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Original Article

Tap-Water Security and Policy Implications in Hanoi, Vietnam

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Abstract: This paper investigates tap-water securities using the management of non-traditional security (MNS) framework. The study found that tap-water in Hanoi is insecure due to uncertain upstream water sources, weak water quality monitoring, and poor wastewater drainage. Main challenges to tap-water security in Hanoi are ineffective management capacity of the local authorities as well as aging pipeline systems. Improvement in tap-water governance and collaborative co-governing is necessary. Privatization of tap-water utilities is not always effective to ensure tap water accessibilities to all residents. Finally, advanced water technologies are essential to achieving tap-water security in Hanoi.

Keywords: Tap-water security, sustainability, crisis management, water management authorities.

1. Introduction

Hanoi, the capital city of Vietnam, has more than 8 million residents [1]. In the past, a large proportion of tap water supply in Hanoi was extracted from groundwater [2]. However, rapid extraction has depleted groundwater, leading to declining quantity and quality in Hanoi. Declining groundwater and deteriorating quality are dramatically raising the costs of groundwater supply. According to the report from Hanoi Water Company, available groundwater for exploitation decreases by 4-6% annually. Therefore, in the future, Hanoi has to rely on surface water to serve its increase in tap-water demand of 2-3% annually due to population increase [2].

Tap-water quality in Hanoi is a growing concern due to polluted upstream water sources and water pipeline leakages. The provision of clean tap water does not only depend on water

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sources but also on the quality of water pipeline network, implying that water might be contaminated due to the erosion of old pipeline system. In 2019, the construction of Duong River surface water plant in Gia Lam district was completed with its first phase capacity of 150,000 cubic meters per day [3]. However, only one-fifth capacity of this plant was supplied to consumers per day, due to no pipelines available yet. The development of water sources and distribution of water was not on a par with the development of water pipeline networks. This reduces water distributing effectiveness and causes tap water insecurity in Hanoi.

Hence, there is a need to assess tap water security in Hanoi urban areas. In this study we apply the approach of Management of Non-traditional Security (MNS) to assess the situation of tap water security in Hanoi, factors affecting tap water security in Hanoi urban districts, and discussing management policies and implications for improving tap water security in Hanoi.

2. Tap Water in Hanoi Areas

2.1. Tap Water Supply and Demand in Hanoi

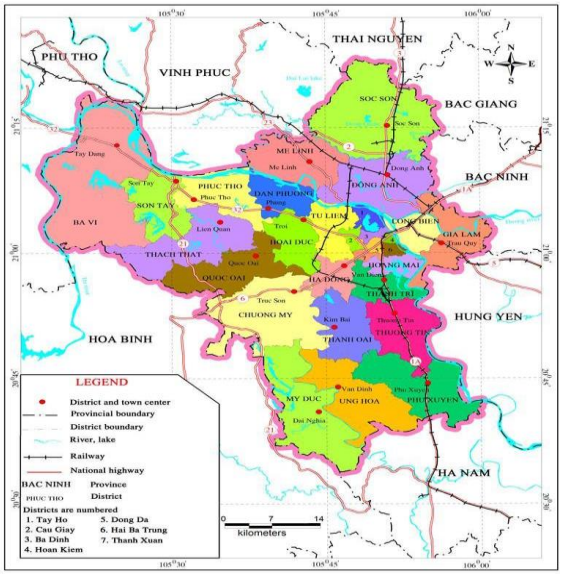

Figure 1. Hanoi areas map.

Hanoi has about 8 million residents, with 30 administrative units including 12 urban districts, 17 suburban districts, 1 satellite town. Hanoi has an area of approximately 3,120 square kilometers, with major districts illustrated in Fig. 1. Living population in Hanoi is scattering from urban downtown to rural suburban areas, with a population density of approximately 14,639 persons per square kilometer [4].

