ጣና ተፋሰስ የተቀናጀ ልማት በጎ-አድራጎት ድርጅት

Charitable Organization for Integrated Tana Basin Development

Evaluation of Water Hyacinth Harvester and WH Management of Lake Tana, Ethiopia

June 2018

Bahir Dar

Ethiopia

Table of Contents

Executive Summary 1

1. Background 3

2. Methodology 5

2.1 Assessment area 5

2.2 Field visit 6

2.3 Survey 7

3. WHH performance 8

4. Results and Discussions 9

4.1 Operation and maintenance of WHH 9

4.2 Training, Operation and Maintenance 11

4.2.1 Training 11

4.2.2 Operation 12

4.2.3 Maintenance 14

4.3 WHH performance 16

4.4 WH management 18

4.5 WHH monitoring 19

4.6 Community perception WHH 20

4.7 Farmers' experience to reduce WH impact on their livelihood 21

4.8 Upcoming WHH 22

5. Summary 24

6. Recommendations 24

6.1 Training on operation and maintenance 24

6.2 WWH Management 25

6.2.1 WHH monitoring and management Option-1 26

6.2.2 WHH monitoring and management Option-2 26

List of Acronyms

WH	Water Hyacinth
WHH	Water Hyacinth Harvester
GCLTR	Global Coalition for Lake Tana Restoration
COITBD	Charitable Organization for Integrated Tana Basin Development
DCEC	Dongfeng Cummins Engine Company
EFWPDA	Environment, Forest and Wildlife Protection and Development Authority

List of Figures

Figure 1: Visited WHH under operation area and WH prone areas in Lake Tana 5

Figure 2: Team of experts during field visit 6

Figure 3: Community discussions about the water hyacinth challenges, removal and extent with harvester perception Achere Kebele (Demebia woreda) 7

Figure 4: Amaga Water hyacinth harvester machine under operation (Photo by COITBD team) .....**Error! Bookmark not defined.**

Figure 5: The captain operating (left) and explaining about the machine for some of the team members .....**Error! Bookmark not defined.**

Figure 6: Part of the machine which have been failed during operation in our field visit 15

Figure 7: The materials added (marked in yellow) in the right part of the harvester to balance 16

Figure 8: WHH loading the water hyacinth from Lake Tana (Left) and disposing near the shore (right)..... 18

Figure 9: Disposed Water hyacinth remain in the wetland and growing again (left) burnt Water hyacinth (right)..... 19

Figure 11: The farmer who started fencing to prevent the effect of the WH on productivity..... 22

Figure 12: WH in Fogera area with the lake shore and the wetland is plain level 23

Figure 13: Water hyacinth in Gorgora kebele (left) and Sheha Gomengie (right) 23

Acknowledgement

This work is financially supported by Global Coalition for Lake Tana Restoration (GCLTR), a nonprofit organization established in the United States. We are grateful for both technical and financial support from GCLTR.

Executive Summary

This report contains the assessment and evaluation results of WHH donated by Amaga plc which is currently under operation in Lake Tana. The team of experts organized by COITB has travelled to the area where the WHH is under operation and visited other WH infested areas. The machine was operational since March 23rd 2018. Field visit and observations were done while the WHH was under operation and interviews with the operators, guards, the local community and different stakeholders has been carried out. In addition, focus group discussions with the community of Achere Kebele were also undertaken. In order to evaluate the performance of WHH, measurements of volume of WH and time required for it were measured. WH disposal and management issues were also assessed through observation and direct interview with WHH crew (one captain, two co-captains and two auto-mechanics), experts and officials of EFWPDA. It was understood that the WH removal by the community especially this year was done substantially. The communities were happy with the arrival of the WHH, with the hope that the machine will support in reducing the workload used to have in clearing the WH from the lake. The WHH in operation does cut out the WH from the lake and dumps near the shore which is likely to re-grow back when the water level rises. The training regarding the WHH operation and maintenance was provided for the crew. However, the assessment revealed that the training was not adequate and enough for the operation and maintenance. This was partly due to a language barrier, as the trainer only speaks Chinese "Mandarin" language. Since its deployment, the WHH has encountered very series problem initially and took 20 days till the required spare part was imported from China. Then after there were frequent failure of the WHH with small and fast wearing spares. The frequent failures and operation problems of the WHH were regularly maintained at Gorgora garage, by dis-assembling the parts and transporting. The management of the WH after disposal is very critical work, where the current practice of dumping by WHH near the shore and on the adjacent farmlands would likely aggravate re-infestation and booming of the weed, when the lake level rises in the upcoming rainy season. It is suggested that future deployment of WHH should consider providing adequate training on operation and maintenance of the machine and needs to be provided in detail with the local language. Future WHH purchase decisions should also consider the shore morphology, nature of the weed as well as the depth of the lake near WH prone areas. The current performance of the WHH was less than its designed performance and requires some adjustments and careful maintenance before and during operation. The lower salary and per-diem for machine operators and mechanics is also a serious concern, as 120 ETB per-diem does not even cover their subsistence in the area. Incentives such as camping, food and other related services will help to engage and work efficiently in the WHH.

