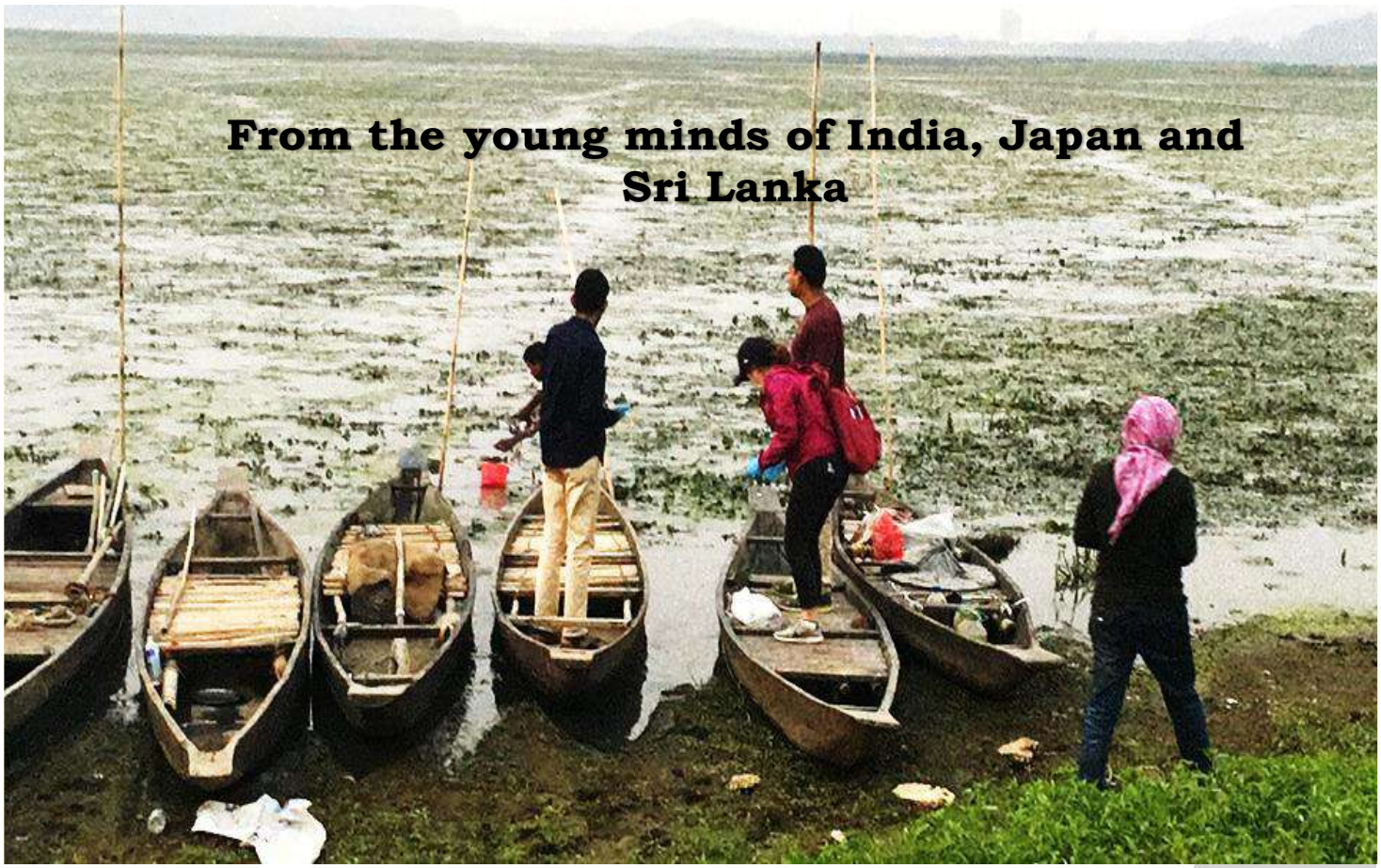
Sustainable Water Management of Rivers: Vision 2030

ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH



Reports on Study Camp on Environmental Technology at TONAMI Camp 2018

Environmental Technology International Course
The Graduate School of Natural Science and Technology, Kanazawa University

Preface

This booklet is a summery session of the Study Camp on Environmental Technology at TONAMI Camp held from 25th August to 2nd September 2018 in Kanazawa University. Total of 34 students participated from all over the world, excluding the professors. The students were from India, Japan Sri Lanka, China, Bangladesh, Iraqi, USA, Cambodia, Indonesia, and Thailand. The students further divided into five groups to complete the group assignments. They were assigned to "propose water management policy for sustainable use of local rivers in different countries until 2030". Target rivers: Brahmaputra River (Guwahati, India), Kelani River (Colombo, Sri Lanka), Jinzu River (Toyama, Japan). Students made a presentation about their discussion and results in the last day of the camp.

The workshop was mainly organized to develop the ability to explore environmental problems in a local community. They were also advised to propose solutions including appropriate technologies with ethical understandings on the social background of the city and to understand the necessary social system/program to achieve the solution.

The assigned group of students thoroughly discussed the problem of their corresponding river and have given their idea based on observation and literature. They have given their thought on the urban water management and policy need to be implemented. Some of the groups have given very insightful ideas which actually can be applied to for better outcome. All the students have very actively participated in the discussion and exchange their ideas and suggestions in the workshop, field trip, group discussion, BBQ party, and farewell party as well.

The young minds are the leader of the future generation, and one day replaces the older generation. This is because young minds have lots of creative ideas because they are not bound with the rules and regulations of the systems. Therefore we have encouraged all the students to participate and to deliver at least one solution to the problem.

The student session was one of the main attraction of the workshop. This was only possible due to the mutual support of supported and co-operation by the funding agency APN and the University of Kanazawa.

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Group A

Group name: The Nerd Heard, Target River: Brahaputra

Brahmaputra River (Guwahati, India)

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1 Description of Brahmaputra

1.1 1.1. User, Demander and Stakeholder

The Brahmaputra River is one of the largest rivers in the world. It has a total drainage area of about 570,000 km^2 and traverses many regions such as China, India, Bhutan and Bangladesh (figure 1). It is the foundation of water, energy and food for an estimated 130 million people living within the basin.

Figure 1.1 River Brahmaputra Location Map

(Vacayholics, 2018)

The Brahmaputra River traverses 1,625 km in Tibet (known there as Yarlung-Tsangpo), and 918 km in India, before flowing through Bangladesh for 337 km and emptying into the Bay of Bengal through a joint channel with River Ganga (another transboundary major river flowing through India and Bangladesh) (Vass et al., 2011). In India, the river flows through the northeastern Indian state of Arunachal Pradesh in a north–south direction for 278 km (where it is known as Siang River), and across the east–west ranges of the Himalayas. After entering the plains of Assam, the Siang River (also known as Dihang) is joined by two large tributaries namely, Dibang and Lohit near Oiramghat (Lakhimpur District) and the combined river is thereafter called the River Brahmaputra (Bhattacharjya, Bhaumik and Sharma, 2017).

1.2 1.2. Roles and Function

Each riparian has their own priorities with regard to the Brahmaputra River.

China: Prioritizes on generation of hydropower to develop its western regions and to invest in clean energy resources. China has built one hydropower dam on the river and has plans for several more.

India: Management of and access to Brahmaputra waters for hydroelectricity, flood control, local development and integration of isolated northeast India into the rest of the country.

Bangladesh: The river is an important source for agriculture such as crop irrigation and also as the transportation.

2 Current and Possible Problem on River Management

There are various issues in the management of this river which can be divided into 3 categories. The three categories are damages caused flooding, water contamination, and transboundary co-operation.

2.1 Flood and Erosion

The Brahmaputra basin represents an acutely flood-prone region, which acts as a bottleneck to agricultural development and is one of the major reasons of economic stagnation of the state. This river traverses three counties and as shown in Figure 2.1 (a), there is a huge drop in elevation when this river enters India, it debouches in the Assam Plain (the red circle is corresponding to the upper Assam). Due to this massive elevation change, the water from the upstream rushes into upper Assam and can flood the region. Another trigger of floods are the

many tributaries that connect to the Bramaputra river all along its course of about 2800Km (Figure 2.1(b)). Therefore, when it rains heavily, a surge of water from each of its several tributaries floods the area. Furthermore, dams built up stream in the Bhutan region are suspected

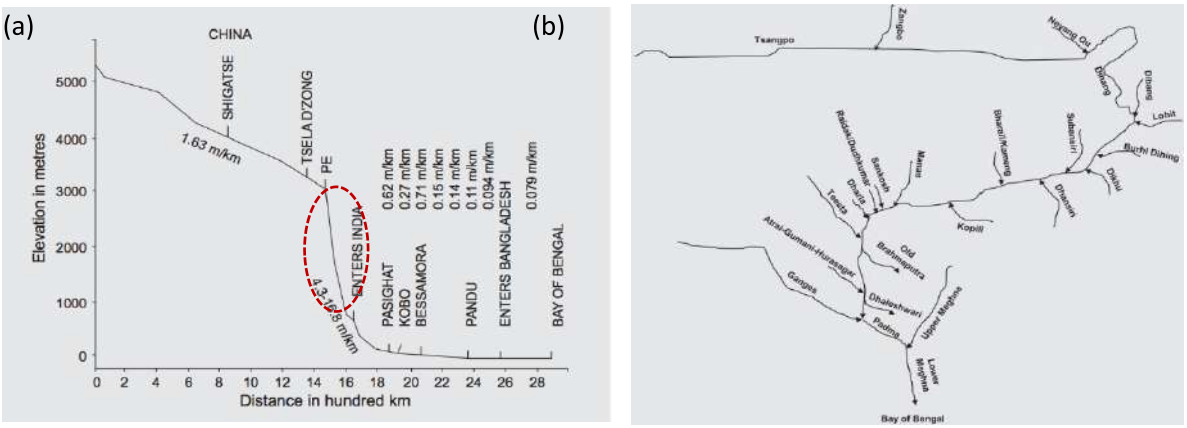

Figure 2.1(a) Long profile of the Brahmaputra river (b) Tributaries along Brahmaputra river

of causing floods in Assam and are believed to produce even more dangerous conditions for other regions further downstream in the future (Das, 2016).

As a consequence of flood, there is large scale erosion of riverbank soil. The rising water levels have "swallowed" islands in the Sundarbans or leave large portions of the islands submerged during the high tide (Shapiro, 2016). In the other hand, it has separated islands from the main land, knocking over trees and making the land uninhabitable for the animals as well. The ecosystem and biodiversity of the region should be conserved and protected with clear policies.

2.2 Contamination of wastes

Bramaputra river has been seriously polluted by domestic and industrial wastewater. Although there are 269 sewage treatment plants in India, only 231 are operational and these existing treatment capacity is just 21% of the present sewage generation (Kamyotra and Bhardwaj, 2011). In addition, most households do not link to the wastewater treatment plants, in contrast, they are leading directly to nearby water environment such as lakes and rivers.

Unfortunately, contamination of wastewater is not the only concern. Generally, municipal solid waste is disposed of in low-lying areas and deposited directly into the river without taking any precautions or operational controls. According to Sharholy *et al*., 2008, many types of solid waste disposal systems have been adopted in India. The two leading innovative mechanisms are composting (aerobic composting and vermi-composting) and waste-to-energy (WTE) (incineration, pelletisation, biomethanation). However, the lack of resources such as financing, infrastructure, suitable planning and data, and leadership, are the main barriers in municipal solid waste management and they are responsible for the accumulation of wastes at every nook and corner.

Wastewater and solid waste are the main sources of harmful microorganisms, heavy metals, as well as Pharmaceuticals and Personal Care Products (PPCPs). Often, chemical substances contained in wastewater are hardly biodegradable and inadequate treatment systems leads to an accumulation in the surface water. As shown in Table 2.1, the amount of Zinc and total Iron exceed the maximum standard level. Moreover, Chromium and Lead are at the border with the standard level. Therefore, if the unsafe disposal of wastewater and solid waste continues, many more chemical and toxicological parameters will exceed the standard level. Consequently, serious damage to the water quality will emerge and lead to unsafe drinking water. Such poor quality of water will negatively impact agricultural irrigation and the soil and ground water. Further concern may include the increase of anitibiotics resistent diseases due to antibiotic exposure and the contamination of harmful organic coupund into the irrigation channels.

Table 2.1 Water Quality Index of Brahmaputra river and toxicity values (Indian Institute of Technology, 2013)

Arsenic (As)	1 µg/L	10 µg/L
Mercury (Hg)	BDL	1 µg/L
Lead (Pb)	10 µg/L	10 µg/L

2.3 Transboundary co-operation

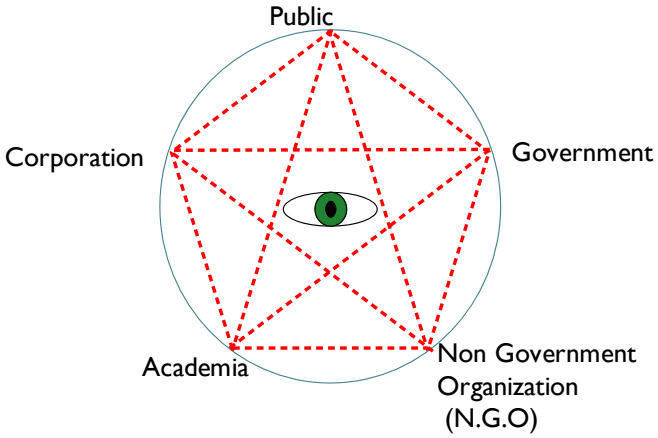

Figure 2.2 Unconnected co-operation diagram

Due to the fact that it is an international river meaning negotiations between different governing groups is essential. However, there has yet to be a strong agreement, so the regulations of river use are inconsistent and vary even within the same country. Figure 2.2 presents the poor/broken connection pipe between 5 main groups which are the public (resident), government, non-government organization (N.G.O), academia and any kind of corporation groups. The poor regional corporation has also lead to an unequal access to hydrological data of the river. China and Bangladesh have much more knowledge than India (Das, 2016). Even still the data collected is insufficient for flood forecasts or accurate climate models. If the problem cannot be solve, ther might be the conflicts over the water resources.

3 Proposal for Sustainable River Management

3.1 Slogan and Targets

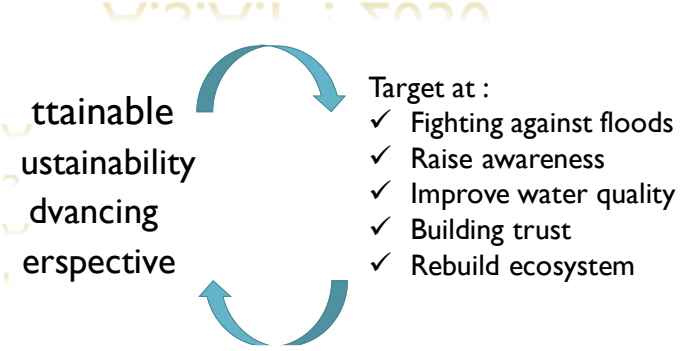

Figure 3.1 Slogan and Target

Figure 3.3 Slogan and Target

Our slogan is A.S.A.P!2030 (Figure 3.1). This slogan expresses the urgency in developing a river management that focuses on achieving reasonable practices that ensure the sustainability of the river as a resource by changing the stakeholders view their responsibility toward the river management. The targets for the year 2030 include preventing floods, improving water quality standards, and raising awareness of these issues. We also want to establish clear channels of communication between the different stakeholders of the Brahmaputra river. The goal of developing these channels is to give everyone a way to share their concerns and opinions of the practices put into place by any and all other stakeholders. This will ensure there is a transparency in the actions taken to improve water quality between governments, industries, locals etc. This transparency and direct communication will build trust between these different stakeholders to guarantee the best cooperation for maintaining the river management. A detailed description of this system will be described in further detail in another section.

3.2 Main part of the proposal

3.2.1 Proposed measure

The engineering measures are proposed in the purpose of solving the flood and contamination problems.

For the case of flood, we want to prioritize the areas that are most prone to inundation, such as the upper region of Assam and the Sundarbans. To help prevent the surge of water in upper Assam, in addition to the embankments, it is necessary to equip the tributaries with checked dams. This would slow down the flow of water and act as a sort of trap for small soil particles. By preventing the flood damage, the money saved for rescue efforts and rebuilding can be put it towards improving the distribution of water for other purposes. One example could be building proper irrigation channels to supply crop fields improving the independence of the local regions. The refined management for the river should be supplemented by efforts to teach residents and students what to do to maintain a clean water quality and still enjoy the resources that the river provides. There should also be more first aid training in the local community to have in times of emergency such as excessive heavy rains that are outside the margins of what the management system can withstand. This would give locals knowledge to perform live saving techniques, while rescue effort are on the way.

Considering on the case of domestic and industrial wastewater contaminated into the river, we propose that there must be proper sewage systems that connect household to the wastewater treatment plant. Furthermore, the amount of plants should be increased and developed to specifically remove or reduce the amount of heavy metal, microorganism, pharmaceuticals and personal care products (PPCPs). Since many of these harmful organic compounds cannot be effectively eliminated by conventional treatment, advanced oxidation processes (AOPs) like non-thermal plasma processes (Magureanu, Bradu & Parvulescu, 2018) should be additionally added to the conventional wastewater treatment as alternative. Moreover, any kind of effective solid waste treatment plant must be operated for treatment of solid waste as well as sludge which resulting from the wastewater treatment plant.

Even though, engineering measures such as solid waste treatment and wastewater treatment are imperative but apart from that, policy measures are also important to solve these problems. Creating policies to lessen the amount of treatment conducted by treatment facilities will help make sure the engineering measure can work more efficiently. Such policies should include education along with laws of enforcement for the residential cooperation with the garbage separation and recycling, standard of industrial wastewater quality before discharge into the water environment, the replacement of the toxic fertilizer which will reduce the runoff of the toxic substances. In addition, reforestation will not just only help in flood and erosion problem by minimize the damage along the floodplain and bring back the wildlife but it will also have an advantage on the air pollution problem as well.

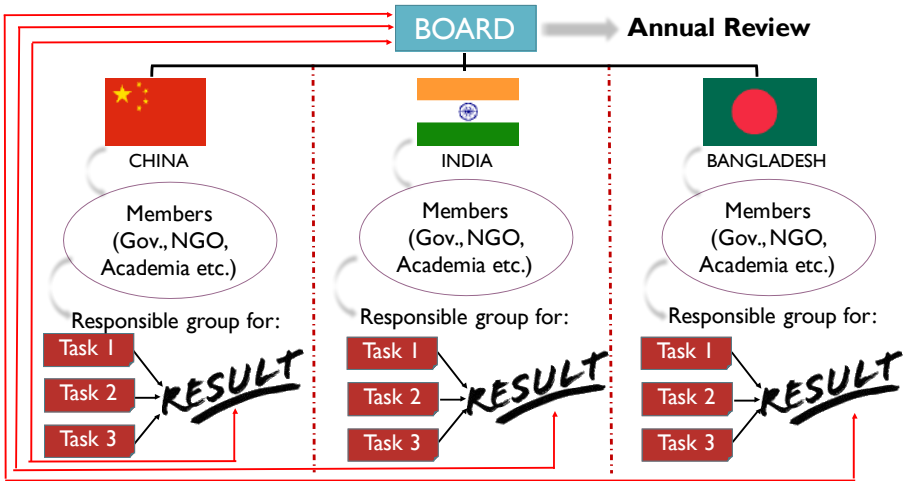

Figure 3.2. A.S.A.P. Review Board System

To improve the transboundary co-operation, a board with members (governors, NGO's staff and academia) from each country should be established (Figure 3.2). The board will be discussing and reach the agreement of:

- Amount of discharged water (task 1): counties located in upstream must inform the county located in downstream if the amount of the discharged water is higher than the agreement amount so that the downstream counties can be well prepared to receive the extra water that will be discharged.
- Standard quality of river water (task 2): the standard river water quality of the upper stream should be more stick than the downstream because more or less, the upper stream water is already polluted before flow down to the downstream. Therefore, it would not be fair to set the standard for the downstream countries as same as the upstream countries.
- And parameters for real-time monitoring (task 3): the monitoring equipment should be the same from all the stakeholder to prevent the data bias.

