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Water Risk Management of Hanoi Urban Environment towards 2030 Sustainable Urban Spatial Development

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Abstract

The process of population growth and "uncontrolled" urbanisation has led to "loose" management by the government of Hanoi, and a lack of proper care of surface water resources and the water environment as well as an orientation towards sustainable spatial development of the Hanoi urban region and its community-based participants in a long-term vision. Therefore, the urgent duties now are to have included management measures, specific solution groups to regulate the activities of surface water risk management of the Hanoi urban environment directed at the related-target group of three rivers running through the Hanoi urban region in order to achieve the 2030 sustainable development goals. Based on the DPSIR research framework (Driving force – Pressure – State – Impact – Response), the result of this study is to propose a model of public-private partnership for management of the Hanoi urban settlement, increasing resilience to environmental changes, as a pilot initiative, based on a case study in Hanoi.

Keywords

Risk Management; Urban Environment; Public-Private Partnership; Spatial Development; Hanoi.

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Introduction

Currently, urban management authorities are raising awareness of the urgency and importance of unified and integrated management of water resources as well as water shortages and socio-economic master planning in Hanoi. The government of Hanoi has implemented many programmes on the rational use of natural resources, environmental protection in general, and natural disaster prevention in particular—including programmes and projects such as KHCN-07-04, KHCN-07-11, and KC-08-02 that have partially focused on the Hanoi region/areas. The results of the above programmes/projects evaluate the natural conditions and resources of geology and minerals, surface water, groundwater, soil, and use of mudflats along the Hong river. For sustainable development of urban areas in Hanoi, the exploitation and use of these results are mainly focused on assessing the status quo and environmental treatment. And, public concerns and ideas emphasising the master plans and promoting natural conditions and history-culture values have provided integration and support for Hanoi development since 1998 (Directive No. 32-CT/TW on the 990 and 1000 year anniversary of Thang Long-Hanoi). In 2008, the 12th National Assembly issued Resolution No. 15/2008/QH12 on adjusting the administrative boundaries of Hanoi Capital (QH 2008). The new Hanoi capital, including the former Hanoi City with the former Ha Tay province, Me Linh district of Vinh Phuc province, and 4 communes of Luong Son district of Hoa Binh province, has a total natural area of 3,344.6 km^2, and a population of 6,350,000 people.

On December 22, 2008, the Prime Minister issued Decision No. 1878/QD-TTg approving the task of master planning construction of Hanoi Capital to expand during the period up to 2030 and a vision for the period up to 2050. However, the government of Hanoi is facing and solving the outstanding issues for sustainable development, including economic degradation with many macro instabilities; social inequality, and job creation; and environmental protection issues in response to global climate change and environmental incidents. The issues

are becoming more and more serious. Especially, the issues include continuous breaking of the clean water supply pipeline of the Da River and those related to the decline in the quality of drinking water of some districts of Hanoi due to the environmental incidents in Hoa Binh reservoir.

Hanoi metropolis is one of the two special cities directly under the Central Government, with a high urbanisation rate of 65-68%, with the population forecasted to rise from 9.0 to 9.2 million in 2030. By 2050, the urbanisation rate of Hanoi will be 70-80% and the population will be approximately 10.8 million people[1].

This shows the rapid growth of industries/sectors that use natural resources, fuel, energy, etc. from neighbouring provinces/areas and environmental changes including nature, society, and artificial buildings in the management of settlements/residents in Hanoi metropolis.

Therefore, the urgent duties of Hanoi Government are now to develop management measures and specific solution groups to regulate surface water risk management of the Hanoi urban environment aimed at the related-target group of three rivers running through the Hanoi urban region in order to achieve the 2030 sustainable development goals, specifically SDG6 and SDG11 aimed at a Greener and Livable City.

