SAFE WATER SUPPLY FOR PEPPER COMMUNITY IN DAK NONG PROVINCE IN THE CONTEXT OF CLIMATE CHANGE

Nguyen Thi Nguyet
Institute for Water and Environment
Vietnam Academy for Water Resources
Nguyen Thi Yen
CARE International in Vietnam

Abstract: *Dak Nong is one of the provinces with a large pepper growing area of the Central Highlands of Viet Nam where the pepper is considered as a major crop. The sources of water for irrigation are mainly from groundwater extraction and partly from surface water in the ponds, lakes, rivers and streams. However, these water sources are exposure to potential unsustainable factors due to water scarcity, water pollution, and inefficient operation of irrigation schemes. This paper introduces research results on safe water supply for pepper producing communities in the context of climate change in Dak Nong province considering gender role in water supply in order to make recommendations to relevant agencies to ensure safe water supply in Dak Nong in particular and the Central Highlands in general, contributing to the achievement of the sustainable development goals in Vietnam.*
Keywords: *Safe water supply, climate change, gender, pepper.*

1. INTRODUCTION

Clean water and sanitation are basic human necessities that represent each family's and country's quality of life. The Sustainable Development Goal (SDG*)* targeted, *"By 2030, achieve universal and equitable access to safe and affordable drinking water for all.”*. On November 24, 2021, the Prime Minister approved the National Strategy in Rural Water Supply and Sanitation by 2030 and vision to 2045, in order to fulfill Vietnam's commitment to achieving sustainable development goals. The objective of the Strategy by 2045 *"Strive for 100% of people in rural areas to have access to safe and sustainable clean water and sanitation"*.

Dak Nong is located in the Central Highlands of Vietnam, and it shares a 130-kilometer border with Dak Lak, Lam Dong, Binh Phuoc provinces, and Mondulkiri province of Cambodia. The natural area of Dak Nong is 651,927 hectares and a population of 625,822 in 2019. The province is a home of 40 ethnic groups, accounting for 33 % of the province's overall population. Dak Nong is one of the largest pepper-growing provinces in the Central Highlands, and pepper is also one of the province's major crops.

With respect to rural water supply in Dak Nong, statistics in 2018 shows that 83% of rural residents have access to safe drinking water, which is lower than the Central Highlands average of 87.6%. However, in terms of clean water[1] access, with 48% of rural residents have access to clean water is higher than the Central Highlands average of 35%, but lower than the country's average of 51.9%. Furthermore, Dak Nong has also the highest percentage of households using clean water in the Central Highlands. Similar to other provinces in the Central Highlands, the sources of rural water supply are mainly from

Receipt Date: May 31th, 2022
Review Approval Date: August 02th, 2022
Publish Approval Date: September 06th, 2022

[1] Clean water is understanded as water quality that meets National Technical Regulation, QCVN: 02/2009/BYT

groundwater extracting from drilled and dug wells, and partly from surface water in the ponds, lakes, rivers, streams. However, rural water supply is potential unsustainable factors due to water resources degraded and scarcity, and water pollution appearing in some places and inefficient operation of piped water supply systems. The increased exploitation of water sources for agriculture production and domestic use and climate change impacts have significantly affected to rural water supply in the Central Highlands. Drought and water shortage occur more frequently and increasing recently affected local people, most affected the poor, women and children.

Because of the topographic characteristics and population distribution in Dak Nong, the pepper farming community frequently uses water directly from the groundwater without treatment. Consequently, on-the-spot safe water supply cannot be guaranteed. Besides, the habit of local people in pepper cultivation is mostly based on experience. It uses a lot of water, and is spontaneous development at present. Therefore, the risk of water scarcity and unsafety is growing and more exacerbation in the context of climate change.

This paper introduces results of a research on "Safe water supply and resilience for pepper community in Dak Nong province in the context of climate change" which was examined in Thuan Hanh and Nam N'Jang Communes, Dak Song District, Dak Nong Province, sponsored by McCormic and conducted in collaboration between CARE International in Vietnam and the Institute for Water and Environment (IWE). The research is expected to provides practical recommendations for (i) improving practices and/or filter technology and equipment to ensure safe water for local people, particularly for women and children (ii) recommendation for improving local water governance towards water resilience taking into accounts climate change factor.

2. RESEARCH AREA AND METHODOLOGY

2.1. Research area

The research is conducted in Thuan Hanh and Nam N'Jang Communes, Dak Song District, Dak Nong Province.

Thuan Hanh is a bordering commune of Dak Song district with a natural area of 73.43 sqkm. There are 11 villages and four of them share the border with Cambodian. The population is 2,732 households with 9,699 inhabitants, and a poverty rate of 3.52%. The commune's principal crops are coffee and pepper. According to the provincial reports of during 2017-2019, coffee producing area has been increasing while pepper growing area has been decreasing. In 2019, the pepper and coffee area were 2,278ha, accounting for 30% and 1,899ha, accounting for 25% of the agricultural production area, respectively.