Members from each country need to assign groups to responsible on these 3 tasks and annually, the results/report from each country will be brought to the board where the discussion will be hold. The discssion and agreement made at the annual board review by 3 involving counties would help to connect the broken pipe and bring all stakeholders to work together.

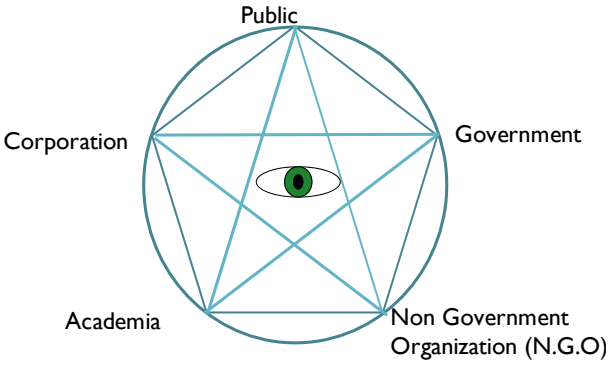

Figure 3.3. Connected co-operation diagram

3.2.2 Road Map

Starting in 2022 the aim is to strive for the coordination of "ecological, economic, and social progress." The ecological, economic progress is obtained after improving the counter measures in flood prone areas to minimize the potential for floods as well as improving response actions

in times of crisis. With improved ecological progress, the flow of water can be managed so that it doesn't cause death and destruction of homes and crops. This decrease in uncertainty due to weather related disasters, will result in economic profit for the local community as they will be able to plan for a better future.

Progress must be made on several fronts with the participation of the locals and Indian government. The government should focus its efforts increasing the number of check dams built in tributaries that lead to the upper Assam regions from 40% to 70%. These will reduce the quantity of water and flow rate of the water as it reaches Assam. In addition, embankments should go from covering 20% in 2022 to 40% in 2026 of the flood prone region. This can help prevent some floods or at least slow down the inundation giving locals more time to evacuate to emergency shelters. The amount of irrigation channels to crop fields should be 60% of all nearby crop fields. The fields that are equipped with irrigations up until 2026 will be chosen based on the variety of crops produced and preference will be given to those willing to donate a portion of the surplus to supplying storage food for shelters.

These shelters are crucial towards saving lives during and even after the floods. The shelters should be supplied with provisions such as clean water, blankets for locals for at least a few days. The staff should be consisted of locals. Our goal for 2026 is to have at least 3 in every 100 people trained to perform basic first aid or to alert the locals as to when it is time to evacuate. As well as advise locals as to precautions to take before and after floods to prevent injury or death. This can serve as a part of social progress as it gives opportunities for young adults to obtain more education and leadership skills that can open opportunities for them in the future if they have an interest in government, public relations, environmental conservation, etc.

With the increase in flood prevention, more resources can be applied to retrofitting villages and cities with more advanced technology to ensure a better access to clean water for all not just those in the flood prone region. Our goals are as follows: 80% of the cities should be equipped with WWTPs, 85% of the houses should be linked to draining system (30% of the WWTPs should include specialized non-thermal atmospheric plasma treatment to treat the PCPs). Under these proposed measures, the government will need to invest more money and attention in the local cities to build WWTPs and make regulations that any new houses that are built must have proper drainage system and offer incentives to those who adapt their homes to connect to the drainage system. Local officials will need to oversee that contractors certify that the house was

built to meet this criterion, while filing copies of the documents for the records. The documents are necessary to keep track of the developing sewage system in each city.

60% of the industrial companies should treat their sewage by itself. The industries will need to delegate task-groups to manage the installation and survey of the performance facility on treated water. A summary of the water quality should be sent to the government for record keeping. Random inspections of each industry should be performed by a neutral party contracted by the government. Locals can also report any suspicious activity toward their local government, which will pass along the information to the third party for consideration during the inspections. Industries which violate the standards will be fined.

Through these previously mentioned measures it seems feasible to expect that 50% of the river's water quality should meet national standards. Solid waste treatment will take and increasing amount of focus as 2026 approaches, by that time 25% of the solid waste should be separated by every house and 50% of the cities should be equipped with solid waste treatment plant.

In terms of cooperation, the ASAP review Board will negotiate and work with the different governments to ensure that 50% of the river dams in China, India and Bangladesh regulate the discharge of water as per agreements;40% of the rivers in China, India and Bangladesh should be equipped with real-time monitoring system; 50% of the rivers in China, India and Bangladesh should meet the water quality standards. All the NGOs and each level of government should share their contamination information for the annual review to distribute the information equally among the stakeholders.

The top priority is to address all of our goals for flood contamination. The safety of the locals living in these regions is most important before improving the water quality of the river. However, with focusing our resources on flood prevention and disaster training means that we have to be realistic about what percentage of our goals for contamination and cooperation can be accomplished. While making sure people are safe from natural disasters can save lives in the moment we also want to improve the quality of the water which is essential to maintaining life and preventing illnesses from using contaminated water. So, our second biggest priority is treating the contaminated water. We know that building these advanced facilities will cost a lot of money in planning, materials, and labor costs. However, it is a necessary investment for these people to have clean water while policies are put into place to prevent pollution from entering the river due to man-made sources.

We hope to have reached 100 percent in nearly all of our proposed measures for flood prevention and management. For contamination, we believe that at least 50% percent of WWTPs should include the plasma treatment. This time will give us the opportunity to evaluate the efficiency of adding the treatment as well as the chance to review any newer technologies that may be more cost effective or more efficient at removing PPCPs. Industries with a large number of employees will all be expected to conclude their own solid waste and water treatment operations. Solid waste treatment is complex system requires more time for implementation for residential areas. In the meantime, policies for local separation of garbage can be introduced and tested but without much money devoted to enforcing these policies; proposals to monitor and enforce separation will need to be considered in 2030. Solid waste treatment plants will be present in roughly 75% of the cities along the river and the remaining 25% will other viable alternatives.

In terms of cooperation, 60% of rivers and dams should be inspected and be in working condition, while the remaining 40% are under review. Things such as dams with problems that will worsen if left untreated and proposed timeline as to when those will be repaired. By 2030, 50% of proposed real time monitoring stations will be set up and evenly distributed along the river. A discussion as to whether or not more monitoring stations are necessary to pinpoint source contamination more quickly will be reviewed and agreed upon in 2030.

4 Conclusion

The Brahmaputra River has three major problems. This river has a steep slope, so in the rainy season, sometimes it can cause floods in downstream area. In relation to floods, erosion of bank and loss of biodiversity are also a concern. The second problem is contamination which is mainly composed of heavy metals and caused by a lack of waste water treatment. Heavy metals come from pharmaceuticals, factory drainage, and untreated waste water that comes from city. Lastly, there is lack of cooperation in each country which contributes to the problem of river management. This river traverses China, India, Bhutan and Bangladesh, yet there is no agreement on how to govern this river, so these countries are in conflict over water rights and pollution.

To solve these problems, we have developed the following proposal. The title of our slogan is “ASAP2030”. ASAP means A-Attainable, S-Sustainability, A-Advancing, P-Perspective, and

we aim to achieve a robust river management by 2030. Target of the slogan are fighting against floods, raise awareness, improve water quality, building water trust and rebuild ecosystem.

The proposed measures are for flood, contamination and cooperation. As measures for flood, we propose building embankment, check dams, educating of cause of flood and first aid response training. To prevent contamination, we propose making WWTP (Waste Water Treatment Plant) in cities, educating of separation, making lows for water quality.

As measures for cooperation, we propose making agreements for discharge of water, water quality and real-time monitor.

Following these, we constructed a detailed road map. Included in the road map we address "who will do what" by 2030. By 2030, the government, NGOs and locals will complete the embankment in the flood areas, making check dams, educating of flood emergency and how to prepare for floods. For the management for contamination, government, local and industry, NGO will complete WWTPs in cities and companies. However, household separation and making agreements in each country will not be completed by 2030, but in the future time will be set aside to review the efficacy of the proposed measures and make agreements on the overall maintenance of the river between these countries.

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Group B

Group Name: BHP-WPSA, Target River: Brahmaputra River

The Final Report for TONAMI Camp

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1 Introduction

The Brahmaputra River or "Son of Brahma" or "Son of God", is a snow fed, large trans-borders river, originates in southern Tibet (China), then penetrates the Himalayan mountain ranges in huge canyons and subsequently enters India in Arunachal Pradesh, when it is called as Dihang. The river runs to the southwest across the Assam Basin known as Brahmaputra River, and then south to Bangladesh, when it fuses with the Ganga to create a huge delta, which is known as the Sunderbans before emptying into the Bay of Bengal (Fig.1).

Fig.1: Map of Brahmaputra River

Brahmaputra River is one of the longest rivers in Asia and the world with a total length of 2880 km across three countries; China (1625 km), India (918 km) and Bangladesh (337 km). The river has more than 100 tributaries. It is also the fourth largest river in the world in terms of annual flow, with average of 680,600 and 589,000 million m3/year in India (Pasighat and Pandu) as well as Bangladesh (Bahadurabad), respectively (WAPCOS, 1993). Only Amazon River carries more water than Brahmaputra.

Brahmaputra River drains an area of around 580,000 km2; 293,000 km2 in China, 45,000 km2 in Bhutan, 195,000 km2 in India, and 47000 km2 in Bangladesh.

During its long trip, considerable variations in width, gradient, discharge and channel pattern occur, the maximum width of the river is 18 km between (Palashbari and Mukalmua), while the narrowest is 1.2 km at Pandu (Guwahati), while the average depth is 38 meters and utmost depth is 120 meters.

Brahmaputra River is disaster-prone in spring, when the snow on the Himalayan mountain ranges melts. The average flow of the river is around 19,300 m3/sec. Inundation levels can attain more than 100,000 m3/sec. The Brahmaputra River is also one of the limited numbers of rivers in the world that display a tidal bore phenomenon, which causes intense turbulence in the water and may be dangerous leading to sudden increase in water levels and devastating floods.

In addition to the natural phenomena, petroleum refineries and other industries discharge majority of their toxic wastes into the river catchment area. The principal crisis on the river drainage area is that of regular inundating, cutting down of trees, and other human actions like encroachment of river banks and wetlands for unplanned urban growth being the main reasons.

2 User, Demander and Stakeholder of Brahmaputra River

There is an extremely high degree of dependence on the freshwater resources to sustain the livelihoods of rural communities and meet the food needs of urban populations.

The Brahmaputra basin, with a total population of about 83 million (across all four countries), is extremely rich in cultural diversity, with many ethnic, socio-cultural and linguistic groups.

About 41% of the basin's population resides in Bangladesh (north central and north western hydrological regions). Another 34% resides in Assam and a further 16% in the West Bengal part of the basin. The remaining 9% of the basin population can be found in Tibet, Bhutan and other north-eastern states of India (Sikkim, Arunachal Pradesh, Meghalaya and Nagaland). A much larger area and population depends on the combined flow, which flows to the bay via the Meghna River. The main water use in the basin is for agriculture (81%), followed by domestic uses (10%) and industries (9%). Groundwater availability at shallow depth (within 20m) is very high in the basin, especially in the valley areas. However, only 4.3% of the existing potential has been developed so far in the Indian part of the basin.

In addition, management of the freshwater resources has been a global challenge, especially for transboundary river waters (TBW). Management of such communal goods or common resources becomes difficult as the interests of the diverse stakeholders involved will always vary. The final consequence of water sharing amongst the riparian's and the level of management success will rely on the dynamics of the level of influence that are at play at the national, regional, and international positions in the region.

Multi-stakeholder (involving the communities, local civil society organizations, non-governmental organizations, academicians, researchers, media, donor agencies, bureaucrats, and politicians) and multilateral dialogues can help to promote trust and confidence among the riparian nations. Participatory dialogues help in building the capacity of the concerned stakeholders through sharing of knowledge among the participants. A huge communication gap exists between the state and the non-state actors. Common people often lack the capacity to communicate with the bureaucrats. The bureaucrats mostly use technical language, which is again not effectively communicated back to the CSOs and communities. Regular dialogues can help to reduce this gap and build trust between them in regards of proper allocation and uses of water.

3 Role and Functions of the Brahmaputra River

The riparian populations are largely depending on the Brahmaputra River for their livelihoods (Fig2). Most of them use for the agricultural and fishing purposes. It also supports navigation, energy production, and terrestrial and aquatic ecosystems. However, the people in this region also experience the huge loss of life and damages due to water-related natural disaster.

The Brahmaputra also serves as a potential resource for the hydropower electricity generation. For this issue some dams are planned or already operating in parts of China, India and Bhutan.

The use of its water resources has become the source of contention between different users in some parts of the river, involving multiple jurisdictions and countries. There is a severe water conflicts over different jurisdiction among various users when it's a matter of water sharing issue. Moreover, the mighty river Brahmaputra provides enormous economic benefits to the agrarian nations such as India and Bangladesh. The river, while flowing through the higher lands, erodes the soil and deposits them on low-lying areas, generating alluvial soils for agriculture. While the river mostly serves as an essential inland waterway, excessive deposition of soil in the lower areas might cause frequent devastating floods. Thus, the river can act both as a creator and a destroyer.

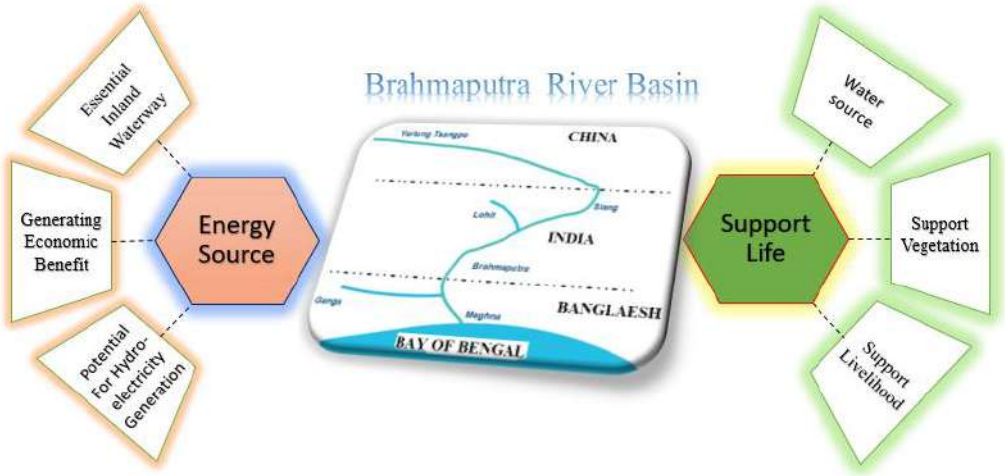


Fig2: water use constrains of Brahmaputra River

The mighty river Brahmaputra has various functions in regards of environmental, economic and social perspective. Some of them listed below:

The mighty Brahmaputra has the potential to meet 30 per cent of India's water requirements and 41 per cent of its hydropower needs. As for Bangladesh, it fulfils 94 per cent of its total water requirements from the Brahmaputra river system.

The mighty Brahmaputra with its 52 principal tributaries, innumerable flood plain lakes and the Barak River system in the south constitute the major water resources of Assam,

supporting over 200 species of aquatic fauna, including the endangered river dolphin. Although many protected areas along the Brahmaputra have been traditionally regarded as a fish granary, it is widely believed that fish production has drastically declined in recent years.

The Brahmaputra's riparian zone is highly unstable and subjected to bank erosion on one or both sides at different places. The fast-flowing section of the river is characterised by rocky substratum and a relatively stable bank

High rainfall and humidity along with varied altitudinal gradients influence the climate that ranges from tropical plains to temperate and alpine hills. These diverse climates support almost all types of vegetation from cultivated plants to grasslands, meadows, marshes, swamps, scrubs, mixed deciduous and humid evergreen forest, temperate and even alpine vegetation.

Brahmaputra valley being the largest plain in the northeast region and has a great significance not only for agriculture and industry of the region but also for its rich vegetation and wild lives preserved in the various protected areas. The forest types are the innumerable river islands or chars formed by the Brahmaputra have also given rise to a unique way of life. It is interesting that, despite their vulnerability to flooding and erosion, the chars have been able to attract human settlements, building their entire lives according to the river's life cycle. Mostly tropical which harbours a rich pool of biodiversity.

4 Current Problems

4.1 Floods

One of the biggest problems in Brahmaputra River is the floods that cause massive destruction to the villages and houses, killing thousands of people, animals and destroying farms and crops every year. Rising the globe temperature due to the climate change, which causes snow melting in the Himalaya Mountains, is one of the reasons for this phenomena. Another reason is the earthquakes especially in the Indo-China border area, which is disaster prone area. These disasters can destroy dams causing a tremendous water flow to the downstream areas. Another possible reason is the Dams' poor maintenance, in addition to the lack or missing of collaboration in dams' management among the concerned countries (China, India and Bangladesh).

Fig.3: Floods in Brahmaputra River

4.1.1 Wastewater Pollution

Brahmaputra River is polluted with different kinds of waste, such as:

Fig.4: Pollution in Brahmaputra River

- Solid Waste: Due to the improper management.
- Heavy Metal: Most of the Industries and factories in the area discharge their waste directly into the river without treatment, some of these wastes are toxic and contain heavy metals such as (Pb, Cr, Cd, Ni, etc.).
- Domestic Wastewater: Domestic sewage also disposed into the river directly without treatment.
- Erosion of Soil: Floods and high-speed flow in some parts of the river especially in the narrow parts and the acute corners along the river long path can cause soil erosion to the riverbanks, which increase the turbidity levels in the river.
- Construction Activities: Especially in the river upstream have a bad effluence of the quality of the river.

5 Potentail Problems

5.1 Population Growth

Based on the population growth rate chart, the population in the brahmaputa basin area in continous increase, this means that the pollution levels in the river will keep increasing and the demand for fresh water will become higher than anytime before.