Keywords: Water Hyacinth; Invasive aquatic weeds; Lake Tana; Blue Nile; Weed Harvesters

1. Background

The recent invasion of water hyacinth (*Eichhornia crassipes*) is the most pressing challenge of Lake Tana, the largest fresh water body of Ethiopia and the source of the Blue Nile River. The weed has created an eminent threat to the water quality and quantity of the Lake and its biodiversity. Water Hyacinth is considered as the most notorious and invasive aquatic weed, and has been identified as one of the 100 most aggressive invasive species and recognized as one of the top ten worst weeds in the world (Gebregiorgis, 2017). The first reports of the invasion of Lake Tana by this weed was reported in September 2011 (FAO, 2013), although the weed is not new in Ethiopian rivers as it existed in the Koka Lake and Awash River since 1965 (Gebregiorgis, 2017; Anteneh *et al*., 2015; FAO, 2013). The water hyacinth infestations were first found near the mouth of the Megech River, on the northern shores of Lake Tana.

Removal of the WH of Lake Tana was carried out manually by the community. This was done by engaging farmers living in the Kebeles surrounding the Lake. This way of removal has been undertaken for years and has become tiresome, backbreaking job and was unable to significantly reduce the WH from the Lake. Indeed, it was un-deniable that the farmers in the surrounding Kebeles tried hard and more than their capability to do in this regard. Following the calls and social media advocacy, people from different part of the Amhara region and other parts of Ethiopia have been engaged in the manual removal of WH. This effort of the public to eradicate water hyacinth from Lake Tana came to be referred to as the "Save Tana" movement.

In 2016, the Save Tana movement across the country and the globe has broken the silence and brought tremendous momentum. Among this, Charitable Organization for Integrated Tana Basin Development (COITBD) have designed projects and tried to carry out assessments. International Charitable Organizations, such as Global Coalition for Lake Tana Restoration (GCLTR) have also been mobilizing the Ethiopian diaspora to support

the Save Tana movement. Generous individuals have also donated WHH that is currently deployed in Lake Tana for removal of WH.

On February 2018 the WHH bought by Amaga Plc and deployed on March 23rd 2018 over Lake Tana to remove the WH. The present WHH on duty was bought from China (Dongfeng Cummins Engine Co. Ltd. (DCEC)). It was transported from China to Ethiopia with very few weeks, from Djibouti to Bahir Dar in few days and reached Gorgora port on 19 Feb. 2010 E.C. It started operation over the lake on March 2010 E.C. Theoretical and practical on the job training was given for the crew members for a total of 12 days. The crew members who received training and currently operating the WHH were five; one captain, two co-captains and 3 mechanics. The crew was organized by selecting the experienced boat captains from Lake Tana Water Transport Organization and the mechanics from the Bahir Dar Vocational and Technic College.

GCLTR very recently has bought one harvesting machine and has planned to buy additional machines and boats. In order to help support future procurement decisions and choice of WHH types, evaluating the operational performance of the current machine, assessment of maintenance and management practices of operational harvesters is vital. As a result, the GCLTR (USA) and the COITBD (Ethiopia) reached an agreement to evaluate and asses the machine performance and management of WH removal using the existing WHH harvester. The objective of the assessment was to evaluate the performance of the WHH over the WH infested portion of Lake Tana. Hence, this report presents the findings of the assessment of the performance of the WHH and WH removal in Lake Tana.

2. Methodology

2.1 Assessment area

The assessment focused on the North East and the Eastern part of Lake Tana (Figure 1). Specifically, the selected sites include the areas where the WH has been widely impacted. In Dembia Woreda Gorgora, Achere and Kirigna kebeles were part of investigation; in Gonder Zuria Woreda, the Sheha Gomengie Kebele; in Fogera Woreda, the Nabega Kebles are part of the assessment. The visit also focused on the area where the WHH currently operating i.e. the Sheha Gomengie kebele. In addition, the team has visited water hyacinth prone areas to discuss with the communities on their view on machine deployment. Visiting other site was vital as it helped to recommend the type of machine to be deployed, based on the shore morphology.

