

Participatory action research method of drinking water supply framework innovation for local indigenous community in Indonesia

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Abstract. Lake Sentani in Kameyakha Village, Ebungfau District, Jayapura Regency, Papua Province, Indonesia, is recognized as a primary source for 45 households. Despite the historical significance, both the quality and quantity have not met water standards, underscoring the need for technological innovation. Therefore, this research aimed to evaluate the effectiveness of Participatory Action Research (PAR) method through outreach strategies, as well as program implementation, monitoring, and program assessment carried out by the local indigenous community of Kameyakha Village. Data were gathered using observational methods, interviews, and focus group discussions (FGD). The results showed that PAR could solve the problem faced in Kameyakha Village by enabling collaboration between stakeholders and community.

1 Introduction

Ebungfau is one of the districts located on the coast of Lake Sentani, Jayapura Regency, Papua Province, Indonesia. This district has a 112.26 km² area bordered by Sentani, Kemtuk, Waibu, and East Sentani Districts to the north, south, west, and east respectively. Meanwhile, Kameyakha Village led by Mr. Yason Ibo, the committed village head, actively collaborates in programs for the application of science and technology, specifically in the field of public health services and the provision of clean drinking water. Water is necessary not only for the survival of all living beings but also for the socioeconomic development of communities worldwide. It helps to achieve the goal of sustainable development and proper management [1]–[3]. During the pandemic, Kameyakha Village as local indigenous community faces a pressing issue, namely the lack of drinking water. Although community uses clean water from ground wells and a portion of Lake Sentani for washing clothes and bathing, the declining quality has led to several skin diseases. Based on data from Jayapura Regency Health Office, there are 10 (ten) types of disease on average, with poor water quality and sanitation conditions ranking second as the impact of disease [4]. Skin infection tops the list with 21,029 cases (13.07%) and diarrhea is seventh with 4,853 cases (3.01%). The economic

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level of most residents in Kameyakha Village falls in the middle to lower economic class category, with the majority working as fishermen, while others are engaged in odd jobs, resulting in the inability to install clean water connections or buy ready-made water filters. Community usually buys refilled gallons of drinking water at Sentani market water depot, which must be reached by motorboat for 30 minutes and followed by a motorized vehicle for about 30 minutes [4]. This situation underscores the need for strategies in using technology to treat Lake Sentani water for drinking purposes. In this context, community service activities have focused on the innovation of a drinking water supply system from raw water sources with the application of easily available water purification technology. Therefore, there is a need to explore the effectiveness of community development program through Participatory Action Research (PAR). Numerous social programs have been implemented to facilitate better access to basic essential items such as water, food, education, and health [1], [2], [5]–[12]. Many community development programs fail to reach the objectives, resulting in inefficient use of resources and unmet demands. To address this, adequate paths in the development community program must be identified. Using appropriate methods may contribute to the success of community development program. In the development of rural and regional communities, the role of government and external parties is to identify needs as well as provide the required services and infrastructures [1], [12]–[21]. Although community development is based on reflection, motivation, organization, and local leadership, service delivery represents only a partial method. Complementing this method entails engaging communities to identify problems, as well as using individual skills and resources to support the development process. To gain a deeper understanding of the challenges faced by local community in Kameyakha Village, specifically regarding the lack of access to fresh water, a combination of different methods and tools was used. These methods which are partly derived from the tradition of participatory rural evaluation include semi-structured interviews, observation, participatory mapping for social, demographic, and water resources, alongside sanitation surveys. Others include community walks and transects, seasonal flow, causality, quantity, and trend diagrams, Venn diagrams of local organizational relationships, score and ranking, estimates and quantifications, brainstorming, key probes and portraits or case [1], [2], [8], [11]. The participatory research method has gained prominence in the health and social sciences, giving voice to community with limited opportunity to influence research efforts, but has a rich valuable body of experience relevant to knowledge development [22]–[26]. In the context of Kameyaka Village where lack of water is a pressing issue, applying PAR method is crucial. However, without a thorough analysis of the real situation, which has been inadequately studied in Indonesia, understanding how local perceives this issue remains questionable. To enhance participation, the program must be adapted to the internal capacities of community to address developmental issues [1]–[3], [8]. Community participation was observed throughout the program, spanning from problem identification, design of alternative solutions, implementation, and evaluation to continuous development [1], [2], [11]. Stakeholders were motivated to develop a strategy to design and implement community development method. Consequently, Jayapura University of Science and Technology promotes research participation through community development program aimed at assisting local indigenous community in promoting wellness.

