

Assessment on People's Perceptions of Environmental Changes at Inle Lake, Myanmar

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Abstract: Inle, the second largest lake in Myanmar, is one of the most important watershed areas in the country, a prominent water resource for huge amount of hydropower and a highly attractive natural heritage place. For decades, the lake has been facing serious threats due to natural and manmade pressures, resulting in decreasing water holding capacity, diminishing water quality, disturbing the navigability, declining in livestock and others. In this study, structural interviews were conducted with tourists and locals from villages in and around the lake to obtain their perceptions on environmental changes in Inle lake, such as open water surface area changes, lake water quality and socio-economic changes. According to the survey's result, the current lake environmental situation seriously affects living practices of indigenous people. In the past, local people used to drink lake water but nowadays, they do not consume it due to awareness of natural water degradation. Furthermore, the lake is getting shallower due to sedimentation that may lead to transportation problems within villages and a declining number of fishes that may ruin the ecosystem of the lake. This research paper can give some effective suggestions how to conserve environmental impacts on Inle lake based on valuable conservation.

Index Terms - sedimentation, water quality, socio-economic, degradation, environmental changes.

I. INTRODUCTION

Inle Lake is the second largest natural lake in Myanmar and is located in the Balu Chaung Valley (884 masl) between the Sindaung (east) and Letmaunggwe, Thandaung and Udaung mountain ranges. It is a shallow lake, where maximum depth varies between approximately 4 m in the dry season and 5-6 m in the rainy season. The average depth is approximately 1.5 m in the dry season. (NIWR2017, referring to IID 2012).

There are 35 villages within Nyaung Shwe township: 17 of these lie within the lake and 5 lie partly in the lake and partly on land. The remaining 13 villages are situated on land around the lake surroundings. The surroundings of Inle lake face environmental degradation such as deforestation, water quality decrease, sedimentation and climate change impacts. Deforestation and more intense agriculture on its western and northern watershed areas contribute to soil erosion and brought in increasing amount of silt and nutrients into the shallow lake. As a consequence, sedimentation and siltation has been seriously affecting the surface area and water depth of the lake.

One of water pollution sources is agriculture. Farmers use chemical fertilizers and pesticides, resulting in contamination of the surrounding lake and area. Furthermore, the Inle region is also well-known for its textile products. Major textile industries use chemical dyes as well as natural dyes and chemical waste from their businesses pollute the environment. In addition, other pollution sources contributing to poor water quality of the lake are the untreated wastewater from residences, dumping of waste and garbage from households, lack of proper sanitation and livestock breeding.

Nowadays, the government organizations and other associations have worked to prevent the contamination of Inle lake from impacts of : reduced surface area of open water, loss of diversity and abundance in aquatic plant communities, declining water quality, sedimentation of in- shore zones, soil erosion in watershed areas, declining and inefficient agricultural productivity in floating gardens, threats to human health, predicted large and rapidly increases in visitor numbers and lack of effective engagement and capacity building in community. However, more work is necessary. In this study, open talks survey and structured questionnaires were conducted by asking tourists and local people around the lake to study people's perceptions on environmental changes.

I. STUDY AREA

It is located within 96°46' - 97°09' E longitude and 20°05' - 21°17' N latitude in WGS 84 coordinate system with the total area of 4975.6 km². Inle Lake area is surrounded by hilly region of elevation (about 900 to 1800 masl). Mountains, hill lands, flat lands, many streams, lake and floating garden build the major landscape units of the study area. The study area is a part of Shan Plateau which has main limestone formation and is situated between Sagaing Active Fault and faults along the Shan scarp. This area has a humid subtropical climate with subtropical highland climate. The ecosystem in Inle region is fresh water wetland ecosystem and there have (527) species of plants, (12) species of aquatic weeds, more than (270) species of birds, (43) species of fish, (3) species of tortile, (93) species of butterfly, (30) species of mammal and (217) species of orchid.(MOALI) Fig.1 shows location of study area and four main streams: there are 29 streams flowing totally as inflow channels in lake Inle catchment area. 17 streams from the eastern side, 11 streams from western side and one major stream from the northern side flowing into lake.