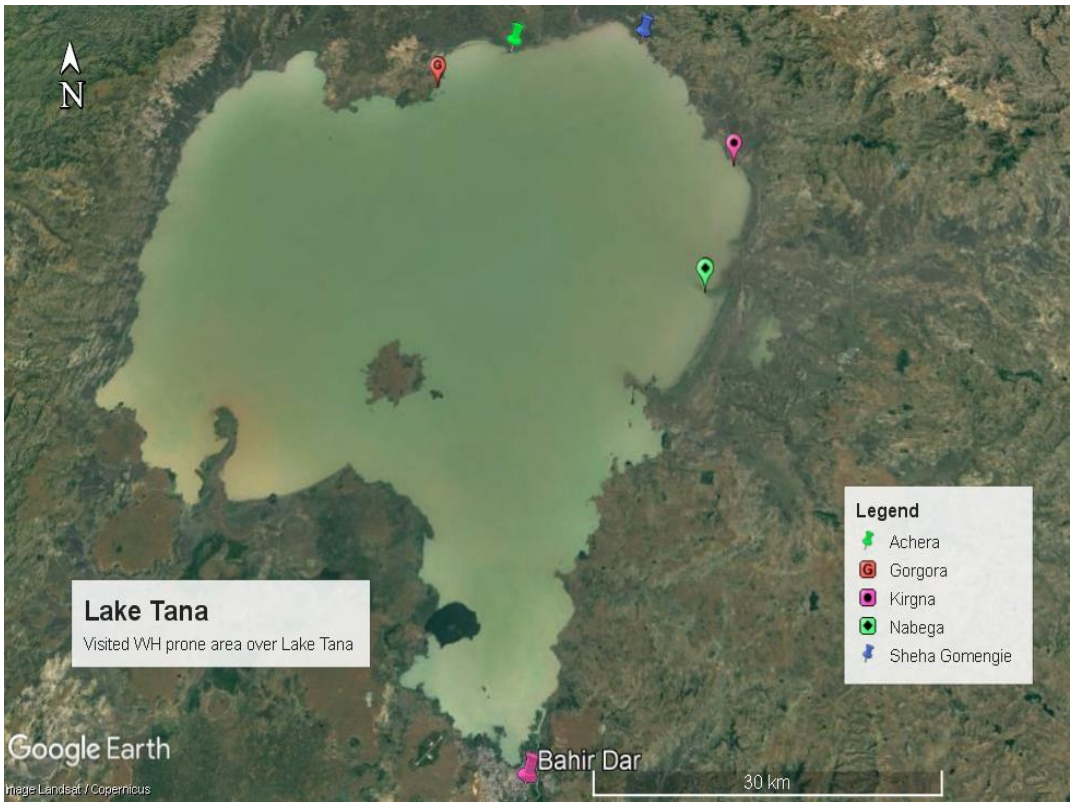


Figure 1: Visited WHH under operation area and WH prone areas in Lake Tana

2.2 Field visit

The technical team has travelled into the sites where the current WHH has been deployed and working i.e the Sheha Gomengie Kebele, Gonder Zuria woreda. After careful observation and collecting the necessary data for the WHH performance evaluation, the team has visited parts of neighboring kebeles that are severely affected by WH; areas such as Achera, Kiggna, Nabega kebeles. The team has also visited Gorgora where the WHH donated by Amaga plc has been installed in Gorgora port. In addition, the team has interviewed and discussed with the farmers living around the visited sites which have been affected by the WH. The discussion focused on the trials and experiences they took to safeguard their farmland before invaded by WH especially in rainy seasons. Their views on what needs to be done in the future to minimize the expansion of the weed has been recorded and included in this report

Figure 2: Team of experts during field visit, based on the top right figure, from right to left *[(Demisew (Water resource Engineer), Mezgebu (EPA expert), Workiye (Aquatic Biologist), Yibeltal (Mechanical Engineer), Mamaru (Hydrologist and team leader), Anteneh (Socio economist), and Dessalegn (Watershed Expert and Chair of COITBD)]*

2.3 Survey

The survey prepared based on the ToR from GCLTR was used to assess important information needed to achieve the objective of this report. Most of the survey was used to assess the machine performance and management. However, the team has interviewed the community on the impact of the water hyacinth on their farmland and productivity. It was also an opportunity to ask the farmers views of how the WH has affected health of Lake Tana and ultimately their livelihood. During the survey, the community also asked about the help of the current machine and the way forward to reduce the expansion of the water hyacinth. The different stakeholders in Bahir Dar were also chosen for direct interview and Key Informant discussions; WHH operators, farmers, experts of EFWPD (Table 1).

Figure 3: Community discussions about the water hyacinth challenges, removal and extent with harvester perception Achere Kebele (Demebia woreda)

Table 1: List of targeted stakeholders for the assessment study

No	Stakes	Number	Frequency
1	EPA	2	1
2	Amaga Plc	1	1
3	Operators	5	2
4	Community	50	1
5	Sectors	3	1

3. WHH performance

The performance of WHH currently in operation was assessed based on the following machine performance and management indicators;

1. Machine capacity in terms of time and volume
2. Machine capability of removing the weed
3. Running, maintenance and operation costs, mechanisms and related issues
4. Assessment of easiness of machine management and other performance indicators
5. How the harvested weed is disposed and managed

4. Results and Discussions

4.1 Operation and maintenance of WHH

The WHH currently undertaking the removal WH (Figure 4) is with two cutters at the front (right and left) and pulling out the WH from the lake through metal conveyor chain to the collecting cart. Once the harvester loads the WH on collecting cart with a capacity of 20m^3 and positioned on the back of the WHH, it moves back closer to the shore and disposes the weed right near the shore.