There is an operating piped water system using groundwater supplying for 168 households Thuan Hanh. Meanwhile the remain population use water from drilled and dug wells, with a total of 108 drilled and 1,647 dug wells. The proportion of households using hygienic water is 74%, and 20% of which uses clean water.

Nam N'Jang Commune is located in the south of Dak Song District with a natural area of 165.46 sqkm. There are 9 villages with 2,756 households and 10,934 inhabitants. A poverty rate is 3.54%. According to the current reports, the coffee producing area has been increasing while the pepper area has been decreasing throughout during 2017-2019. In 2019, the pepper and coffee area were 2,840 ha, accounting for 34.3% and 2,721 ha, accounting for 32.8 % of the agricultural production area, respectively.

There is no piped water system in Nam N'Jang commune. Drilled and dug wells are used for domestic water supply with 183 drilled wells and 1,658 dug wells. The proportion of households using hygienic water is 72.8%. Of which 35% of poor households uses hygienic water, as presented in Table 1.

Table 1: General information on the communes of Thuan Hanh and Nam N'Jang

Commune	Number of households	Number of people	Poverty rate (%)	Natural area (ha)	Agricultural production area (ha)	Pepper growing area (ha)	Coffee growing area (ha)
Thuan Hanh Commune	2,732	9,669	3.52	7,343	6,555	2,278	1,899
Nam N'Jang Commune	3,132	11,797	3.54	16,546	8,285	2,840	2,721

2.2. Methodology

- *Modeling tool*

The models such as MIKE and HYPE were used to analyze water availability in correspondence with climate change scenarios in the region launched by the Ministry of Natural Resources and Environment.

- *Field study*

The research team conducted a study in Dak Nong province. The meetings were conducted with local departments and agencies of Dak Nong Province and Dak Song District, and Thuan Hanh and Nam N'Jang Communes. The interviews with local residents in Thuan Hanh and Nam N'Jang Communes were also carried out. In total, 313 households were interviewed and 47 households were placed in group discussions in the two communes. In which, the number of households interviewed are 161 and 152 in Thuan Hanh and Nam N'Jang, respectively. The number of participated households in group discussions are 21 in Thuan Hanh and 26 in Nam N'Jang.

- *Data analysis and processing*

Excel or SPSS are used to analysis data and information. Based on the criteria and assumptions defined from the project design, key parameters must be identified to measure existing circumstances of the study area such as the rate of clean water consumption, human behaviors on clean water, and so on.

Among the given numerals, the appropriate data sources for the primary investigation report should be selected.

+ Secondary data: collected from relevant reports and field surveys through data tables and questionnaire.

+ Primary data: local economy and income, demography, health care, water sources, livelihoods, and education, etc.

+ Cross-checked: Mix methods and sources.

- *Group discussion*

Group discussions were held throughout the research process from planning to field work, data analysis, etc. The discussions between research team's members were conducted frequently during the research.

A specific task is assigned for every team's member corresponding with the positions they are in charge of. The assigned contents must be prepared before the group discussions led by the team leader.

Discussion tools are used for group discussion including papers, markers, projectors, screens, and other materials.

3. RESULTS AND DISCUSSION

3.1. Water resources and climate change impacts in Dak Song

- *Water resources in Dak Song*

Dak Song district is located in the north of Dak Nong Province and is known for having good water resource conditions in the province [14]. The water available in the Dak Song is evaluated using modeling method. The MIKE-NAM rainfall-runoff model was applied to assess present surface water resources as well as climate change impacts on surface water resources. Furthermore, the CROPWAT model is utilized to determine current water usages for agriculture cultivation. The hydrometeorology data set used in the report is monitoring data at Dak Nong station between 1978 and 2014.

According to the calculation results, total annual rainfall and rainfall in the rainy and dry seasons have all decreased over the years 1995 to 2014. It's also been noted that surface runoff is on the decline. The average annual flow is 386.26 MCM[2], and the flood and dry season flow are 304 and 82.36 MCM, respectively.

Table 2: Characteristics of average flow from 1995 to 2014

Station	F (km^2)	Q_o (m^3/s)	M_o ($l/s.km^2$)	Total flow in flood season (MCM)	Total flow in dry season (MCM)	Total annual flow (MCM)
Đak Nông	280	12.18	43.50	303.99	82.26	386.26

Figure 1 shows the imbalance of flow distribution in months of the year when most of the flow discharge allocates in July, August, September, October, and November with the total volume of flood season flow accounting for 79% of the annual flow total volume. The total volume of flow in the dry season accounts for only 21% of the annual flow total volume.

