FOSTERING TRANSNATIONAL RESEARCH, INNOVATION AND EDUCATION THROUGH AN INTERNATIONAL EUROPE AND AFRICA COLLABORATION PROJECT

I. Mocanu[1], O. Cramariuc[1], K. Bierwirth[2], H. Lebik[3], B. Kodom[4], M. Mecklin[5]

[1]Centrul IT pentru Stiinta si Tehnologie SRL (ROMANIA)
[2]Institut für Sozialforschung und Sozialwirtschaft (iso) e.V. (GERMANY)
[3]Unité de Développement des Equipements Solaires, UDES/EPST- Centre de Développement des Énergies Renouvelables (ALGERIA)
[4]University of Lomé, Laboratory of Apply Hydrology and Environment (TOGO)
[5]Tampere University (FINLAND)

Abstract

In this paper, we are presenting an overview of the LEDSOL project along with the strategies for user-involvement and expected input for the technological design and impact evaluation are presented in this paper. LEDSOL is a transnational project which aims to foster long-term collaboration between African and European organizations on sustainable and affordable technologies to provide off the grid clean water by using a smart portable unit based on UV/LED disinfection augmented with classical decontamination and powered by renewable energy sources. As part of the development a user-centered approach to technology development is implemented. For this purpose, a needs analysis with qualitative survey methods is conducted on site at the beginning of the project. A multidisciplinary consortium comprising partners from Algeria, Togo, Romania, Germany and Finland is gathering the needed expertise for the project implementation and for reaching the objectives set up in the proposal.

Keywords: Europe-Africa collaboration, renewable energy, clean water, university education, user-centered design.

1 INTRODUCTION

Access to clean drinking water is both a human right and part of the Sustainable Development Goals of the United Nations [1]. Safe and clean drinking water is vital to human life but access to drinkable water is not a standard in many countries around the world. Especially in remote areas like rural zones in Africa, people often only have access to water sources such as self-constructed wells or boreholes which are contaminated by bacteria and germs. Another factor that exacerbates water scarcity is the increasing climate change with extensive periods of drought or other extreme weather conditions. In Africa, one in three citizens is affected by water scarcity and about 400 million people do not have access to drinking water. In order to obtain water, people must travel long distances on partly dangerous roads.

The LEDSOL transnational project aims at contributing to the initiative of the European Commission and the Horizon 2020 program of fostering long-term collaboration between Europe and Africa in the framework of sustainable research and innovation in renewable energy. Energy is a key driver of national development and energy access is crucial to the delivery of fundamental services such as healthcare and education. At the same time, providing reliable and safe water will help unlock economic potential by allowing time for education, work and imagination. The World Water Day (www.worldwaterday.org) aims to bring global attention to the world’s freshwater resources and to emphasize that access to clean water has enormous and complex value for households, culture, health, education, economics and the integrity of our natural environment.

Algeria, like all Mediterranean countries, is facing water stress due to climate change, growing population and water resources overexploitation [2]. The problem of supplying people with safe drinking water has been partially solved by the construction of 14 desalination plants along the coast in 2011. These cover the needs of safe drinking water for 84% and 81% of the urban and rural populations, respectively. However, desalination is a highly energy-demanding process and its availability in remote areas is poor. In inland regions, the populations who do not have access to water are forced to use existing natural resources (groundwater, surface water), although the quality of the latter may be inappropriate for human consumption. According to the National Agency of Water Resources, significant sections of rivers in the Tafna, Macta, Cheliff, Soummam and Seybous basins are polluted. This led to the cholera outbreak in 2018.

In Togo, the rate of effective access to drinking water in rural and semi-urban areas is 48% [3]. According to Worldometer, 36.9 % of the population of Togo does not have access to safe drinking water. Thus, people often drink untreated surface water which is under threat by contamination from natural sources and anthropogenic sources such as bad hygiene practices, bad pesticide utilization in agriculture and fishing, inorganic and organic fertilizers utilization in agriculture, oxen drink during transhumance etc. Currently, most diarrhoea-related deaths worldwide are explained by a lack of access to safe drinking water or a deficiency in personal hygiene. Diarrhoea is a leading killer of children in Togo, causing approximately 10% of deaths in children less than five years of age [4].