Figure 4: WHH donated by Amaga (Photo by COITBD team)

Since it dumps the harvested weed near the Lake, it is very likely for the weed to be back into the lake, with the rise of the lake level and rainfall. This would also aggravate the re-infestation and spread of the WH in the Lake, if it gets back. Hence disposal of the WH is one critical aspect which needs much attention. In this regard three main options could be proposed for resolving the existing limitations of the disposal of WH.

1. The harvested WH should be transported to a furthest disposal place from the lake, by preparing a dumping site. For instance, trucks could be used which probably would help transport starting from the Lake to the dumping place. Another option for transportation could be using the self-propelled wheeled side tip sugarcane buggies which have been successfully used to transport the WH. However, care must be taken when side tipping as it is designed to lean against a cane bin and could topple. In addition, wet water hyacinth can be compacted/ chopped to reduce the water content prior to transportation, which can help to reduce transportation costs. If is directly being moved off-site, material can only be removed in a sealed truck to avoid leakage or spillage and may require a permit for transportation from the concerned government agencies.

2. Water hyacinth has been known to survive for months in mud away from water. Harvested plants must be either buried nearby on site or piled away from the shore line, above the flood level and spread out to dry completely or left in piles to decompose. Due to the high-water content in water hyacinth, piles will leak water for some time. To stop water from flowing back into the water body, taking viable seeds and other contaminants with it, it may be necessary to bund the piles.

3. Keeping the WH in the field far from the shore in common place for some time and waiting till it get dry and then burning with fuel gas. This could be efficient if the community under EWLPDA monitoring where they should help the WH to dry by letting the sunlight in every piece of the WH. In this case efficient distribution of fuel is critical. Currently this approach has is being practiced with very few farmers due to shortage

and distribution of the fuel and the WH has not got dry because of less management to dry it.

In order to implement this options the coordination between governmental structures starting from the regional authority to the Keble level.

4.2 Training, Operation and Maintenance

4.2.1 Training

The crew members selected and trained for operating the WHH were five in number (one captain, two co-captains and two mechanics). Three of the machine operators were temporarily assigned for this job from Tana Haik Water Transport Organization. Whereas the two mechanics were from the technical and vocational college of Bahir Dar, trained in Auto mechanics (diploma graduates). The training was given onsite provided by a person sent from Dongfeng Company, China. It was given for 12 days on operation and assembling the WHH. Specifically the scope of the training was on how to operate and safety of the WHH. It was given with Chinese language known as Mandarin. Hence there was a huge gap between the Mandarin speaking Chinease guy and Amharic speaker Ethiopian crew members. Even neither the trainer nor the trainees were able to speak English. The trainees reported that there was indeed a great communication gap between them. During this time translation from Mandarin to Amharic was done through phone with Ethiopians based in Gonder town, who understand some Mandarin. As matter of fact, all of the training given by the Chinese trainer was not fully understood by the crew. The training was planned for 7 days originally and later added another 5 day due to the misunderstanding between the trainer and the crew. Arrangement the extra days of training was by Amaga plc and partially sponsored by EFWPDA. This at least helped the crew members to start operation of the WHH, manage after operation and dis-assemble the parts when it got broken during operation. Upon discussion with the crew members, it was understood that the training provided was not enough and adequate to operate, maintain and manage the WHH.

4.2.2 Operation

The crew took the responsibility of operating the WHH since March 2018 and tried their best to operate the WHH and safely mange it. The crew members are paid on the daily basis and were not permanently hired by EFWPDA. Even though they were not satisfied with the training, they still are struggling to work with the WHH to the maximum of their capacity. There are also some systematic trial and error operations by them in times where the machine got stack while working (Figure 5). This is due to the rapid heating up of the engine after its start of the operation. The operators are living in the nearby town of Maksegent, which is around 12 km from the current working site. For transporting them to the site, EFWPDA arranged one car to transport the crew early in the morning and back after work.

Figure 5: The captain operating (left) and explaining about the machine for some of the team members (right)

The proposed working hour of the WHH is from 8:00 AM morning to 4:00 PM in the afternoon. However, due to its frequent problems, it was not able to work full hours. Till now, the maximum working hour of the WHH was only 4 hours and commonly 3 hours per day. On average, one captain works from 1.5-2.5 hours and is replaced by the

two co-captains interchangeably. With its maximum operation capacity, the WHH does remove nearly 40 full back box ($20m^3$) "biajo" of WH in an hour. After the daily working hours, the crew performs cleaning, greasing and stationing the machine in appropriate place. With the limited training and the challenge associated with the machine such as repeated failure and poorly supplied spare parts, the operator's skill to work with WHH looks good. After some time operation (two hours working), the engine of WHH heats up. . For this reason, it was not able to move around by carrying the full volume of the WH. During such difficulties, the operator dumps part of the harvested WH in to the lake and disposes half out of the lake near the shore. Some additional challenge of the current WHH faced which was understood from the observation of the team and the discussion with key informants includes;

1. The placement of fuel and oil tanker in only on one side. This hinders the filling up of fuel, as it creates an in-balance of the WHH during operation.
2. The WHH motor is open and below the WH transferring conveyor chain. Which make it susceptible for water to enter in to the motor and exposed for failure of motor
3. There are cases where the conveyor chain jumps over and creates problem in operation

Some of these challenges have been tried to be resolved by crew members through trial and error, with systematic operation of the WHH, including dis-assembling of broken parts and quickly transporting it to be maintained at Gorgora garage. The overall judgment of operators on the WHH operation capacity is unsatisfactory. They recommend some improvements on the current WHH. Some of these recommendations are presented as follows:

1. The very dense nature of WH and the substrate it creates with the mud makes it hard to cut and transport in to the chains. Before the WHH tries to load the WH, there should be chopper machine or fitted blade which cuts the dense part of WH in to pieces to easily pick by the WHH.

