Prior Study for the Biology and Economic Condition as Rapidly Environmental Change of Limboto Lake in Gorontalo, Indonesia

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Abstract. It is estimated that Water area of Limboto Lake will disappear before 2030. Groundwater is also decreasing. Those phenomena affect biological environment of lake. Lotus that perennial plant disappeared because water depth is falling 15cm/year and water hyacinth that brought by river multiply from around 2000. Those rapidly environmental change and fish farming from 1995 influenced that fishes are small and few than past. And flood is happen every rainy season. People who live around lake choice modern style house and filled 1m depth water flood. It is thought that their economic condition might relate to their choice. Fisher's earning is approximately Rp.51-16million/year, farmer's one is Rp.10-17million/year. Their income is not much at all. The possibility that their economic conditions worsen more is very high in situation of rapidly environmental change. It is necessary how to develop new sustainable work under the present conditions.

Keywords: Limboto Lake; Rapidly environmental change; economic condition of fishe and farmer.

1. Introduction

Rapidly environmental changes occur because natural factor or artificial factor and both. Even if it is either case, changes influence to works and lives of people who live around those environment. If they face a sudden change, they must hurry to think and decide about correspondence against change. It is considered as the directionality that stopping or weakening change, escaping from change, and groping for new work and life style on the assumption accepting change. In order to giving an answer, it is necessary to conduct a detailed investigation.

Limboto Lake in Gorontalo District and Gorontalo City, Indonesia is one of the examples having intense rapidly environmental change, because lake area is decreasing rapidly. Because much sediment flow into the lake every year, depth of the water becomes shallow and lake area becomes narrow. The details are mentioned later, the quantity of sediment is estimated at 1.5million m^3/year, and it is estimated that lake will disappear 10-20 years later in this situation. Segmentation is seriously and big problem. It has been said that the cause of the erosion is agriculture in the mountainous area. There are 27rivers flowing into Limboto Lake, Alo-Pohu River from west area of lake is the biggest one and it is bringing 63.8% of sediment. [1]

Lake area is decreasing rapidly. It was 7,000ha in 1932, 4,000ha in 1960, and 1,900-3,000ha in 1999. Furthermore, floods are frequent happen and it affects big changes to human life and ecological system. When floods were happen, water stayed around houses during 1month over. People must vary the life and occupation, especially fishers and farmers.

Rapidly decreasing of lake area brings big influence in people's life. After grasping situation of environmental change, we have to prove clearly life situation of inhabitants, especially fisher and farmer. Until now, there are not the data which are concrete their work and details of income. Because it is important to show it, we prove real life of inhabitant in this article, and we also suggest a direction and viewpoint of future investigations.

2. General condition of study area and method of investigation

2.1. Limboto Lake

At first, we have to know about Limboto Lake totally because environmental situation greatly varied according to each period.

2.1.1. Overview. Limboto Lake is located in east area of Gorontalo District, Gorontalo Province, Indonesia. In 2017, there is between 00°33'03" and 00°37'00" north latitude and 122°56'37" and 123°00'57" east longitude. The square of lake is 2,450ha in 2014. There are wide farmlands extend at west of lake and there was lake area in the past. Gorontalo City that capital of Gorontalo Province is at the east and south of lake, approximately population is 200thousand and it forms a base of the regional economy. (Figure 1)

