Destination Management Plan for the Inlay Lake Region -- Environmental Assessment

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Consultant report

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DISCLAIMER

This report contains a summary of issues relating to sustainable management of environmental resources for Inlay Lake and its watershed, in the context of increasing pressures from international and domestic tourists. The environmental information and recommendations for actions are based on the best available information, but there are significant limitations in the extent and reliability of baseline data.

Data on the Inlay Lake region in this report should be taken as indicative of conditions, rather than verified measurements. Large variations in data from different sources are apparent, such as the common use of a single figure to describe depth, width, length and area of a large lake with varying depths and an irregular shoreline. Much information is anecdotal, and has been included to fill gaps in measured data.

Nonetheless, there are sufficient data to identify priorities to address immediate threats to the health of the Inlay Lake ecosystem and its watershed, as well as threats to the health and well-being of dependent human communities.

The report recommends future monitoring to acquire consistent baseline information and regular monitoring updates. Knowledge gaps and priorities for further research are also identified.

Some confusion may arise from multiple spellings of names and places in Myanmar language. The spellings used in this report have been standardised, but there may be two or three alternate variations for the same place names or personal names.

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Introduction

This report outlines threats to the environmental health of Inlay Lake and its watershed, and proposes possible solutions for sustainable management of tourism impacts in the context of the ***Tourism Destination Management Plan for Inlay Lake Region***.

Inlay Lake[1] Region in Shan State north-east of Yangon is one of Myanmar's four top designated flagship destinations, nominated for its cultural, historical and religious values. Inlay Lake is also one of 21 designated eco-tourism destinations in a country which anticipates rapid expansion of tourist numbers, as more international travellers are attracted to visiting Myanmar.

The prime tourism destination is Inlay Lake itself, with several other key destinations in the watershed zone of the hilly areas, including Pindaya Cave, Kakku Pagoda complex, and the colonial hill station towns of Taunggyi and Kalaw. There are many annual festivals, with Kakku and Pindaya Cave in late February, Phaung Daw Oo Pagoda in late October, and Taunggyi hot air balloon festival in November.

Inlay Lake combines rich historic and cultural values with significant environmental values due to its high biodiversity and invaluable ecosystem services (Jensen, 2012). It has been listed as an important heritage area for South-East Asia and it would meet the criteria for listing as a wetland of international importance for migratory waterbirds, as it is a critical staging post on the East Asia-Australasian flyway from Siberia to Australia.

The lake and its surrounding watershed provides essential resources to the local and regional populations through food, fuel, fibre, shelter and water for drinking, cooking and livelihoods. Sustaining the lake is essential to sustaining local communities and sources of income, as well as maintaining a national asset (Jensen, 2012). Without a healthy lake and watershed there would not be a tourism destination or livelihoods for local communities.

Figure 1 **Typical passenger boat carrying local residents passing a memorial marker on Inlay Lake**

[1] For consistency, the spelling of 'Inlay Lake' is used in this report, but the spelling of 'Inle Lake' is also common

Sustainable Tourism

Inlay Lake, the second largest freshwater lake in Myanmar, is renowned for its beauty and serenity, and has been attracting visitors for hundreds of years. It is the site of two famous pagodas, Phaung Daw Oo and Aah Lo Daw, which date back 800 years, as well as many pagoda's and stupa fields in the lake environs.

Inlay Lake is one of four key tourism destinations in Myanmar, alongside Mandalay and Bagan, and attracts approximately 200,000 visitors annually, including both international tourists and national visitors on pilgrimage. The Pagoda Festival in October is a major draw-card, and the culture of the *Intha* people is of particular interest, with the unique leg-rowing fishermen, and the floating garden agriculture, as well as artisan crafts of silk weaving, silver smiths and lotus cloth.

Tourists visiting the Inlay region expect clean air, clean water, vibrant local communities, thriving local culture and industries, comfortable hygienic accommodation, and a unique experience. The lake itself and the surrounding watershed of the Inlay Lake Region need to have healthy working ecosystems to provide these experiences, to sustain tourism pressures into the future and to provide an income to local communities.

Tourism pressure on Inlay Lake is predicted to rise significantly in the short term, with significant impacts on the lake ecosystem and potential threats to the cultural well-being of local communities (Molstad & Munz, 2012). Current figures indicate a base of approximately 100,000 international tourists visiting Inlay Lake, combined with approximately 100,000 domestic Myanmar visitors, primarily pilgrims visiting multiple sacred religious sites around the Lake. It is estimated that the local population on and around Inlay Lake is also ~100,000 people, with 890,000 people living in the watershed (Jensen, 2012). Visitor numbers to destinations in the wider region of the lake watershed and beyond, including Pindaya and Kakku, are difficult to confirm, and the current project undertook visitor surveys to provide a baseline assessment of tourism pressures (*see TDMP for Inlay Lake Region – Tourism Survey*).

Previous investigations and discussions with stakeholders have indicated that the industry, region and community are quite unprepared for the impact and needs of such an expansion (Jensen *et al.,* 2012, Molstad & Munz, 2012). This lack of preparedness encompasses the following:

- low level capacity for planning, including planning for tourism and environmental protection
- absence of reliable baselines for future forecasting and monitoring of visitor numbers and impacts (both positive and negative)
- lack of existing systematic environmental, cultural and social safeguards
- little community and other stakeholder involvement in tourism sector planning
- skills gaps and lack of awareness among communities on tourism impacts.

As a result, the local tourism industry as an *economic sector* is not in a position to develop effective policies, strategies and development plans to ensure that the potential revenue from the increase in tourist numbers leads to a positive economic impact on the communities of the lake and its watershed, and equitable participation in profits.

From an environmental viewpoint, there is a very real danger that the growth in tourism will damage the region's natural resources, cause a decline in ecosystem health, degrade traditional cultures, and corrode societal strengths, thereby undermining the very assets that attract visitors to the region.

The desired outcome is that the growth in tourism income can be converted into an opportunity to maintain the environmental assets of the lake and its watershed, and to support and nurture the cultural history and

diversity of its local communities. The increase in tourism can be an important opportunity to ensure sustainable long term management of the lake and its watershed.

This report identifies opportunities for linking sustainable environmental management with sustainable tourism management.

Context of RTDMP Project

The Tourism Destination Management Plan for the Inlay Lake Region is being developed in the context of several relevant plans, including the Myanmar Tourism Master Plan and Myanmar Responsible Tourism Policy.

The key plan for sustainable management of Inlay Lake is the MOECAF ***Action Plan for Environmental Conservation and Sustainable Management of Inlay Lake 2010-2025.*** UNDP has commenced a project in May 2014 to develop the second five-year cycle of the Action Plan.

A report of especial relevance to environmental issues and sustainable tourism management is the *Inlay Lake Conservation Project* (IID, 2012a), which identified key management issues and proposed a package of 19 project proposals to commence implementation (IID, 2012b). The RTDMP project is the first project from that package to be funded, to address the key issue of sustainable tourism development.

MoECAF Plan 2010-2015

The MOECAF ***Action Plan for Environmental Conservation and Sustainable Management of Inlay Lake***, covers the period 2010-2025 in 5 year increments. Specific actions are recommended for core, buffer and remote areas under key topics such as erosion control.

Key guidelines were issued by the Head of State of Myanmar regarding management of Inlay Lake, including the following directives:

- not to allow the expansion of villages, house and floating islands in Inlay Lake
- to remove the undesirable floating islands, weed, sediments
- to restore the water flow of nine streams
- to take action against tree cutting and shifting cultivation in the surrounding areas of twenty miles in Inlay Lake
- to form a team for forest conservation in watershed area of Inlay Lake
- to form a team in collaboration with the Ministries of Agriculture and Irrigation
- to base an administration office in Nyaung Shwe Township.

Key partners of MOECAF and represented in the Central Steering Committee, chaired by the Minister of MOECAF, are the Ministries of Hotel and Tourism, Agriculture and Irrigation, Electric Power, Progress of Border Areas and National Races Affairs and Shan State Government.

Other stakeholders in management of Inlay Lake include:

- International supporters, Government of Norway, UNDP, UNESCO, MIID and other supporters.
- The Tourism industry
- Self-Administered zone (Pa-O, Danu), Intha community and Township Authorities
- Local civil society, traders, local tourism industry, farmers associations
- University departments, including among others:
  - Taunggyi Department of Zoology
  - Taunggyi Department of Botany
  - Taunggyi Department of Geology

Inlay Lake Conservation Project (2012)

The *Inlay Lake Conservation Project* assessed the current status of Inlay Lake, and evaluated progress in implementation of the MOECAF ***Action Plan for Environmental Conservation and Sustainable Management of Inlay Lake 2010-2025*** (IID, 2012a). It was observed that, while the MOECAF Action Plan provides a solid basis for sustainable management of Inlay Lake, it needs accelerated funding and commitment of resources for effective implementation.

The *Inlay Lake Conservation Project* developed a package of project proposals designed to accelerate implementation of priority actions to implement the MOECAF Action Plan (IID, 2012b). It was recommended that funding be sought to enable implementation of this package of recommendations and project proposals.

Pro-active management will be required to enhance the benefits of expanding development and tourism and to reduce the negative impacts from development on Inlay Lake. Local communities have shown great willingness to change current practices if technical support and extension services are provided. They strongly support coordinated planning and effective implementation for sustainable management of Inlay Lake.

Priority Issues

Management issues for Inlay Lake are many, complex and interactive. The Inlay Lake Conservation Project (IID, 2012a) assessed the following issues as being top priority for immediate action to reduce the primary threats:

1. Reducing surface area of open water
2. Loss of diversity and abundance in aquatic plant communities
3. Declining water quality
4. Sedimentation of in-shore zones
5. Soil erosion in watershed areas
6. Declining and inefficient agricultural productivity in floating gardens
7. Threats to human health
8. Predicted large and rapid increases in visitor numbers
9. Lack of effective engagement and capacity building in community.

Priority Framework Actions

The *Inlay Lake Conservation Project* recommended a set of Framework Actions which are needed to establish the governance system for sustainable management of Inlay Lake (IID, 2012a), as summarised below:

1. Establish an Inlay Lake Conservation Authority to coordinate implementation of the Inlay Lake Action Plan 2010-2025, starting with recommendations of the Inlay Lake Conservation Project
2. Provide secure funding through the Inlay Lake Conservation Fund
3. Build an Inlay Lake Conservation Centre at Nyaung Shwe to house the Authority
4. Include a Visitor Interpretation Centre and Environmental Education Centre in the Authority building
5. Establish a coordinated monitoring system for lake condition, with systematic data collection from a comprehensive grid of points measured regularly with standardised methodology
6. Establish a lake database, with information to be shared with all relevant agencies and communities for a system of sustainable management, housed in the Inlay Lake Conservation Centre
7. Develop a communication and education strategy to engage local communities, stakeholders and agencies in ongoing implementation actions and to coordinate and support education activities.

Priority Specific Actions

Specific Actions were developed to address the priority issues, with short, medium and long term priorities for implementation (IID, 2012a). Specific actions for immediate implementation include to:

- conduct a comprehensive beliefs and behaviours survey among lake and lakeside villagers and hillside communities to understand how to achieve long-term changes in sanitation and farming practices
- assess the adequacy and security of drinking water supplies to lake villages
- develop a program to promote sanitation and health measures, starting with trials in poor households
- assess the feasibility of installing a crematorium incinerator in Kayla graveyard
- develop a project for biological control of water hyacinth
- analyse available satellite imagery to assess the history and condition of lake and watershed vegetation
- investigate options for engineering a more environmentally friendly Namlet Channel to reduce transport of silt and improve biodiversity
- identify sites to stabilise exposed earthern banks in navigation channels to reduce re-suspension of sediments into water and transport of silt
- construct erosion control actions at nominated 'hot spots' in the watershed
- develop a control program to reduce red snails
- develop an environmental school and mobile education program, starting with Farmer Field Schools
- conduct a visitor survey to establish a baseline for future forecasting and monitoring of future tourism impacts
- commence process to prepare a tourism management plan to provide facilities for a predicted doubling of tourist numbers in the next three years
- develop a tourism training school to facilitate the employment of local people in the industry, including farmers who want to give up unsustainable agriculture
- evaluate expansion of the payment for ecosystem services program (PES) to promote and protect the values of the ecosystem services provided by Inlay Lake.

Figure 2 **Intha fisherman demonstrating the famous traditional leg-rowing technique of Inlay Lake**

Lake Authority and Fund

The first recommendations of the *Inlay Lake Conservation Project* were designed to provide a governance mechanism to support implementation of the MOECAF Action Plan, with specific priorities to develop a coordination system of information to support management actions and engage stakeholders (IID, 2012b):

1. Establish a governance mechanism for coordinating projects and research to address an agreed long-term plan, with an overall coordinating Inlay Lake Conservation Authority with multiple representation, and secure funding (Inlay Lake Conservation Fund) to ensure effective implementation and continuity of action (Kristensen, 2012), including:

    - Lake leadership & coordination group
      (expanded from existing MOECAF Action Plan Central Steering Committee)
    - Lake technical advisory group (influential eminent persons)
    - Lake stakeholder advisory group
    - Permanent action plan with review process, updates and sustainable management
    - Active implementation and enforcement system
    - Secretariat/office in Lake region
    - Inlay Lake Conservation Centre to include Environmental Education Centre , Visitor Interpretation Centre and Meteorology and Hydrology Centre
    - Lake and Watershed Database (access, coordination)
    - Coordinated monitoring program
    - Reporting and communication mechanisms
    - Identification of potential external funding sources
    - Identification of potential income (tourism levy, offsets, sales)
    - Involvement of national, regional and self-administered government levels.

2. House the Inlay Lake Conservation Authority in a new purpose-built facility called the Inlay Lake Conservation Centre at Nyaung Shwe, incorporating the MOECAF Action Plan proposals to build a Meteorology and Hydrology Centre and an Environmental Education Centre.

3. Establish a coordinated monitoring system for lake condition, with systematic data collection from a comprehensive grid of points measured regularly with consistent methodology, covering key parameters to measure water quality, water level, water depth, sedimentation rates at identified hot spots, aquatic plant communities, status of native fish, and status of invasive species (Jensen, 2012).

4. Establish a coordinated lake database, with information to be shared with all relevant agencies and communities for a system of sustainable management, to be housed at the Inlay Lake Conservation Centre. It is recommended that the Lake Authority, with assistance from the Technical Review Panel, develop and promote the baseline description of ecosystem status and processes for agency staff, researchers and NGOs to build a consistent base for actions.

5. Establish a visitor information centre in the Inlay Lake Environmental Education Centre, linked to research and the database, to provide interactive visitor interpretation displays.

6. Develop a communication and education strategy to engage local communities, stakeholders and agencies in ongoing implementation actions, and to coordinate and support education activities.

Recommendations for Sustainable Tourism Management

The *Inlay Lake Conservation Project* recommended actions to ensure sustainable management of expanding tourism pressure.

Management of Tourism Impacts and Increasing Visitor Numbers

- Develop a robust forecast model to predict patterns of visitor numbers and demands for facilities
  - Conduct a visitor survey to establish a baseline for future forecasting and monitoring of impacts. Commence collection of repeatable, reliable statistics of international and domestic visitors to Inlay Lake, including Buddhist pilgrims, to provide data for a robust forecast model
  - Assess infrastructure needs to provide capacity for a predicted doubling of tourist numbers in the next three years
- Develop a coordinated tourism management strategy
  - Establish a code of practice for hotels, businesses and public facilities for sustainable management of water resources, including internal water efficiency programs and water-saving technology in rooms, facilities and attractions. Recycling of grey water should be included, and rainwater systems encouraged.
  - Develop a program to work with local tourism operators and artisans to develop local inputs to the tourism experience
  - Develop a training school to facilitate the employment of local people in the industry including farmers who give up unsustainable farming
  - Develop guidelines for sustainable tourism for tourist operators for sustainable tourism activities, including protection of the lake ecosystem, support of Inlay culture and cooperation with local communities.
  - Investigate using the image of an opening lotus flower as the key symbol for the Inlay Lake tourism product
- As part of the provisions in the MOECAF Action Plan for Payment for Ecosystem Services (PES), investigate raising the tourism levy from the present $USD5 per visitor, and allocate the additional funds to the Inlay Lake Conservation Fund*:*
  - Commence an investigation of impacts on related sectors, to identify ways to reduce impacts and protect ecosystem services (see *Tools for Sustainable Management*)
- Develop measures for sustainable management of expanding tourism pressures*:*
  - Develop management measures to enable tourist operators and local communities to provide facilities and services to appropriate standards
  - Develop management measures for identified 'hot spots' of tourism pressure
  - Investigate the feasibility of extending Inlay Lake to an all-year destination (mid-October to mid-August)
- Implement sustainable management of expanding tourism pressures:
  - set targets for improving levels of tourism services and facilities
  - implement management measures to meet targets
  - continue systematic monitoring of expanding tourism pressures and feed information back into decision-making for adaptive management.

Inlay Lake Watershed Features

Located more than 2950 feet (884 m) above sea level, Inlay Lake is situated between two limestone mountain ranges over 5000 feet (1500 m) high, providing a dramatic backdrop rising up to 2500 feet (760 m) above the serene blue lake. The lake is only 20 feet (6.0 m) deep at the deepest point in the wet season, and 12 feet (3.6 m) in the dry season, with mean depth of 13.3 feet (4.0 m). It is very shallow compared to the steep slopes at the edges of the valley which rise 2100-2500 feet (630-760 m) above the lake (Figure 3).

Inlay Lake formed more than 1.5 million years ago and is a remnant lake from a much more extensive series of lakes which included the former Heho Lake upstream (Figure 4). These lakes formed as water dissolved limestone in the landscape ('*solution*' lakes), and areas around Inlay Lake have many limestone features such as caves, sinkholes, springs, spurs and intermittent streams. As a result of the dominant limestone in the watershed, Inlay Lake is naturally alkaline, with pH values generally >8.0, and native species are adapted to these conditions (Jensen, 2012).

This unique geological history and its resulting water quality have created habitat conditions which led to a high degree of endemism, with many native species found only in Inlay Lake. These include 14 species of fish, of which one may now be extinct. The most notable is the Inlay carp, *nga-phein*, which is of great cultural significance to the local Intha people, but is reported to be decreasing in numbers due to declining water quality and loss of habitat.

While there are a total of 29 streams in the watershed flowing into the lake, Inlay Lake receives most of its run-off from four major sub-watersheds containing 12 streams (IID, 2012a, Figure 5). The Namlet sub-watershed channels water from north of the lake in the Namlet Chaung. The Negye sub-watershed (also known as Yei Pe) channels water from the north-east into the Namlet Chaung before it reaches the open water of the lake. The Kalaw sub-watershed (also known as Thandaung) channels water from the western part of the watershed, reaching the lake via a complex of channels which form the 'bird foot' delta on the western coastal plain (Figure 6). The Inndein sub-watershed (also called Upper Balu) channels water from the south-west through the channels of the Inndein delta.

Water flows out of the southern end of Inlay Lake into Balu Chaung, entering Saga Lake and the Loi Kaw Basin, continuing to the Moybe Reservoir which supplies Law Pi Ta hydropower station (Figure 7). Inlay Lake is upstream lake in the series of lakes supplying the power station, and it is the deeper downstream lakes which are the major source of supply. The quality and supply of water to the hydropower station does not significantly influenced conditions in Inlay Lake, except in very dry conditions or periods of high demand for electricity, when the supply of water to the power station may cause lower levels in Inlay Lake, with impacts on local communities.

The shallow form of the lake and the natural flows of water and sediment have created extensive marshes on the edges of Inlay Lake. Reports from 1918 describe extensive marshes at the northern end of the lake, with flows from the Namlet sub-watershed and the Negye sub-watershed reaching the open water of the lake via multiple winding channels through the marsh (Figure 4; Annandale 1918).

The volume of water flowing into the lake generally is replaced every three months by the relatively high volume of run-off and through-flow, although water on the lake edges has a slower exchange rate.

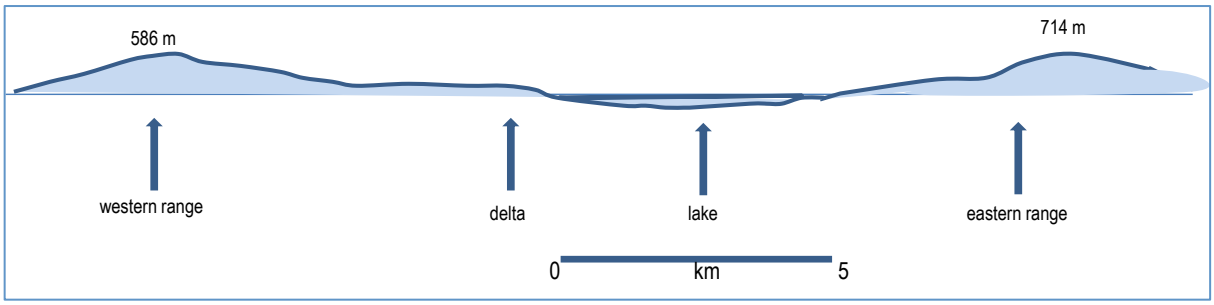


Figure 3 Relative dimensions of Inlay Lake in Southern Shan state landscape

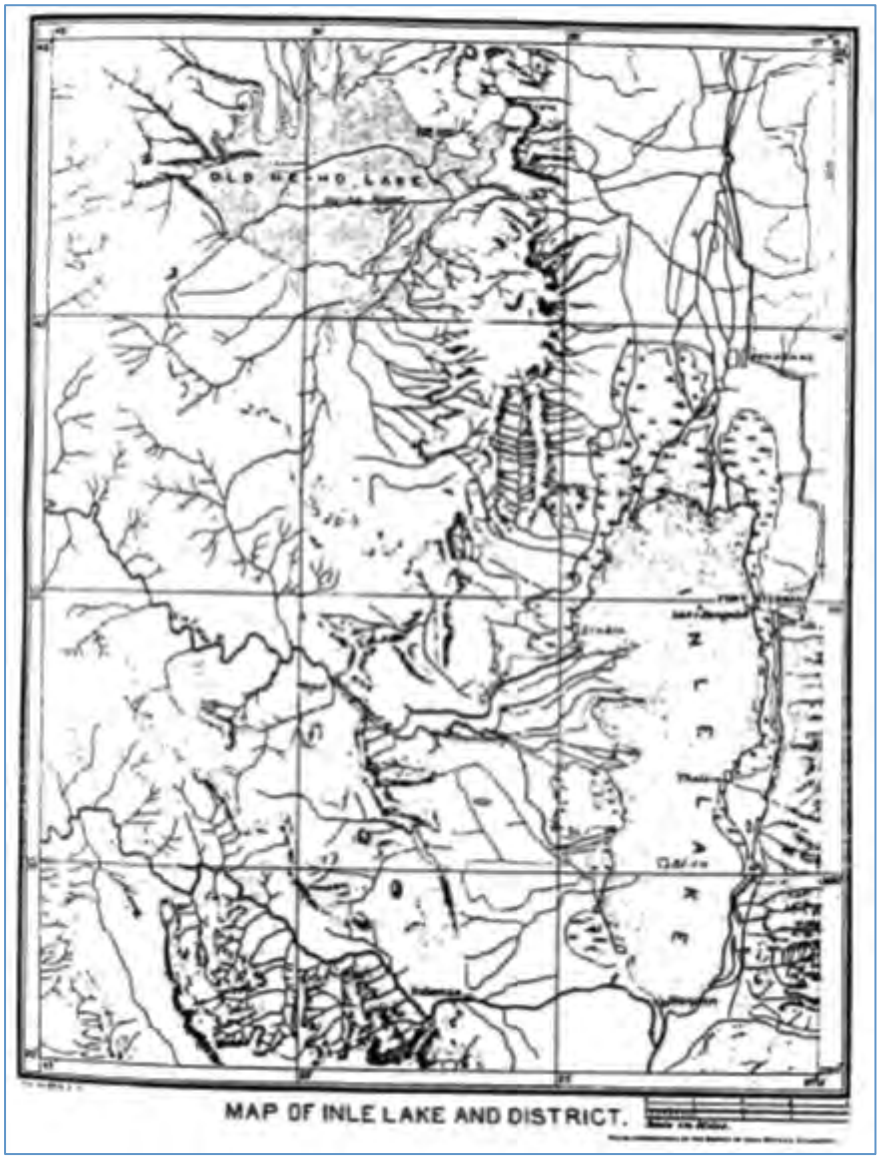


Figure 4 Map of Inlay Lake in 1918, showing multiple inflow channels from the Namlet Chaung watershed north of the lake, and the Old Heho Lake to the north-west

Large volumes of silt as well as water are transported from the upper watershed down through the streams. The natural process of silt transport has built the deltas on the lake shores, but this has increased significantly over the last 50 years compared with the previous base rate (Furuichi, 2008). In its natural state, Inlay Lake had deltas of the typical red *terra rossa* soils on its coastal plains, interspersed with floating marshes (Figure 6). This natural feature led to the development of floating agriculture techniques, now considered to be a special cultural feature of Inlay Lake and a major focus of agricultural production. The fertile soils of the deltas support extensive land-based farming, with the streams of the deltas providing irrigation water for rice paddies and other crops.