2. The problems related to the fuel tanker and the motor of the WHH position need to be resolved to adjust the balance and weight. This would help for easily operating and preventing the motor from failure.
3. The operation and maintenance manual needs to include the whole part of the WHH, not only the motor. But the manual that is available with the machine is only a manual for the engine.
4. Some of the critical operation and maintenance issues need to be translated in to local language for the crew members to refer it any time they face problems.

4.2.3 Maintenance

As it was discussed above, the training provided for maintenance of WHH was not enough and adequate. One of the main reasons was communication barrier between the crew members (Amharic speakers) and Chinese trainer (Mandarin speaker). The captain has only the knowledge of medium size boat and has no much experience about maintenance of the WHH, implying that the crew would not be able to maintain the WHH, any time it stops working. Since the commencement of removing the WH using the machine, the WHH has encountered failures more than three times.

1. After the first ten days of operation the WHH has failed. It halted operation for 20 days. This was due to the unavailability of the spare parts in Ethiopia. Later with the imported spare parts the maintenance (2 days for fitting) was carried out by mechanics at Gorgora garage started operation.
2. After one week of operation, it again failed due to the left side cutter gear oil spill. The material i.e the cutter was dis-assembled and transported to Gorgora for fixing the problem. This time, the WHH stopped working for about 5 days as well.
3. During the visit by the team, the WHH under operation again faced with the left side cutter gear oil leak (Figure 6). Similarly it was dis-assembled from the WHH and transported to Gorgora for maintenance.
4. There are some minor problems during operation of the WHH, for instance jumping of chain, oil spill and left pedal failure.

5. Currently (till 06/01/2018) the propellers pump has failed and stopped working to remove the WH over Lake Tana.

Dis-assembling the broken or failed part of the machine is undertaken by the auto mechanics (WHH crew members). The body of the WHH and the motor are too heavy and made from metal, which makes the machine unable to operate especially in the shallower portion of the Lake. This coupled with the dense nature of the water hyacinth in Lake Tana makes the WHH to operate below the expectations and the designed standards. Moreover limited skill of the crew for operation and maintenance has made the WHH to work with low performance. Sometimes the malfunctioning, failures and breaks are done by trial and error as we understood from crew interview. It was also understood that the fuel tanker position in one side of the WHH makes it difficult to work. However, crews are very curious to work with it by balancing the other side by putting some material (Figure 7). This additional load and the fuel tank and motor position issues made the WHH to move and operate at less speed and sometimes stack in the middle of operation.

Figure 6: Part of the machine which have been failed during operation in our field visit

Figure 7: The materials added such as bricks and stone (marked in yellow) in the right part of the harvester to balance the fuel tank on the other side of the WHH.

4.3 WHH performance

Evaluating the technical performance of the harvester was made based on the field survey and visual inspection while it was operating. The manual along with the harvester was also used to evaluate the company standard, designed capacity and performance, and the current operation of the harvester. The manual was obtained from Dongfeng Cummins Engine Co. Ltd. (DCEC), where that harvester has been bought. The manual only explains about the external engine component demonstrations and safety features. It was written in English with black and white copy. This could be difficult to be understood by the crew members. The manual hasn`t had illustrations and demonstrations of other parts of the WHH such as the cutter, chain and WH carrying box and more importantly about the hydraulic parts of the machine, which makes it difficult for maintenance. The machine performance was evaluated in terms of area cleared and volume of water hyacinth removed by the harvester per hour. This was carried out by measuring the harvester carrying capacity and recording activities and time required for operating.

The current WHH with storage cart full (at back) collects 20 m^3 of WH. It took 15 minutes to collect and dispose this amount. In one hour it would collect and disposes 80 m^3 of WH. In one day (working for maximum of 8 hours), it was estimated to collect 640 m^3 of WH. The WHH is capable of clearing a dense WH area of 40 m^2 in one hour. The WHH machine performs in slow speed and sometimes stacks while working, due to less power to penetrate the dense WH.