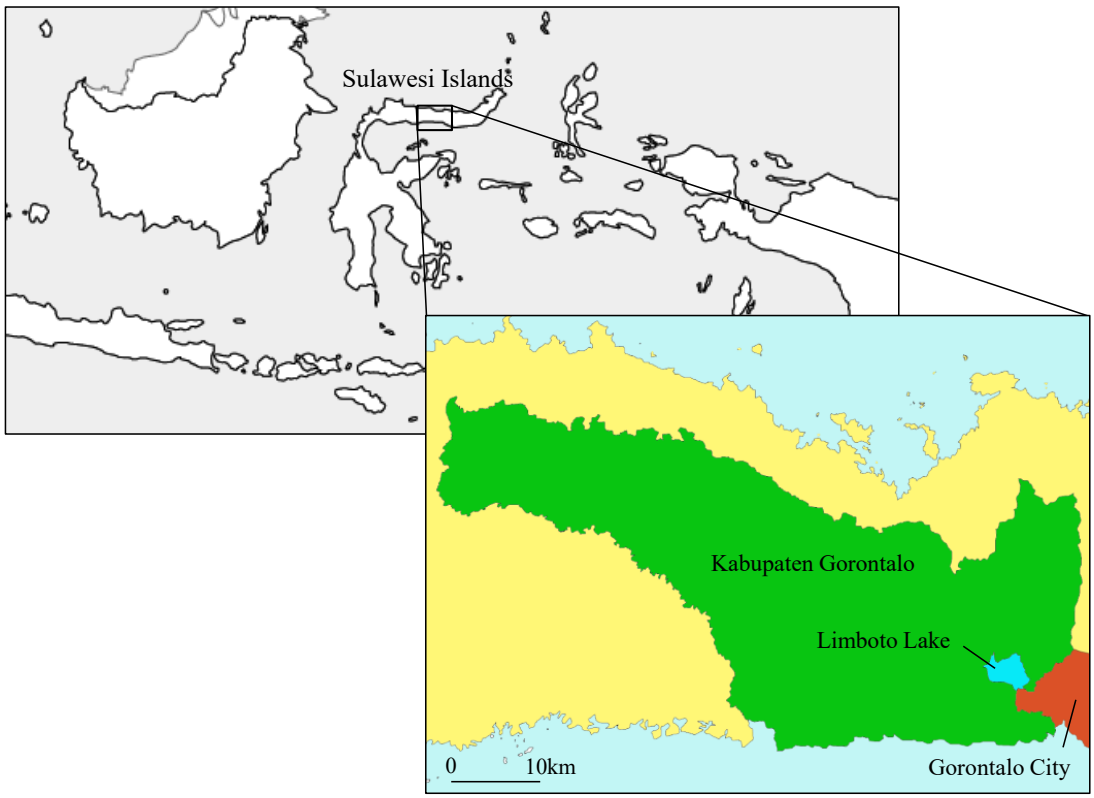

Figure 1. Map around Limboto Lake

2.1.2. Change of lake area and depth. The change of Limboto Lake was described as next: "Limboto lake, based on the genesis formation is a low basin or lagoon that also referred to as a type of shallow lakes or lake types of exposure to flooding (flood plain)". [2] We can guess that Limboto Lake was wide lagoon and sometimes flood happen. They also explained about sedimentation, "The process of sedimentation actually has been started since million years ago". If those are right, sedimentation did not start by artificial cause.

In 1863, C.B.H Von Rosenberg, a Dutch scientist, made a jouney to Gorontalo. He drew the landscapes of Gorontalo when he arrived there. He told about his journey and recorded his travel in "Reistogten in de afdeling Gorontalo" (the trip to the Gorontalo branch) published in 1865. He explained length of the lake is more than 18km and the width is 7.5km.From this, very rough square is 135ha. He also reported the depth of lake is 2½ fathoms and a few feet, exchanging this, it becomes 4.6m and a few feet. [3]

According to Santosa S. Putra et al, "In 1932, the area of Lake Limboto reached 7000 ha with a depth of 30m". After a time, "in 1999 ranged between 1900-3000 ha, with a depth of 2-4 meters". At last, their estimation is next, "When these issues are not resolved well in 2025 the Lake Limboto feared would vanish from the earth of Gorontalo". [4] Another study suggested same situation as next: "1934 with the lake reaching approximately 70 km2 and a depth of 14 m, and now the area is approximately 30 km2 with a depth of 2,5-4 m". [5] And in 1960, lake area was 4000ha and depth was 10m. [6]

2.1.3. Sediment. Over 20rivers flow into the lake but river from lake is only one named Tapodu River. Stream of Tapodu River starts from southeast of lake and after 2.6km confluences Bone River. Much water flow into the lake but drain volume is very little. Consequently, floods happen in rainy season and approximately water come into houses that settled near water's edge in rainy season. To protect from flood, government made 11km bank at east side of lake in 2015.

The focus of this paper is sediment and quantity of lake water. Research of JICA in 2004 and 2005 suggested those things. The sediment flow into Limboto Lake from the neighbouring riverbeds, and the quantity is estimated at an average of 1.5million m^3/year. The main sources of sediment are estimated that soil of cornfield or dilapidation farm and weathering granite in the basin. [7] The big deltas of Alo-Pohu River and Biyonga River continue growing up now. [8] In this situation, Limboto Lake may dry up or become damp ground after 10-20 years. [9] Also the end of the lake is predicted as follows by Santosa S. Putra et al: "When these issues are not resolved well in 2015 the lake Limboto feared would vanish from the earth of Gorontalo." [10] A cause affecting the reduction of Limboto Lake with sedimentation is the change of the water balance of the basin by the constructing of the irrigation system (expansion of the water consumption). In the basin which surrounded Limboto Lake, irrigation development was pushed forward positively after the 1970s, and water intake facilities were built. In fact, in comparison with the 1960s before dams were constructed, the water level of lake in the dry season decreased from 1970s through 1980s. [11]

2.2 Method of Investigation

Elucidating various matters about the rapidly environmental changes is useful to understand more information, to solute human life problems. But qualitative data is not enough.