2 Materials and methods

This research used PAR method, utilizing interviews to enable participants describe personal situations, experiences, and ideas in their own words [1], [3], [8], [11]. PAR entails collecting information through face-to-face communication using direct questioning. Data analysis adopted a qualitative method and comprised primary and secondary types. Primary data included (1) experience of taking part in an action research project with 30 respondents; (2)

present activities influencing the drinking water supply project; and (3) perspectives regarding drinking water supply projects for the Indonesian government. Meanwhile, secondary data comprised information extracted from Data Profile Kampung reports.

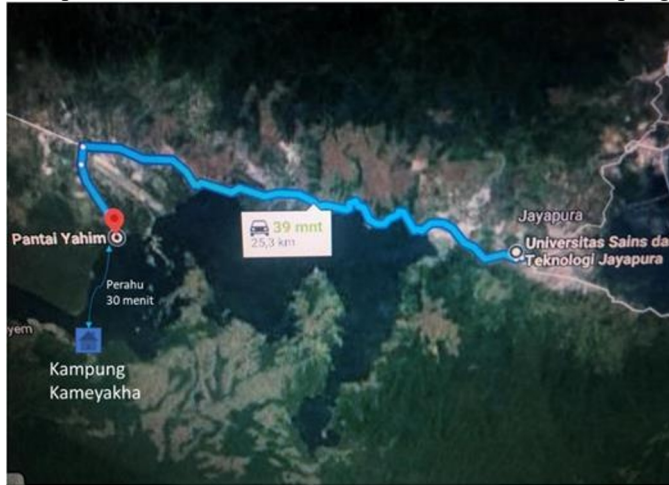


Fig. 1. Satellite view of Kameyakha village map (Source: Google Maps)

Fig 1 shows that the distance between Kameyakha Village and Jayapura University of Science and Technology can be explained as the research location, entailing a road trip of approximately 39 minutes with a distance of 25.3 km to the Yahim jetty on the edge of Lake Sentani. Subsequently, a 20-30 minute boat was taken to cross the lake and arrive at Kameyakha Village. The total distance traveled was approximately one hour. To extract data, a mentoring method was used based on PAR. In this context, PAR is a research method carried out in a participatory manner among members of a lower-level community whose enthusiasm is to promote transformative actions to liberate society from the shackles of ideology and relations [11], [22], [26], [27]. Focus group discussion (FGD) is a socially oriented process and a method where several participants are interviewed as a group to obtain data [1], [8], [11]. Furthermore, the mentoring activities in analyzing problems were carried out by mapping, transects, and understanding the history and traditions of community. Initial mapping was carried out to identify the social situation and conditions occurring in community [1], [8], [11], [22]–[24], [26]. The purpose of this mapping was to determine the geographical location of Kameyakha Village and the administrative limits. Beyond population, other information such as the culture, religion, education, and economy of community can be gleaned from the initial mapping activity. Collaborative design played an essential role in planning and implementing the program, entailing suggestions and collaborations with relevant parties. The primary objective was to ensure the participation of community, along with trained students and lecturers, in the development of an effective design to ensure the adoption of the technological solution [11]. Collaborative design comprises user engagement, task identification, understanding user needs and perspective, needs assessment, technology assessment, identification of technical skills, selecting the most appropriate technology, solution intrusive thoughts, solution design, and more [11], [22], [24].

The research team, students, and community formulated the theory of social change based on the results, learning processes, and implemented action programs. The success of PAR program is measured not only through the results of the activities during the process but also by the degree of sustainability and the emergence of local organizers as well as leaders who

continue to lead change actions. In this way, Kameyaka Village can learn, conduct research, and independently solve problems.