The DPSIR framework, developed by the OECD in 2003 (originally referred to as the PSIR framework, is a model of identifying, analysing, and evaluating cause-effect (OECD, 2003). The more causes of environmental problems, the more responses to them. The DSPIR includes five criteria. The first, Driving force (D), implies human socio-economic development activities are the root cause of environmental changes that generate direct waste sources as environmental pollution and environmental degradation. The second is Pressure –(P). The current State (S) or status of environmental quality is measured by soil, water, and air indexes. The Impact (I) of environmental pollution is evaluated concerning health, socio-economic development, and ecological environment. And, the Responses (R) are implemented to increase environmental protection (Nguyen & Be, 2017). Based on the theory and quantitative analysis of the DPSIR indicators, we can use the model to assess environmental impacts in urban settlement management as well as propose planning solutions as public-private policy and the design of an environmental information management system for “good urban governance” (Nguyen 2017, 2018, 2019; IOER, 2018). In this study, the author uses the DPSIR framework to consider Hanoi urban environmental impacts on water risk management towards 2030s urban spatial development.

The DPSIR framework is used in this paper as a mixed analysis in an attempt to evaluate water risks. This paper focuses on the significance of public private partnerships (PPPs) in restructuring public sector and urban governance, as well as the participation of the private sector in building urban infrastructure and delivering Internet public services towards digital government transformation. Then, this paper uses the DPSIR’s indicators to evaluate surface water risk with the specific three rivers running through Hanoi, namely the Hong, Duong, and Da. And, the general recommendations suggest the Hanoi authorities take a number of action points in the term “Right and Good” governance and the mode of PPP so that water-use planning is performed in terms of an effectiveness or efficiency of a local administrative system. Last, but not least, the indicators and scoring system are under scrutiny in order to improve the policy-making process for sustainable urban development and review the water-use planning of Hanoi and the provision of clean water as a public service delivery. Based on that, this paper proposes some solutions to improve and support the institutional framework of PPPs in practice.

Scope, Content and Methods

The scope

The scope of this study is focused on the Hanoi metropolis consolidated by the Prime Minister's Decision No. 1259 / QD-TTg dated July 26, 2011 on approving the Master Plan for construction of Hanoi Capital up to 2030 and its vision to 2050 (Figure 1).

Based on the DPSIR’s research framework (Driving force—Pressure—State—Impact—Response), the result of the study is evaluation of the water risk management of the Hanoi urban environment and proposal of a model of PPP for management of the Hanoi urban settlement to increase resilience to environmental changes.

[1] Thủ tướng Chính phủ (2011). Quyết định phê duyệt chung xây dựng thủ đô Hà Nội đến năm 2030 và tầm nhìn đến năm 2050. (QĐ 1259/QĐ-TTg ngày 26/7/2011). Tr1.

The content

- Current situation of natural conditions, natural resources and water environment in Hanoi.
- Current situation of water environment risk in Hanoi.
- Current situation of water environment risk management by specialised authorities and proposals to improve the water risk management of the Hanoi urban environment.

The methods

The paper uses a mixed method approach. A UNDP reference book analysis on good governance, including its public administrative, public financial, and PARs implications and lesson learned from practice, was conducted (Acuna-Alfaro, 2009). Empirical work included a review of urban planning and its institutional reform in Hanoi with specific elements such as Driving forces, Pressure, State, Impact, and Responses (as seen in Table 2) and the level of environmental risk mentioned in Table 1.

In the paper, the Author evaluated statistical data regarding the Provincial Governance and Public Administration Performance Index (PAPI), population and economic growth, as well as the specified impacts including public health, landmark changes, and urban flooding. The urban spatial development orientation of Hanoi and scientific reports were included as well as planning of water-use in the residential areas of old-city (restricted) and new (expansion) cities. And two projects funded by NAPA with a focus on environmental risk management of industrial zones (2018) and evaluating the environmental impact by using a DPSIR framework (2019) were conducted in Hanoi and its neighbour.

Total score (weighted index)	The level of environmental risk
0 – 200	Non risk
200 – 400	Low risk
400 – 600	Risk
600 – 800	Potential risk
800 – 1000	High risk

