Harnessing Fog Harvesting Technology for Water Sustainability in Sub-Saharan African Humanitarian Shelters

Maria Giovanna DI BITONTO*, Nathaly Michelle RODRIGUEZ TORRES*, Nicolò Elio GIORGETTI*, Alara KUTLU*, Alessandra ZANELLI*

*ABC Department, Textile Architecture Network, Politecnico di Milano
mariagiovanna.dibitonto@polimi.it, nathalymichelle.rodriguez@polimi.it, nicoloelio.giorgetti@mail.polimi.it, alara.kutlu@polimi.it, alessandra.zanelli@polimi.it

Harnessing Fog Harvesting Technology for Water Sustainability in Sub-Saharan African Humanitarian Shelters

Maria Giovanna DI BITONTO*, Nathaly Michelle RODRIGUEZ TORRES*, Nicolò Elio GIORGETTI*, Alara KUTLU*, Alessandra ZANELLI*

*ABC Department, Textile Architecture Network, Politecnico di Milano
mariagiovanna.dibitonto@polimi.it, nathalymichelle.rodriguez@polimi.it, nicoloelio.giorgetti@mail.polimi.it, alara.kutlu@polimi.it, alessandra.zanelli@polimi.it

Keywords: fog harvesting, emergency shelters, sustainable water resources, lightweight design

Abstract

This research focuses on an innovative project in Sub-Saharan Africa aimed at improving water sustainability in humanitarian shelters. The primary goal is to enhance existing emergency tents by integrating fog harvesting systems, ensuring a dependable water supply for camp residents. Fog harvesting, a proven technique in various regions, including Africa, holds promise in addressing water scarcity in these areas. The project aims to seamlessly integrate fog harvesting technology into the design of emergency tents, creating what's known as a Smart Water Collecting Envelope (SWCE). This concept incorporates fog collectors into shelter envelopes, promoting self-sufficiency in water supply. By efficiently capturing and storing water from foggy environments, these shelters can address the critical issue of limited water resources crucial for the well-being of displaced communities. The implementation of fog harvesting technology was tested on Multipurpose tents, with a prototype of ten units evaluated by the Senegal and Luxembourg Red Cross delegation. This involved designing hinges that could be added to existing tent joints without altering their configuration. These hinges enable the insertion of fog mesh, which serves as a fog collector during fog events and provides shading during sunny periods, reducing radiation and enhancing comfort for camp inhabitants. The fog collectors, known as Large Fog Collectors, are cost-effective textile-tensile structures comprising mesh, poles, and cables. This practical solution harnesses water from fog, utilizing vertical space in tents to meet basic human needs. The SWCE concept offers additional benefits, including shading effects, reduced need for cooling systems, lower energy demand, and a smaller ecological footprint in camps. Depending on fog liquid water content, the collected water can cover basic needs and potentially extend to domestic uses, improving the quality of life for sheltered populations. In summary, this project seeks to revolutionize water sustainability in Sub-Saharan African humanitarian shelters by integrating fog harvesting technology into emergency tents. The SWCE concept not only ensures a reliable water supply but also provides shading and environmental benefits, ultimately improving the lives of displaced communities.

Introduction

The global water crisis is a pressing issue that transcends borders and affects millions of people worldwide. Access to clean and safe drinking water is a fundamental human right, yet a significant portion of the global population continues to grapple with water scarcity and contamination (Tiwari et al., 2022). While this crisis is pervasive, it is particularly acute in the Sub-Saharan region of Africa, often marked by arid landscapes and erratic rainfall patterns, where water scarcity has become a relentless adversary (Schiller, 1992; Almer et al., 2017). According to the UNHCR (2022), the Sahel region of Africa faces one of the most tragic and fastest-growing displacement crises in the world. Unyielding and indiscriminate violence has forced countless people to abandon their homes and pushed them to seek refuge within their own nations or venture across borders in search of safety. Refugee camps are established to provide refuge and support to the displaced populations, often fleeing conflict, natural disasters, or other crises, who find themselves in precarious living conditions where access to clean water is far from guaranteed. Overcrowded camps, strained infrastructure, and limited resources exacerbate this dire situation, leading to water conflicts and disease burden, mainly due to incomplete or poor water supply and sanitation (Cronin et al., 2009). The consequences are severe, with compromised hygiene, sanitation, and overall well-being for those seeking refuge in these shelters (Zerbo et al., 2020). Due to its temporary nature, adaptable and sustainable solutions are required to meet the basic needs of residents, including access to safe water.