In Hanoi, tap-water system is supplying domestic water for 12 urban districts with about 4 million residents, mainly used groundwater from 16 water plants and numerous small water supply stations. Total tap-water demand in Hanoi is about 1,250,000 – 1,350,000 m^3/day, while total tap-water supplying capacity of Hanoi is about 1,530,000 m^3/day. There are five main water companies, which are Hanoi Water Limited Company (Hawacom) with a capacity of 550,000 – 650,000 m^3/day, Song Da Water Investment JSC (VIWASUPCO) with a capacity of 300,000 m^3/day, and Duong River Surface Water Plant JSC (SDWTP) with a capacity of 300,000 m^3/day, Freshwater Business & Investment Construction JSC (VIWACO) with a capacity of about 180,000 m^3/day, and Ha Dong Water One-Member Limited Liability Company (HADOWA) with capacity of about 100,000 m^3/day (Hanoi Department of Construction, 2023). Groundwater still accounted for majority of (51%) tap-water supplies. However, groundwater in Hanoi is deteriorating both in quantity and quality due to over exploitation leading to land subsidence and depleting groundwater [5].

Water plants' capacities in Hanoi barely meet its tap-water demand. However, tap-water is not well distributed equally. Therefore, there are still water shortages in places where are at the ends of water pipeline systems, in high-altitudes, and/or using water supplied from Song Da surface water by VIWASUPCO, such as Thach That, Quoc Oai, Chuong My, Hoai Đuc, Nam Tu Liem, Ha Đong, Thanh Xuan, Hoang Mai districts. In sub-urban districts of Hanoi, residents have limited access to tap water, only 264 out of 413 suburban communes in Hanoi

have access to tap water (64%) is sufficiently supplied to urban districts.

2.2. Tap Water Quality in Hanoi

Most of Hanoi residents do not know the sources of their tap water used from ground or surface water, and from which water plants. Tap water quality is also not published openly. In recent years, there has been a lot of concerns about the tap water quality and incidence of water turbidity, scum, and deposits around water containers. Many residents have tested water samples and found residual of metal or hardness content, ammonium (NH4+), Nitrite (NO2-), iron, manganese, arsenic, etc. which exceeds the allowable standards for domestic water and drinking water as prescribed by the Ministry of Health. Tap water quality problems are found in urban districts of Hanoi, as well as in suburban districts [6].

According to the Hanoi Environment & Natural Resource Department (2023), Hanoi has discharged about 300,000 tons of wasted water every from domestic, agricultural and industrial uses. The wastewater contains about 3,600 tons organic matters, 320 tons of light and heavy oil, tens tons of metal, many chemicals, pesticide, fertilizer, bacteria, etc. Among discharged wastewater, only about 10% is treated, and 90% are directly discharged to local lakes, rivers, and water bodies. Therefore, all the lake, river, water bodies in Hanoi are heavily polluted. Those polluted surface water will seep down to groundwater, which is in turn pumped out to supply to tap water plants in Hanoi.

The Decision 554/QĐ-TTg date 6/4/2021 on master plan for tap water supply in Hanoi emphasized that "Hanoi rationally exploits groundwater and surface water sources, give priority to exploiting surface water sources, gradually reduce groundwater exploitation, build inter-regional connection water supply system in order to diversify water supply options for Hanoi in the long-term". Hanoi policy to reduce groundwater is suitable for the real situation of depleting groundwater level and increasing contamination incidences. Therefore, Hanoi will increasingly exploit surface water from nearby river systems such as Red river, Duong river and Da river. However, those rivers are threatened by pollution from agriculture and industries. Their upstream watershed is not well protected. Hence water quantity and quality supplied to Hanoi are uncertain and beyond the control of Hanoi authority.

2.3. Tap Water Policy

Hanoi policy is changing residents' opinion and behavior toward more tap water security, such as water pollution prevention, and water saving. The local authority has invested in changing local residents, but those investment are not significant and impactful enough [7]. Therefore, local residents have lack of confidence in local tap water administration system due to local authority do not share information on planning, public investment and management of tap water [7]. In addition, economic tools/incentives for tap water management such as wasted water discharging fee and maintenance fee are too low, and not effective to improve water security. On the other hand, local authority provides heavy subsidies to related resource and environmental services, as so local residents taking its for grants. For example, 90% of Hanoi residents consider tap water price of 6.000 vnd/m^3 for first 10 m^3 to be low [8], hence do not practice water saving.