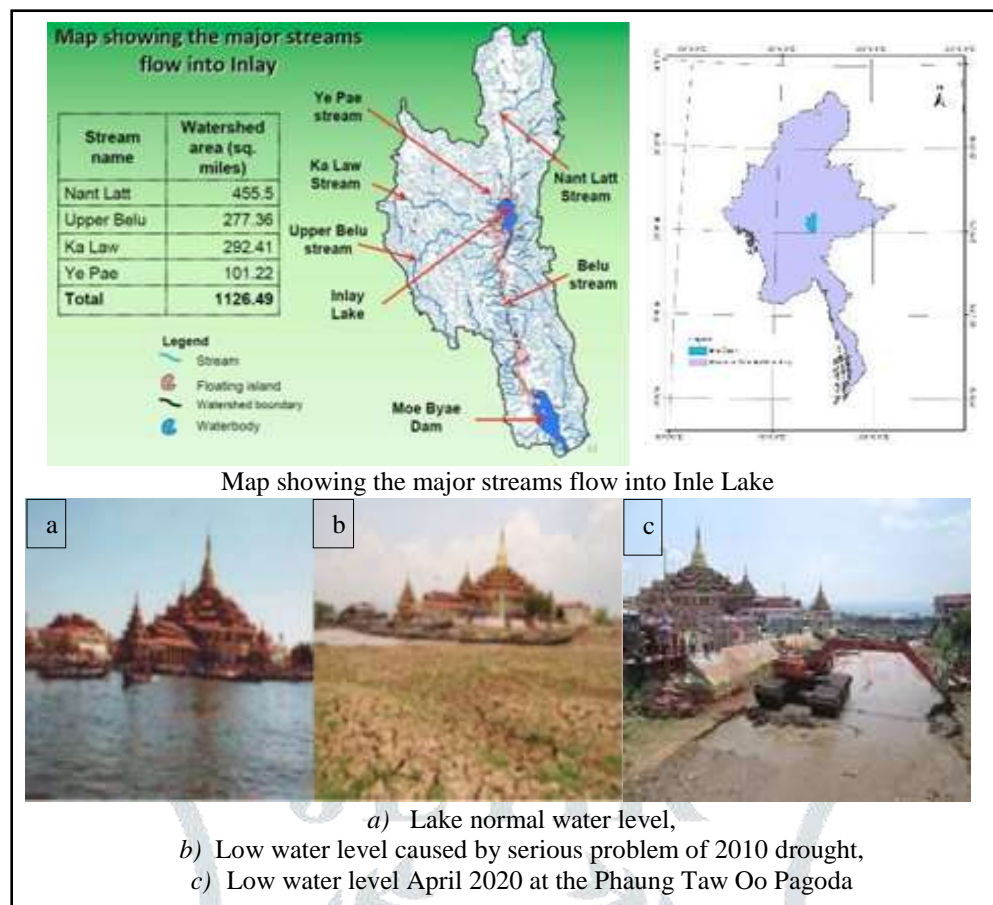


Fig.1 Location of study area (Source: MOECAP2014)

Table.1 General information of villages ,Nyaung Shwe(2019)
 (Source; Department of Rural Development, Shan State Development Committee)

No.	MainVillage Name	Sub Group Number	Housing No.	Population	No.	MainVillage Name	Sub Group Number	Housing No.	Population
1	Nan Thae	8	790	4566	19	Naung Taw	26	1630	7714
2	Kyun Gyi	6	940	5640	20	Inn Hlyar,Kyaing Kham	14	964	4750
3	Linn Kinn	14	1022	4689	21	Taung To	22	1015	5102
4	Khaung Tine	5	729	3299	22	Kyauk Tine	11	577	2924
5	Lat Maung Kway	8	606	2663	23	Kyay Paw Khone	15	1518	7563
6	Taung Poet Gyi	14	861	3859	24	Inn Tain	6	820	3709
7	Taung Chay	24	1389	5990	25	Inn Chan Kay Lar	6	1060	5169
8	Mine Thauk	17	1166	5599	26	Inn Paw Khone	13	936	4720
9	Ywar Thar	11	893	4292	27	Tha Lae Oo	25	1408	5953
10	Ti Law	27	2839	13598	28	San Karr	9	749	3885
11	Min Chaung	12	1844	10396	29	Lone Kan	9	632	3957
12	Nann Pan	11	967	3973	30	Yae Puu	4	421	2024
13	Tone Lal	9	1040	3979	31	Linn Lan Taung	6	613	2997
14	Tha Pyay Pin	9	1267	5460	32	Inn Tann	9	456	2259
15	Nga Phal Chaung	8	651	2896	33	Bann Pyin	19	1405	6340
16	Ywar Ma	13	818	3115	34	Linn Lan Myauk	7	648	3418
17	Thar Layy	13	988	4886	35	Pone Muu	24	1200	5771
18	Mine Pyoe	11	430	2171		Total	445	35292	169326

II. MATERIALS AND METHODS

To obtain basic data, structured interviews and open talks were conducted with local people from various villages in the lake and around the lake. The questionnaires were prepared based on open water surface area changes, water quality, agriculture, water

usages and socio-economic status affected by climate change. Interviews were conducted for two groups: structured interview for local people and tourists and open talks with governmental officers from Forest Department, Agriculture and Irrigation Department, Education Departments, Agriculture Department, Medical Departments and non-government organization (MIID, GIZ, NGOs), together with Kristin Peters, M.Sc. Environmental Management student from Kiel University, Germany. Fig.2 shows flow chart for assessment on people's perceptions on environmental changes.