One promising technology that offers hope in addressing the water crisis within African camps is atmospheric water harvesting technology. This technology is used to capture water coming from rain, dew, and fog. Fog catchers are innovative systems designed to capture moisture from the air, particularly in regions with high humidity and persistent fog. These mesh-like structures trap water droplets from passing fog, which then condense and accumulate into usable water (Klemm et al., 2012). Rain catcher technology is a system designed to capture and store rainwater for various uses, including irrigation and drinking water. Dew catcher technology is a passive moisture collection system that extracts water from the atmosphere through condensation (Jarimi et al., 2020). By harnessing this atmospheric water source, the water catchers can provide a consistent and reliable supply of clean water to displaced populations, reducing their dependency on already-stretched local resources and alleviating the burden of waterborne diseases. This eco-friendly technology not only addresses immediate water needs but also contributes to the resilience and self-sufficiency of emergency camps, creating spaces of community and coexistence in Africa's most vulnerable populations.

Knowing the critical importance of addressing water accessibility, quality, and sustainability challenges emerging within emergency camps in sub-Saharan Africa. The proposal presented in this paper aims to guarantee the basic human right to water for displaced populations and to promote resilience and sustainability in regions that are already burdened by water-related problems.

Atmospheric water harvesting technique has been successfully employed in regions of sub-Saharan Africa (Eritrea and central Tanzania), where environmental conditions are suitable. This paper delves into the details of this innovative approach, presenting the design and implementation of atmospheric harvesting technology within pre-existing emergency shelters, using the *Multipurpose Tent* as the case study. Through practical and cost-effective solutions, this research demonstrates how atmospheric harvesting technology can harness the top space of tents to provide for the basic human needs of camp inhabitants, offering hope and improved living conditions of displaced communities in Sub-Saharan Africa in humanitarian shelters.

Location and its conflicts

Sub-Saharan Africa is the region located south of the Sahara Desert. The Sahel is a transitional belt within Sub-Saharan, spanning from the Sahara Desert in the north to the Sudanese savanna in the south, and from the Atlantic Ocean in the west to the Red Sea in the east. It includes countries like Gambia, Senegal, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, South Sudan, Cameroon, and Eritrea. The Sahel has a history of recurring droughts, with recent ones being more frequent and severe (Xue & Shukla, 1993).

In Africa, the Sub-Saharan region is recognized as the most susceptible to the impacts of climate change (Ringler et al., 2010; Thompson et al., 2010). This vulnerability arises from the region's exceptionally low adaptive capacity, primarily attributable to widespread poverty and a lack of requisite infrastructure for addressing and adapting to shifting climatic conditions (Ringler et al., 2010).

The last decades have seen the development of severe drought in sub-Saharan Africa, however, since the 1980s, there has been a positive development in the Sahel's climate. Summer rainfall in the region has been on the rise, leading to what is commonly referred to as a 'greening' of the Sahel. This increase in rainfall can be attributed to changes in the African easterly jet, which is known to induce wet anomalies. A study in 2011 found that shifts in the position of the African easterly jet and African easterly waves have accompanied the northward migration of the Sahel rainband, contributing to the observed increase in rainfall (Wang & Gillies 2011).

Repeated poor harvests, droughts, and pest infestations drive up food prices and push families to leave their homes, sell or slaughter livestock, and deplete food stocks earlier than usual. In Niger, cereal production has dropped by 30%, and Chad's last harvest yielded 34% less grain than needed to feed the nation, leading to the establishment of several refugee camps (Vogel, 2010).

Climatic and topographical conditions for atmospheric water harvesting

Rainwater, a clean and sustainable source, can be easily harvested using systems like rain barrels and cisterns with minimal environmental impact. Its use alleviates stress on conventional water sources, reduces treatment needs, and mitigates flood risks, making it a vital solution for water scarcity and environmental concerns. Another alternative source of water is fog. Fog is a natural phenomenon that consists of water droplets suspended in the air, it is classified depending on its formation process. Usually, the fog suitable for fog harvesting is Advection fog and Orographic fog, which can be found in coastal desert regions and cloud forests.

