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Full Length Research Paper

Alternative water filtration materials, technologies, practices and sources of knowledge in Kenya's Arid and Semi-Arid Lands (ASALs) and high rainfall areas

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Indigenous knowledge and practices (IKP) can be incorporated into low-tech environmentally sustainable water filtration methods for low-income rural Sub- Saharan African communities. This study sought to identify alternative water filtration materials, technologies, practices and sources of this knowledge in Kenya's arid and semi-arid lands and high rainfall regions. Adult household heads were interviewed through the administration of open and close ended questionnaires. From the respondents, 25% of the arid and semi-arid lands used clay vessels, 62.5% gravel and pebbles, and 12.5% bark of *Acacia albida*. Out of respondents from high rainfall areas, 59% used clay vessels, 27% gravel and pebbles, 14% leaves of *Rhus natalensis*, and 25% filtration with cloth. The major technologies used by respondents from arid and semi-arid lands were sedimentation (36%), sun heating (27%) and filtration using gravel and pebbles (21%) while those from high rainfall regions mainly used filtration with clay pots (28%), leaves of plants (21%) and boiling (18%). Respondents from arid and semi-arid lands indicated that 9% gained this knowledge by word of mouth, and 91% through observation, while 17% from the high rainfall regions by word of mouth and 83% from observation. The findings indicated that different communities applied the various technologies in a customized way. Traditional water filtration materials are eco-friendly, cost-effective and easily adaptable, and their use should be encouraged. Conventional methods should seek to modify and improve these methods to ensure higher purification efficiency.

Key words: Alternative water filtration materials, technologies, indigenous knowledge (IK), Kenya.

INTRODUCTION

The increasing global population and industrialization have led to significant environmental degradation, escalating water consumption, and the deterioration of both water quality and quantity (Agrawal et al., 2021; Estrada-Rivera et al., 2022). Kenya, classified as a water-scarce country, has a renewable freshwater supply of less than 1000 m³ per capita annually, with approximately 80% of its land designated as arid or semi-arid (Mulwa et al., 2021). Therefore, the available water sources must be maximized and used in the best ways possible. Various conventional and non-conventional water treatment methods have been developed to address the

challenge of poor water quality. Conventional methods, which combine physical, chemical, and biological processes, include coagulation/flocculation, filtration, and chlorination (Fahad et al., 2019).

These methods often require skilled labour, automation, and high operational costs (Gedda et al., 2021). Despite their effectiveness and compact design, the high installation costs can be a drawback for widespread use (Schultz et al., 2005; Muhammad et al., 2017). Non-conventional methods, which are low-cost and less technical, are commonly employed in areas where land availability is not a constraint. These methods are particularly effective in pathogen removal, making them suitable for water treatment in regions with limited access to advanced technologies. Water treatment facilities in developing countries often face challenges due to inadequate funding, low-quality equipment, and a shortage of skilled personnel (Xiao et al., 2021).

Traditional water filtration methods are widely used in rural communities all over the world to improve water quality and render it acceptable for use (Reddy and Lakshmi, 2024). They are cost-effective and easy to install, efficiently removing larger contaminants and some pathogens without requiring chemicals, making them environmentally friendly (Ombeni et al., 2024; Kumari et al., 2025). However, a major limitation is their inability to remove most pathogens, which can render the water unsafe for human consumption (Ombeni et al., 2024). Various indigenous filtration methods are practiced worldwide. Meserecordias (2024) reviewed four traditional water purification techniques in East Africa: local media filtration, solar disinfection, *Moringa* seed coagulation, and boiling with improved storage. For example, in Mali, winnowing sieves filter out wind-borne debris, while cloth filtration in India, Mali, and Niger removes coarse particles (Malik et al., 2024). Other techniques include clay vessel filtration and plant-based clarifiers, along with the Jempeng stone filters in Bali, Indonesia. In the Jempeng method, porous stone units called “cadas” are placed in ponds, allowing water to filter through a gravel bed (Normal, 2020). Activated carbon, produced from plant materials or animal residues, is commonly used as an adsorbent. *Moringa oleifera* seeds serve as a coagulant for drinking and wastewater treatment, while other plants such as *Vigna unguiculata, Voandzeia subterranean*, and *Arachis hypogea* are used for purification (Sivaranjani and Rakshit, 2016). *M. oleifera* has been used for water treatment (Gazala and Haritma, 2016) and has achieved positive results. In Dhaka, Bangladesh, an indigenous filter made of gravel, fine sand and coal achieved a zero-coliform count, rendering sullage water suitable for daily use (Sikder et al., 2016). In Kenya, different communities have embraced alternative water filtration methods guided by locally available materials and possession of indigenous knowledge (IK). Evidence of the use of ceramic pots made of black clay, red soil, and sand in Kitui, Kenya, has been found effective in microbial reduction (Chung et al., 2013). A survey conducted on point-of-use household technologies in the Nzoia River basin, Kenya, identified that 12% of the respondents used ceramic filtration candles, while 1% used concrete. 54% of the respondents preferred boiling (Ernest, 2019). IK has been found to bear a traditional theme yet remains effective despite the present digital era (Ossai, 2010) because of its ability to provide valuable lessons on sustainable resource use and survival within the natural surroundings. Traditional knowledge of plants and animals is gained by children through observation, participation, and instruction (Joseph and Turner, 2020). This is an important avenue of ensuring that this important knowledge is passed on to future generations and ensuring continuity. Deidra (2021) recognized that intergenerational messaging plays an important role in providing continuity of knowledge, especially regarding cultural, social, and spiritual practices.