3. Conceptual Framework and Methodology

3.1. Water Security Concepts

The concept of water security is defined as an acceptable level of water-related risks to humans and ecosystems, coupled with the availability of sufficiently quantity and quality water to support livelihoods, national security, human health, and ecosystem services [9]. Water security is also defined as the capacity of a population to maintain sustainable access to adequate quantities of quality water for

sustaining livelihoods, human well-being and socio-economic development, ensuring protection against water pollution and water-related disasters, and preserving ecosystems [10]. Grey and Sadoff (2007) make it clear that water security is the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystem and production, at an acceptable level of water-related risks to people, environments and economies [11]. Indeed, the concept of water security tends to vary with contextual and disciplinary perspectives [12]. From a legal perspective, water security has been associated with water allocation mechanism that secure people's entitlements to desired water quantities and qualities. From agricultural perspectives, water security relates to the protection of farming from flood and drought risks. From a public health perspective, water security refers to the access to water sanitation and water freeing from contaminations.

3.2. Urban Water Security

Cities are rapidly growing and becoming the centers of economic growth. Hence, urban water security is increasingly imperative. The rate of urbanization in Asia was approximately 2.2% per annum during 2015–2020 and is expected to decline to 0.8% by 2045 [13]. Urban water security is essential in achieving livable, resilient, and productive cities. However, rapid urbanization and climate change have caused significant challenges to urban water security. The concept of urban water security is multi-faceted and interrelated with broader concepts of urbanization, integrated urban water management, resilient and adaptive urban water management, and water-sensitive cities [14]. Urban water security can be considered as the capacity of local water supply systems to maintain sustainable and equitable accesses for urban residents to water quantities and quality at affordable costs. Hence, urban water security has three dimensions: i) Capacity for sustaining human well-being and socio-economic development in urban areas; ii) Capacity for protecting urban residents against water-borne pollutions and disasters; and iii) Capacity for preserving ecosystems that provide water resources and absorb polluted water [14]. According to the Asian Development Bank (2020), urban water security comprises five elements: water supply, water sanitation, water affordability, water drainage, and water environment e.g. landscape, lake and pollution [15]. The Asian Development Bank also incorporates risk factors (natural, technical, social, financial, and institutional, etc.) in urban water security. There are four risk indicators to be assessed, such as urban growth rate (%), non-revenue water (%), water consumption and energy cost (%). The urban growth rate is a particularly important influence on urban water risk because growing populations need more infrastructure and services. Water consumption is expected to vary according to geographic and climatic conditions, using high volumes may be wasteful, while using too little may reflect poor access. Low-cost and reliable energy supplies can improve water treatment and shifting to more climate-resilient water supplies, e.g. recycled water [15].

There are three pillars of urban water security: economic efficiency, social equity, and environmental sustainability: i) In respect to the economic dimension, water security focuses on the welfare of urban dwellers. The welfare value of a water system can be measured through its services to ensure water availability, water safety, and water sustainability; ii) In respect to social dimensions, water security is viewed in terms of social equity. For example, the poor people' s access to proper drinking water and sanitation, and resilience in facing extreme water events; and iii) In respect to the environmental dimension, water security means environmental and ecological sustainability of water bodies [16].

3.3. Management of Non-traditional Security (MNS) for Urban Water

Tap-water does not come to urban residents as a free service. Tap water is a service or a result of certain actions carried out by responsible actors such as: water extraction, water treatment,

water distribution, and water quality monitoring. This study employs the Management of Non-traditional Security (MNS) framework proposed by Hoang Dinh Phi et. al. (2019) to assess institutional and administrative factors affecting tap-water security in Hanoi, Vietnam. The management of non-traditional security (MNS) approach is summarized in th equation below [17]:

MNS = [Safety (S1) + Stability (S2) + Sustainability (S3)] – [Cost for risk managemen (C1) + Cost for crisis management (C2) + Cos for after-crisis recoveries (C3)]

or,

$$MNS = (S_1 + S_2 + S_3) – (C_1 + C_2 + C_3)$$

The MNS equation is developed and tested based on the principle that any security value must be considered in relation to the loss and cost of related activities. S_1, S_2, and S_3 represent results or securities. While C_1, C_2, and C_3 reflect associated costs to achieve security [17].