In Sub-Saharan Africa fog is primarily associated with coastal areas and highland regions. Coastal regions along the Atlantic and Indian Oceans, such as those in West Africa and parts of East Africa, experience occasional fog events, particularly during the cool, dry seasons. Highland areas, including Ethiopia's highlands, exhibit a higher frequency of fog formation, primarily due to their elevation and temperature gradients. It is important to note that fog frequency and density vary across sub-Saharan Africa, making localized assessments essential. Moreover, another area associated with fog formation are the Cloud Forest, which can be found in in Cameroon. Several projects have been developed in these forests, especially the ones located in Ecuador (Carrera-Villacrés et al., 2017). The potential for fog harvesting technology is largely dependent on the presence and persistence of fog in specific regions. Fog collectors can effectively capture water droplets from fog, providing a sustainable source of freshwater. While such collectors have been successfully employed in various global contexts, their implementation in the Sahal region remains limited. Several projects have been developed in Africa, especially in Morocco, South Africa, Ethiopia, Namibia, Kenya and Eritrea, the latter one is part of the Sahal climate.

Socio-economic impact of the technology

Although the introduction of fog collection technology in many countries has often relied on foreign assistance, users can readily embrace its technical implementation and operation. For this to occur, it is imperative that beneficiary communities recognize this technology as a viable alternative to conventional methods and actively engage in the project.

In many cases, the development of fog harvesting projects resulted in the empowerment of the community and the rise of local economies. Since the primary reason for the rise of refugee camps is the migration due to lack of food, the atmospheric water collected could be used for the development of horticultural activities.

In rural communities where a local source of water is lacking, women often bear the arduous responsibility of fetching water, a task that is both physically demanding and time-consuming (Marzol & Megía, 2008). This demanding chore frequently results in girls being unable to attend school. However, the introduction of fog harvesting projects in such areas can have profound social impacts, particularly in empowering women, as demonstrated in the project developed in Boutmezguida and Ifini, Morocco (Marzol & Megía, 2008). Di Tullio (2023), in her study developed in a community of Peña Balanca (Chile), highlights the importance that the introduction of the fog harvesting project had in the emerging economies administrated by women. These projects provide a sustainable and local source of water, thereby alleviating the burden on women and girls and freeing up their time for education and other pursuits. This transformation can lead to a significant societal shift, promoting gender equality and expanding opportunities for women.

Likewise, the fog collector project in Eritrea places significant emphasis on its social aspect, recognizing the pivotal role of beneficiary communities in its success. The project's effectiveness is gauged through these communities' active participation in installing and operating the fog-harvesting system, ensuring that their voices and needs are at the forefront. Equally important is the cultivation of a sense of ownership and acceptance of this innovative technology as a viable water supply system among the beneficiaries. By soliciting their preferences regarding alternative water supply systems, the project aims to align its efforts with the community's desires, thus enhancing its sustainability and potential for future expansion. This approach addresses water scarcity and fosters community engagement and empowerment, marking a significant step towards a more sustainable and water-secure future in Eritrea (Fessehaye et al., 2017).

Proposal

The proposed emergency camp is organized in blocks (Figure 1). The block is made up of 8 tents that provide shelter for 60 people, and it is equipped with toilets and a water distribution system with taps. It is used as an infinitely repeatable module to be calibrated according to local needs. To maximize the collection efficiency of the fog collectors, the block and the emergency field must have a development suited to the climatic characteristics of the locality in which it is located.

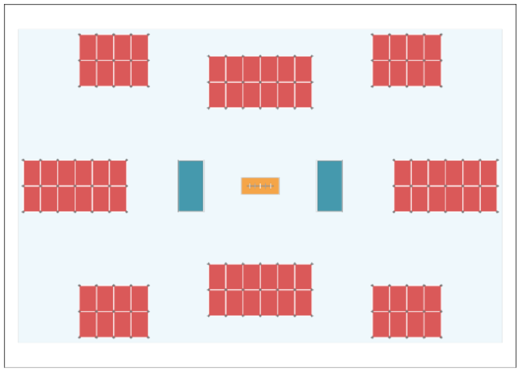

Fig 1. The block with tents (red), sanitary facilities (blue) and a water distribution system (orange).