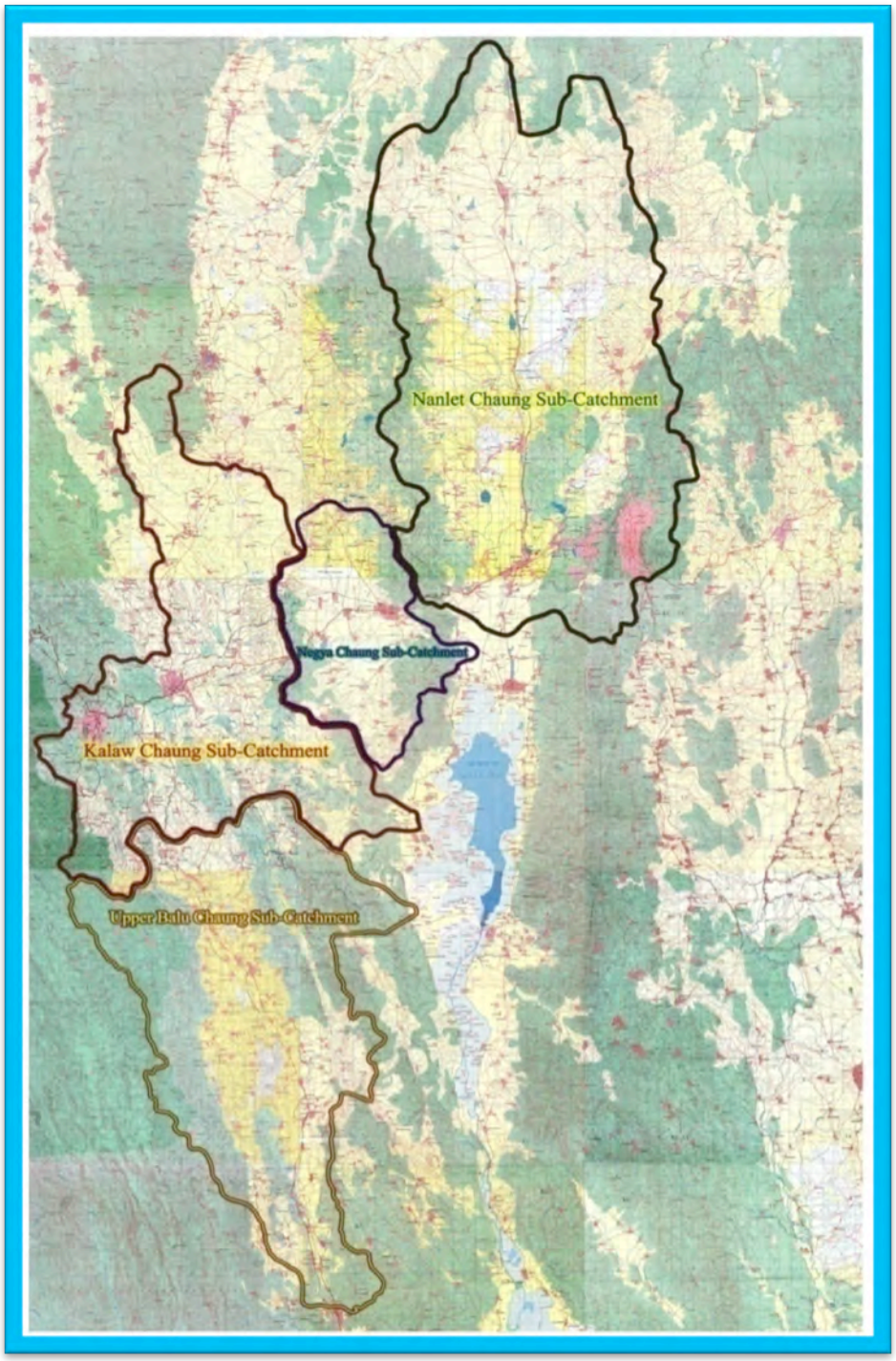


Figure 5 **Four major sub-watersheds direct flow into Inlay Lake from the north and west**

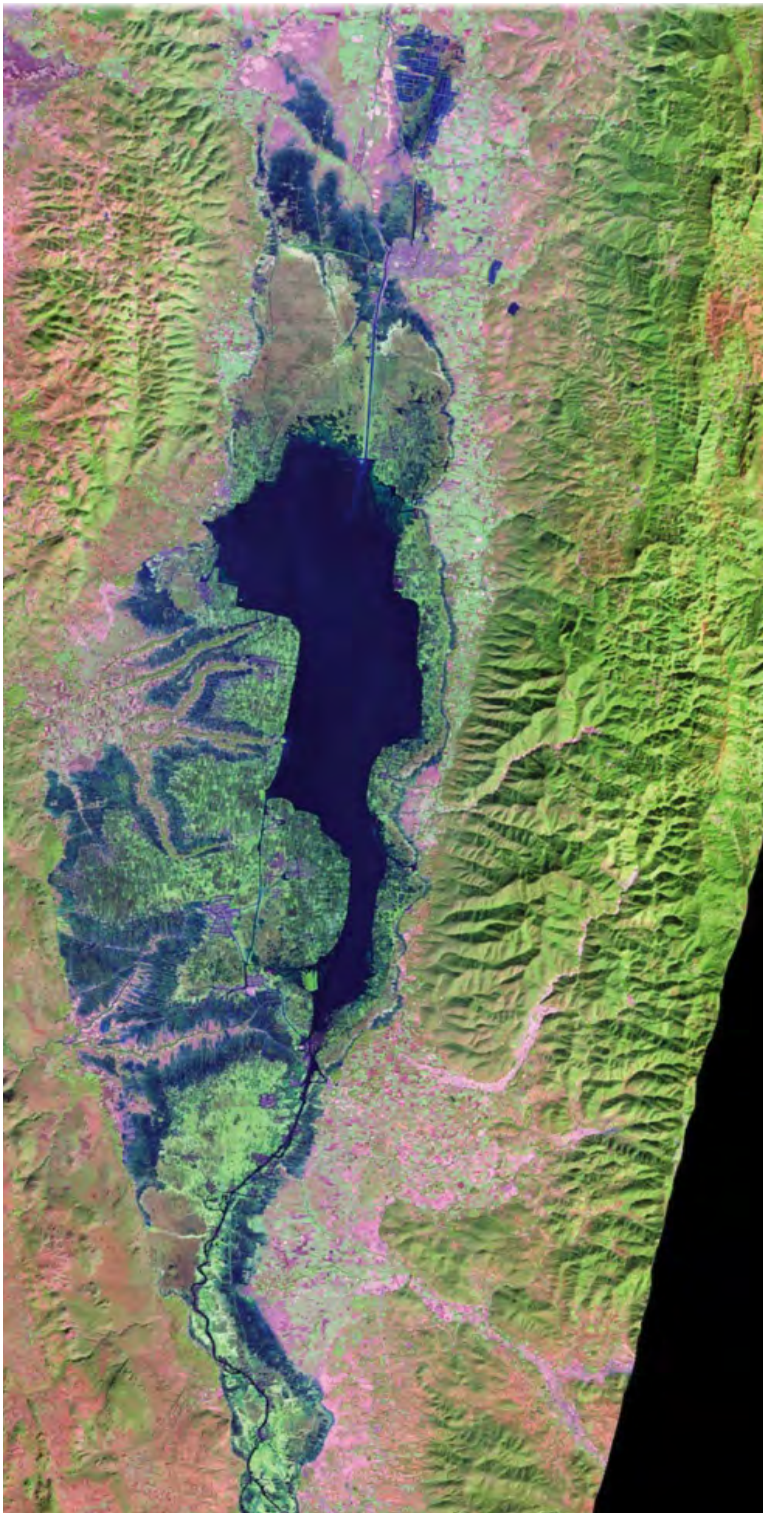


Figure 6 Landsat image of Inlay Lake in 2007 clearly shows the Kalaw Delta and Inndein Delta on the western shore, and the Namlet Marsh at the northern end of the Lake. The floating gardens have infilled all the marshes between the fingers of the deltas and along the lake shores, and extend well out into the main lake area, significantly reducing the area of open water. (Source: Inlay Lake Workshop 2010).

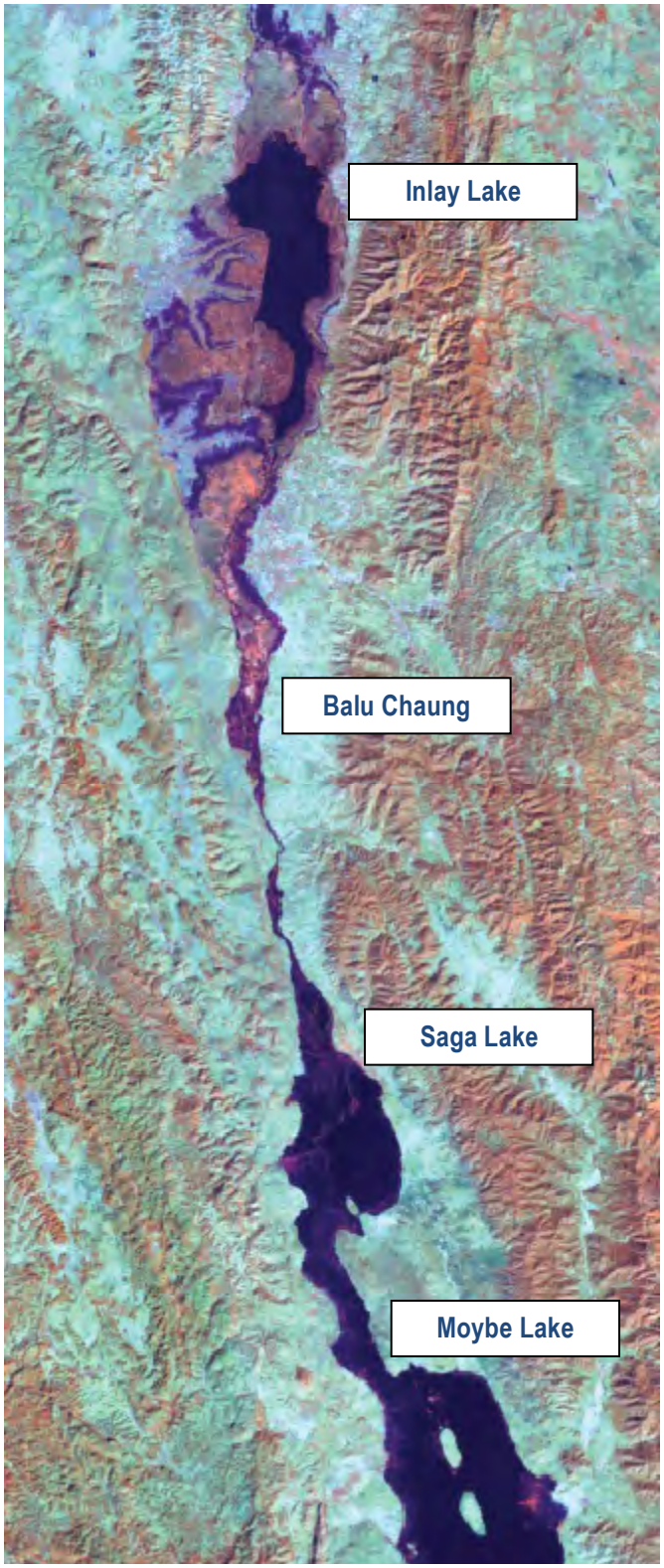


Figure 7 Inlay Lake is connected to Saga Lake and Moybe Lake by Balu Chaung stream (Source: UNDP Inlay Lake Workshop, 2010)

Lake Dimensions

It is widely accepted and reported in workshop presentations and reports, as well as the media, that Inlay Lake has shrunk dramatically in area and water-holding capacity, and is in danger of filling with silt. However, analyses of available data in this project and in a recent PhD study, as well as a study conducted in 2008, have found no evidence that the water capacity of the main lake is reduced.

Evidence has been found that the area of the lake itself is relatively unchanged, with the edges of the lake remaining stable from 1918 to 2013 (Figure 8). Comparison of the area of the lake edges indicates that the lake basin has not changed significantly, perhaps from 60 to 54 km^2 (Michalon, 2014; Figure 9). A detailed analysis of available data and satellite images concluded that the total lake area remains stable, and the main water body still retains similar water-holding capacity. The holding capacity of the lake basin was also reported as unchanged in 2008 (Furuichi, 2008).

The lake has been reported by multiple authors to expand and contract significantly between the wet and dry seasons. However, contrary to all previous reports, Michalon (2014) has found no evidence of significant seasonal variation in lake area, with the position of the lake basin edges and the head of the lake remaining in approximately the same position from 1938 to 2013 through all seasons (Figure 9).

Michalon (2014) found that the total area of the lake has been around 160 km^2 since the 1930s and estimates the current area for the whole lake at 150 km^2, with approximately 50 km^2 of open water, 50 km^2 of marshes, and 50 km^2 of floating gardens and stilt villages. This area is similar to the lake area estimate by UNDP of 160 km^2 (UNDP, 2012).

The earliest description found for Inlay Lake was from an expedition sponsored by the Museum of India in 1918. At that time, Inlay Lake was described as 14 miles (22.4 km) long and about 4 miles (6.5 km) wide (56 square miles), with crystal clear waters, completely surrounded by floating islands of native species (Figure 4; Annandale, 1918). This suggests the original area of the lake was 56 square miles.

Other authors quote smaller dimensions for Inlay Lake. For example, Inlay Lake is described as having an area of about 60 km^2 (12 km in length and 5 km in breadth, 60 km^2, 23.4 square miles) during the dry season, and about 126 km^2 (18 km in length and 7 km in breadth) during the rainy season (126 km^2, 50.4 square miles) (Sidle *et al.,* 2007; Furuichi, 2008). This highlights the difficulty of comparing different data, since it is not clear exactly what areas are being measured.

The original area of Inlay Lake is often quoted in reports and presentations as 104 square miles and then compared to the current area of open water, as evidence that the lake is rapidly filling with sediment. However, it has been confirmed that 104 square miles includes all marshes from Nyaung Shwe to Liguang, and was not the original area of open water (Figure 8; Kyaw Kyaw Oo, Department of Irrigation, pers comm., June 2014).

These results reinforce earlier recommendations for regular standardised measurements of lake depth and surface area, and identification of a recognised boundary of the lake. It is critical to obtain objective measurements of the current state of the lake to identify causes of problems before adopting actions to solve the problems, for example recommendations for dredging should be limited to confirmed identified 'hot spots' in navigation channels and on hillslopes (IID, 2012a).

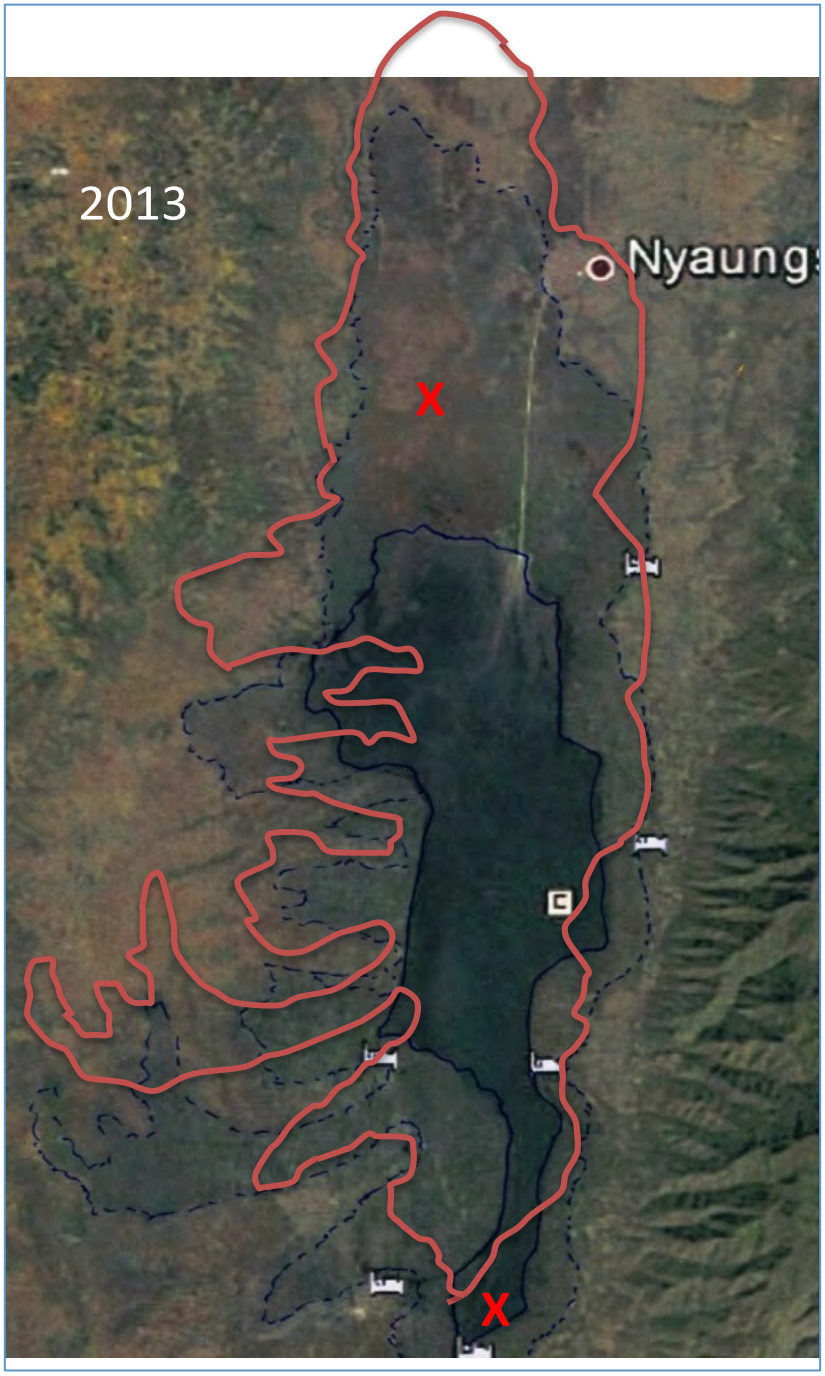


Figure 8 Area of open water in Inlay Lake in 2013 outlined in blue, with original area of marshes in 1918 outlined in red. The position of the head of the lake is indicated by the red cross X, and the positions of Nyaung Shwe and Nampan are marked. These should be compared with the maps in Figure 9, indicating the declining area of open water from 1918 to 2013, and the relative positions of the head of the lake and the two towns. This series of maps clearly indicates that the original area of open water was approximately 60 km^2 and is now approximately 50 km^2. The biggest reduction in surface area has occurred with the infilling of the marshes and areas of open water adjacent to the south-western deltas.

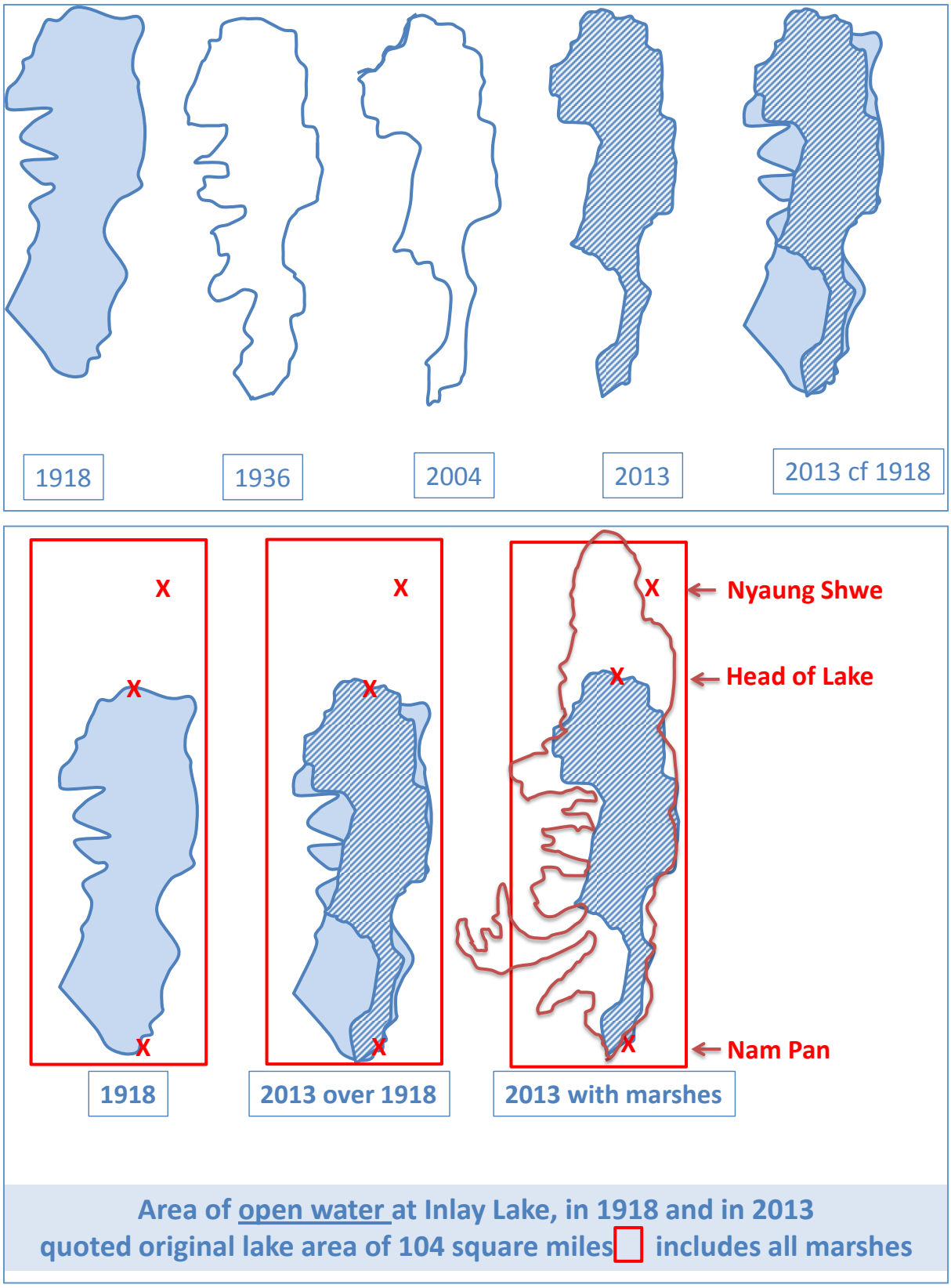


Figure 9 Declining area of open surface water at Inlay Lake, from 1918 to 2013, indicating that the original lake area quoted as 104 square miles includes all marsh areas up to Nyaung Shwe, not just open water

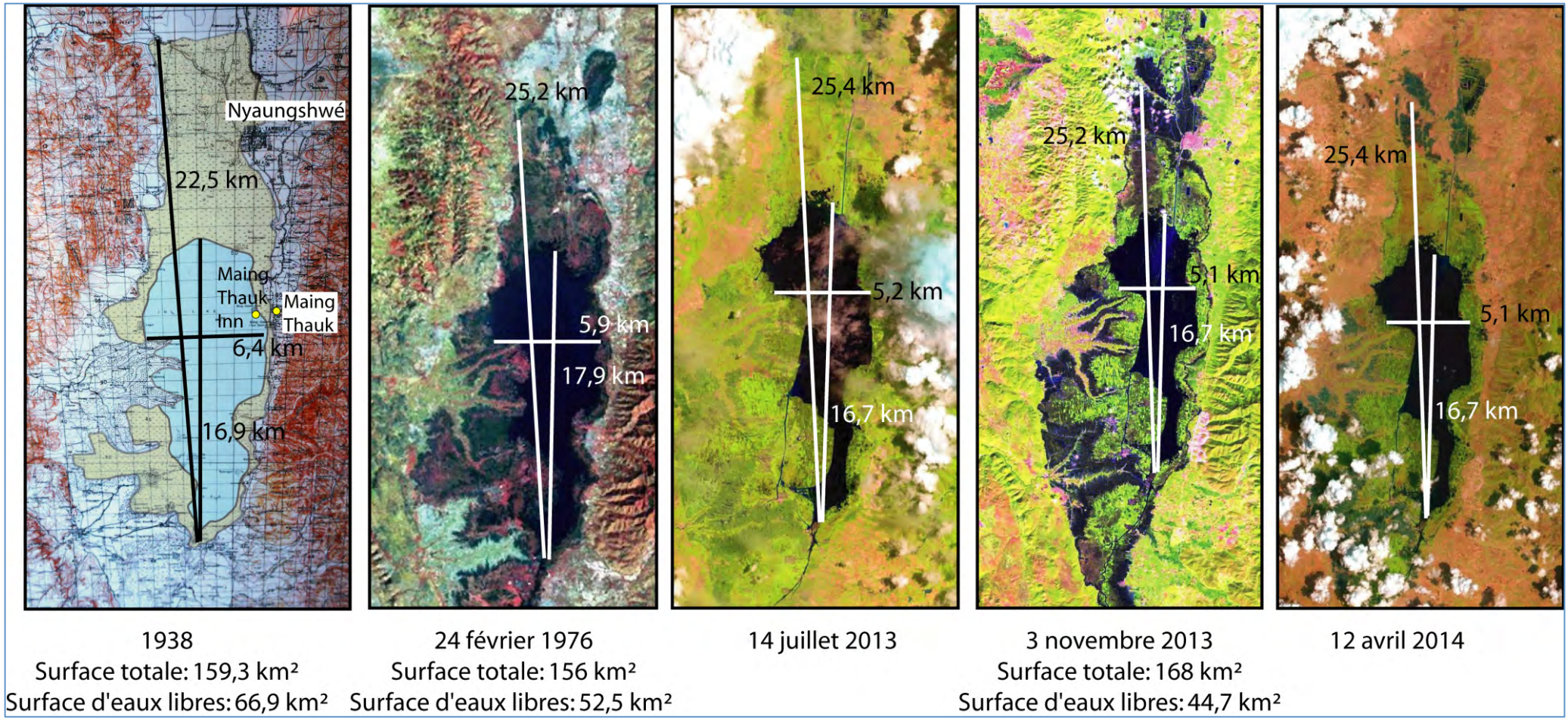


Figure 10: Measurements of lake area for Inlay Lake since 1938 show decreasing width due to expansion of floating gardens, but no significant change in length.

Source: Figure 3 in Michalon (2014) Map by Lewis 1938, modified by Martin Michalon; Landsat images, downloaded from usgs.earthexplorer.gov, modified by Martin Michalon.

There is a popular misconception that Inlay Lake will disappear, like the Aral Sea in Uzbekistan and Lake Oromeiah in Iraq. However, the primary cause of both of these lakes drying up was major water diversions out of their watersheds for irrigation. Major diversions are not occurring in the Inlay Lake watershed, and there is no evidence that the main lake is filling with sediment.

If Inlay Lake were to disappear, it could come from a completely different cause. It has been noted that Inlay Lake is a solution lake in a karst landscape, and the former Heho Lake upstream in the same watershed is reported to have disappeared due to formation of a sinkhole in the lakebed (Annandale 1918). The same geological process could occur at Inlay Lake, but the risk would be very small in the foreseeable future.

Loss of Surface Area

While lake capacity has not changed, what has changed is the surface area of open water, with extensive encroachment by floating gardens, water hyacinth and wild islands covering more than 32% of the surface from 1935 to 2000. While there is no evidence that the main part of the lake is filling up, there is evidence of significant sedimentation around lake villages and in boat channels restricting boat access, especially at river mouths (*see Perspective on Sedimentation Issues*).

For the future health of Inlay Lake and local communities, it is the loss of open water surface area that is the critical problem, much more so than siltation on the edges. There has been a clear intrusion of floating gardens across the lake surface from the edges of the Kalaw and Inndein deltas (Figure 6).

Floating garden cultivation and other forms of agriculture have expanded with the increasing population and economic needs of communities. Floating gardens are concentrated into the open water areas between 'fingers' of the deltas, infilling until the deltas have become a continuous area (Figures 6, 8).

There is a set of well-substantiated measurements of the reduction of open water area, based on comparison of survey maps in 1935 with Landsat images from 2000. From 1935 to 2000, the net open water area of Inlay Lake decreased from 69.10 km^2 to 39.65 km^2, a loss of 32% during the 72-year period (Figure 11; Sidle *et al.*, 2007).

Conclusions on Lake Dimensions

Current analyses indicate that Inlay Lake is not reducing in water-holding capacity or area as defined by the lake edges of depth of the main water body. The reported shallowing of the lake is only at the margins and in the inflowing streams, not in the deeper sections of the lake itself. There are no objective data to support the widely-held view that the main lake is filling up with sediment.

The major change is loss of open surface water area, due to expansion of floating gardens, water hyacinth and wild islands, and this is causing problems for the lake ecosystem.

While the lake is not filling with sediment, shallowing at the lake margins, particularly in boat channels, is causing transport problems.

Actions for sustainable management of Inlay Lake should give high priority to reducing the area of floating gardens on the lake surface, controlling water hyacinth and managing siltation problems at 'hot spots' in navigation channels and at erosion 'hot spots' in the watershed.

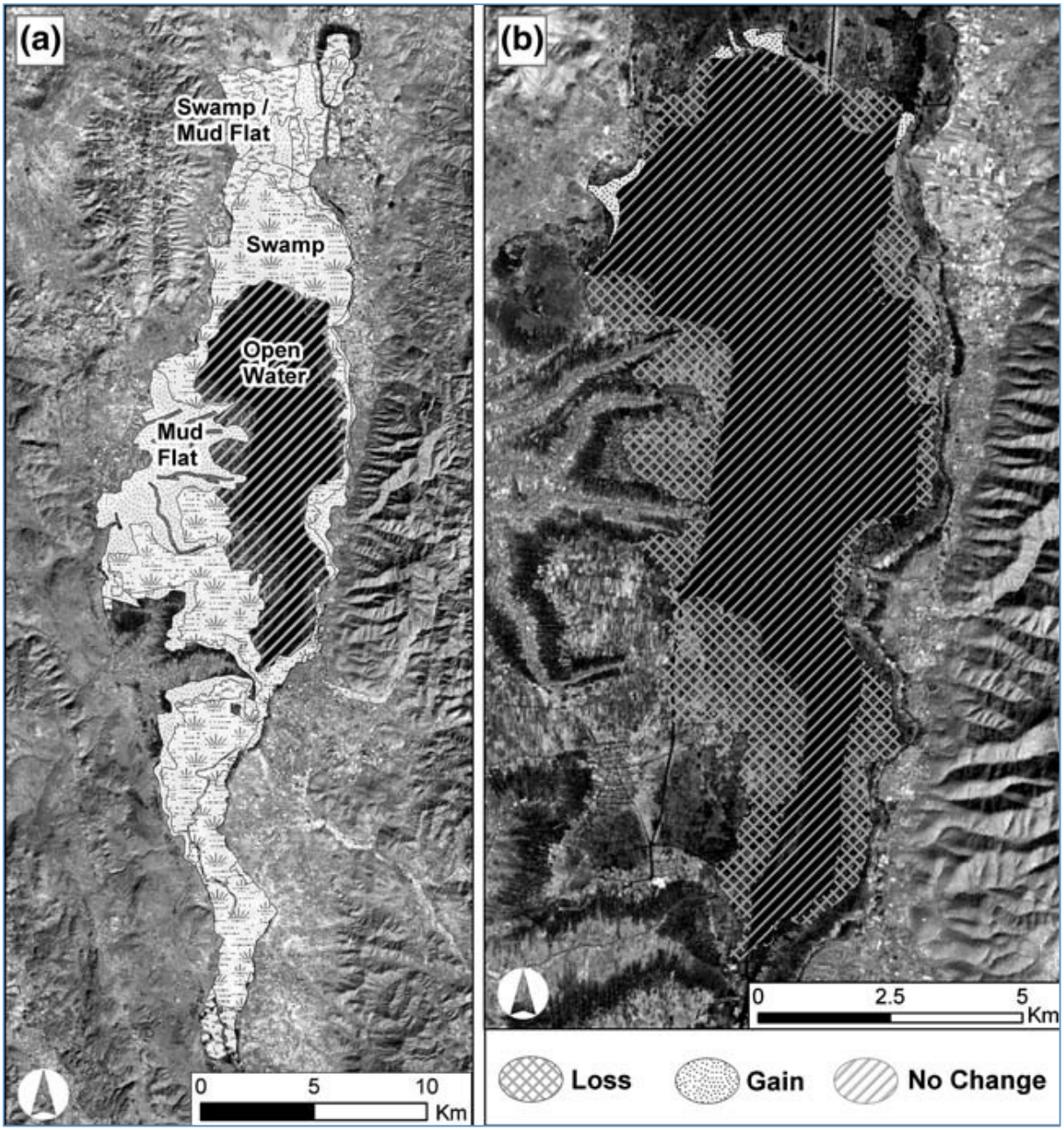


Figure 11 Comparison of open water area in 1935 and 2000, showing 42.6% reduction mainly due to expansion of floating gardens around lake edges and major deltas on western coastal plains (source: Sidle *et al.*, 2007)

Inlay Region Climate

The seasons at Inlay Lake are characterised by the cold dry winter season from November to February, the hot dry summer season from March to May, and the rainy season (June to October) (IID, 2012a; Figure 12).