In this study, four dimensions of MNS equation are selected to assess water security in Hanoi, including S_1, S_2, S_3 and C_2. While S_1, S_2, S_3 reflect the water security, C_2 expresses the losses caused by water crises.

3.4. Research Design and Methods

This research uses secondary data and desk studies, and qualitative analysis to review and discuss the situation and issues of tap water development and security in Hanoi.

In order to employ the MNS framework to assess tap water security in Hanoi, we conduct a primary data survey on water availability, water quality organoleptic properties (taste, color and odor) and related security criteria of tap water. An online questionnaire is developed based on the MNS framework and pretested. The structured questionnaire then is revised and sent to Hanoi urban residents in a convenient way through research team network with people living across Hanoi urban districts. This is a convenient snow ball sampling method. This method has a limitation of not randomly sampling, and we try fixing this problem with spreading the questionnaire to 500 residents through our network across Hanoi, and we get 284 responses for the online questionnaire.

4. Results and Discussion

4.1. Safety

The survey shows that 77.58% of respondents worry about the quality of tap water they consumed. The reasons are that they have experienced bad quality tap water in the past. 18.15% of respondent households have found their tap watercolor turned opaque and dark sometimes; 23.93% of respondent households confirm bad smell in tap water (see Table 1). In Hanoi there are no independent agencies to monitor tap water quality. Information on tap water quality is not made public widely to urban dwellers. Tap water quality can be found on water companies' reports and websites. However, Dwellers in Hanoi do not have confidence in provided tap water quality, only 27.5% of respondents' states that given information on tap water quality is reliable.

There are several factors affecting tap water safety, 61.2 % of respondents state that polluted water supplies to processing plants is the primary reason for their water safety concern. Input water for tap water processing plants in Hanoi are from two sources, groundwater, and surface water, which are both facing threats of pollutants from industrial, agricultural and domestic activities [18]. In respect to operational factors of tap water processing plants, 48.8% of respondents do not have confidence in current water processing plants. Residents believe that water processing technologies are outdated, operations of water plants are not transparent, and there is a lack of a third party, independent agency that monitors tap water processing plants.

Water safety is related to water supply and water drainage also. In Hanoi, a large proportion of wastewater is untreated and discharged directly to lake, river, and water bodies. Those untreated waste water then pollute groundwater

and surface water and creating risks to urban residents. However, those threats are not recognized by residents and authorities. In this study, no residents have awareness or concern about water safety related to water drainage and water pollution.

Table 1. Water Safety

Criteria	Access to water quality information	Concerns about water quality	Occurrence of turbidity in tap water	Occurrence of bad smell in tap water	Use of water filtering devices
Households living in inner urban areas	23.3%	75.2%	17.6%	22.9%	76.2%
Households living in suburban areas	22.5%	84.5%	19.7%	27.1%	82.9%
Total	23.13%	77.58%	18.15%	23.93%	77.86%

Source: Survey 2022.

4.2. Stability

Stability is about how residents change their concerns on tap water security over time. In other words, stability is a condition, interfaces and interconnections among water supply, sanitation, water price, wastewater drainage and water pollution over time. Regarding water supply and availability are stable, as 77.5% of respondents state that they've never experienced tap water cut-off over last year, and 92.5% of respondents respond that their water pipelines have never broken, and 87.5% of respondents agree that their tap water supplies are stable. Tap water is stable in terms of pricing, as 80.7% of respondents report that they are happy with tap water pricing policy.

