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Rural Water Supply Solution In Climate Change Conditions In Quang Ngai Province.

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ABSTRACT

In order to maintain development and achieve sustainability, rural clean water supply in Quang Ngai province must overcome the effects of climate change. Based on the assessment of surface water and groundwater reserves and ability to exploit water sources, this article presents some research results and proposals for rural clean water supply in Quang Ngai province in the context of climate change. Rural clean water supply solutions in the context of climate change that are suitable for implementation in the new rural construction phase in Viet Nam are important grounds for managing and investing in rural clean water supply and especially in responding to abnormal weather conditions so as to ensure sustainable water supply.

Keywords: Climate change, current situation of water supply, rural water supply, water supply zoning, Quang Ngai province, water supply solutions.

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INTRODUCTION

Quang Ngai is a coastal province located in the South Central Coast region of Vietnam. Quang Ngai has a coast of approximately 129 km long and 11,000 km² of territorial waters with 6 marine estuaries. The province is rich in marine resources and has a number of beautiful beaches. Quang Ngai is located in the central key economic zone in the South Central region, with Dung Quat area having been chosen by the Government to build Vietnam's first refinery. Quang Ngai has relatively complex terrain with a tendency to decrease from west to east over hilly terrain and coastal plains. The west of the province is the eastern slope of the Truong Son range, followed by low mountains and hills alternating with plains. The mountains in some areas run close to the sea. The climate in Quang Ngai is tropical and monsoonal with high and less volatile temperature. The province has a diverse sunlight and rainfall regime with an average temperature of 25-26.9°C [6]. The year is divided into 2 distinct seasons which are rainy season and sunny season.

Results of implementation of the rural water supply and sanitation program as of 2016 in Quang Ngai Province are as follows: the percentage of rural people having access to hygienic water is 87.2%, increased by 2.05% compared to 2015; percentage of poor people using hygienic water is 73.9%, an increase of 2.84% compared to 2015; percentage of schools (including primary and secondary schools) having access to hygienic water and latrines is 61.1%, increased by 4.4% compared to 2015; percentage of commune health stations having access to hygienic water and latrines is 90.9%, a decrease of 0.5% compared to 2015.

In recent years, however, floods and droughts have occurred in Quang Ngai province with increasing frequency and intensity. With the combined effects of typhoons, tropical low pressure systems, and tropical convergence zones with northeast monsoons, heavy rains during the rainy season often cause floods. Landslides also occur in most mountainous districts. The province has 75 points at risk of landslides, including 21 high risk areas, distributed in the districts of Ba To, Tra Bong, Tay Tra, Minh Long, Son Ha, and Son Tay. Heavy rains and large floods often destroy structures of concentrated water supply facilities, especially of gravity water supply facilities in mountainous areas. Flood water also swells and dissolves many kinds of dirt accumulated during dry months (i.e. dirt from garbage dumps, stagnant water in toilets, sewers, and other storage facilities), reducing water quality and making it difficult and expensive to treat water. Climate change also causes widespread droughts in Quang Ngai. The impact of climate change has caused many people in coastal Quang Ngai to suffer severe water shortages. With no other option, people have to rely on groundwater for living and production, but due to the unplanned drilling activities, groundwater has been exhausted and many wells are bottomless and deserted. The unplanned drilling and digging of wells also cause coastal water sources in Quang Ngai province to be at risk of saltwater intrusion as well as the "breaking" of fresh water aquifer.

Besides the results achieved, the supply of clean water in Quang Ngai province still has some shortcomings, such as lack of durability, shortage of water sources, and use of inadequate treatment technologies due to the omission of climate change impacts in calculating the rural water supply system; use of small-scale facilities, high investment rate of construction works, and low technology application capability; lack of professionalism in managing and operating rural clean water supply facilities resulting in low revenue that is inadequate to cover expenses as well as in the facilities not getting repaired periodically; ineffective dissemination of information and community consultation in some areas, especially in mountainous areas; ineffective water resource protection resulting in irregular upstream water system and decreased water storage capacity.