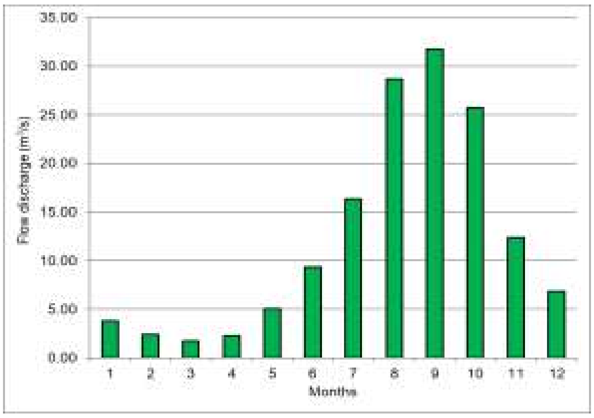

Figure 1: Monthly average flow distribution over years from 1994 to 2014

- Climate change impacts

+ Water demand

The study calculated the current water demand for the major sectors such as cultivation, domestic uses, livestock, industry, and fisheries in Dak Song district. Table 3 displays the results.

Tables 2 and 3 show that the overall water demand is 152 MCM per year, whereas the surface water available is 386.26 MCM per year. Thus, if considering the period of 1 year, the amount of surface water available in the Dak Song can completely meet the water demand of all sectors. However, during the dry season, the water demand for cultivation is 126.5 MCM, while the water available is 82.26 MCM. Thus, the water shortage is 44.24 MCM, or approximately 35%.

+ Climate change impacts on water resources

The climate change scenarios RCP 4.5[3] and RCP 8.5[4] are applied to calculate the climate change impacts on water resources in Dak Song District.

According to the calculation results, in the future periods in the both scenarios RCP 4.5 and RCP 8.5, rainwater resources tend to increase in annual rainfall and rainy season rainfall while decreasing in dry season rainfall. Annual rainfall and rainy season rainfall increase to a maximum in the period 2080 - 2099 are 1.2% and 2.4% respectively under the RCP 4.5 and 1.6 % and 3.6 % under the RCP 8.5. In addition, rainfall in the dry season decreases to a minimum during the period 2080 - 2099 are 13.2% and 22.4% under the RCP 4.5 and RCP 8.5 respectively.

[2] MCM – Million Cubic Meters

[3] RCP 4.5 - the medium emissions scenario

[4] RCP 8.5 - the high emission scenario

Table 3: Current water demand in Dak Song District *Unit: MCM*

Cultivation			Livestock	Domestic water	Industry	Fisheries	Livestock	Total
Flood season	Dry season	Year						
13.5	126.5	140.0	0.2	1.7	3.8	6.3	0.2	152

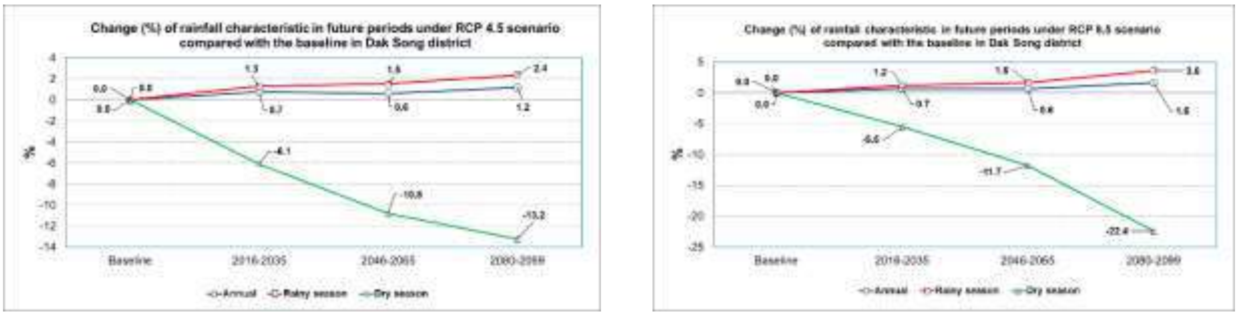

Figure 2: Variation (%) of annual rainfall, rainy season rainfall and dry season rainfall of future periods compared with the baseline in Dak Song district under the RCP 4.5 and RCP 8.5 scenarios

According to the RCP 4.5 and RCP 8.5 scenarios, in the future periods, surface water resources have a tendency to increase in annual flow and flood season flow while decreasing in dry season flow. In the period 2016 - 2035, annual flow increased to the peak flow at 0.5 % and 0.6 %, respectively. The flood season flow increases to the peak at 1.5 and 2.0 % in the period 2080-2099. The dry season flow drops dramatically in the period 2046 - 2065, reaching 4.7% and 7.4%, respectively.

