73RD INTERNATIONAL EXECUTIVE COUNCIL MEETING

24th ICID INTERNATIONAL CONGRESS 73rd IEC MEETING

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Theme: Innovation and research in agriculture water management to achieve sustainable development goals

24th International Congress on Irrigation and Drainage & 73rd IEC Meeting
3-10 October 2022, Adelaide, Australia

INTERNATIONAL WORKSHOP ON "THE WATER ENERGY FOOD NEXUS: IMPLEMENTATION AND EXAMPLES OF APPLICATIONS"

04 October 2022: 08:45-10:30 and 11:15 to 13:00 Hours
Adelaide, Australia

24th International Congress on Irrigation and Drainage & 73rd IEC Meeting
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SOLAR – POWERED MICRO – IRRIGATION DEMONSTRATIONS FOR FOOD SECURITY, YOUTH AND WOMEN EMPOWERMENT IN MALAWI AND ZAMBIA

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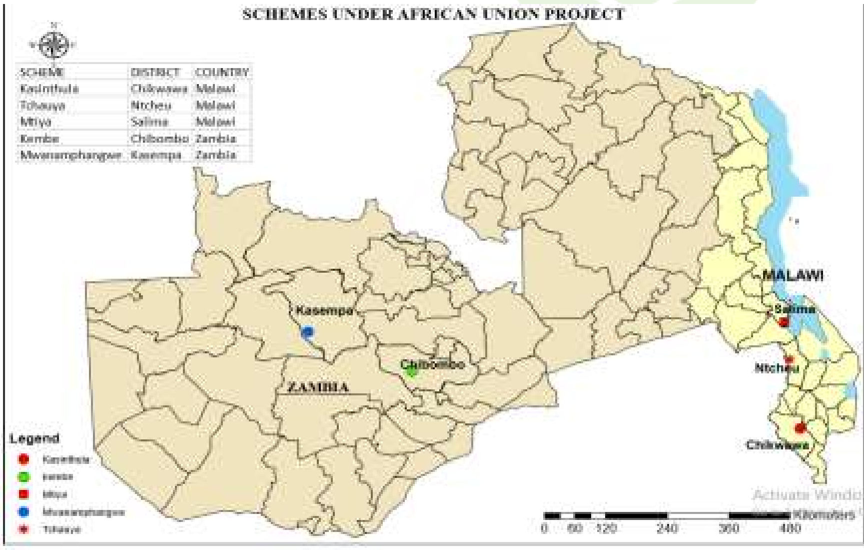
1. INTRODUCTION

- Achievement of Food security, one of the greatest need of Malawian and Zambian people, has been hampered by effects of climate change.
  - Drought
  - Floods
  - Rising temperature
- Irrigation is an option to cab drought effects on crop production, however, it is affected by shortage of diesel and electricity.
- Provision of efficient, cheap irrigation and reliable renewable energy technology would increase crop productivity and resource conservation as well as environment.
- This paper discusses the impact of solar-powered micro-irrigation demonstrations on food-water-energy nexus and how this empowered youth and women in Malawi and Zambia.

2. METHOD OF SOLAR-POWERED MICRO-IRRIGATION ESTABLISHMENTS

- Project Sites in Malawi and Zambia



Beneficiaries
DIRECT BENEFICIARIES –
• 228 where 142 were from Malawi and 86 from Zambia
INDIRECT BENEFICIARIES -
• 2,673 with 2193 from Malawi and 480 from Zambia

Household, Feasibility Study and Design

- A household surveys and focus group discussions was conducted at the beginning of the project and data was collected using open data kit (ODK) program and analysed using SPSS.

- Feasibility studies were conducted followed by topographic surveying (Figure 2) and mapping that provided detailed topographic maps and water courses.

- The maps were then used in designing and plac structures. Topography played a pivotal role on the conveyance and distribution methods in an irrigation

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2.4 Solar-powered micro irrigation system installation

- Six solar – powered irrigation system designs established (figures 3 - 8), three each country, Malawi (19ha) and Zambia (3h

Figure 3: Solar –Powered irrigation system.

Figure 4: Tanks storing water pumped b solar to irrigate by micro irrigation.

- The installation solar – powered irrigation scheme involved
  - drilling and flashing of a borehole for groundwater
  - installation of pumps,
  - solar panels,
  - erecting tank stands and mounting a tank,
  - drip irrigation equipment installation and finally the establishment of solar – Powered demonstration scheme fields.