There has been a number of studies on the effects of climate change on rural water supply (i.e. Plan for rural clean water supply in Quang Ngai province in the context of climate change to 2030 [1], Plan for clean water supply in the context of climate change in the Red River Delta [2], Plan for rural water supply in the context of climate change in the Mekong Delta [3], and Plans for water supply of Quang Nam province and Binh Dinh province in the context of climate change [4], [5]). Researching and proposing clean water supply solutions for Quang Ngai province aimed at overcoming the above-mentioned problems, ensuring sustainable development, and adapting to climate change and other challenges are, therefore, extremely necessary.

Some solutions for rural clean water supply in quang ngai province in the context of climate change

According to the climate change and sea level rise scenarios for Vietnam issued by the Ministry of Natural Resources and Environment in 2016, climate change scenarios for Quang Ngai province were calculated with reference to every station for accuracy assessment of impact of climate change on the fields of operation in and regions of Quang Ngai province. Climate change scenarios for Quang Ngai province were also divided into three levels (i.e. low (B1), medium (B2), and high (A2)) with details on change in temperature, precipitation, and sea level rise for each future period (2020-2039, 2040-2059, 2060-2079, 2080-2099) in comparison to the based period of 1980-1999.

The results of calculation of change in temperature compared to the base period show that the temperature rise of the plain, coastal, and mountainous areas in 2020 compared to the base period will be fairly uniform, with increases ranging from 0.4°C to 0.6°C. However, by the end of the 21st century, the annual average temperature in the mountainous area is likely to rise sharply than in the plain and coastal areas, especially in high emission scenarios. Compared with the base period, annual average temperatures in the plain and coastal areas are likely to increase from 1.5°C to 2.8°C, up to 3.3°C in April while annual average temperature in the mountainous area will increase from 1.6°C to 3.0°C, up to 4.2°C in May.

The trend of rainfall change contrasts with the trend of temperature change among regions in Quang Ngai. Compared to the base period, annual rainfall in the mountainous area will increase less than in the plain and coastal areas. In 2020, annual rainfall is likely to increase from 2.12% (B1) to 2.57% (A2) in the mountainous area and from 2.97% (B1) to 3.57% (A2) in the plain and coastal areas. By the end of the 21st century, annual rainfall is likely to increase from 6.28% (B1) to 10.66% (A2) in the mountainous area and from 8.67% (B1) to 14.69% (A2) in the plain and coastal areas.

Compared with the base period, the average sea level in Quang Ngai province is likely to increase from 7cm (B1) to 9cm (A2) in the 2020s and from 52cm (B1) to 97cm (A2) by the end of the 21st century.

Based on the results of calculation of climate change impacts on different fields of operation and regions in Quang Ngai province, it can be affirmed that climate change will strongly affect some fields such as natural resources and environment (including water resources, land resources, and mineral resources), agriculture, transportation, etc. In particular, climate change causes a significant increase in rainfall during the flood season, leading to floods and decrease in the dry season and severe water shortages and deep saltwater intrusion into rivers. Land resources in Quang Ngai province are at an increased risk of saltwater intrusion, alum infection, erosion and accretion, impoverishing, hardening, and desertification. In terms of mineral resources, most of the sand mining areas in the plain and coastal areas are at risk of flooding. In agriculture, the area of agricultural land at risk of flooding will increase, the demand for water will also increase, and crop yields will significantly reduce. Most of the mountainous areas in Quang Ngai province have increasing numbers of days being at risk of occurrence of fire, increasing by 30-40% compared to the base period. National highways and railways in Quang Ngai province are at high risk of flooding. Waterway traffic in Quang Ngai's rivers (i.e. Tra Bong, Tra Khuc, Ve) will also be affected by climate change. As water level in the dry months decreases, the flow depth will not ensure safe travel of water transport means.

The regions of Quang Ngai province have also been assessed in terms of impact of climate change. In particular, the mountainous area is prone to flash floods and mountain slides; the plain and coastal areas are at risk of flooding, increasing saltwater intrusion as well as river bank and shoreline erosion; the islands will be affected by extreme weather under the influence of climate change.

Vulnerability to climate change has also been assessed for each district of Quang Ngai province. At present, Quang Ngai has low vulnerability to climate change (Figure 1).