The tent examined for the project proposal is the T2 Multipurpose tent produced by Ferrino and designed for the Speedkit project by the Textile Architecture Network (TAN) of the Politecnico of Milan: the final product can be used for many functions and purposes such as storage, hospital, dispensary, school or office. The complete shelter design procedure was carried out following several requirements such as MSF, IRC and IFRC standards which are widely applied in the emergency field. The ground area of the covers a total of 48 m2 (or 75 m2 for the larger version), the components and materials are specified in Table 1**.**

	Structural frame	Crosspiece junction	Tent mesh	Shading / Rain collector mesh	Fog collector junction node	Fog collector structure	Fog collector mesh
Element	32 poles $\emptyset\ 35mm$	15	1	1	5	5 poles $\emptyset\ 35mm$	4
Material	aluminum	steel	Nylon - PVC	Polycotton	steel	aluminum	Raschel
Dimension	55 m	-	136 mq	60 mq	-	12.5 m	20mq

Table 1. Quantity and materials for the construction of the multipurpose tent with the fog collector

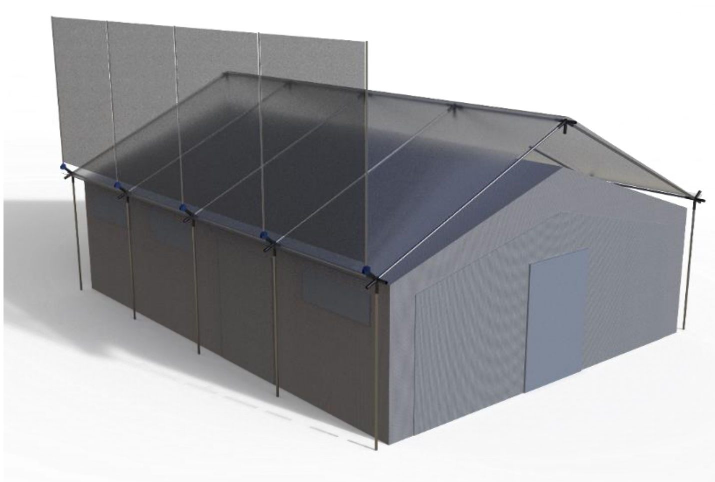

Fig 2. Multipurpose tent with fog collector and rain collection mesh.

The proposed innovation in the shelters is based on the integration of the fog harvesting device thanks to a special joint, can be attached to the already existing tent without modifying it. In this way the atmospheric water collector can be integrated in new camps but also in the already existing ones. The Fog collecting mesh can be used with a dual function: thanks to the presence of hinges and pulleys, the structure can be positioned both vertically, during the night hours to capture the fog; and horizontally, favoring the shading of the tent and its surroundings during daylight hours. The positioning of the meshes, and consequently also of the fog collectors, must be strategic so that the flow of fog is not significantly slowed down or hindered by the first rows of collectors: therefore, having the possibility of varying the inclination of the meshes can be an advantage for the collection. The design is illustrated in Figures 2,3,4.

In contexts with a high probability of rain it is possible to use the outer layer of the tent as a rain collector, a gutter made of the same membrane will collect the water both from the fog collector and the roof.