In this study, there are 35 main villages (445 sub- villages) in Nyaung Shwe Township. Therefore, the random survey based on their business is the most suitable. Among the villages, 148 people were asked with structured interviews. In addition, visitors' perceptions were collected with questionnaires from 15 tourists. Moreover, open talk interviews and informal talks with governmental employees were carried out to know the environmental problems and present management systems in this area. and Population was 105,533 (1995) and 169,326 (2019); about 60 percent increase within 25 years (Source; Department of Rural Development, Shan State Development Committee).

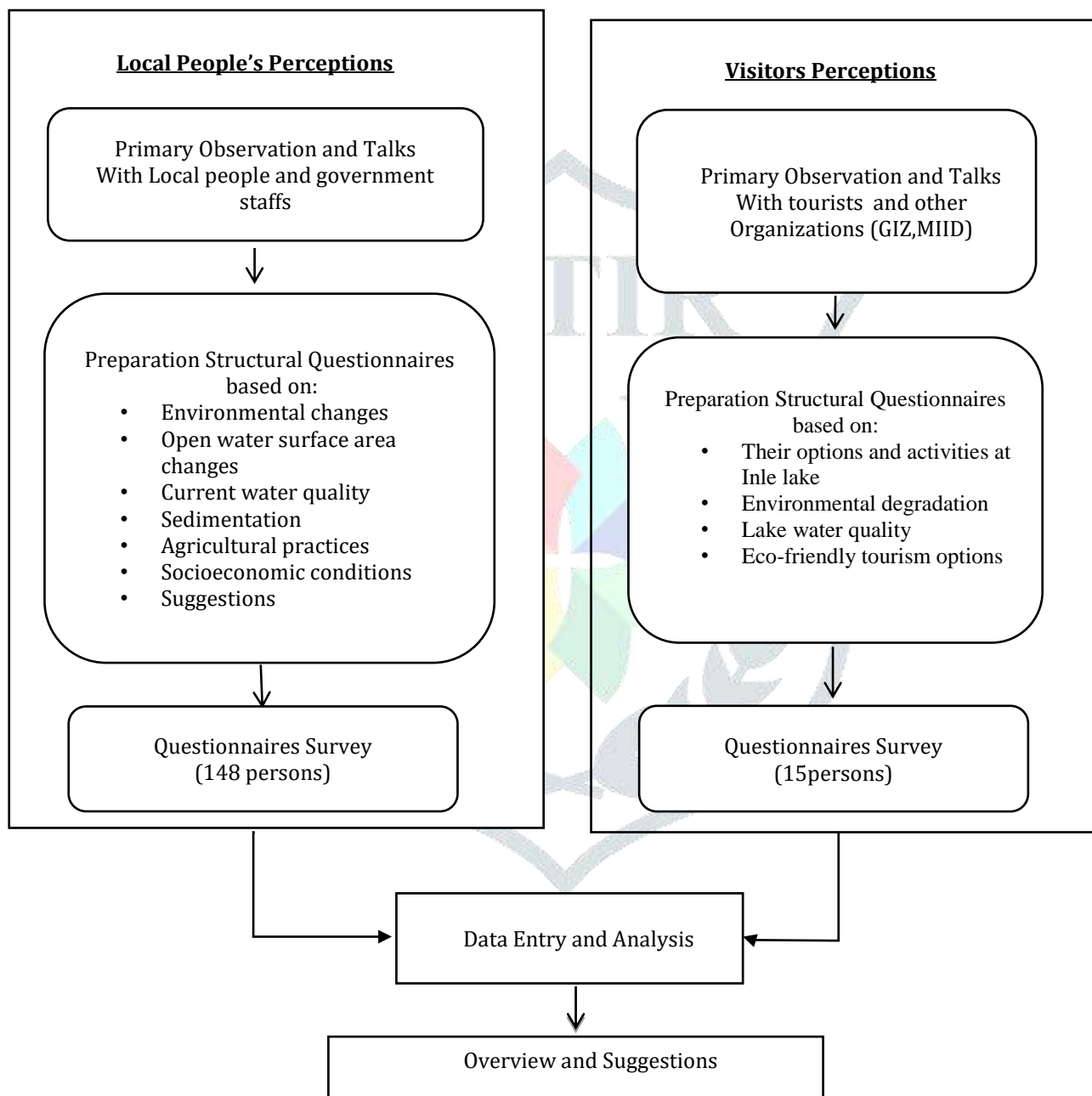


Fig. 2 Flow Chart for Assessment on People's Perceptions on Environmental Changes