MAP OF QUANG NGAI'S VULNERABILITY TO CLIMATE CHANGE (AT PRESENT)

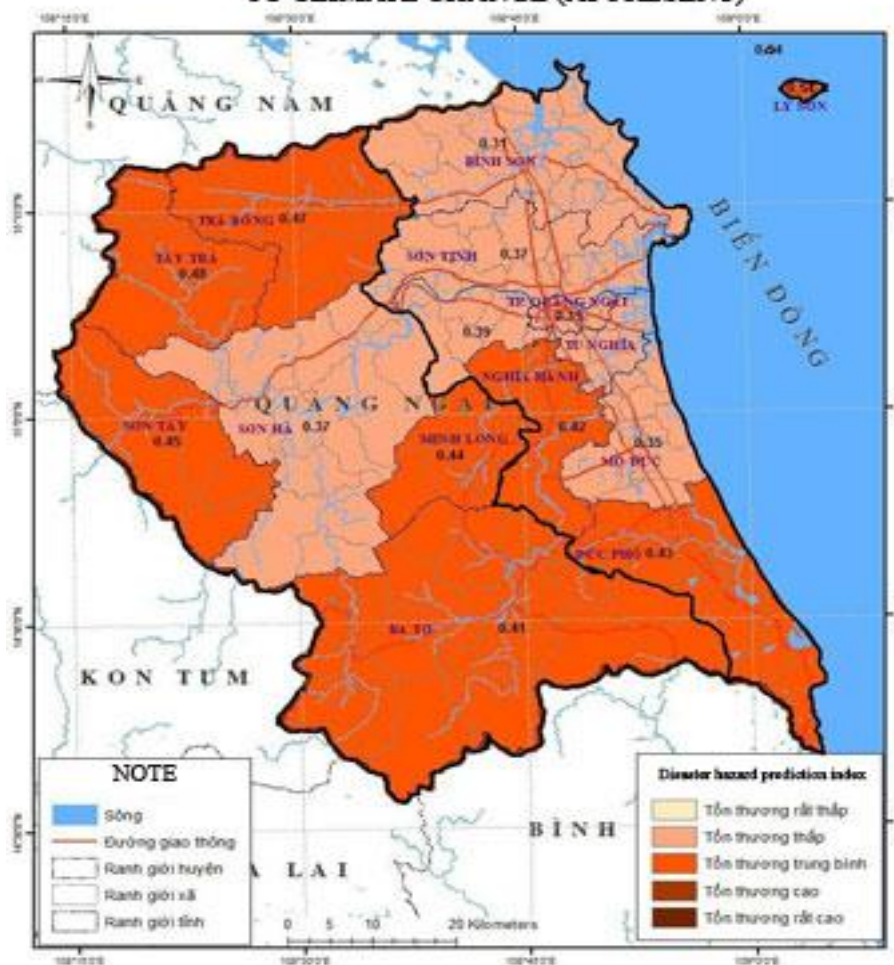


Figure 1: Map of Quang Ngai's vulnerability to climate change (at present).

Ly Son district is the most vulnerable to climate change. The inhabitants of the island rely on fishing and growing garlic. However, the exploitation of coastal sand for planting garlic and onion has caused considerable damage from erosion. In addition, facilities on the island remain underdeveloped and the people do not have access to information on climate change, leading to the district's ability to adapt to climate change remaining the lowest in the province.

Proposed rural clean water solutions for adaptation and response to climate change in Quang Ngai include non-construction and construction measures and are considered recommendations for effective management and response to climate change as well as for sustainable development in Quang Ngai.

Zoning for the purpose of supplying water to rural areas

The water supply zoning in Quang Ngai is based on a number of principles (i.e. status of distribution of water resources, geo-hydrological data, topography, natural conditions, economic – social conditions, population density of each region, technological types and solutions for water supply, and effects of climate change). Based on this, Quang Ngai can be divided into 3 main water supply zones as follows:

*** Zone I (mountainous area): the zone with relatively favorable water sources**

This is a mountainous zone with difficulty in exploiting groundwater (via dug wells or bored wells). This zone has a vast number of rivers and streams which is favorable for the exploitation of surface water sources. This zones includes 7 communes of Tra Bong district; part of Tra Thanh commune (where it is possible

to exploit water from the upstream of Tra Bong river); Tra Tan commune and Tra Bui commune of Tay Tra district; 8 communes and part of Tra Thanh commune (where it is possible to exploit water from the upstream of Tra Khuc river) of Tan Tra district; 13 communes and town of Son Ha district; 06 communes of Son Tay district; 5 communes of Minh Long district (where it is possible to exploit water from the upstream of Tra Khuc river), 3 communes (where it is possible to exploit water from the upstream of Tra Khuc river), and 14 communes (where it is possible to exploit surface water of Tra Cau river) of Ba To district.