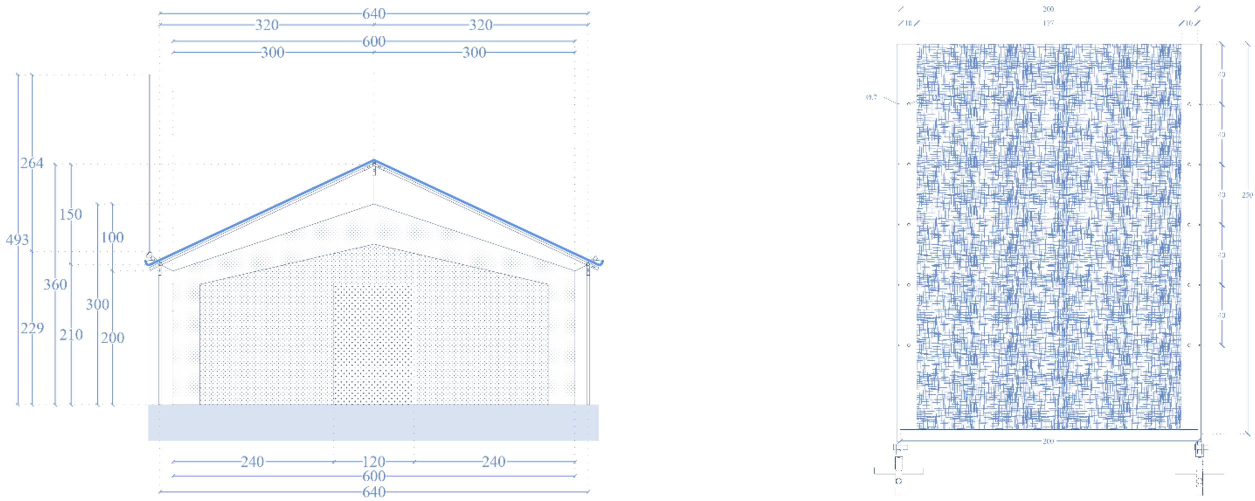

Fig 3. Technical drawings of Multipurpose tent and fog collector

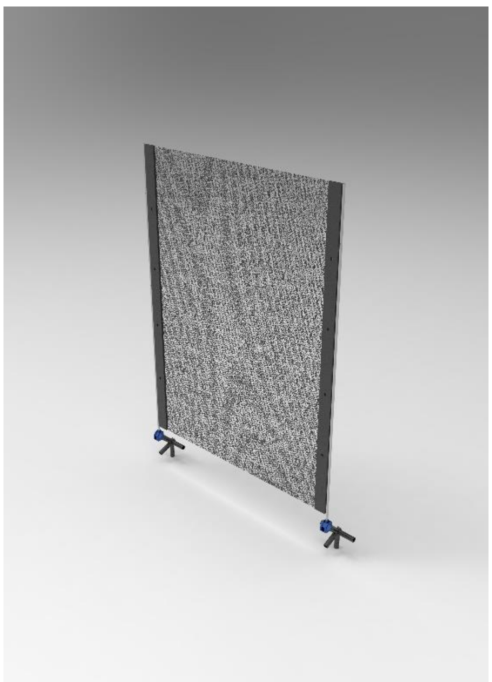
Fig 4. Three-dimensional view of the fog collector

Economic aspects

The estimation carried out for the production cost of the innovative tent proposal is based on studying the state of the art of a comparable product distributed for the same purposes of emergency camping, with the goal of providing a price quotation that falls within an acceptable range. The reference of this study are the multipurpose tents distributed by UNICEF during their various operations of humanitarian response activities, including three different sizes of: 24m², 42m² and 72m², fit primarily for use in moderately hot climates and maximum wind forces of 75km/h. (UNICEF, 2017) Recently, a lack of meeting with the actual site requirements, which are brought to table with the changing needs of different disaster types and locations, was pointed out by the organization. UNICEF launched a communication for types of products that could narrow the gap between what is distributed and what is needed, mainly because the unmet requirements are claimed to reduce the effectiveness of their operations. These products are indicated as add-ons to the existing multipurpose types distributed, since UNICEF does not include them in the available tent kits. Target unit cost of the multipurpose tents and add-ons were quoted by the organization, with foreseen prices ranging from ideal to maximum (Table 2).

	Maximum (in USD)	Ideal (in USD)
Multipurpose tent with standard liner	1200/1750/2550	950/1350/2000
Add-on 1: Winter liner	650 / 920 / 1300	300 / 400 / 600
Add-on 2: Inner liner	200 / 270 / 400	120 / 160 / 240
Add-on 3: Hard floor	1000 / 2000 / 3000	720 / 1440 / 2160
Add-on 4: Solar lighting kit	180 / 360 / 540	100 / 200 / 300
Add-on 5: Electrical lighting kit	100 / 200 / 300	50 / 100 / 150
Add-on 6: Partitioning kit	40	15

Table 2 – Price table with columns x,y,z indicating the ranges of the various UNICEF tents, following the order of sizes: 24 m², 48 m² and 72 m² - Source: UNICEF, 2017

Unlike UNICEF's multipurpose, Ferrino tent already includes the add-in layers listed above, such as its shading mesh layer (Table 1. Quantity and materials for the construction of the multipurpose tent with the fog collector) which is the same of solar lightning kit. To establish a baseline for the cost of the proposal in this paper, the best strategy would be to keep the price of Ferrino within the UNICEF standard multipurpose tent price ranges. The estimated price would be approximately corresponded maximum to €5.500, where the calculation is based on the middle-sized product (48 m²) and considers the additional prices of add-ins since Ferrino tent provides them within its standard kit. However, the price of the integrated fog collector device must be determined independently, based on the quantity and type of materials that will be employed in its manufacture. The calculation would be primarily parallel to the type of material chosen, where in the case of Raschel mesh it can be considered like the solar lighting add-on mentioned above in the Table 1, since it is simply made by a layer of mesh. From literature, the cost of a Large Fog Collector is estimated to be around $1500 (Qadir et al. 2018), it can be predicted that the integrated fog collection device in this proposal will have a total production cost corresponding approximately to the same amount, even though its size is smaller but it has more hinges.