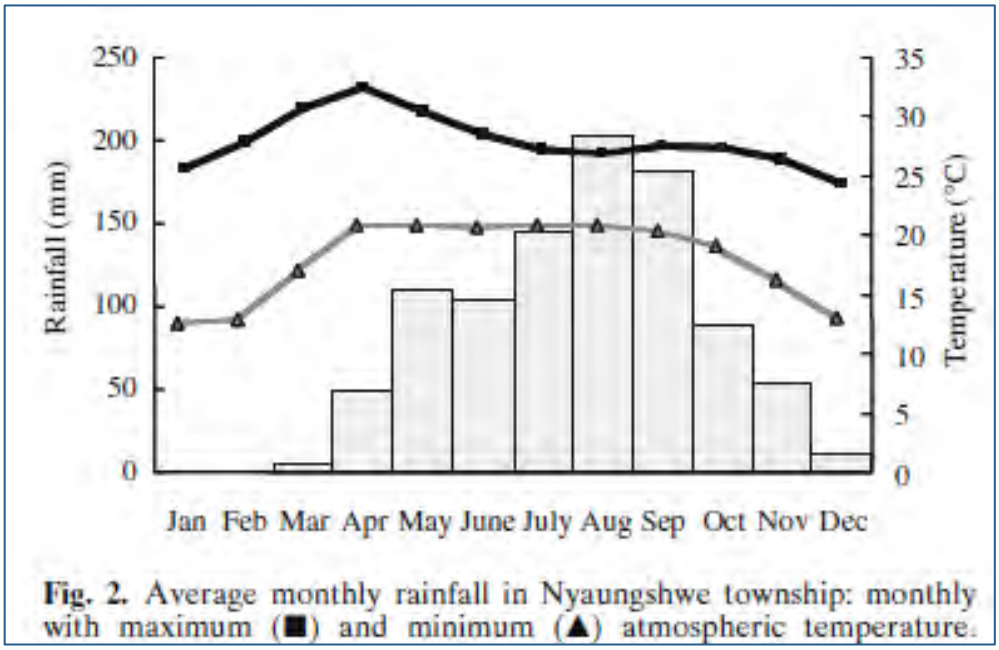


Figure 12 Seasonal cycles of rainfall and temperature for Inlay Lake (Source: Figure 2 Akaishi, 2006)

Predicted Effects of Climate Change

Predictions of the effects of climate change for Myanmar indicate rising temperatures and reduced rainfall, with later onset and shorter duration of the annual monsoon systems (Tun Lwin, 2010; Figure 13). Specific predictions are not available for the Inlay Lake region, but the increased probability of droughts such as that experienced in 2010, as well as shorter more intensive rain events, should be anticipated in future planning and management of water resources.

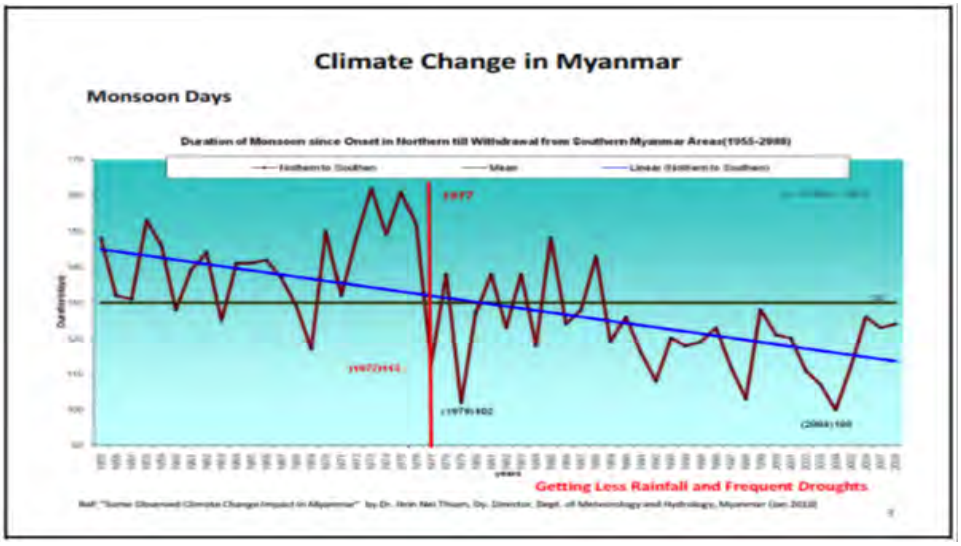


Figure 13 Predictions for the effects of climate change on Myanmar (source: Dr Tun Lwin, 2010)

Environmental Assessment and Issues

The ecosystem of Inlay Lake watershed provides a range of environmental services which support local communities and the products which create the tourism destination of the Inlay Lake region. The Inlay Lake ecosystem needs to be in a healthy state to sustain provision of ecosystem services and to support dependent communities. The many benefits include drinking water, fish resources, water for agricultural use, and resources for operation of floating gardens (Figure 15).

It is critical to understand the current state of health of the Inlay Lake ecosystem, the key threats to its well-being, and to design management actions needed to protect its health into the future.

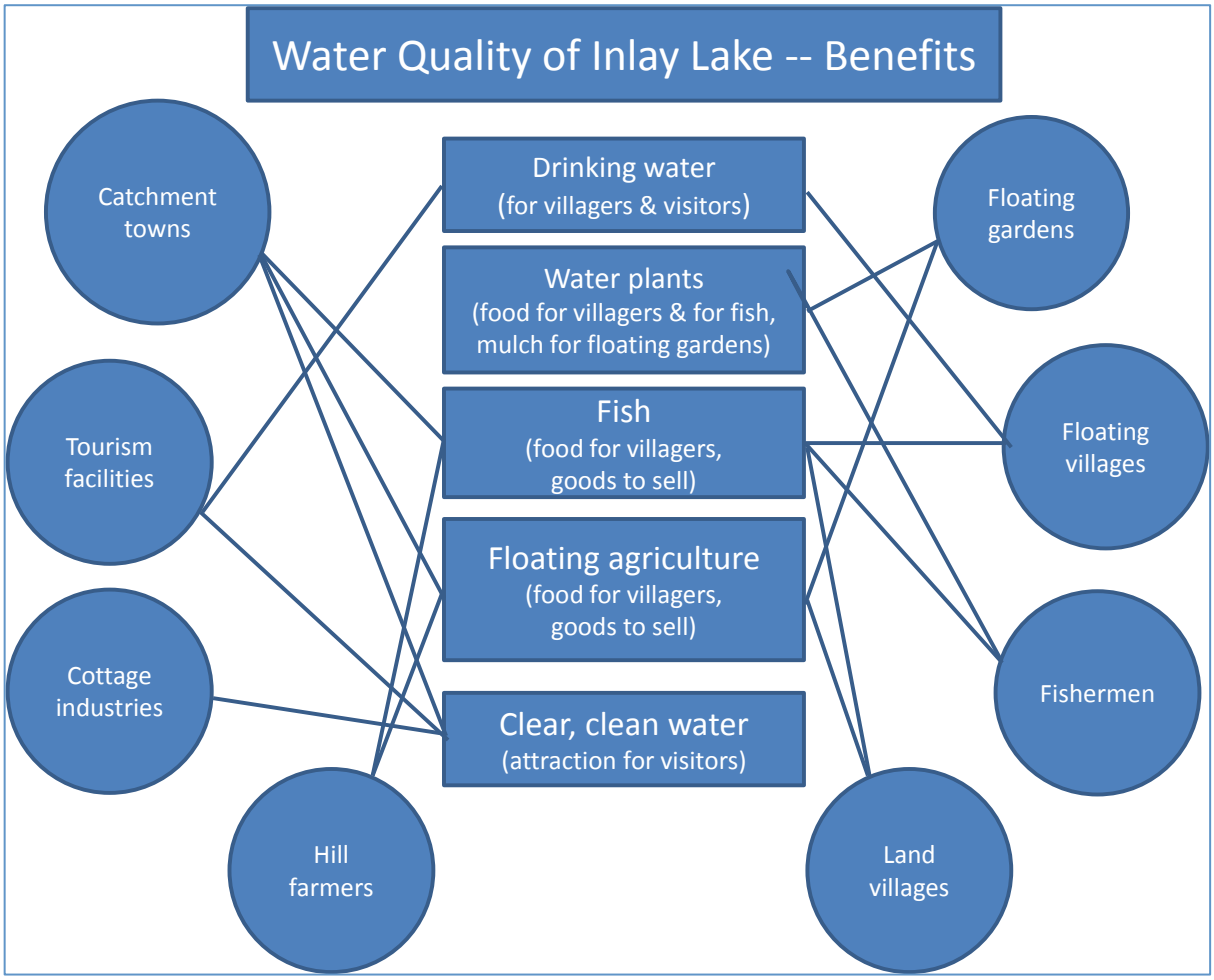


Figure 14 Inlay Lake provides a range of resources for all community groups in the region

Ecological Principles

The four laws of ecology provide a useful summary of ecosystem principles which apply to Inlay Lake and its watershed (Figure 14). They are a good reminder of the linkages throughout the watershed, with water flowing downhill to the lake, and the consequences of interfering with natural systems. In particular, there is a cost for taking resources from the ecosystem, such as harvesting water plants, or using the streams and marshes as a free dumping ground for waste, particularly plastics. 'Out of sight' does not mean that there are no downstream effects on water quality or quantity or ecosystem health, and this applies particularly to hanging latrines in floating villages which dump raw sewage directly into the lake.

Sustainable management for Inlay Lake needs to take account of these linkages and consequences, to ensure that the Lake remains healthy enough to support dependent communities.

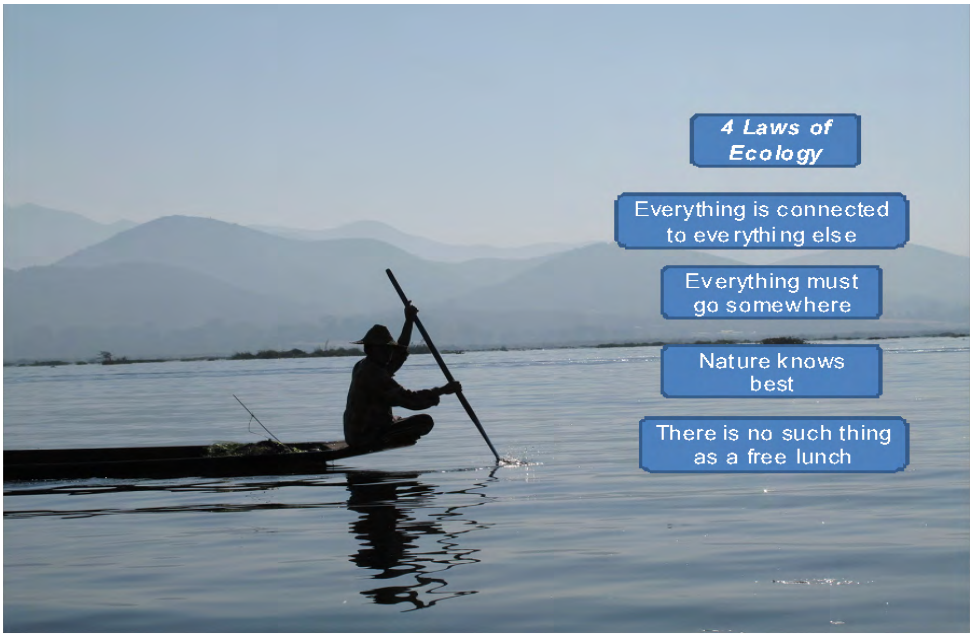


Figure 15 **The four laws of ecology) emphasise the linkages in ecosystems and the consequences of pollution and damage to natural resources (Cominer 1976).**

Environmental Values

Inlay Lake combines rich historic and cultural values with significant environmental values due to its high biodiversity and invaluable ecosystem services. The special environmental features of Inlay Lake include:

- clear water, shallow lake, available light supports 2-3 m tall dense forests of water plants (*locally called algae*) which critical as the basis for the lake food chain
- a relatively rapid turn-over of lake water (3-4 months)
- the unique geology and high natural alkalinity gives the water special qualities and creates the habitat for the unique community of lake species
- a high number of species are only found in Inlay Lake (endemic species)
- extensive marshes surround the open water of the Lake provide key sites for migratory birds, as well as filtering water entering the lake
- high value peat deposits in and around Inlay Lake are of international conservation importance.

Lake Environmental Services and Linkages to Tourism Products

The ecosystem services of Inlay Lake support local communities as well as the tourism industry. Sustaining a healthy lake and watershed will sustain lake communities and their livelihoods, as well as providing the fundamental elements of the tourism destination product. The ecosystem services provided by Inlay Lake and its watershed cover the staple requirements of food, fibre, water, shelter and fuel (Table 1).

The Inlay region is rich in biodiversity, as indicated by the high numbers of species of plants, birds and fish, and its value as habitat for threatened and endangered species. It also has a high degree of endemism in its species. The forests in the watershed provide important habitat for many plant and animal species (IID, 2012a). Inlay Lake would meet the criteria for listing as a wetland of international importance under the Ramsar convention because of the high numbers of migratory waterbirds visiting the lake *en route* between Siberia and Australia (Jensen, 2012).

Inlay Lake provides several ecosystem services on which local people depend directly or indirectly. Some of these ecosystem services are more obvious, such as water resources for domestic purposes and agricultural practices for local inhabitants, especially in hydroponics farming (floating garden cultivation) and irrigation of rice paddies and sugar (IID, 2012a). Aquatic plants in the lake provide habitat for macro-invertebrates, amphibians and juvenile fish, and filter pollutants and nutrients from the water (Table 1).

Many of these services are taken for granted and not protected or maintained, and there is a significant risk of degradation and loss of the fundamental services which are supporting livelihoods and social values (IID, 2012a). The Lake is under increasing pressure from use of its resources by local residents and increasing numbers of visitors. Forest resources have been depleted greatly since the 18th century and are still being degraded by unsustainable harvesting of forest products. Land use pressures are causing increasing erosion and movement of sediments onto the lake delta zones and marshes, with some flowing into the lake in wet season inflows and reducing water clarity. Protection of biodiversity values and the lake watershed ecosystem is an investment in future ecosystem services like water quality and quantity, flood protection, fish stocks, recreation and tourism industries, control of algal blooms, and human health.

A healthy ecosystem provides social and economic benefits, so there is a need to protect lake and catchment ecosystem services to support local communities and base for tourism. In summary the ecosystem services provided by Inlay Lake and its watershed include:

- clean air
- clean water
- cooler climate
- tranquillity and serenity
- fish stocks
- ecotourism resources and tourism destinations
- sustainable livelihoods and community support
- ecosystem goods, food, fibre, timber
- biodiversity conservation
- water filtration
- carbon mitigation
- peat formation
- part of water supply system for hydropower plant
- transport.

Inlay Lake Ecosystem Services		
PROVISIONING SERVICES		
1	Food (e.g. fish, game, fruit)	Fish (Inlay carp, tilapia, other fish species), fish aquaculture (grass carp), rice crops, maize, eggplant, tomatoes, other vegetables in floating island agriculture and on coastal plain deltas
2	Water (e.g. for drinking, irrigation, cooling)	Drinking water (springs), washing, cooking, stock, watering crops (rice), small industries, boat transport, communication for lake villages
3	Raw Materials (e.g. fiber, timber, fuel wood, fodder, fertilizer)	Lotus stems, cooking fuel, bamboo, hornwort & chara for natural mulch on tomato beds, kaing marsh for floating agriculture beds
4	Genetic resources (e.g. for crop-improvement and medicinal purposes)	unknown
5	Medicinal resources (e.g. biochemical products, models & test-organisms)	Unknown, neem leaf extract for control of pests
6	Ornamental resources (e.g. artisan work, decorative plants, pet animals, fashion)	Lotus weaving, blacksmith, silversmith, weaving, markets
REGULATING SERVICES		
7	Air quality regulation (e.g. capturing (fine) dust, chemicals, etc)	Clean air in dry season
8	Climate regulation (including carbon sequestration, influence of vegetation on rainfall, etc.)	Evapotranspiration from lake surface linked to rainfall cycle, carbon sequestered in marshes and forests, peat formation, cooling effect on temperature
9	Moderation of extreme events (e.g. storm protection and flood prevention)	Rise of water levels in rainy season buffers flood flows
10	Regulation of water flows (e.g. natural drainage, irrigation and drought prevention)	Natural water storage, secure supply in normal rainfall years, irrigation supply in watershed
11	Waste treatment (especially water purification)	Clear water in main lake, filtration of nutrients entering water, sediment retention in marshes, uptake of nutrients into water plants
12	Erosion prevention	Natural vegetation cover stabilizes soils on slopes and higher altitudes of watershed, marshes in riparian zones retain sediment and dampen waves
13	Maintenance of soil fertility (incl. soil formation)	sediment movement downslope supplies new soils and nutrients to agriculture on lakeside plains in delta zones
14	Pollination	Unknown, assumed necessary for native plants and some crops, provided by birds and bees

15	Biological control (e.g. seed dispersal, pest and disease control)	Potential pest control from waterbirds visiting lake, eg glossy ibis will take beetles from irrigated fields
HABITAT SERVICES		
16	Maintenance of life cycles of migratory species (incl. nursery service)	Nursery areas for fish, frogs, turtles in shallow edge zones and marshes, staging post and feeding zone on East Asia-Australasian flyway from Siberia to Australia for migratory waterbirds
17	Maintenance of genetic diversity (especially in gene pool protection)	High diversity, high degree of endemism in species, need to maintain habitat for threatened and vulnerable species
CULTURAL & AMENITY SERVICES		
18	Aesthetic information	Especially beautiful location, famous for recreation and serenity, one of four key tourism destinations in Myanmar
19	Opportunities for recreation & tourism	Well-known tourist destination with multiple attractions for visitors, minimum stay 2 days. Cool climate is in itself a reason to visit, especially in periods where lowland weather patterns are not conducive to tourism
20	Inspiration for culture, art and design	Exceptional cultural sites, with pagodas, stupas, regional markets, festivals and handicrafts. A variety of ethnic minorities present, adding to cultural diversity
21	Spiritual experience	Site for pilgrimage to primary religious sites for domestic as well as international visitors; various annual festivals add to Inlay's popularity
22	Information for cognitive development	Development of Inlay Lake story, history and values, promotion of value to local, national and international community

Table 1 Ecosystem services derived from Inlay Lake (IID, 2012a)

Figure 16 **Tomatoes growing in floating gardens on Inlay Lake**

Environmental Threats and Opportunities for Inlay Lake and Hill Areas

Environmental degradation is the most significant threat to the long term sustainability of the lake, with impacts originating from a variety of sources. Increasing tourism pressures are part of the threats, but also offer opportunities for sustainable management of the environmental services provided by the Lake and its watershed.

Inlay Lake is under major threat – the lake could become an ecological catastrophe with turbid water, nuisance algae, polluted air, no native water plants, no native fish, very little open water, extensive water hyacinth mats and nuisance snails (Figure 18). There are already many signs that the balance is tipping towards catastrophe, with rubbish, polluted water, disappearing native fish, disappearing native water plants, invasive species and nuisance algae around villages.

Without a healthy lake, local communities will not thrive and the attraction of the Inlay Lake region as a tourism destination will decline. Action can be taken now to ensure more open water, clean water, clean air, healthy water plants and healthy fish stocks, so that local communities and tourism development will thrive.

Threats to Ecosystem Values

The water quality and clarity of the lake is a primary indicator of its health, and also the basis of its attraction as a tourism destination. Another key indicator of the health of the lake is the presence of dense thickets of native water plant species growing in the clear lake water. As the lake is fresh and shallow, it can support dense underwater stands of aquatic macrophytes and giant algae. Light infiltrates to the lake bed through the clear water, and there is minimal variation in water temperature.

The presence and abundance of key species like coontail (*Ceratophyllum dimersum*), musk grass and pondweed (*Potomageton crispus*) is one of the first signs of a healthy lake ecosystem (Figure 17; Jensen, 2012). The value of these communities as the essential basis of the food chain in the Lake is not being recognised by stakeholders, and the health of these essential plant communities is not being protected. They are being seriously disturbed by harvesting for use as mulch in floating gardens.

The decline of native aquatic plant communities is a serious issue (IID, 2012a). It is clear that the balance in the plant communities is seriously disturbed, with harvesting for mulch a contributing factor. It is a top priority to take protective action to maintain the native aquatic vegetation communities. A healthy functioning ecosystem in Inlay Lake can reduce eutrophication, prevent water pollution, maintain water clarity and provide habitat for native fish.

Figure 17
healthy native water plants growing in the centre of Inlay Lake

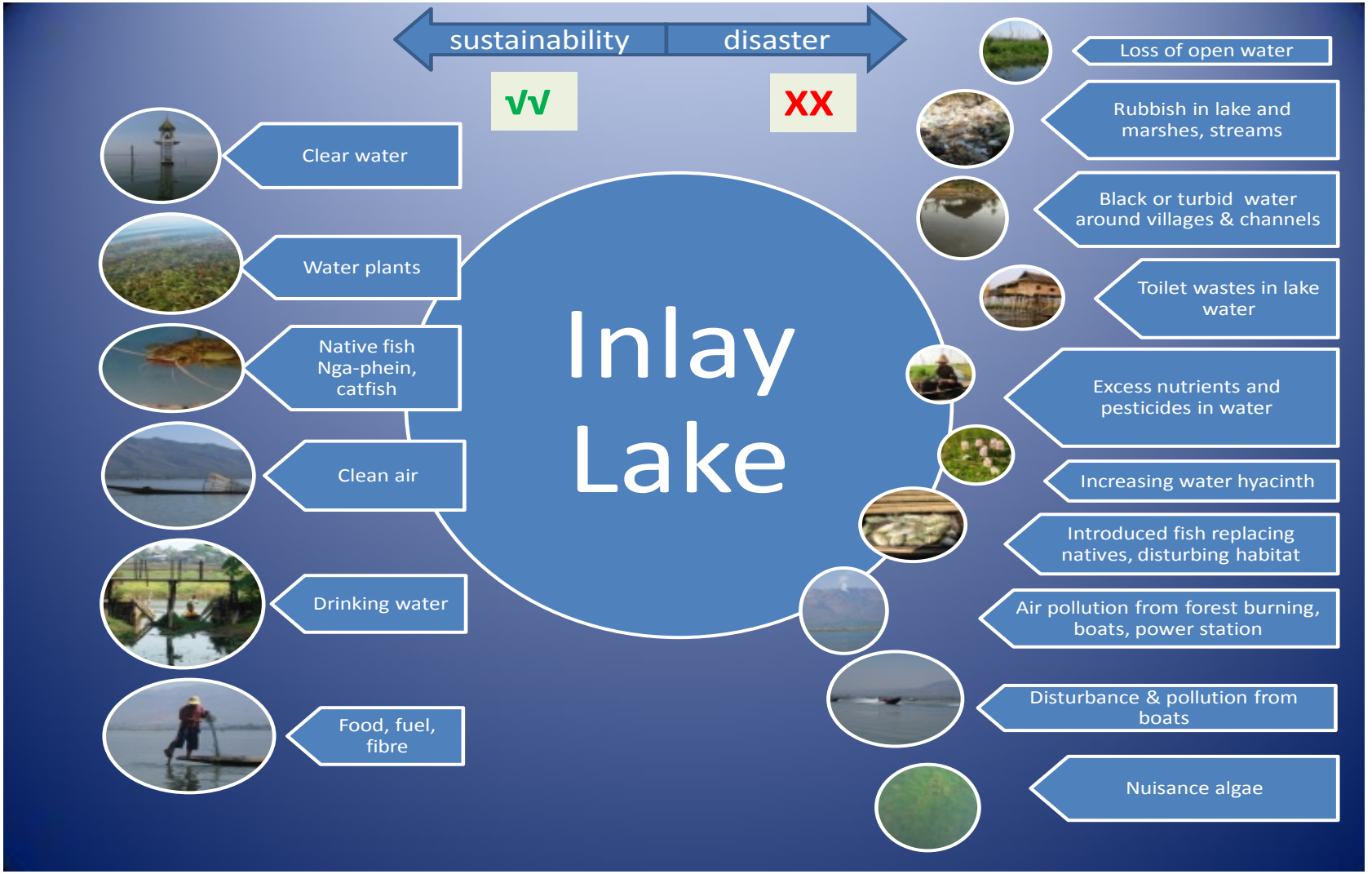


Figure 18 Without active intervention, Inlay Lake could become an ecological catastrophe with turbid water, nuisance algae, polluted air, no native water plants, no native fish, very little open water, extensive water hyacinth mats and nuisance snails

Key Environmental Threats

The *Inlay Lake Conservation Project* (IID, 2012a) identified the following key threats to the health of Inlay Lake:

- surface area of open water reducing due to floating gardens (32.4% surface area lost from 1936 to 2000)
- over-harvesting of key water plants, leading to native water plant communities and fish stocks declining, and threatening the lake food chain
- bacterial pollution due to poor sanitation (>60,000 people live over water around the lake)
- shading of water column and lake bed by water hyacinth and floating gardens
- increased nutrient levels in water
- increased mobilisation of silt out of deltas into lake littoral zones
- land use changes and forest degradation in erosion 'hotspots' causing sediment flow onto deltas and marshes (hills only 30% forested, only 6% dense healthy canopies).
- loss of fringing marshes, conversion to floating gardens
- over-fishing of native fish species, including loss of native fish (Nga-Phein)
- disturbance of fish nursery areas and bird feeding zones by fishermen beating the water, boat traffic and noise.
- increasing fish biomass of introduced species, eg *Tilape,* common carp, and danger of hydridisation of native fish species with introduced species
- impacts of increasing boat traffic (pollution, disturbance, oil and fuel spills).

The ecosystem values of Inlay Lake are under threat from a combination of processes, including:

- loss of habitat, including fringing marshes and clear open water column
- reduced recruitment of key species
- over-harvesting of key water plants reducing habitat and food sources
- over-fishing of native fish species
- increased nutrient levels in water from toilet wastes and fertilisers
- pesticides entering lake water from floating gardens
- invasive snails damaging rice and tomato crops, with unknown effects on native species
- land use changes and forest degradation in erosion 'hotspots' causing sediment flow onto deltas and marshes
- increased mobilisation of silt out of deltas into lake littoral zones
- unknown effect of check dams and silt barriers on fish migrations and spawning
- changed conditions favouring introduced competing species, eg *Tilapea*
- danger of hydridisation of fish species with introduced species
- disturbance of fish nursery areas and bird feeding zones by fishermen beating the water, boat traffic, oil spills and noise
- rubbish being discarded in riparian zones and on floating islands.