Other areas are some communes of the plain and midland districts i.e. 4 communes of Binh Son district (where it is possible to exploit water from the upstream of Tra Bong river); 2 communes of Son Tinh district; 3 communes (where it is possible to exploit water from the upstream of Tra Khuc river) of Tu Nghia district; 3 communes (where it is possible to exploit water from the upstream of Ve river) of Nghia Hanh district; Pho Phong commune and Pho Nhon commune (where it is possible to exploit water of Tra Cau river) of Duc Pho district.

*** Zone II (plain and midland area): the zone with relatively difficult access to water sources**

In this zone, groundwater reserve is low, at risk of iron contamination, microbial contamination, and nitrogen contamination due to human activity, and is recommended for limit exploitation. In addition, shortage of surface water sources in downstream areas often occurs in the dry season. Therefore, it is necessary to build inter-commune and inter-regional reservoirs and concentrated water supply facilities. This area includes the following communes:

+ Binh Son district: 7 communes, part of Binh Hoa commune (where it is possible to exploit surface water in the downstream of Tra Bong river), part of Binh Hoa and Binh Tan communes (where it is possible to exploit surface water in the downstream of Tra Khuc river). Son Tinh district: 04 communes (where it is possible to exploit surface water in the downstream of Tra Khuc river), Tinh Bac, Tinh Minh, Tinh Son (where it is possible to exploit surface water in the upstream of Tra Khuc river); Tinh Tho (where it is possible to exploit surface water in the downstream of Tra Bong river); Tinh Tra (where it is possible to exploit surface water of Tra Bong river).

+ Tu Nghia district: 4 communes and part of Nghia Thuong commune (where it is possible to exploit surface water in the downstream of Tra Khuc river); Nghia Hoa, Nghia Hiep, Nghia Phuong, Nghia My communes and part of Nghia Thuong commune (where it is possible to exploit surface water in the downstream of Ve river); Nghia Thuan and Nghia Thang communes (where it is possible to exploit surface water in the upstream of Tra Khuc river).

+ Nghia Hanh district: part of Hanh Dung commune, part of Hanh Nhan commune, Hanh Thuan and Hanh Minh communes (where it is possible to exploit surface water in the downstream of Tra Khuc river); part of Hanh Dung commune, part of Hanh Nhan commune (where it is possible to exploit surface water in the upstream of Tra Khuc river); Hanh Trung, Hanh Phuoc, Hanh Duc, part of Hanh Thinh commune (where it is possible to exploit surface water in the downstream of Ve river); part of Hanh Thinh commune (where it is possible to exploit surface water in the upstream of Ve river).

+ Mo Duc district: 4 communes and part of Duc Tan commune, part of Duc Hoa and Duc Thang communes (where it is possible to exploit surface water in the downstream of Ve river); part of Duc Tan commune, part of Duc Lan and Duc Phu communes, part of Duc Hoa commune (where it is possible to exploit surface water in the upstream of Ve river); part of Duc Lan commune (where it is possible to exploit surface water of Tra Cau river). Quang Ngai city: 05 communes with the prefix "Tinh" and Nghia Dong, Nghia Dung wards (where it is possible to exploit surface water in the downstream of Tra Khuc river). Duc Pho district: 5 communes with the prefix "Pho" (where it is possible to exploit surface water of Tra Cau river).

*** Zone III (coastal area and islands): the zone with difficult access to water sources,**

This zone's surface water and groundwater are often intruded by saltwater. The zone use water exploited from other areas, causing difficulty and adding to the overall cost. It is suitable for the construction of fresh water reservoirs and household rainwater storage tanks. This zone includes the following communes: 6 communes (where it is possible to exploit water in the downstream of Tra Bong river); Binh Phu, Binh Chau

(where it is possible to exploit water in the downstream of Tra Khuc river) of Binh Son district; 3 communes of Quang Ngai city; Nghia Phu and Nghia An communes (where it is possible to exploit water in the downstream of Tra Khuc river) of Tu Nghia district; Duc Loi an Duc Minh communes (where it is possible to exploit surface water in the downstream of Ve river) of Mo Duc district; 6 communes (where it is possible to exploit surface water of Tra Cau river) of Duc Pho district; Ly Hai and Ly Vinh communes (where it is possible to exploit water of Thoi Loi lake) of Ly Son district.