III. DATA ANALYSIS

A. Various Social Classes of Interviewees

Structured interviews (35 questions) were conducted to local people group regardless of age and occupations. (Current water quality in Inle lake were measured in December 2019, February and March 2020 for Ph.D. research). Within 3rd to 17th March 2020, interviews were collected around Naung Shwe and villages namely Nan Pan village, Inn Paw Kon village, Kayla village,

Maing Thauk village, Ywama village, Myaing Pyo village, See Son village, Hal Kann Oo village, Naung Won village, Kay Zar Kon village, Naung Kar village, Sakar Kon Thar village, Nan Thae village, Pal Zar Kon village, Lin Kae village, Eain Thauk Kyi village, Tha Lae Oo village, Myin Ni Kon village, Tha Pyay Pin village, Kan Hla village, Phaung Daw Oo Pagoda, Nga Pha Stream Monastery, Alo Taw Pauk Pagoda, Maing Thauk five day market and Nan Pan five days market. Fig.3 shows interview locations on and around Inle lake.

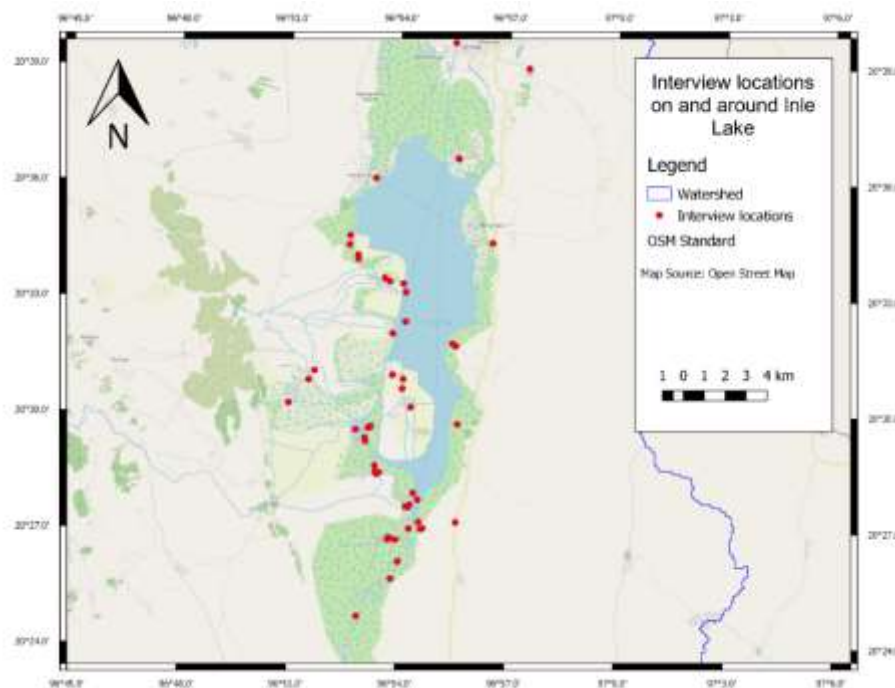


Fig.3 Interview locations on and around Inle Lake

Structured interviews were conducted from groups of different status and occupations such as floating garden farmers and on land farmers (31.1%), weaving business (6.1%), gold, silver and black smith (2.7%), fishermen (5.3%), shopkeepers (10.1%), hotel and restaurant staffs (9.5%), education staff (3.4%), hospital staffs (1.4%), boat drivers (3.4%), carpenters (1.4%) and the others are (27.7%) persons who are medical staff, educational staff, university students, shopkeepers, retired persons and workers. The age composition of interviewees can be classified into six groups such as under 20 (4.1%) between 21 and 30 (25%), between 31 and 40 (24.3%), between 41 and 50 (22.3%), between 51 and 60 (17.6%) and over 60 (6.8%) respectively.