Figure 5: Solar pump house.

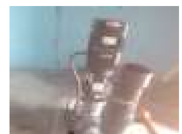
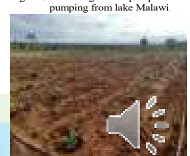


Figure 6 :Centrifugal solar pump pumping from lake Malawi



2.5 Training and capacity enhancement in solar-powered micro-irrigation crop production.

- Farmers were trained in crop production of various high valued crops as per scheme choice that included – banana, potatoes, common beans and tomatoes.

- At least 75 young farmers in Malawi were trained in agribusiness and group dynamics.

Figure 9 : Farmers learning solar-powered micro-irrigation operation by doing.

Figure 10 :Technical staff trained in design and installation of solar – powered micro – irrigation system.

2.6 Monitoring soil moisture changes under micro – irrigation using soil moisture sensors.

- Soil moisture sensors “Chameleon Readers/sensors” and wetting front detectors were installed at solar-powered micro-irrigation schemes in Malawi to monitor soil moisture changes (Figure 11-14).
- Installation of monitoring tools in the experimental plots comprised of
  - Set of soil moisture sensors which will help farmers to monitor the level of soil moisture in the field hence helping them to make a decision of when to irrigate their crops
  - Set of Wetting Front Detector (WFD) which would help farmers to determine the depth of water during irrigation hence help them to make a decision of when to stop irrigating during an irrigation event,
  - (3) Wi-Fi field reader which is connected to the soil moisture sensors and help the farmers to determine the level of soil moisture by observing the colors of the lights.

Figure 11 : Installing soil moisture sensor.

Figure 12: Monitoring soil moisture using chameleon sensor system.

Figure 13: Women highly participating in managing the water-energy-Food Nexus using sensors.

Figure 14 : Expetriate learning and policy maker involvement.

3.0 Experiences with solar-powered micro-irrigation and the water-energy-food-nexus in the demonstration

- **3.1 Baseline**
- Targeted project sites were characterized by a distribution of 60% male headed households and 40% female headed households where at least 60% are married couples, low education levels and with agriculture as the main source of income and livelihoods.
- Over 19% of the respondents indicated that they practiced irrigation during the dry season. Farmers expressed numerous benefits realized from irrigation as irrigation made them have more than one harvest, improved crop quality and yield and increased income.

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3.2 Solar-powered micro-irrigation impact on water – energy – food nexus

- Beneficiaries for the solar – powered irrigation system in both countries firstly observed the water and energy nexus when solar started providing them with energy in a remote areas without electricity to move water in its cycle - from its surface or ground source and then collecting and distributing it to the designated place for irrigated agriculture production.
- Solar-powered micro-irrigation helped rural farmers to become resilient to impact of climate change and their food security as water use efficiency and access increased.
- Solar-powered micro-irrigation combines efficient ways to manage water and energy for food production. Integration of the youths, creates employment for them as it is attractive as well as sustainable adoption of innovative technology.

Achievement of nexus was demonstrated on various crops grown using solar irrigation that included crops like banana, green maize, tomato, Onion, cabbage and leafy vegetables in both Malawi and Zambia (Figure 15 - 16).

Figure 15 : Banana under Micro-irrigation

Figure 16: Cabbage under micro-irrigation

- World Food programme has also reported that solar-powered irrigation scheme has gradually improved the food security, livelihoods and economic opportunities of the Domwe community in Malawi.
- The irrigation scheme is now providing more predictable yields and a more diverse diet, and the scheme has opened new business opportunities for some smallholder farmers in that particular area (Figure 17).

Figure 17: Sample of high tech: Solar-powered irrigation for climate-smart integrated resilience programme, supported by WFP and the UK in Malawi.

3.3 Impact of integrating soil moisture monitoring in solar-powered micro-irrigation system.

- The soil moisture monitoring system benefited the food – wate – energy nexus as follows:
  - Gave farmers new frames of reference in water and nutrient management;
  - Improved farmers on time, labour and water-saving by reducing irrigation intervals by 50%; and
  - Also reduced conflict for irrigation water by 75% between users apart from improving crop yield and water and nutrient use efficiency.
- This tool use expanded farmers' knowledge on water management, initiated a new way of thinking and alter their behaviour in water and energy use for crop production.
- Furthermore, the change in behavior led to measurable improvements in yield and financial outcomes among farmers.
- Youthful farmers were now able to identify irrigation related problems and act on the information provided by the soil moisture monitoring tools. As such, this action led to yield increase by more than 80 percent across all irrigation schemes and crops (Table 1).
- This also contributed to average gross margins increased by more than threefold across all schemes and crops (Figure 18). Based on the findings outlined, it can concluded that improving farmers' knowledge and skills in water-energy-food nexus is beneficial to both irrigators and the environment.
- It can transform smallholder irrigation schemes into profitable and sustainable investment.