ABILITY TO EXPLOIT WATER SOURCES

Surface water sources

According to the Irrigation Plan for Quang Ngai Province [6], the total amount of water by source is as follows:

Mountainous area

This area has mountainous and uneven terrain with relatively abundant surface water sources in the upstream regions of Tra Bong river, Tra Khuc river, Ve river and Tra Cau river basin. Therefore, this area is relatively favorable in terms of water resources. The upstream of Tra Bong river has a total water volume of 564.6 million m³; upstream of Tra Khuc river has a total water volume of 3,519 million m³; upstream of Ve river has a total water volume of 1,135.5 million m³; Tra Cau river basin has a total water reserve of 356.356 million m³.

Water reservoirs have already been built in the area, but, due to steep terrain, shortage of water still occurs during some certain months. Therefore, it is necessary to build other facilities to supply water in the dry season when severe water shortage occurs.

Plain and midland area

The area lies in the downstream of Tra Bong, Tra Khuc, Ve rivers, Tra Cau river basin, and Ve river basin. The rivers in this area are narrow, short, and steep. The downstream of Tra Bong, Tra Khuc, and Ve rivers with a total water volume of about 5,528.66 million m³ form a plain favorable for water supply. Tra Cau river has a total water volume of 489.17 million m³.

According to survey results, water shortage still occurs in some months of the year i.e. February and March. If all irrigation measures were applied to collect the total water volume to the area, the basic monthly flow of water would still not meet the demand for water. The area's minimum demand for water is also significantly met in part by Thach Nham dam system. Therefore, in the future, when demand for water increases, measures (i.e. constructing new water reservoirs or inter-commune and inter-regional water plants) will need to be applied.

Coastal area and islands

Ly Son island district has a total water reserve of 11.51 million m³ with water shortage occurring mainly in February and March. Ly Son district has also invested in constructing Thoi Loi reservoir with a design capacity of 270,085 m³, but the reservoir is still inadequate to supply water to its people. In other areas, people have to drill wells or use water supplied by water supply facilities that exploit surface water from the downstream regions of Tra Bong, Tra Khuc, and Ve river, and Tra river.

Groundwater sources

Mountainous area

Groundwater in these districts is poor in volume and only caters to small-scale and scatteredly distributed water supply facilities.

Table 1: Groundwater reserve of the mountainous area

No.	Area for calculation of reserve/Aquifer	Dynamic reserve (m ³ /person)	Static reserve (m ³ /person)	Potential reserve (m ³ /person)	Potential module (m ³ /person/ha)	Forecasted reserve (m ³ /person)	Forecasted module (m ³ /person/ha)	Daily water layer (MM)
1	Qh	116,142.47	7,820	130,662.4	31.85	76,477.07	18.63	1.863
2	Qp	227,575.35	13,206	240,781.3	29.52	140,903.1	17.3	1.73
3	Pr	405,549.31	116,837.7	522,386.91	28.99	329,686.0	16.14	1.614
4	edQ	297,093.43	13,941.9	311,035.33	8.31	182,856.8	4.88	0.488
	Total	1,046,361	151,805.6	1,244,863	25.78	729,923.2	14.79	1.404

Source: Plan for clean water supply in Quang Ngai province to 2030 [7]

Plain and midland area

The supply of water to Quang Ngai city can rely on groundwater under the accretion bank by Tra Bong river via the water absorbent corridors arranged along the river bank.

The supply of water to Tu Nghia district and part of Duc Pho district can rely on the exploitation of groundwater via wells (along sand dunes) to 30-50m depth.

The supply of water to Dung Quat-Van Tuong area can rely on broken zones in basalt masses in addition to the Quaternary aquifers via bored wells to 70-100m depth.

The supply of water to Mo Duc district can rely on the exploitation of underwater with a flow of 1.000 m³ per day and night via bored wells to 8-10m depth.