In the above context, and aiming to support clean water availability to the population relying on unsafe water sources, LEDSOL is aiming to foster long-term collaboration between African and European organizations on sustainable and affordable technologies to provide off-the-grid clean water by using a smart portable unit based on UV/LED disinfection augmented with classical decontamination and powered by renewable energy sources. A multidisciplinary consortium comprising partners from Algeria, Togo, Romania, Germany and Finland is gathering the needed expertise for the project implementation and for reaching the objectives set up in the proposal. By involving both industrial and academic partners, LEDSOL will contribute to enhanced university curricula, attractive positions for master and doctorate students as well as opportunities for the students to become acquainted with company-specific aspects related to commercialization strategies and business planning. A user-centred design will facilitate researchers and educators an in-depth exploration of the requirements, needs, constraints, and barriers of the targeted user groups. For this purpose, the project will employ mixed methods such as participant observation, focus groups and problem-centred, partially standardized interviews. Special attention will be paid to the improvement or facilitation of daily life through the improved availability of clean drinking water.

An overview of the LEDSOL project along with the strategies for user involvement and expected input for the technological design and impact evaluation are presented in this paper.

2 METHODOLOGY

As part of the development of an innovative, smart water decontamination system, a user-centred approach to technology development is crucial for optimized system development. For this purpose, a needs analysis with qualitative survey methods is being conducted on-site in a mixed-methods design consisting of participant observation, focus groups and problem-centred semi-standardized interviews with representatives of the addressed target group. The users' demands on the system will be determined based on their living circumstances, their daily routines as well as barriers and opportunities in their local living environment. Special focus will be put on social and economic aspects of water procurement and use, routines of the family division of labour, and social status and gender aspects will be included in the analysis which will be explored in the participating observation as well as by qualitative interviews and the focus groups.

The social science analysis allows for an in-depth exploration of the requirements, needs, constraints, and barriers of the targeted user groups, which in turn allows the water purification system to be developed in a need- and user-oriented manner. The human-centred design process ensures a targeted results-oriented approach to technology development that incorporates user needs and identifies and consequently minimizes system weaknesses. This guarantees the deployment of a needs-based and user-friendly water purification prototype in the real-world environment which will increase user satisfaction significantly.

3 RESULTS

3.1 LEDSOL overview and design

The LEDSOL project is developing a water disinfection unit incorporated in a backpack to be carried by individual users or transported in a vehicle capable of covering large areas to reach remote communities or needs (e.g., farms). The solar cells developed within the consortium ensure, along with wind energy whenever suitable, an autonomous unit which can cover both domestic and industrial (e.g., agricultural) needs of communities which rely on unsafe water sources. Pilot studies will be organized both in Africa (around Lomé; Tipaza and Blida) and in rural communities in Romania (Baragan area). In order to keep track of the water sources (including water properties) and the LEDSOL usage, enhanced wireless positioning and tracking algorithms are being proposed. A business to exploit the project results will foster long-term cooperation between Europe and Africa. The LEDSOL system is presented schematically in Fig. 1.

The system will comprise two water reservoirs of 20 l (e.g., 32x25x25 cm³) each; one will work as intermediate water storage and will be filled directly from the water source. A pipe with a rough filter and pump will be used for filling the intermediate reservoir with a flow rate of at least 5 l/min. A pump will transfer the water from the intermediate reservoir to the final one through the filter and disinfection subsystem with a flow rate up to 2 l/min. Classical water filters will be used prior to the disinfection unit which has a target processing capacity of 2 l/min. The solar panel will be used as an energy source along with a battery unit for energy storage. Digital and power electronics will ensure tasks like energy supply for pumps and UV-filter, localization, supervision, communication, etc. The device fully loaded with 20 l of water is expected to weigh approximately 24 kg, while its size would be roughly 75 cm height, 35 cm width and 30 cm depth. This is a reasonable weight to be carried even for hiking or tracking trips [5].

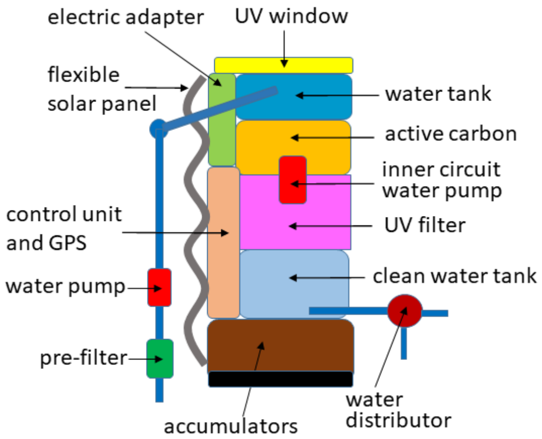

Figure 1. Schematic representation of the LEDSOL system.

