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EWB Sheffield Report 2015 – Small Scale Irrigation in Nkhata Bay, Malawi

1. Summary

This report aims to summarise the methods, activities and outcomes of the trip which Sam Stedman and Andrew Merson took to Butterfly Space, Malawi in August-October 2015. We hope this will concisely explain to our donors and fellow volunteers what happened and help to guide the project in the future.

2. Mzuzu University Workshop

In the first few days of our visit we organised a workshop showcasing our pedal powered irrigation-pump to interested academics and technicians at the University of Mzuzu (Mzuni).

The main aim of this workshop was to start a partnership with Rochelle Holmes and Mphatso Malota, members of the Centre for Excellence in Water and Sanitation with the future development of our pump in mind. The workshop also raised some important issues and criticisms which provided us with some good ideas for improving the design and our approach. After the presentation we were encouraged to conduct our research in collaboration with the department, for which we were required to apply for ethical approval beforehand from the government of Malawi.

We were told that there was a 30 day wait for approval to be granted, without which Mzuni could not legally use our data for research papers, a delay we thought was worth it if we wanted Mzuni to be a committed partner. 42 days later we began research with two students from Mzuni acting as translators, continued in Section 4.

3. Work with Government in Nkhata Bay District

Our design test work in Malawi began after being introduced to Mr Msiska, head of the Nkhata Bay District Agriculture Office, an arm of the government that advises low-income farmers with the aim to provide food security and raise standards of living. Mr Chester Msisika (Agriculture Extension Development Co-ordinator) and his most trusted sub-ordinate, Mr Davies G Siame (AED-Officer) were the primary contacts and facilitators for pump testing and improvement.

3.1 Pump Testing Period 1

After approaching Mr Msiska we agreed that the pump should be tested with one of the farming groups in his district. He proposed a pair of irrigation sites near Chandero village. The two sites are shared by approximately 30 families and have been used as a test bed for government farming trials in the past. We gave a short demonstration to some members of the scheme to explain how the pump is setup and used and then gathered beneath a tree to discuss how we would test it.

Siame leading the immediate feedback session beneath a tree beside the maize fields in Chandero village.

Mr Msiska (left) with a member of the irrigation scheme, beside the open water source used to irrigate the crops at Chandero village.

We agreed to leave the pump with them for 3 days after which time we would return to receive their feedback. We stressed heavily that we wanted negative comments and criticisms so that we could improve the pump to suit their needs as much as possible. The key points that we learnt from their feedback were:

- The women were much less comfortable pedalling the bicycle than the men. The reasons were: they did not usually ride bicycles so the wobbling made them feel unsafe, they did not want to show their legs to the men when pedalling, and the seat was very firm which was uncomfortable. (Using the mountain bike from Butterfly Space - see photo)
- Initially we had to encourage the men to sit on the bike and pedal with their legs instead of using their arms to turn the cranks. (They did this with one person on each crank arm)
- They were disappointed with the flow rate in proportion to the amount of work they had to put in.
- The pump had to be re-primed many times during pumping
- They preferred using the mountain bike as opposed to their own local bike as the higher gear ratio allowed them to pedal more slowly
- They could not put the pump into transportation mode on their local bicycle because the rear mudguard was too wide to fit inside the pump casing

Armed with this feedback and feedback from Mzuni we returned to Butterfly to design and build some improvements on the pump.

3.2 Pump Rebuild

Based on the feedback we received at Chandero and Mzuzu Uni along with our own observations and testing at Butterfly we decided that there were 4 key areas that needed improving. They are listed below with an outline of the reasons for selecting the key problems and the solution we devised.