Table 2: Groundwater reserve of the plain and midland area

No.	Area for calculation of reserve/Aquifer	Dynamic reserve (m ³ /person)	Static reserve (m ³ /person)	Potential reserve (m ³ /person)	Potential module (m ³ /person/ha)	Forecasted reserve (m ³ /person)	Forecasted module (m ³ /person/ha)	Daily water layer (MM)
1	Qh	73,279.46	658.5	66,937.96	37.68	39,174.98	22.05	2.205
2	Qp	141,842.46	3,470	145,312.45	35.71	94,500.59	20.65	2.065
3	Pr	46,356.16	425	46,781.16	9.79	30,263.95	5.51	0.551
4	edQ	257,918.36	1,567.7	259,486	6.96	159,558.35	4.07	0.41
5	B	4,635.62	840	475.6	6.16	3,888.57	3.33	0.333
	Total	524,032.06	5,961.2	68,993.17	96.30	327,386.44	55.61	5.56

Source: Plan for clean water supply in Quang Ngai province to 2030 [7]

The plain and midland area has low groundwater reserves and high population density. In the future, it is expected that the exploited capacity will remain the same and capacity expansion is limited. The expansion of capacity will only be conducted in some areas where shortage of surface water occurs.

Coastal area and islands

Groundwater reserve in Ly Son island is relatively large. Potential groundwater reserve of the district

is about 26,349 m³, but, due to the large number of exploitation facilities (132 boreholes, bored wells, and a concentrated water supply station), the risk of a break-down of the fresh water aquifer and saltwater intrusion of groundwater are very high if no solution on using surface water and limiting the exploitation of groundwater is applied. The area also includes some other communes in the districts of Duc Pho, Mo Duc, Son Tinh, Binh Son, and Quang Ngai city. These regions are often affected by saltwater intrusion, so it is necessary to limit the exploitation of groundwater in these regions.

Solutions On Exploiting Water Sources

To establish zones of protection of freshwater on Tra Bong, Tra Khuc, Ve, and Tra Cau rivers and zone river basins that need to be protected to avoid contamination of freshwater and groundwater; to manage drilling and exploitation of groundwater so as to ensure the satisfaction of the requirements of professionalism, technologies, etc. applicable to the exploitation of groundwater for the purpose of supplying domestic water.

To raise awareness and responsibilities of organizations and communities in exploiting, using, and saving water sources especially in the dry season (peak in September - October); to disseminate information and educate people on the benefits of using clean water and basic knowledge in the creation, preserve, and protection of clean water sources.

To build and integrate automatic checkpoints for river water quality at raw water supply stations; to perfect the system for monitoring river surface water quality and increase the frequency of monitoring in order to control the quality of water sources.

To intensify the control of polluting sources that cause water pollution; to closely control the exploitation and use of water in a thrifty, efficient, and sustainable manner; to evaluate the current status of exploitation and use of water as well as the demand for water at exploitation and use establishments; to ensure the issue of licenses for exploitation and use of water sources; to use water sources as permitted; to plant trees and establish buffer zones along rivers in areas with surface water having been contaminated or at high risk of contamination.

Solutions For Water Supply Facilities

- Investors should clearly define the functions and tasks of water quality monitoring and management teams at each facility so as to avoid overlapping functions and provide estimated costs for the production of clean water as well as for the management and operation of clean water supply networks in rural areas.
- To improve the organizational structure and management in order to optimize service efficiency of rural concentrated water supply facilities, it is necessary to establish a close cooperation and linkages between local authorities and management units and the people during the implementation of management and operation with an aim to promote the effectiveness of the facilities. Appropriate management models will ensure that the system operates continuously, saving time for households in exploiting water for domestic use.
- Water supply facilities after being handed over and put into use must be managed and equipped with appropriate technologies. Management and operation units at rural water supply facilities should establish appropriate production and business plans as well as step-by-step implementation plans so as to ensure the facilities meet requirements on service quality, ensure profitable production and business activities, and fulfill tax obligations to the State according to regulations. It is necessary to periodically improve professional skills for the staff who manage and operate the facilities as well as to periodically monitor and inspect the quality of water sources and water supplies so as to establish appropriate treatment plans in a timely manner. Management units should also build plans to approach more customers (i.e. offering incentives) and increase the number of clean water connections (i.e. reducing connection costs for households requesting for batch connection, reducing cost of installation accessories, reducing cost of water meter installation). The units also need to apply measures to prevent water loss and ensure effective financial management.