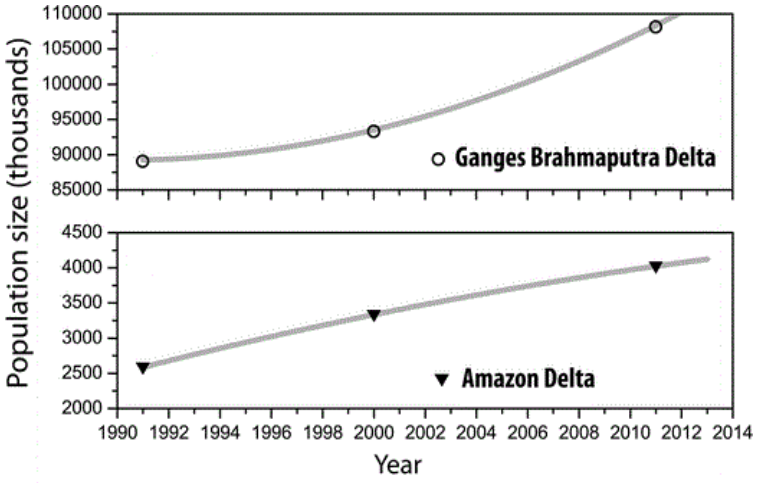


Fig.5: population growth rate in Brahmaputra River and Amazon Delta

Source: Population dynamics, delta vulnerability and environmental change: comparison of the Mekong, Ganges–Brahmaputra and Amazon delta regions

5.1.1 International Water Sharing Agreement

2.2.2. International Water Sharing Agreement

Inactive or non-exist of international agreements for water sharing among the shared countries (China, India, and Bangladesh), cause an inequality of the river water amount provided to each country. In addition to the pollution caused by one-sided actions from the upstream countries especially, without considering the negative impacts, can lead to a tension among these countries which may eventually develops to a conflict or war for the resources.

6 Slogan and Targets

6.1 Slogan "Limited Resources, Unlimited Loops"

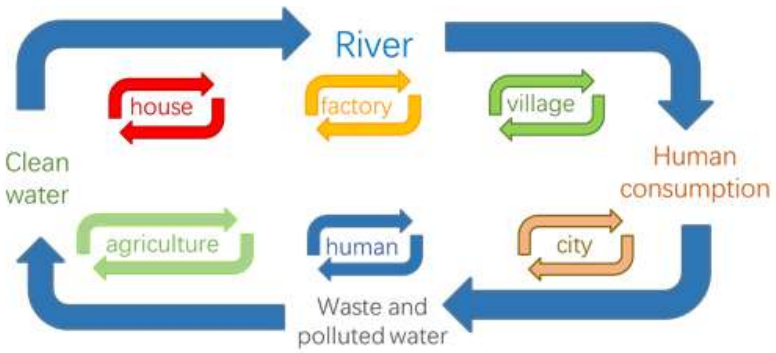


Fig.7: the slogan of the study

The limited resources refer to the water of Brahmaputra river, which is fresh water (fresh water represents 0.3% from the surface water in the planet). From the objective point of view, the water resources of Brahmaputra River are limited, which reminds people to think seriously how to protect the river and use it efficiently. The other part "Unlimited Loops" shows the way to solve the problem through treating and reusing the river water. From the figure above (Figure 7), some examples of the loops can be seen. People use river water for different purposes such as domestic, industry, agriculture, etc. and every one of these elements can represent a loop through treating water, ensure an efficient use, and stop the actions that polluted the river. Unfortunately, currently most of the effluent water disposed directly into the river. That's why measures and actions need to be taken to stop the pollution and clean the water before disposing into the river again.

To make better use of Brahmaputra River, three targets are listed in this study.

The first target is about floods protection; the massive floods destroy farms, kill people and animals and harm the country's economy, so some preventive actions should be taken as a priority to reduce the losses.

The second one is controlling water pollution and solid waste management; for the people who are using the river water for drinking, domestic use, agriculture and so on.

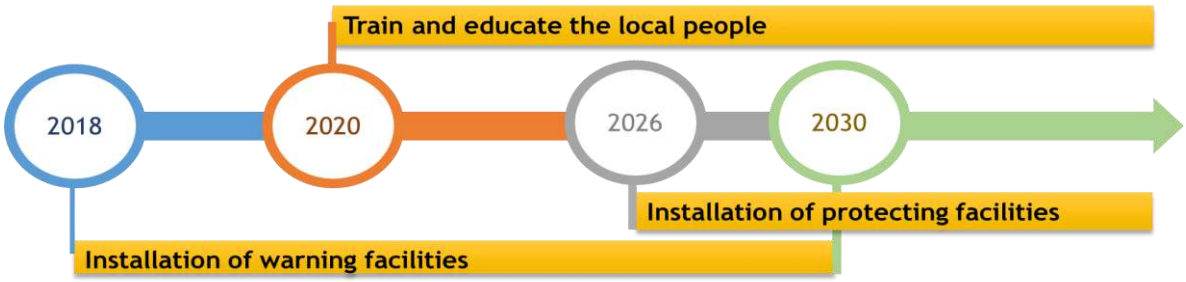
The third one is establishing an international joint commission of Brahmaputra River; to ensure an equal sharing of water among the shared countries and prevent pollution.

The detailed information about how to achieve these targets will be discussed below.

7 Targets

Target 1: Protection from Floods

The first target is focusing on protecting the life of people from the disastrous floods, through installation of warning facilities, train the locals and provide them with the required knowledge and installing facilities to reduce the floods.



The Roadmap

2018-2020

Start installation of floods warning facilities, the first step is to investigate the affected areas. Study and develop the technique which is the most suitable for each target area before introduce it to locals is required. The responsible person should include the government agency, the specialist on the flood and related issues. The target of this period is to complete 50% of research in targets River by 2 years.

In addition, after completing the study, the warning system and warning facilities such as construction of multipurpose used building which we can used as learning center and the refugee camp during flooding in each areas. All facilities should complete in year of 2025.

2020 Onward

Right after start building the facilities, the locals and people who is living alongside the river, should be introduced to deal with it. Educate and train the people of how to respond to the warning system and survive when the flood occur. The education of the people needs to do continuously.

2026 Onward

Installation of protecting floods to protect the life and manage the water resources:

Construction the embankment along the river bank.

Construction of porous roads (porous pavement) which allowed the water directly flow into the ground (Figure 8).

Development of rain water harvesting facilities.

Planting along the riverbank to prevent soil erosion and reduce the speed of water.

Periodical maintenance of the facilities is necessary to maintain the functional ability.

Fig.8: Porous pavement

Target 2: Controlling Brahmaputra river water pollution and solid waste management

The Brahmaputra River, as a transboundary river of 2,900 km long it faces lots of dispute of water sharing, dam construction, pollution, etc., and is in an extremely hazardous condition now. Elevated arsenic concentrations have long been detected in Southeast Asia (eg. West Bengal, Bangladesh, Thailand, Vietnam, Cambodia, Taiwan, China, Mongolia, Nepal and Pakistan (Nickson et al. 1998; Berg et al. 2008; van Geen et al. 2008) with more new areas (Myanmar, Datong Basin, China etc.) reported to have As contamination levels beyond the World Health Organization (WHO) drinking water limit of 0.01 mg/L (van Geen et al. 2013; Xie et al. 2014). Groundwater As contamination in the Brahmaputra Valley in Assam, India, is a relatively recent finding that has exposed a significantly large population to serious health threats, although the actual distribution and extent of the As affected groundwater in the aquifers are yet to be established (Goswami et al. 2013).

Besides arsenic contamination in the Ganga-Bhrahmaputra river basin unequal water sharing between the populations of China, India and Bangladesh has been a major problem. Any action taken at the upstream of the river has its effects at the downstream. As all these three countries have huge population problem and the two downstream countries India and Bangladesh is basically an agriculture based economy and a huge number of the riparian population depends on this river for their livelihood. Along with floods and river water pollution these two countries do not have proper solid waste management systems. On December of 2017, Assam (India) times reported that all of a sudden, the river Brahmaputra has started flowing with dirty water much the major concern of the millions of people in Assam to have spotted the disaster in their lifeline. The polluted water was spotted only from Jonai area in Dhemaji down to the north eastern city of Guwahati. Earlier that September, NDTV had reported that, Brahmaputra in Assam is dealing with oil pollution, lack of sewage treatment plants and disposal of waste in the river, resulting in its gradual decay and over-pollution. With its growth, Guwahati is the worst polluter due to lack of sewage treatment plants. According to The Times of India, the Assam government raised its finger at China for the polluted Brahmaputra River. Also, according to this news report, a cabinet minister in Assam Dr Himanta Biswa Sarma said that dam building activities across the Indian border could be a reason for pollution of the Siang River in Arunachal Pradesh, which has now contaminated the Brahmaputra River as well. The Siang is the principal constituent of the Brahmaputra River. According to The Quint, the chief minister of Assam Sarbananda Sonowal asked that the Indian government take up the matter with Beijing. Also, the recent plan of govt. of India to divert the

mainstream of Brahmaputra river to water scarce regions has raised concerns in the downstream Bangladesh.

Whatever the reason for pollution in the water of Brahmaputra River, it will have a long-term ecological and environmental impact on the entire Brahmaputra valley. Without an effective working mechanism between the three countries, water conflicts could potentially become a serious challenge and lead to water war. Keeping mainly the river pollution factor in mind, the target 3 has been divided into three sub-targets as follows:

a) Time period: 2018-contd.

Continuous monitoring of the mainstream of Brahmaputra as well as all its tributaries (for parameters like (turbidity, TSS, BOD, COD, pH, heavy metals and total coliform bacteria and keeping proper records of both pre-monsoon and post-monsoon) right from the starting point of where it enters in India in Arunachal Pradesh and to the point where it leaves India by installation of water quality monitoring systems. This way we can know the pollution load we are contributing to the river and can better manage it by appropriate measures.

Educating people to separate municipal wastes at the source and then dispose them. Waste segregation can be encouraged and done in villages as well as cities in very basic scale in the beginning e.g. educate and encourage people to separate organic and inorganic waste segregation. There should be proper waste collection systems (e.g. municipal committees) and they will collect the segregated wastes for treatment and disposal.

Making policies for industrial waste water discharge as currently there are no permissible limits for waste water effluent in Assam. There should be strict rule by the state as well as the central govt. for the small and large scale industries to install their waste water treatment plant and monitor the effluent discharge to maintain. Taking the example of minamata disease in Japan, the local community can form committees to visit heavy polluting industries biannually to check their effluent quality.

b) Time period: 2020-2025

Building WWTP should be completed by this time period for the existing industries. And premier research institutes should invest money to build and operate their own waste water

treatment plants of not only municipal waste but the water from the laboratories, before their discharge.

Proper guidelines for the permissible limits of discharge water should be developed and implemented. Strict laws on effluent discharge should be made and the companies/institutes should pay compensation for violation of regulations.

For solid waste management the waste researchers should consulted and work along with the state govt. and NGOs (non-governmental organizations) to provide the simplest designed equipment such as composter and digesters in the villages and cities. The kitchen waste and municipal waste can be composted and used in kitchen gardens or supplied to the farmers at tea gardens and other farmlands free of cost or minimal cost replacing chemical fertilizers to organic. Also, the digested biogas can be used for cooking.

Building waste separation stations in the cities should be completed by this time period.

Developing SMS (solid waste management system) application/app by software engineers along with the state govt. which will be advertised to install by the people. People can have their account in the app and report any cases of waste mis-disposal, lodge complaints and have two-way feedback. Also, they will be taught simplest techniques and educated about waste separation through the app. People can report their own waste disposal reports and earn points and hence prizes like recycled papers, cloth tote bags, replacement of plastic containers etc. after gaining certain points in the app and also can be awarded best responsible citizen awards in an annual local conference in the state.

Constructions of roads and pavements can be with wastes and new technologies can be applied like construction of green buildings and soil-less farming in cities.

Increasing of navigation, inland water transportation and increasing tourist cruises would lead to cleaning of the river by dredging.

Organizing river festivals annually or in every alternate year where riparian and other citizens of all the three countries viz., China, India and Bangladesh would participate and share knowledge and culture among themselves and share on social media as well. This will create more concern to protect the river and also cause more belongingness to the river. Currently the Assam govt. has conducted the river festival “Namami Brahmaputra” in Guwahati city and can be extended further.

c) Time period: 2026-2030

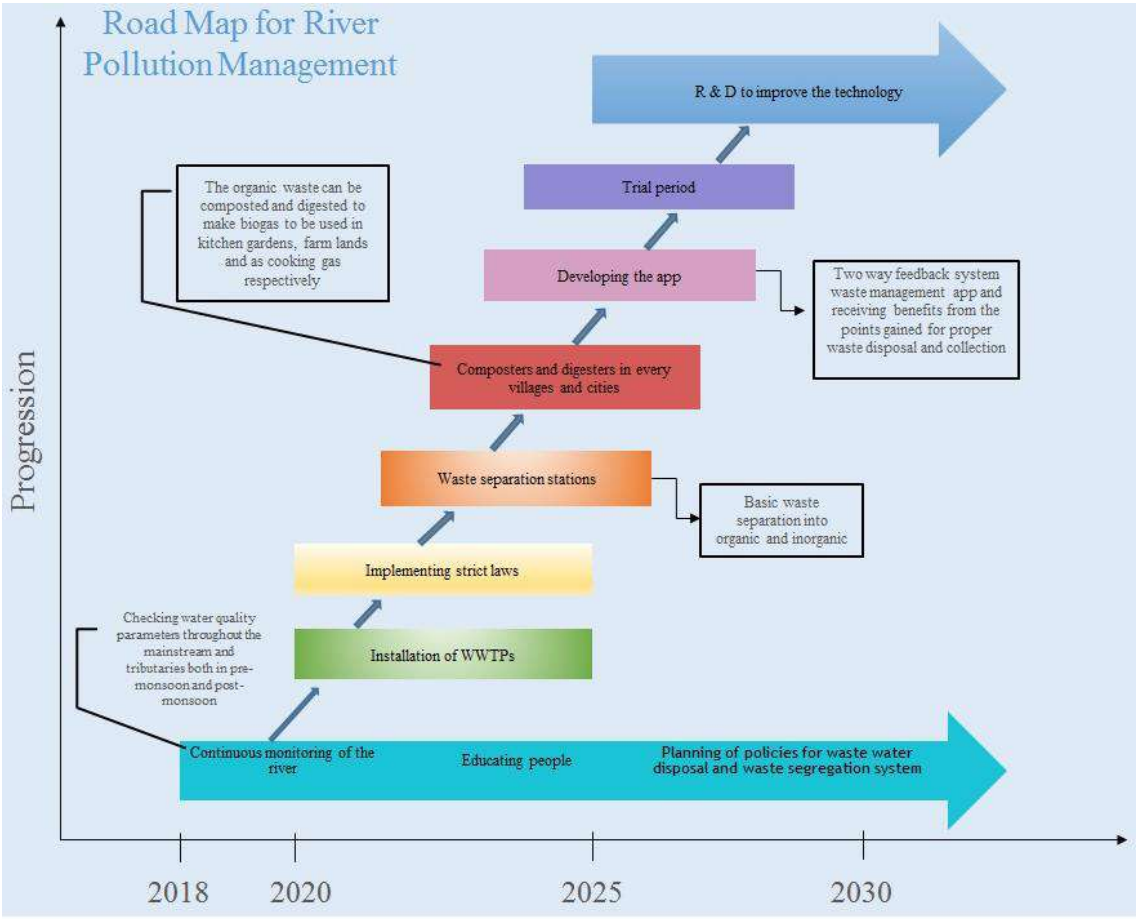
Verifying the water quality monitoring systems and WWTPs should be done regularly and improved. With the available recorded data, river water condition can be predicted and point sources of pollution can be identified and rectified.

R & D should be done to improve technology.

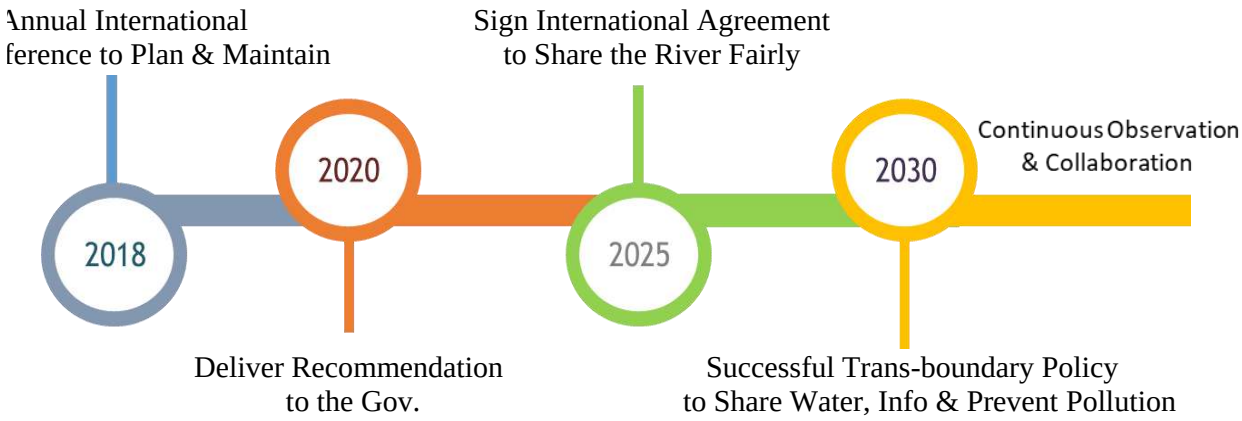
Implementation of new waste water treatment technologies.

Implementation of recycling units.

Considering the above points, the following road map has been made:



Target 3: Establishing a Joint Commission for Brahmaputra River



The second target is to establish a joint commission for Brahmaputra River, to share, discuss and set plans for the river.

2018 – 2020:

① Establishing an annual international conference to set plans and maintain the river, such conference can be held by scientists, researchers, NGOs, and governmental agencies from the three countries. The aim of this conference is to

Share and discuss the current data, policies, concerns and conflicts in the river basin.

Recommend scientific solutions to the current and potential problems.

Examples:

- Discussing the Socio-Ecological Impacts of one-sided actions on the other countries and on the river itself, including the aquatic life and diversity.
- Deciding the proper locations for building dams and their management.
- Involving locals and stakeholders in making decisions.
- Establish a specialized institution for the river research to train engineers, researchers and academics for the next generations.
- ② Handing the outcomes of the annual international conference to the governments and publish it in TV, newspapers and public media.

2021 – 2025:

Creating a public opinion and social pressure through TV, newspapers, social media, etc. to push the governments in the three countries towards approving and implying the achieved the outcomes. Social pressure and protests proved in many cases (such as the itai-itai disease case and changing the trash treatment system in South Korea) to be an effective tool to force the governments to listen to people demands.

By the end of 2025, politicians of the highest levels in the three countries should sign an official international agreement, based on the recommended outcomes.

2026 – 2030:

After earning the official approval, the practical actions should take a place. This period can be considered as a trial period to observe the river situation and modify the plans according to the present conditions by that time. Such task is a duty of the established Joint Commission.

By the end of this period, a successful trans-boundary policy, that guaranties fair sharing of water amount, information and prevent pollution, should have been achieved.

The joint commission keeps observing the river conditions and collaborating with the specialized authorities in each country to maintain and ensure the water quality, provided quantity and lowering the risks of the disasters.

8 Conclusion

The connection between water sources and the life of the human beings are extremely critical. Millions of People and even animals depending on the river as a major source of living, in deferent means. Unfortunately, those people are one of the biggest reasons for the river pollution. Poor waste management and disposal of untreated wastewater directly into the river stream leads to damage the important recourse of life. In additional to the natural phenomena (floods, earthquakes, etc.) which pollute the river and disorder the harmony of nature. A virtuous cycle to protect our limited recourses, must take place. Floods; which one of the worst nightmares for the locals can be significantly reduced, by combining the ecofriendly means such as planting trees to strength the soil and protect the manned areas, with the last innovative technologies such as paving the streets with porous pavement to absorb water and so on. Improving water quality and prevent further degradation of the river condition, through

building wastewater treatment plants, establishing waste separation and collection system, forcing the factories and the industries to treat their wastewater before disposing. The authorities should ensure a proper implementation of these actions through rewarding who follow and fining who doesn't. Reaching a successful trans-boundary policy to share the water in an equal manner, share the Information transparently and prevent pollution is an extremely important target to prevent future conflicts on resources. "Anyone who can solve the problems of water will be worthy of two Nobel prizes - one for peace and one for science" John F. Kennedy, the 35th president of the United States.