In order to get information about Limboto Lake, we interviewed to local people at 11villages (Hutadaa Village, Ilotidea Village, Dembe1 Village, Iluta Village, Ilohungayo Village, Teratai Village, Tabongo Timur Village, Ilomangga Village, Haya-haya Village, Bongomeme Village, Kayubulan Village) showing Figure 2 in 2017. Contents of interview are place of water's edge, change of groundwater, flood situation, sediment from river, change of species and amount of fish, and economic situation of fishery and agriculture. We selected respondents who concerned issue directly, for example fisher, farmer, and inhabitant who live near from water's edge. Because it is difficult to remove completely biased view of local people by interview, we paid attention to get qualitative and objective data of environment, life, and work. And to raise the accuracy of data, we interviewed plural people or group in same village.

Especially to grasp now and past information of water's edge, we interviewed inhabitants who live in the nearest place from water's edge. But inhabitants of Kayubulan Village don't have past information because it is new village established by government of Gorontalo District in 2015. To grasp correct village locations, we used 1:50,000 map that published by Universitas Negeri Gorontalo. After field survey in each village, we measured detail distance by GIS map and data.

Figure 2. Research Point

3. Result of investigation

3.1. Transition of water's edge of Limboto Lake at each village

Ilotidea Village and neighbouring villages were bottoms of the lake until 1982, but now in dry season, the water's edge was 730m opposite side from village. There were cultivating lands on dried lake.

Usman Isa Road at Dembe1 Village was constructed in 1940. It was lake water until upper part of this road in 1960. The lower side of road was under lake in 1967. Depth of lake in front of Dembe1 Village was around 10m in 1980. However, many houses were built between the road and the water's edge until 2017. That maximum distance is approximate 300m from Usuman Isa Road.

At Ilohungayo Village, a branch road that distance is 1.9km spreads toward the lake from main road name is Raya Batudaa Road. In dry season of 1970, the water's edge was until the end of branch road, but in recent years, it is opposite side 200m to the lake. In addition, in rainy season, the water's edge comes to end of branch road. Past time, the water's edge was 200m upper from end of branch road. The water's edge is going to lakeside approximate 50m/10years.

Local people who live at the edge of Teratai Village said the water's edge was near house in 1950. In rainy season of that year, the water's edge was 1km upper from house. In rainy season of 2000, it was water flood and water level was 1m from ground. In recent years the water's edge is approximate 500m opposite side to lake in dry season, and no water flood whatever in rainy season.

Based on these results and using GIS map and data, we estimated calculated the rough distance that water's edge retreated and the change of water level about per year at each village (Table 1). Distances that water's edge retreated are difference minimum is 4.3m/year at Ilohungayo Village and maximum is 20.9m/year at Ilotidea Village. Because the slants at each spot are different, such a big difference appeared. Water level of Limboto Lake is decreasing approximate 6-15cm/year. Depth of decreasing at west area (Ilohungayo VIllage and Teratai Village) is around 6cm/year, but east area (Ilotidea Village and Denbe1 Village) is 14-16cm/year.

Table 1. Estimation change of water's edge and water level

Village name	Change of water's edge		Change of water level	
	Rough change	per year	Rough change	per year
Ilotidea	-730m/35years	-20.9m	-5m/35years	-14.3cm
Denbe1	-300m/37years	-8.1m	-6m/37years	-16.2cm
Ilohungayo	-200m/47years	-4.3m	-3m/47years	-6.4cm
Teratai	-500m/67years	-7.5m	-4m/67years	-6.0cm

We suppose so much sediment is piled on bottom of lake at west area, that depth of water seems littler than east area. For that reason, decreasing water level at east area is accurate. Based that depth of lake is 2m now, lake water will disappear less than 13years. Therefore, we predict that Limboto Lake will disappear before 2030. This estimation supports past hypothesises that lake disappears around 2015-2025.

We have to take notice that this result is rough estimation, because water's edge distances are according to interview. And water level is greatly different between dry season and rainy season. Anyhow, because there is a few time had left, all stakeholders must begin to think about a living and work when lake disappeared immediately.

In connection with decreasing water level, we point out about irrigation water level. Irrigation of Bongomeme Village was constructed in1997. In 1990, depth of old irrigation was around 120cm, but it was already little water when constructed year. Now depth is around 20cm. From this situation, we can suppose that the decreasing of water flow from rivers to lake causes decreasing water level of Limboto Lake.

3.2. Transition of groundwater

The decreasing water happen not only surface water but also water level under the ground. At Dembe1 Village, each house has wells and Water is enough. At Haya-haya Village, groundwater is enough in rainy season, but water level is becoming low. In the past, it was 8m from ground, but it is 10m. Most people cannot get water in dry season from wells. At Bongomeme Village in 1990s, groundwater level was approximate 1.5m higher than 2017.