However, in some circumstances urban dwellers in Hanoi still face unstable water security, such as in summertime and typhoon circumstances. 41.4% of respondents state that their tap water supply can be disrupted during hot summertime or occurrences of typhoons or hurricanes. Even though Hanoi residents do not have confidence in their tap water quality, they report that tap water quality is stable, this means water quality does not fluctuate much, 87.4% of respondents (see Table 2).

Table 2. Water Stability

Criteria	Frequencies of water cut	Stability of water quality	Stability of water price	Concerns about water cut-offs in summer or typhoon
Households living in inner urban areas	1.41%	90.87%	84.69%	40.95%
Households living in suburban areas	8.57%	77.14%	68.57%	42.86%
Total	6.76%	87.41%	80.65%	41.43%

Source: Survey 2022.

Tap water stability varies between urban and suburban areas. Residents living in urban areas have less frequencies of water cut-offs, more stabilities on water quality and water price. They also suffer less from seasonal effects such as summer times and typhoon.

Water stability factors are inter-correlated, the higher frequencies of water cut and water price increase, residents use less tap water. Residents have more stable water quality, also face more stable prices and less water disruption. The stability of tap water supply and its quality have a negative correlation (-0.23.22%). It means that in those residential areas where the tap water supplying is not completed, residents face less stable water quality, which is prevalent in newly developed residential, or in very old residential areas. Similarly, the stability of tap water supply is negatively correlated with tap water use prices (-16.86%), as well as tap water use costs, but not significant (-0.98%). The stability of tap water quality in Hanoi is positively correlated with the stability in tap water price (17.41%). Residents have more access to the stable water quality, worry less about water disruption (-20.66%), and save costs on water use. The finding shows the importance of tap water distribution system, residential areas with well-established tap water systems will have better water security.

Noticeably, there is a small proportion of Hanoi residents facing water instability, who is living in newly developing urban areas or suburban areas. In recent years, urbanization is rapid and newly established resident areas are often lacking good infrastructure such as electricity, water supply and road systems. This shows a need for Hanoi authority to improve the city's urban development planning.

In principle, Hanoi dwellers are satisfied with tap water stability in terms of availability, price and quality. 80.5% of respondents report that they have confidence in the tap water stability policy. However, they have more concern on water stability policy in the long run.

4.3. Sustainability

The sustainability of tap water security is assessed in economic, social and environmental aspects. From the MNS framework, water sustainability is assessed in terms of water supply, water affordability (e.g. price, and accessibility), and environment sustainability (e.g. water reservoir pollution, water sources and water landscape). The sustainability of tap water supply in Hanoi is uncertain in the long-term. In the past, water supplies are mainly from groundwater, and almost depleted [18]. Therefore, Hanoi tap water is currently supplied from surface water of Song Da River and Song Duong River.

In Vietnam, upstream watersheds are not strictly protected. Therefore, in the long term, the sustainability of water supply to Hanoi is endangered. The majority of Hanoi residents have confidence in tap water policy in the city, as 80.5%, residents believe that Hanoi is an important political and socio-economical capital city, hence the Government of Vietnam has to prioritize public utility services for Hanoi.

In the economic aspect, water sustainability means that tap water brings higher benefit than costs. In other words, tap water cost should be acceptable to residents. The survey results reveal that only 23.2% of respondents report that tap water price is relatively expensive to them, and 76.8% of respondents state that tap water price is low or reasonable. However, most Hanoi residents (67.86%) responded that they are worried about water price increasing.

In terms of environmental sustainability, current tap water system has had an issue with wastewater treatment and pollution that affect nearby lakes, rivers and water bodies.

4.4. Crisis Management

Grey and Sadoff (2007) define that water security is the availability of an acceptable quantity and quality at an acceptable level of water-related risks [11]. Tap water-related crises are interpreted as the probability of adverse water-related events and its negative impacts or costs to residents. From the MNS framework, the tap water crisis is assessed based on the losses caused by water insecurity events.

Tap water crisis has been a potential problem in Hanoi due to water shortages and broken

pipelines. Hanoi residents has reported that tap water smells bad, which was caused by wasted oil dumping on the upstream of the Song Da water company. Hanoi authorities warned its residents not to use tap water for cooking and drinking during the occurrence.