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Group C

Sustainable Water Management in Local River for 2030 (Jinzu River)

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1 Description of the Target River

The Jinzu River is a river that flows from Gifu Prefecture to Toyama Prefecture in Japan (Figure 1). It is called Miya River in Gifu. It is 120km in length and has a watershed of 2,720km^2. There are 380 thousands people in basin[1)]. The main roles of the Jinzu River are as follows.

Water resources of the Jinzu River is used for agricultural water, hydropower, domestic water supply, industrial water and so on (Figure 2, Table 1). There are 58 power plant which are using the topography and abundant water volume in the upstream part. After using for the power generation, the water is used for agriculture in the downstream. In addition to the above, recreation facilities such as parks, boardwalks, playgrounds, waterside plazas, etc. have been established in river beds, and are used by many people such as walks and large-scale events. The total number of river space users in the Jinzu River is about 300,000 people. Table 2 shows the number of people of each type of usage.

Figure 1: Location map[1)]

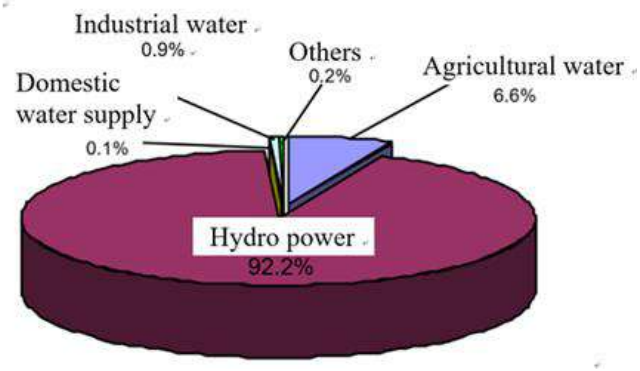

Figure 2: Roles and functions of Jinzu River[2)]

Table 1: Roles and functions of Jinzu River[2)]

Purpose	Water intake(m^3/s)	Case
Agricultural water	103.289	777
Hydro power	1441.452	58
Domestic water supply	1.853	4
Industrial water	13.972	21
Others	2.301	8
Total	1562.867	868

Table 2: Recreation facilities[2)]

	Item	Annual estimate ($x10^3$)	Rate (%)
By usage type	Sports	34.647	0.12
	Playing in the water	7.109	0.03
	Fishing	63.646	0.22
	Walking	177.49	0.63
	Total	283	
Another place to use	Surface of water	24.448	0.09
	Shoreline	46.307	0.16
	Flood channel	191.339	0.68
	Embankment	20.798	0.07
	Total	282.892	

2 Current and possible problems on the river management

The first problem is flooding around downstream of Jinzu River by heavy rain. The Jinzu River is one of Japan's fastest rivers. On July in 2018, the second largest flood in observation history occurred on Jinzu River. Due to the influence of Typhoon No. 7, total rainfall exceeded 400 mm/h from July 4th to 8th in Toyama. Figure 3 shows the state of the Jinzu River during heavy rain. The water level of the river exceeded the evacuation judgment level and it was in a very dangerous state.

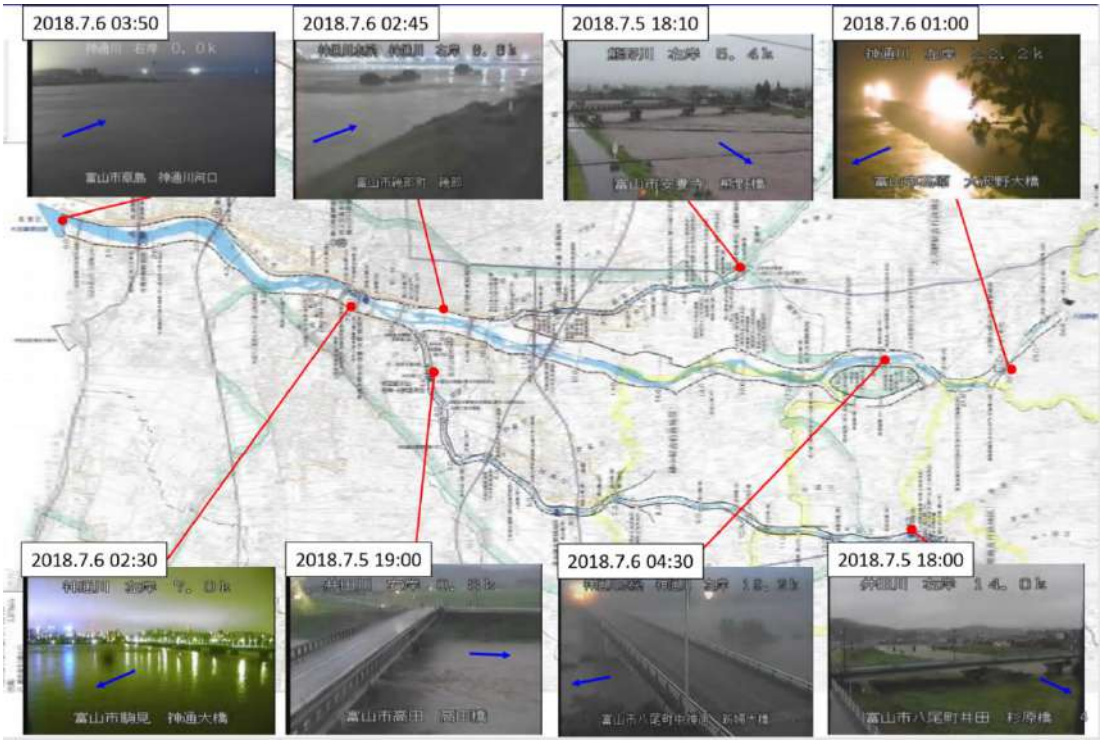

Figure 3: The state of the Jinzu River during heavy rain[3)]

The second problem is erosion of river side of Jinzu River by heavy rain. Jinzu River is one of the fastest rivers in Japan. Therefore, when a flood occurs, the river bank is eroded. In the flood in July 2018, there are places where river banks were largely eroded (Figure 4a). There was no damage on the riverbank which was previously eroded by the flood and already protected (Figure 4b).

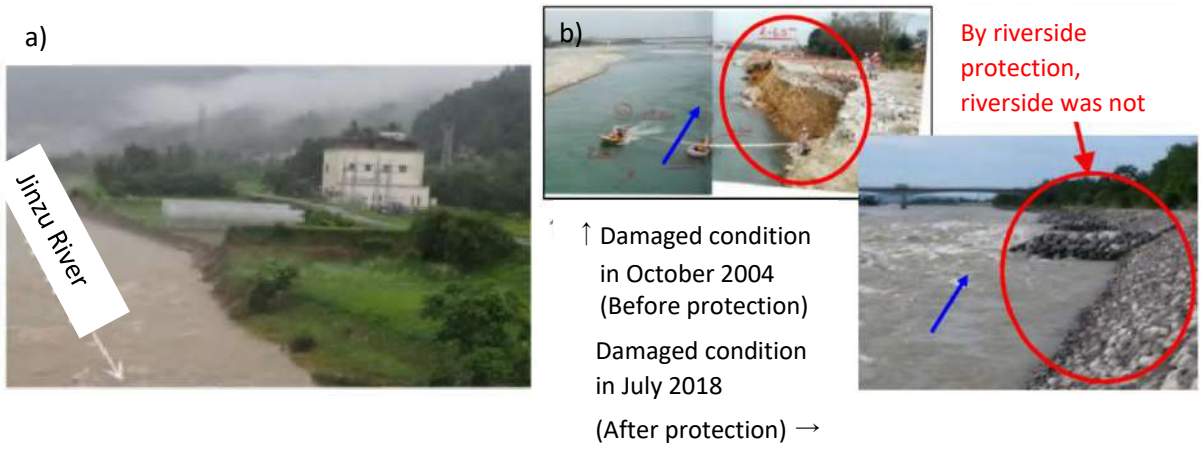

Figure 4: River bank erosion due to flooding and the effect of protection of river banks[3)]

3 Proposal for Sustainable River Management

3.1 Slogan and Targets

In order to fix current potential problems, our group figure out three targets which have to be met in 2030, which is:

-Best management	➔Aiming to improve renewable energy use from 23% to 30%.
-No flooding	➔Solve flood problems.
-Environmentally friendly	➔Improve the environment in Toyama Prefecture and promote tourism development.

Therefore, through these three targets, the research mainly focuses on management in human behaviors to Jinzu River. The slogan can be refined from the three targets, which is "river for generations". A better relationship between people as well as their generations and the environment are the hope to Jinzu River. The Chinese character "**間**" is also introduced to be as the logo corresponding to our slogan, which means space or relationship (Figure 5). In this Chinese character, we can see three English letters, which represent the three targets of our group. B means Best management, the first F means No Flooding, and the second F means Environmental Friendly.

Figure 5: The logo of our group meaning “between”

Figure 6: Three English letters “B, F, F”

3.2 Main part of the proposal

3.2.1 Road Map

Our goal is to: 1 increase the utilization rate of renewable energy (mainly hydropower) from 23% to 30%; 2 solve flood disasters; 3 Improve the environment in Toyama Prefecture and promote tourism development (Figure 7).

3.2.1.1 Best management

First, the hydropower generation facilities can be upgraded to improve the efficiency of hydropower generation. Secondly, the factory is encouraged to use electricity at night, staggering the peak of electricity consumption, and distributing electricity reasonably. Finally, a new hydroelectric power station was replaced instead of a hot spot power plant.

3.2.1.2 No Flooding

First of all, regarding solving the flood problem, we must first protect the river bank, protect the unprotected river bank, and periodically check and repair it. This work should be organized by the Japanese government because the Jingzu River is subject to Japan. Government-managed. In the second step, the dam in the Jinzu River is maintained to remove mud and sand from the bottom of the dam, which can be handled by Hokuriku Power Company. The third step is to improve the forecasting system and hope that it will be completed by the Japanese government in the last 10 years or so.

3.2.1.3 Environmental Friendly

In order to improve the river environment, the establishment of a wetland park is a good choice and can be jointly built by the Toyama County government and the company.

In addition, each household can increase rainwater buckets and increase the utilization of rainwater. Finally set up a river festival, with NGOs or local Culture committee.

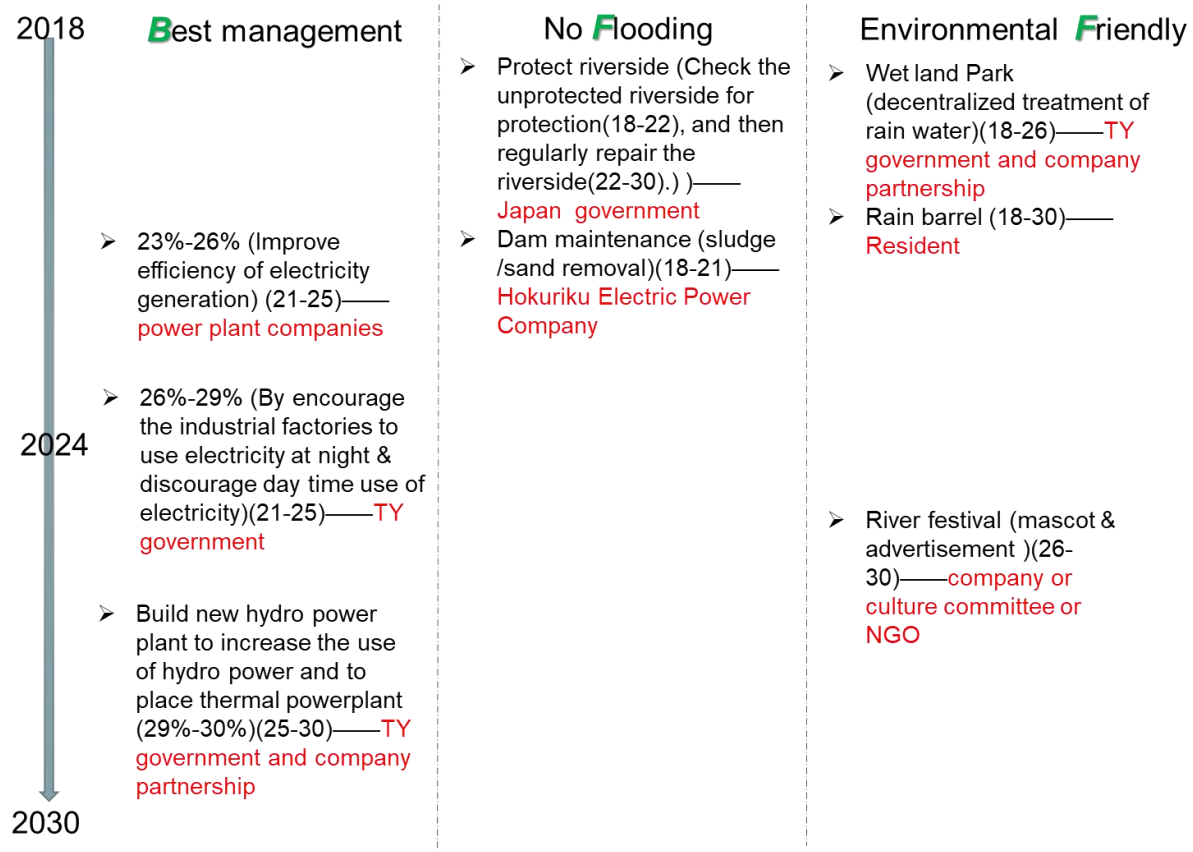

Figure 7: Road map to solve three targets

3.2.2 Solutions for Hydropower Use

Composition of electricity supply sources in Toyama Prefecture are 63% (Coal), 23% (Hydraulic power), 8% (Oil), 3% (Sun and Wind power), 1% (LNG) and 2% (Others) in 2016[4]. This means we are still 70% depending on unsustainable energy sources, so we decided to suggest some improvements especially increasing the use of hydropower because Toyama Prefecture has large potential about water supply for the aim of sustainable future.

3.2.2.1 Improve Electricity Generation Efficiency

We decided to suggest improvement of electricity generation efficiency by replacing turbines of a power station attached to the Jinzu River First Dam. Commonly efficiency of Kaplan turbine is better than Francis turbine, and the turbines of Jinzu River First Dam are still Francis. Additionally Kaplan turbine is suitable for dams with moderate altitude (10-70 m) [5)], so Jinzu River First Dam is the nice condition to install as its height is 62.5 m. We are expecting improvement in power generation efficiency to about 5% by installation of Kaplan turbine. There are some differences between Francis and Kaplan turbine. Kaplan turbine is more flexible to water flow, this is because they have better efficiency, and their size is smaller than Francis, so it is easy to install. Bad point is the only difficulty of maintenance because of its complicated mechanism[6)].

3.2.2.2 Encourage Reduction of Household electricity Consumption

Potential of improvement by introducing better turbines is limited, so it is also important to call for cooperation to citizen and companies. Every year, electric power usage in daytime is higher than night time, and it is more than 1.5 times higher in daytime at most[7)]. Basically electric supply from hydropower is constant, so when we need more power than it is necessary to provide supply from thermal power generations. This case is not ideal because thermal power uses a lot of non-renewable resources and they can cause environmental problem like global warming. There are two suggestions that could be realized. First is encouraging companies to operate plants in night time as best as they can. If they can delay operating time of plants systematically, we can cut electric consuming amount of the highest peak, thus we can average power usage. Second is discouraging electricity usage in each family. Household electricity consumption is 4,400 kwh/household year, and among these value standby power consumption account for 220 kwh (5%). It is easier to reduce standby power use, just by encouraging three ways. The first is frequently turning off main power. The second is unplugging the outlet. The third is using auto-off and display-off functions. We expect we can cut half of electricity usage (220 to 110 kwh/household) by these three approaches.

3.2.2.3 Build Small Hydropower Plants

By 3.2.2.1 and 3.2.2.2, we can improve some degree of unsustainable problem, but we still have some potential that could be reached. We can build more hydropower plants which are smaller than dam related ones, so we can construct them at waterways that are used for irrigation. In Japan rice cultivation is popular, and Toyama has many paddy fields (we can see

them from highways and trains). Toyama Prefecture already set its target number as more than 45 small hydropower stations by 2020, and the number was 26 in 2015[8]. Small power plants can generate less than 1,000 kw[9], so if we set each plant can generate 500 kw and also build 34 plants (Build 10 more plants in ten years) by 2030, electric generation capacity by renewable resources will become higher.

3.2.2.4 Total Calculation

It is important to calculate possible results using concrete data because it is easy to understand and it is also easy to persuade stakeholder. In this section we discuss about our achievements by improving hydropower generation, encouraging and discouraging people and companies, and installing small hydropower plants. Electric usage in Toyama is $13{,}000\times10^6$ kwh/year, and 3200×10^6 (23%) kwh/year is from hydropower[10]. We calculated our achievement at below Table 3. Still renewable resource ratio is not high, but we can improve gradually towards the future.

Table 3: Calculation of electric power and achievements

		Ratio of Sustainable Resources (%)		
Methods	Increase or Decrease Amount (kwh)	Start	Goal	Year
Improve Turbines	25×10^6 ↑	23	24	2021
Encourage Company Electric Night Time Use	$(50\uparrow+50\downarrow)\times10^6$	24	25	2025
Discourage Citizen Electric Daytime Use	100×10^6 ↓	25	26	2025
Build Small Hydropower plants	150×10^6 ↑	26	27	2030

3.2.3 Solutions for No Flooding

Jinzu River is one of the fastest rivers in Japan and Flooding often occur at heavy rain. On July in 2018, the second largest flood in observation history occurred in Jinzu River. We thought that measures to prevent the damage caused by the flood are necessary because it is predicted that the frequency of such heavy rain will increase in the future. In Japan there are dams for power generation and dams for flood control. The administrator of the dam for power generation is the company and the administrator of the flood control dam is the government of the prefecture. As a function of each dam, only the power generation is carried out at the power

generation dam, and flood control is not carried out, but at the flood control dam, both the power generation and the flood control are carried out. Nowadays, there are three dams for hydroelectric power generation such as Jinzu first dam, Jinzu second dam, Jinzu third dam on Jinzu River. And there are three dams for flood control such as Muromaki dam, Kumanogawa dam, Kubusugawa dam on Jinzu River drainage system (Figure 8).