3 Results and discussion

3.1 Situation analysis

Lake Sentani is located in Jayapura Regency, Papua Province, at coordinates 140°23' – 140°50' east longitude and 2°31' – 2°41' south latitude. This lake is under the slopes of the Cyclops Mountains Nature Reserve which covers an area of about 245,000 hectares. It is the largest lake in Papua and is supplied by 21 small islands with approximately ±34 springs from the Cyclops mountains [28]. The catchment area is about 600 km² and the lake has a stable water structure, with temperatures ranging from 29-32°C in the top 10 m layer, a pH of about 6.2 - 6.8, and a plankton density of 1-2 mg/L. The results showed that, in general, the quality of the lake water remained good, although a declining trend was observed. Anthropogenic influences, particularly pollution, pose a threat to several lake-dwelling species vulnerable to frequent changes in water quality. The increasing pollution load reduces the carrying capacity of the lake. However, the comparison between the load value and the assimilation capacity value showed that, in general, Lake Sentani was still in fairly good condition. From the indicator parameters studied, TDS, BOD, and COD were below the value of assimilation capacity. Kameyaka Village has an area of 1.10 km² or 0.985 of the total area in Ebungfau District. The village has the highest male and female population of 378 and 404, respectively. The number of household heads was 308 or 32% of the total number in Ebungfau District. The current problem faced by community is the lack of access to drinking water. The community rely on water from ground wells and part of Lake Sentani for washing clothes and bathing. However, due to the declining quality of the lake water, an increasing number of people are suffering from skin diseases. To address this issue, community service activities have focused on establishing a drinking water supply system using Lake Sentani as a source with the application of easily available purification technology. Kameyakha Village is a strategic position where the only Puskesmas in Ebungfau District is located, making it a center for health services and community gatherings.

3.2. Participatory Mapping

Based on the results of discussions with community in Kameyakha Village, a mapping of the current conditions was obtained as shown in Table 1.

Table 1. The sanitation condition of Kameyakha Village

No	The problem description	The Current condition				
		Total number of Household	A house that has a groundwater well drilled	A house that uses lake water	The Houses using other sources	The Village public facilities
1.	The water supply system	308	28	45	3	No data
2.	The Domestic sewage system	dumped into the lake				

3.	The drinking water source	50% refilled bottled water, 30% of well water is cooked, and the remaining 20% is boiled lake water				
4.	A skin disease that occurs	-	No complaint	there are complaints	there are complaints	-
5.	Water usage/family/day (Liters)	50-120 Liters/person/day				
6.	Drinking water consumption/family/day (gallons)	1-2 gallons per day				
7.	Sanitary facilities for hand washing for COVID-19 prevention	No available				

The results of interviews and direct observations of the research team showed that from 308 households in Kameyakha Village, 28 used groundwater-drilled wells, 45 used Sentani Lake water, and the remaining three used rainwater. The sanitation conditions present a significant challenge with domestic household waste draining directly into Lake Sentani. Some houses have bathrooms and latrines with septic tanks, but others dispose of sewage directly into the lake, resulting in declining water quality. Field facts also showed that the number of community members with skin diseases was relatively high.

Based on data from Jayapura Regency Health Office [4], 10 (ten) types of diseases are present in Puskesmas at Jayapura Regency. The number of diseases caused by poor water quality and sanitation conditions was in second place, namely skin infections with 21,029 cases, while diarrhea ranks seventh with 4,853 cases. The economic level of most of community members was in the middle to lower economic class category. The majority were working as fishermen and engaged in odd jobs, resulting in the inability to install clean water connections or buy ready-made water filters. It is difficult for PDAM to reach this area due to the location in the coastal area of the lake. Consequently, community has difficulty getting drinking water that meets health requirements. Based on the results, residents usually buys bottled water in gallons at Sentani market, which must be reached by motorboat for 30 minutes and followed by a motorized vehicle for about 30 minutes. The price of water per gallon at Kameyakha Village is estimated to be around Rp. 20,000, - to Rp. 30.000,- [4]. The limited supply of water that does not meet health quality standards, both physically, biologically, and chemically, underscores the need for appropriate technology adapted to environmental conditions. The technology must be safe, simple, and cheap to be carried out by community even with economic and technological limitations.