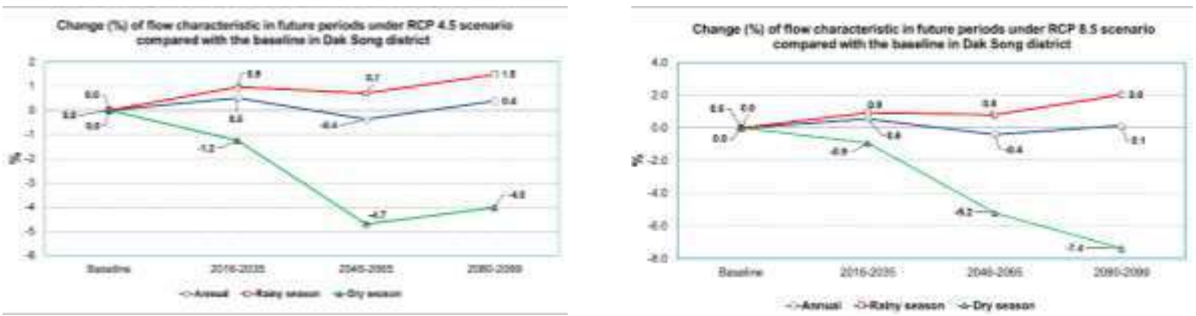

Figure 3: Variation (%) of annual flow, flood and dry season flow of future periods compared with the baseline period in Dak Song district under RCP 4.5 and RCP 8.5 scenarios

c. Climate change impact on water demand for cultivation

Among the water-using sectors, cultivation is the most affected by climate change. CROPWAT model is applied to calculate and analyze the water demand for cultivation. The inputs for the model are meteorological data corresponding to the RCP 4.5 and RCP 8.5 scenarios. The results show that, the future potential evaporation cause an increase in the water demand for cultivation in both RCP 4.5 and RCP 8.5 scenarios. According to the above computation, surface water resources in the dry season are expected to decrease in the future, while water demand for crops tends to increase leading to water shortage in the dry season.

Table 4: Impacts of climate change on surface water resources, water demand and water shortage corresponding to the RCP 4.5 and RCp 8.5

	The amount of dry season water available (MCM)			Water demand in dry season (MCM)			Water shortage in the dry season (MCM)		
Period	2016 – 2035	2046 - 2065	2080 - 2099	2016 – 2035	2046 - 2065	2080 - 2099	2016 – 2035	2046 - 2065	2080 - 2099
RCP 4.5	75.53	72.91	73.43	135.08	141.30	145.35	59.55	68.38	71.92
RCP 8.5	75.77	72.53	70.90	134.04	142.55	158.30	58.26	70.02	87.39

The climate change impacts are becoming increasingly in the area. It shows in precipitation tend to increase in the rainy season and decrease in the dry season causing unusual floods and droughts.

The results of the modeling under the scenarios RCP 4.5 and RCP 8.5 demonstrate that water shortage due to climate change impacts in the dry season ranges from 43% to 55%, respectively (Figure 4). Hence, water resource planning and allocation should be developed appropriately, and the priority should be considered for cultivation. It is one of the most water consumption sectors.

Figure 4: Water shortage due to climate change impacts under the scenarios

3.2. Current situations in rural water supply in Dak Nong Province

3.2.1. Water supply sources.

Ground water from drilled and dug wells is primarily source for domestic water supply, accounting for more than 90%. The rest uses water from the piped water supply systems, which mostly also use groundwater as the supply sources and a very few uses rainwater and surface water. Furthermore, this rate is also compatible with the surveyed data in Thuan Hanh and Nam N'Jang communes. 100% of the surveyed households used groundwater, with 90% use drilled and dug wells. Several households in Thuan Hanh Commune use the piped water supply system, and only a small proportion of them use rainwater and surface water drawn from ponds, lakes, rivers, and streams (Figure 5).

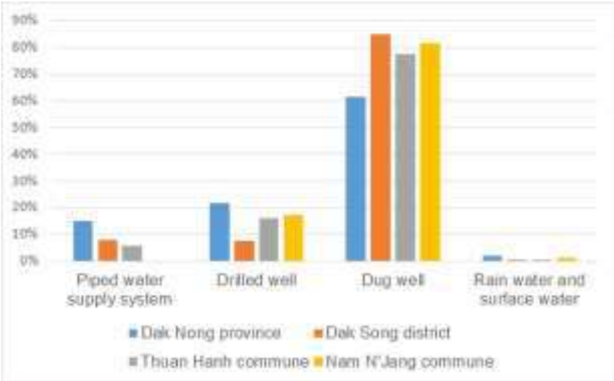

Figure 5: Water supply sources in Dak Nong Province, Dak Song District, and the two communes

3.2.2. Decreasing water quantity

The depletion of groundwater and surface water in the region have been seen in both modeling calculations and actual surveys, with 100% of interviewees agreed that water quantity has been declining recently.