Active intervention is required to reduce and control the threats and reverse the threatening processes. There are already signs of serious decline in the ecological health of Inlay Lake, as indicated by the red lines in Figures 19 & 20.

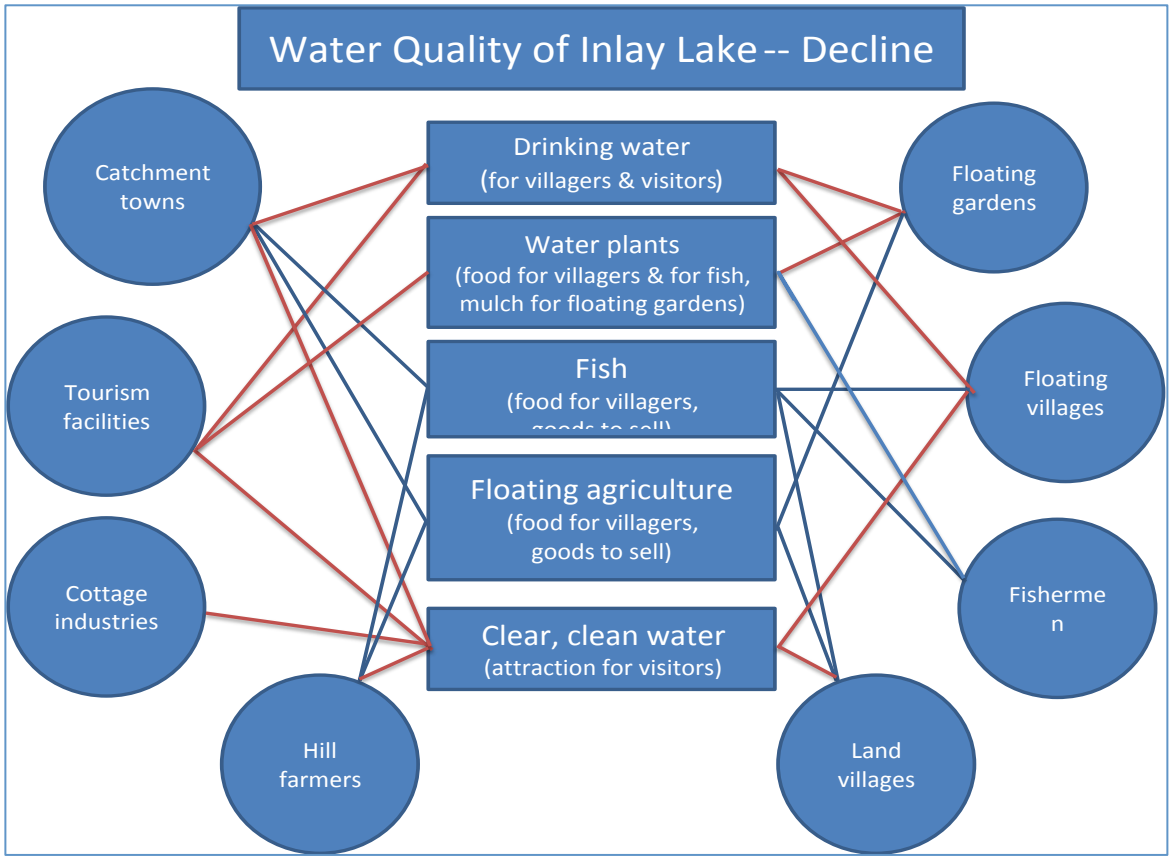


Figure 19 Negative impacts from different user groups on the health of the Inlay Lake ecosystem are shown by red lines, emphasizing the complicated interactions between sources and resulting condition

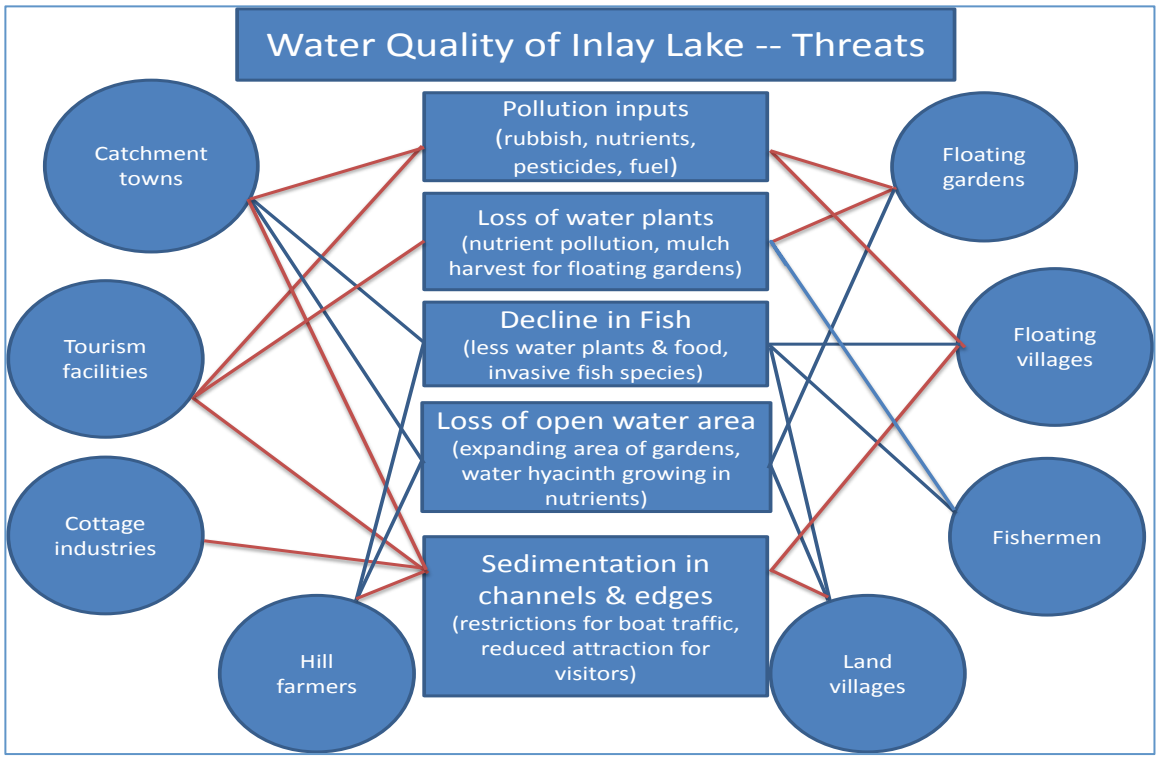


Figure 20 Threats to ecosystem health in Inlay Lake come from a combination of sources and result in a range of negative effects on the lake, which in turn reduce environmental services from the lake

Opportunities for Sustainable Management

Expanding tourism offers opportunities for better management of pressures on Inlay Lake.

Tourism products need to support conservation of Inlay region, including:

- keeping native water plant (large '*algae*') communities healthy
- keeping water clear and clean
- increasing area of open surface water
- maintaining native fish and birds
- improving air quality
- supporting livelihoods of local communities
- maintaining and promoting local culture.

The key issues are summarised below, followed by recommendations for priority actions as part of sustainable tourism management to secure the ecosystem base for the tourism industry.

Causes of Reduced Lake Surface Area

The priority issue for lake health is the reducing area of open water at Inlay Lake (IID, 2012a). The primary causes of reduced lake surface area are the expansion of floating garden agriculture, and the expansion of floating mats of water hyacinth. Wild islands are a minor contributor to the problem.

Floating Agriculture

The loss of open water has been quantified as 32.4% reduction in area from 1935 to 2000, with the primary cause being expansion of floating island agriculture (Figure 11; Sidle *et al.* 2007). About 93% of the recent loss in open water area of the lake is due to the development of the floating garden agriculture, largely along the west side of the lake adjacent to the deltas of Kalaw Chaung and Inndein Chaung.

Floating gardens have expanded by 500% from 1992 to 2009, from 1434 acres to 7278 acres (Figure 21; San San Ye, 2010). While floating gardens were only 5.7% of agricultural production and 2% of area used in the watershed, they covered 38 km^2 or 23% of the water surface area of Inlay Lake by 2007 (Ngwe Sint & Catalan, 2000). The area of greatest concern is at the southern end of the lake, where floating gardens cover more than half the original width of open water. In particular, the area east of the main north-south boat channel to the Phaung Daw Oo pagoda forms a very large continuous island covering the southern lake surface (Figure 22).

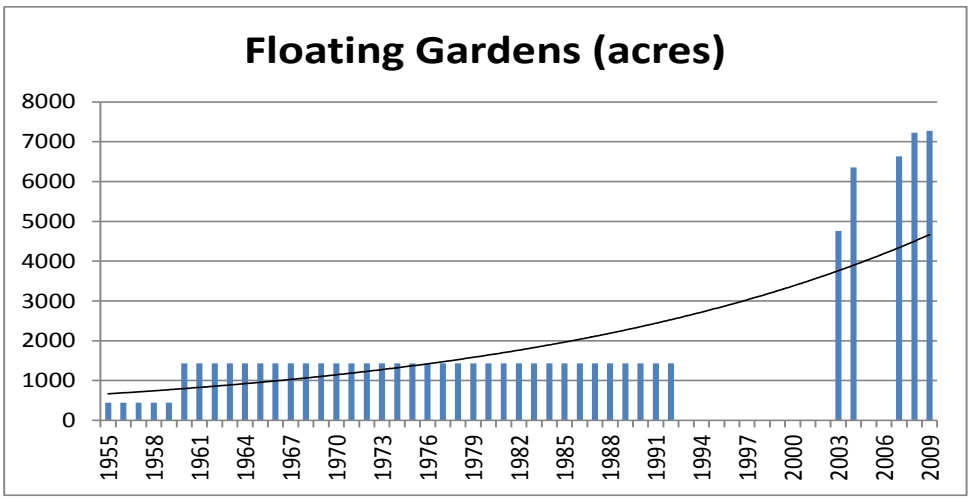
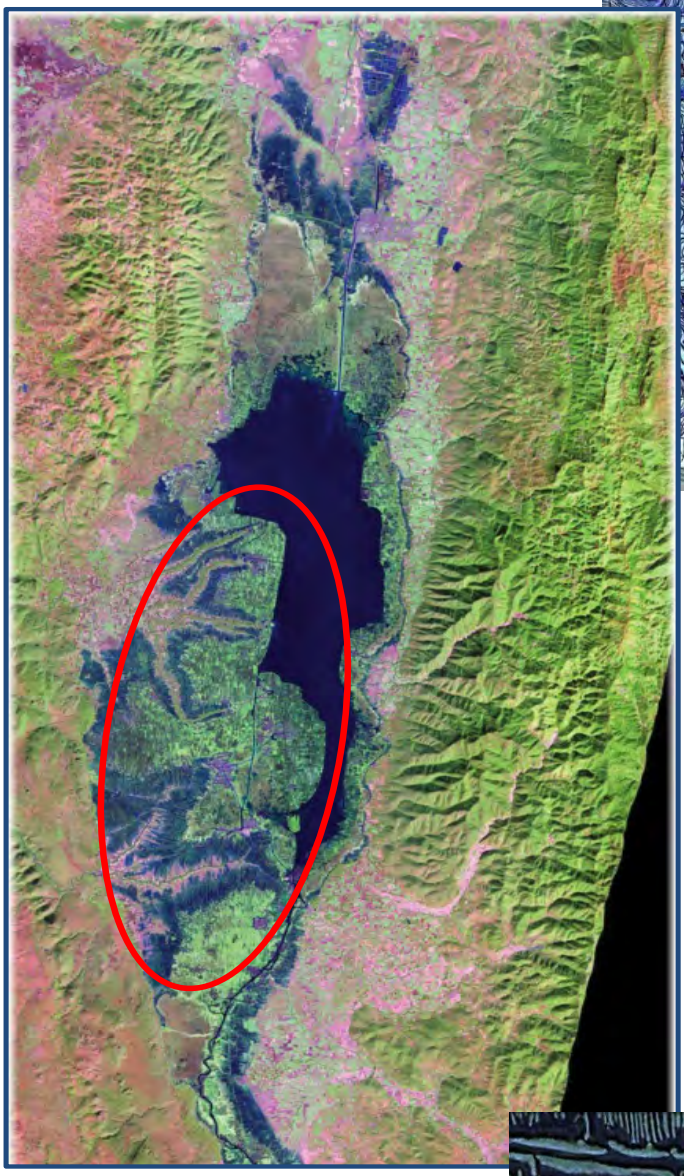


Figure 21 Significant increase in area of floating gardens producing tomatoes 1955-2009 (San San Ye, 2010)



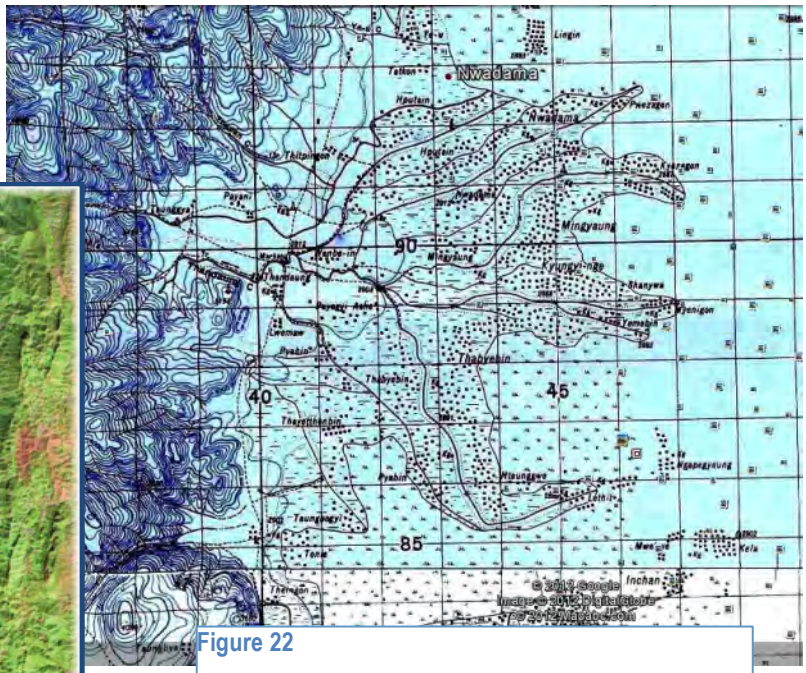
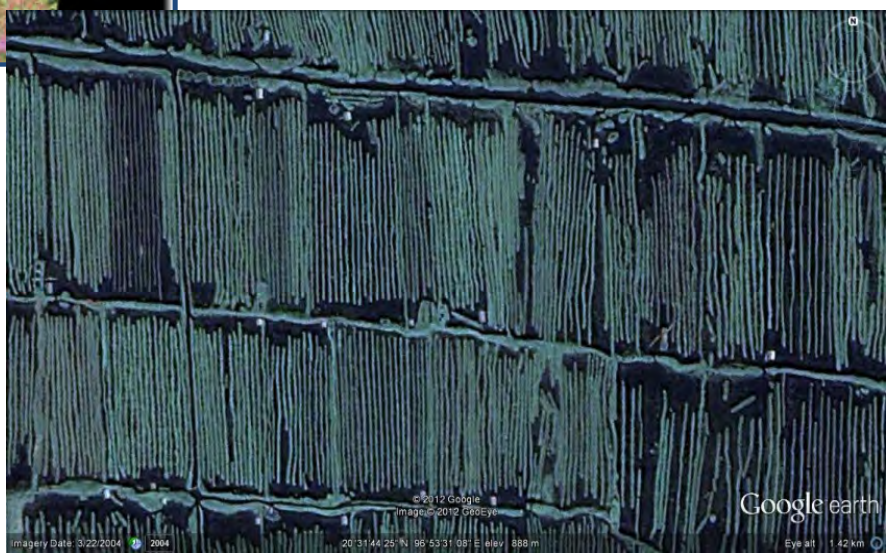


Figure 22

Kalaw Delta as mapped in 1936, had its earth 'fingers' extending into open water

Extensive infill by floating gardens had occurred by 2010, extending out into the open water of the lake (red circle on colour-corrected satellite image);

Detail of floating island farms in the same area, with 100 m x 2 m strips of marsh beds in parallel lines between navigation channels (from Google Earth satellite image)



Water Hyacinth

The expansion of the introduced water hyacinth is supported by artificial nutrients added to the lake from excessive use of nutrients in floating garden agriculture. Water hyacinth, *Eichhornia crassipes*, is a native of South America from the upper Amazon catchment, and is one of the world's worst aquatic weeds. It forms dense mats that clog waterways and make them useless for navigation and other uses (Figure 23; CSIRO, 2011).

This pest plant is reported to have been introduced to Inlay Lake as an ornamental plant in the 1950s (Myo Su, pers comm, 2012). It has spread rapidly on the lake surface due to abundant nutrients from floating garden agriculture, as well as warm temperatures and the available open space on the lake surface.

Impacts from water hyacinth in Inlay Lake include blockage of boat transport, interference with water supply, accumulation around villages and structures, and increased breeding of mosquitoes. The dense plant mass shades and deoxygenates the water, blocks light penetration into the water column, reduces nutrients for young fish, reduces fish stocks and interrupts fishing. The water hyacinth mats create conditions that favour breeding of vectors for disease (Julien *et al.,* 2001).

The feasibility of biological control of water hyacinth at Inlay Lake has been investigated with CSIRO Australia (IID, 2012b). It is anticipated that more than 80% of water hyacinth biomass could be removed from Inlay Lake in 3-5 years, using local expertise and community involvement to breed and spread weevils, and to monitor and report progress. Not all hyacinth plants would be removed, so there would still be a resource for the limited use of this species by farmers and the furniture industry.

In order to generate support for a water hyacinth control project, it is recommended that a party of community and government representatives should visit Phayao Lake in northern Thailand, where water hyacinth has been successfully controlled.

Figure 23 **Water hyacinth flowering (left) and farmers collecting water hyacinth for mulch (right) because they could not find enough of the preferred *Nitella***

Perspective on Sedimentation Issues

There is a general perception that Inlay Lake is filling with silt, and this is frequently repeated with warnings that Inlay Lake is another Aral Sea-type situation. It is important to understand that this is not the case, and the data do not support this view (IID, 2012a; Michalon, 2014).

The community perception of the connection between hillside erosion and sedimentation in the lake was fuelled by the severe drought conditions in 2010, which led to extremely low water levels in the lake and left many villages stranded and navigation channels too shallow for boat passage. Severe droughts in 1988 and 1998 had similar impacts. Comparisons with the drying of the Aral Sea have been repeated in the press, but without supporting evidence. The situation at Inlay Lake does not compare with the Aral Sea, as the volumes flowing into the lake are not being significantly reduced by upstream diversions.

The actual situation is more complex and understanding this complexity is important as a basis for finding effective management solutions for Inlay Lake. While the main lake is not filling with sediment, a shallowing effect is occurring around the edges of the lake, near floating gardens, under floating villages, in river mouths and in navigation channels.

The extent of sedimentation processes was examined in an extensive study in 2005-2007, which assessed the rates of sediment flow through sub-catchments, and identified 'hot spots' where accelerated erosion contributes the highest proportion of sediment moving downstream through the watershed (Furuichi, 2008). It was found that almost all of the silt is stored in the deltas and marshes, and only 1% is deposited in the main body of the lake (Table 2).

The fine clay silt drops out as it reaches deeper water in the main lake, with 12% collecting in river mouths. During the wet season, distinctive plumes of silt-laden water can be seen, with pale yellow silt issuing from the Namlet Chaung, while the Thandaung Chaung is the red of 'terra rossa' soils, and the Inndein Chaung is a rich brown-red (Figures 24 & 27). Localised sedimentation is occurring in the river mouths of Inndein delta and the Namlet Chaung.

Deposition of sediment occurs in the near-shore zones, not in the deeper sections of the lake (Figures 25 & 26). The rate of sedimentation at the lake margins is causing social and economic problems, as well as potential ecological problems for the lake ecosystem where silty water reduces the amount of light reaching water plants.

Navigation channels are maintained through the delta areas to connect the many lake villages to land. Channels are cut through the deposited silts, allowing boat traffic to pass exposed earth banks, with waves from boat wash re-suspending sediments and carrying them directly to the lake. Increasing population on and around the lake, as well as increasing tourism, has led to significant increases in boat traffic, exacerbating this re-suspension of silt into the water. This occurs particularly in boat channels around Ywama and the Phaung Daw Oo pagoda.

Activity in villages is also constantly accumulating silt in the lakeside zones as villagers seek to create a small patch of land under their houses to grow vegetables and keep a small number of livestock. Farmers of floating gardens have difficulties in keeping their garden beds afloat if lake levels drop, as silt accumulates under the gardens. Other sediments accumulate from rubbish and nutrient deposition below villages and gardens.

Actions to control sediment flows should focus on erosion 'hot spots' in the watershed, and locations where silt accumulates in boat channels. Any dredging in marshes should be very carefully managed, in order not to disturb the natural processes which retain sediments and filter water entering the lake.

Location	% silt stored
Delta soils	62%
Marshes	20%
River mouths	12%
Outflow	5%
Lake	1%

Table 2 Distribution of silt flowing from highlands in the Inlay Lake watershed shows most soils are trapped in the deltas and marshes, with almost no sediment settling in the lake basin (Source: Furuichi, 2008)

Figure 24 Yellow silt has been washed off unsecured earthern banks by boat traffic around Ywama – it is not coming from the higher catchment

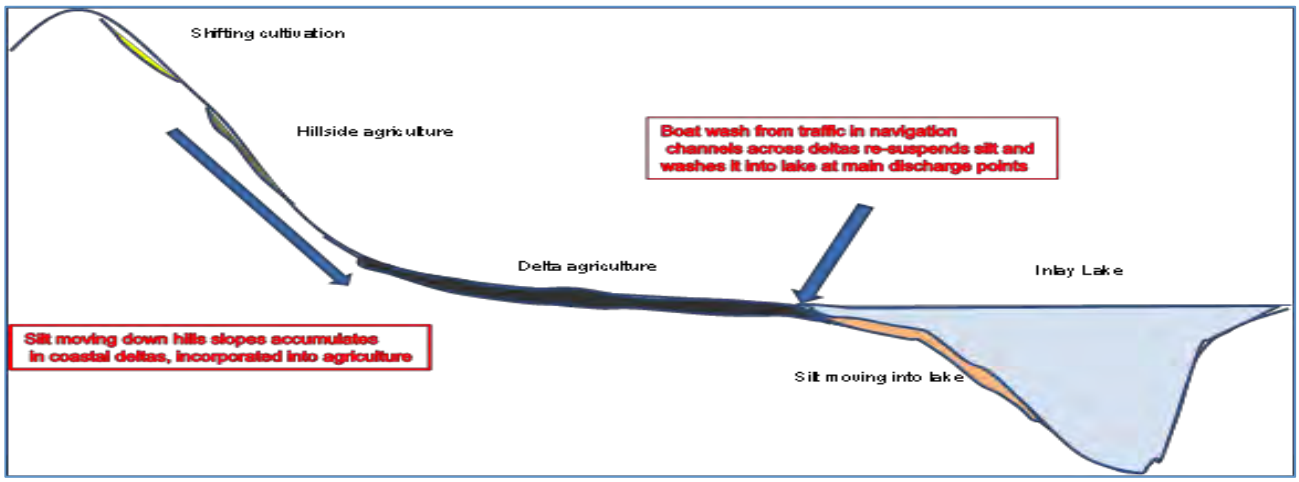


Figure 25 Diagram showing sedimentation processes which result in deposition of silt onto lake edges. Note that this diagram is not to scale, in order to show the processes (see Fig. 4.8). Inlay Lake is shallow and located in a flat-bottomed valley 10 km wide at the widest point.

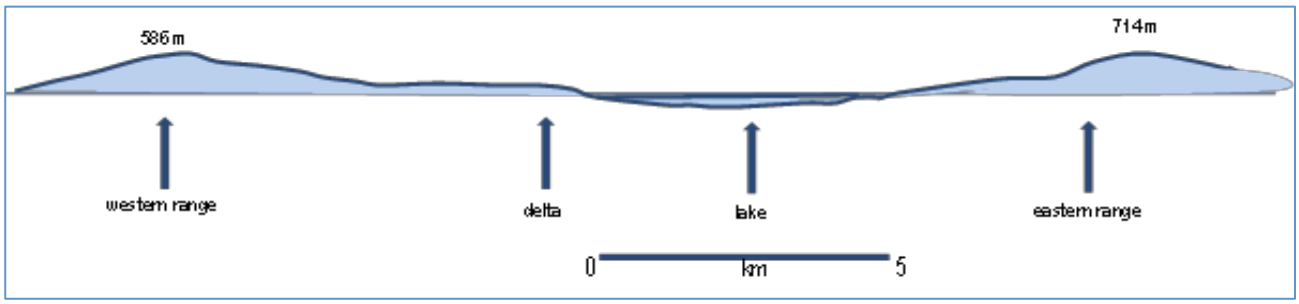
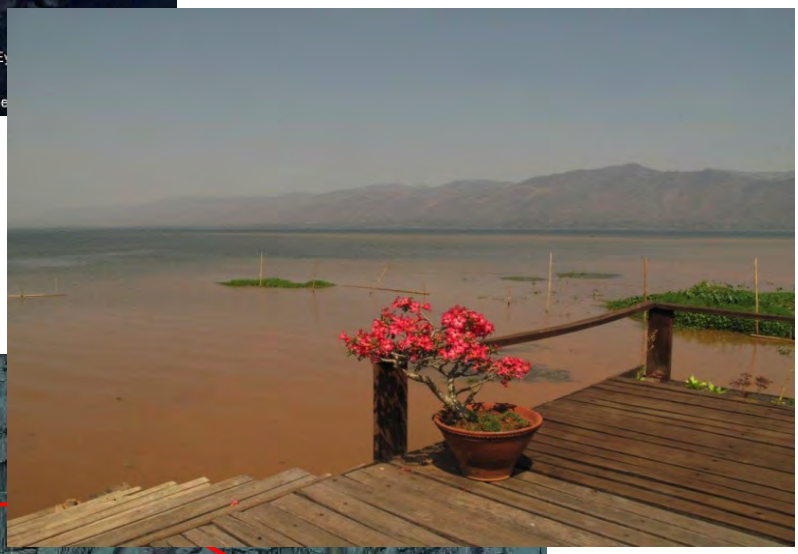


Figure 26 West-east cross-section diagram showing relative width and depth of Inlay Lake, width of delta and height of bordering ranges. Note that relative depth and height scales are not to scale, as the maximum lake depth of 6 m is only 1% of the height of surrounding ranges on average 586 m and 714 m high. The horizontal axis is to scale.

Figure 27 Silt plume of red terra rossa soils flowing into the lake from Thandaung Chaung (Kalaw Delta) is from lakeside soils stirred up by boat wash – the stream was dry in March 2012, so this silt is not actively flowing down from erosion on the hills



Project to Re-meander Namlet Chaung

It is recommended that a project be developed to re-meander Namlet Chaung, to intercept silt transport into the northern end of Inlay Lake, and to restore wetland habitat in the marshes. A feasibility study should be conducted to develop a suitable design, incorporating provision for boat traffic to the lake, while trapping as much sediment as possible. The feasibility study should also consider re-commissioning the historic series of sediment basins in the Namlet Chaung valley.

Prior to construction of the current channel in 1989, Namlet Chaung had no single straight channel into Inlay Lake, instead there were multiple meandering channels where the stream crossed the large marsh at the north end of the lake (Figures 28 & 29). A short channel was constructed in the early 1930s from Nyaung Shwe into the large marsh at the northern end of lake, and linked to several meandering channels to enter the lake.

The current Namlet Channel into Inlay Lake was constructed in 1989, to provide a straighter, more efficient channel for boat traffic and transportation of goods. However, this straight channel facilitates transport of silt into the lake, with waves from boat wash eroding silt from the banks and adding to the sediment load. It also short-circuits flow of water into the marshes, reducing habitat diversity (Figure 30).

The project should evaluate options for re-design of the Namlet Chaung channel, with the primary aim of reducing silt deposits at the mouth of the channel and extending into Inlay Lake (Figure 31). Design options should also support potential benefits in more diverse habitats for wetland species and waterbirds and improved water quality in the northern marshes.