The priority issues agreed upon by Kameyakha community are as follows:

1. Community of the coastal area of Lake Sentani, specifically Kameyakha Village, do not yet understand how to treat water properly and fulfill drinking water requirements.
2. Community need additional knowledge of processing drinking water that meets health requirements.
3. Community need technology to treat drinking water which can be used as economic income.
4. A high number of diseases are caused by poor water quality, including skin diseases and diarrhea.

3.3. Defining Problem and Solution

Since 2021, community has been developing strategies, methods, and tools to address managerial problems and to monitor the effect of any reforms on service performance. One of the main management skills to be strengthened is effective monitoring of both the research

process, as well as impact. Close, continuous monitoring facilitates adjustments of the strategies, methods, and tools based on local results and requirements [6], [29]. After compiling the potential and problems from observation and interview, several FGD sessions were organized to share the results with local. Communication and discussion in finding a solution together with local is the critical activity in PAR method [1]. FGD recommended the need for better community health improvement through the use of local resources with economic value, enhancing community professionalism skills, and increasing the ability to implement technology. Furthermore, the application of membrane filtration technology and UV lamp sterilization for the water supply system of Lake Sentani referred to community service activities at Lake Tempe [28] and research on the design of water purification systems from rivers based on biosand filters and ultraviolet lamps [29], [30]. The filtration technology applied in Kameyakha Village entailed using activated carbon, silica sand, zeolite, and gravel combined with UV lamp sterilization and reverse osmosis for drinking water supply. Table 2 shows the problem-solving strategies discussed in FGD.

Table 2. Problem-Solving Strategy

No	Problem Type	Problem Aspect	Problem-Solving Strategy
1.	The drinking water supply system for households has not met the quality and quantity	▪ The raw water quality of Lake Sentani is not suitable for consumption for drinking and other household purposes. ▪ Community has difficulty getting water for drinking, bathing, and cooking. ▪ The behavior of Kameyakha Village community in garbage disposal and domestic wastewater into the lake.	Training program for making water purification equipment with filtration and RO (reverse osmosis) methods to fulfill drinking water needs in collaboration with university academics. Environmental seminar with the theme of overcoming the impact of Lake Sentani pollution on community in Kameyakha Village in collaboration with environmental practitioners/academics.
2.	Promotion of sanitation and socialization of PHBS (Clean and Healthy Lifestyle) and CPTS (Washing Hands with Soap) for community has not been optimally implemented	The number of sufferers of skin diseases and diarrhea in children is high.	Program to improve the health status of healthy skin through CPTS and PHBS counseling for children of primary school age.

3.4. Implementation

3.4.1. Tools assembly and testing

The assembled equipment comprised the establishment of a pipe network from Lake Sentani water source to the first stage filtration system. Subsequently, pipes were assembled to the water reservoir tower, the second stage filtration system, and a reverse osmosis device placed in the house. The installed drinking water purifier is capable of draining 500 GPD of water or the equivalent of 1800 liters/day. However, given the limited storage capacity of 500 liters installed, the use is restricted to 500 liters/day. The raw water source is from Lake Sentani where the quality requires filtration treatment to reduce high levels of nitrate, phosphate, and organic. Consequently, three stages of filtration/filtration are installed, namely the first physical filtration by a prefilter to filter out moss and mud absorbed in waterways. The second stage is by a sediment cartridge filter to remove suspended solids, as well as small amounts of iron, manganese, and other organic contaminants. The third stage is a rapid filtration process carried out using granular media, namely zeolite, activated carbon, and silica sand in 2 FRP tubes with a diameter of 10 inches and a height of 35 inches. The rapid filtration with FRP tubes using quartz/silica sand media will retain valence alkaline deposits. The final filtration in this preliminary process is to remove odors and colors with activated carbon filter media. The last stage of purification is reverse osmosis technology, which entails filtering using a semipermeable membrane and is widely adopted in drinking water depots. The advantage of this technology is the ability to process water rapidly into low-contaminant drinking water [30] facilitated by pump power. The reverse membrane system used can be in the form of a hollow fiber membrane, plate, or spiral wound. This membrane can reduce pollutant levels up to 95-98%, hence, processed water is free from bacteria and immediately potable.