At Dembe1 Village located in southeast of lake, groundwater comes from south mountainous area. Because there is near lake, groundwater level is hard to become low. On the other hand, at Haya-haya Village and Bongomeme Village located in northwest and east area, groundwater may flow along Alo-Pohu River. Because those villages are not near the lake, groundwater levels are low. Especially in dry season, groundwater levels are lower than rainy season.

3.3. Transition of flood

Though water level decreasing, flood sometimes happens. We introduce several situations at each village.

Flood is increasing at Bongomeme Village. There was no sediment by flood in 1990, but much sediment came after 2000s. Flood sediment is not good for rice paddy.

The case of Ilohungayo Village, flood happened once every year. Floodwater was inundated from narrow river that flows through village. When flood happened, water was level with a chest.

At Teratai Village, flood in 2000, water level was 1m from ground. But it is no flood after 2000.

Ilomangga Village is located at southwest of lake and southern area of Alo-Pohu River. We interviewed local people who live in place of 500m from Alo-Pohu River. Long time ago, there was under the lake, but now already extended farmlands. In 2013, government made levees at both side of Alo-Pohu River. Every year flood came around house until 2013, but now it is no flood.

From these situations, we understand that the frequency of flood varies according to location of village. At first, floodwater does not come from lake but from rivers. Water flow over from river and drift around houses in the low land. Next, water collects in the lake, and surface water of lake is higher.

At last, water stay around a houses for several days.

3.4. Transition of biological environment

Environment of Limboto Lake is changing rapidly. Lake water is decreasing now, much sediment is brought by rivers when flood, and government made long bank at east side of lake. Those changes bring influences to plants and fishes of lake.

There were a lot of wild lotuses. People ate seed and stalk with boiling, using leaves to wrap fishes. In the past, fishers were disturbed to move ships by lotus. Now there is no lotus. One of the reasons of extinct may be disappearing surface water rapidly. Another one is changing bottom of lake to sand from mud by sediment. On the other hand, water hyacinths are increasing rapidly from 2000 or 2001. Before those years, there were few water hyacinths. But now, they are brought by river and multiply. In 2017, almost the coasts were filled up by them (Figure 3).

Many species of fish have habitation in Limboto Lake, for example fishers catch fishes named mujair, ful, merah ful, manngabai, payanga and so on. Fishers who use net or fishing rod said there is not the extinct fish species in the past approximately 30 years. Long time ago, crocodiles lived in lake at place near rivers, but now crocodiles became extinct because local people caught them to use skin and to eat their meats.

The kind of fish does not change, but the number of fish decreases and the individual size becomes small. Fishers think there is the cause from fish farming and non-sustainable fishery. Fish farming started in 1995 at Limboto Lake as one of the industrial development plans. Farming fishers use nets that settled underwater. They keep baby fishes named nila in there, but small fishes can escape from nets. Because they can grow very rapidly in the lake, so they can become more dominant other fishes in struggle for existence.

Some fishers are performing electronic shocks fishery. All creatures which are in the range of a radius of approximately 10m die when fisher performs electronic shocks fishery. It is difficult that baby and child of wild fishes live at shore of lake grow bigger.

One of the causes of the rapidly change of the lake environment is the inflow of sediment. We can guess that a change of plants was caused with it. However, fish farming and electric shocks fishery are direct influence on fish situation. In addition to this, the extinct thing by the indiscriminate catches of the crocodile happened in the past. We must think that human activities have bigger influence on ecosystem.

Figure 3. As one of the environmental change, we indicate increasing water hyacinth from around 2000. The bay of village located at water's edge is filled with water hyacinths untill 2km offing. Fishers go to fishing by small boat, they have to row while pushing water hyacinths aside. This picture shows fishers coming back to Kayubulan Village from center of Limboto Lake, December 2017.

3.5 Construction of house

With keeping in mind that sometimes flood happen around the Limboto Lake, we interviewed about life style of local people, especially construction of houses.

At end of branch road of Ilohungayo Village, people live there for a long time. One of the houses was constructed 50years ago. Before this house, old house was at same place, it was constructed 1920s. In rainy season of 1920, the land should have been under lake water. Therefore, that entrance of house was 1m upper from ground.

This is called aboveground house style, usually entrance and floor on high place for a flood. We found this traditional style house at Tabongo Timur Village. It was constructed in 1958. Base of house was made of stone and limestone. When flood came in the past, water overflowed to 50m ahead of the house, but they could live in their traditional style house.