Solutions On Enhancing Post-Investment Management Of Water Supply Facilities

In order to optimize post-investment service efficiency of water supply facilities, it is necessary to establish a close cooperation and linkages between local authorities and management units and the people during the implementation of management and operation. The management unit model in particular plays an important role in maintaining the rural clean water supply system. Appropriate management models will ensure that the system operates continuously, saving time for households in exploiting water for domestic use.

- Water supply facilities that are being constructed, about to be completed or are in the planning stage that have yet to be assigned management units must be reviewed in terms of scale, capacity, and area for the determination of appropriate management units. The proposal of management and operation units should be made right from the stage of preparation of investment project, whereby investors should also be assigned to manage and operate the projects when put into use. Combining the title of investor, owner, and manager into one legal entity who is responsible for the whole process of investment, operation, recovery of investment capital, and long-term development of the rural clean water supply system not only helps improve the quality of construction but also ensures the maintenance is paid attention to, damage is repaired in time, cost is reduced, and rate of loss decreases.

- Facilities that have been built must be reviewed for proposal of plans for selecting appropriate management and operation units so as to ensure timely handover according to regulations. Some specific proposals on the management of rural water supply facilities with reference to the current conditions of Quang Ngai province are as follows:

For facilities with sustainable or medium performance

- To continue the activities and ensure funding for routine operation, maintenance, and repair of the system; actively improve management and operation capacity; ensure the quality of supplied water meets preset standards.

- Management and operation units to establish rational production and business plans as well as clean water price schemes with appropriate accuracy and completeness to be submitted for review and approval by competent authorities.

- To promote awareness among people about the role of clean water in daily life, raise the rate of connection to concentrated water supply facilities, and raise awareness about economical use of water and about protection of clean water facilities and water sources.

For facilities with poor performance or inactive facilities

- Based on the current status of the water supply system, it is necessary to consider proposing a list of works in need of socialization in the management and operation so as to select appropriate management and operation units to ensure efficiency.

- Management and operation units shall establish production and business plans as well as clean water price schemes which clearly state the contents of the management process, the operation process, the orientation of the roadmaps for upgrading and renovating the works, the contents of promotion and marketing programs to approach customers, the professional training for skill improvement for management and operation staff, the contents of water quality inspection and supervision, the plans for handling emergency situations when incidents occur at the sources of water, the measures to control and prevent water loss, etc.

- Communal People's Committees shall be assigned to manage small-scale and inefficient works in mountainous areas that have previously been managed by the community (via the establishment of a management and operation team and collection of water charges which, though small in value, will be used as a source of fund for repairing minor damages). The water center shall provide technical assistance, training, and guidance to local authorities in the management and operation of such works.

For inactive facilities

- To continue to review the conditions of inactive facilities and consider the possibility of renovation and upgrading these works for the supply of water; in cases where it is not possible to remedy the situation, requests should be made to the province for liquidation according to regulations.

- For facilities that can be repaired, it is necessary to identify the causes to their inactive state; facilities that

are inactive due to a number of reasons should be treated with a combination of several measures.

Solutions on strengthening the inspection, examination, and handling of violations of rural clean water legislation

- To enhance the handover of responsibility to local communities in supervising water supply facilities based on the principle of “people know, people discuss, people do, people check”.
- Competent state authorities at all levels to intensify the inspection, examination, and strict handling of violations of water supply legislation committed by organizations and individuals and resolutely suspend the operation of or relocate production establishments that cause severe environmental pollution out of residential areas.
- To intensify the inspection, examination of, and control over water supply facilities which have been put into operation so as to ensure compliance with quality regulations (i.e. ensuring the management, operation of water supply facilities and the supply of water are conducted in proper processes and water inputs and drainage facilities are in strict compliance with the regulations on protection of natural resources and environment).
- To intensify the supervision and observation of the operation of water supply facilities; improve the capacity for monitoring and warning of violations (i.e. adding officers in charge of controlling the quality of operation of water supply facilities in those districts and communes for timely handling of incidents); train management officers and inspectors on responsibility and mobility; regularly inspect, examine, and supervise production establishments in order to detect and promptly handle cases of violation; establish regulations on administrative sanctions against acts of obstructing the supply of clean water to rural areas.