Regarding the fuel consumption it was not easy to estimate per working hour per cleared WH area. Though it is dependent on the number of cylinder, there is no any indication about the blades, rakes, conveyers and loading parts from the manual. We were unable to find that in the manual. It was tried to estimate by filling the fuel tanker to know the fuel consumption per unit area and time. This option was not possible in spite of the problem of filling the tanker which could result the un-balance of WHH to the left side. This would not let the WHH to function in full energy. However the captain and experts of woreda has informed 7 liter per hour to clear 40 m^2 of WH covered area. To clear one hectare of the same area the WHH could use 473.5 liter of fuel. The running cost of the machine such as fuel, oil and maintenance including the crew perdium and guards' salary is covered by EFWPDA.

Though the harvester could work after the last maintenance it`s performance is adequate enough to solve the existing problem. Especially in helping the community for WH removal from the Lake. Re-adjusting the current WHH by Amaga by discussing with the supplier is critical in order to utilize it properly and help the community in WH removal.

It was clearly understood from the crew members of the WHH that the operation is not that much complex except some kind of the machine irregularities and training issues. Some additional of the WHH problems or failures include

1. Oil leak on the front cutter *Gomine*
2. Slow performance when the water hyacinth is thick and form a mat.
3. Jumping of the chain

4. WHH stack during work
5. Stationing problems

Besides some strong training, some parts of the WHH spare part especially which are fast wearing has to be part of the deal and come along with the upcoming WHH. But for the existing one the Amaga plc and EPWLDA has to deal with the company to get this fast wearing spare part of the machine.

Figure 8 WHH loading the water hyacinth from Lake Tana (Left) and disposing near the shore (right)

4.4 WH management

WHH disposes the WH near the shore along with the lake water (Figure 8). There is no prepared specific disposal site. The cutter installed in the front part of the WHH cuts the WH from the bottom once and transfers to the back box part by using the conveyor made from metal chain. Both the WH removed by hand through community campaign has got dried. This was due that the when the lake water recedes due to lowering of water level. Similarly part of WH removed by the harvester was dried but not enough like later one. From the Authority, zonal experts and community it was understood that there was a plan to burn the dried WH with fuel gas partially distributed by the woreda and in rare cases the team observed the burned WH (Figure 9). This is to prevent the re-

production of the water hyacinth when it gets moisture by rainfall or when the lake water level rise back. Still large volume remains there and showed a tendency to re-grow (Figure 9). It was because of the very few amount of gas for the community was distributed by the woreda to burn the dried out WH.

Figure 9: Disposed Water hyacinth remain in the wetland and growing again (left) burnt Water hyacinth (right)

The WHH travels long distance while nearly up to 10 km when it changes the site for instance from kebele to kebele. However during the operation (observed in the field visit) it could travel the maximum of 50m to load one "biajo" of water hyacinth. During one loading time the machine clears nearly $10m^2$. Nevertheless due to the density of WH it again covers part of area cleared with some cut pieces of the WH moving from the side with scattered density. Again the WHH re-clear the path it left before with some additional thick or dense part of the water hyacinth area from both sides.

4.5 WHH monitoring

The WHH monitoring is carried out by the EFWPDA. In the authority the water hyacinth control and management core process is responsible for monitoring the harvester. Deployment of the current WHH, partial sponsoring of the trainer, crew establishment and follow up of the WHH was led by the authority. The authority hired the crew on the daily basis payment i.e perdium. Four guards hired by the authority for safeguarding the machine during operation and night time. The guards are paid on the

monthly basis i.e 1000 birr/month. During our observation they were complaining about the payment issue. They raised two questions the late payment and less salary need to be discussed and adjusted with some convenience. EFWDPA needs to discuss with them and convince for smooth relationship and take in care of the current WHH and the upcoming ones.

4.6 Community perception WHH

The community has been struggling with water hyacinth since the 2011 by hand removal in annual mass campaign every year from December -February. Especially this year the campaign has started in October/2018 in every Kebele till March 2018. This times was early in terms of starting which previously was in late December to March every year since the WHH have been observed. Due to this years extended period campaign of WH removal the most affected areas has become free from the water hyacinth. For instance in the Achere kebele the WH coverage has not been completely removed since 2011. This year the community managed the WH removal nearly 100 % and it was disposed in the wetland and farming land (Figure 10). The disposed and accumulated WH in the agricultural land has reduced the farming land of the community. This ultimately has decreased the agricultural productivity. Upon discussion with the community, they warmly welcome the arrival of the machine. They emphasize that upcoming WHH should at least help work of WH removal in areas where the human being is unable to do easily. The community promised to work hard in our discussion. But still they need help in areas which are the difficult to remove the WH due to depth of water (above human height) and community afraid of the harmful aquatic animals.