At Teratai Village, when surface water was upper than now, people constructed houses on island or higher place. One of family moved here from another place of Teratai Village. Because son of patriarch wanted to depend from his family, he was finding new land. He constructed new house on the land where was already dry in 1990. In 2010 when after 20years later, he got landownership from government.

Almost of houses near lake are modern styles. Therefore, those entrance and floor are same level or low level near ground, that houses will be flooded. If it is aboveground house style, they can prevent the inundation to their house. But people don't choice aboveground house style, because building cost of house is expensive than modern style (Figure 4).

Figure 4. If flood happens, people can save their life on high floor of aboveground house style (upper picture, constructed in 1958 at Tabonogo Timur Village). But nowadays, almost people choice modern style house (below picture, constructed in 2014 at Ilomangga Village) because aboveground house style is more expensive than modern style. Flood continues around 1month over in rainy season, 1m depth water remain around houses. Floor of modern style house is not high from ground, so water come into the house when flood. Family members have to move furniture from first floor of houses that filled water several weeks until water has gone.

3.6. Economic conditions of fisher and fish seller

We clarify present status of inhabitants to think about the correspondence to rapidly environmental changes. We show economic conditions of fisher and farmer because many fishers and farmers live around Limboto Lake. So fishers not only do fishing but sometimes farming that it is difficult to separate economic condition fisher and farmer. We clarify general income and expenditure of fishery and agriculture.

3.6.1. Fisher who catch wild fish. Fishers have many methods to catch fishes, for example, using "sero", using net, using rod and string, fish farming, and electric shocks fishery. But electric shocks fishery is

prohibited now but only few fishers use it. "Sero" is traditional trap made by bamboo. At Ilotidea Village has 300ha area in front of village to fishing. Owner of those places is government and fishers of village manage there. 1fisher can use 1ha. Usually 2fishers go to fishing together.

It is very difficult to grasp the income of fisher statistically because detailed economic statistic data of fishery do not exist. In order to estimate fisher's income, we got basic data at 2 places, Ilotidea Village and Hutadaa Village. (Figure 5)

Fishers in Ilotidea Village can catch nila and mujair with rod and string. In Hutadaa Village, fishers used net to catch manngabai. They sell fishes to fish seller at bay of village. They sell fishes to fish seller. Basic data and estimation of fisher's economic situation show at Table 2. Because quantity of fishes is different each day and season, this result is approximate calculation. The minimum and the maximum have over triple difference. But we can guess that estimation of fisher's earnings is Rp.51,583,000-155,750,000/year and person.

Figure 5. One boat with 2fishers departured from small port at Hutadaa Village at night and came back here late morning. They caught manngabai by net. Fishes in yellow colander is outcome for a night. There are few fish catches this time, but always they can catch 2-3times of this. December 2017.

Table 2. Basic data and calcuration of fisher's economy

Case one : Ilotidea Village (Fishing nila and mujair by rod and string)		
Basic data from interview		Estimation
amount of fish (1)	30-35kg/day	income per day (6) = (1) * (2) deduction (minimum-maximum) (7) = {(6) * (3) – (4)} / (5) = Rp.85,383,500-104,400,000/year and person
selling price (2)	Rp.22,000-23,000/kg	
annual operation days (3)	260days/year	
price of boat (4)	Rp.2.500.000/3-5years	
fishing team person (5)	2person	
Case two : Hutadaa Village (Catching manggabai by net)		
Basic data from interview		Estimation
selling price (1)	Rp.200,000-600,000/time	income per day (6) = (1) * (2) deduction (minimum-maximum) (7) = {(6) * (3) – (4)} / (5) = Rp.51,583,000-155,750,000 /year and person
number of fishing (2)	2times/day	
annual operation days (3)	260days/year	
price of boat (4)	Rp.2,500,000/3-5years	
fishing team person (5)	2person	

According to interview, usually fisher goes to fishing 5days per week. In this calculation, annual operation days is 260days based on this result.

3.6.2. Fish seller. Fish sellers buy fishes from fishers every day. They sell fishes at market and each house. They can bring only approximate 20-30kg because they usually use bicycle or motorbike to bring fishes.

According case of Ilotidea Village on table 3, earnings of fish Seller is Rp.46,800,000-75,400,000/year. This price is also rough, and it is not big different from lower earning class fisher.

Table 3. Basic data and calcuration of fish seller's economy

Basic data from interview		Estimation
amount of fish to buy (1)	20-30kg/day	income (6) : (1) * (3) * (4)
purchase price (2)	Rp.22,000-23,000/kg	expenditure (7) : {(1) * (2) + (5)} * (4)
selling price at market (3)	Rp.36,000/kg	deduction (minimum-maximum) (8) : (6) – (7)
annual operation days (4)	260days/year	= Rp.46,800,000-75,400,000/year
price of fuel and ice (5)	Rp.100.000/day	

According to interview, usually fisher goes to fishing 5days per week. In this calculation, annual operation days is 260days based on this result.