Table 1. Surface water risk
Source: Nguyen & Be, 2017

Group	Notation	Name of indicator	Explanation	Scoring
Driving forces	D1	Public Administration & Governance	Urban Governance, PARs, Effective public service for SDG implementation (PAPI's Index[2])	1. High PAPI (0-3); 2. Moderate PAPAI (4-6); 3. Low PAPI (7-10)
	D2	Economic growth	Average income, standard of living, and society security	1. High income >3000 $/year (0-3) 2. Moderate income 2500÷ 3000 $/year (4-6). 3. Low income <2500 $/year (7-10)
	D3	Historical and Cultural values	Folk, traditional culture and historical landmarks in ThangLong-Hanoi. (HDI's Index[3])	1. High quality (0-3); 2. Moderate quality (4-6); 3. Low quality (7-10).
Pressure	P1	Disaster	Natural disasters can be faced such as storms, tornadoes, floods, earthquakes, etc.	1. fewer occur and not serious (0-3); 2. Serious, but not unexpected and infrequent (4-6); 3. Often, suddenly, seriously (7-10).
	P2	Environment Accident	Artificial risks inpact urban environment such as leakage of hazardous waste or broken water pipes	1. Property damage (0-3); 2. Loss of environment, ecosystem (4-6); 3. human death and harm to animals and trees (7-10).
	P3	Population growth	The growth rate of the mechanical population (reflecting the distribution of labour)	1. High rate> 3% (7-10). 2. Moderate rate from 2 to 3% (4-6). 3. Low rate <2% (0-3).
	P4	Natural Conditions	Climate and hydrological regime: rainfall, humidity, evaporation	1. High water balance (0-3); 2. Moderate water balance (4-6). 3. Low water balance (7-10).
State	S1	DO - disolved Oxygen (mg/l)	According to VN surface water (TCCP B)	1. Non polluted >6.5 (8-10); 2. Low polluted 4.5÷6.5 (5-7). 3. Average polluted 2.0 ÷4.4 (2-4). 4. High polluted < 2.0 (0-2)
	S2	BOD_5 - Biochemical Oxgen Demand (mg/l)	According to VN surface water (TCCP B)	1. Non polluted <3 (8-10); 2. Low polluted 3÷5 (5-7).

[2] The Provincial Governance and Public Administration Performance Index (PAPI) includes 8 content sector indicators, 28 component content indicators and 92 component indicators on governance and public administration efficiency of the entire sector. 63 provinces / cities. PAPI index is made up of calculations, synthesized from 5,796 variables constituting the target, grouped into 1,368 variables constituting the component index and 378 variables constituting six content areas. http://papi.org.vn/chi-so

[3] Human Development Index (UNDP) is a construct designed to measure human development of countries around the world. HDI is a composite statistic of life expectancy, education, and income per capita indicators, which are used to rank countries into four tiers of human development. In other words, the HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. http://hdr.undp.org/en/content/human-development-index-hdi

Group	Notation	Name of indicator	Explanation	Scoring
				3. Average polluted 5÷15 (2-4). 4. High polluted >15 (0-2)
	S3	SS - Suspended compounds (mg/l)	According to VN surface water (TCCP B)	1. Non polluted <20 (8-10); 2. Low polluted 20÷49 (5-7). 3. Average polluted 50÷100 (2-4). 4. High polluted >100 (0-2)
	S4	NH4-N Amonium and nitrogen compounds (mg/l)	According to VN surface water (TCCP B)	1. Non polluted <0.5 (8-10); 2. Low polluted 0.5÷0.9 (5-7). 3. Average polluted 1.3÷3.0 (2-4). 4. High polluted >3.0 (0-2)
	S5	Heavy Metal: such as Pb, Hg, Mn, Zn etc and residues of chemical fertilizers and pesticides	According to VN surface water (TCCP B)	1. Non polluted <20 (8-10); 2. Low polluted 20÷49 (5-7). 3. Average polluted 50÷100 (2-4). 4. High polluted >100 (0-2)
Impact	I1	Public health	The diseases due to use and contact of polluted water sources	1. Immediate effect on gastrointestinal and skin systems by contact of polluted water (0-3); 2. Disease caused by water use. The patients could be treated by medical doctors (4-6); 3. Serious, life threatening (7-10)).
	I2	Landmark changes	Invasion, erosion of river banks, change of flow regime	1. The area of mudflats increases due to the accumulation of silt (7-10) 2. The dykes of river are destroyed due to the erosion of banks (4-6) 3. The area of accumulated mudflats causes changes in flow and saline intrusion in downstream areas (0-3)
	I3	Urban Flooding	Flooding control, increase water drainage in urban settlement areas	1. The urban drainage systems are not planned (7-10). 2. The vegetation cover and surface permeability decreased due to construction (4-6). 3. The lake systems do not plan for regulating rainwater (0-3).
Responses	R1	Water processing center	To eliminate and reduce wastewater in both quantity and toxicity	1. The water treatment/process improves (7-10)