To make the project financially viable, the minimum water price should generate revenue that covers both the initial and operational costs. The maintenance costs are considered irrelevant since the temporary shelters are installed for short-term periods. For the project, a lifespan of 10 years has been considered for the tents, which corresponds also to the life span of the Raschel mesh. The calculated minimum water price must equal or be lower than the current market price of water, which as be considered 3$ for 1m^3 (Fessehaye et al., 2015), for the fog water collection system to be deemed an economically feasible and competitive water supply solution.

The lifespan of ten years for the camps, therefore also for the shelters and the integrated fog collector, the cost of the integration of the atmospheric water collection is 150$ a year, the cost includes the materials and the installation and tanks.

Considering an annual fog collection of 3.1l/m^2/day, which means 1131.5l, considering the installation of 20m^2 mesh for each tent, it results in 18104l in a year for each tent.

Moreover, taking into consideration also the precipitation, which is in Eritrea an average of 350mm (Climate change Knowledge Portal, 2021), the collection of rainwater in a tent would be 16800l per year, corresponding to 46 liters a day.
The minimum required standard is 15l a day per person, summing up the fog water and the rainwater, each tent can provide the 5 people living in it with 19 liters daily.
In conclusion, a liter of water collected by the tent, composed of rain and fog water, will cost around 4,3$ per m^3 for ten years of installation. The price is higher than the current market price of water, but it must be taken into consideration that, currently, the reservoir of the distribution systems is filled from underground wells through pumps or water trucks, underground basins are not a reliable water resource, and these systems require energy to function, while fog harvesting is a passive system.

Discussion

In all emergency situations, water collected from alternative and uncontrolled water sources must be considered a priori unhealthy and at high risk for the health safety of the camp. To avoid worsening already critical situations, it is necessary to treat the water collected by the atmospheric water collectors with special filtering systems before introducing it into the central distribution system.
This eventuality does not lead to a risk for the health of the camp as the water is filtered and made drinkable in any case. However, it could be a problem for collection efficiency, as the presence of impurities could reduce the contact surface with the water droplets present in the fog.
Concerning the quality of fog water, several studies have been developed to investigate the suitability of fog-harvested water for drinking and they concluded that it consistently meets established potable water standards (Abdul-Wahab et al., 2007).

Conclusions

In conclusion, the global water crisis remains a pressing issue, with severe implications for vulnerable populations in Sub-Saharan Africa. Displacement, droughts, and poor harvests have exacerbated this crisis, leading to food scarcity and the establishment of refugee camps. In these emergency settings, access to clean water is a fundamental challenge.
The introduction of atmospheric water harvesting technology offers a sustainable solution to address water scarcity in these camps. Fog catchers, which capture moisture from the air, provide a reliable source of clean water, reducing the burden on already-stressed local resources and improving living conditions. This technology not only ensures immediate water needs but also promotes self-sufficiency and resilience in emergency camps.
Furthermore, atmospheric water harvesting projects have the potential to empower local communities, particularly women. This shift can lead to societal transformation and the rise of small businesses.
The proposal outlined in this paper considers the practical implementation of fog harvesting technology in emergency camps. The Smart Water Collecting Envelope (SWCE) concept integrates fog collectors into the design of emergency tents, offering a sustainable and efficient water supply system. The system includes water tanks and distribution infrastructure to meet the daily needs of camp inhabitants.
Economically, the viability of this project depends on the minimum water price, which must cover both initial and operational costs. The calculated price must be competitive with the current market

price of water. Despite the higher cost, fog harvesting offers advantages over traditional water sources, as it is sustainable and eco-friendly, eliminating the need for energy-intensive pumping.
In terms of water quality, fog-harvested water consistently meets established potable water standards, reducing health risks. However, proper filtration and treatment systems are necessary before integrating this water into the central distribution system, particularly in emergency settings.
Overall, fog harvesting technology represents a promising solution to the water crisis in Sub-Saharan Africa's refugee camps. By providing clean and sustainable water sources, empowering communities, and promoting resilience, it offers hope for a better future in regions plagued by water scarcity and displacement.