3.6.3. Farming fisher. Fisher also breeds fish called nila. Case of Iluta Village, fisher buys baby fishes from this area or Jawa, and price of 20,000 baby fishes is Rp.5,000,000. At first, they are brought up together. After one month, they are separated by size. Fisher feeds fishes twice a day. Feeds are two types. One of them that floats on the water is Rp.305,000/30kg and other that sinks under the water is Rp.440,000/50kg. Fisher uses 1.5ton feeds until selling. After 4 - 6months, fishers sell adult fishes. Fisher can harvest 80% of 20,000fishes and that weight is approximately 1ton. Fisher brings adult fishes to market far from village. Reducing stress and keep alive, fishers forward all fishes only 1time in early morning. Selling price is Rp.25,000-30,000/kg. Fisher can breed fishes 2 or 3times in a year.

From this situation, table 4 shows economic condition of fish farming. Earnings is approximately Rp.4,700,000-11,800,000/season. Another case of Denbe1 Village, earing is Rp.6,495,000-12,595,000/season. Taken together, the earnings of fish farming is Rp.9,400,000-37,785,000/year.

Table 4. Basic data and calcuration of farming fisher's economy

Case one : Iluta Village			
Basic data from interview			
Expenditure		Income	
price of babies (1)	Rp.5,000,000/time	selling price (4)	Rp.25,000-30,000/kg
fish feed (2)	Rp.10,200-8,800/kg	selling amount (5)	1,000kg
amount of 1 season feed (3)	1,500kg		
Estimation			
expenditure (6) = (1) + (2) * (3) = Rp.18,200,000-20,300,000			
income (7) = (4) * (5) = Rp.25,000,000-30,000,000			
deduction (minimum-maximum) (8) = (7) – (6) = Rp.4,700,000-11,800,000/season			
=Rp.9,400,000-35,400,000/year			
Case two : Denbe1 Village			
Basic data from interview			
Expenditure		Income	
price of babies (1)	Rp.315,000/gallon	loss (5)	20%
amount of babies (2)	7gallon = 1,000babies	selling price (6)	Rp.30,000-35,000/kg
fish feed (3)	Rp.10,200-8,800/kg		
amount of 1 season feed (4)	1,500kg		
Estimation			
expenditure (7) = (1) * (2) + (3) * (4) = Rp.13,200,000-15,300,000			
income (8) = (2) 1,000fishes * (5) * (6) = Rp.24,000,000-28,000,000			
deduction (minimum-maximum) (9) = (8) – (7) = Rp.6,495,000-12,595,000/season			
=Rp.12,990,000-37,785,000/year			

"loss (4)" means dead, swim away and so on.
Selling price of case 2 : small size is Rp.30,000/kg and big size is Rp.35,000/kg.

3.7. Economic condition of farmer

In most area of Indonesia, farmers make rice 4 or 3times/year, because rice growth 3months. Nevertheless, farmers who live around Limboto Lake cannot engage agriculture in all season. Farmland is under water in rainy season especially flooded, so rice cannot alive in high water level. While farmers

cannot do agriculture especially in rainy season, they do fishing. Moreover, in dry season, irrigation system is not enough for all of agricultural land, so they only wait for rain. Because of those reasons, they can make rice only 3 or 2times/year. Farmers also cannot make other crops in rainy season with same reason. Follows are economical test calculation about general farmers.

3.7.1. Rice. We calculated earning of rice farmer about 1ha, there are 2 types. Type one is farmer who can employ helpful farmers and borrow 1ha paddy. Type two is cultivating own land with only family workers and using least chemical fertilizer. (Figure 6) Method of calculations is different because type one is case of Haya-haya Village and type two is case of Ilomangga Village.

According to tables 5, type one earns Rp.5,725,000/time, and type two earns Rp.5,000,000/time. Because rice farmer who live around Limboto Lake can make rice 2 or 3times, estimation of farmer's earning is Rp.10,000,000-17,175,000/year. The amount of each farmer earning has big difference because small farmer cannot use enough material and cultivation chance changes 2times or 3times every year. If earning is too little, farmer will make other crops like maize.

3.7.2. Maize. Normally farmers can get approximately 7t/ha at once in Indonesia, but most Limboto Lake farmers get only 3-4t/ha. It is considered half price of common farmers. One of the reasons is poverty, so they cannot use enough fertilizers. Other reason is less rain in dry season. If enough water is provided to Maize farm, fertilizer cannot effect to crops. And if flood happens on farm land, it flow fertilizer away.