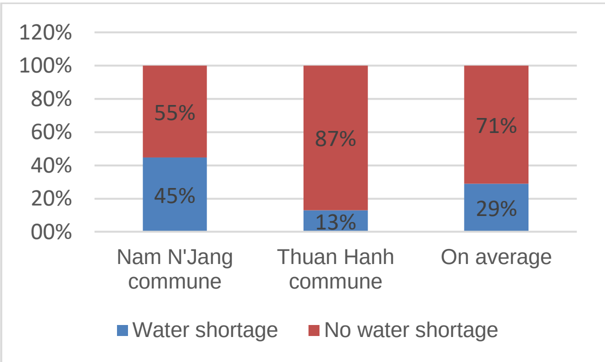

Figure 6: Water shortage situation in dry season in Thuan Hanh and Nam N'Jang Communes

Water shortage has occurred in households during the dry season, from January to May. This is more prevalent in Nam N'Jang, where 44.7% of affected households and only 13% in Thuan Hanh (Figure 6).

3.2.3. Water supply systems

Piped water supply system: There are 246 piped water supply systems in Dak Nong Province [3]. Only three of which use surface water. In which, 24 systems using groundwater were built in Dak Song district. The rate of systems with treatment technology is low, accounting for 9.7% and 12.5% in Dak Nong and Dak Song respectively.

Table 4: Current situations of centralized rural water supply systems in Dak Nong Province and Dak Song District

Management department	Number of systems	Water sources		Treatment technology available	Number of households use	Meet the water quality	Active status			
		Ground water	Surface water				Sustainable	Medium	Less effective	Inactive
Dak Nong Province	246	243	3	24	27.008	66	31	35	10	170
Dak Song District	24	24		3	2076	7	2	4		18

Source: Department of Agriculture and Rural Development of Dak Nong Province

The high rate of piped water supply systems is no longer operation, more than 69 % in Dak Nong Province, and 75% in Dak Song District. In two research communes, only two piped water supply systems were constructed taking groundwater in Thuan Hanh commune. However, only one is operating to supply water for 168 households.

Small water supply system: Drilled and dug wells extract water from both the shallow and deep aquifers. Almost households in Thuan Hanh and Nam N'Jang use groundwater, 80% of dug wells and 17% of drilled wells. Some use water from piped water supply system in Thuan Hanh. The rest use rainwater and surface water taking from ponds, lakes, rivers, and streams, but this is a very small. Drilled and dug wells have been constructed at household-scale and uncontrolled. This is potential pollution and depletion of groundwater.

3.2.4. Deteriorating water quality

To assess water quality, water samples were taken in Thuan Hanh and Nam N'Jang and analyzed. Ten water samples were taken from dug wells, drilled wells, water purifiers, and rainwater. The analysis results show that, physical parameters, such as color, taste and turbidity, are under National Technical Regulation, and water has a sensation of turbidity and color. Chemical parameters such as pH, residual chlorine, and fluoride are under the National Technical Regulation QCVN 02:2009/BYT, Column II. PH value of between 6.9 and 7.1 indicates that no signal of acid and basic contaminated water.

Ammonium parameter: Ammonium value of 10 samples is within the allowed thresholds of the National Technical Regulation of QCVN 02:2009/BYT, Column II. However, high ammonium concentration found in 2 over 10 samples.

Metal parameter: The excess of iron (Fe) concentration 1.04 time in 1 over 10 samples compared to national standards showed the aluminum water contamination. Additionally, observation at some households was also found the phenomenon of scum and yellowing stick storage water facilities. This indicates the possible water contaminated with alum.

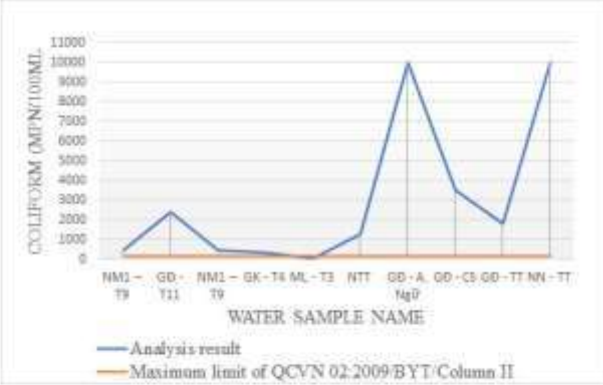

Figure 7: Coliform analysis results compared to Vietnamese National Technical Regulation QCVN 02:2009/BYT – column II

Microbiological parameter: The excess of coliform concentration was found in 8 over 10 samples of from 2.2 times to 66.67 times compared to National Technical Regulation of QCVN 02:2009/BYT column II show the microbiological water contamination. The reasons explained for high coliform concentration are: (i) it might be affected by livestock waste; (ii) it may be polluted from surface runoff pollutants into shallow groundwater (dug wells); (iii) improper operation and maintenance of water storage and delivery facilities. On the other hand, the water purifier system has not been maintained or replaced for a long time, resulting in reduced filtration efficiency and microbiological contamination in the filtered water (78 MPN/100ml).

3.2.5. Over domestic water consumption

Use two much water for domestic supply will aggravate the water scarcity in the region. As observation during field survey, local residents consume more water than in other rural areas because of their habits and characteristics of farming on red basaltic soils. The average daily water used is 250 liters per person, which is 2.5 times the rural water supply standard in Dak Song in 2020 (100 liters per person per day) and 4.2 times the Vietnam rural water supply standard TCXDVN 33:2006.