Successful examples of re-engineering channels are available, from the Skjern River in Denmark and the Kissimmee River in Florida, where ecosystems have been able to recover when rivers have been allowed to follow their original meandering paths, with floods allowed to spill onto floodplains (Figure 32).

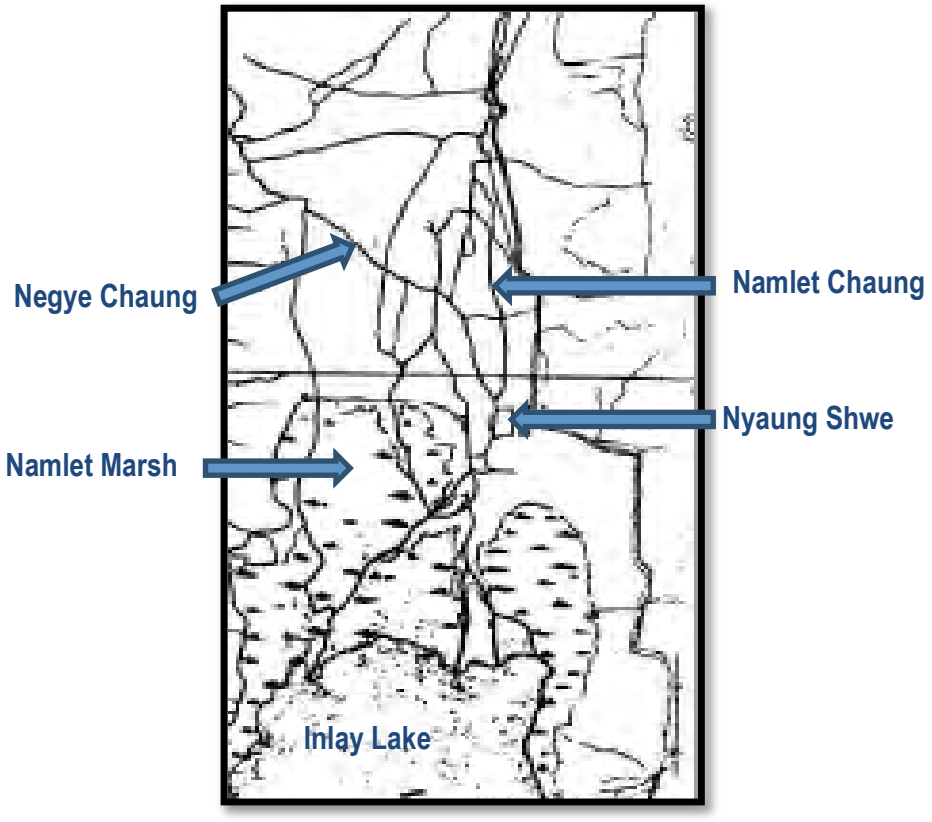


Figure 28
Excerpt from map by Annandale 1918 shows multiple channels through Namlet Marsh connecting Namlet Chaung from Nyaung Shwe to Inlay Lake

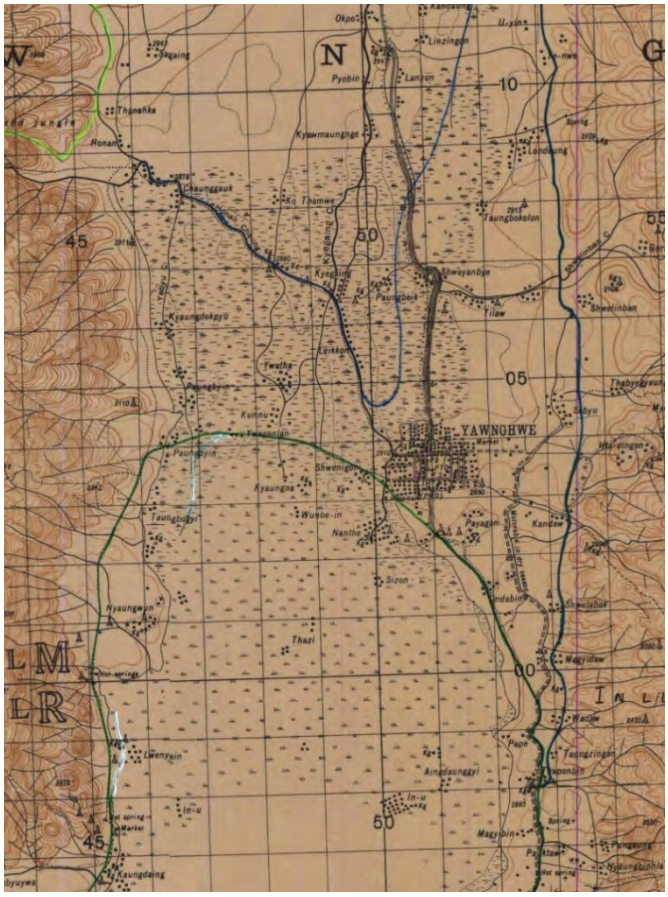


Figure 29
Excerpt from 1936-37 survey map shows short channel extending Namlet Chaung past Nyaung Shwe ending in the marshes, with no specific channel marked entering Inlay Lake (Source: Thura Awng)

Figure 30
Silt plume from Namlet Chaung in November 2013 (Source: Google Earth)

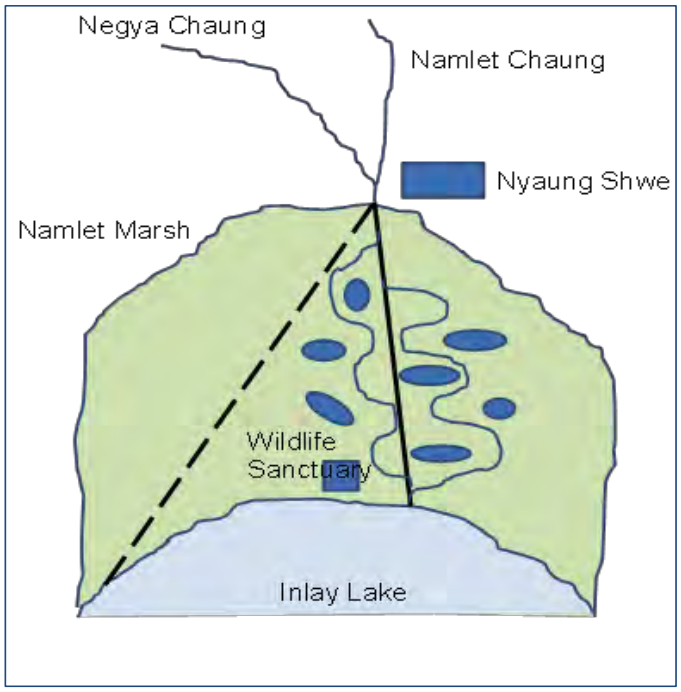


Figure 31
Concept design for re-meandering of Namlet Channel, to create wetland habitat and prevent transport of silt into Inlay Lake

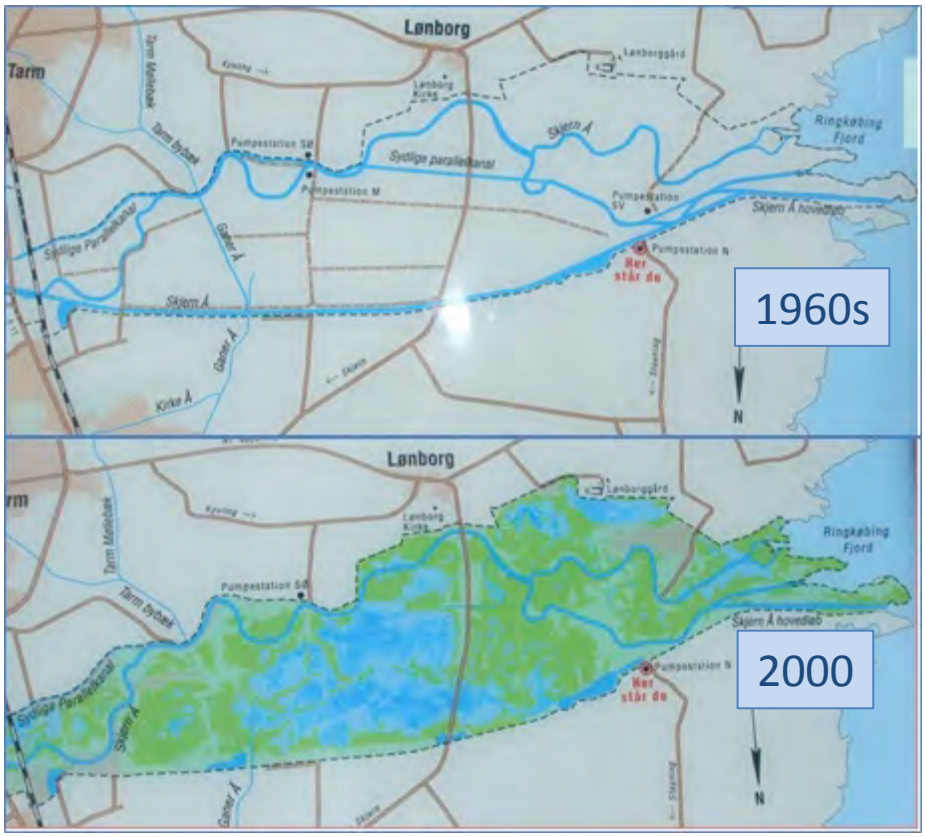


Figure 32 **Re-meandering of water meadows at downstream end of Skjern River in Denmark, showing the channelized system in 1960s (top of figure) and re-meandered system in 2002 (bottom of figure). The re-meandering of Skjern River is Europe's most successful river restoration project.**

Cultural and Social Values of Inlay Lake

A recent investigation of Inlay Lake concluded that the lake is highly anthropomorphized, with key cultural influences through Intha fishing practices and the 5-day inter-ethnic market cycle for exchange of goods across the Inlay watershed and hill areas (Michalon, 2014). Sites of religious importance attract high levels of visitation by domestic and South-East Asian pilgrims (Figure 33).

The dominant ethnic groups settled in the Inlay Lake region are Inthas, Shans, Pa-O and Da-Nu. The population at Inlay Lake is 70% Intha and 15% Shan (Sidle *et al.,* 2007). According to evidence found at the locations Htat Aein Gu and Loo Yoe Taung, human beings would have lived in the Inlay Lake region from the Stone Age (Department of Fisheries, 2010).

The original name of Inlay Lake is based on the first four ('le') villages ('in') found around the present lake area. It is believed that the four villages in the first settlement were Nanpan, Ywagyi Banpon, Naung Taw and Heya Ywama. The name 'Inlay' was derived from these first four villages and expressed as *'Inlay Ywa'* (Thi Dar Win, 1996), but later this changed to 'Inlay'.

The development of villages in the Inlay area has been narrated through generations as folk-tales. King Along Si Thu of 12th century Bagan promoted settlement of the Inlay Lake Region as he toured the country. Many different races and groups followed the King, including the Dawei group who stayed behind to settle there. The Saophalon of Nyaung Shwe, Sao Saipha, granted them the right to stay as lake settlers or *Inthas*. The name 'Intha' can be translated as 'sons of the lake' or 'dwellers on the lake'. Their homes are built on bamboo stilts in the shallow areas of the lake, and all transport and communication is by boat (Thi Dar Win, 1996).

Livelihoods and Traditions

Local inhabitants in Inlay Lake are unique in the way they have adapted their lifestyle and livelihoods to their biophysical environment (Thi Dar Win, 1996). Most of them earn their income by traditional methods of hydroponic farming and fishing. The floating agriculture on the lake and the fisheries provide the villages with food and export opportunities (Saw Mon Theint, 2009).

Intha farmers practice one of the most famous types of agriculture in the world, floating island agriculture, locally called 'Yechan', which is a form of hydroponic farming (Thi Dar Win, 1996). They grow vegetables, especially tomatoes, and fruit on the floating islands. As water is abundant for irrigation and organic matter is naturally enriched in the wild floating mats, crop cultivation on the floating islands is very productive and provides significant economic benefits. Tomatoes, the primary cash crop, comprise about two-thirds of the region's agriculture (Butkus and Myint Su, 2001).

Intha fishermen are famous for their unique leg-rowing style, which enables them to see fish from a greater height, and leaves their hands free to manage the fishing net. They have a particular affinity with the endemic Intha carp species, which is their prime catch species and regarded as having special value in their culture (Ma Thanegi, 2005).

Some Inthas practice small-scale cottage industries such as weaving bags, shawls, longyis, traditional fawn-colored cloth (*Pin-ni*) and weaving lotus cloth *Thingan* (a unique industry, not found anywhere else, until recent expansion into Japan by the daughters of the original weaver). Other cottage industries include handicrafts, silver and goldsmiths, coppersmith and blacksmiths.

Shan people in the Inlay Lake area generally live and earn in a simple pastoral lifestyle. They are devout Buddhists but some believe in traditional spirits (Animists). They also practice agriculture and some of them are traders (Thi Dar Win, 1996).

Pa-O villages are found along the spurs of western and eastern ranges of Inlay Lake. The Pa-O people are Buddhists and they are primarily agriculturalists, although some of them are traders. They practice *taungya* or shifting agriculture[2] and mostly plant cheroot leaves, tea leaves, garlic and potatoes on their farms. Although they mostly live at some distance from the lake on higher slopes, they have good access and communication with the local communities, attending markets which are held every five days at different locations around the lake.

Da-Nu people are mostly found in the western portion of the lake, especially in such villages as Tonle, Khaungtaing, Lwenyein and Kyaw Maung Nge. Although they are mostly Buddhist, the Da-Nu deeply believe in spiritual and supernatural beings. Traditionally, their main occupation was farming but now most of them are traders, especially in textile and other religious goods and wares (Thi Dar Win, 1996).

Lotus Flower at Inlay Lake

A very special resident at Inlay Lake is the lotus flower. Lotus is perceived to have healing properties, and to symbolise purity, divine beauty, fertility, birth, rebirth, resurrection and enlightenment. It is used in many ways, for medicines, treatments and a variety of foods (De Reuver, 2014).

Lotus plants grow from mud up through clear water, with the flower rising up into the sunlight. It is one of eight auspicious symbols in Buddhism. It has been held sacred for over 5,000 years, with deep spiritual meaning. Its growth habit, emerging from dormancy during drought to spring into life when suitable weather and water conditions return is seen as an analogy for life and the human condition. It is said that when Gautama Buddha was born on his first seven steps, wherever he placed his foot, a lotus flower bloomed.

Inlay Lake is the only region in the world where lotus silk is produced. More than 100 years ago, a woman wove lotus fibres into *a kya thingahn*, a special robe for a monk. It is believed that wearing lotus silk gives the wearer calmness and promotes a meditative state. The tradition continues with the labour-intensive production of the unique and exclusive lotus silk woven cloth *kyar chi* (De Reuver, 2014).

The lotus flower could be considered to symbolise the health, culture and well-being of Inlay Lake, and would be a very powerful symbol for marketing the regional Inlay tourism destination. Lotus plants require clean water and environmental conditions to grow, so they would be a good indicator of the health of Inlay Lake.

Figure 33
Field of stupas at Kakku religious site, north-east of Inlay Lake

[2] Shifting agriculture involves clearing forest patches in the dry season, burning prior to the rainy season to release nutrients, cultivation of the cleared patch for a period of years, fallowing, and then allowing secondary re-growth (Sidle *et al.* 2007)

Community Health Issues at Inlay Lake

A review of community health in relation to water, sanitation and health (WASH) identified serious concerns for the health of communities in floating villages (IID, 2012a; Tracey, 2012a). WASH programs cover water, sanitation and health behaviour. As a general rule, solutions rely 30-40% on changing behaviours in communities, and 30% on providing technical solutions.

The aims of WASH programs include:

- safe disposal of faeces
- safe disposal of grey and black water
- safe disposal of solid wastes
- safe hygiene practices

for all households for effective results.

It was noted that there were a low numbers of hygienic latrines at Inlay Lake, especially in the floating villages (Tracey 2012a). Effective latrines were very expensive for villagers, and there were no effective methods for emptying latrines. Risky behaviours with respect to hygiene were widespread, with most household latrines lacking facilities for hand-washing. Over the past 20 years, the Ministry of Health has actively promoted safe hygiene practices through the '4-cleans' campaign. However, the campaign has had little effect on behaviour change.

There was no effective treatment of grey water, and solid wastes were dumped.

For Inlay Lake, a serious concern in the 2012 survey was the high rate of diarrhoea and dysentery, much higher than the national average. The highest levels of these illnesses were at the southern end of the lake, suggesting an accumulation of bacteria flowing from upstream (Tracey 2012a).

Severe diarrhoea and dysentery are ranked as the two leading causes of morbidity in Nyuang Shwe Township and severe diarrhoea is also one of the leading causes of mortality, particularly for children under 5 years old (Tracey 2012a). In the period from 2009 to 2011, there was an average prevalence rate of 7.3% for diarrhoea, peaking at 7.9% in 2009, which was considerably higher than the national average of 6.5% (Figure 34). These figures represent only cases reported to medical officers, so could be significantly understated.

Information from discussions and interviews revealed a very high prevalence of risky hygiene practices across the entire target area within a limited enabling environment. The links between contaminated water and diarrhoea and contaminated water and food preparation was not understood, and the there was little understanding of faecal-oral transmission routes.

All respondents attributed diarrhoea to the excessive use of pesticides and fertilizers in the floating gardens while some also believed it could be attributed to eating the 'wrong types of food' (pork).

It was concluded that effective implementation of remedial actions to improve sanitation would need to be accompanied by community engagement programs to explain the contamination links, why sanitation was important, and how to operate new toilets effectively. These programs would need to be based on an understanding of community knowledge and beliefs, in order to tailor the information and training for effective uptake (IID, 2012a).

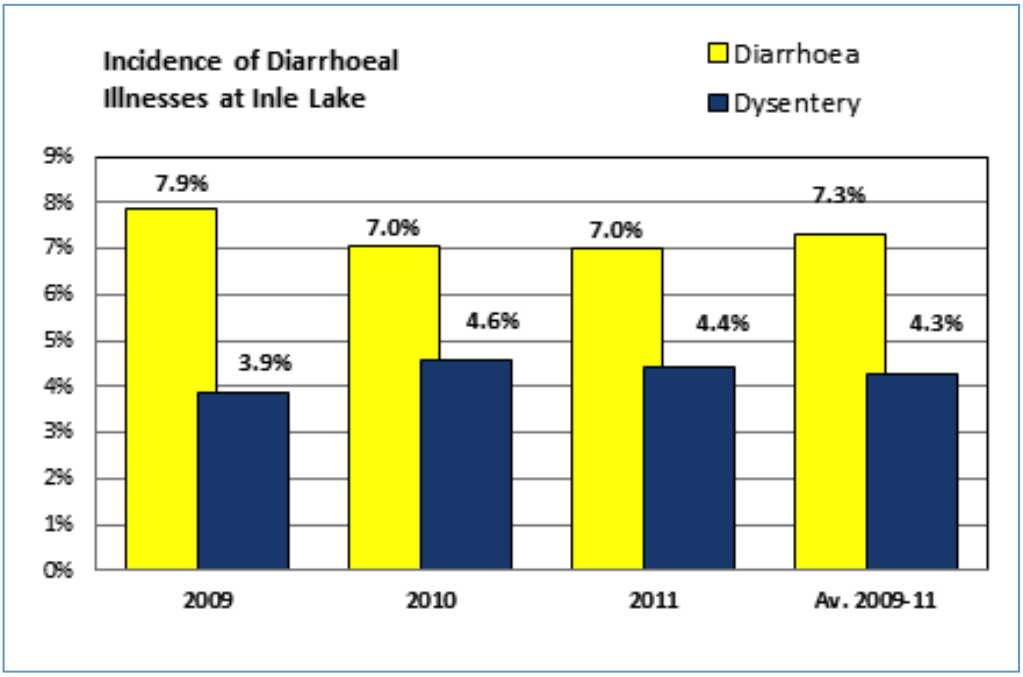


Figure 34 Rates of diarrhoea and dysentery for Inlay Lake are significantly higher than the national average (6.5% for diarrhoea) (Tracey, 2012)

Smoke Pollution from Agricultural Fires

In March 2014, there was a constant haze from regional burning across the landscape. The practice of burning in the dry season is widespread, with several purposes. Forest fires are lit by villagers for hunting or for agriculture. In shifting cultivation, part of the cycle includes creation of ash which acts as a natural fertiliser. Fires are also lit in sugar cane fields to encourage regrowth of shoots without re-planting.

While the practice is widely used, the fires that were observed appeared to be out-of-control and burning in steep inaccessible areas beyond where villagers could use the land for agriculture. It was reported that fires are burned annually, which would have a significant effect on the understorey of the forests, and habitat for native fauna.

In addition, the fires contribute to serious air pollution across the region.

The impacts of the fires are likely to have a serious detriment on native fauna, community composition of hillside vegetation and reduced quality of landscape amenity for visitors to Inlay Lake.

Population Pressure on Inlay Lake

Population data are variable and the precise communities being counted need to be defined in order to con. At least 60,000 people and possibly over 100,000 people are living in locations around Inlay Lake that are inundated either in the wet season or all year round.

Visitor numbers are highly significant, both international visitors and national visitors including pilgrims, and expected increases in these numbers will add to requirements for facilities, infrastructure and sanitation. Key population data include:

- watershed population 890,000 (2011 data)
- Inlay Lake contained within Nyaung Shwe Township
  (36 tracts, 444 villages, 168,130 people in 32,139 households)
- 70% of villages in and around Inlay Lake permanently or seasonally inundated
  163 villages in 17 tracts over water, 148 in 5 tracts seasonally inundated, 132 villages in 13 tracts on higher ground (2006 data)
- 144 villages in 23 tracts over water, 60,000 people (2012 data)
- Locals: >60,000 up to 100,000 people in wet zones
- plus more than 200,000 international and national tourists every year.

Inlay Tourism Values

International tourists have visited Inlay Lake since the early 1950s, with a more significant trend since 1996 after the Myanmar government focused on increasing tourism (Akaishi *et al.,* 2006). In 2001, the Myanmar government nominated Inlay Lake as one of nine key sightseeing sites for the development of tourism.

Inlay Lake is an ASEAN heritage site, declared in December 2004, as well as being a Protected Area System (PAS). It is increasingly popular as a tourism destination for foreign tourists, for its high cultural and biodiversity values. Inlay Lake is a major destination for Buddhist pilgrims, for both domestic and international visitors.

The primary attractions are the *Intha* culture, including floating gardens, leg rowers and flat-bottomed boats, floating markets, and cloth woven from lotus stalks and silk. Other crafts which attract tourists include goldsmiths, silversmiths, weaving of Shan bags and longyi, and other handicrafts, and the experience of travelling across the lake by long boats.

In addition, there are many pagodas and stupas that were built on the lake in the eleventh century. Phaung Daw Oo and Ah Lo Daw Pauk Pagodas are of very high cultural and spiritual significance. The forms of many pagodas in Inndein village area are similar to the Bagan period. Stone inscriptions at Shwe Indain Pagoda and Thandaung Pagoda (1785 AD) indicate links to Bagan cultural heritage and style. Some pagodas and shrines date from 800 years ago, for example in Samkar village on Saga (or Samkar) Lake, downstream of Inlay Lake.

A key attraction is the festivals held during September and October. The ceremonial Phaung Daw Oo Festival, which lasts for almost three weeks, features traditional boat racing, with dozens of leg-rowers in Shan dress on each boat. This is closely followed by the Thadingyut festival of lights, when Inthas and Shan turn out in traditional dress in great numbers to celebrate the Buddhist Lent.

Visitor Numbers

Data on visitor numbers is inconsistent and unreliable, although there is a clear trend of increasing numbers in both international and domestic visitors (*see Tourism Destination Management Plan for Inlay Lake Region*). There is also a clear division between the dry and wet seasons (Figure 35).

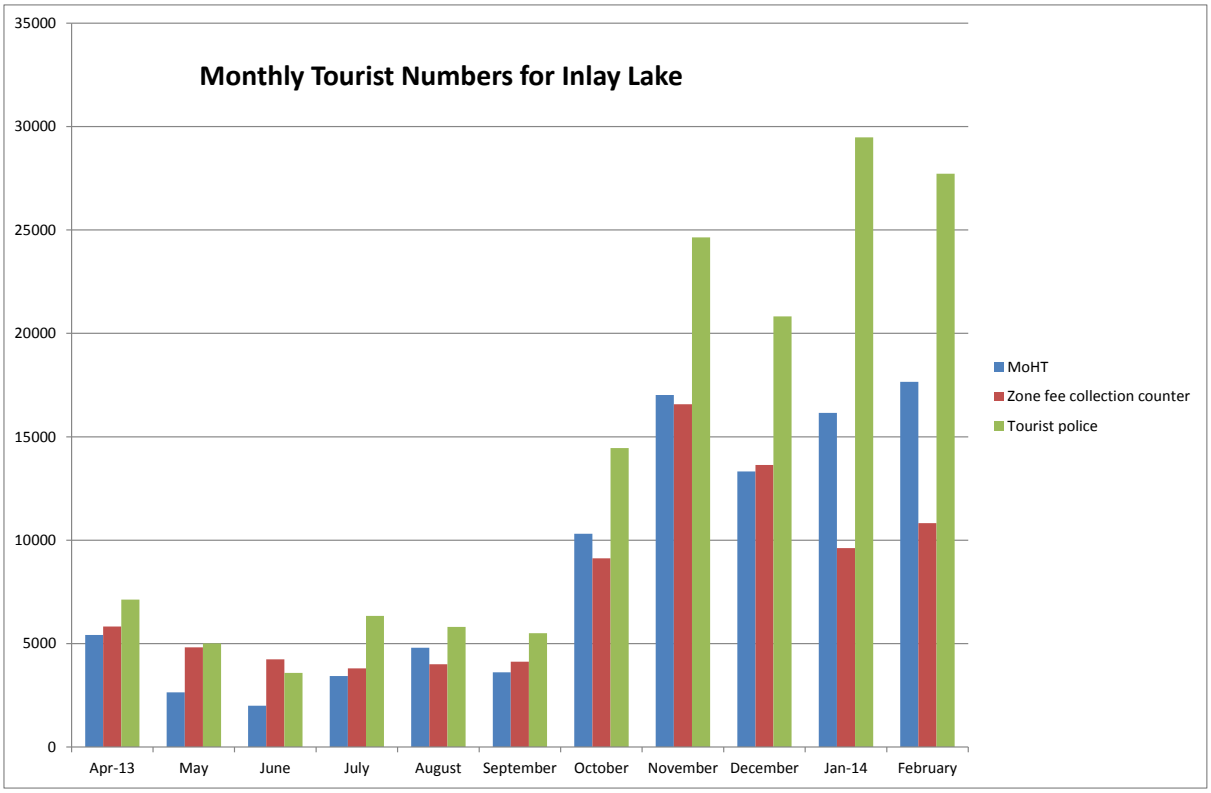


Figure 35 **Data on tourist numbers is highly variable, depending on source, but confirms the higher visitor numbers in the dry season (October-February).**

Data on Boat Traffic

A boat census was conducted by PhD student Martin Michalon in mid-March 2014, to assess the numbers of boats and pattern of travel throughout the day (Michalon, pers comm., June 2014; Figures 36 & 37).

Tourists tend to travel mostly in the early morning (before 9 am) and in the late afternoon (up to 6:30 pm), with morning traffic in both directions to and from Nyaung Shwe, and most afternoon traffic returning to Nyaung Shwe. Tourists staying floating resorts travel north to Nyaung Shwe for day trips to Pindaya or Kakku, or depart via Heho airport. Independent travellers staying in Nyaung Shwe travel south to visit Inlay Lake destinations or Saga Lake, and return in the afternoon.

Local ferries travel in both directions all day, with a big peak in travel into Nyaung Shwe in the morning and a smaller peak out of Nyaung Shwe in the late afternoon.

Goods boats travel in both directions all day, with early morning and late afternoon peaks. Most morning travel is towards Nyaung Shwe with vegetables, and most afternoon travel is out of Nyaung Shwe with consumer goods, including rice, soft drinks for restaurants, petrol, motor bikes, television sets, etc.