Basic data of common maze farmer is Table 6. We got this information from farmer by interview at Haya-haya Village. Common maize farmer who sell low moist quality can get Rp.12,640,000. But if they sell high moist quality, earning is only Rp.5,640,000. From above, we guess earning of Limboto Lake farmers is Rp.2,820,000 (high moist) or Rp.6,320,000 (low moist), because their amount of harvest is approximately half of common farmer.

3.7.3. Red onion. At Ilomangga Village, we met farmer family who have 0.5ha vegetable farm. They are making red onion, eggplant, and much kind of vegetables. Earning of leaf vegetables is not stable but we can calculate about red onion. They plant red onion that got last season from their farm and harvest after 2months. They can cultivate 3times per year and harvest 380kg at once.

Farmer can earn approximately Rp.10,000,000/year. Red onion is not main earning but it is important for sub economy. Furthermore red onion and other vegetables are suitable for cultivating on little water farm without irrigation system.

Figure 6. The west part of Limboto Lake is large farmland. But irrigation facilities are not enough. A farmer family who live near Alo-pohu River at Ilomangga Village has 1ha paddy and 0.5ha vegetable farm, and they make rice and several vegetables with only family workers. Because here are no irrigations, to get water they have to wait for rain in dry season. September 2017.

Table 5. Basic data and calcuration of rice farmer's economy

Type one : Farmer who can employ helpful farmers an borrow 1ha paddy			
Basic data from interview			
Expenditure		Income	
budget (1)	Rp.350,000/petak	amount of crop (8)	20paddy bags/petak
planting (2)	Rp.250,000/petak	payment (9)	8paddy bags/petak
cultivate wage (3)	Rp.540,000/petak	price polishing loss (10)	40%
fertilizer (4)	Rp.275,000/petak	selling price (11)	Rp.8,000/kg
herbicide (5)	Rp.200,000/petak		
agricultural chemical (6)	Rp.80,000/petak		
pesticide (7)	Rp.40,000/petak		
Estimation			
(12) total expenditure = (1) + (2) + (3) + (4) + (5) + (6) + (7) = Rp.1,735,000			
(13) total income = {(8) - (9)} * (10) * 50kg * (11) = Rp.2,880,000			
(14) deduction = (13) – (12) = Rp. 1,145,000/petak			
(15) 1ha income = (14) * 5 = Rp.5,725,000/time			
Type two : Farmer who cultivate own land with only family workers and using least chemical fertilizer			
Basic data from interview			
expenditure		income	
expense (1)	Rp.3,000,000/ha	amount of crop (2)	1,000kg/ha
		selling price (3)	Rp.8,000/kg
expenditure (4) = (1)			
income (5) = {(2) * (3)} - (1) = Rp.5,000,000			

1Petak = 2,000m^2.
1paddy bag = 50kg.
Farmer of type one has to give 3bags to workers and 5bags to land owner.
"expense (1)" of type two includes chemical fertilizer, herbicide, agricultural chemical and pesticide.

Table 6. Basic data and calcuration of common maze farmer's economy

Basic data from interview			
expenditure		income	
tractor (1)	Rp.1,500,000/ha	selling price of low moist (7)	Rp.3,500
seed (2)	Rp.4,500,000/ha	selling price of high moist (8)	Rp.2,500
fertilizer (3)	Rp.1,170,000/ha		
agricultural chemical (4)	Rp.3,740,000/ha		
cultivate wage (5)	Rp.600,000/ha		
taking seeds process (6)	Rp.350,000/ha		
Estimation			
total expenditure (9) = (1) + (2) + (3) + (4) + (5) + (6) = Rp.11,860,000			
total income (low moist) (10) = 7,000kg * (7) = Rp.24,500,000			
total income (high moist) (11) = 7,000kg * (8) = Rp.17,500,000			
deduction (low moist) (12) = (11) – (10) = Rp. 12,640,000/ha			
deduction (high moist) (13) = (12) – (10) = Rp. 5,640,000/ha			

Moisture percentage of low moist is 17%.
High moist is non-dry. Moisture percentage is 25-30%.

4. Conclusions

4.1. Discussion

We showed process of reducing surface water of Limboto Lake and estimated future situation. According to estimation of edge and depth movement of water by interview, we suggest lake will disappear before 2030. This article supports past hypothesizes.

And we also grasped inhabitants' life that involved flood. Even if they know flood will happen every year, they have to live on water's edge. Moreover, usually they choice modern style house because it is cheaper than aboveground house style. Generally, modern style house is chosen now, but owner of house should choice aboveground style house when they built house in the place of near the lake. Economic conditions might relate to their choice, too.