Teachers have been recognized as an important link between the generations due to diversity, versatility, and the cosmopolitan nature of the world today. Ouma (2022) recognized that traditional knowledge transfer to new generations is a place-based practice that is greatly affected by the current rural-urban migration trends. The objectives of this study were to identify alternative water filtration materials, technologies, and practices, and to find out the sources of this knowledge of alternative water filtration materials, technologies, and practices in Kenya’s Arid and Semi-Arid Lands (ASALs) and high rainfall regions. These enabled the researchers to answer the research questions:

(1) What are the alternative water filtration materials, technologies, and practices in Kenya’s ASALs and high rainfall areas?
(2) What are the sources of knowledge on alternative water filtration materials, technologies, and practices in Kenya’s ASALs and high rainfall areas?

Acquisition of knowledge on the indigenous materials and technologies used in water filtration among Kenyans communities and their efficacy and efficiency will build on

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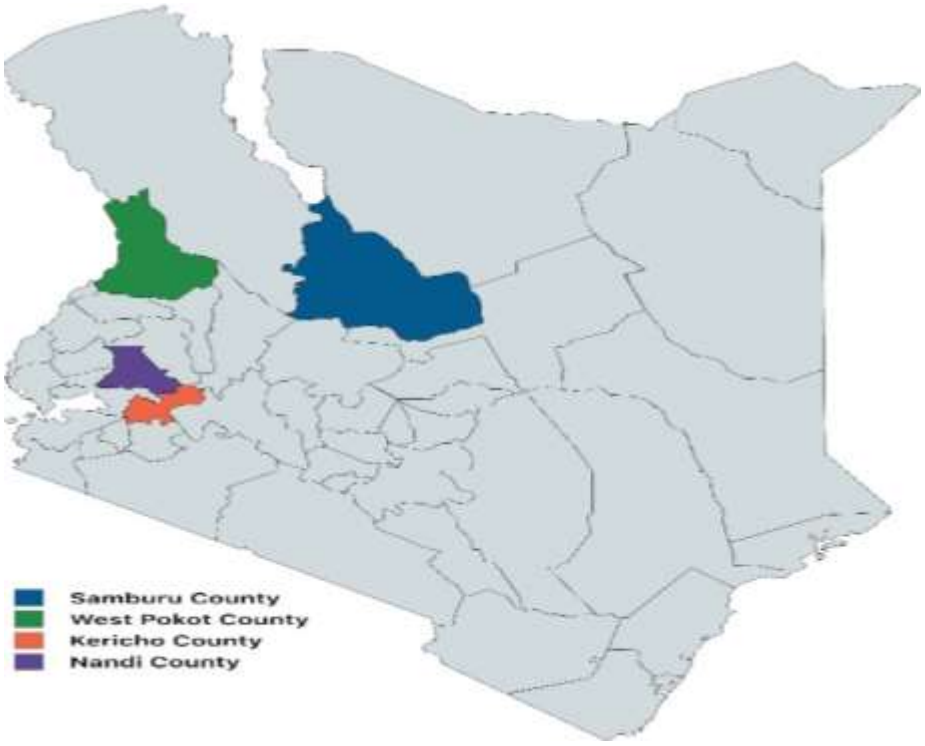

Figure 1. Map of Kenya showing location of the study areas.

the role IK on informing contemporary environmentally sustainable technologies which can be incorporated in current wastewater management practices and policies. Due to water scarcity and limited access to water sources in the ASALs, it is expected that they would be more innovative in embracing alternative water filtration materials and technologies than those in high rainfall regions.