Group	Notation	Name of indicator	Explanation	Scoring
				2. Wastewater reuses (4-6) 3. Wastewater recycles (0-3)
	R2	Water advanced technology	To improve the efficiency of water use, and protect the ecological environment	1. Non applied (7-10) 2. Average applied (3-6) 3. Well applied (0-3)
	R3	Water resource integrated management	To coordinate of surface water resources for multi-purposes	1. Non applied (7-10) 2. Average applied (3-6) 3. Well applied (0-3)
	R4	Public-Private Partnership	To encourage the participation of domestic and foreign enterprises and corporations in the construction of urban water supply plants.	1. No participation or rarely (7-10) 2. Average participation (4-6) 3. High Participation and high efficiency (0-3)
	R5	Eco-city	To approach urban ecological model for circulating of surface water, run off and rainwater. And, after having treated, Its can be used for irrigation, fish farming etc.	1. Water resources are not recycled (7-10) 2. Water resources use for multi-purposes (4-6) 3. Water resources reuse by advanced technologies (0-3)

Table 2. DPSIR indicators for evaluating surface water risk
Source: Author 2020

Hanoi Urban Governance and Water-use planning

Hanoi is bounded by the Red river in the East, the ToLich river in the West, the KimNguu river in the South, and West lake in the North and contains many other lakes and water ponds. Hanoi has had a 1011 year-history since Thang Long-Hanoi was officially named as the capital of Vietnam by King Ly Thai To, one of the most powerful dynasties in Vietnamese history. Espcially, the Decree on capital move (Chieu doi do) issued by the King in 1010, not only highlighted nationalism, and aspiration for independence, but also expressed the profound meanings and the King's visions of feng-shui in the planning of Hanoi urban development.

Hanoi Urban Governance

During more than 35 years of implementing the "*doimoi*." Hanoi has taken important steps in reforming its state management, building an enabling government with integrity. And, these activities contribute to the process of accelerating Hanoi's industrialisation and urbanisation and global and regional integration.

In recent years, the capacity of Hanoi management regarding urban environmental risks has achieved positive results. Hanoi is continuing its efforts to implement administrative performance and enhance its access to social and public services through data systems, sharing, and integration databases, and to improve the ability to meet the needs of people at all levels. In general, Hanoi urban pollution prevention improved accountability and transparency and its water environment has made remarkable progress in particular.

Still, Hanoi's water risk management and urban pollution prevention are facing many challenges. And this will be one of the causes affecting regional competitiveness. Hanoi's planning and management of the urban environment addresses many difficulties by short-term thinking, and group interests. And Hanoi's authorities also have weak capacity for forecasting and risk management to prevent pollution of surface water and groundwater and sanitation. Satisfaction of citizens and organisations to be met in terms of providing clean water, wastewater treatment, against floods and flooding is still a difficult problem for Hanoi authorities (Nguyen, 2020).

There are some barriers of water risk management of Hanoi urban environment, as follows:

- Urban development planning and water environment protection have not been in compliance with standards;
- Resources are limited;

- Natural disasters, and flooding and poor drainage are being caused by climate change;
- Encouragement and participation policies have not been given adequate attention by the State;
- Limited financial potential and capacity of the State apparatus are available;
- Limited exchange of information and international cooperation on urban water environmental protection ae available.

Water-use planning

Domestic water supply

The demand for the Hanoi domestic water supply that has been determined by the Government's Decree No.72/2001/ND-CP on urban grades and by the national strategy of the Ministry of Agriculture and Rural Development on rural areas is synthesised in Table 3.

N°	Categories	Period			
		2010	2020	2030	2050
1	Rural area	60	80	100	120
2	Urban grade 2,3,4	110	120	130	150
3	Urban grade 1	150	200	230	270

Table 3. Demand for domestic water per capita
Source: Nguyen, 2020

According to Hanoi's forecast on population (Pop.) to 2030 and orientation to 2050, the total domestic water (W) demand for Hanoi metropolis is presented in Table 4.