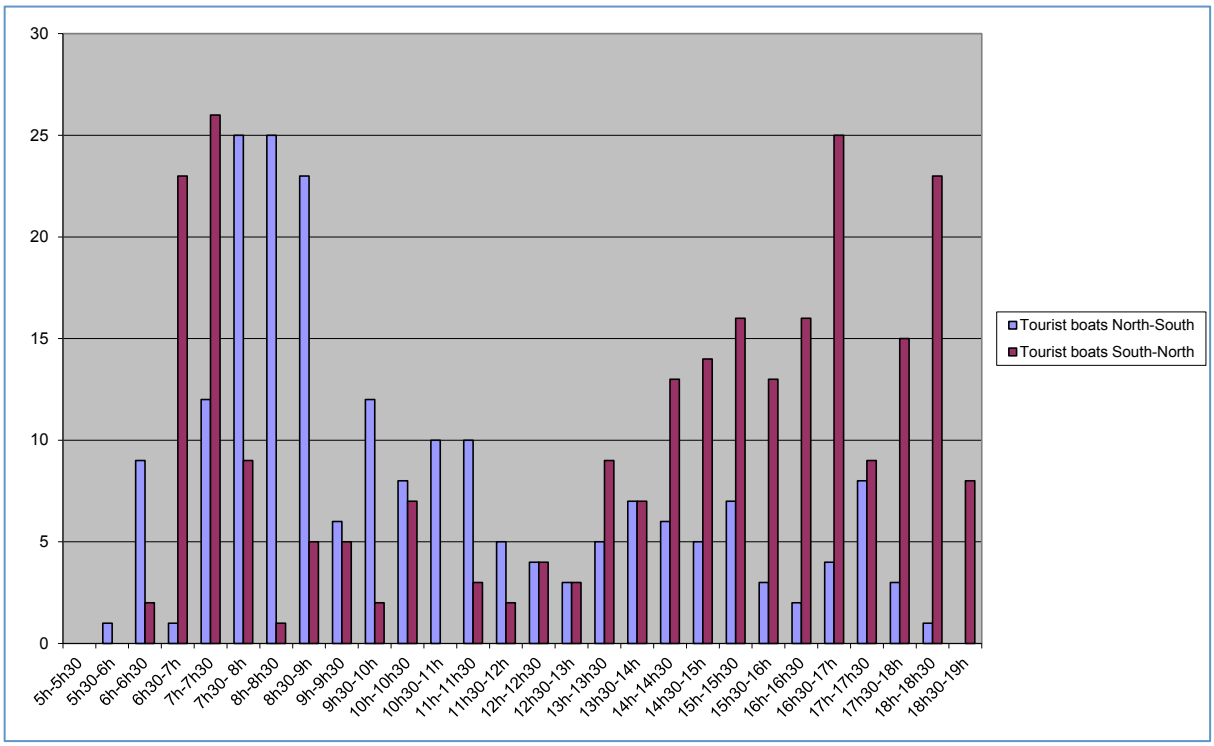


Figure 36 Record of one day of tourist boat traffic to and from Nyaung Shwe in March 2014 (source: Michalon 2014)

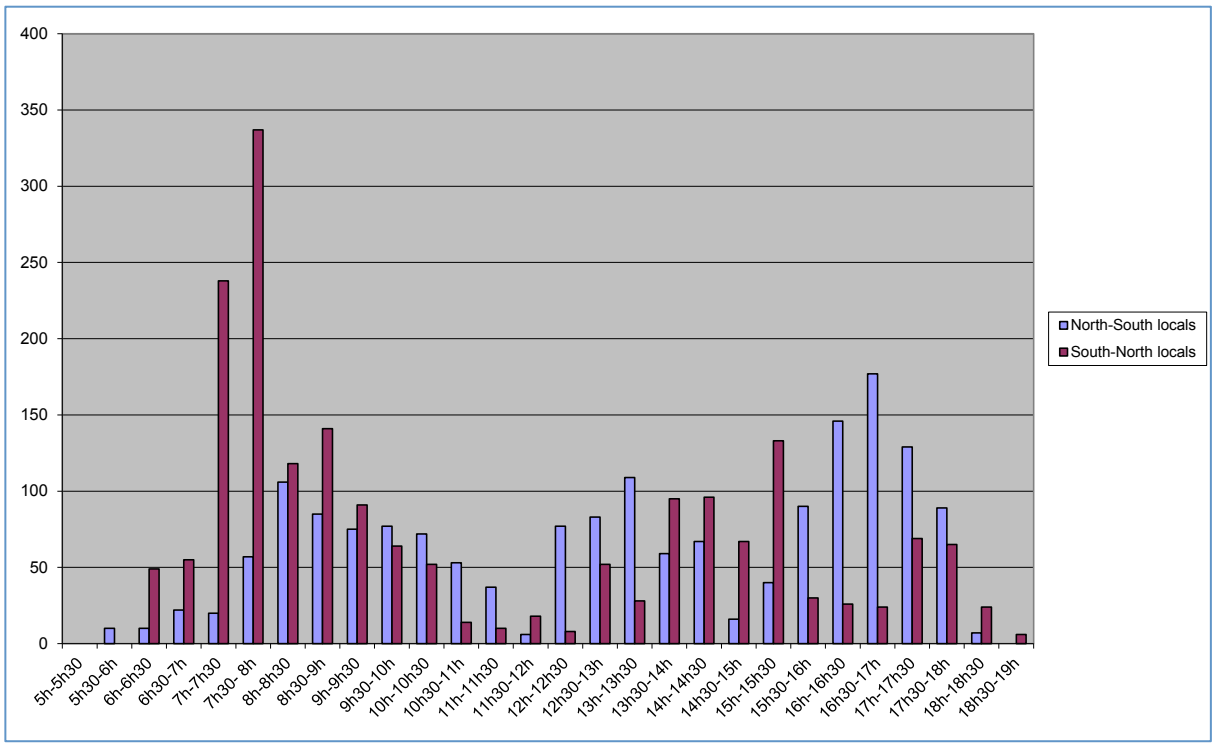


Figure 37 Record of one day of local boat traffic to and from Nyaung Shwe in March 2014 (source: Michalon 2014)

Environmental Carrying Capacity Assessment

While Inlay Lake, its watershed and hilly areas can support use of resources by local communities and visitors up to a certain point, the limits of carrying capacity appear as long term damage begins to occur.

A healthy lake ecosystem is essential to support local communities and expanding tourism. A set of targets and project proposals has been developed to maintain Inlay Lake in a sufficiently healthy state to support continued provision of environmental services to local communities and provision of tourism assets.

These provisions apply to local communities as well as facilities for international and national visitors. A brief summary of conditions at four key tourism destinations is given in Table 3, and indicates the general conditions across Inlay Lake and the hilly areas of the wider watershed. Note that comments on water supply relate to quantity only, not quality.

Critical Triggers for Environmental Safeguards

Inlay Lake has already exceeded its capacity to absorb impacts from the existing population and current level of tourism visitation.

The key parameters which have already exceeded their critical levels include:

- Increase surface area of lake by reducing area of floating agriculture and area of water hyacinth
- Reduce rate of harvesting native water plants and replace with alternative natural mulch
- Reduce bacterial pollution of lake water from toilet wastes
- Reduce, recycle and re-use plastics and increase composting of organic materials
- Reduce rate of application of fertilisers to recommended levels and replace with alternative natural fertilisers
- Reduce rate of application of pesticides to recommended levels
- Reduce invasive fish (if possible)
- Reduce smoke pollution by reducing forest burning, reduced pollution from boat motors, and increased efficiency of operation at point sources of smoke (eg power station).

Action is needed to reduce these impacts, with a series of targets to achieve a healthy lake ecosystem.

Critical Issues for Sustainable Tourism Management

To support sustainable tourism management, the six ***first priority*** actions for lake health are:

- reduce the area of floating gardens by 30% in10 years, especially in the southern part of the lake
- reduce harvesting of water plants (find replacement mulch)
- reduce area of water hyacinth (80% in 5 years)
- manage rubbish, especially recycling organics and reducing plastic bags, reduce volumes to be incinerated
- phase out hanging latrines in floating villages (introduce wetland handy pod toilets to 30% of floating villages in 5 years)
- develop systems for treatment of grey water and storm water before discharge to watershed streams, particularly for Kalaw and Taunggyi in next 2 years.

The management of water supply and sanitation at hotels in Inlay Lake is very important, to set a standard of sustainable water management for both visitors and local residents. The demonstration of water-saving systems and re-use and recycling measures will justify the payment of the tourism levy to visitors, and engage their interest in protecting the ecosystem of Inlay Lake. Water-saving technologies have short pay-back times, and are very effective in reducing water consumption by guests. There is a major opportunity to apply these standards in the Hotel Zone, as a highly-visible demonstration of sustainable management.

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	PINDAYA	KALAW
Water supply	30,000 people Pone Teloke Lake 1 year supply fills in rainy season supply to local villages	35,000 people Reservoir built by British to supply 5,000 people Water from springs at Innbyin Problems in drought, water restrictions, water by tanker
Sewage treatment (toilet waste)	Long drop toilets on each property 6 metres deep	Pit toilets on each property 1x2 metres, dig a new one if fills up
Grey water treatment (shower & kitchen)	Not known	Discharged to Kalaw Chaung, serious pollution with rubbish, enters Inlay Lake catchment
Rubbish management	Rubbish bins around Pagoda complex Children recycling bottles and cans Serious rubbish problem in market, especially plastic bags	Serious rubbish problem at railway station and along line, especially plastic bags and lunch boxes
	KAKKU	**TAUNGGYI**
Water supply	Local springs, adequate	19 springs, adequate
Sewage treatment (toilet waste)	Only 4 toilets in restaurant for visitors Pit toilet system	Town sewage treatment system
Grey water treatment (shower & kitchen)	Discharged to soil near restaurant	Discharged to local streams, serious pollution with soap and rubbish, enters Inlay Lake catchment
Rubbish management	Organic waste recycled to local farmer Rubbish bins inside Pagoda complex Serious rubbish problem in market, especially plastic bags	Serious rubbish problem at stadium following festival, especially plastic bags

Table 3 Review of the state of water supply and water treatment facilities at key tourism destinations

Capacity for Tourists

This assessment of capacity to support tourism is from the environmental perspective; issues relating to capacity of facilities and infrastructure are being addressed by the international tourism specialists in the RTDMP team (*see Tourism Destination Management Plan for Inlay Lake Region*).

The issues of most immediate concern for tourism are listed below:

- drinking water
- sanitation and health
- rubbish management
- transport (alternatives)
- information
- green options
- engagement with local communities
- visible use of tourist fees for sustainable management.

Nyaung Shwe Town

Key issues for Nyaung Shwe town, as the gateway to Inlay Lake, arise from increasing visitor numbers and increasing demands on inadequate infrastructure and urban support services. In particular, rubbish and wastewater management are unable to process current waste streams and need to be upgraded. Multiple water channels through the town are full of discarded rubbish and water quality is extremely poor for washing clothes, swimming and bathing children (Figure 38).

Rubbish collection services managed by the Municipal Office are limited to the major roads, and houses on minor roads are not serviced. Rubbish is collected by two trucks and transported to a landfill site near Shwenyaung. Some sewage treatment occurs on-site, but only a minority of houses have on shallow septic tanks with inadequate land area for these to function effectively and the majority of houses release wastes to the streams. A more extensive investigation is needed to assess the current situation and to develop practical working solutions for effective treatment of wastewater.

New hotels are being built, but it is not clear what standards of construction and waste management are being required (*see Tourism Destination Management Plan for Inlay Lake Region*). It is critical that minimal provisions are made for collection and treatment of sewage and storm water before discharge to Namlet Chaung.

It is recommended that a detailed study be undertaken in partnership with the Municipal Office, to assess the best way to improve and expand current services, and how to ensure that new buildings include appropriate standards of wastewater treatment and storm water treatment. The study should also include a study of sources of drinking water, and ways to ensure adequate potable supplies for the future.

The model of Remember Inn's program offering spring water to replace bottled water in return for a donation to a local orphanage should be promoted to other hotels and points of hospitality (*see Appendix 2 Case Studies*).

Floating and Riparian Villages

The primary issue for villages situated over or near the main water body of Inlay Lake is inadequate sanitation, with toilet wastes entering lake waters. Multiple previous projects have sought to address the problem, introducing various toilet systems into villages. However, these have not been adopted effectively. A key problem is the lack of understanding by village communities about why they need to change their toilet systems, since

they do not understand the link between toilet wastes and diseases like diarrhoea and dysentery, rather believing that these are caused by drinking rainwater or eating pork (Tracey, 2012a).

It is recommended that a program promoting household hygiene and using the WASH video to explain the links be undertaken with local village communities. This should be linked with presentations about the wetland pod floating toilet system which is operating successful at Tonle Sap Lake in Cambodia. The wetland pod system has very high suitability for Inlay Lake floating villages and, if adopted, has the potential to create new jobs. It also provides a recycling use for 1.5L PET bottles, which can be used as floats for the frame. Funding should be sought for the community support program, and for a pilot project to install wetland pod toilets in two villages.

Watershed Villages and Towns

The primary issue for land-based villages and towns in the Inlay Lake Region is treatment of grey water and storm water. The first objective should be to remove plastic waste from all streams, as well as sources of soap and other pollutants from all waterways which flow to Inlay Lake. A particularly intractable form of rubbish has been identified as 'slippers' (thongs). It is reported that these are discarded monthly, suggesting 12 pairs of rubber slippers are thrown away by every citizen, and they are often thrown into the nearest stream.

Figure 38 **Rubbish accumulated in the Mong Li channel of Namlet Chaung flowing through Nyaung Shwe town (June 2014)**

Rubbish Management

Rubbish management is a critical issue for the lake and its watershed, and this issue is raised repeatedly by community groups at discussion workshops concerning management issues for Inlay Lake.

There are real opportunities for community action with low technology options at village scale. These should be based on the international rubbish management philosophy of avoid, reduce, recycle, re-use.

Multiple community members have made the observation that the habit of discarding rubbish is inbuilt in Myanmar culture, except that previously the items being discarded were all bio-degradable. Packages were carried in woven baskets, tied with natural string, or wrapped in banana leaves. Plastics have only entered Myanmar in the last 10-14 years, and people have not yet recognised that plastics are not bio-degradable and persist in the environment for a very long time.

Environmental education programs should be developed to promote recycling and sustainable rubbish management in all village communities. A good example is the OSMOSE Environmental Education project in the floating villages on Tonle Sap Lake (*see Appendix 1 Case Histories*). Funding should be sought to provide resources for community education and support for local engagement in rubbish management, including community resource officers to conduct community training in practical application of rubbish management methods suitable for local application (*see Appendix 2 Fact Sheets*).

Incineration of rubbish should be the last resort and volumes of rubbish incinerated kept as small as possible.

Opportunities for Composting

Composting of organic materials is a major opportunity for reduction of waste volumes and creation of a useful product. There is potential to reduce the waste stream, currently being burnt, by as much as 60-70%, simply by composting organic materials. This can be done at village level with very few tools or mechanisation.

The mulch can be recycled back to agriculture or village gardens. This would also address another problem, which is the over-harvesting of native water plants from the lake to use as mulch in floating gardens.

Composting Demonstration Trial

A demonstration site should be created to check the practical requirements for composting in the Inlay Lake climatic conditions. It is recommended that the demonstration site should initially be a pile of organic materials, 4 feet by 4 feet by 5 feet high. A high profile site could be the concrete base behind the Phaung Daw Oo pagoda, near the market, where rubbish is already being burnt. It should be made up of layers of dry leaves, twigs, grass, dry vegetables, alternating with organic materials (soft vegetables, fruits, flowers). There should be twice as much dry matter as wet materials. The pile should be protected from wind and direct sun, perhaps covered with a plastic sheet. The pile should be turned over every 2-3 days with a fork, to move cool material from the outside to the hot centre (*see Appendix 2 Fact Sheets*).

In theory, it should take 2-3 weeks to create finished compost, but it is necessary to check if this is correct for Inlay Lake. During the trial, photographs should be taken each time when the pile is turned over, to record how fast the material decomposes.

If it is successful, then it can be expanded to treat all the organic materials at Phaung Daw Oo market and Thar-Lay village, and also to other villages around the Lake.

Reducing Plastic Rubbish

A second major issue is the accumulation of plastic rubbish, which is accumulating in marshes and in vegetation on the edges of the lake. A number of actions could be taken to reduce the amount of plastics being discarded, including replacing plastic bags with re-usable or bio-degradable bags, and re-filling water bottles or recycling them.

Replacement of light-weight plastic bags by cloth bags (eg Intha or Shan bags) or bio-degradable bags would be an effective solution which would also provide additional markets for weavers. Bio-degradable bags can be manufactured from maize, which is in plentiful supply in the Inlay Lake Region. These bags are currently manufactured in Thailand for BioBag world, which is a major supplier to Australian and European local government authorities for use in household and community composting systems.

Options for recycling plastic, like plastic bottles, would need to be in a bigger town or city, and would require a factory which can run extrusion processes to re-form the plastic into another product, like water pipe. 1.5L PET bottles can be used as floats in wetland pod toilets, which can be used to solve the problem of toilet wastes entering lake waters from houses in floating villages.

Use of plastic bottles can be reduced by schemes like that of Remember Inn in Nyaung Shwe, which offers free spring water to re-fill bottles, in return for a donation to a local orphanage (*see Appendix 1 Case Histories*).

Figure 39 rubbish accumulated on floating vegetation near Nam Pan village (June 2014)

Local Activities

The MoECAF Park Warden is working with local village communities on waste management, providing tools and advice to 444 villages in 35 communities around the whole lake. The Thar Lay volunteer group are part of the network. There are two incinerators, at Nampan market site and Phaung Daw Oo Pagoda market site, but there is a need for 4-5 incinerators and land fill sites around lake. This bottom-up approach is likely to succeed, provided that sufficient staff and funds are available.

A new group was formed in June 2014 for coordination of regional and local managers with responsibilities relating to rubbish management and other management issues for Inlay Lake. The Inlay Lake Local Action Group should be supported with funding and resources to increase its capacity for local community action.

Development of Sustainable Management Practice in Tourism Developments

Guidelines for sustainable tourism should include a code of practice for hotels, businesses and public facilities for sustainable management of water resources (IID, 2012a). These guidelines should include internal water efficiency programs and water-saving technology in rooms, facilities and attractions. Recycling of grey water should be included, and rainwater systems encouraged. Each facility should have tertiary treatment of black water, and wetland treatment of any water being discharge back to the lake or watershed streams.

The management of water supply and sanitation at hotels in Inlay Lake is very important, to set a standard of sustainable water management for both visitors and local residents. The demonstration of water-saving systems and re-use and recycling measures will justify the payment of the tourism levy to visitors, and engage their interest in protecting the ecosystem of Inlay Lake (IID, 2012a). Water-saving technologies have short pay-back times, and are very effective in reducing water consumption by guests (UNEP, 2011).

The construction, building and operating standards in the Hotel Zone should be world's best practice as suited to tropical conditions in a developing country. The operating guidelines for the Hotel Zone make all the required provisions for sustainable management, including standards for wastewater treatment, and these should be fully implemented and monitored for compliance. The conditions relevant to environmental issues are:

(f) A fund should be set up for the sustainability and conservation of the watershed areas of Inlay Lake.

(g) A separate fund should be set up for the greening of the hotel zone.

(h) A fund should be set up to handle Payment for Environmental Services (PES) and Ecosystem Services in promoting business enterprises in accordance with the Environmental Conservation Law.

(i) Waste management systems should be established to minimize impact on the environment.

The Hotel Zone should be a flagship demonstration site of environmentally sustainable management for Inlay Lake.

Options for Green Technologies in Sustainable Management

A number of opportunities have been identified for the use of green technologies in the Inlay Lake Region. These should be encouraged with funds for investigation and start-up. Potential technologies include:

- Use recycled organics for mulch
- Control boat traffic and develop alternative, quieter engines
- Alternatives forms of transport for land traffic, including improved public transport services
- Solar power and wind power
- Reduce plastic bags, use alternatives
- Methane power
- Alternative fuels and fuel-efficient stoves (eg rice husks, sugar cane husks).

Recommendations for Tourism Destination Management Plan for the Inlay Lake Region

Sustainable tourism requires sustainable tourism operations which address priority issues, as applicable for floating villages, riparian villages, hotels, restaurants, shops, markets and watershed towns and villages.

Tourism products and activities need to support conservation of the Inlay region:

- keep native water plant (large '*algae*') communities healthy
- keep water clear and clean
- increase area of open surface water
- maintain native fish and birds
- improve air quality
- support livelihoods of local communities
- maintain and promote local culture.

First Priority Actions to manage sustainable tourism and reduce environmental impacts are listed below:

- promote the Hotel Zone as a demonstration of sustainable management, especially in water supply and wastewater treatment, and ensure effective implementation of the official guidelines for operations in the Hotel Zone
- support community action in rubbish management throughout the watershed, and particularly for floating and riparian villages, following the international principles of 'avoid, reduce, re-use, recycle', with a particular focus on recycling organic wastes into compost for re-use in agriculture, replacing plastic bags with cloth bags or biodegradable bags, and recycling plastics into other products
- manage accommodation facilities to appropriate construction and operating standards, including management of silt during construction, water and energy conservation, and use of sustainable services and food sources
- introduce measures to ensure hygienic conditions for visitors and for local communities, to minimise risks to health
- develop systems for treatment of grey water and storm water before discharge to watershed streams, particularly for Kalaw and Taunggyi
- secure water supplies of adequate quality for visitors and local communities
- develop systems for controlling boat traffic across the lake, to minimise water pollution, air pollution, noise pollution and disturbance of wildlife
- support actions to manage erosion 'hot spots' and to reduce erosion of banks along boating channels.

Priorities to Maintain Healthy Lake Ecosystem

In addition to the actions identified above to manage tourism pressures on Inlay Lake and its watershed, the watershed ecosystem needs to be maintained in a healthy state in order to support increasing tourism pressures and to provide the ecosystem services which create the tourism products of the destination. A healthy lake ecosystem supports healthy communities and provides their livelihoods, including supporting tourism livelihoods.

First Priority Actions to maintain a healthy lake ecosystem which can support tourism and local communities are listed below:

- halt and reverse the expansion of floating gardens across the surface of the Lake, particularly the westward expansion from Inndein Delta and Kalaw Delta which is encroaching on the southern basin between Nam Pan and Thar-Lay villages
- maintain native water plant communities to filter lake water and provide the basis of the natural lake food chain, to support fish and waterbirds, and reduce harvesting pressure on water plants by finding alternative sources of mulch for tomato gardens
- control expansion of water hyacinth pest plants by introducing hyacinth weevils, and reducing nutrient inputs from fertilisers
- improve sanitation in floating villages, by introducing wetland pod toilets and providing training in construction and installation of units
- introduce grey water treatment in watershed towns and villages, particularly for screening out plastic rubbish and reducing soap products from discharges to watershed streams
- support coordinated rubbish management for lake areas and tributary streams, including community-driven rubbish management activities
- maintain motor-free boat zones to protect fish and waterbird nursery areas in the Inlay Wildlife Zone.

Longer term priorities for action include:

- reduce use of chemical fertilisers and pesticides in tomato gardens, to reduce nutrient and pesticide inputs to the Lake, through training of farmers in more sustainable farming techniques, such as use of recycled organic mulch, as well as re-training for employment in other sectors such as tourism
- reduce sediment flows into the Lake from Namlet Chaung through re-meandering the channel from Nyaung Shwe
- reduce sediment re-suspension in boat channels around Ywama and Thar-Lay villages through vegetation of exposed earthern banks
- manage identified erosion 'hot spots' in the Inlay watershed
- coordinate water supply for all floating villages
- promote fuel-efficient stoves and alternative sources of fuel
- support and extend *Community Forestry* initiatives to conserve hillslope vegetation and promote alternative livelihoods and sources of fuel, and to discourage widespread landscape burning practices
- develop controls for air pollution, including diffuse sources (landscape burning) and point sources (power station, incinerators).

Targets for Healthy Lake Ecosystem

- More open water (reduce area of floating agriculture – reduce by 30% in 10 years, particularly in southern part of Inlay Lake; reduce area of water hyacinth – 80% less in 5 years)
- Reduce bacterial and nutrient pollution from poor sanitation – introduce wetland pod toilets to 30% of lake villages in 5 years
- Maintain water plants – phase out harvesting for mulch on tomato gardens in 5 years, replace with organic mulch from village recycling
- Reduce input of nutrients and pesticides from floating gardens, train farmers to use appropriate amounts, train in sustainable farming techniques
- Reduce area of tomato farming by 30% in 10 years, find alternative livelihoods for tomato farmers, for example in rubbish recycling, tourism services
- Develop coordinated systems to manage rubbish, recycle organics, re-use materials, incineration options for each population centre and at village scale
- Promote alternative sources of fuel, including recycled methane and by-products from incineration
- More access to electricity – set target of 30% access in 5 years
- Prevent erosion at 'hot spots' and in boat channels (sites identified in Furuichi 2008)
- Department of Irrigation to continue dredging as required at river mouths, dredging to be limited to identified 'hot spots'
- Re-meander Namlet Channel to create wetland habitat and decrease silt flows into lake
- Protect lakeside marshes as valuable habitat and buffer for lake health
- Protect hillside vegetation, develop profitable boundaries, promote Community Forestry for sustainable agriculture and alternative income sources
- Hotel Zone can be model of sustainable development and sensitive urban water design – tertiary treatment, CEDS, wetland overflow at bottom of hill along road (where new drain being dug)
- Promote tertiary treatment of black water in all population centres by appropriate methods
- Treat grey water before discharge to watershed streams, with first priority for Taunggyi and Kalaw, extending to all regional towns.

Engage Local Communities in Sustainable Management of Inlay Lake & Watershed

Many previous projects have attempted to address issues such as improved sanitation with little or no success. For effective implementation, it is essential to engage local communities in understanding why action is needed, for example, how to make toilet systems and hygienic actions effective. As a first step, local communities need to understand the cause-and-effect relationship between toilet wastes and illnesses such as dysentery and diarrhoea. Local misconceptions include beliefs that rainwater and pork are the cause of these illnesses (Tracey, 2012).

Local communities can also provide significant resources to implement actions throughout the Lake watershed. A new group was formed in June 2014 for coordination of regional and local managers with responsibilities relating to rubbish management and other management issues for Inlay Lake. The Inlay Lake Local Action Working Group should be supported with funding and resources to increase its capacity for local community action.

Implementation Projects

Implementation of these recommendations will require the following projects to assist

- Knowledge & beliefs survey to understand how to engage community groups in changing practices and implementing projects
- Social science support for change processes (workshops and re-training)
- Hygiene program for local communities and hospitality workers
- Demonstrate sustainable management of water, wastewater and rubbish in Hotel Zone
- Demonstrate investment of tourism fees in sustainable management of lake and watershed ecosystems, and develop an arrival package to provide information for visitors
- Promote protection of lotus
- Develop a central system for data coordination and citizen science projects, with a central accessible data base
- Visitor Information Centre in Nyaung Shwe to provide central information and meeting points.

Tourism Business Opportunities

A number of potential business opportunities have been identified during consultations with local community members. These are listed below:

- Use lotus as symbol of Inlay Lake & watershed destinations
- Promote frangipani for Lake Samkar and the village of Samkar
- Things a tourist can do that are fun and will help:
    - plant a tree
    - splash snail eggs to reduce nuisance red snails
    - take a quiet moment on the lake with the boat motor off
    - donate to volunteer groups or participate in their activities
    - order a woven bag including tourist's name
- Paid Thar Lay village tours with local Volunteer group
- 'Welcome to Inlay' pack on payment of tourism fee, presented in local woven bag to sustain weaving traditions
- Woven bags for sale in stores and markets, alternative to plastic bags
- Coordinating composting systems and selling products.