3.2.6. Local water governance

There is a lack of coordination between local sectors in water resources management. The usage and exploitation of water, particularly groundwater, has not been adequately managed. It has not paid attention enough on water resources management at the district and commune levels.

- Unlicensed exploitation of water is very common. River and stream plans for water protection and exploitation have not been developed, resulting the overlap hydraulic works constructed and ongoing conflicts that cause mutual harm.

- It is a common occurrence of unmanaged and in violation of water protection regulations in groundwater exploitation for domestic use and agriculture production causing the rapidly declined groundwater sources.

- Piped water supply system management: After the construction completed, the new piped water supply system is transferred to the Commune People's Committee (CPC). The CPC assign to the village's self-governing boards or operation groups elected by the local people for management. However, no technical training on maintenance and management is provided. On the other hand, monitoring and inspection have not yet conducted regularly by the local authorities. There is also no technical staff on rural water supply working in profession agencies at district and commune levels.

3.2.7. Household water treatment

Most households use untreated water pumped directly from drilled and dug wells. Around 35% of households use R.O water purifiers for drinking, other daily activities such as cleaning and washing use unfiltered water. Water purifiers used are very diverse and from many manufactures. It has not been verified the purifier's quality and efficiency by any local responsible agency.

The period to change the filters varies as well. Instead of following the manufacturer's instructions, most households merely change them when they become dirty. The filter replacement intervals are ranging from 2 months, 3 months, 6 months to 12 months.

Water quality test: Generally, water quality monitoring has been carried out annually by DONRE. However, monitoring locations (1–2 spots per commune) and frequency (2–4 times per year) are limited, and such do not fully reflect the water quality situation in the areas. At household level, no water quality tests have been conducted and the farmers are unaware where to do so.

3.2.8. Local people awareness in clean water use

Local people awareness in clean water use has been seen during the field survey. Results showed that they are aware of the need of using clean water for domestic supply and current water quality in the area. Hence, some used water purifiers for drinking.

- 100% of interviewees were aware of hygiene and clean water. When it comes to the concept of clean water, many of them have never heard of QCVN 02:2009/BYT - National Technical Regulation on household water quality. And their understanding of clean water is simply clear water without pathogens or dangerous substances.
- 11.8% of interviewees have heard the information on water sources protection and management in upstream reservoirs or rivers through the loudspeaker system and commune officials.
- 100% of interviewees aware that unhygienic water use causes diseases affecting human health and living equipment.
- Most of the ideas state that they will warning or remind if waste or appliances are thrown into water resources by someone.

Figure 8: The water quality assessment by the local residents in Thuan Hanh and Nam N'Jang Communes

3.2.9. Role of gender in water supply

Gender and division of labor in the family

Division of labor in the family and gender difference was one of the core topics discussed in group discussions organized in Thuan Hanh and Nam N'Jang Communes. Each commune formed two groups, one male and one female, who discussed separately in addition to household interview. Most people believe that because of the different physical characteristics, women are more likely to undertake activities requiring less physical strength like cooking, washing, looking after children, cleaning, and so on, whereas males are more likely to do heavy works like production, construction, well digging, maintenance, tank cleaning, and so on. Some say that men occasionally support women do household work such as cleaning and childcare.

Both wife and husband participate in pepper production tasks such as weeding, fertilizing, watering, spraying, and harvesting. While the husband is mainly in charge of making decisions and performing activities such as pumping water, spraying, carrying and grinding, the wife is in charge of stripping pipes, pulling the string, holding watering hoses, picking, and drying. According to findings from both current and previous study conducted by CARE, women are primarily responsible for taking care of their families and children, and other unpaid works. However, these works spent more their times compared to men's.

Role of gender in domestic water supply

Residents said they spent an extra 15 to 30 minutes to collect water during the dry season. Men oversee irrigation water, while women are in charge of domestic water. This increases the burden on them, particularly women, who use the most domestic water. Men dominate decision-making, even though women and children suffer the most impacts in using unsanitary water. Regarding to investing in domestic water supply, 71.9% said that all family members were involved in the discussion, but the husband/father made the final decisions. Women are thought to be lacking in technological knowledge and skills, as well as misunderstanding on equipment used for domestic water supply and irrigation. Therefore, men are mostly responsible for making decisions. In addition, the husband is primarily responsible for household water supply system operations, such as water pumping, tank cleaning, and filter replacement. Women, on the other hand, share the same investment obligation as men in domestic water supply systems (Figure 9). Indeed, men make the major decisions while women bear a fair portion of the investment expenses in the household.