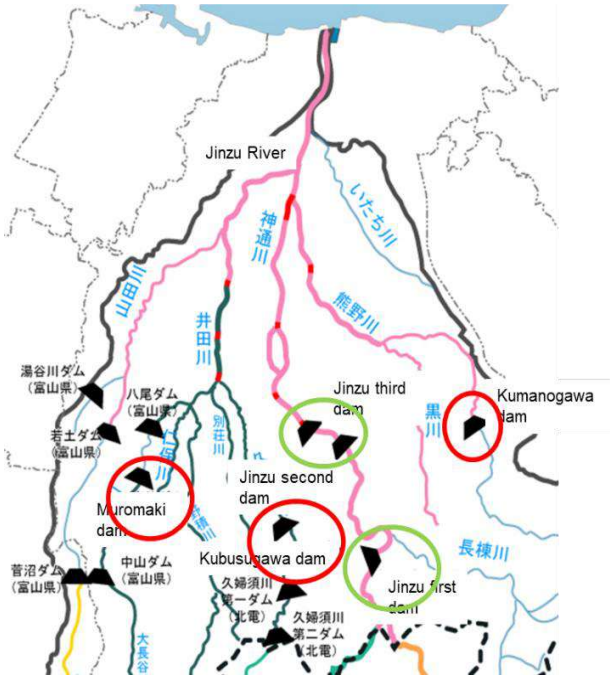

Figure 8: Jinzu River watershed and dams[2)]

As one solution to the flood, we propose flood control with power generation dam only during heavy rain. A plan for flood control with a power generation dam has been considered in recent years[11)]. However, the structural difference between the flood dam and the power generation dam makes new operation difficult. The power generation dam does not have the function of releasing water at a low water level like the flood control dam. For this reason, the power generation dams do not have facilities that greatly reduce the water level like the flood control dams, and flood response is done only with the flood discharge gate installed at the top (Figure 9). Amid such problems, some electric company have voluntarily secured capacity to reduce floods by establishing a guide water level lower than the preliminary discharge water level (Figure 10). We thought whether we could set voluntary flood control by setting a guide water level also in Jiuzu dam.

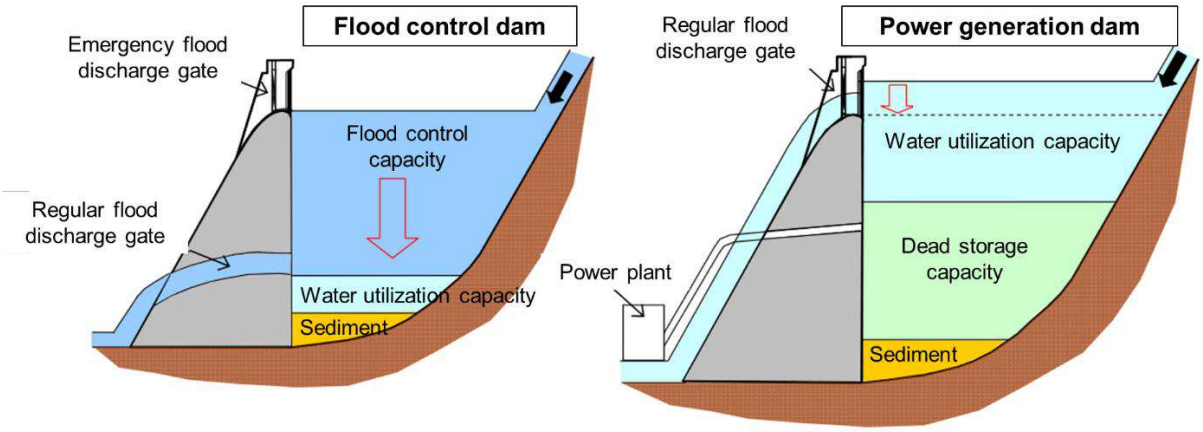

Figure 9: Structural difference between the flood dam and the power generation dam[11)]

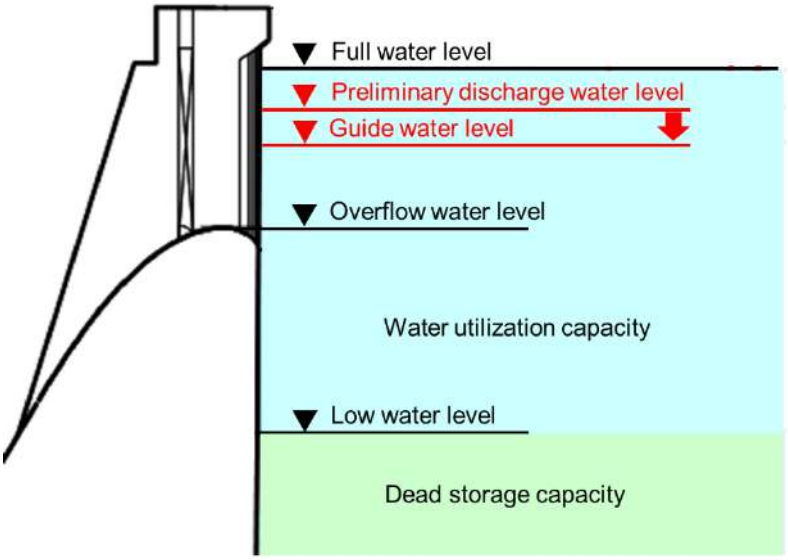

Figure 10: Preliminary discharge water level and Guide water level[11)]

However, there is a problem in carrying out this plan. In Jinzu first and second dam, power generation water is being withdrawn from surface water. So that, if we lower the water level too much, we can not generate electricity until the water level returns to its original level. By not being able to generate electricity, it affects residents and it will be necessary to compensate damages incurred by the company. In order not to lower the water level too much, it is necessary to cooperate with more accurate and prompt weather forecasting technology. We think it is possible to control the flood by power generation dam because there is a power generation dam which actually controls the flood.

As second solution to the flood, we should dredge the sediment from bottom of dams. The amount of the sediment on each dam is shown in Table 4. The sediment capacity of Japanese dam is designed to be able to use for 100 years, but in Jinzu first and second dam, the

sediment exceeds sediment capacity and it is necessary to dredge sediment. Even in Muromaki dam, it is necessary to dredge sediment because the sediment occupies most of the sediment capacity and the sediment directly affects flood control. If the amount of sediment is increase, the water utilization capacity will decrease (Figure 11a). And if the sediment is in the flood control capacity, it will affect to the function of flood control (Figure 11b). Therefore, we think it is necessary to remove the sediment. When installing the dredging ship of Figure 12, we estimated that how many years it will take to remove sediment. As the result, it takes 1.3 years to remove all the sediment (Formula 1). After dredging, the sand and sludge will be reused for protecting river side. Removal of sediments enables sustainable management of dam use and flood control.

Table 4: The amount of the sediment and sediment capacity on each dam[12)]

Dam	Jinzu first
Manager	Hokuriku Electric
Catchment area(km^2)	1960.0
Completion date(Year)	1954
Total water capacity ($x10^3 m^3$)	11,346
Sediment capacity ($x10^3 m^3$)	2,703
Sediment volume in 2015($x10^3 m^3$)	7,163

Dam	Jinzu second
Manager	Hokuriku Electric Power Company
Catchment area(km^2)	2060.0
Completion date(Year)	1954
Total water capacity ($x10^3 m^3$)	11,265
Sediment capacity ($x10^3 m^3$)	2,121
Sediment volume in 2015($x10^3 m^3$)	4,991

Dam	Jinzu third
Manager	Hokuriku Electric Power Company
Catchment area(km^2)	2063.0
Completion date(Year)	1955
Total water capacity ($x10^3 m^3$)	1,231
Sediment capacity ($x10^3 m^3$)	237
Sediment volume in 2015($x10^3 m^3$)	-194

Dam	Muromaki
Manager	Toyama Prefecture
Catchment area(km^2)	85.2
Completion date(Year)	1961
Total water capacity ($x10^3 m^3$)	17,000
Sediment capacity ($x10^3 m^3$)	3,500
Sediment volume in 2015($x10^3 m^3$)	2,829

Dam	Kumanogawa
Manager	Toyama Prefecture
Catchment area(km^2)	39.8
Completion date(Year)	1985
Total water capacity ($x10^3 m^3$)	9,100
Sediment capacity ($x10^3 m^3$)	2,500
Sediment volume in 2015($x10^3 m^3$)	599

Dam	Kubusugawa
Manager	Toyama Prefecture
Catchment area(km^2)	58.7
Completion date(Year)	2002
Total water capacity ($x10^3 m^3$)	10,000
Sediment capacity ($x10^3 m^3$)	3,100
Sediment volume in 2015($x10^3 m^3$)	673

a) Power generation dam

b) Flood control dam

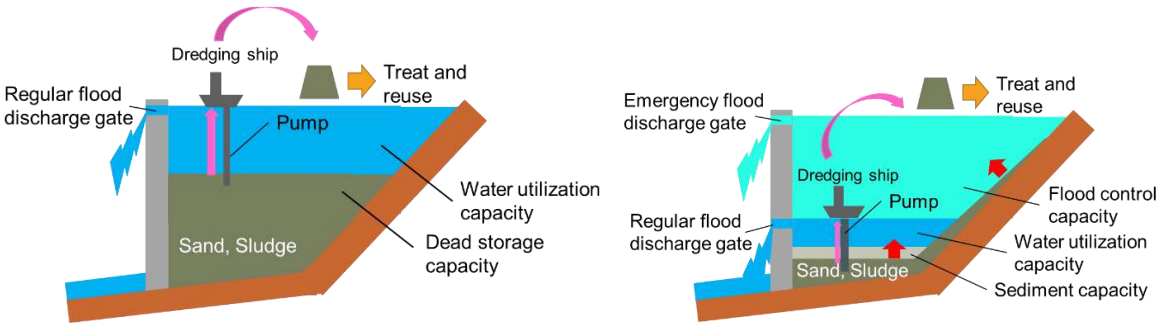

Figure 11: Dredging of sediment from power generation dam and flood control dam

Table 5: Dredging ability of the ship[13)]

Dredging ability (m^3/h)	1,500
Applicable depth (m)	5 - 30

$$1{,}500[m^3/\mathrm{h}] \times 6[\mathrm{h}] \times 245[\mathrm{day}] \times \mathrm{A}[\mathrm{year}] = 2{,}829{,}000[m^3]$$

$$\mathrm{A} \fallingdotseq 1.3$$

Figure 12: Dredging ship[13)]

We propose the protection of river side as one way of reducing flood damage. As the river bank erodes and the embankment is broken as shown in Figure 4, the damage caused by flooding becomes large. As shown in Figure 13, there are many undeveloped river banks in the Jinzu River. Therefore, we think that we should promote riverside protection. And after protecting, we should restore the vegetation of the protected river side (Figure 14). We aim to sustainable management by restoring the ecosystem.

Through these three methods, we aim to solve flood problems and to achieve sustainable management.

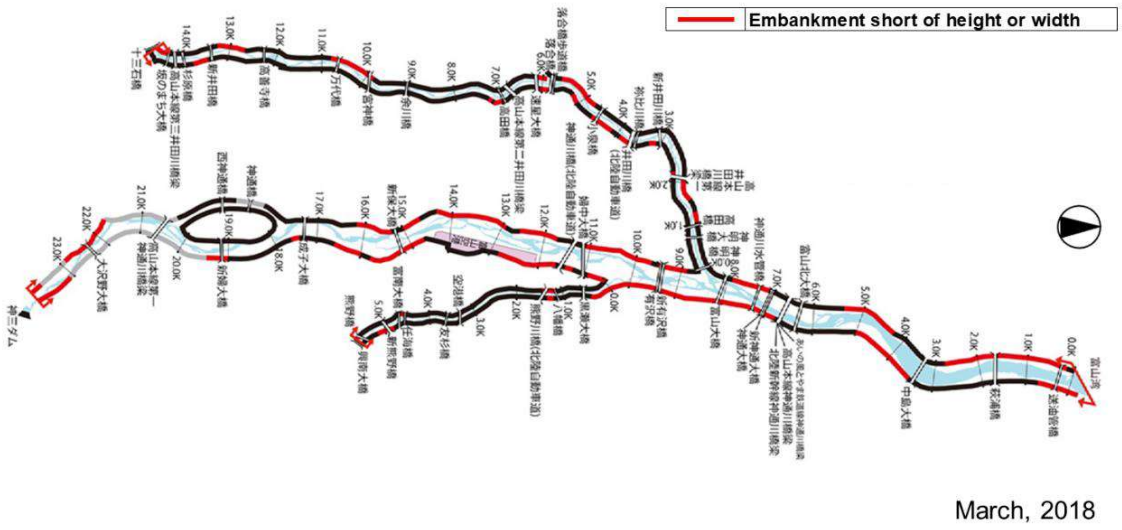

Figure 13: Status of embankment construction in the Jinzu River[14)]

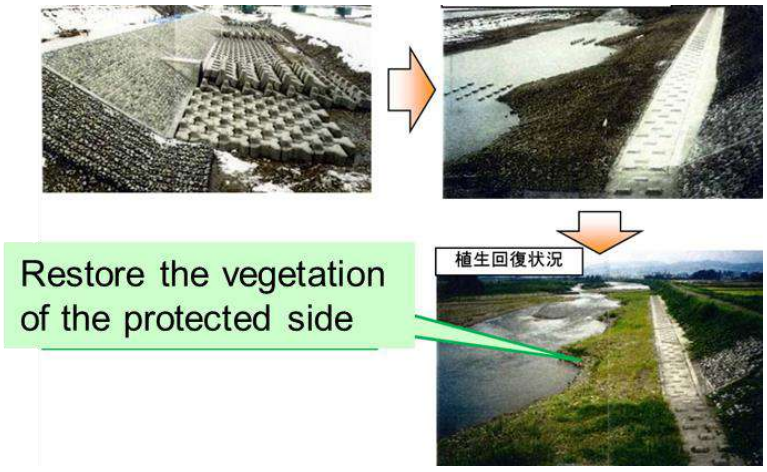

Figure 14 Restoration the vegetation of the protected river side[14)]

3.2.4 Eco-Friendly

3.2.4.1 Wetland park

There is a wetland park in Toyama Prefecture but it is far from Jinzu river. So our first engineering measure is that Toyama will have a wetland park near the river about 80 hectares by 2030 (Figure 15). The wetland park will reduce the rain volume flow into Jinzu river thus help avoid flood. Also, it plays an important role of saving the endangered fresh water species (Figure 16, 17).

Figure 15: Possible location of the wetland park

Figure 16: Water system in wetland park

Figure 17: Fresh water species

3.2.4.2 Efficient use and conservation of rainwater

To make efficient use and conservation of rainwater, decentralized ways of rain management are recommended as our second engineering measurement. According to calculation results, by building up bio-retention cell and rain barrel in the residential area of Jinzu river basin, 40,000m^3 rain water will be generated at most per rainfall (Figure 18).

Figure 18: Proper management of rain water

3.2.4.3 River festival/Carnival

Adopting a policy of holding river festival will definitely win Jinzu river good fame of sound water resource management as well as increasing tourism income for Toyama prefecture. Only renewable energy like hydraulic electricity will be used so that the festival celebrated in Jinzu river is certainly ecofriendly one (Figure 19).

Figure 19: The river festival

3.2.5 Schematic Integration

In order to manage the river for sustainable, our planning process are based on environmental sustainable development chart which contains the correlation targets of environmental responsibility, economic efficiency and social cohesion. The first operation is

in the correlation of environmental and social which is to solve and prepare for the flooding problem, so the local people and other living things nearby will not be the victim from the flood. The second operation is to focus on the increase of using renewable energy instead of non-renewable energy which is in the correlation of environmental and economic since not only reduce the use of non-renewable energy but also increase the international connection by selling the hydroelectricity. The final operation is the correlation of social and economic by establish the interested point to increase the tourism visiting the river which cause the better economy. The operation is run by the government, private companies, and people (Figure 20).

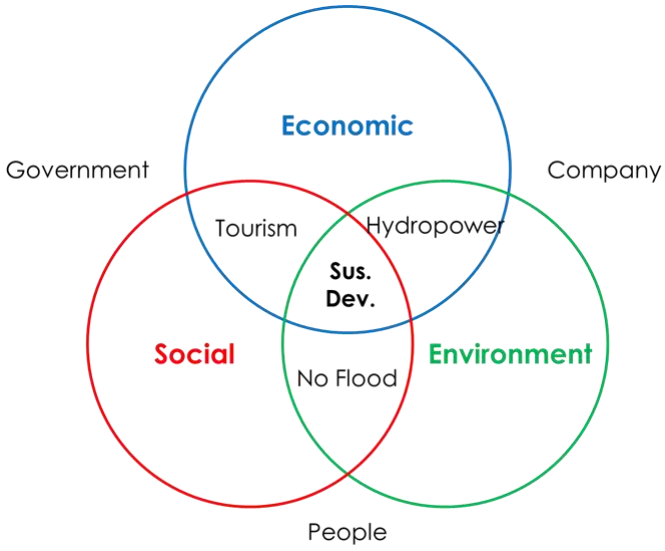

Figure 20: Schematic integration among actions and stakeholders

4 Conclusions

Jinsu River is a major source of water for over 300 000 people living in Toyama today and future. Sustainable water use in this river is very important. Three targets for the future of the river were established, including best management, environmental friendly and no flooding for 2030.

Best management aim to increase hydraulic energy use by improving the electrical generation efficiency, encouraging household to reducing the electricity consumption use in day time to use in night time, and building the small hydraulic power. We found that the efficiency will reach about 5% after replacing Kaplan turbine in first dam of Jinsu River, and

half of standby power consumption by household will cut off after encouraging the people to reduce the power will be processing.

No Flooding aim to solve the flood problem by three suggestion solution include flood control with power generation during heavy rain, dredge the sediment from bottom of dams to maintain the capacity of dams, and protection of river side. It need to involve by company and government together, company need to add more flood control system on their power generation dams and maintain the capacity of dams together, therefore, the dams will can be used in long term and prevent the flooding during the heavy rain. One more think, protection the river side also important of reducing flood damage and prevent flooding become large.

Ecofriendly aim to measure the policies to make the Jinsu River more ecofriendly by creating new wetland park near to the river to reduce rain volume flow into the river and prevent the flood, efficient use and conservation of rain water, and river carnival. As the calculation, we plan to build wetland about 80 hectares near the river by 2030, and 40 000m^3 rain water will be generated at most per rain fall. In addition, encourage the people to carefully the environmental of river by making the water festival also increasing the tourism income economic of the people in Toyama prefecture.

These three targets will achieved in 2030 in systematically as following the road map target if the government, company and people have to work together in result to solve and help each other as shown in schematic integration. Therefore, good socialites, environmental friendly, and economic development will establish to have the unlimited of water for the future. The actions not just fully completed for 2030 but forever and for the future of people living in Toyama prefecture.

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Group D

Group Name: Chorei, Target River Name: Jinzu River

The Final Report for the TONAMI Camp

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1 Description of the Jinzu River

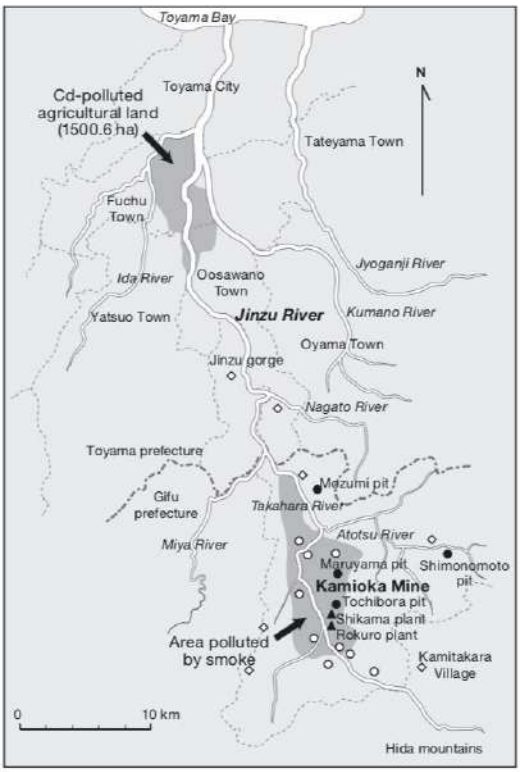

Fig. 1 Location of the Jinzu River

Fig. 2 The Jinzu River Basin and the location of the Kamioka mine (Masanori 2012)

The Jinzu River flows from the Kaore Mountain, Gifu Prefecture, into the Toyama Bay, Toyama Prefecture, Japan (Figure 1). The size of a catchment area, quantity of flow and length are 2720 km^2, 163.6 m^3/s and 120 km respectively. The midstream and upstream are steep, so it was known as a river likely to flood and it is one of the 7 biggest rivers in Toyama.