KEY PROBLEM	REASON	SOLUTION & RESULTS	LESSONS LEARNT
STABILITY	The farmers at Chandero (particularly the women, who do most of the irrigation) felt like the bicycle was too unstable and could fall over sideways. We also observed that there was too much sideways movement of the rear wheel meaning that it could easily rub on the edge of the pump casing. This was also observed by Josie when the prisoners were testing it.	The solution was twofold: **Firstly** we remade the attachment points following the method outlined in the construction manual. By constraining the socket movement there was much less movement in the rear wheel during operation. By reducing the clearance between the threaded bar and the inside of the socket this movement can be further reduced. **Secondly** we welded a spike to the underside of the frame at each corner, the idea being that the spikes are driven into the ground when the frame is put into pumping mode giving it greater stability.	
WATER OUTPUT	The farmers voiced their disappointment that the volume of water leaving the pipe was insufficient for the amount of work they were putting in. We recorded around 20l/minute when testing for short periods pushing up 1m in head at Butterfly.	At first we were convinced that the pressure losses from the pipe would be so minimal that the flow rate would not be affected. What we failed to realise was that the cross-sectional area of the pipe was actually restricting the flow. By changing some of the pipe connections to ensure the flow was not traveling through any cross-sections smaller than ¾" and changing the outlet pipe to 1" internal diameter we noticed an increase in the flow rate by almost 20%.	Never make judgments based solely on an engineering principal you learnt in the classroom. Always thick logically and test your idea before adopting it or discarding another.
PUMP POSITIONING	Whilst setting up the pump at Chandero we threaded the bolt on the pump base which held the pump in position. Not only was this unacceptable but it was also very difficult to access when the frame was in pumping mode making repositioning of the pump difficult.	When the pump base broke during testing one of the farmers quickly took a piece of rubber chord from the pannier rack on his bike and tied it around the pump to hold it in position. This gave us inspiration to redesign the pump base so that it was simple and focussed on local skills. Because rubber chord is used by nearly everybody to tie cargo to their bikes we decided to use it as the key part of the redesign. Using this and off-cuts of building timber makes the new design much simpler and intuitive to locals for ease of manufacture and repair.	Always make sure you design with local skills and knowledge in mind. This is very hard to do but by observing how the farmers used our pump we were quickly able to see where the unnecessary complications were. At every step ask yourself; if I was in Nkhata Bay how would I manufacture/use/do this.
PRIMING	From our own testing and testing at Chandero we found that the priming took up to 5 minutes, required 3 people and would often have to be repeated after pumping was stopped, even for short periods. Although the farmers at Chandero did not identify this as a problem we felt that over time the process would become tiresome and would also make it difficult to identify the source of a problem when one occurred.	We tried many different arrangements of check valve and priming method including pouring water through the outlet pipe (this didn't work because the air was forced into the end of the inlet pipe and had no way of escaping). We concluded that the best method was to pour water into the inlet pipe whilst holding the outlet pipe at a higher elevation (to prevent water flowing through the outlet pipe). Pouring water straight through check valve whilst holding it open is very laborious so we added a T-junction just upstream of the check valve fitted to a funnel to pour water through for priming. A plastic bottle was an effective funnel and some whittled wood was an effective cork.	

3.3 Pump Testing Period 2

After making improvements to the pump we met with Mr Msiska and Siame to discuss the next round of pump testing. It was decided that the pump should return to Chandero so that we could compare the feedback from the farmers to that which they gave before the pump improvements. As we felt the irrigation area was too large for the output of the pump we agreed to split the site into separate zones and rotate the pump between each. We agreed to split the pump between the two irrigation plots at Chandero with each plot using the pump on alternate weeks. We also agreed that they would use the pump until the end of the dry season. We handed Siame a series of feedback forms to be completed every day by a member of the group.

After rectifying an initial issue with air entering the pipes through the pump outlet we left the pump and the mountain bike in their hands. We agreed that after a time they would use their own local bicycle. However since, at their insistence, we left the mountain bike with them there is no guarantee that there will be feedback on using the irrigation pump with a fixed gear (local) bicycle. We hope to receive the feedback in March 2016 to help determine the next steps for the project.