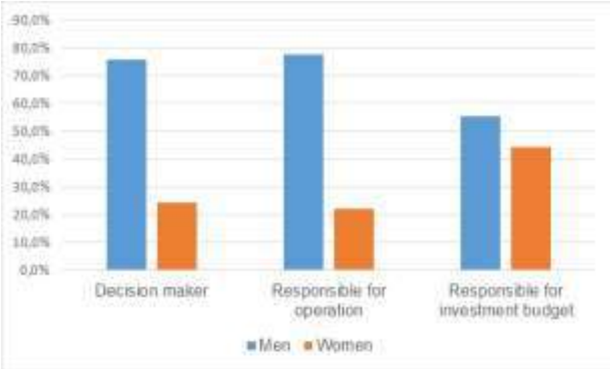

Figure 9: Role of men and women in domestic water supply in Thuan Hanh and Nam N'Jang Communes

3.2.10. Agriculture practices and living activities affecting water resources

Local agricultural production activities currently pose a significant threat to water resources. As the cultivation technics and the habits of utilizing chemical fertilizers and pesticides at present, a considerable amount of chemical fertilizers and crop protection chemicals are left in the soil, and the process of infiltration and leaching will pollute soil, surface water, and groundwater. Water pollution is also caused by fertilizer and pesticide packaging. According to the environmental report in Dak Song District from 2016 to 2020 [11], around 1,500 tons of chemical fertilizers and crop protection chemicals had been used annually for 1 hectare of agricultural cultivation which are double as the guidance of the Department of Crop Production of the Ministry of Agriculture and Rural Development [6].

The survey data on the use of fertilizers and pesticides in coffee and pepper cultivation in the Thuan Hanh and Nam N'Jang show that, the farmer habits of using fertilizer and pesticide base on personal experience are very common. Of which they use a lot of chemical fertilizers and pesticides with chemical origin. Furthermore, fertilizer application during the rainy season has the potential impact to water sources since the unabsorbed fertilizer when raining will be flowing into rivers and streams.

+ Fertilizer uses: Residents claimed that they used less fertilizer than in prior years due to a fall in pepper prices at the time of investigation. According to survey data, manure and organic fertilizer are used less frequently, ranging from 0.1 to 9.3 tons per ha, whereas chemical fertilizer is used more frequently. In Nam N'Jang Commune and Thuan Hanh Commune, respectively, 37 % and 32 % of the households utilized chemical fertilizer as directed. More than 60% of the households surveyed said they used more than in the instructions. (Figure 10).

+ Crop protection chemical uses: Over 60% of households use crop protection chemicals. Furthermore, containing bags or packaging have not been properly collected and treated. The treatment measures applied here are burning and burying and some bags with green markings are collected and sold as junk.

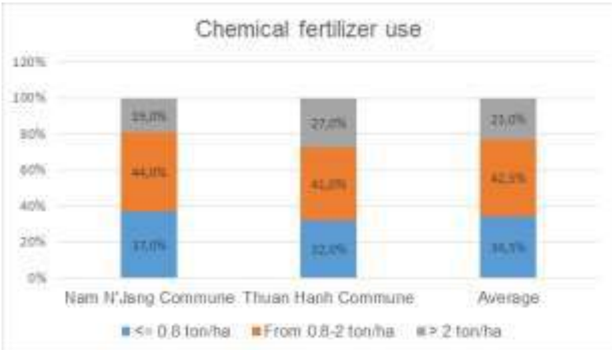

Figure 10: Chemical fertilizer use for pepper in Thuan Hanh and Nam N'Jang Communes

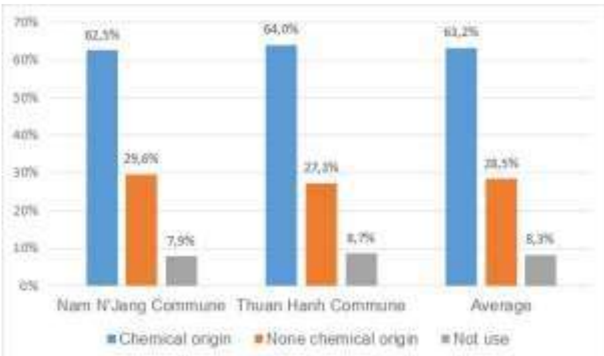

Figure 11: Crop protection chemicals use in Thuan Hanh and Nam N'Jang Communes

People's daily activities generate garbage and waste water, which have potential to pollute water sources. In addition, more modern equipment used as a result of rapid population growth and improved quality of life, consequence of increasing solid waste and domestic waste water. This will pollute water if improperly collected and treated measures applied.

- Domestic solid waste: The survey data show that, solid waste has been collected in some villages in two communes, but it's not much waste collected. The proportion is 33.5% and 54.6% in Thuan Hanh and Nam N'Jang respectively. The rest of the households gathered and dumped into the garden, where they were buried or burned. This is potential pollution of surrounding water sources.