Table 1: Change of average crop yields between pre and post introduction of soil moisture monitoring tools.

Crop	Average Yields (t/ha)			Percent of increase between Ave 2014-6 and 2018 yields (%)
	2014-16	2017	2018	
Maize	0.74	0.97	2.01	131
Maize	1.47	1.52	2.8	88
Beans	0.49	0.5	1.34	170
Maize	1.82	1.98	3.88	104
Beans	0.47	0.5	1.27	160
Maize	0.74	0.74	3.17	328
Beans	0.42	0.51	1.2	153

Note : 2014-16 = Average scheme yields before farmers started using soil water monitoring tools (source: Agricultural production estimate survey (APES) 2014-2016).

3.4 Solar-powered micro-irrigation impact on youth and women empowerment

- The SPIS demonstrations provided direct employment and business creation to the youths and women.
- The SPIS also led to social pacification, youth and elderly women as well as men and women worked together.
- The youths either worked in the agricultural sector or civil works on solar – powered micro – irrigation scheme establishment whilst others worked in the agribusiness sector, selling the produce from the solar-powered micro-irrigation schemes.
- WEF is source of joy to women in Africa.

3.5 Opportunities and challenges revealed by solar-powered micro-irrigation demonstration.

3.5.1 Opportunities and advantages of solar-powered irrigation in Malawi

- Solar-powered irrigation is independent (flexible and accessible) in remote areas where there is no access to electric and diesel.
- Solar- powered irrigation help to mitigate climate change by reducing gas emission.
- Solar-powered irrigation increase resilience and adaptation to climate change impacts.
- Solar – Powered irrigation is more profitable than electrical and diesel powered irrigation in remote areas.

3.5.2 Challenges of solar-powered micro-irrigation system in Malawi and Zambia

- Limited capacity in terms of personnel and equipment for solar – powered micro-irrigation.
- Limited financing and coordination in the solar-powered irrigation projects among state actors

CONCLUSION AND RECOMMENDATIONS

- This project demonstrated that solar-powered micro-irrigation system is clean technology option for water-energy-food nexus, allowing the use of solar energy for water pumping for food production, replacing fossil fuel as energy source and reducing gas emission from irrigated agriculture.
- It is one of the combined practices that farmers can use to save energy directly and to use water more efficiently and effectively whilst empowering the youths and women.
- In addition, farmers can apply soil moisture sensor technology to monitor the changes of moisture for next irrigation and can also change cropping patterns that require less water, while others could improve irrigation practice to make more efficient use of water.
- Conservation of energy is more cost effective with improved selection and maintenance of irrigation facilities that reduce pump size requirements and improve overall efficiency of the system like micro – irrigation system.
- It can be concluded that combination of efficient water and energy use is the best Water Energy Food Nexus in Africa. It can help many farmers to achieve food security and sustainable Agriculture regardless climate change.

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CONCLUSION AND RECOMMENDATIONS

- For this to be achieved, the following recommendation need to be taken care of by the governments:
  - Since the potential for energy saving is so great in sustainable agriculture intensification for food security, research on Water-Energy-Food nexus should receive high priority as it target high returns from low input and low – cost approach.
  - Capacity building of farmers and technical professionals on the effective use of solar pumps and groundwater management.
  - Promoting water use efficiency by 1) combining solar pumps with micro-irrigation technologies like drip systems; 2) leveraging surface water sources and creating water storage capacity, 3) Advancing monitoring soil moisture using soil moisture sensors and 4) promoting regular cleaning and maintenance to prevent leakages and breakdowns.
  - Establish formal coordination mechanisms on solar-powered irrigation, such as interdepartmental bodies and convergence and steering committees for WEF nexus policies.
  - Explore financing schemes or partnerships with financial institutions, such as banks, to help finance subsidies through the Agriculture Infrastructure Fund and scale up implementation.

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