MATERIALS AND METHODS

Study site

The study was carried out in selected households from the ASALs in Samburu County (1.1667ºN, 36ºE) and West Pokot County (1.6210ºN, 35.3905ºE). The study in high rainfall regions was Kericho County (0º 22' 0.00'' N, 35º 17' 60.00''E) and Nandi County (0º 10' 0.00'' N, 35º 08' 60.00'' E) of Kenya, respectively as shown in Figure 1.

Sample size and questionnaire administration

A descriptive cross-sectional study was carried out to provide information on traditional water filtration materials, technologies, practices and sources of this knowledge in Kenya's ASALs and high rainfall regions. Adult respondents of selected households were selected by simple random sampling described using Neyman's formula (Olaniyi et al., 2013).

$$N1 = \frac{N}{(1+N*e^2)}$$

where N1= the sample size, N= population, e= the desired margin of error (0.1).

The survey was carried out in two ASAL and two high rainfall counties which were identified using purposive sampling. The ASAL Counties selected were West Pokot and Samburu while high rainfall regions selected were Nandi and Kericho. The number of households in the ASAL Counties ranged from 13,000 to 36,000 while the number of households in the high rainfall Counties ranged from 24,000 to 44,000. To evaluate clarity of the questionnaire items, challenges in understanding the questions and overall suitability of the research instrument, a pilot study was conducted. The choice of pilot study sample was informed by the guideline that 10% of the sample size is sufficient for piloting of study instruments (Kothari, 2004). Therefore, 20 participants from Narok county to represent ASALs and 20 participants from Bomet county to represent High rainfall regions.

The pilot study participants did not participate in the final study. Determination of validity of the questionnaire involved evaluation of ease with which the respondents' provided answers to the research questions. In case the answers were unclear; they were modified to enhance straightforward responses. Reliability of the research instrument was done to measure consistency of responses. Four individuals were involved in the test, and the responses were checked for consistency. The Cronbach's alpha test was used.

Values obtained ranged between 0.79 and 0.88. Research

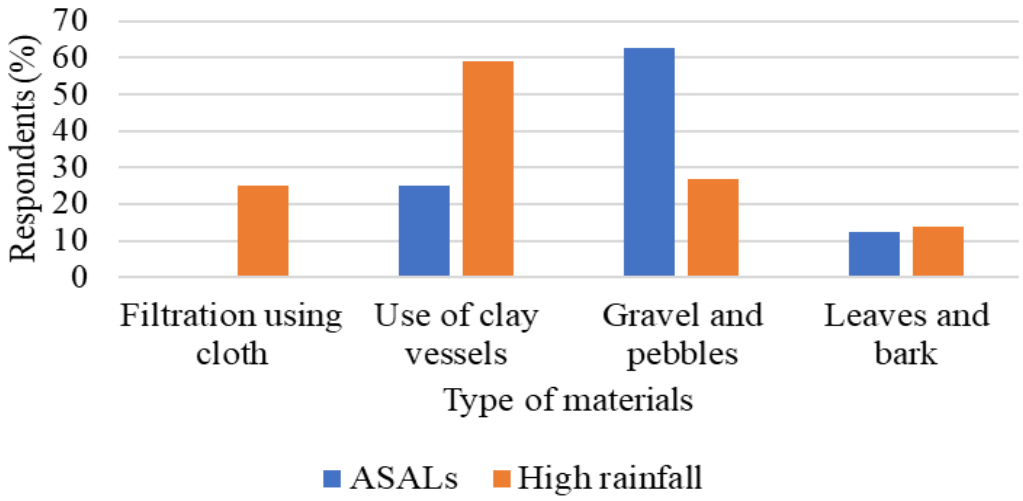

Figure 2. Materials used by respondents from ASALs and high rainfall regions to make the water fit for consumption.