The river is quite famous in Japan because the cadmium poisoning happened only in the Jinzu river. The contamination mechanism was concluded that the Jintsu River basin was contaminated with cadmium due to refining and mining activities for zinc and lead at the Kamioka mine located at an upstream in the river, and the water was used for cultivation of rice and staple food. Therefore, many residents around the river were exposed to high intakes of cadmium. The pollution brought especially elder women severe chronic cadmium poisoning called Itai-Itai disease because women generally have less body weight and bone density, and their physiology specifically enhances the uptake of cadmium and therefore its damage (Matsunami 2010, p. 451−461). The disease name resulted from the fact that a patient who got the disease said ‘Itai’ many times (‘Itai’ means painful

Table 1 Detail description of Fig. 3

Purpose	Amount of use (m^3/s)	Number of uses
Agriculture	103	777
Power generation	1441	58
Drinking water	1.85	4
Industrial water	13.9	21
Others	2.30	8
Sum	1562	868

in English). The distinctive feature of Itai-Itai disease is damage of kidney and bone, namely osteomalacia with osteoporosis and atrophy and degeneration of kidney. Then, families

of victims and casualties filed a lawsuit against the company, Mitsui Mining & Smelting Co., that caused the damage, and eventually, the victims won. The lawsuit exerted big effects on results of other lawsuits for pollution in Japan.

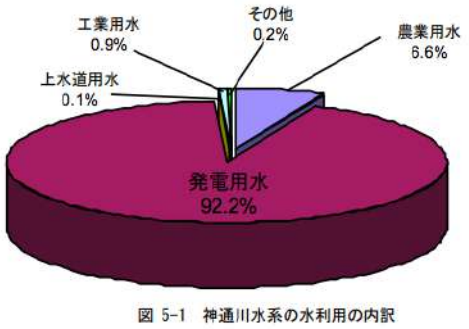

Fig. 3 Usage of the water

The usage of the water in the Jinzu river, namely key functions, is shown in Figure 3 (Toyama Office of River and National Highway, 2012) and detail descriptions are shown in Table 1. As we mentioned, the river is very steep, so it is mainly being used for hydro power generation, 92.2%. Toyama prefecture has more electricity generated by hydro generation compared to other prefectures. The second largest purpose is agriculture-6.6% being used for staple food in Toyama, such as rice. The water is provided to Toyama City, Takayama City, etc., and it is used as industrial water, thermal power plant, chemical plant and so on (0.9%). The rest of usage is for drinking (0.1%) and other purposes (0.2%). In our research, the 0.2% include water for melting snow, meaning that when cities have much amount of snow, the water is used for melting the snow on roads.

2 Current and possible problems on the Jinzu River management

All problems that can be considered now and in future are shown as follows.

1. There are some insecure parts of the embankments along the river.

The embankments have been constructed based on experiences, such as disasters that have occurred. However, it was not designed by analytical scrutiny concerning the destruction process of the embankment.

2. Some invasive species have been observed already.

There are two types of non-native species. One is called invasive ones that may lead to extinction of native ones, and another one is called alien species that can adjust to the cultures. The invasive species include not only animals but also plants. The number of invasive species is getting larger currently, so they may have bad effects on native species in future.

3. Garbage problems

The number of illegally dumped garbage is getting smaller, but still now, it has been observed along the river. Around 160 m^3 of garbage, such as refrigerators, TV, air conditioners and so on (Toyama Office of River and National Highway, 2012), is dumped annually.

4. Management of river facilities

About 30 years have passed since 40% of facilities were installed (Toyama Office of River and National Highway, 2012), so such aging equipment may decrease the water quality of the river because they contain heavy metals, iron, copper and zinc.

3 Proposal for Sustainable River Management

3.1 Slogan and Targets

Our slogan is "No Jinzu (陣痛) for the Jinzu River", which means that keep the clean Jinzu River for next generations. The reason why the slogan means clean river for next generations is that in Japanese, 陣痛 represents pain when mothers give birth, namely next generations, so "No Jinzu (陣痛)" denotes that we should keep the good quality of the Jinzu River so as not for next generations to suffer from polluted water.

There are some insecure parts of the embankments along the river. Some are beyond standards for the safety, and others are below the standard, which means flood might happen due to heavy rain. To prevent flood along the river, the first target is to make the embankments along the river secure and improve water capacity for flood.

Along the Jinzu river, illegally dumped garbage is still observed though it is on the downward trend. The amount of garbage is about 100 – 160 m^3 annually. Therefore, the garbage may lead to bad water quality. Currently, the water quality is A type which means good quality, so the second target is to keep water quality.

Invasive species might cause damaging effect on the ecosystem, such as excluding local species and leading to water quality deterioration, which shows the close relationship between the second target and the third target. To prevent loss of biodiversity and protect the aquatic ecosystem, the third target for sustainable river management is to keep invasive species out of the Jinzu River.

3.2 Proposal for Sustainable River Management

3.2.1 Target 1 - Protect City from Floods

3.2.1.1 Biopore

Biopore is expected to suppress the environmental impacts during dry season and rainy season, in addition it can serve as water container. In detail, the biopore is able to absorb rain water with high intensity, thus suppressing the occurrence of puddles and even floods. In the dry season, biopore can be used to overcome drought because it is able to maintain the availability of ground water. Biopore is an appropriate technology and environmentally friendly to cope with the flood by increasing absorption of water, transforming organic waste to fertilizer and reducing emission of GHGs (CO_2 and CH_4), and utilizing activity of soil organisms and plants root. For soil health, biopore can also increase the activity of organisms and soil microorganisms so that it improves soil health and roots of surrounding plants. Organisms and soil microorganisms play an important role in ecology such as Detrivora and nitrogen catching from the atmosphere. Nitrogen catching can increase nitrogen levels in soil so that the use of inorganic fertilizers will decrease (DPLH Sulawesi Selatan, 2016).

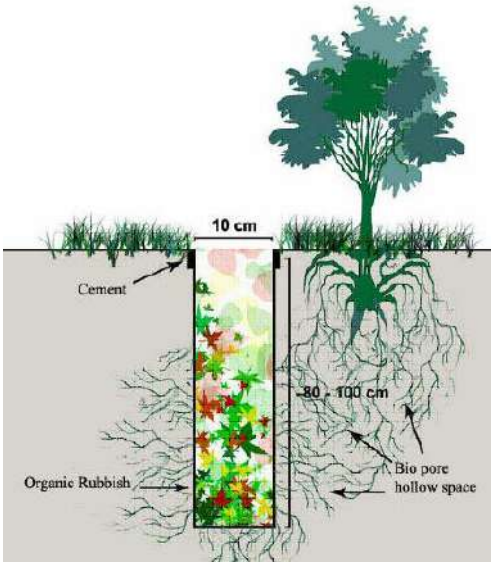

Fig. 4. Biopore

The biopore absorption hole is a cylindrical opening made vertically into the ground as a water catchment method intended to overcome waterlogging by increasing the water absorption capacity of the soil. Increasing of water absorbency in the soil is done by drilling a hole in the soil and piling it with organic wastes to produce compost. The organic wastes dumped in this hole are able to support the soil faunas such as worms which in turn create pores in the soil as shown in Figure 4 (Wikipedia, 2016).

Biopore is made vertically into the ground with 10 cm in diameter and 80-100 cm deep, or does not exceed the ground water level. The hole is filled with organic garbage to help the formation of biopores. Biopores are small pores resulted from living organisms activity below the ground which consume the organic garbage in the hole.

Installation of biopore in certain area follows the following formula to maximize the absorption of the water into the ground (Permatasari, 2015).

$n = I \times L / V$

Remarks:

n = number of Biopore

I = Rainfall intensity (mm/h)

L = Area of impervious land (m^2)

V = Rate of water infiltration per hole (L/h)

Target areas for installation of biopores are adjusted based on the landscape. Acting as water absorber, biopores are installed on area where the water tends to accumulate. Moreover they can be installed on ditch or around the trees. In this case biopores will be installed around the Toyama City especially on the low absorption area (downtown) to help increase the land absorption ability of water and reduce the amount of water runoff directly to the river, low lying area, and

Fig. 5. Target Area of Biopores (A) Low-lying Area (B) Upstream (C) Low Absorption Area

upstream area of the river. In the upstream area which is forest area, the presence of biopores will create good distribution of nutrients. Illustration of target area is shown in Figure 5.

3.2.1.2 Embankment

Embankment, dike, or levee is a structure built parallel along the river channel to prevent flooding into undesired areas such as city. The structure of embankment is wider at the base and narrower at the top and built from less permeable soil like clay (Brain and Lamb, 2018). The components of embankment are shown in Figure 6.

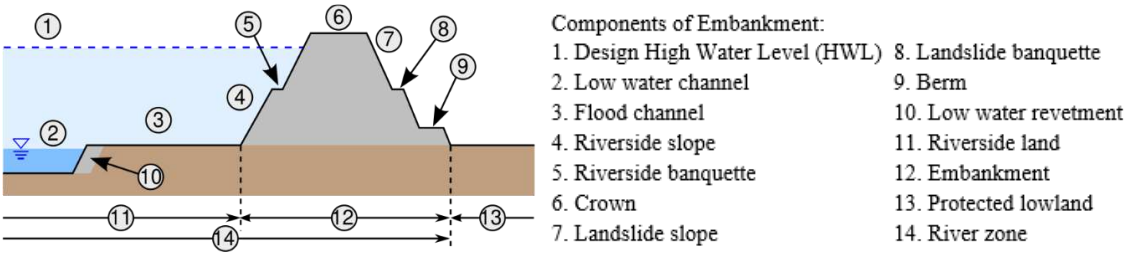

Fig. 6. Components of embankment

Toyama city is located on the alluvium fan, which was resulted from sediment run-off from the upstream of the rivers (Northern Alps). Alluvial fans are subject to flooding because of the geographical morphology, flat low-lying plains. Embankments have been built along the Jinzu

River, however some of the area are prone to the flooding because they are still below the safety standards. The previous section has proposed an engineering method to prevent flooding in the future by installing biopores, however the risk of the flood must be taken into consideration. Therefore, the second measure to protect the city from floods is to build embankments along the river which are below the safety standards. Those areas are shown in Figure 7.

Fig. 7. Installed Embankments along the Jinzu River

3.2.1.3 Roadmap

In order to protect Toyama City from floods by 2030 by the above engineering methods, it needs cooperation from various stakeholders and users. The brief plan/roadmap to achieve the goal is shown in Figure 8.

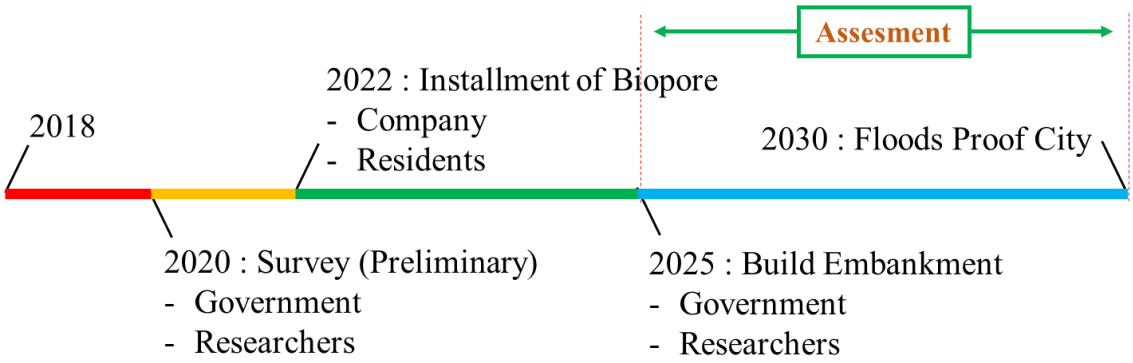

Fig. 8. Roadmap to Achieve Flood Proof City

To determine the best approach, methods, and location for embankment and biopores, preliminary survey for location of installment of biopores and embankments to be built will be conducted in the prospective area, where local government cooperates with researchers to determine the best engineering plan. It is expected that the preliminary survey finish by 2020 and following by that installment of biopores will start. Chosen company will install the biopores in the designated area determined from the previous survey followed by cooperation from local residents to help maintain the biopores. The installment of biopores in the designated areas are expected to finish by 2025 and at the same year building of embankments will start. In this work, researchers and engineers take part in the designing and building of embankments while government provides the necessary budget, hiring construction company and promoting about the ongoing projects. Finally, by 2030 all the goal, bipores and embankments, are finished and during 5 years between 2025 and 2030 there will be assessment of the projects to assess the effectiveness of those method to prevent flood, especially the biopores and the progress of the ongoing project.

3.2.2 Target 2 – Keep Water Quality

3.2.2.1 Current water quality and possible problems of the Jinzu River

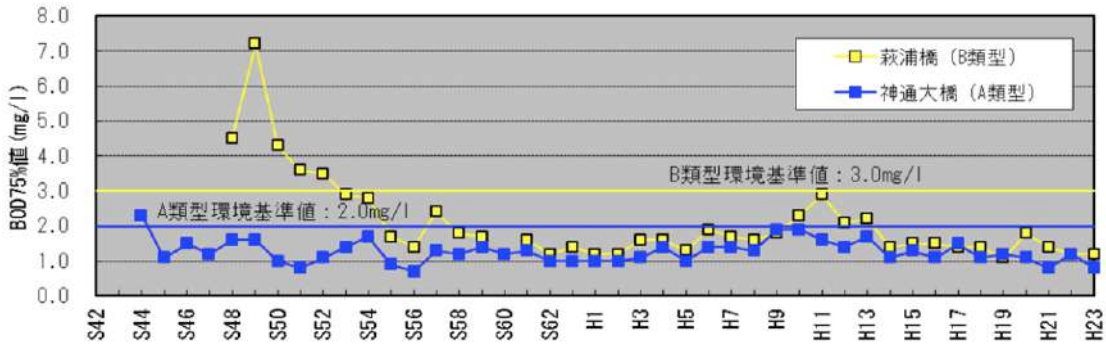

Fig. 9. BOD abundance in Jinzu bridge and Oginoura bridge

In Japan the Jinzu River basin was notorious for that it's used to be the most heavily cadmium (Cd)-polluted region, which bred serious endemic Itai-itai disease. Kamioka Mine, one of the largest Zn-Pb mine in Gifu prefecture in Japan, has been the source of heavy metal pollution in the Jinzu River. Contamination of water and soils is one of grave problems at mining area. Toxic heavy metals released from an abandoned dump into the Jinzu River can cause serious health problem in the downstream areas.

In fact, current water quality of the Jinzu River is almost excellent. Learning the lessons from Itai-itai disease, the local government take drastic steps to limit mining activities and power generation plants and spend so much effort to rebuild ecosystem. According to the data from Toyama Office of River and National Highwayin the year of 2012, taking BOD for example, the abundance of BOD in the Jinzu River is lower than the blue line in most monitoring points in Figure 9, which means water quality of the river is better than type-A quality in Japan water quality standards. Nowadays, the Jinzu River is one of the most beautiful landscapes in Toyama and attracts tourists around the world.

However, there is some people dumping household waste to the river because they don't want to pay money for domestic rubbish disposal. E-waste, particularly, takes a considerable part of the rubbish in river which should be treated seriously. Also, water gate should be considered.

3.2.2.2 Develop new environmental-friendly material for water facility

Since aging water facility might be one of the main threats to future water quality, better management on them is required. On the one hand, detailed maintenance plan should be carried out to check and renew the current water facility regularly. On the other hand, new environmental-friendly materials will be developed to replace the old iron water facility which might easily rust and pollute the water. Kevlar is one of the examples. Kevlar is a heat-resistant and strong synthetic fiber, related to other aramids such as Nomex and Technora. Kevlar's structure consists of relatively rigid molecules which tend to form mostly planar sheet-like structures. The structure of Kevlar is shown in Figure 10. It has high tensile strength-to-weight ratio which is 5 times stronger than steel. When used as a woven material, for that it can withstand high impact, it is suitable for mooring lines and other underwater applications. (Stephanie Kwolek 2012). In addition, Kevlar fibers can reinforce flexible pipe bend. The flexible pipe bend can not only reduce the structural vibration and fluid noise in pipeline, but also realize the flexible connection of a horizontal line and a vertical line and compensate the displacement of three dimensions produced by the shock or vibration of pipeline in the special situations.(Shuai et al 2003) Using Kevlar coating pipes to replace the old pipes can definitely ensure the safety of water transport system and reduce the risk of old aging pipes.

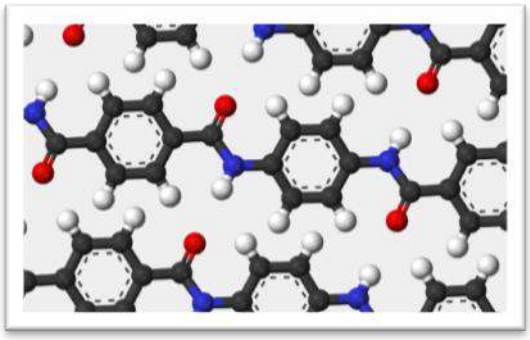

Fig. 10. The structure of Kevlar

3.2.2.3 Road map

To keep the water quality of the Jinzu River by 2030, it needs feasible and proper measures step by step. The roadmap to achieve the second target by various stakeholders and users is shown as follows.

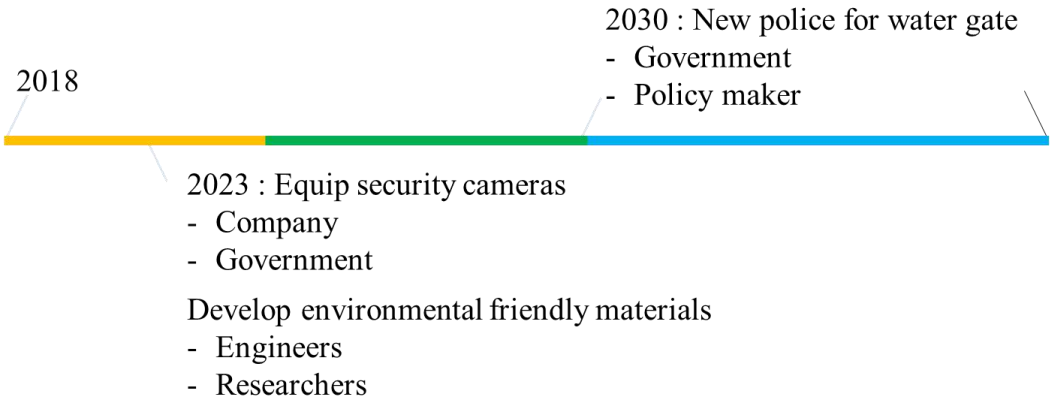

Fig. 11. Roadmap to Keep Water Quality

By 2023, after investigations and site testing, the government should corporate with professional companies to equip security cameras to prevent dumping waste to river combined with heavy punishment. In addition, it is expected that engineers and researchers figure out how to use environmentally friendly materials to replace old aging equipment. And then, policy maker and government have 7 years (till 2030) to publish proper policy for regular maintenance

and renewal of water gates. Through these measures and policy, it is believed that the water quality of the Jinzu River would remain excellent.