There are also hidden crises with tap water system in Hanoi, which are not fully assessed, especially potential crises arising with water quality, public health safety, and the stability of the tap water supplying system. The survey results reveal a moderate frequency of adverse events such as tap-water supply disruption and tap-water poor quality. The probability of water supply disruption and quality deterioration are reported moderately low. The losses caused by the incidents are unknown. In terms of wastewater drainage and environmental pollution, the probability is moderate, but its negative impacts to people and society are high. However, Hanoi residents are not well-aware about these risks.

It is the responsibility of Hanoi authorities and independent agencies to conduct a comprehensive assessment of potential risk and crisis to the tap water system in Hanoi and to develop a risk and crisis management plan to mitigate the likelihood and damage costs of potential risks and crisis events in Hanoi.

5. Conclusion and Policy Implications

5.1. Conclusion

This study employs the management of non-traditional security (MNS) framework developed by Phi Dinh Hoang et al., (2019) to assess tap-water security in Hanoi [17]. Data is collected both from secondary and primary sources through an online survey of 284 households from April 2021–May 2021. The main findings are below:

First, Hanoi's tap water is relatively insecure according to the four-dimension MNS framework. Tap water security in Hanoi is lower in suburban and newly urbanized areas, such as in western and southwestern districts of Hanoi, e.g. districts of Thanh Xuan, Ha Dong, Nam Tu Liem, Hoang Mai districts.

Second, the level of tap water security in Hanoi is acceptable in the short-term for majority of Hanoi residents. However, in the long-term, it is alarming due to several critical factors affecting tap water security, such as upstream water source management, water quality monitoring, and wastewater drainage treatment and water pollution.

Third, the utmost needs of Hanoi residents for water quality, safety, stability, and sustainability, particularly for the those in the suburban areas, are still critical. There is no doubt that people living in off-grid water systems also need urgent solutions. Main challenges to water security in Hanoi in the coming years are ineffective management capacity, inadequate and aging pipeline systems, uncertain upstream water resources.

5.2. Policy Implications

To ensure tap-water security is vital for Hanoi capital city. Therefore, policy recommendations for improving the governance of tap water in Hanoi are necessary. Hanoi municipal city should undertake research on local sustainable tap water, to strategize about long-term pathways to tap water security, to undertake short-term solutions to existing system, and to explore the possibility of collaboratively co-governing tap water in Hanoi. The authors give policy recommendations below:

First, Hanoi authorities should raise the awareness of water security and improve the collaboration among governmental agencies in charge. Many problems of water insecurity could be solved by raising the awareness of water security. It is better for the Hanoi city to have a close collaboration and knowledge exchange and effective connections with specific agencies. Such as MARD and MONRE to develop a strategy that ensures the tap-water security issues.

Second, Hanoi could apply traditional methods of harvesting rainwater, together with

advanced water technologies to ensure its water sources. Rainwater remains a significant sources of water supply to urban poor residents. Chidozie Charles Nnaji (2018) showed that rainwater could meet 100% of water consumption demand of low-income groups. Lack of appropriate technology in many cases are main cause of water loss (Samah Jawad Jabari, 2017). Advanced water technologies such as membrane separation for water processing, water recycling at industrial scales or purifying water from air is essential to achieving the city's water security.

Third, suburban areas should be connected to the water grid. Water for the daily use of many suburban residents is simply pumped and processed from local wells. An affordable pipeline system should be part of the solutions, and this enables many people in these areas to be connected to the city water grid as their essential rights.

Furthermore, the city government should utilize smart technologies and create an open data platform for water. We are in an era where cities, individuals and companies can incorporate new technologies that ensure better water security for all. Hanoi water management authorities can apply low-cost sensors to collect data and using data for optimizing water use and detecting potential tap water insecurity problems. The city can use an Open Water Map and data center, where geospatial data on water are stored, easily and publicly accessible. Real-time water quality monitored by water companies should also be transferred to this platform for the public.

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