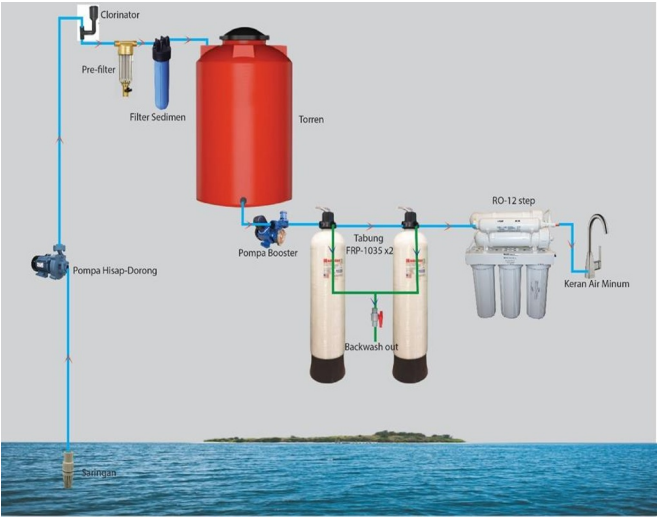


Fig. 2. Schematic diagram of the village drinking water

3.4.2. Training program/workshop for making drinking water purification equipment

Drinking water treatment can be effectively carried out using reverse osmosis technology [30]. Training sessions were conducted for the fabrication of water purification equipment in Kameyaka Village. In this context, a comprehensive method was adopted, entailing gradual filtration, reverse osmosis, as well as UV lamp sterilization according to the equipment assembled and installed. The training activity was attended by village and district official, indigenous community, and posyandu cadre, alongside youth organization, totaling 30 participants. The presentation of material on drinking water treatment technology was carried out at the village hall by a team of academics and continued with training on the operation of purification equipment installed at the home of the village head. During the training, many people asked about how to operate the equipment, starting from turning on the pump, cleaning the prefilter tube, replacing the sediment filter cartridge, operating reverse osmosis

device, and running the drinking water faucet (Fig 3). The training activity ended in a question-and-answer discussion with the participants by the presenters. It was concluded that most of participants had a general understanding of drinking water technology, namely filtration and reverse osmosis. The success of the project in Kameyaka Village underscores the efficacy of using PAR in community development initiatives. The integration of PAR has the potential to enhance the overall impact of development projects on the welfare of community. This participative method fosters heightened awareness and empathy, allowing a more nuanced understanding of community conditions. This inherent strength enables research to pinpoint and address issues faced in the real context, thereby facilitating the formulation of an effective solution [1], [11]. In future investigations, PAR should be implemented in a different rural location with varying cultural backgrounds to observe the correlation between culture and the implementation of this method.



Fig. 3 Guidance to community on how to use the equipment

4 Conclusion

In conclusion, PAR can be a viable solution to addressing the challenges faced in Kameyaka Village, fostering collaborative problem-solving between community and external agents. The strength of the method lies in the ability to empower community to actively engage in identifying and resolving issues. By engaging community in the process, PAR ensures that the solutions are genuinely responsive to basic needs, enhancing the effectiveness of the program. The sense of belonging from local is one crucial aspect to ensure the sustainability of the project.

References

- 1 A. B. Pangestu, A. Wisesa, and N. A. R. Putranto. *The Asian Journal of Technology Management (AJTM)*, vol. **11**, no. 2, pp. 70–78, (2018)
- 2 E. Asaba and Y. Suarez-Balcazar. *Scandinavian Journal of Occupational Therapy*, vol. **25**, no. 5. Taylor and Francis Ltd, pp. 309–312. (2018)
- 3 M. P. Lammerink. *Participatory Action Research (PAR) on Community Management of Rural Water Supply* (1998)