References

Abdul-Wahab, S. A., Al-Hinai, H., Al-Najar, K. A., & Al-Kalbani, M. S. (2007a). Fog water harvesting: Quality of fog water collected for domestic and agricultural use. Environmental Engineering Science, 24(4), 446–456. https://doi.org/10.1089/ees.2006.06-0066

Almer, C., Laurent-Lucchetti, J., & Oechslin, M. (2017). Water scarcity and rioting: Disaggregated evidence from Sub-Saharan Africa. Journal of Environmental Economics and Management, 86, 193-209.

Carrera-Villacrés, D. V., Robalino, I. C., Rodríguez, F. F., Sandoval, W. R., Hidalgo, D. L., & Toulkeridis, T. (2017). An innovative fog catcher system applied in the Andean communities of Ecuador. Transactions of the ASABE, 60(6), 1917-1923.

Cronin, A. A., Shrestha, D., Spiegel, P., Gore, F., & Hering, H. (2009). Quantifying the burden of disease associated with inadequate provision of water and sanitation in selected sub-Saharan refugee camps. Journal of water and health, 7(4), 557-568.

Di Tullio, Viola (2023). The socio-political dimensions of fog. An ethnography of fog Catchers in peña blanca, northern Chile. 9th International Conference on Fog, Fog Collection and Dew, 88.

Fessehaye, M., Abdul-Wahab, S. A., Savage, M. J., Kohler, T., Gherezghiher, T., & Hurni, H. (2017). Assessment of fog-water collection on the eastern escarpment of Eritrea. Water International, 42(8), 1022-1036.

FogQuest. (2005). Sustainable water solutions (fog collection, rainwater collection and rural water projects). Ontario, Canada. Retrieved from http://www.fogquest.org/?page_id=658

Jarimi, H., Powell, R., & Riffat, S. (2020). Review of sustainable methods for atmospheric water harvesting. International Journal of Low-Carbon Technologies, 15(2), 253-276.

Klemm, O., Schemenauer, R. S., Lummerich, A., Cereceda, P., Marzol, V., Corell, D., ... & Fessehaye, G. M. (2012). Fog as a fresh-water resource: overview and perspectives. Ambio, 41, 221-234.

Marzol, M. V., & Megía, J. L. S. (2008). Fog water harvesting in Ifni, Morocco. An assessment of potential and demand. Erde, 139(1–2), 97–119.

Qadir, M., Jiménez, G. C., Farnum, R. L., Dodson, L. L., & Smakhtin, V. (2018). Fog water collection: challenges beyond technology. Water, 10(4), 372.

Ringler, C., Zhu, T., Cai, X., Koo, J., & Wang, D. (2010). Climate change impacts on food security in Sub-Saharan Africa: Insights from comprehensive climate change scenarios (No. 1042). International Food Policy Research Institute (IFPRI).

Schiller, E. J. (1992). Water Resources: An Emerging Crisis. Canadian Journal of Development Studies/Revue canadienne d'études du développement, 13(4), 7-11.

Thompson, H. E., Berrang-Ford, L., & Ford, J. D. (2010). Climate change and food security in sub-Saharan Africa: a systematic literature review. Sustainability, 2(8), 2719-2733.

Tiwari, A. K., Kumar, A., Singh, A. K., Singh, T. N., Suozzi, E., Matta, G., & Russo, S. L. (Eds.). (2022). Water Scarcity, Contamination and Management. Elsevier.

UNICEF Supply Division Innovation Unit. (2017). UNICEF Target Product Profile Multipurpose tent 24m², 48m² and 72m². Retrieved from: https://www.unicef.org/supply/media/1306/file/Target%20product%20profile%20-%20emergency%20structures%20-%20multipurpose%20tents%20.pdf

UNHCR The UN Refugee Agency. (2022). Sahel emergency. Retrieved from https://www.unhcr.org/emergencies/sahel-emergency

Vogel, L. (2010). Food crisis escalates in Africa’s Sahel region.

Wang, S. Y., & Gillies, R. R. (2011). Observed change in Sahel rainfall, circulations, African easterly waves, and Atlantic hurricanes since 1979. International Journal of Geophysics, 2011, 1-14.

Zerbo, A., Delgado, R. C., & González, P. A. (2020). Vulnerability and everyday health risks of urban informal settlements in Sub-Saharan Africa. Global Health Journal, 4(2), 46-50.