3.2.3 Proposal for Target 3

3.2.3.1 Invasive Species Campaign

The alien species might come from intentional or accidental release by people. Though Ministry of the Environment issued the law *Invasive Alien Species Act* in 2004, which restricted the raising, import, transfer, and releasing invasive species, the public awareness about invasive species impact is still under expectation. Therefore, the key point of this target is to raise public awareness and get different stakeholders involved in keeping out invasive species.

An invasive species campaign will help raising public awareness and promote the biodiversity conservation in two ways: new invasive species prevention and existed invasive species treatment. The former goal could be achieved by residents, and the latter one requires technical support from researchers and well-educated residents. The more people participate, the easier it is to achieve the goal. Possible measures for the awareness campaign are shown as follow:

Launch a website to address the invasive species impact throughout the public and promote biodiversity conservation policy. For example, the website of Toyama prefecture (Nature Conservation Division of Toyama Prefecture, 2018) is now lack of adequate information about invasive species and requires improvement. Based on the information gained from biodiversity investigation, the improved website could be organized in "what-why-how" order, introducing the current situation of invasive species, the reason for the problems, and simple but effective steps for prevention. For example, introduce "Clean, Drain, Dry" principle to every boater and the prohibition against releasing pets into the Jinzu River to every resident (Japanese Ministry of the Environment, 2004). Both local residents and tourists from home and abroad are encouraged to learn about the seriousness of the problems and take part in later action against invasive species. Other effective educational approach such as newspaper, television, radio and brochure will of great benefit for building public awareness.

Develop national-level database and update it regularly to provide up-to-date information and characteristics of invasive species. Both researchers and residents have access to the database. For researchers working on biodiversity conservation, the shared database offers

basic evidence for developing site-specific management strategies. Moreover, the database is an effective approach to help the residents who are concerned about the problems to learn how to identify invasive species. With the basic knowledge of common invasive species, the residents are able to report the observation of them to the local government and ask for further treatment.

3.2.3.2 Invasive Species Management Plan

Invasive species management plan has been published by many other areas and proved to be necessary (Environmental Audit Committee, 2014, National Invasive Species Council, 2016). The government should establish and implement a river-level or state-level management plan consisting of detection, rapid response, and control action.

The responsible department of each action should be well defined in the plan. Customs and departments of inspection and quarantine play the most important role in early detection. However, invasive species come from not only foreign countries, but other prefectures in Japan as well. As a complement, the residents are encouraged to report the sighting of invasive species. Additionally, the cameras set along the river for water quality preservation could also work as useful tools for early detection and monitoring. While receiving the report, the government should conduct invasive species treatment or removal operation to prevent the spread of the invasive species. In order to measure the target achievement, regular survey should be carried out so the researchers are able to compare the biodiversity situation with the baseline situation, update the online database and provide suggestion on renewing the management plan.

3.2.3.3 Roadmap

In order to keep the invasive species out of the Jinzu River by 2030, a three-step roadmap is designed to integrate the measures mentioned above and guide the stakeholders (shown in Figure 12).

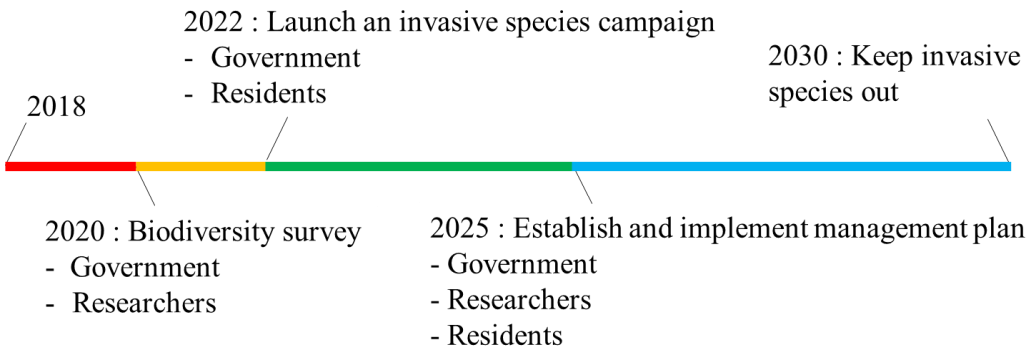

Fig. 42. Roadmap to achieve target 3

First of all, detail and reliable information of biodiversity in the Jinzu River is the basis for further campaign and action, thus biodiversity survey should be conducted in the recent two years. During the survey, the researchers are supposed to identify the key invasive species, assess their current situation and adverse effects. The data and information of species in both the aquatic and terrestrial environments should be well documented. These results will serve as baseline criteria and important evidence for policy and engineering measures. After the survey, the government and NGO should work together and lead an invasive species campaign to raise public awareness. By 2022, the campaign are expected to reach more than 90% of people living around the Jinzu River. The third step of the roadmap, from 2023 to 2025, is to establish a periodic management plan. From 2025, the management plans are going to be implemented.

4 Conclusion

According to the investigation of the current situation of the Jinzu River, three achievable and measurable targets -protect city from floods, keep water quality and keep invasive species out - have been set for sustainable river management. For each target, we considered the solutions and constructed a roadmap, which are concluded as below.

Target 1 – Protect City from Floods

Protect city from floods by installing bio-pore and constructing embankments. Biopore is expected to reduce the storm runoff by absorbing and maintaining the water during dry season and rainy season. The second solution is to improve embankments which currently do not meet the safety standard in many places. In order to help companies and residents with the

installation of biopores until 2022, the government and researchers will finish investigating suitable methods and installation location by 2020. After that, government and researchers are expected to improve embankments by 2025. In this way, we protect city from floods by increasing water capacity and meeting safety standard.

Target 2 – Keep Water Quality

Keep water quality by equipping security camera and developing environmentally friendly materials such as Kevlar. Security cameras are used to prevent illegal dumping of garbage. Environmentally friendly material is developed to replace the aging water facility such as water gate. Until 2023, companies and government equip security camera, while engineers and researchers develop environmentally friendly materials. And then, policy makers and government are expected to establish proper policy for regular maintenance and renewal of water gates. In this way we will keep water quality until 2030.

Target 3 – Keep invasive species out

Keep biodiversity by holding invasive species campaign and planning invasive species management. Invasive species campaign is held for preventing new invasive species and existing invasive species treatment, which are achieved by the cooperation of government and residents. The species management plan consists of early detection, rapid response, and control action for invasive species. Until 2020, government undertake biodiversity survey. This survey become basis of campaign and action. During the survey, the researchers are supposed to identify the key invasive species, assess their current situation and adverse effects. From 2023 to 2025, researchers and residents establish a periodic management plan. And then, this management plan is going to be implemented.

Figure13 shows the relationship of these targets and their stakeholders. As is mentioned before, the second and third target are closely related because rich biodiversity relies on good water quality and invasive species might lead to water quality deterioration. Different stakeholders are jointly responsible for this roadmap. Local government plays a significant role leading the way in organizing all the stakeholders, carrying out policy and increasing the public awareness of invasive species issues. The researchers provide technical assistance including cost-effective engineering strategies and policy suggestion for all steps in the roadmap. The related companies and residents are supposed to take an active part in measure implementation.

Only when all the stakeholders work together can we keep the safe and clean Jinzu River for next generation.

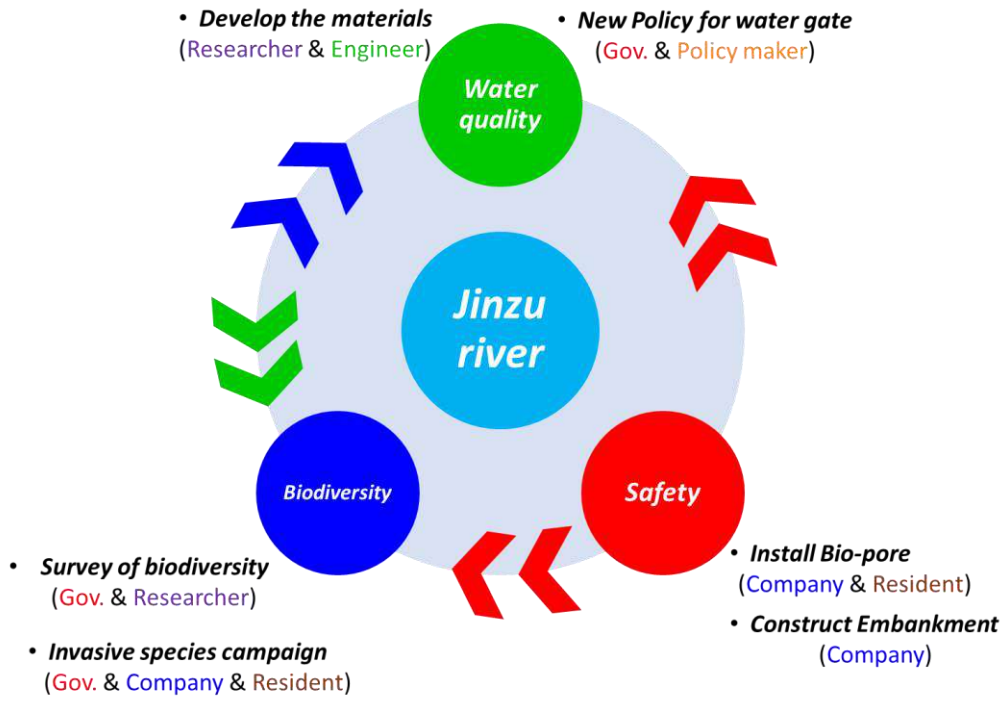

Fig.13 Relationship of the targets

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Group E

Group Name: Siri, Target River Name: Kelani River

The Final Report for The TONAMI Camp

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1 Description of Kelani River

The Kelani river is the fourth longest and the second largest watershed in Sri Lanka, which is 145 km in length and drains approximately 2,292 square kilometers of land area. It is located in between northern latitudes of 6o47' to 7o05' and eastern longitudes of 79o52' to 80o13' (Kottagoda and Abeysingha, 2017), which is catchment within three provinces in the country such as Western Province about 34% (800sq. km); Central Province about 47% (1,100 sq. km.) and Sabaragamuwa Province about 19% (430 sq. km) (Goonatilake. et al, 2016). Kelani river starts from the Sri Pada mountain range and drain through Kithulgala, Awissawella, Hanwella, Ambathale, Kaduwela and ending with the Colombo outfall into the Indian Ocean. Kelani river basin divided into three parts: the upper basin is mountainous and the lower basin, which is below Hanwella, has plain features (Kottagoda and Abeysingha, 2017).

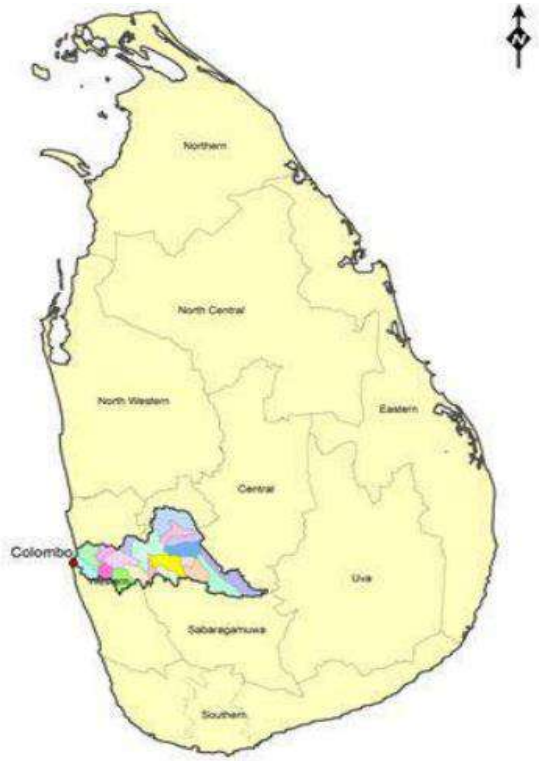

Fig. 1 Kelani river basin

Kelani river basin support water to more than 25% of the Sri Lanka population covering 7 districts. It satifies about 80% of the drinking water requirement of Colombo area (IUCN, 2018) where is the highest population density and the highest density of industries in Sri Lanka. The water intake is located at Ambatale.

Besides being water resource as drinking and daily use, this basin supports socioeconomic activities such as agriculture, mining, industrial development, and power generation by hydroelectricity. It also contains some of the most picturesque landscapes in Sri Lanka, which is offer the tourist destinations.

Over 10,000 industries and businesses mainly located in the lower Kelani river catchment , which depend on the natural resources and services provided by this river including two large industrial zones with central waste treatment facilities that are located at Seethawaka and Biyagama, and many industries and businesses are located outside the industrial zones along the river (IUCN, 2018). Ceylon Cold Stores PLC, Coca Cola beverages, Pepsi and American waters are the large-scale water dependent manufacturing companies also rely on the Kelani river water (Ananda, 2016).

2 Current problem

The Kelani River is known as the most polluted river in Sir Lanka because of its increasing of pollution, which is caused by industrial discharges, poor local authority service delivery, weak environment management and governance. As a result, poor condition of water quality occur mostly in the middle and lower catchment area, which consist of flatbed areas, are highly urbanized such as industrialization and urbanization, which the upper catchment of Kelani river basin is mainly agricultural land use and forest (Kottagoda and Abeysingha, 2017; Liyanage and Yamada, 2017). Therefore, this river is polluted due to both industrial and waste discharge and diffusion waste form domestic. At the same time, disaster such flooding and saline are also the problem that threaten to human being as well as biodiversity in the river.

2.1 Point pollution source

Kelani river is the main water resource for many industries and business, meanwhile with many industries and high population centers mainly located within the lower catchment area of Kelani River Basin as seen in **Fig.2**, any chemical accident can be disastrous not only to the humans but also to the natural environment. Some accidents can be instant accidents or others may be slow such as leaking petrol station storage or storage of agro-chemicals or radio-active material.

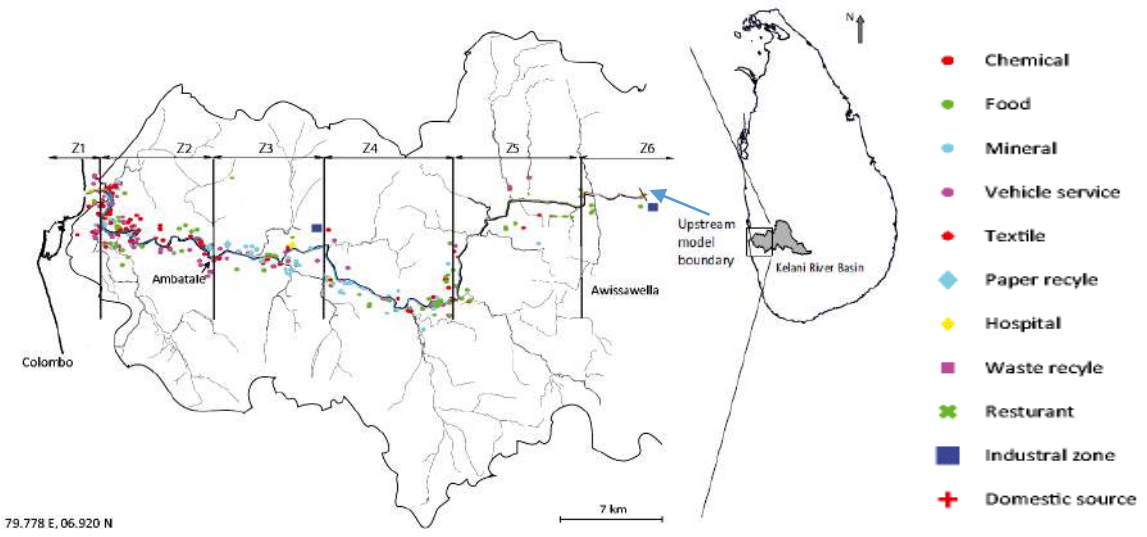

Fig. 2. Spatial distribution of point sources.

There are two large industrial zones along this river. Zone I is in Seethawaka where composed of 30 companies and is located in upstream Asissawella aabout 55 km from the

ocean point in Colombo and zone II is located in Biyagama where composed of 65 companies where its wastewater generated is discharged into Rakgahawatte canal that about 3 km upstream from the Ambatale water intake. Even though, these industrial zones consist of central waste treatment facilities that are managed by the Board of Investment (BOI) in cooperation with the Central Environmental Authority (CEA) (Gunawardena *et al.*, 2017), polluted is still detected. The polluted from zone I is mainly heavy metal, while chemical waste is found in the river around zone II. Beside pollutant from these two main industrial parks, other industrial outside this parks also influence to water quality as well. For example, diesel unintentionally leaked from Coca Cola factory into the Kelani river in 2015 (Groundviews, 2015). In fact, the water quality near industrial locations, base on safe water quality limits are constantly exceeded, including chemical oxygen demand (36-37% over acceptable standards), dissolved oxygen (27-43% over acceptable standards), biological oxygen demand (7-13% over), and heavy metals (7% over) (Sathananthan and Johann, 2017).

2.2 Diffused pollution source

Apart from the industries, Kelani River downstream has become a habitable area for large number of households as well. Population and housing density increase towards downstream direction as indicated in Fig 3, which has influenced the provision of services, development of the infrastructure facilities etc. (NRMMU, 2016). According to Liyanage, C. P. and Yamada, K. (2017) that studied about the related between population density and water quality of Kelani river concluded that a watershed with a population density of less than 2375 is safe for drinking and bathing purposes, whereas a watershed with a population density between 2375 and 2672 is acceptable for fish and aquatic life. Over than these, the water quality become worse and worse.

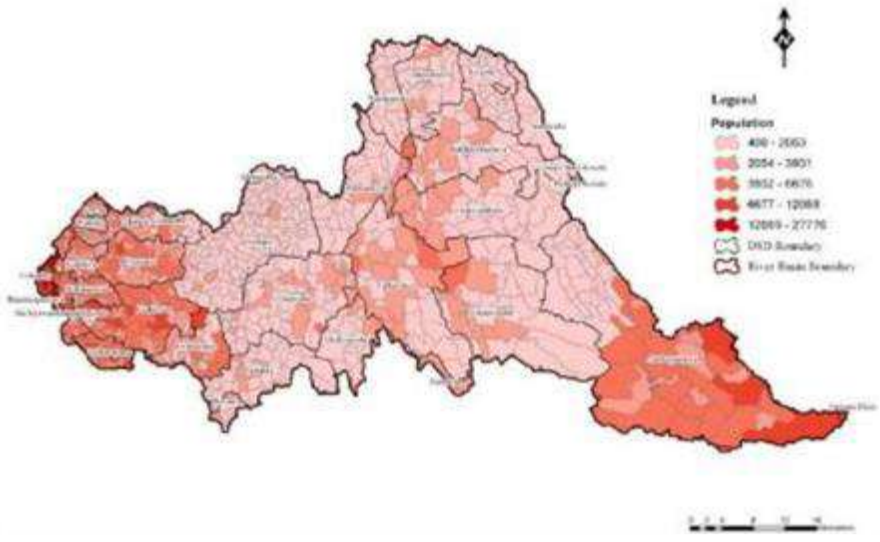

Fig. 3. Population and housing density in Kelani river basin.

However, along with the excessive population increase, provision of services such as waste and sewerage management has become very complicated, resulting in a significant increase in illegal disposal of solid waste as well as sewerage into Kelani River which could be identified as a diffused source pollution. About a quarter of people live in the river basin and the river is not in a healthy situation (Economy next, 2016), which is the main reason behind the improper disposal methods.