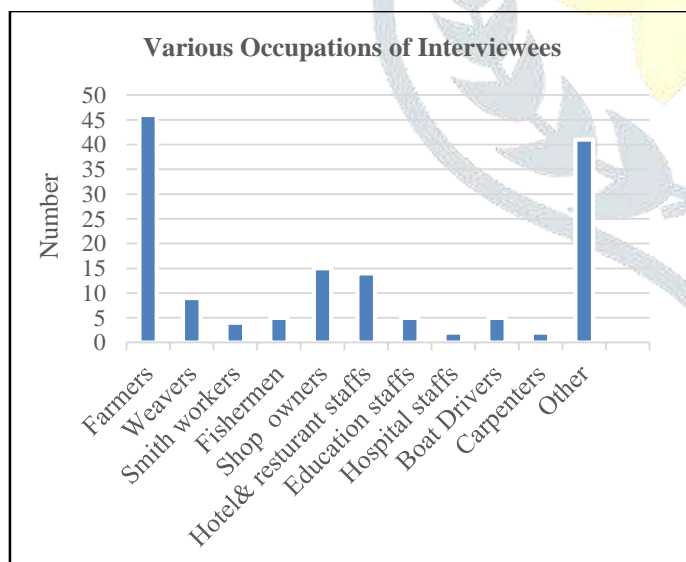


Fig.4 Numbers and various occupation of interviewees

Analysis of age group of interviewees

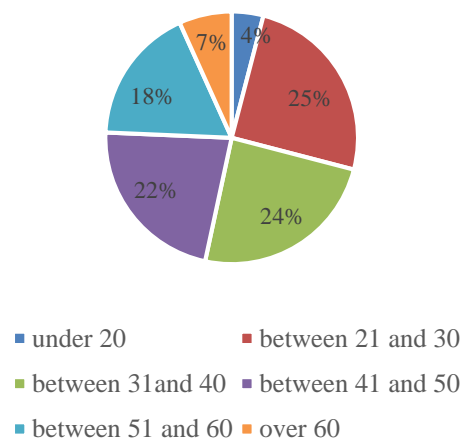


Fig.5 Analysis of age group of interviewees

1) Local Perceptions on Environmental Changes

In Inle region, natural environment is changing rapidly due to global warming and manmade impacts such as agriculture extension, reforestation, extraction of over fishing and loss of biodiversity, etc. From result of environmental survey, it is observed that the vast majority of local people (about 90%) were aware of degradation. Fig. 6 shows analysis of local people's perceptions on environmental changes.