- 4 L. Corsita, Tanwir, S. Usman, S. Widiastuti, and M. Maitindom. [Online]. Available: <https://journals.upi-yai.ac.id/index.php/IKRAITH-ABDIMAS/issue/archive> (2022)
- 5 K. Bywater. *Policy Futures in Education*, vol. **12**, no. 7, pp. 920–932. (2014)
- 6 D. Badimo, P. K. Mogomotsi, and G. E. J. Mogomotsi. *Physics and Chemistry of the Earth, Vol. 124*. (2021)
- 7 G. Brown, M. Kyttä, and P. Reed. *Landsc Urban Plan.* vol. **218**.(2022)
- 8 C. F. Rammelt. *Syst Pract Action Res*, vol. **27**, no. 3, pp. 195–210. (2014)
- 9 G. Brown and M. Kyttä. *Applied Geography*, vol. **95**, pp. 1–8, (2018)
- 10 A. Esteban *et al.* Participatory Action Research As A Methodology For The Development Of Appropriate Technologies By Communities.
- 11 D. S. Varma *et al.* *Technol Forecast Soc Change*, vol. **172**, (2021)
- 12 N. Neverre, N. Surdyk, C. Hérivaux, and N. Baran. *J Environ Manage*, vol. **314**, p. 115022 (2022)
- 13 A. Roth, F. Pinta, S. Negny, and L. Montastruc. *Comput Chem Eng*, vol. **155**, p. 107530, Dec. (2021).
- 14 S. O. I. Ramirez-Gomez, G. Brown, P. A. Verweij, and R. Boot. *J Nat Conserv*, vol. , pp. 69–78, Feb. (2016)
- 15 S. M. Sen and A. Kansal. Achieving water security in rural Indian Himalayas: A participatory account of challenges and potential solutions. *J Environ Manage*, vol. **245**, pp. 398–408, Sep. (2019).
- 16 S. O. I. Ramirez-Gomez, G. Brown, P. A. Verweij, and R. Boot. *J Nat Conserv*, vol. **29**, pp. 69–78, (2016)
- 17 S. M. Sen and A. Kansal. *J Environ Manage*, vol. **245**, pp. 398–408. (2019).
- 18 D. S. Varma *et al.* *Technol Forecast Soc Change*, vol. **172**, Nov. (2021)
- 19 N. Neverre, N. Surdyk, C. Hérivaux, and N. Baran. *J Environ Manage*, vol. **314**, p. 115022, Jul. (2022)
- 20 R. Sisto, L. A. Fernández-Portillo, M. Yazdani, L. Estepa-Mohedano, and A. E. Torkayesh. *Socioecon Plann Sci*, vol. **82**, p. 101248, Aug. (2022)
- 21 A. Esteban *et al.*, “Participatory Action Research As A Methodology For The Development Of Appropriate Technologies By Communities.”
- 22 N. C. Dey, M. Parvez, M. R. Islam, S. K. Mistry, and D. I. Levine. *Int J Hyg Environ Health*, vol. **222**, no. 8, pp. 1098–1108. (2019)
- 23 D. Burdon *et al.*, *Ecosyst Serv*, vol. **39**, p. 101009. (2019)
- 24 A. Roth, F. Pinta, S. Negny, and L. Montastruc. *Comput Chem Eng*, vol. **155**, p. 107530, (2021)
- 25 M. Spies, M. Zuberi, M. Mähli, A. Zakirova, H. Alff, and C. Raab, *Sustain Prod Consum*, vol. **31**, pp. 557–568, (2022)
- 26 R. Sultana *et al.*, *MethodsX*, vol. **6**, pp. 2822–2837. (2019).
- 27 H. Halomoan, *Ecotrophic*.
- 28 A. R. Asrib and T. Natsir, Prosiding Seminar Hasil Pengabdian Kepada Masyarakat (SNP2M)(2017)
- 29 L. Corsita, A. Alstolaris, A. Monim, and H. Duwit, *Jurnal Tiarsie; Vol 19 No 3* (2022)

- 30 Endarko *et al.*, “Rancang Bangun Sistem Penjernihan dan Dekontaminasi Air Sungai Berbasis Biosand Filter dan Lampu Ultraviolet,” (2013).