the locals who are mostly peasants depend on the mangrove for fuelwood as well as making of charcoal hence degradation of the forest.

(b) **Economic Factors:** With the surge in shrimp farming in the 1980's and 1990's, rich investors from Bangkok also cashed into the trade and established farms in the wetlands and with money to spare, large areas of mangroves went down. The solution to this problem lies in the mainstreaming of ecosystem services from wetlands into economic decisions (ten Brink *et al.,* 2012).

(c) **Scientific and technological innovations:** The use of antibiotics in the shrimp farms is a source of concern as environmental accumulation may lead to development of resistance by bacteria. The effect of this human intervention as well as others indirectly affects the ecology of wetlands with associated losses (Ajibola *et al.,* 2012).

(d) **Institutional gaps:** The regulatory authorities realized only after harm has been done to the environment that the activity of the people around these wetlands is detrimental. Absence of monitors has led to over-exploitation of fisheries and forest resources in the wetlands via illegal logging and poaching. The use of an approach termed as working wetland potential (WWP) as proposed by McCartney *et al.,* (2005) can be of benefit in tackling the effect of this driver.

Assessment of current management systems' ability to manage drivers of change

The current management systems in the two wetlands have effectively stemmed the tide of over-exploitation as well as destruction of the mangrove forests. Pollution control is being carried out at the Kung Krabaen bay with the use of the wetland as a purification platform. Also, the use of the water from the bay for shrimp farming activities and discharge of waste water into the bay has been controlled at a very great cost through a sea water irrigation system. The sustainability of this system is however being brought to question since there is declining markets for shrimps and the farmers are not able to pay the monthly return for producing in the area. The utilization of mangrove endophytes for production of bioactive compounds holds some promise considering the report of Babu *et al.*, (2013) since traditional shrimp farming is declining in profitability.

Climate change as a direct driver is being tackled by the use of an extensive area of mangrove to sequester CO_2 from the atmosphere. This is a highly specialized project that is being monitored by the Japanese International Cooperation Agency (JICA). The carbon sequestration ability of the Welu wetland can be further increased with the application of distilled liquid byproduct of biogas production which according to Singla and Inubushi (2013) reduces the production of CO_2 and CH_4. Population change is effectively checked at the Welu wetland with just about 1,000 families being allowed on the wetland. The Kung Krabaen bay controls population around the immediate project site through lease agreements with farmers who make returns. However, population in the wider area covered by the project is not under its control. The use of integrated management as well as co-management in these wetlands has created an environment where all stakeholders can derive benefits while maintaining the integrity of the wetlands. However, there is need for greater transparency on the part of the community leadership in the Welu wetlands in order to ensure compliance. The use of education and development of livelihood activities is a very important approach as it ensures that people are not bewildered about the need to keep the forest intact when they are in need of resources for livelihoods or wellbeing.

How can we improve the management?

There is a need for greater investment into the management of these wetlands especially the Welu wetland. International cooperation is also a key to ensuring that the ecosystem of these wetlands is maintained. Funding for research into the value and ecosystem opportunities that lie within these wetlands will be of immense value. Finally, the cooperation of the various government agencies that have jurisdiction over the various resources in these wetlands will be vital to achieving the goals of conservation. Effective co-management can be achieved if linkages and areas of cohesion are developed using systemic models.

Conclusion

Wetlands offer a diverse array of resources and also serve as a means to mitigate flood and climate change. The rational use of the resources provided by wetlands is a key factor in their conservation. Recovery from overexploitation may take time but these wetlands are showing resilience and there is need to improve management regimes via international cooperation.

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