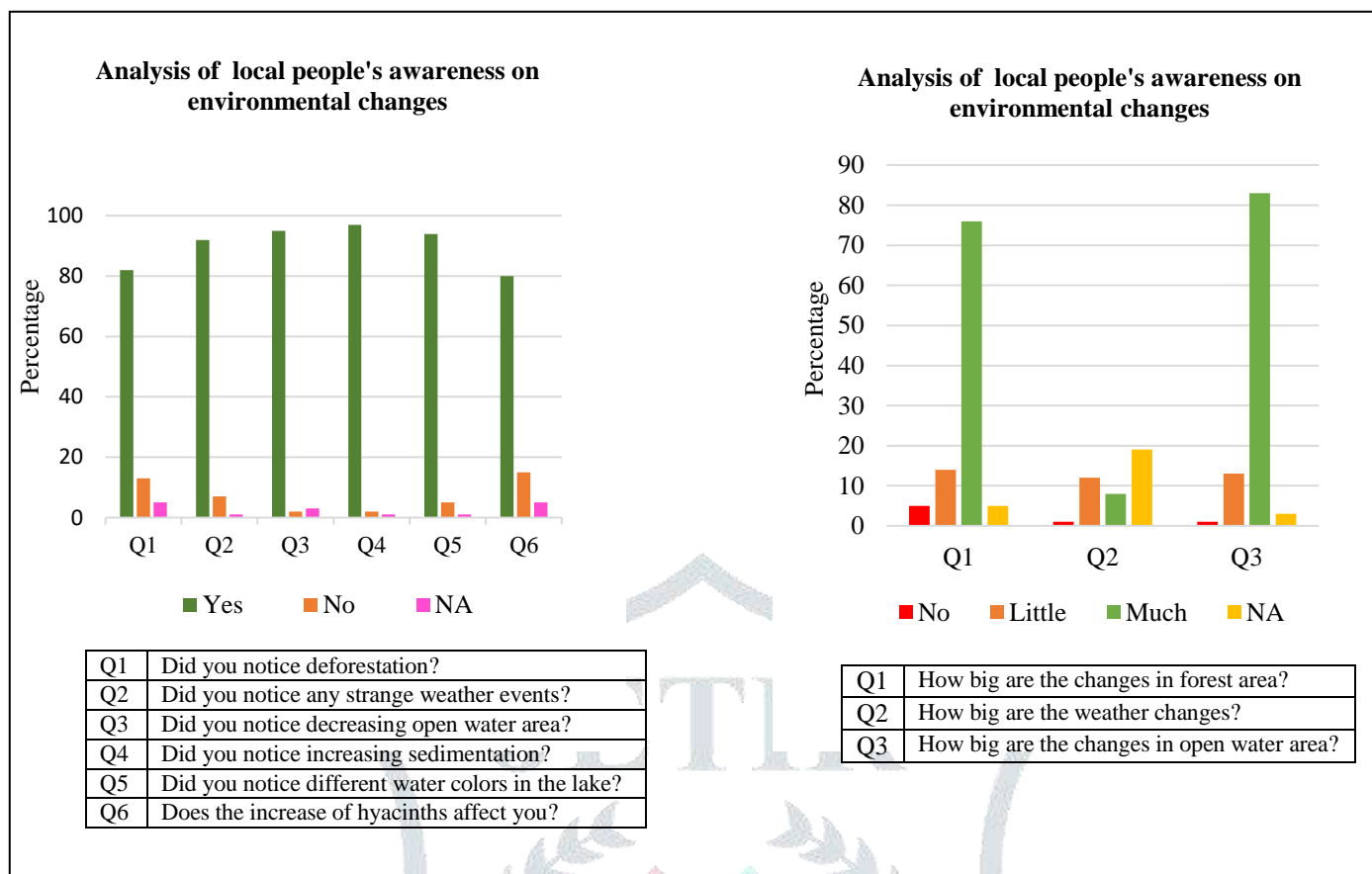


Fig. 6 Analysis of local people's awareness on environmental change

2) Local Perceptions on Open Water Surface area Changes

Open water surface area changes are one of the important problems in Inle lake. From 1935 to 2000, the net open water area of Inle Lake decreased from 69.10 km² to 46.69 km², a loss of 32.4% during this 65-year period (IID). From environmental survey results, 95 percent of interviewees noticed about open water surface area changes and 83 percent of interviewees replied that it's big changing and because of population growth and extension of houses, the propagation of hyacinth, extension of floating garden cultivation and sedimentation. By using google earth pro, open water surface of Inle lake is 48.8 km² (1995), 42.7 km² (2010) and 40.2 km² (2019) and it is decreasing.[12]



Fig. 7 (a) & (b) Area measurement boundary lines (blue-2010: red_2019) of Inle lake using google earth pro



Fig.8 Environmental survey around Inle region

3) Local Perceptions on sedimentation

In the western part of Inle lake, sedimentation problems occur as a result of reforestation which accelerates surface runoff and soil erosion, silting up of the lake is going on and it has gradually become shallower and decreases the water holding capacity. The young local ambassadors (MIID) measured water depths from 33 stations in Inle lake on the 8th march 2020 and water depth was 1 to 7 ft (0.33-2.2m) and average depth 3.5ft (1m). From environmental survey result, 94% of interviewees noticed about increasing sedimentation and most of interviewees replied that mean water depth is about 2.37 m in rainy season and about 0.98 m in dry season. In dry season, transportation problems take place within villages. The 97% of interviewees noticed the different colours of lake. Fig.9 shows different water colour in lake and within villages due to sedimentation.



Fig.9 Different water colour in lake and villages due to sedimentation



Fig .10 Low water level at 5days market and within village and dredging work from irrigation department at Nyaung Shwe canal

4) Local Perceptions on Current Water Quality Changes

From environmental survey results, for drinking water, about 13% of interviewees used ground water, 21% of interviewees used water from distribution than one source. For domestic water, 45% of interviewees used ground water, 14% of interviewees used water from distribution system, 25% of interviewees used water from lake and 14% of interviewees used water from more than

one source. Today, the government organizations and other associations have coordinated for integrated water management of Inle lake and seasonally water quality measurement of lake and knowledge sharing for this result to local people were made in public area such as 5 days markets.

The young local ambassadors (MIID) collected 20 water samples from 18 villages on the 8th march 2020. After test, all water samples displayed contamination with E-coli (source :MIID). So that most of local people knew about lake water quality and 79 percent of interviewees replied that lake water should not be consumed directly. About 72% of interviewees think that the reason for decreasing fishes may be decreasing water quantity and 19% of interviewees think that the reason for decreasing fishes may be degradation of water quality. Some of interview replied that fishes migrated to Sakar Inn because of noise from boats and One species of fish (Zalarbia) which breed from government eat local fish species.



Fig.11 Weaving bussiness : chemicals discharged directly into lake water and land



Fig.12 E-coli measurement within Kela village (source: water quality measurement working together with Robbert De Lange from Delft University of Technology, The Netherlands) The result is that the water contains >100 MPN/100 mL, which means highly contaminated water with high health risks.

5) Local Perceptions on Agriculture

In term of amount of water used for irrigation purpose, it can be seen that over half of interviewees (55%) use lake water for irrigation, whereas only 1% of them use from ground water and 8% of them from more than one source. It is observed that 19% plant one season, 34% plant 2 seasons and 9% plant 3 seasons. Most of interviewees replied that they use chemical fertilizer: mostly Awba, Kaw mat, Armo, Palae, etc. Some interviewees replied that natural fertilizer was used such as sea weed, animal waste and some household waste. Furthermore, most of interviewees replied that pesticide was used for their plant. About 54% of interviewees knew the fact that fertilizers influence the lake water quality and they replied that they use it systematically. They mostly grow tomato and the other plants: eggplant, cucumber, flowers, beans, corn, sunflowers, chilies, salad, rice, onion, sugarcane, garlic, pumpkin, grout, etc. Some of farmers replied that they did not get good selling price for vegetable (mainly tomato) within this year. On land, sprinkler irrigation is used in most farms and advanced agriculture practices are initiated.