4. Field Research: 'Examining Hopes and Aspirations for Irrigation Scheme Users in Nkhata Bay District'

After the field-testing and improvements were complete, we moved onto the second stage of the project. Once ethical approval had been granted, one member of the team had a little over 3 weeks in which to interview the preliminary target of 100 farmers using a pre-determined closed-answer questionnaire. Although the students were only able to visit on weekends, it was hoped that visits to irrigation schemes could happen during the week using government field officers as translators instead. Unfortunately progress on this front was a lot slower than expected due to the work commitments of D.G Siame (AEDO) and his boss Chester Msisika (AEDC), so it was arranged that research would continue independently from EWB-UK with the government and Mzuni continuing to work in partnership. In total 120 farmers at 9 irrigation schemes within the district and 2 senior government co-ordinators were interviewed. The University of Mzuzu is currently analysing the collected data and comparing it to previous research in the area in order to determine data quality and publish conclusions by the end of March.

4.1 Future Research

Although remote research is now finished, there remains considerable scope for future research. Although the Nkhata Bay District will have been very well covered by this point, other nearby districts will have very different conditions and subsequent irrigation needs.

For example, the control group of Limphasa EPA (a neighbouring district) was used to compare answers to Nkhata Bay EPA. The majority of the irrigation scheme members used paddy fields and gravity fed canals to grow rice, which was starkly different to the use of buckets and growing of maize found elsewhere so far. Although the interview answers the Limphasa rice growers gave were largely similar to other schemes, almost all of them had a strong preference for passive irrigation systems (like canals or solar pumps) rather than a tiring-to-use mechanical active system like pedal power or treadle pumps.

Improvised canals used with buckets in Nkhata Bay EPA (active system)

Official government scheme fed from a large dam in Limphasa EPA (supposed to be passive but secondary canals not working correctly)

Further research should be conducted to determine if the previous exposure to passive systems like paddy fields, weirs and concrete canals used to grow their rice influences the answers they give, or whether such a passive system is genuinely the easiest and/or best solution.

5. Future Steps

The feedback from the 2nd period of testing will help determine the next steps for the project. This is the first time the pump has been tested by farmers in Nkhata Bay for an extended period of time so the feedback will give us valuable insight into the appropriateness of this technology for small-scale farming in Nkhata Bay and the wider area. If the feedback is positive we can begin looking for a sustainable source of centrifugal water pumps and a sustainable method of manufacturing and selling the pedal powered pump locally. This will be lead by our partner in Nkhata Bay who has good knowledge of the local resources and manufacturing capacity.

Once the research paper has been published we will have a better idea for the most appropriate form of implementation for the pump, a concrete understating of the current irrigation implementation, and an approximate idea of technical, financial and water-resource constraints. This will aid in the development of a sustainable business model (if the 2nd testing period was successful) for the production of the pedal powered pumps. Our level of collaboration with the University of Mzuzu has been considerably strengthened by the research initiative and we hope to further build upon the joint project when the next group visits later this year in order to guarantee their future involvement with the project.

6. Note to Funders

We are extremely grateful for your support in covering these costs, without which our trip would not have been possible. We hope you will be satisfied with how the donations were used and will continue to support the project going forward. We will keep you updated with the progress of the research paper and the overall project. Please do not hesitate to contact us at committee.sheffield@ewb-uk.org for more information.

Appendix A - Breakdown of Costs

Below is a breakdown of the costs incurred on this trip.

Item	**Amount (£)**
Airfares	£1787
Vaccinations (exc. Antimalarials)	£0
Antimalarials	£140
Visas	£16
Partner Donation - Please outline all payments made to the partner and describe what these costs entailed eg. Turbine motor - £100 Etc. Use boxes below.	Accommodation - £350
Internal Travel (to attend workshops, showcases, to conduct research and to purchase parts)	£75
MzuzuUni Workshop food and travel for attendees	£150
Research Costs (inc research approval fee from NCST and travel and food allowance for 2 students and 2 government officials)	Research Approval: £100 Travel: £75 Food: £20
TOTAL	£2713