Most inhabitants who live around the lake are fisher and farmer, but there is no report that grasped their economic situation until now. This time, we estimated their earning is not enough. It is important that this article shows a guide to think about their economic conditions.

4.2. Viewpoint of investigation

Based on the above-mentioned results, it is necessary to investigate it in the following viewpoint immediately.

4.2.1. The change of precipitation and rainfalls. Decreasing of water area of Limboto Lake is inexplicable only by the irrigation water intake in dry season. Irrigation water level falls, and this is causing of impossibility enough watering. In addition, the situation that groundwater decreasing at a place without the irrigation has no relation to the irrigation water intake from the river. We suggest one of the reasons is the precipitation change.

JICA report suggests precipitation actual survey data are imperfect. We also cannot mention relations with the precipitation exactly. But it should not speak the reason of the decrease about lake water and groundwater with ignoring rainy influence. We need long time precipitation and way of rainfall data.

However, local people said the annual precipitation becomes less than the past. Moreover, torrential rain is increasing. After torrential rain for one week, water does not go down and remaining above the land during two months. This phenomenon has various influences on the environment of the lake and ground water. Because rainwater cannot filter into soil, much water floods occur.

4.2.2. Searching true cause of sediment. Source of sediment may be not only from cornfield of mountainous area but other causes. Because decreasing of water area of Limboto Lake started long time ago. If sediment that 1.5million m^3/year flow into lake as JICA report point out and on the assumption that 10cm surface soil of cornfield flow away, 1,500ha cornfield is lost every year. The amount closes to 10% of 17,452ha cornfields that in basin Limboto Lake. [12] This is too much so it is hard to think this phenomenon is the only cause. We must search another cause with geological method.

4.2.3. Demand and using of the land. With retreat of the surface water of Limboto Lake, dry land appears. Then people construct houses on there. We understand necessary new land for development agriculture and improvement of their living. But flood will happen every several years in some place. Off course they might know this fact. The reasons are difficulty to get dry land, price of land is expensive, and earnings are few for fisher and farmer. We guess that flood is one of a part in their life.

Aboveground house style house can keep the living of the family from a flood. But when people want to construct their house, most of them do not choice aboveground house style. Because building cost of this traditional style is more expensive than modern style.

4.2.4. Less earning of fisher and farmer. Farmers cannot cultivate enough time because few water in dry season and flood covers farmland for several months in rainy season. Because earning of farmer that lives around Limboto Lake is less than other area, they cannot get favourable land or construct

aboveground style house. Even life on the water for many days is not good for their health.

Increasing income will solve problems of living. But rapidly environmental change does not give good effect for fisher and farmer. In addition to preventing environmental change, it is a problem to hurry to change their living. Income improvement is a big problem but necessary.

Now approximate main earning of fisher is Rp.50,000,000-150,000,000/year and farmer is 10,000,000-17,000,000/year. In addition to main earning, fisher and farmer often operate side business. For example, fisher do fishing and fish farming, farmer make corn and vegetable in season except the rice. Fishers also do agriculture when water condition is good. Even if so, their income is not much at all. Based on these conditions, we must grasp how to bring out new works clearly.

4.3. Suggestion

Incomes of fisher and farmer are not much at all. In addition, disappearance water area of Limboto Lake will come soon. The possibility that their economic condition worsen more is very high in situation of rapidly environmental change like this. Therefore it is effective to pay attention to the next point to make sustainable work under the present conditions.

4.3.1. Ability of using sediment. In order to bring out new works and increase earning of local people, we suggest using sediment that flow into the lake. Amount of sediment is too much, but it is possible using it with local technique.

One of the uses is making bricks. There is already the technique and seems to be made from sediment of the lake. We want to research details about making and using bricks in this area. Other way is using for agriculture. Sediment is not good for paddy, but it is good for chilies, tomatoes and gingers. We also find new crops to increase earning of fisher and farmer.

We will find the other ways how to use sediment that accumulated in the lake. The problem of using sediment is how to take and bring sediment from lake. And amount of 1.5million m^3/year sediment is too much, if local people want to use it for new works. For that reason, new works must be sustainable and stable big industry.

4.3.2. Necessary of comprehensive correspondence. To solve problems of Limboto Lake, we must research and think about many issues, for example decreasing water level of lake, flowing sediment into the lake, effects to inhabitants' life, and increasing earning. Furthermore, it is necessary technique of engineering, solution of social and economic problems. On the other hands, it is possible finding innovation and new method of agriculture and industries from environmental changing. In other words, comprehensive correspondence is indispensable.

We have to relate many stakeholders, for example government, organizations, university, company, and people within and without the region. It is necessary to make a scene and a system of discussion and the promotion, or it is impossible to solve many complex problems in near the future.

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