Fig.13 (a) farmers using chemical fertilizers and pesticides, (b) natural fertilizers (aquatic weed) for floating garden, (c) floating garden (d) sprinkler irrigation on land farm

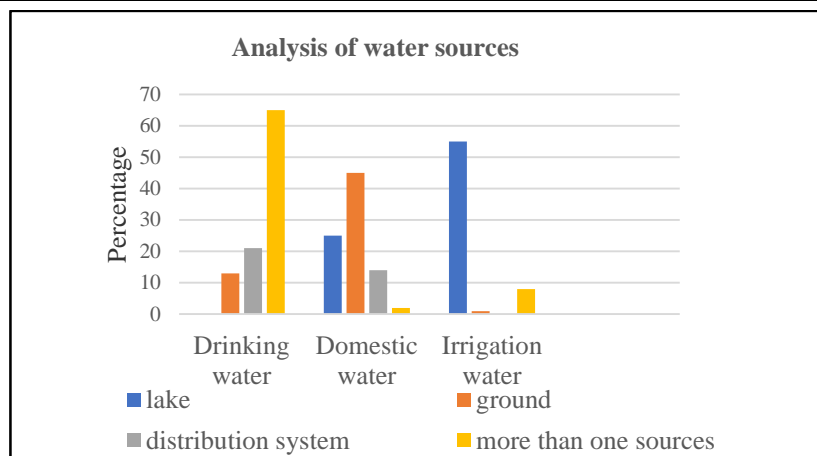


Fig. 14 Analysis of water sources from environmental survey

6) Local Perceptions on Waste Management System

From environmental survey result, about 58% of interviewees replied that they released their domestic waste water into the lake and about 79% of interviewees replied that they did not released their sanitary water into the lake directly. About 86% of interviewees replied that they have solid waste management system and they collect their households waste by boats and discharge on land and burn them per month. Some interviewees replied that they dig the ground tank and waste it into the tank and burn it. Fig.15 show waste system of inle region.



Fig.15 (a) Solid wastes at the bank of lake, (b) Domestic water discharged directly into lake, (c) Burning wastes

7) Local Perceptions on Socio Economic Changes

From environmental survey results, about 57 percent of interviewees were working 15 years in this area and 4 percent were working more than 20 years. Most interviewees (96%) replied that they get electricity in their houses and their sources for cooking were fire (1%), gas (3%) and electricity (63%). Most of interviewees (61%) replied that medical clinic were opened in (near) villages and 75% of interview replied that knowledge sharing programs for environmental protection were made from government and NGO.



Fig.16 (a) Gold and silver smith, (b) black smith, (c) weaving business, (d) cigarette workshop, (e) famous Shan paper work, (f) Shan Tobu (food) work