Values obtained ranged between 0.79 and 0.88. Research instruments with Cronbach's alpha values of more than 0.7 are considered to have enough internal consistency (Malhotra, 2004). Oral informed consent was obtained from all respondents prior to administering the study questionnaire and they had the right to stop the questioning at any time. The researcher observed ethical procedures which ensured the respondents' rights were not violated.

Using Neyman's formula, the sample size for each of the counties under study was 100 respondents, distributed equally among the four counties. The gender representation in this study was 50:50. A total of 400 respondents from both the high rainfall areas and the ASALs participated in the study. The age distribution of the respondents was between 18 and 69 years. The survey sought to find out the materials used in water filtration, the technologies employed in using them, how the practices were carried out, and the sources of this knowledge.

Data analysis

The data obtained were analyzed using descriptive statistics: percentages and frequency tables in the Statistical Package for the Social Sciences Version 25 (SPSS). Chi-Square test was performed to test if there was an association between the variables studied in the ASAL and high rainfall regions.

Ethical Considerations

Ethical clearances were sought from Maasai Mara Postgraduate Board and National Commission for Science, Technology, and Innovation in Kenya (NACOSTI) (REF: NACOSTI/P/23/668940). Additional approval was sought from community civic and local administration prior to the study. Oral informed consent was obtained from all respondents prior to administering the study questionnaire and they had the right to stop the questioning at any time. The researcher observed ethical procedures which ensured the respondents' right were not violet.

RESULTS AND DISCUSSION

Traditional water filtration materials, technologies and practices

The alternative methods/technologies used to treat water in the communities within the ASALs and high rainfall regions were assessed. The main materials used by respondents from the ASALs were gravel and pebbles (62.5%), clay vessels (25%), use of plant parts (12.5%) and none used cloth to filter the water. In the high rainfall regions, 59% of the respondents used clay vessels, 27% gravel and pebbles, 25% filtered the water using cloth, while 14% used plant parts, as shown in Figure 2. The alternative methods/technologies used to treat water in the communities within the ASALs and high rainfall regions were assessed. Chi square analysis obtained $p>0.05$ therefore, there was no association of these methods between the two regions under study ($p=0.547$). This was an indication that the methods of water filtration used in the two regions under study were independent of each other. Investigations were also conducted to find out the source of the traditional materials, how they were prepared, how effective these materials were, and the source of the knowledge about the materials/technology. 87% of the respondents from the ASALs were aware of traditional water filtration methods, while 13% were not aware. In the high rainfall regions, 83.3% were aware of water filtration technologies, while 16.7% were not aware. The Chi square test revealed that there was no relationship in awareness of the water filtration methods by respondents from the two regions ($p=0.436$), hence

Table 1. Water filtration methods used by respondents from ASALs and high rainfall regions.

Water purification method	Level of preferences (%)	
	ASALs	High rainfall regions
Boiling	13	18
Sedimentation	36	4
Use of clay pots	0	28
Filtration using cloth	0	17
Sun heating	27	0
Gravel and pebbles	21	12
Use of plant leaves and bark	3	21

the method practiced in one region were not dependent on those practiced in the other region. Table 1 shows the water filtration methods used by respondents in these two regions.

The most commonly used methods by the respondents from ASALs were sedimentation (36%), where the water was left in the collection vessel to settle for a given duration, usually overnight, then the supernatant was drained off, and the muddy sediment that had settled at the bottom Sun heating was practiced by 27% of the respondents, which involved fetching the water in the morning hours, pouring it into a clear-colored container, and leaving it in the sun until late afternoon. Gravel and pebbles were used by 21% of the respondents. They placed pebbles of varying sizes into a hollow, narrow-necked container, then added a thick layer of gravel that had been washed and rinsed using initially filtered water. The water to be filtered was then poured into the open end and left to trickle out through the layers of gravel and pebbles. Further, boiling of the water was practiced by 13% of the respondents who acknowledged having obtained this knowledge from community health workers, and they found that the method gave them more confidence, allowing them to use the water, especially for drinking purposes, without fear of infections. Finally, those who used plant parts accounted for 3% of the respondents. They explained that most of the locally available plants were not favorable for human consumption as they were bitter; hence they could not be explored for clarification of the water. However, among the respondents from West Pokot, those who could gain access to *Acacia albida* (white acacia) used its bark as a water filtration agent. 28% of the respondents from high rainfall regions used clay pots to filter the water. These were specially prepared ceramic pots with an outlet at the bottom. The pots were lined with a layer of differently sized ceramic pieces, which were rinsed out periodically after a day of use as filter materials. 21% of the respondents used plant parts. The most common plant used for filtration of the water was the bark of *A. albida* (Soget-Keiyo dialect, Seretuet-Kalenjin language). Some of these respondents reported using the leaves of *Rhus natalensis* (siriat/basiriat-Kalenjin dialect, kumusangura-Bukusu dialect) to improve the taste and color of the water.