The system is developed to be cost-efficient and self-sufficient. Thus, besides production costs only relatively low maintenance costs are expected. The backpack, reservoirs, classical filters, pipes, and other small parts are expected to cost about 80 EUR at the current retail price. E.g., one 20 l reservoir can be acquired for about 14 EUR. The two pumps cost approximately 50 EUR in total. A portable solar panel capable to provide power of up to 100 W costs roughly 120 EUR. All prices are estimated based on the prices available on the European market, e.g., via the Amazon Europe online store. The costs of the UV module are dominated by those of the LEDs. For a processing capacity of 2 l/min we estimate the need for 12 UV-C LEDs with a total UV flux of 240 mW, 4 UV-B LEDs amounting to 80 mW of UV radiation and 1 UV-A LED of 850 mW. The total cost of these LEDs is approximately 85 EUR, based on a price offer from the manufacturer. The estimated power consumption is 14 W. The LEDs can be driven directly from the battery by using constant current LED drivers. We estimated the cost of these parts to approximately 15 EUR. The battery should be able to sustain the filtering and disinfection by itself with 50% of its capacity. Considering the power needed during this process to be 30 W and a duration of 10 minutes, one can assess that under the above-mentioned conditions a 12 V battery needs a capacity of about 1.7 Ah. A laptop battery exceeding this needs costs about 24 EUR. The charge controller for connecting the solar panel to the battery costs approx. 20 EUR. Finally, digital electronics are estimated to cost approx. 100 EUR. Thus, the total cost of the device with parts at retail prices is approximately 500 EUR. It is important to note that wholesale prices can be 50% of the retail prices and that some components such as UV LEDs and solar panels are expected to decrease in price in the next years. Thus, we can expect a production cost of 250 EUR per system or even less.

Besides the technological development, LEDSOL is also addressing basic scientific research in terms of developing low-cost low-energy positioning algorithms to support the portability and sustainability of the proposed system, as well as enhanced multi-system and multi-frequency GNSS receiver algorithms. The latter will deal with increased ionospheric delays and higher scintillations in African regions close to Equator, to combat/mitigate various interference sources such as jammers, spoofers, multipaths, and to deal with deep forest canopies (e.g., water sources inside jungle forest) and hilly terrains with heavy reflections, where traditional single-system single-carrier solutions are not enough to cope with low Carrier-to-Noise (CNR) ratios. In multipath- and interference-rich scenarios, the hybridization of Medium

Earth Orbit (MEO) GNSS with Low Earth Orbit (LEO) signals are studied for enhanced coverage and positioning accuracy as well as enhanced robustness to interference. Mega LEO constellations such as OneWeb, SpaceX Starlink, and Amazon Kuiper are already offering good coverage towards Equatorial regions and this coverage is likely to be improved in the near future with new launches of LEO satellites in the sky. The LEO-MEO combination could increase the accuracy of positioning also under low CNR conditions such as those of water sources inside the deep jungle and surrounded by hilly terrains.

We will study both standalone GNSS and GNSS-LEO positioning receiver algorithms and we will offer novel positioning algorithms and theoretical models more adapted to the challenges of the African landscape. The cost efficiency of the positioning methods and their sustainability, when powered by flexible solar cells, will also be investigated. The target outcomes are to offer new or enhanced positioning algorithms able to deal better with multipath- and interference-rich scenarios.

3.2 User involvement strategy

The needs analysis will be carried out in Algeria and Togo on-site. In both countries, an urban and a rural study setting were identified which require different approaches due to the different social contexts but will allow exploring the water procurement process in different living conditions. For the interviews, a semi-standardized questionnaire based on the Water/sanitation, Assets, Maternal education, and Income -Index (WAMI) and the Household Water Insecurity Access Scale HWIAS was created [6],[7]. Additionally, questions regarding age, sex and living conditions were added to be able to distinguish between subgroups within the sample. Transnational studies imply the consideration of and the adaption to cultural differences. Therefore, modified and individualized questionnaires for Togo and Algeria were created. The questionnaires include aspects such as water and sanitation; availability of water; maternal education; income; technology usage.