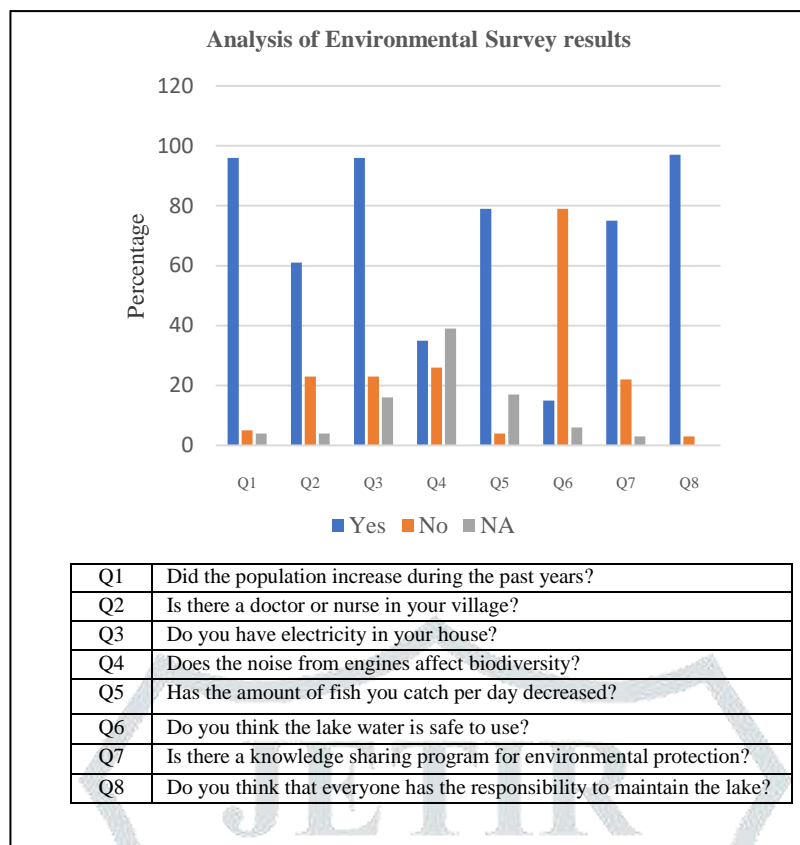


Fig.17 Analysis of Environmental survey results

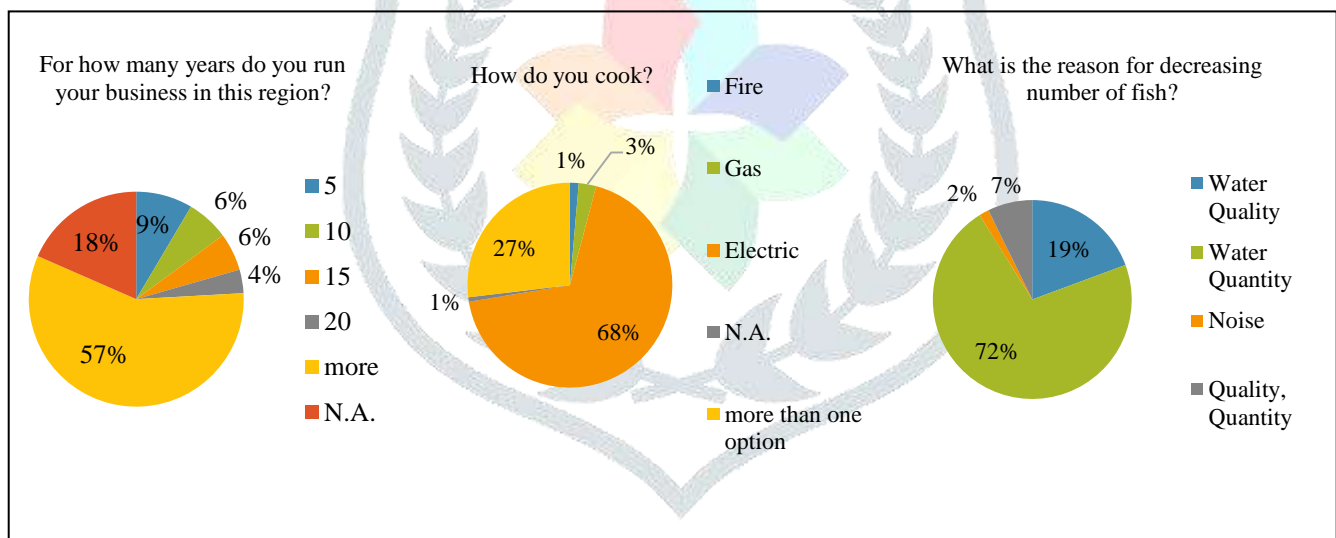


Fig.18 Pie chart for environmental survey results

8) Perceptions of Tourists

Most of interviewees replied that the activities they want to do are sightseeing, bike tour, boat tour and hiking. Most of interviewees replied that the main reasons for visiting Inle lake to explore the local culture, do sightseeing, learn about the lives of fishermen and relax. Among them, about 92% of interviewees were conscious about environmental degradation because of overfishing, utilizing chemicals and 73% noticed about different water colour and excessing amount of hyacinth in lake. About 64% of interviewees thought that the lake water has not good quality because of waste water released from households, chemical fertilizer usage influenced by agriculture, boats, plastic, lack of proper waste management and burning waste. About 80% of interviewees choose eco-friendly tourism options that they suggest to use refill water bottles, bike tours in spite of bus, support communities, no plastic bags usages, etc.



Fig. 19 (a) Village on lake water surface , (b) Interesting fishing Practice ,(c) The Paung Daw Oo Buddha images are going around 21 places in October every year(source: U Kyaw Kyaw Oo)

CONCLUSIONS

From environmental survey, about ethnic group's local culture, businesses, local products, agricultural practices, environment situations, socio-economic conditions, integrated lake management system of government and other societies were well known. Some villages have poor sanitary condition and waste management system caused water quality degradation so local people should care a good practice for public health. Using chemical fertilizer and pesticide and extension of floating garden should be controlled systematically. The west side of lake happen in serious condition of this sedimentation due to deforestation and should protect extinction of Inle lake and prevent siltation from the inflow streams of the lake. Therefore, local people should have some knowledges for controlling sedimentation problems and watershed because Inle lake is one of the most important watershed areas and it is the responsibility of local people to enhance the health of the lake.

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