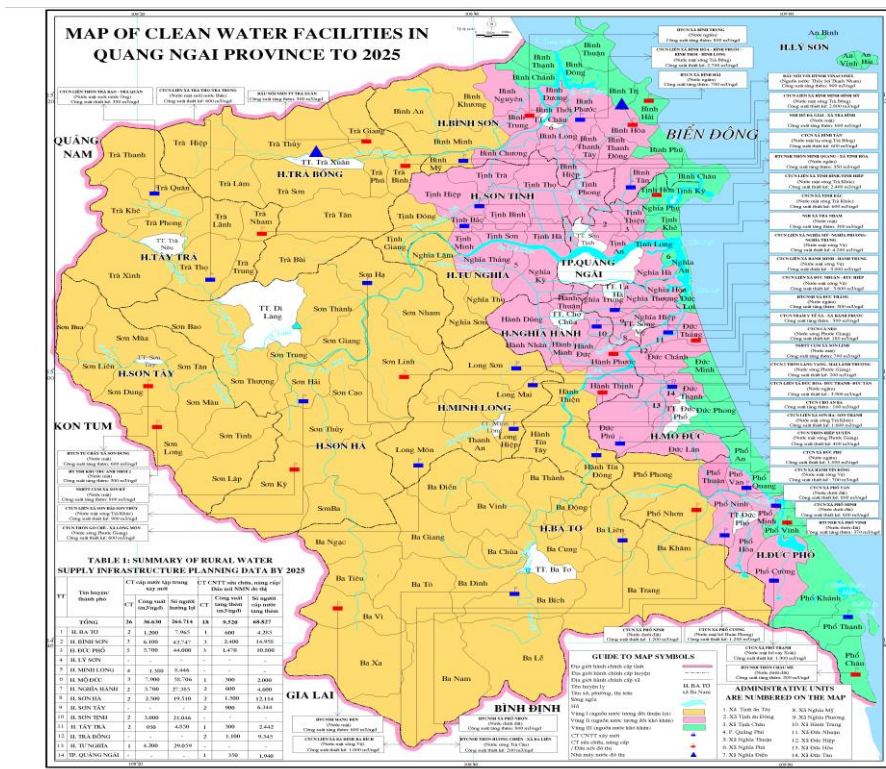


Figure 2: Map of clean water facilities in Quang Ngai province to 2025

Allocation of clean water facilities in response to climate change to 2025

Based on the status of distribution of groundwater and surface water sources, the results of assessment of the ability to exploit surface water and underground water sources for the purpose of supplying water for domestic use, the above-mentioned method of dividing the province into three water supply areas as well as the climate change scenarios published by the Ministry of Natural Resources and Environment in

2016, water supply facilities in Quang Ngai province are planned to be allocated by 2025 as shown in Figure 2.

CONCLUSIONS

The solutions for rural clean water supply in the context of climate change, which are suitable with the new rural construction stage, form an important foundation for the management and investment in rural water supply for domestic use. Proposed solutions have shown to meet requirements in terms of ensuring the achievement of water supply targets in the period up to 2025, supporting the construction of new rural areas and sustainable development of water supply facilities, ensuring the adaptation to climate change, and ensuring the effective implementation that is in line with the orientation of socialization in rural clean water supply. The zoning and assessment of the availability of water sources have also shown to support the planning and construction of large-scale water supply systems and help establish links among small-scale water supply systems for incorporation into a larger transmission network so as to facilitate the management, operation, and application of management technology, and to cut costs.

In order to promote the effectiveness of investment in rural water supply facilities, it is necessary to establish policies, plan, and invest in line with the development orientation outlined by the Government, eliminate the thinking of investment in small-scale construction of water supply facilities under subsidy policies, and focus on establishing inter-regional and inter-commune facilities that are favorable in terms of management and are cost effective. The investment in and construction of facilities must be synchronous with a view to sustainability and must focus on areas where people have actual demand for domestic water. In addition, there should be mechanisms to bind people who are granted access to water supplied by the facilities so as to create sufficient funds for self-management, operation, and repair of damage, thereby raising the responsibility and ensuring sustainable use of the facilities.

The above-mentioned results and solutions are approved by the appraisal committee of the People's Committee of Quang Ngai province on June 29, 2017 and approved by the People's Committee of Quang Ngai province in Decision No. 884/QD-UBND dated November 27, 2017 for implementing in Quang Ngai starting from December 2017.

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