This was obtained from along the riverbanks; 18% of the respondents boiled the water, while 17% filtered using a cloth. This filtration was mainly done to remove plant debris, leaves, grass, small twigs, and branches. 12% of the respondents used gravel and pebbles, which involved placing pebbles of varying sizes into a hollow, narrow-necked container, then adding a thick layer of gravel that had been washed and rinsed using initially filtered water. The water to be filtered was then poured into the open end and left to trickle out through the layers of gravel and pebbles. 4% of the respondents practiced sedimentation, which involved leaving the water in the collection vessel to settle for a given duration, usually overnight (12 h), depending on the level of turbidity, then the supernatant was drained off, and the muddy sediment that had settled at the bottom was discarded. These findings agree with those of other researchers, such the filtration of water using cloth in India, Mali, and Niger to remove coarse particles, (Sivaranjani and Rakshit, 2016), use of clay vessels and plant-based clarifiers, along with the Jempeng stone filters in Bali, Indonesia, *M. oleifera* seeds used as a coagulant for drinking and wastewater treatment; and other plants like *V. unguiculata, V. subterranean*, and *A. hypogea* used for water purification (Sivaranjani and Rakshit, 2016), an indigenous filter made of gravel, fine sand, and coal to achieve a zero-coliform count in Dhaka, Bangladesh (Sikder et al., 2016); filtration in Egypt done by use of clay vessels, in Khem using gravity filters; oyster filters in Australia, hollow wax balls by Aristotle and natural coagulants like *M. oleifera* in India, Africa and Arabian countries (Shiksha et al., 2024), use of carbon-embedded ceramic filters using activated carbon from coconut shells showing high efficacy in pathogen removal (Puttanaiah, 2017), use of ceramic water filters widely produced in the Thar Desert

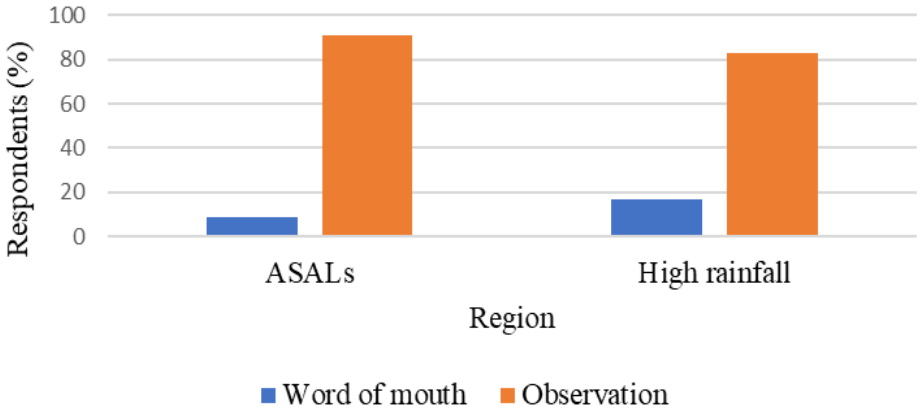

Figure 3. Sources of knowledge on alternative methods of water filtration techniques.

of India composed of clay and sawdust to achieve over 99% *E. coli* removal (Plappally et al., 2018), ceramic pots made of black clay, red soil and sand in Kitui, Kenya effective in microbial reduction (Chung et al., 2013) and point of use household technologies in Nzoia River basin, Kenya using ceramic filtration candles and concrete to purify water for use (Ernest, 2019). These findings concur with findings from the present study where these materials and technologies were all used in the filtration of water for domestic use. Alternative water filtration technologies and practices have been found to be limited by reliance on local resources, labour demands, hygiene risks and the inability to maintain consistent standards (Meserecordias, 2024).