Implementation Actions

Managing for Sustainable Tourism

- Coordinated Rubbish Management for Inlay Lake region:
    - Promote recycling and reuse programs to reduce volume of rubbish
    - Expand market rubbish management programs, eg traders pay for clean up at Nam Baung market
    - Develop organic recycling program for all markets and villages in region
    - Develop system of incinerators and landfill at key sites around lake, and at key tourism destinations in watershed, particularly Kalaw and Kakku
    - Develop system for recycling plastic materials, and promote reduction in use of plastic bags (promote alternative native woven bags)
    - Include cremation services for floating villages
    - Expand and support village rubbish management programs, eg pilot project in Nyaung Shwe to install street corner bins in selected quarter, collection to be organised by Municipality office
    - Develop stormwater management and water recycling systems for Kalaw and Taunggyi to remove rubbish from streams, and provide tertiary treatment of stormwater and grey water before discharge to tributary streams of Inlay Lake
    - Promote a 'clean the streams' program
- Hotel Zone should be model of sustainable management:
    - Water supply to include capacity for additional supply to nearby villages
    - Sanitation systems and tertiary waste treatment process ending in wetland filtration stage, water clean enough for irrigation or return to lake
    - Rubbish management to incorporate organic recycling (products returned to nearby farmers), recycling of containers, landfill and incineration with additional capacity for local floating villages without sufficient suitable land (including cremation service)
    - Landscaping to promote local native plants, protect against erosion, plant profitable boundaries with species available for food, fibre, fuel use by hotels and adjacent villages
- Manage Tourist facilities and control pressures (both domestic and international):
    - Ensure adequate water supply
    - Ensure sufficient facilities for adequate sanitation at accommodation, restaurants, shops and key destinations
    - Ensure proper hygiene protocols and training for hospitality staff
    - Provide water testing laboratory close to Inlay Lake for regular sampling of coliform bacteria levels to check bacterial contamination (samples need to be processed within 6 hours)

- Control boat traffic:
    - Separation zones on lake (maintain no-motor zone in Wildlife Reserve), designate boat corridors to reduce disturbance to wildlife and local traffic, designate bird watching zone
    - Develop system to reduce noise of boat motors
    - Slow down land traffic, control and slow boats
    - Encourage operators to turn off motor and allow passengers to enjoy a quiet moment
- Control land traffic:
    - Develop a drop-off zone at Nyaung Shwe boat station, with a remote bus parking site, transfer service to boats with tri-shaws and horse wagons; reduce traffic along waterside road, rationalise truck and bus traffic
    - Introduce speed limits at congested points
    - Encourage reduced use of horns
    - Encourage use of headlights by all vehicles at night on roads.

Manage Lake Health to Support Tourism

- Protect water plant communities in Inlay Lake:
    - Maintain clear open water (increase surface area, reduce silt flows in boat channels and at river mouths – *see below*)
    - Reduce harvesting of water plants for mulch in floating gardens
    - Promote use of recycled organic materials as alternative mulch
    - Reduce use of fertilisers on floating gardens
    - Reduce use of pesticides on floating gardens
    - Provide support through farmer training schools to reduce use of fertiliser and pesticides
    - Provide information on cost savings from using less fertiliser and pesticides, lack of agricultural benefits and health risks.
- Increase surface area of Inlay Lake:
    - Reduce area of floating gardens by 30% in 10 years, particularly in southern section of lake
    - Target southern zones west of Inndein delta, and outer edges of gardens west of Kalaw delta
    - Provide support to re-train farmers in alternate livelihoods, including alternative crops, tourism and recycling
    - Reduce area of water hyacinth by 80% in 3-5 years by introduction of hyacinth weevils (*see Appendix 2 Fact Sheets)*
    - Reduce inputs of nutrients to lake by training farmers to use less fertiliser and promoting use of recycled organic mulch as an alternative fertiliser (*see Appendix 2 Fact Sheets)*.
- Manage siltation in navigation channels and river mouths, and at erosion hot spots in the middle watershed

- Target zones around Ywama and Phaung Daw Oo pagoda to stabilise exposed banks with plants or sandbags
- Plant rushes around edge of accumulated sediments at mouth of Thandaung Chaung to prevent re-suspension by boat traffic, create a wetland garden at Ann's Heritage Lodge
- Continue dredging of river mouths by Department of Irrigation
- Continue works to address erosion 'hot spots' in middle watershed (see Furuichi (2008) and Midgeley *et al.* (2012) for priority sites)
- Undertake feasibility study of re-meandering Namlet Chaung to prevent silt flows into northern Inlay Lake (*see Appendix 2 Fact Sheets*)
- Promote profitable boundaries in watershed areas, to provide alternative income and alternative fuel sources
- Promote fuel-efficient stoves and use of bio-gas as alternative fuel sources (Mehm Ko Ko Gyi, 2012).

- Promote improved sanitation in floating villages:
  - Introduce floating wetland pod toilets in 30% of floating villages within 5 years (IID, 2012b; *see Appendix 2 Fact Sheets*)
  - Promote hygiene in households with community engagement program (IID, 2012b).

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Appendix 1 Case Histories

A series of case histories has been collected to illustrate community-driven activities currently being undertaken at Inlay Lake. These activities offer a model for engagement of communities in addressing priority issues like rubbish management.

These case histories include:

- The Shwe Insa rubbish collection service
- Heritage House
- Shwe Inn Thar Hotel & Heritage Lodge
- Inle Speaks
- 'Cash the Trash' Project in Nepal
- Recycling Plastcs
- Green Sjopping Bag Project, Nepal
- OSMOSE Environmental Education Project, Tonle Sap, Cambodia
- Remember Inn Free Bottle RE-fills

Case History: Rubbish Collection Shwe Insa volunteer group

The Shwe Insa volunteer group of young men from Thar-Lay village (which includes Phaung Daw Oo pagoda) are providing a rubbish collection service and undertaking/cremation service: The group is mentored and supported by Daw Tin Tin Ye (Ann). Features of the service include:

- Thar Lay village has 220 households, 1200 people
- The service collects100 viss per day, 500 viss per week
- Households get 1-2 rice bags which are collected once every 5 days
- Rubbish bins are placed around the village, in a wooden frame, lined with blue fish net bags
- Returns from recycled drink containers include 25 MKK per bottle, 5 MKK per can, 20 MKK per beer can
- Volunteers bought their boat, earned the money by selling a photo of a Bhudda statue with 'hair' (=mould!)
- Money is needed for ongoing transport costs (diesel for boat)
- Hotels & restaurant pay for rubbish collections
- Incinerator at Nampan is on land donated by Daw Ann (near Nampan market)
- Burial incinerator lacks fuel, burning plastic as fuel but problems with smell, worried about air pollution
- Need village level incinerators, only Nampan incinerator and disposal site at pagoda now
- Only open concrete base at pagoda, no chimney
- Need 10-15 incinerators around lake
- Need land for landfill and incinerators
- Want to know about technology for effective chimney, air quality, scrubbers
- Hotel Zone needs to manage rubbish to sustainable standard, has potential to take rubbish from lake villages with no land
- Nampan provides water supply for surrounding villages

Photos:

Volunteer rubbish service boat
Rubbish bin in Thar Lay village
Land collection point for rubbish in Thar Lay village
Incinerator site in Nam Pan village


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Case History: Heritage House

The Heritage House complex in Inn Kyaw Phone village includes a vocational training school, cultural collection, Burmese cat breeding, fish aquarium, restaurant of traditional cultural recipes, organic farming, waste water treatment, solar power, and provides a water source for people from local villages. The primary motivation is a demonstration of sustainable management for duplication at other sites around Inlay Lake.

The Heritage House project is directed by Yin Myo Su (MiSuu).

Demonstration of Sustainable Management

- Pilot equivalent of village of 2000 people, demonstrating sustainable management
- $2000 for water treatment system
- Solar power provides sufficient power for guests to recharge devices overnight
- Waste water treatment to tertiary level, plus wetland filtration
- Water filtration system, with capacity to provide drinking water to nearby villages
- Aquarium demonstrates all native fish, plus 5 invasive species, with detailed information
- Labour-intensive operation to filter water and provide appropriate food for each species in aquarium
- Reconstructed grandparents' house with original furniture to show traditional housing
- Restaurant serving grandmother's recipes
- Sponsoring artists,
- Breeding Burmese cats,
- Creating multi-faceted tourist destination
- Vocational training school
- 6 bungalows 'bed & breakfast' operation.

Photos:
Heritage House herb garden
Kitchen garden
Wastewater treatment system
Water filtration system
Villager collecting potable water
Wetland treatment final stage


WATER
SOFTENER
WATER
SOFTENER

Case History: Shwe Inn Thar Hotel and Heritage Lodge

Shwe Inn Thar Hotel seeks to promote the Inntha culture and promotes sustainable management measures in the hotel and tourism activities (Figure 40).

The Shwe Inn Tha Hotel has a water treatment system with carbon filters, encourages water conservation by guests, and encourages recycling.

Daw Tin Tin Ye (Ann) has sponsored and mentored the volunteer group which provides the rubbish collection service in the local village of Thar Lay.

Figure 40 Shwe Inn Thar Hotel, Inlay Lake

Case History: Inle Speaks Community Centre

The Inle Speaks program opened in September 2013. The program is funded by the Partnership for Change program.

Inle Speaks supports a community resource centre designed to build environmental awareness, create a strong community, develop innovation and business entrepreneurship skills, and improve community coalitions between the ethnic groups. The centre is located centrally at the tourist wharf in Nyaung Shwe (Figure 41).

Among the programs are environmental awareness and clean-up programs, English and computer literacy training, entrepreneurship classes with marketing, financial planning and general business skills, environmental art programs, as well as programs to enrich and save the local heritage.

The overall objective of their work in the Inlay Region is to provide support to save the region´s critically endangered ecosystems by strengthening the linkages to tourism's role as a source of sustainable financing for a series of urgently needed interventions. These are designed to produce added value and sustainable synergies among a wide variety of economic sectors along tourism's value chain. These include agriculture, fisheries, forestry, transportation, energy, IT, personal services and textile production.

Inle Speaks offers a potential base for community support officers to facilitate education and local action programs in village communities around Inlay Lake.

Figure 41 Community workshop held at Inle Speaks community centre in Nyaung Shwe

Case History: 'Cash The Trash' Plastic Waste Management Project in Nepal

About the Project

The 'Cash the Trash' project in Lalitpur, Nepal, for recycling of plastic material waste is a profit generating activity which is self-sufficient and independent. The two other main aims are:

- to have a positive effect on the local environment by offering a better solution for waste treatment than simple disposal
- to enhance economic activity in the region by creating several jobs, and by increasing the revenue from plastic waste in Nepal.

The project is being run by the Women's Environment Preservation Committee (WEPCO), which is dedicated to cleaning and conserving the urban environment in the Kathmandu Valley.

WEPCO and Lucie Pecinkova are working together in Cash the Trash to set up a process of plastic recycling in the Kathmandu Valley. In this way the collected waste can be processed locally, allowing Nepali industries to use plastic waste as a cheap resource for the production of plastic products. In the process of recycling, jobs are created while cleaning the environment and improving conditions for the local population.

About the Problem

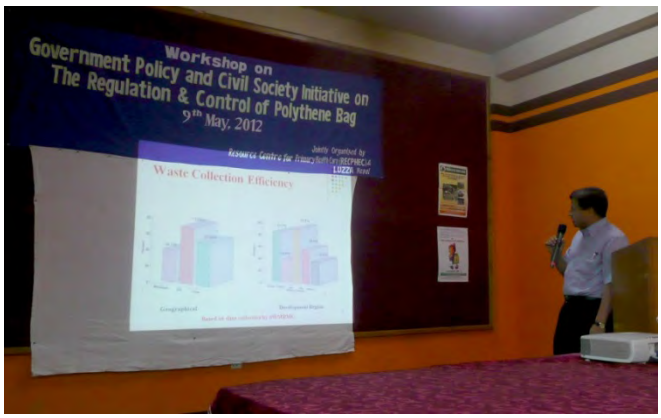
The municipality of Lalitpur lacks an efficient system of waste collection and treatment. Waste is not collected everywhere, and more importantly, a large portion of the waste is simply disposed of at river sites, in the streets or at dump sites. This situation has a negative effect on both the local environment and the community as it increases health and environmental hazards.

The use of plastic products in Nepal is extensive and steadily increasing and plastic waste constitutes a prominent part of the solid waste. Unfortunately, plastic material requires decades for complete decomposition, thus the piles of garbage remain on the streets, river banks and dump sites for ages.

The usual way to get rid of the waste is burning it

Management Options

One feasible option that eliminates the amount of waste for disposal is recycling. When plastic waste is collected and recycled it will decrease the amount that ends up in public areas, causing various problems. Additionally, if collected and treated in a proper way to improve its quality and mechanically processed, plastic waste becomes a new secondary resource of material. This material can be used in the production of different plastic products by local manufacturers.



Conference organized by local municipality and NGOs finding the solution for plastic waste and polyethylene bags especially 'Clean the Streets of Kathmandu" organized by the municipality

Currently, there is a lack of technology and opportunities to recycle plastic locally. That is why only a very small amount of plastic waste material is collected and reused. The majority of the collected material is sold for a low price to India, where it is processed. In this way Nepal misses out on a cheap resource of plastic material for local production, and has to rely on more expensive imported plastic for production. Cash the Trash fills this gap perfectly by supplying cheap plastic through recycling the abundant waste

Target groups

The target of the project is the local community of Lalitpur. There are three main groups in this community who will benefit from this project. The first group is 3300 households who will have their plastic waste collected and processed in a responsible way. The second group consists of people who already collect or sell plastic waste or manufacture plastic material, and among them there are 24 plastic pickers already working for WEPCO and its two sister organizations. They will be able to improve their income by selling for better prices and will profit from a steady and increasing demand for their product. Thirdly, the project will create new positions for local people in the collecting, cleaning and recycling process. Currently unemployed or underemployed people from Lalitpur who can gain employment make up the third group of people who will benefit from this project.

Sustainability

For the sustainability of the project, the local partner WEPCO has been working in solid waste management for two decades, providing, with its sister organizations, a garbage collection service to the 3300 families in Kupondole and Sanepa. The organization has extensive experience in waste collection, sorting and recycling.

Social entrepreneur Lucie Pecinkova is cooperating with WEPCO to set up a plastic recycling activity in Lalitpur. WEPCO will supply the property for the Cleaning Station and other facilities for the duration of the project. The people from WEPCO are involved in the planning and the decision making process, and play an active role throughout the setting up of this project. When the recycling activity is up and running, this physical and personal investment from WEPCO in the project will ensure that WEPCO is both able and willing to continue to run and develop this project when the involvement from Lucie Pecinkova is ended.

WEPCO agrees on mutual cooperation with the private recycling companies beforehand, to secure the sale of processed material. Both companies have long experience in the recycling process.

Local women sorting different plastic foils

Factory producing plastic pipes from recycled material

Reference

http://www.cashthetrash.org/index.php/about-the-project

accessed 16 April 2014

Case History: Recycling Plastics

In order to reduce the amount of plastic waste in the landscape, it will be necessary to develop a recycling process which can use very large volumes of plastic materials. There are multiple examples of communities in developing countries finding ways to use plastic by shredding or melting it and forming new products, including water hose and posts which are suitable for fencing and building.

Information about successful projects is available from the links below, including a manual for establishing a plastics recycling business, two PhD theses from Ghana on the topic, and two youtube links demonstrating successful projects in Kenya. This information was provided by Lucie Peckinkova, who is working with the 'Cash the Trash' project in Nepal.

1, http://www.worldwidehelpers.org/wwhweb/uploads/files/KnO-100399_Recycling%20plastics.pdf

2, http://practicalanswers.lk/PDFs/Mechanical_waste_plastic_recycling.pdf

3, https://www.youtube.com/watch?v=ZcIYuhjPH60

4, https://www.youtube.com/watch?v=IFq3EoxJg3A

5, http://www.unep.org/ietc/ourwork/wastemanagement/projects/wasteplasticsproject/tabid/79203/default.aspx

6, http://www.theseus.fi/bitstream/handle/10024/42852/Charles%20Abota%20final%20thesis1.pdf?sequence=1

7, http://www.theseus.fi/bitstream/handle/10024/39056/Roger_Teye.pdf?sequence=1

It is recommended that a project proposal be developed to investigate practical options for processing plastic wastes from the Inlay Lake Region.

Case History: Green Shopping Bag Project, Nepal

The Green Shopping Project is an effort to establish a self-sustained green social enterprise by creating the demand and supply chain of cloth bags produced, marketed, sold and distributed by disadvantaged young girls of Nepal. It aims to gradually replace the use of polythene bags in Kathmandu, in partnership with the private sector, and with the support of educated young volunteers and consumers.

Why Green Shopping Project?

The use of polythene bags in Kathmandu is increasing at an alarming rate, posing an enormous challenge for solid waste management in Kathmandu. Kathmandu, once a huge attraction for visitors from across the world as a Shangri-La, is now considered one of the dirtiest capitals of the world.

An average polythene bag stays in the environment and takes more than 1,000 years to degrade.
Excessive use of these polythene bags is accumulating problems for coming generations. Hence, there is an urgent need to create environmentally friendly alternatives to polythene bags.

Targets

1. To build demand and maintain regular supply of environmentally-friendly cloth shopping bags as an alternative to replace polythene bags.
2. To bring about behavioural changes in the consumers, encouraging them to use eco-friendly cloth bags and also to green the shopping experience
3. To lobby in order to bring about regulatory and enabling conditions favouring the use of environmentally friendly alternatives for polythene bags
4. To create a self-sustaining green social enterprise.

Approach

- Employ young women for the production, marketing and distribution of cotton shopping bags
- Discourage polythene bag consumption in Kathmandu and create demand for cloth bags by creating a system of charging 1 Rupee for each polythene bag given to the customers in supermarkets and shopping malls.
- Engage media, public personalities, celebrities and youth volunteers at a mass scale for promotion, awareness and campaigning of the project.

Eco-friendly cotton shopping bags are available at nominal prices.

How will the bag fee be used?

Fees paid for polythene bags are donated to the 'Hamri Bahini Fund'. This fund will be monitored by well known personalities of Nepali civil society and used transparently to fund activities under 'Hamri Bahini-The Green Angels'. The fund will be used to produce cotton bags and to create other green jobs of similar nature to provide respectable jobs for young women and to improve the degrading environment of Kathmandu.

http://hamribahini.org/?page_id=48

accessed 15 April 2014

Case History: OSMOSE Environmental Education Project, Tonle Sap, Cambodia

The OSMOSE Environmental Education Project started in the year 2000 as first of its kind in the Tonle Sap area. Since then it has gradually grown into a fully established project offering daily environmental education classes and activities to up to 1,100 children in Prek Toal and Peak Kantiel floating villages. The classes are especially adapted to the environment of the Tonle Sap and the local context and are conducted indoors and outdoors by local educators.

In July 2010, OSMOSE and ASAD began to implement a one-year project called "Environmental awareness, budget and business management, alternative livelihood development for the floating communities of Tonle Sap (Prek Toal, Pech Kantiel and Kbal Taol)". The project focused on three areas:

1. Environmental awareness;
2. Business and financial management training;
3. Alternative livelihoods support.

For the environmental awareness Project, OSMOSE has brought together over 1000 children on the lake working in an environmental education Project. As a result, these children have engaged in indoor and outdoor classes, bird watching, awareness on floating garden and waste management and recycling activities. The Project was initiated with the idea of reaching all of the children in the villages in which OSMOSE operates and providing them the information needed to protect and preserve their unique environment.

One of the objectives was to contribute towards creating the next generation of guardians for this unique and fragile environment. Through formal education methods, art, outdoor classes (bird watching, flora and fauna identification, floating garden), waste management and recycling lessons, the children were shown different perspectives on their environment.

Implemented since 2004, this Project needed to be renewed and strengthened. Preparing an environmentally responsible generation for the future is an important part of the response to the environmental threats on the Tonle Sap. But, as some major environmental issues are becoming more and more real (over fishing, global warming, hydroelectric construction on Mekong basin), delivering the message to the current adult generation has become crucial. Although OSMOSE environmental awareness Project has been mainly dedicated to children, as the core idea was to aware the future generation of adults, the environmental education Project was extended to adults in the lake in order to work with both groups of population.

The OSMOSE waste collection program is designed to engage local communities in waste management and sustainable management for their local environment. Features of the programs include:

- teaching the children about waste management
- teaching them how to separate wastes into those that cannot be recycled and those that can be recycled
- during the waste collection activity, we bury those wastes that will decay in the ground
- plastics are burnt, which is not so good due to air pollution but a better way has not been found yet.

Activity 4 Extension and new phase

Following the Strategic Plan 2012-2014, OSMOSE is committed to shift the Project approach towards greater community participation and to adapt its content to gradually evolve into the Education for Sustainable Development (ESD) concept. ESD is a model endorsed by the United Nations Development Project and described as an educational process aiming to achieve human development ("the three pillars of human

development": economic growth, social development, and environmental protection) in an equitable and secure manner.

In this process, OSMOSE EE Project wishes to foster reflective thinking and a deeper sense of stewardship for the surrounding ecosystem amongst the local communities. To reach this goal the following main working points are addressed: 1) move EE to school responsibility, 2) re-brand EE, 3) establish 'young activators', 4) re-establish adult education, 5) link EE further to other Projects of OSMOSE and 6) establish other effective EE outreach tool(s).

School Cooperation

In view to steadily progress the EE Project towards the concept of ESD, the EE OSMOSE team started to work in close cooperation with the public schools. After re-assessment of the present situation of the governmental curriculum in the public schools and meetings with the school directors of the two primary schools, it is wished to entirely transfer the OSMOSE EE indoor classes to the public schools.

Public primary school in Prek Toal

This will mean a bigger impact and a higher sustainability. As of June 2012, it has been agreed that the OSMOSE EE educators will be granted 2 hours per day of teaching their EE curriculum in the Prek Toal primary school.

This will transfer a greater sense of ownership and responsibility to the public schools and strengthen the capacity of the OSMOSE EE educators which will receive further pedagogical training in preparation of the change.

Extension of Outdoor classes: 'Young Activators'

Along with the transfer of the indoor classes to the public schools, the most motivated children will be identified and offered to join groups of 'Young Activators' to participate in special outdoor classes and activities. It is anticipated for these groups to become an active and awareness-raising part of their community and over the long-term potentially evolve into local environmental and social leaders in their communities. Therefore this educative support of the selected children will be associated with a pledge back to their community and the project.

The activities will be designed to ensure knowledge transfer between children and adults. Additionally they will allow reacting on local, environment-threatening events.

Teacher Training and Student Study trips

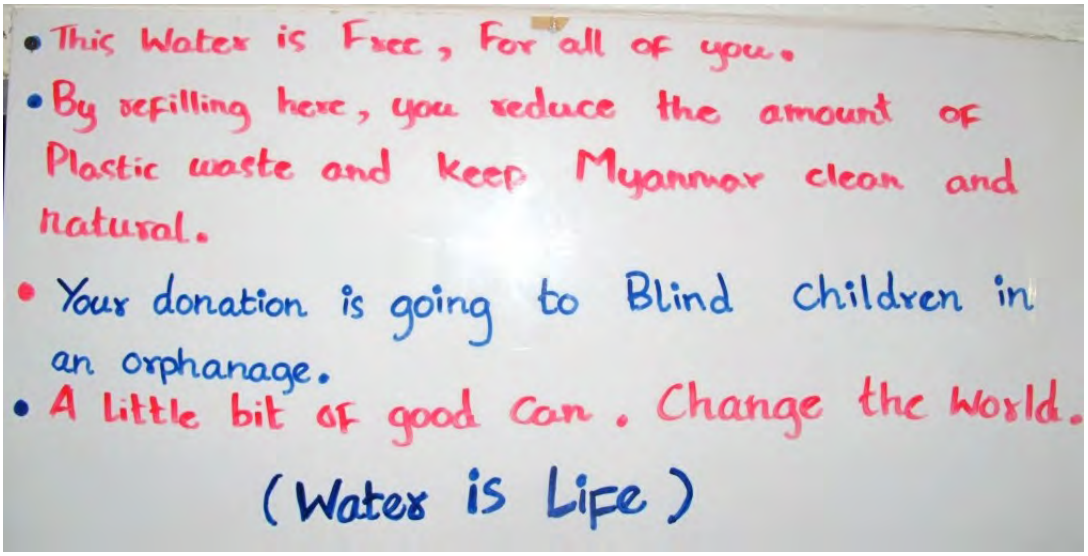
A dedicated training for the EE educators is planned in order to prepare them for the transfer of EE classes to the public schools. The training will take place at the OSMOSE platform in Prek Toal and will comprise pedagogical teaching methods. Ideally a small number of governmental teachers will be invited to participate in the training.

After the successful change of operations of the Indoor classes, study trips for EE children are planned to take place later this year.

Website:
www.osmosetonlesap.net

Case History: Remember Inn Bottle Re-fill Program

Remember Inn in Nyaung Shwe offers free re-fills of drinking water to patrons, requesting a donation to a local orphanage in return. The potable water offered is from a local spring. Most patrons accept the offer and contribute donations, instead of buying new packaged water bottles. This program is an excellent example of a win-win solution, reducing plastic bottles while generating funds for the orphanage.



Appendix 2 Fact Sheets

A series of fact sheets has been produced on the following topics, and these are available as pdf files in both English and Myanmar language.

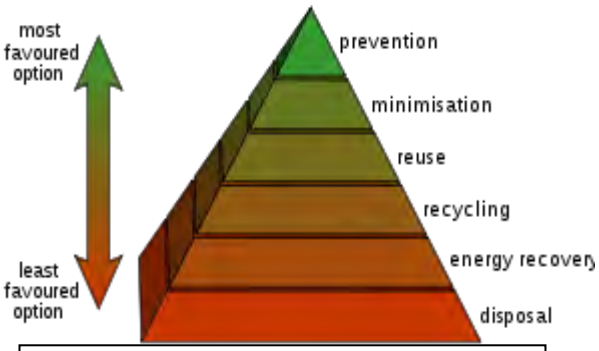
- **Waste Management Options**
- **Composting Organics**
- **Waste Sorting**
- **Wastewater treatment and management**
- **Wetland Pod Toilets for Floating Villages**
- **Reduction of Water Hyacinth**
- **Management of Red Snails**
- **Reducing Fertiliser and Pesticide Use**

Waste Management Options

Waste management is based on the principle of 'reduce, re-use, recycle' which aims to reduce the amount of waste to be disposed of or treated. The aim is to extract the maximum practical benefits from products and to generate the minimum amount of waste.

Waste can be a valuable resource, and there is an opportunity to reap a range of benefits, including:

- economic benefits from valuable materials being recovered for reuse and the potential for new jobs and new business opportunities.
- social benefits from reducing adverse impacts on health and new sources of employment, with income for communities
- environmental benefits through reducing or eliminating adverse impacts on the environment, including improved air and water quality and reduction of greenhouse emissions.



http://en.wikipedia.org/wiki/Waste_management

Methods of Disposal

Landfill

Disposal of waste in a landfill involves burying the waste. A landfill site needs to be designed to minimise leaching and release of methane gas, and to prevent attracting vermin such as mice and rats. Leachate can be contained with clay or plastic lining material at the site. Waste can be compacted and covered to reduce vermin.

Many landfills also have landfill gas extraction systems installed to extract the landfill gas. Gas is pumped out of the landfill using perforated pipes and flared off or burnt in a gas engine to generate electricity.

Incineration

Incineration is used to dispose of solid, liquid and gaseous waste. Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

Incineration is common in countries where land is scarce, as these facilities generally do not require as much area as landfills. Incineration can generate energy -- waste can be burnt in a furnace or boiler to generate heat, steam or electricity. Combustion in an incinerator is not always perfect and there are concerns about pollutants in gaseous emissions from incinerator stacks.

Recycling

Recycling refers to the collection and reuse of waste materials such as empty beverage containers, with the materials reprocessed into new products. Items for recycling need to be separated from other rubbish, either by the householder or by the rubbish management agency.

The most common consumer products recycled include aluminium such as beverage cans, copper wire, steel from food and aerosol cans, polyethylene and PET bottles, glass bottles and jars, paperboard cartons, newspapers, magazines and light paper, and corrugated fibreboard boxes.

Biological reprocessing

The intention of biological processing in waste management is to control and accelerate the natural process of decomposition of organic matter.

Recoverable materials that are organic in nature, such as plant material, food scraps, and paper products, can be recovered through composting and digestion processes to decompose the organic matter. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes.

In addition, waste gas from the process (such as methane) can be captured and used for generating electricity and heat (CHP/co-generation) maximising efficiencies.

Energy recovery

The energy content of waste products can to fuel by direct combustion, or by indirectly processing them into another type of fuel. Thermal treatment ranges from using waste as a fuel source for cooking or heating and the use of the gas fuel to fuel for boilers to generate steam and electricity in a turbine.