Figure 10: The removed WH from the lake water in the framing fields

4.7 Farmers' experience to reduce WH impact on their livelihood

When the lake level increases the line WH will move out with water and cover decent amount of farmlands. Where the area covered by the WH above water could not provide yield as it prevents the crops to get sunlight as well as damages it mechanically. As the result the farmers faced challenge to their livelihood. To reduce this problem very few farmers installed fence around their farmlands to prevent the entrance of WH with the lake water. Hence the can help to grow water loving crops such as rice and hence obtained optimum yield than the other farmers whom exposed their farmland without fencing it. For instance in Achere Kebele farmer named by Ademe belay (Figure 11) did the fencing before the lake water rise and covers with WH. On account of this he was able to produce 2500 kg of rice /4 acre of land. In addition his fence has saved the farmlands of other 10 farmers neighboring to his farmland and they were able to able to produce rice. The experience observed from this brave farmer was appreciated by most farmers. Each farmers plan to follow the footsteps be implemented in their farm land. It was also suggested that fencing along the shore could help them to produce rice by protecting the WH entrance to their field. Our team has appreciated the farmers' effort to produce rice by fencing their farmland. It was also reached an agreement that with

fencing of some places it at least could reduce the impact of WH on the farmlands and help them to produce rice on the flood plain.

Figure 11: The farmer who started fencing to prevent the effect of the WH on farmland

4.8 Upcoming WHH

It is absolutely important that WHH was critical for the removal of the weed from Lake Tana. However the type of the harvester to be deployed need to be in line with the nature of the lake shore in each kebele. This varies across kebele differently. In some part of the lake shore and the ground are flat and in others there is clear barrier between the lake water and the shore with boundary. In some of the other parts it is connected to the wetland and the recession of the lake water is with the wetland. In Fogera area where the shore and the wetland are plain type with much sediment near the shore (Figure 12), the amphibian harvester (which works both on water and land) is very important. In addition to collecting the WH it just cuts WH in to pieces pushes out of the lake water and the muddy sediment deposited wetlands. Moreover these areas in places where the WHH couldn`t reach due to low water level and wetland the fence

near the shore should be installed to hinder the movement of the water hyacinth to the farmlands could be considered.

Figure 12 WH in Fogera area with the lake shore and the wetland is plain level

In Kebeles such as Gorgora and Sheha Gomengie the WHH with chopper is recommended (Figure 13). This is due that the nature of the water hyacinth is very thick and dense where the community needs help. In addition the shore of the lake at this positions not plain with the wetland. It has clear boundary and depth where the hand pick removal is difficult.

Figure 13 Water hyacinth in Gorgora kebele (left) and Sheha Gomengie (right)

5. Summary

In this assessment report for evaluating the performance of WHH it was understood that the deployment of the WHH by the Amaga plc is very appreciable. However currently the WHH is not working in a good performance. This was due to several reasons such as less training in operation and Maintenance, distance of the crew residence and working position, payment issues and the nature of the WH to easily remove by the current machine. Overviews on the WHH has also indicated the durability of part of the harvester and weight made it to work and move slowly and sometimes unable to move if it carries the desired amount of WH. WHH removal performance was not as expected and needs some adjustments and careful maintenance is required before operation. The WH removal campaign needs to be also run by separate institutional system under EFWPDA Hence the upcoming machine needs to be deployed and the performance and adaptability of the WH harvesting system has to be evaluated before additional machine to be bought.

6. Recommendations

For current WHH we recommend to be fully maintained and the irregularities to be solved so that the harvester can at least work in areas where the WH is not dense. In addition it would be good if it is accompanied by a chopper which can cut the mat forming WH. Some of the parts even might need re-fabrication in order to make it compatible with the motor. For instance the pumps of propeller are failing continuously due to the motor provided higher power than the pump need. Hence these areas need be fitted with compatible.

6.1 Training on operation and maintenance

It was understood there observable challenges related to training in operation and maintenance. Hence it was highly recommended that the training on operation and maintenance should be provided for some time during deployment of the WWH. On job training after deployment should also be given for the crew of the WHH. The training should be given for the crew with local language by using translator. In addition some fast wearing replacement harvester parts should be provided. Regarding the maintenance

the harvester parts during machine failure the port site to be constructed in Achere Kebele.

Only the WHH are not the only machines to be deployed and work in Lake Tana. There would be additional machines such as excavators, WH carrying trucks or tractors. Hence the maintenance issue would be very critical. Hence to improve the maintenance capability of the crew and above all to facilitate the accessibility of the service, we recommend some medium scale maintenance procedures and facilities has to be fixed somewhere in the port near the proposed WHH station.