The pollution is observable in the downstream starting from Hanwella, of which the community responsible for the pollution can be grouped into several categories as follows;

Type 1: People without neither a proper house nor a proper sanitary facility

Type 2: People with a proper house but not a proper sanitary disposal method

Type 3: People having operating problems with their sanitary disposal method

2.3 Flooding and saline

The water flow varies between 800-1500m3/s during the monsoon and about 20-25 in dry season. The annual rainfall distribution in the basin varies from 500 mm to 5,000 mm with an average mean annual rainfall about 3,450 millimeters. As a result, flooding during the monsoon become one of the main concerns to people live along this river. The watersheds in the middle of the Kelani River Basin receive the highest rainfall. The total volume of water falling within the basin is estimated at 7,865 Million Cubic Meters (MCM) with about 43% of rainfall ending in the Indian Ocean. For example, in 2010 the floods occurred in many parts along the river as seen in fig 4 (Goonatilake et al, 2016).

The minimum and maximum elevations in the Kelani river basin range from 0 to 2345 m above mean

Fig 4. Flood Inundation Area 2010

sea level, as shown in fig 5. As a main source of water supply for domestic and industrial area mainly around Colombo, the extending of water supply increases due to the increase of population and industrial. Salinity intrusion has become the problem in the lower reach of the Kelani river due to the increased demand for Greater Colombo area, continued sand mining and the lowering of dry season flows (Nanseer and Rajkumar, 2006). Saline intrusion is mainly problem during dry season.

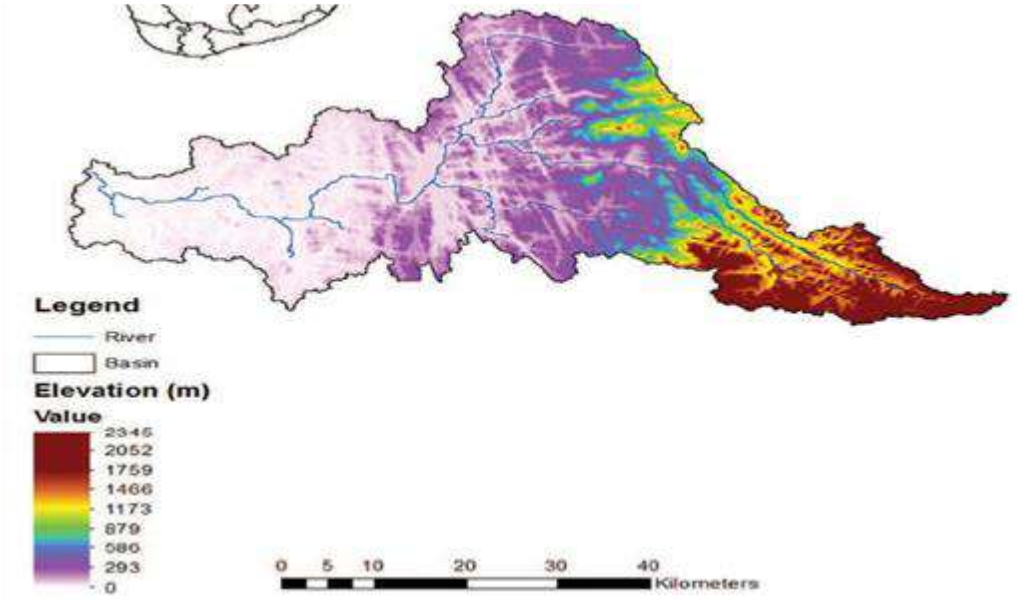

Fig 5. Location of Kelani river basin in Sri Lanka and variation of its elevation.

3 Proposal for Sustainable River Management

3.1 Slogan and Targets

25% of Sri Lanka population rely on Kelani river as the main water source. They use it in many purposes such as drinking, daily usage, business, and fisheries, whereas they also can get some benefits indirectly from tourist as well. This mean that they link their daily life with Kelani river, as a result, we propose one slogan that is about “Better Kelani, Better life!!” in order to give a message to all stakeholders of this river get attention on it. To achieve this slogan, three targets need to be completed. Since this river is polluted due to both industrial and domestic waste discharge, so these two main problems need to solve to recover the water quality of Kelani River. Therefore, the first target is to eliminate point source pollution. Point source refers to a thing like a factory wastage where the place of occurrence has been determined. Whereas, the second is to control diffused source pollution with solid waste management. Diffused source refers to things that do not have an established place like household wastewater. The third is sustainable water management in the river basin which is included the flooding and saline control, and education awareness about environmental protection.

3.2 Roadmap

<table>
<tr><th>Years</th><th>MILESTONE</th><th colspan="6">Strategy</th><th>Stakeholder</th></tr>
<tr><td>2018</td><td></td><td colspan="6">1 Appoint the Kelani River Management Committee. (less than 1 month)</td><td>1: Government, factory, citizen, researcher.</td></tr>
<tr><td></td><td></td><td colspan="6">2- target 1
Sampling and analyzing. Identity the pollution, the source pollution and quantity. (1 year)
2- target 2
--Obtain the census of each type of householder. (1 year)
--Solid Waste Separation: food waste, paper, glass, plastic, metal, electronic waste, and others. (1 year)
2- target 3
Investigate the quantity of water usage. (1year)</td><td>2- target1: researcher, factory.
2: committee; employee, staff.
2- target2: government
2- target3: researcher</td></tr>
<tr><td>2020</td><td>Milestone1:
Investigate the current situation and establish policies.</td><td colspan="6">3 monitoring system for WWTP/river/ leakage/solid waste/ sand mining.
3- target2
--Categorize factories based on pollutant types and load, then warn the bad factories. (1 year)
(according to Water quality standards for effluent / river)</td><td>3: government
3- target 2: government, researcher.</td></tr>
<tr><td rowspan="4">2024</td><td rowspan="4">Milestone 2:
--Complete construction in industrial zones and Section2.
--Water quality: 30% pollutant is decreased.
--Water quantity: the river level rise 20%.</td><td>target1</td><td colspan="2">target2</td><td colspan="2">Target3</td><td rowspan="4">(10 years)
Education
1. set subjects on environmental protection from primary school.
2. organize workshops for the workers and citizens.
3. Make some posters and paintings about environmental protection.

Develop water saving system for people.
Plan recreation areas/ parks and protect wetland along the river.</td><td rowspan="4">2- target1: researcher, factory.
2: committee; employee, staff.
2- target2: government
2- target3: researcher</td></tr>
<tr><td></td><td colspan="2">Diffuse source pollution</td><td>Solid waste</td><td colspan="2"></td></tr>
<tr><td>--Design and build water waste treatment plant and sewer network.
--Determine the monitoring methods, work out the payment scheme according to the pollutant load.</td><td>Type1
Design and construct housing schemes for unauthorized household.

Type2+Section2(the area between water intake and Kaduwela)
Build sewer network and WWTP.</td><td>Type3
--Check the tank of type3 household when we do the census.
--Ask them to repair the tank.

Recheck and re-repair every 5 years.</td><td>Collection and transportation system:
build facility; employ staff and trucks; place bins.

Section2</td><td>1 establish a rainwater harvest system for houses. (5 years to make sure every house uses the syst.)

And build permeable pavement.
2improve the existing salinity barrier.

Section2</td></tr>
<tr><td>--monitoring the water quality of treatment plant.
--shut down the factories whose effluent doesn't reach the standard.</td><td>Type1&2+Section3(the area between water intake and Colombo)
Build sewer network and WWTP.</td><td>Section3</td><td>Section3</td></tr>
<tr><td>2028</td><td>Milestone 3:
--Complete construction in Section3.
--Water quality: 80% pollutant is decreased.
--Water quantity: the river level rise 30%.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2030</td><td>Milestone 4:
--Complete construction in Section1.
--Water quality: 100% pollutant is decreased.
--Water quantity: the river level rise 40%.</td><td></td><td>Type2+Section1(the area between Kaduwela and Hawella)
Build sewer network and WWTP.</td><td></td><td>Section1</td><td>Section1</td><td></td><td></td></tr>
</table>

3.2.1 Milestone 1

Our first milestone is at the end of 2020. We will investigate the current situation to get a more comprehensive understanding of the specific problems of river basins in these two years. Although the Sri Lankan government already has certain laws, these laws are not very perfect, so we will also establish some relevant policies.

We believe that the most important thing is to have consensus among all stakeholders, only when we have a common goal can we take measures to achieve it. So, we will appoint the

Kelani River Management Committee by the government, researchers, citizens and factories. As mentioned above, we have three targets, so we will take corresponding measures at each stage to address these three different targets.

For target one, point source pollution, we collect water samples from river basins and industrial outlets and have them analyzed by professional researchers. We will identify the types, quantity and possible sources of major pollutants.

For target two, diffused pollution, we will mainly do three things. Government and researchers will obtain the census of each type of householder. They will also think about the solid waste separation, which will be divided into the following seven categories: food waste, paper, glass, plastic, metal, electronic waste, and others. The factory will assist the government and researchers to categorize them based on pollutant types and load. Then the bad factories will be warned according to water quality standards for effluent / river.

For target two, sustainable water management in the river basin, the quantity of water usage will be investigated by the government and researchers. This is an important basis for subsequent water supply and sewer network construction. Monitoring system is very important to ensure the implementation of the law. For Kelani River, we need monitoring system for WWTP, river, leakage, solid waste and sand mining. And these monitoring systems are not only about the technical means, but also social supervision.

Milestone 2

Our second milestone in 2020-2024 is that, complete construction in industrial zones and Section2. Meanwhile will are going to restore water quality and control water quantity to improve Kelani river water conditions. The specific goal until 2020 is that 30% pollutant is decreased to improve water quality and the river level rise 20% to improve water quantity.

For the target one, design and build water waste treatment plant and sewer network. Determine the monitoring methods, work out the payment scheme according to the pollutant load.

For the target two, we focus on control the diffuse source pollution. There are 3 types household in this area as mentioned above. For the type 1 (People without neither a proper house nor a proper sanitary facility), government and researchers design, and construction company construct housing schemes for unauthorized household to support type 1 householder life. For type 2 (People with a proper house but not a proper sanitary disposal method), the

same stakeholders build sewer network and waste water treatment plant. According to different pollution degree, we divide 3 different sections of this area. Government carries out measures for type 2 householders one by one in each milestone. First, in this milestone two, complete construction in Section 2, the area between water intake and Kaduwela. For type 3 (People having operating problems with their sanitary disposal method), the tank of householder is the key construction to collect waste water. Therefore, the specific department of government check the tank conditions of household every 5 years. If there is leachate leaking situation, the tank should be repaired timely to ensure the tank work safely. In diffuse source pollution area, controlling solid waste quantity is also important. Basically, government should construct and develop Solid Waste Collection and Transportation System: build facility for collect and storage solid waste, employ staff for operating this system and trucks for transporting the solid waste, and place bins along the street or household communities in Section2.

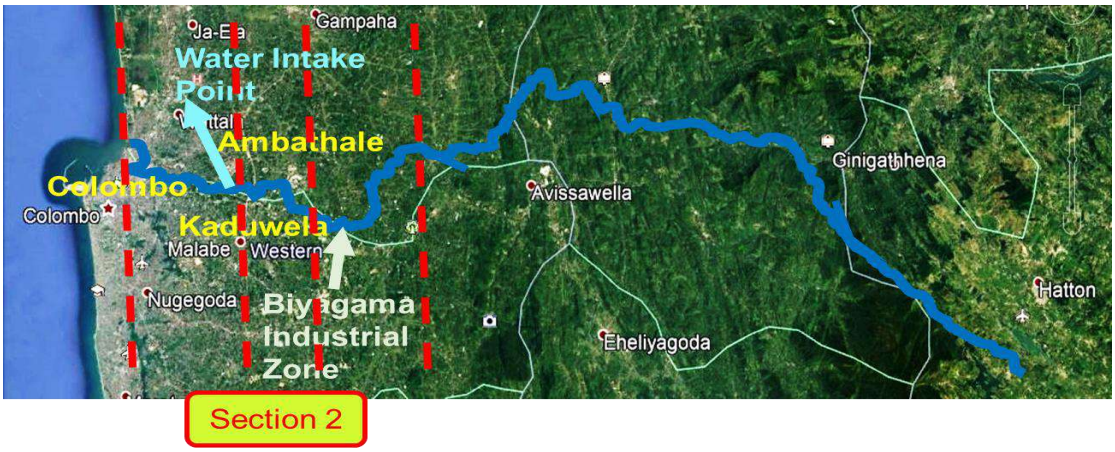

Fig 6. Section 2 along Kelani river (the area between water intake and Kaduwela.)

For target three, there are 2 main measurements be carried out. First, to ensure development of Kelani river, some new design should be applied in the community and city along Kelani river. Researchers design, and construction company establish the rainwater harvest system for houses. Develop this system and make sure every house uses the system around 5 years. Build permeable pavement area to adjust the water quantity we concerned. Improve the existing salinity barrier and so on. Recreate area or parks to protect wetland along the river. Second, education on protect Kelani river is also necessary for everyone who live with Kelani river. For school education, set subjects on environmental protection from primary school to improve the awareness of protecting water. Children are the hope of country so that education from childhood is more effectively. For workers and citizens, organize workshops, training and develop new technology and policies regularly to improve the awareness of every city

constructor. For everyone in this country, make some posters and paintings about environmental protection along the street to bring attention to them.

Milestone 3

Our third milestone from 2024 to 2028 is that, complete construction in Section3. Meanwhile will are going to restore water quality and control water quantity to improve Kelani river water conditions. The specific goal until 2028 is that 80% pollutant is decreased to improve water quality and the river level rise 30% to improve water quantity.

For target one, in last four years, waste water treatment plants have been constructed and monitoring system has already been determined. In the next 6 years of milestone 3 and 4, apply the monitoring system to monitor the water quality of treatment plant. Meanwhile shut down the factories whose effluent doesn't reach the standard.

For target two, carry out same measurement in Section 3, the area between water intake and Colombo and develop the sewer network according to the section 2 operation effect.

For target three, continue developing the technology and construction mentioned in milestone 2 in Section 3. Education of Kelani river protection keep updating.

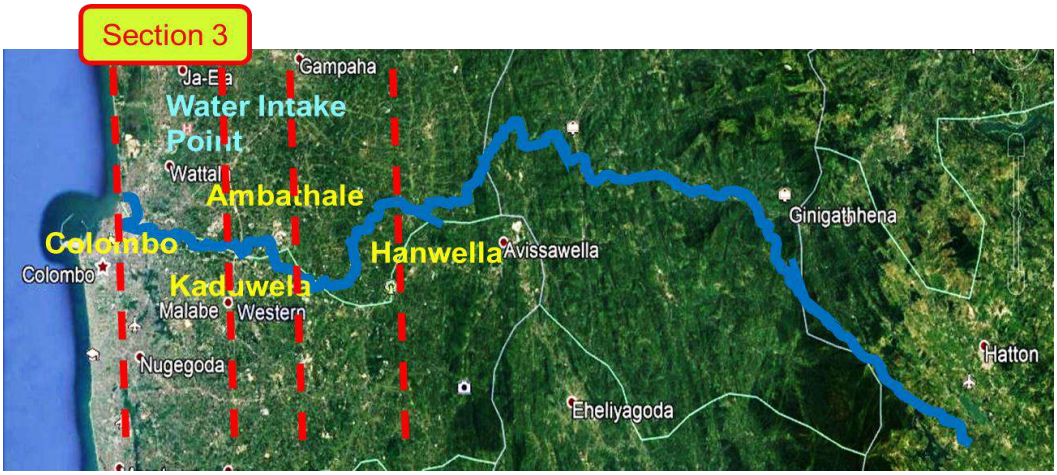

Fig 7. Section 3 along Kelani river (the area between water intake and Colombo)

3.2.2 Milestone 4

Our final milestone from 2028 to 2030 is that, complete construction in Section1. Meanwhile we are going to take same measures to restore water quality and control water quantity to improve Kelani river water conditions. The specific goal until 2030 is that 100%

pollutant is decreased to improve water quality and the river level rise 40% to improve water quantity.

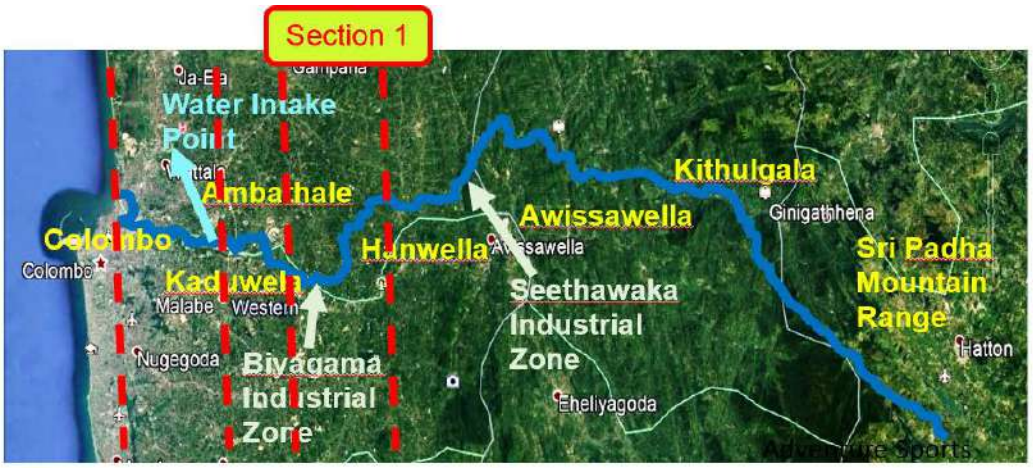

Fig 8. Section 1 along Kelani river (the area between Kaduwela and Hawella

Complete the construction in Section 1, the area between Kaduwela and Hawella. Make sure every measurement is carried out steadily.

4 Conclusion

During the search and discussion, we determine two main problems that people who live along the river basis face are poor water quality and disasters such as flooding during monsoon season and saline during drying season. To solve these problems, its sources need to be figured out. Two main sources that make water rive basis become poor are industrial waste discharge know as point pollution source and septage leakage from domestic as well as solid waste dumpling into the river that figured as diffusion pollution source. Our propose are eliminating point source pollution, controlling diffusion source pollution and managing the sustainable water.

To eliminate point source pollution, design and build wastewater treatment plant and sewer network depend on characteristic of wastewater from each industrial; apply the payment scheme according to the pollutant load need to be implement. After done, we must monitor it regularly to ensure its performance.

To control diffusion pollution source, domestic wastewater treatment plant needs to be constructed operated properly. Meanwhile, we need to design and construct housing schemes

for unauthorized household to be more effective in wastewater management. For the house that already consists of septic tank, which is the sanitary disposal method, we need to check and repair to avoid its leachate. For house that doesn't consists of sanitary disposal method, we need to build the sewer network by connect in block or small district to store their waste before going into wastewater treatment plant. Solid waste management is important to control diffusion pollution as well.

To achieve the sustainable water management, we should establish a rainwater harvest system for houses to be not waste of water and build permeable pavement as a result some amount of rain water will be collect and some will be runoff quickly to soil. Flood mostly occurred in short period because it mainly causes by rain water, so rain water management is one part to reduce flood. Apart of monsoon season, saline intrusion become a problem during dry season, so we should check, repair and improve the existing salinity barrier. Education is one of the important steps to achieve the sustainable environmental protection

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