Sources of knowledge on alternative materials and methods

Knowledge about the alternative materials and methods of water filtration practiced by respondents from the ASALs and high rainfall regions was acquired from the sources as shown in Figure 3. Figure 3, indicates that 91% of respondents from ASALs gained their knowledge on alternative water filtration materials and methods by observing grandparents and parents and 9% by word of mouth, primarily from grandparents, parents, and peers. 83% of respondents from the high rainfall regions gained this knowledge by observation of grandparents and parents while 17% by word of mouth primarily from parents and peers. Chi square analysis found $p>0.05$ ($p=0.409$), therefore, it was concluded that there was no relationship in the sources of knowledge for ASALs and high rainfall regions.

IK has been found to bear a traditional theme yet still be effective despite the present digital era (Ossai, 2010). This is because of its ability to provide valuable lessons on sustainable resource use and survival within the natural surroundings. Wilson (2004) termed the recovery of IK as an anticolonial project, where traditional methods of seeing, being, and interacting with the world had been skillfully eradicated. It is while bearing this in mind that the study sought to explore the sources of knowledge for traditional methods of water purification in the ASALs and high rainfall regions of Kenya. Dweba and Mearns (2011) emphasized that the transfer of IK would ensure the availability and utilization of the same. This was in a study on the use of traditional vegetables at a rural Xhosa village in the Eastern Cape Province of South Africa where it was revealed that despite traditional vegetables being available, there was a decline in their use due to a lack of knowledge of their existence and use. Likewise, in this study, some of the respondents were not aware of the presence of any traditional water purification technologies, while some had obtained the information from secondary sources like books and published articles. Hence, it is important that this information be passed from generation to generation by word of mouth and cultural rituals (Senanayake, 2006; Brucha, 2020), written media and broadcasting including emerging media platforms. In their report after gathering information from secondary data, Noor et al. (2018) indicated that IK has a significant role in sustainable development. It has been found to play a role in nature conservation, the production of food, forestry development, medicine, and disaster risk reduction among others. It further revealed that there are setbacks in preserving and promoting IK systems, for instance, it is primitive in the age of evolving practices and technologies. Therefore, it is important to preserve IK for future generations (Hunter, 2005).

Traditional knowledge of plants and animals is gained

by children through observation, participation, and instruction (Joseph and Turner, 2020). This is an important avenue for ensuring that this important knowledge is passed on to future generations and ensure continuity. Deidra (2021) recognized that intergenerational messaging plays an important role in providing continuity of knowledge, especially regarding cultural, social, and spiritual practices. Teachers have been recognized as an important link between the generations, due to the diversity, versatility and cosmopolitan nature of the world today. Ouma (2022) recognized that traditional knowledge transfer to new generations is a place-based practice that is greatly affected by the current rural-urban migration trends. This was in a survey on the transfer of traditional medicinal knowledge to a new generation of practitioners in the Eastern Lake Victoria Region. In addition, research on the knowledge journey practices of indigenous elders relevant to the younger generation emphasized the need for passing down weaving techniques among the Ngarringjeri community of Australia (Jelina, 2022). These reports concur with findings from the study in which the respondents acknowledged having gained knowledge by observation and word of mouth from older members of the community and from peers. This study thus contributes to the decolonization of science and highlights the role of indigenous knowledge and practices (IKPs) in promoting water resource management in Sub-Saharan African communities.

Conclusion

The findings indicated that traditional water filtration materials are still being used in ASALs and high rainfall regions of Kenya. The inhabitants used the most common locally available materials and incorporated the methods passed down from one generation to another. These materials are eco-friendly and of minimal cost, hence the quality of the water sources in the study area should be determined before and after filtration to assess the effectiveness of the various methods identified in the study, thereafter, their use should be encouraged. The challenge of sustainability due to reliance on local resources can be addressed, and explorations of further alternatives can be undertaken, as well as addressing questions on the efficacy and consistency of maintaining standards. Opportunities of these technologies can be harnessed by integrating them with scientific expertise and maintaining input from local communities. The study acknowledged the importance of indigenous knowledge in the preservation of these technologies. Also, it pointed out the need to pass on this knowledge, especially in the present world that is faced with rural-urban migration and infiltration by conventional methods and technologies.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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