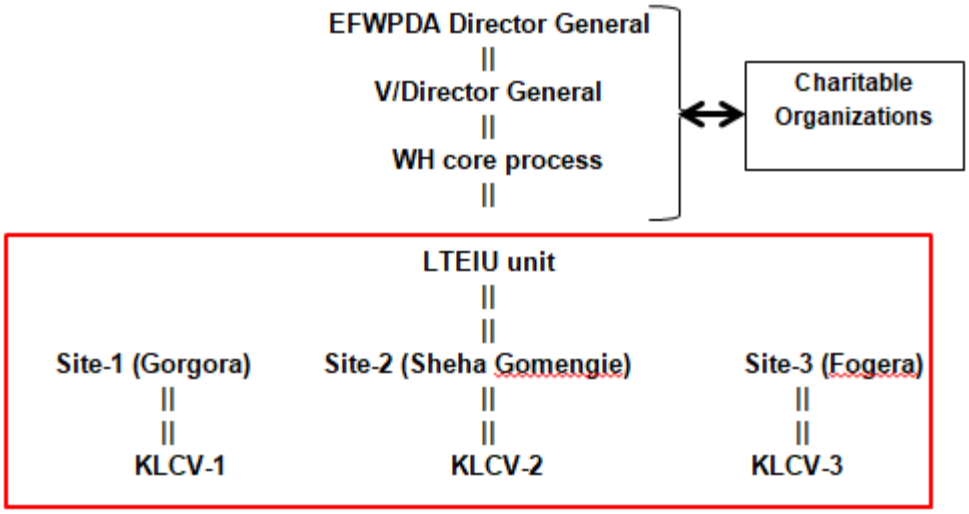
6.2 WWH Management

Currently WHH and WH removal is monitored and managed by EFWPDA. It in deed should also be in the future. During the field visit it was also observed that the authority has established a new core processor to handle this job. The establishment of this process work was based on the challenges related to water hyacinth. However the management for the campaign removing WH needs some additional strong monitoring management. As the result we recommend two options if WH removal management monitoring system for sustainably reduce the WH.

Under EFWPDA there is an existing and new organizational establishment and personnel and frame work. Hence in order to sustainably make the reduction WH we propose the working flow of water hyacinth mechanical WH remove system. As it was indicated EFWDPA will take the lead and through its structure it will establish Lake Tana Environment Improvement Unit (LTEIU). Mainly the unit will first select monitoring sites by stationing at 3 sites. Where in the site the WH and the Harvester need to be managed to improve the outreach for every corner where the water hyacinth. In each of the WH sites the operation (4 crew members in each WHH) & Maintenance (2 mechanics) community facilitators (volunteer) including the guards of WHH.

6.2.1 WHH monitoring and management Option-1

In this option of WH management the EEWDPA current structure up to the WH removal process owner has to remain as it is but working strongly with the charitable organizations. However the new Lake Tana Environment improvement has to be established in three main prone areas as the center. In this area the ports should be constructed and WH removal dump suites too. The Unit needs to have one coordinator to be hired in the kebele and to coordinate and monitor the operation of WHH and WH management. Under the unit there has to be community Volunteers which will help the unit coordinator as well as the WHH operator crew. The Coordinator unit and the crew members have to be stationed nearby kebele or residence need to be constructed in each port site.



LTEIU= *Lake Tana Environment Improvement Unit*
KLCV= *Kebele level community volunteer group*

Figure 12 work flow for establishment of Keble level environmental coordinator unit (marked in red)

6.2.2 WHH monitoring and management Option-2

In this option we propose to implement the government structure to the kebele level by assigning the focal persons of Environmental protection agents (EPA`s). For instance there is one natural resource DA`s and similarly one person assigned for land

administration. Hence all the coordination assignment could be cascaded from the authority to the kebeles level environmental protection agent (EPA) with some project fund or government but especially for the mostly affected kebeles neighboring Lake Tana need the implementation very soon.

As one of the options, mechanical method to minimize the spread of WH over Lake Tana, the following points need to be considered in order to sustain the WH removal and management over Lake Tana.

1. Before buying machines (WHHs) careful consideration of the availability of the spares is valuable and the machine should be accompanied by enough spare parts especially with fast wearing part of WHH
2. Some spare parts should be available onsite to reduce the time loss in importing the spars from abroad.
3. Training on the operation and maintenance for the crew should be given by the local language.
4. Close monitoring and follow up should be there by EFWPDA.
5. Integration among stakeholders' should be strong enough to protect Lake Tana.
6. Community mobilization has to be done systematically with the support of the current and Upcoming WH as the support during each kebele campaigns.
7. As part of mechanical method of WH reduction mechanism the Fence near the shore in some areas need to be implemented to prevent the farmers cultivated land before it damages the rainy season production.

More importantly under current circumstances two WHH are deployed over Lake Tana. One WHH donated by Amaga Plc, which stopped working and another is the new Aquamarine from GCLTR. In addition there is another one upcoming from GCLTR. There would also be two huge transporter boats and one big WHH, made by Mulat

Industrial Engineering and Bahir Dar University which would be tested soon. Totally it will become six after all got deployed may be in one month time. As a result we suggest discuss and freeze quite some time WHH purchase and work on how to effectively utilize the existing and upcoming (already bought and ready for test) WHH.

Acknowledgment

We would like to extend our very high gratitude and appreciation to Global Coalition for Lake Tana Restoration for investigations and supporting field visit fund. We also like to acknowledge very much for EFWPDA supporting vehicles and boat to visit the sites and providing the necessary materials.

Annex-A Figure 1

Right to Left➔ [(Amare (Zonal EPA expert), Dr. Mamaru (Hydrologist and team leader) Demisew (Water resource Engineer), Dr. Dessalegn (Watershed and Chair COITDB), Yibeletal (Mechanical Engineer), Anteneh (Socio economist), Mezgebu (EPA expert), Workiye (Aquatic Biologist)]