Avoidance and reduction methods

An important method is waste reduction through avoiding generation of waste. This includes reuse of second-hand products, repairing broken items instead of buying new, designing products to be refillable or reusable (such as cotton instead of plastic shopping bags, or re-filling water bottles), encouraging consumers to avoid using disposable products, removing any food/liquid remains from cans and packaging, and designing products that use less material to achieve the same purpose (for example, light-weighting of beverage cans).

Figure 1 Many markets produce a large amount of rubbish, such as the Kakku Market in March 2014, and a system of recycling and re-use is required to manage this problem.

Composting Techniques

Organic matter can be recycled by composting to produce mulch which can be mixed into soil or used as mulch. Organic materials can be as much as 80% of the waste stream, so composting can be very beneficial in reducing the amount of rubbish to be processed, as well as producing a valuable product for use in agriculture and gardens.

Organic matter should be collected into a space where the mix of inputs can be controlled and the mixture can be aerated. The mixture requires suitable small-sized organic matter, nitrogen, air and water, and a warm location protected from wind and direct sunlight. Layers of grass, lawn clippings, leaves or shredded paper are added on top of layers of food waste to reduce odours.

Suitable organic materials include:

- plant waste, including leaves, grass clippings, plant stalks, vines, weeds, twigs and branches
- food wastes including fruit and vegetable scraps, coffee grounds, eggshells and nutshells
- other compostable materials, including hair clippings, feathers, straw, and livestock manure.

Materials which should NOT be included are:

- meat, fish, poultry, dairy products, foods containing animal fats, human/pet faeces, weeds with developed seed heads, and plants infected with or highly susceptible to disease.

Suitable nitrogen sources include:

- fresh grass clippings and manure.

Figure 1 **Household compost bin in southern Australian suburban home breaks down organic kitchen waste to mulch; base of bin is open to soil, allowing worms to enter the compost; plastic bin with fitted lid contains heat within the mulch and prevents access by rats; mulch is returned to kitchen garden once a year (climate is warm temperate, cool winters and hot summers with low humidity, so composting rate is slower).**

Starting Composting

To start the process, a minimum of 34 cubic feet of small organic materials is needed (say 3'x3'x4').

Begin the pile with a 1 foot layer of plant matter. Add a shallow layer of nitrogen sources like grass clippings. Repeat these 2 layers, then add vegetables, fruit and flowers. Repeat layers to about 5' high, with a final layer of plant matter (leaves, twigs, sugar cane husks).

Chop vertically through the pile with a pitchfork to thoroughly mix the materials. Add just enough water to moisten the pile, then cover it with a black plastic sheet weighted down at the edges.

The pile will generate heat, and should be turned every few days, as the centre cools, to bring the material on the edge into the centre. Turning the pile maintains the temperature and ensures that all material is exposed to the centre heat. When the compost is finished, the pile will no longer heat up.

Make a series of similar piles 3'x3' x5' as needed to treat organic waste. Keep the piles to a manageable size to allow turning and temperature control.

Finished Compost

Finished compost is dark brown, crumbly, and has an earthy odour. Depending upon seasonal temperatures, a well-built, well-tended pile generally yields finished compost in 2 weeks to 4 months, depending on local climate. The compost can be added to soil or used as mulch. This product could be sold or given to farmers as mulch and fertiliser, for example to tomato farmers to use as a substitute for harvesting water plants from Inlay Lake.

Figure 2 **Organic matter in rubbish heap at Phaung Daw Oo market at Inlay Lake could be separated and turned into compost using multiple small heaps approximately 3'x3'x5'**

Reference

http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/facts/compost.htm
accessed 10/04/201

Waste Sorting

Waste management is based on the principle of 'reduce, re-use, recycle' which aims to reduce the amount of waste to be disposed of or treated.

In order to extract the maximum practical benefits from products and to generate the minimum amount of waste, waste needs to be separated into different elements.

It is best if this is done at the source, so that waste is not mixed. Organic waste and other wastes contaminate each other and reduce the efficiency of the management process and reduce the value of the final products.

GOLDEN RULE OF SORTING WASTE:

Waste needs to be separated at the source
DO NOT MIX ORGANIC MATERIALS WITH OTHER WASTE

Waste Categories

The way that waste is sorted must reflect local capacity to process the different types of waste.

The following categories are common:

- Compost
- Paper
- Cardboard (including packaging for return to suppliers)
- Glass (clear, tinted – no light bulbs or window panes, which belong with residual waste)
- Plastics
- Scrap metal
- Special/hazardous waste
- Residual waste.

Waste should be divided into dry and wet categories. **Dry waste** includes wood and related products, metals and glass. **Wet waste** usually refers to organic waste which is damp.

Organic Waste

Organic waste includes:

- Fruit and vegetables, peelings and scraps
- Eggshells and nut shells
- Cut flowers
- Dairy products, including cheese and yoghurt
- Fish including bones
- Coffee grindings, tea bags
- Paper towels and tissues
- Corks.

Cooked or raw meat scraps and bones should generally not be included because of the risk of attracting rats and other scavengers. It is better to incinerate meat-based rubbish if it cannot be used as stock food or dog food.

Chip pan oil (fryer oil), used fats, vegetable oil and the content of fat filters can be converted to bio-fuel.

More Information

Inlay Lake & Hill Areas Fact Sheet: ***Composting Organics***

http://en.wikipedia.org/wiki/Waste_sorting

zerowaste.sa.gov.au/recycle-right

Figure 1 **Many local markets produce a large amount of rubbish, such as the Kakku Market in March 2014, and a system of sorting rubbish into organic materials and other categories for recycling and re-use is required to manage this problem.**

Wastewater Management Options

Wastewater is divided into **grey water**, which includes bath, shower, hand-basin and laundry water, and **black water**, which is sewage water from toilets. Kitchen grey water cannot be re-used, as grease and oil clog irrigation systems and build up on soil surfaces. It should be treated with black water.

Methods of Treatment

Sewage treatment (toilet wastes or black water)

Sewage treatment can involve up to three stages, following preliminary treatment to screen out larger solid inorganic material such as paper and plastics:

- Primary treatment: uses sedimentation to separates solids, grease and oil, creating solid organic sludge
- Secondary treatment: uses micro-organisms to break down dissolved and suspended organic solids and remove biological matter as a concentrated sludge
- Tertiary treatment: treats clarified wastewater with anaerobic digestion and disinfection (usually chlorine, but can also be large ponds open to sunlight) to reduce pathogens

Tertiary treatment is required for wastewater that is released into sensitive ecosystems.

Figure 1 **Tertiary treatment system for wastewater at Heritage House in Inn Kyaw Phone village, Inlay Lake, with wetland treatment final stage**

Sludge Treatment and Products

Sludge collected during the treatment process contains a large amount of biodegradable material which is treated by anaerobic bacteria, which do not need oxygen for growth. This takes place in special fully enclosed digesters heated to 35 °C.

The gas produced during this anaerobic process contains a large amount of methane and can be used to heat the digesting sludge to maintain the efficiency of the process. Alternatively, the gas fuel can be used to generate electricity, with the waste heat used to maintain the digestion process.

Water is removed from the digested sludge through mechanical means such as centrifuging, or by natural solar evaporation in lagoons. The stable, solid material remaining, called *biosolids*, looks, feels and smells like damp earth and makes ideal conditioner for soil.

Biosolids

Biosolids are a valuable resource which can be used in agriculture to improve and maintain productive soils and to stimulate plant growth. They are used to increase soil fertility and as a source of nutrients for various crops. They also provide benefit by improving the water holding capacity of soil. The slow release of nutrients as the organic matter decomposes gives a long term effect from the initial application and appears well suited to native plants and grasses.

Methods of Disposal

Grey water can be re-used on lawns and gardens. Care should be taken in re-using grey water because of potential health risks and environmental damage from chemicals and nutrients in the water. It should not be used to grow vegetables for human consumption or for drinking.

Treated wastewater can be released onto land sites, including:

- surface irrigation (spray above ground)
- sub-surface irrigation (drippers in shallow trenches – large surface area)
- covered surface irrigation (drippers on natural ground covered by mulch, woodchip, etc)
- evapotranspiration-absorption trenches/beds/mounds.

Wetland Treatment

Constructed wetlands can be used as part of the treatment process, in particular to reduce phosphorus and nitrogen levels. Physical, chemical, and biological processes combine in wetlands to remove contaminants from wastewater. Vegetation in a wetland provides a substrate (roots, stems, and leaves) upon which microorganisms can grow and break down organic materials, removing up to 90% of pollutants.

Aerobic and anaerobic micro-organisms facilitate decomposition of organic matter. Microbial nitrification releases nitrogen as gas to the atmosphere. Phosphorus is co-precipitated with iron, aluminium, and calcium compounds located in the root-bed medium. Suspended solids filter out as they settle in the water column in surface flow wetlands, or are physically filtered out by flowing through the substrate. Harmful bacteria and viruses are reduced by filtration and adsorption by biofilms.

A *treatment wetland* is an engineered sequence of water bodies designed to filter and treat waterborne pollutants found in stormwater run-off or effluent. System types are surface flow, sub-surface flow or vertical flow. The wetlands are placed in a basin with a substrate. The bottom is lined with a polymer membrane or concrete or clay in order to protect the water table and surrounding ground. The substrate in the wetland bed can be either gravel, sand or a mixture of various sizes of particles. The plants used are normally reeds, but a wide range of native wetland plants are suitable.

References

http://www.sawater.com.au/sawater/education/ourwastewatersystems/wastewater+treatment+process.htm
accessed 04/04/2014
http://www.sunshinecoast.qld.gov.au/sitePage.cfm?code=ostp-and-greywater
accessed 09/04/2014
http://en.wikipedia.org/wiki/Constructed_wetland
accessed 29/04/2014

Further information about biosolids is available at www.biosolids.com.au

Need for Improved Toilets in Floating Villages on Inlay Lake

Living on a lake poses particular issues for hygiene, health and waste disposal, as the water medium facilitates very high rates of infection. Inlay Lake has more than 60,000 people living in floating villages, with more than 72% of those households discharging toilet wastes directly into the lake.

Sanitation in lake villages usually consists of 'hanging' latrines, with wastes dropping directly into the lake (Figure 1). While some dwellings have effective septic systems, these are usually too costly for villagers, and there are practical problems with operation during wet and stormy conditions, due to wave action breaking connecting pipes and inundation of tanks.

There is a high level of bacterial contamination in all lake waters and very high rates of diarrhoea and dysentery due to toilet wastes in the lake water. The highest rates are at the southern end of the lake.

There is the potential for a 30% improvement in human health if more working toilets are installed in the floating villages of Inlay Lake.

This requires provision of floating toilets for lake households which work in flooded conditions and development of a practical, low-cost toilet design.

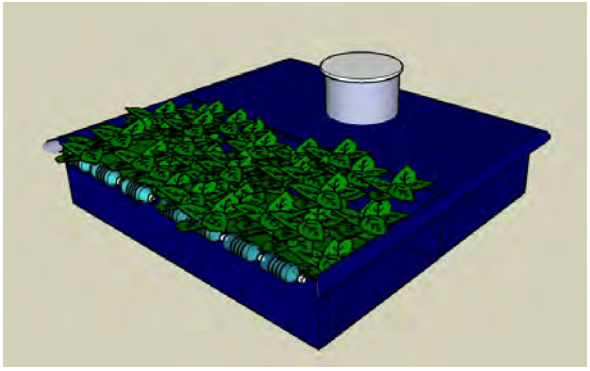
Figure 1 Typical hanging latrine and bamboo stilt house in a floating village on Inlay Lake

However, it is critical to work with lake communities to understand how to provide help to introduce better sanitation to households and effective uptake of the new toilet systems. Previous programs have not been effective, as communities have some misconceptions and misunderstandings about the cause of the problem and the need for effective action to improve lake water quality. As well as providing practical technology, there is a need to develop accompanying education programs and extension services to promote sanitation and health measures.

A Practical Toilet Option for Floating Villages

International NGO *Wetlands Work!* has developed a low cost, practical toilet design called *Handy Pod* which is being used at Tonle Sap Lake floating villages in Cambodia.

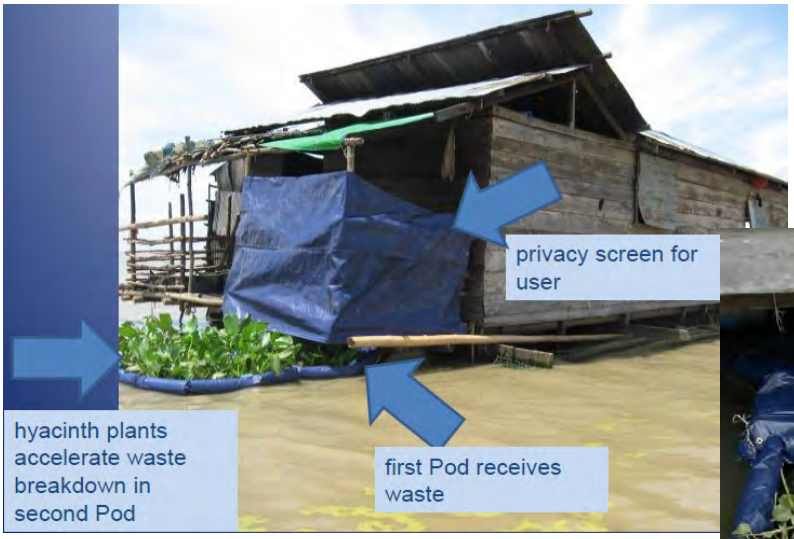
The *Handy Pod* is a floating system that stores and treats household waste, and works in low and high water conditions. The *Handy Pod* is filled with plant material, such as water hyacinth, and the bacteria on the hyacinth roots feed on organic sewage, reducing pollution and disease-causing microbes.



The *Handy Pod* unit is made of simple locally-available materials at low cost (less than $US 15 /13,000 kyat). Local materials like cane baskets and bamboo screens can be used to cover the blue plastic of the pod, to blend into the lake landscape. Alternative designs are being developed using bamboo, empty 1.5L PET bottles and minimal plastic sheeting.

Summary of Wetland Pod Option

- a simple design, requiring minimal behaviour change
- low maintenance and cost
- greatly reduces disease-causing bacteria levels in water
- proven operation for floating villages at Tonle Sap in Cambodia
- high potential for use at Inlay Lake
- If hyacinth weevils are present, it may be necessary to add plants to the pod occasionally.



Wetlands Work! Ltd.
Phnom Penh, Cambodia
www.wetlandswork.org

Need for Reduction of Water Hyacinth in Inlay Lake

A major contributor to the loss of open surface water at Inlay Lake is the rapid expansion of water hyacinth.

Water hyacinth is reported to have been introduced to Inlay Lake as an ornamental plant in the 1950s and it has spread rapidly on the lake surface, fed by abundant nutrients from floating garden agriculture, as well as warm temperatures and the available space on the open lake surface.

Problems caused in Inlay Lake by water hyacinth include blockage of boat transport, interference with water supply, accumulation around villages and structures, and increased breeding of mosquitoes. The dense plant mass shades and deoxygenates the water, blocks light penetration into the water column, reduces nutrients for young fish, reduces fish stocks and interrupts fishing. The water hyacinth mats create conditions that favour breeding of vectors for disease.

Hyacinth plants have migrated downstream into Saga Lake and Moybe Reservoirs, and are reported to cause problems by blocking intakes at the Law Pi Ta hydro-power plant downstream of Inlay Lake.

Biology of Water Hyacinth

Water hyacinth, *Eichhornia crassipes*, is a native of South America from the upper Amazon catchment, and is one of the world's worst aquatic weeds. It forms dense mats that clog waterways and make them useless for navigation and other uses. The dense mats out-compete native aquatic plants.

Water hyacinth is an attractive, floating waterweed with lilac-coloured flowers in dense vertical spikes above the mass of plants with their green rounded leaves (Figure 1). This species can reproduce both vegetatively and through the production of vast quantities of seed, and an infestation can double in size in a few weeks. It is often introduced to new sites because of its attractive flower, and then escapes to form problem mass infestations.

Some villagers have been observed collecting water hyacinth to be composted and added to the mulch on tomato gardens. However, other villagers stated that water hyacinth is not suitable as material for mulch in floating gardens, as it does not contribute to fertility of garden beds.

There is some very limited use of water hyacinth fibres to build furniture.

Figure 1 One entire water hyacinth plant, showing lilac flowers and trailing root mass.

Biological control methods

International research has identified several effective biocontrol agents, particularly two weevils (beetles) *Neochetina eichhorniae* and *N bruchi*, whose larvae tunnel in the stems of water hyacinth, leading to decomposition of the plants (Figure 2). The weevils feed on the leaves, while the larvae tunnel into the leaf stalk and crown, destroying the growing points. This causes the plants to rot and die and eventually sink. Once the weevils become established on water hyacinth, the impact is rapid, visible and long lasting.

Figure 2 **Water hyacinth mats at Inlay Lake; Neochetina weevil (right) used for biological control of water hyacinth**

Action on Water Hyacinth

If weevils were introduced to Inlay Lake, it is estimated that more than 80% of water hyacinth biomass could be removed from Inlay Lake in 3-5 years.

Up to 20% of hyacinth plants would remain, so there would still be a resource for use of this species by farmers and the small furniture industry. The plants would also continue to multiply as long as nutrients were available.

Scientists have undertaken trials at multiple international sites to ensure that the weevils do not cause other environmental problems, and found that the weevils will eat only water hyacinth The *Neochetina* weevils used to control water hyacinth are specific to this host species, and would not harm lotus plants at Inlay Lake.

The feasibility of biological control of water hyacinth at Inlay Lake has been investigated with CSIRO Australia. A project could be developed based on Australian expertise, using local knowledge and community involvement to breed and spread weevils, and to monitor and report progress. There is potential for local agricultural high schools to participate in the process of rearing weevils. Permission would be sought from the appropriate government agencies for permission to import live weevils from field populations in Australia.

Monitoring data are needed to monitor the current rate of expansion of hyacinth, location of hot spots where control action should be given priority, and progress of decline of hyacinth after commencement of control measures.

The hyacinth control project should be undertaken in conjunction with actions to reduce the sources of excess nutrients entering the lake. It is also recommended that a research project be undertaken to monitor the response in the ecosystem as the impact of hyacinth is reduced.

The project should start with a field visit by representatives from Inlay Lake visiting Phayao Lake in northern Thailand to see successful water hyacinth control at that site.

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Control of Red Snail at Inlay Lake

The pest snail species Golden Apple Snail (*Pomacea canaliculata*) was first noticed in abundance in Inlay Lake from 2006, with a marked increase from 2009. The local common name is red snail. Its high and expanding abundance is clear from the bright pink clusters of eggs which can be seen on floating green vegetation and posts around the lake.

The snails are causing serious damage to rice crops. On Inlay Lake, farmers report that snails eat tomato plants, and they are a major pest in rice crops. In rice paddies, dry snail shells accumulate in dense drifts at the corners, indicating the high numbers of snails grazing there. The snails eat kitchen wastes and congregate around villages in the vicinity of houses. They prefer soft aquatic plants.

While villagers report that the snails do not eat water hyacinth, it has been reported as feeding on water hyacinth in other locations, and it was observed in Inlay Lake that the snails use hyacinth as a preferred egg-laying habitat. The snails are observed to thrive in poorer quality water, and numbers have increased in locations with declining water quality.

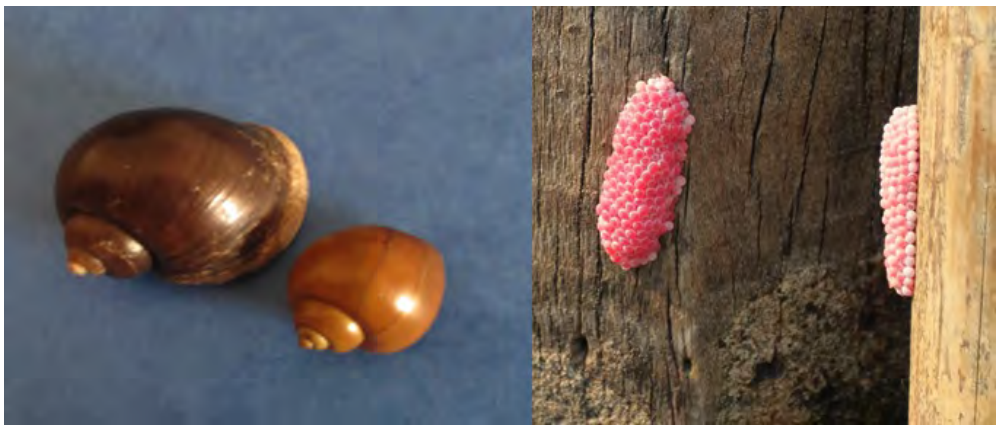

Figure 1 **Invasive red snail – adults (left) and egg masses (right).**

Biology of Red Snail

The golden apple snail is a native of South America (Brazil and Argentina). It was introduced to Taiwan for potential production as food for humans and farm animals, but spread to the Philippines and then to south-east Asia, where it has become a major pest of rice. Golden apple snails feed on a wide range of plants such as algae, azolla, duck weed, water hyacinth, rice seedlings and other succulent leafy plants.

The golden apple snail lives for 2-6 years and has high fertility. In warm conditions with abundant food, the life cycle can be less than three months, and the snails can reproduce through the whole year. This is likely to be the case at Inlay Lake.

Eggs are laid by female snails during the night or early morning on a stem of emergent aquatic vegetation or other expose d surfaces like stones or wood, 5-80 cm above the water line. At Inlay Lake, they are frequently laid on wooden piles or jetties. Golden apple snails lay 1000-1200 eggs a month.

The eggs hatch in 7-14 days, and the hatchlings take 15-25 days to develop into juvenile snails. They are sexually mature at 45-59 days (Figure 2). In dry conditions, the snails can aestivate, sealing themselves into their shells and burying in the mud.

Native predators of the snails include birds (kites, storks, ducks), turtles and fish. Snails are also eaten by domestic ducks and rats.

The highly visible bright pink egg clutches contrast with the green vegetation, and this is a warning sign, as the eggs are unpalatable to potential predators (Figure 1). The eggs are not eaten by fish or birds. Humans report an itchy skin response if they touch egg masses, and this inhibits attempts to harvest the eggs to control snail numbers.

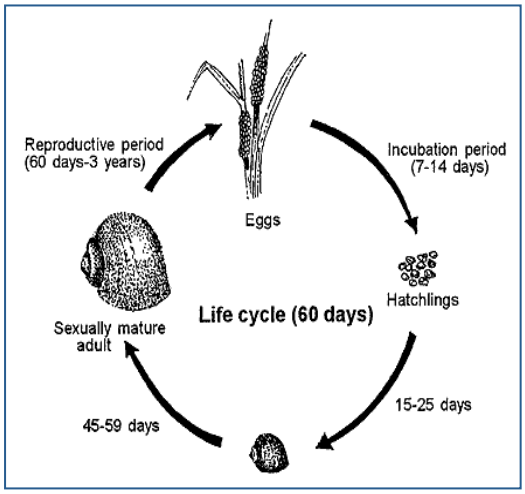

Figure 2 **Life cycle of red snail (*Pomacae caniculata*)**

Options for Control of Red Snails

Potential control methods for red snails at Inlay Lake include hand collection of adult snails from rice paddies at dawn and dusk, and knocking egg masses into the water, as they do not survive inundation.

Egg destruction is a very effective control strategy, given the high numbers of eggs per clutch. Inundated snail eggs do not hatch (www.applesnail.net/), and a possible control method is to knock egg clusters into the water, or to splash them with water. The eggs should not be touched by hand, owing to the problem with skin irritation.

Potential uses for the adult snails include stock feed for pigs and ducks, and human consumption as a delicacy. South Koreans consider the snails to be a delicacy.

Naturally occurring biological control agents include red ants, which feed on the eggs, ducks and rats, which eat juvenile and smaller adult snails. Collected snails can be cooked and eaten or crushed and fed to livestock. Ducks can be herded into rice paddies immediately after harvesting of rice, and prior to new planting, to eat the snails.

A variety of techniques can be used to reduce snail impacts on rice paddies, including removal by hand in the morning and evening when they are most active. Attractants include other plants and old newspapers to collect snails, or use of channels and screens to trap snails.

Use of natural Neem pesticide, from a plant oil derived from local Neem leaves, is considered the most effective method for control by villagers from Kaylar.

The numbers of egg clusters should be counted at a series of monitoring points to record progress in controlling red snails.

Need to Reduce Fertiliser and Pesticide Use in Floating Garden Agriculture

Floating garden agriculture is a unique feature of Inlay Lake, and forms part of the attraction as a tourist destination, as well as being a major source of income for local communities. However, the rapid expansion of horticulture on floating gardens has created several problems, including inappropriate agricultural practices that cause ecological damage to the lake and create a health hazard for farmers and local populations.

Inlay Lake floating gardens have become a national production area for tomatoes, supplying markets all over Myanmar. Seventy-five per cent of the tomato yield is exported to Yangon and other states and divisions of the country. The annual production may be as much as 90,000 tonnes, with 300 tonnes per day harvested in the peak production season. The tomatoes are large and well-shaped, commanding a higher price, although production costs are also relatively high. Other crops include long beans, cucumbers, onions, garlic and flowers.

There are serious problems with declining agricultural productivity, coupled with excessive and inefficient use of fertilizer and pesticides, with very high input costs and serious consequences for the water quality and ecological health of the lake. This system is similar to hydroponic agriculture and, without soil as a buffer and close spacing between beds, it is more susceptible to pathogen attacks. This weakness may be the reason for the very high use of fertilizer and different 'cocktails' of pesticides, insecticides and fungicides.

Excessive Use of Fertiliser

The excessive use of artificial fertilisers goes far beyond the recommended rate, with little benefit in improved production for the extra costs. Farmers have requested assistance to develop better fertigation systems to improve profitability and reduce impact. Information and training are needed for farmers to learn appropriate application rates of appropriate products.

The aggressive expansion of water hyacinth is attributed to the availability of excess nutrients.

Excessive Use of Pesticides

Control of insects and fungal diseases is challenging in the uncontrolled hydroponic environment of Inlay Lake, with conditions of high humidity, highly variable wind conditions and densely planted crops. As a result, there has been heavy use of pesticides, with serious consequences for the ecological health of the lake and for human health in lake villages.

The spraying regime used by the tomato growers is to mix insecticides, fungicides and foliar nutrients and apply such a tonic once a week to try and stay ahead of disease, which in this environment can build very rapidly causing heavy losses. Pesticides are sprayed 2 weeks after transplanting, and then every 10 days. The primary pests are red spider mites and cutworms, which are controlled by monochorophos and cypermethrin respectively. Lateblight is controlled by daconil or ridomil.

Some of the chemicals are extremely poisonous for people, birds and reptiles, as well as fish. Cypermethrin is currently applied at up to **15 times** the recommended rate. Metalaxyl is applied at as much as **59 times** the recommended rate. The over-application of these pesticides is not only costly to the farmer, but also causes unnecessary pollution that threatens the health of lakeside residents and the ecosystem of the lake.

Alternative Natural Fertilisers

UNDP has been conducting training workshops in composting of organic materials to produce natural mulch, as an alternative to chemical fertilisers in farming, at locations in the Kalaw sub-catchment.

Recycling of organic materials into mulch from village rubbish collections could be used as an alternative to the current use of native water plants for mulch in tomato gardens.

Develop New Varieties

In recent years, a high yield variety of tomato seeds has been introduced from Thailand and China, reportedly supplied free by the suppliers of agricultural chemicals. The suppliers then recommend very high rates of application of artificial fertilisers and pesticides, for which they control the market. The fertilizer companies need to be engaged in this debate, eg AWBA, and encouraged to promote reduced sustainable rates of application of fertilisers and pesticides. Farmers need specific information and training in the safest and most effective use of fertilisers and pesticides.

Further research is required to develop plants better suited to the climatic conditions of Inlay Lake, with greater resistance to the main pests.

Improved Extension and Support for Farmers

Specific information is needed for farmer training in safe farm practices, economic and safe application rates of fertiliser and pesticides, as well as choice of appropriate products. Changes in farming practice could reduce the need for pesticides, including development of new varieties of crop plants. Information and training are needed for farmers to learn appropriate application rates of appropriate products in a safe manner. Farmers have requested assistance to improve their profitability and to reduce impacts, of which they are well aware.

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