- Domestic waste water: Estimation of wastewater discharged into the environment in the two communes is 5,366.5 m^3 per day. In which, toilet wastewater contains the highest concentration of contaminants. However, approximately 90% of households use septic toilets or squat toilets. Therefore, the large amount of wastewater is not discharged directly into rivers and streams, but rather through septic tanks. It's pretreated here, and then discharged into absorbing wells and out into the garden or canals around the house, before being discharged into rivers and streams. Furthermore, the current population density is less likely to have an impact on water resources.

3.2.11. Safe drinking water assess of local people

Residents have not yet used safe water for domestic purposes. Water borne diseases have appeared such as diarrhea, pinkeye, and dental caries, etc. Even though they are aware of the importance of using clean and hygiene water, they lack understanding of how to collect, store, and treat to get clean and hygiene water. Additionally, it has not yet supported from the local authorities in clean water supply and use.

Women and children are the most vulnerable to unclean water use. However, water supply operations and investment for the both domestic and irrigation are decided by men.

Households' ability to invest in water supply: Local people are aware of the importance of using safe water and are capable in contributing a portion of the cost of water supply and treatment systems. However, poor and near-poor households find it difficult to invest in those systems due to the recent drop in coffee and pepper prices in the past 2 years, which has made life tough for them.

4. CONCLUSION AND RECOMMENDATIONS

Rural water supply in Dak Nong Province contains potentially unsustainable factors in both water quantity and quality: (i) Water quantity and quality are decreasing noticeably; (ii) Unsafe domestic and production activities cause water pollution; (iii) Weak coordination between the local responsible agencies in water management. And Water resources has not yet exploited and managed properly, particularly groundwater resources; and (iv) climate change impacts are potentially exacerbating the safe water supply in Dak Nong province.

Integrated water resource management is appropriate approach in addressing issues and challenges in current rural water supply as well as water resources. Recommendations are made to ensure the safe water supply areas as following:

- A complete water supply policy framework such as investment policy, operation and management policy, water price policy, and so on, should be developed, and appropriate resources for rural water supply investment should be allocated.

- Training and awareness raising on safe water supply and treatment should be enhanced. Warning about water quality situation and guiding on how to protect water resources and using water safely should be provided for local people.

- Communication on saving water use and water sources and environmental protection should be conducted regularly.

- Mobilizing support from international organizations such as McCormick, CARE, UNDP, and others to develop the community based sustainable integrated management models such as ecological pepper production models. Certificates for sample models must also be provided to expand models to new areas. The scale and scope of models are determined depending on the cost; an integrated measure for clean water supply and sustainable pepper models should be provided in order to respond to climate change as well as gender equality challenges oriented to disadvantaged groups benefited.

REFERENCES

[1] Cục Thống kê Dak Nong (2018), Niên giám thống kê 2018 tỉnh Dak Nong;

[2] Chi cục thống kê Dak Song (2018), Niên giám thống kê 2018 huyện Dak Song;

[3] Trung tâm sạch và VSMTNT – Sở Nông nghiệp và PTNT Dak Nong (2020). Báo cáo tình hình hoạt động của các công trình cấp nước tập trung trên địa bàn tỉnh năm 2020.

[4] Chi cục phát triển nông nghiệp – Sở Nông nghiệp và PTNT Dak Nong (2020). Báo cáo tình hình sản xuất hồ tiêu trên địa bàn tỉnh Dak Nong.

[5] Bộ NN&PTNT 2021, Sổ tay hướng dẫn kỹ thuật canh tác cây hồ tiêu thích ứng với biến đổi khí hậu.

[6] Sở Tài nguyên và Môi trường Dak Nong (2019). Báo cáo thực hiện công tác quản lý tài nguyên nước năm 2019.

[7] Sở Nông nghiệp và PTNT Dak Nong (2020). Báo cáo Kết quả thực hiện quản lý công tác nước sạch nông thôn năm 2019 và tiến độ triển khai thực hiện Chương trình Mở rộng quy mô vệ sinh và nước sạch nông thôn dựa trên kết quả, vay vốn Ngân hàng Thế giới (WB).

[8] UBND huyện Dak Song (2019). Báo cáo Kết quả kiểm tra rà soát các công trình nước sạch tập trung bị hư hỏng, ngưng hoạt động trên địa bàn huyện Dak Song;

[9] UBND huyện Dak Song (2018). Báo cáo Bộ chỉ số nước sạch và VSMTNT huyện Dak Song 2018;

[10] UBND huyện Dak Song (2020). Báo cáo Thực trạng nước sinh hoạt và VSMTNT huyện;

[11] UBND huyện Dak Song (2020). Báo cáo Hiện trạng môi trường huyện Dak Song 05 năm giai đoạn 2016-2020;

[12] Một số chính sách liên quan về nước sạch và vệ sinh môi trường nông thôn tỉnh Dak Nong.

[13] Bộ Tài Nguyên và Môi Trường (2016). Kịch bản BĐKH cho Việt Nam 2016.

[14] Japan International Cooperation Agency (JICA) (2018). Data collection survey on water resources management in Central Highlands.