A protocol for the participating observation was developed and the recording media was defined. The focus groups will consist of local experts like community speakers and members of Non-Governmental Organizations as well as local people. Guidelines to structure the focus group were formulated. The triangulation of the results from qualitative and partially standardized survey methods will provide a comprehensive evaluation of user needs and the resulting technology requirements. The knowledge gained from this will form an important basis for the development of the technical system. After implementation and model testing, the user experiences and the outcomes targeted in the project will be evaluated in a downstream mixed-methods survey on-site. Special attention will be paid to the facilitation of everyday life and the development of quality of life through the improved availability of clean drinking water.

4 CONCLUSIONS

In this paper, we are presenting an overview of the LEDSOL project along with the strategies for user involvement and expected input for the technological design and impact evaluation are presented in this paper. LEDSOL is a transnational project which aims to foster long-term collaboration between African and European organizations on sustainable and affordable technologies to provide off-the-grid clean water by using a smart portable unit based on UV/LED disinfection augmented with classical decontamination and powered by renewable energy sources.

According to the World Health Organization (WHO), 1.1 billion people suffer from diseases caused by polluted water, the majority of whom live in Africa and Asia. These are diseases such as diarrheal diseases such as cholera, typhoid fever and dysentery, and other water-borne tropical diseases. About 90% of child deaths are due to diseases caused by contaminated water. In addition to that, reliable access to drinking water is directly related to cultural and social development and economic growth. Women are often responsible for the process of obtaining water, which is an obstacle to cultural and social progress in developing countries. After all, women are also responsible for raising children and managing the household, and they usually also take care of the elderly. It is not uncommon for children to be hired for these activities when their mothers are absent, or they must fetch the water for their family. This in turn leads to the fact that children cannot go to school regularly because they must take care of family obligations.

With this in mind, and aiming to develop a product suitable for its target users, the LEDSOL project is implementing a user-centered approach to technology development. For this purpose, a needs analysis with qualitative survey methods is conducted on-site at the beginning of the project. A multidisciplinary consortium comprising partners from Algeria, Togo, Romania, Germany and Finland is gathering the needed expertise for the project implementation and for reaching the objectives set up in the proposal.

ACKNOWLEDGEMENTS

This work was supported via the LEAP-RE Program by: (1) a grant of the Romanian Ministry of Research, Innovation and Digitization, CNCS/CCCDI - UEFISCDI, project number COFUND-LEAP-RE-LEDSOL, within PNCDI III; (2) Academy of Finland (project #352364), who is gratefully acknowledged; (3) the Ministry of Higher Education and Scientific Research (MESRS) – Algeria; (4) the German Federal Ministry of Education and Research (BMBF), FKZ 03SF0681; (5) Université de Lomé in Togo.

REFERENCES

[1] United Nations. (2022). Goal 6 | Department of Economic and Social Affairs [online] https://sdgs.un.org/goals/goal6 [retrieved on 29.07.2022].

[2] R. Masmoudi, A. Kettab, B. Brémond, "Drinking water consumption and loss in Algeria the case of networks with low level counting", *Journal of Urban and Environmental Engineering*, vol. 10, no. 2, pp. 162–168, 2016.

[3] M. Yomo, K.A. Mourad, M.D.T. Gnazou, "Examining Water Security in the Challenging Environment in Togo, West Africa", *Water*, vol. 11, no. 2, pp. 231, 2019.

[4] G.D. Demissie GD, Y. Yeshaw, W. Aleminew, Y. Akalu, "Diarrhea and associated factors among under five children in sub-Saharan Africa: Evidence from demographic and health surveys of 34 sub-Saharan countries", *PLoS One*, vol. 16, no. 9, pp. e0257522, 2021.

[5] M. Oshea, "Backpack Weight and the Scaling of the Human Frame", *The Physics Teacher*, vol. 52, no. 8, pp. 479-481.

[6] S.R. Psaki, J.C. Seidman, M. Miller, M. Gottlieb, Z.A. Bhutta, T. Ahmed, A.S. Ahmed, P. Bessong, S.M. John, G. Kang, M. Kosek, A. Lima, P. Shrestha, E. Svensen, W. Checkley, "MAL-ED Network Investigators. Measuring socioeconomic status in multicountry studies: results from the eight-country MAL-ED study", *Population Health Metrics*, vol. 12, no. 1:8, 2014.

[7] A.C. Tsai, B. Kakuhikire, R. Mushavi, D. Vořechovská, J.M. Perkins, A.Q. McDonough, D.R. Bangsberg, "Population-based study of intra-household gender differences in water insecurity: Reliability and validity of a survey instrument for use in rural Uganda", *Journal of Water and Health*, vol. *14, no.* 2, pp. 280-292, 2014.