	2010		2020		2030		2050	
	Pop.	W	Pop.	W	Pop.	W	Pop.	W
Urban area	2,627.4	143.9	4,445	324.5	7,360	617.9	9,720	957.9
Rural area	719.7	26.3	1,905	104.3	1,840	134.3	1,080	90.7
Sum	3,347.1	170.2	6,350	428.8	9,200	752.2	10,800	1,048.6

Table 4. Total demand for Hanoi's domestic water supply
Source: (Nguyen, 2020)
Units: Thousands of people - million m^3

- The demand for industrial water is equal to 15% of domestic water supply.
- Water demand for services, including water used for public works, fire fighting, watering plants, washing roads, etc, is equal to 10% of domestic water supply.
- The rate of water loss is equal to 25% of the total three types of water (above).
- Water consumption for the treatment plant itself is equal to 5% of the total four types of water (above).
- The total demand for Hanoi's water exploitation forecasts from 2010 to 2050 are shown in Table 5.

Năm 2010	Năm 2020	Năm 2030	Năm 2050
765,025.7	1,927,397	3,381,036	4,713,313

Table 5. Total demand for Hanoi's water exploitation
Source: Nguyen, 2020
Unit: m3/d&n

Hanoi's total groundwater reserve is 1,232,000m^3/day. There are two main areas where Hanoi's groundwater is derived along Hong river; this includes about 700,000m^3/day in the south and 532,000m^3/day in the north. Currently, Hanoi has exploited the total amount of water to reach the safe limit of ground water reserves. Therefore, to meet the demand for urban water supply to 2030 and 2050, the expansion of Hanoi's underground water plants is impossible, due to exceeding the amount of groundwater. The government of Hanoi has been promoting the construction of a surface water treatment plant and transmission systems for pumping water from Da River (Hoa Binh Lake) and Duong River in order to supply Hanoi and its adjacency.

The total water demand exceeds 1,927,000m^3/day in 2020. With groundwater capacity of 1,232,000m^3/day, and the amount of surface water supplied from Hoa Binh reservoir (Da river) and Duong river (both periods), Hanoi's necessary water supply is still short of about 95,000m^3/day.

Therefore, it is necessary in order to meet the demand for domestic water supply to 2030, as follows:

- Improve the quality of clean water supply with advanced water treatment technology measures.
- Improve and completely expand the water supply network to reduce water loss and consumption from 25-35% to 20% or less.
- Quickly build and put into operation a system of water supply from surface water sources of rivers flowing through the Hanoi area such as Da river, Red river, Duong river, Cau river, etc. The main criteria for selecting water plans are extraction capacity, water quality, and construction and operating costs.
- Encourage the participation of domestic and foreign enterprises in order to ensure a clean water supply for Hanoi and its environs.

Agricultural water supply

With a high rate of urbanisation, Hanoi will reduce the land-use for agriculture development. The government of Hanoi proposes water storage in highland areas, and integration management of water resources in agricultural down-river areas. Therefore, there are some development orientations in the coming years, as follow:

- Increase the proportion of aquaculture.
- Increase forest cover.
- Research, survey, and invest in 60-100 rural water supply stations to exploit a mixture of surface water and groundwater. Depending on geographical location, the stations have water capacity from 500 to 1,800m^3/day.

Water risk management of the Hanoi urban environment

Public sector reforms have played an important role in bringing about changes in the state-owned enterprises. Decreasing investment capital in Hanoi urban technical infrastructure—using financial resources, technologies and capacity management of the private sector—is to expanded to benefit both the state and the people (Dang, 2014). These public sector reform efforts are also conducted by sharing/linking to the portal of national public services as a plan to simplify administrative procedures. The Vietnamese government has also managed to make progress, although recent studies suggest that this has not, in turn, upgraded the entire online process to deliver public service at level 3 and 4 in the big cities as Hanoi and Ho Chi Minh. The provision of public services is overlapping among ministries, branches, and localities, leading to some inefficient public services (Doan, 2021).

In Hanoi, the private sector is participating in public service deliveries through the mode of PPP projects such as education, health care, social housing, and water-use and sanitation. Through these practices, Hanoi urban

governance should be able to improve the institutional framework of PPP as a case study of water-use cost reform towards supporting "Right and Good" management.

Cities	2016	2017	2018	2019	2020
Hanoi	33.81	34.64	42.33	41.54	41.63
Haiphong	35.55	35.8	42.80	41.53	42.29
Danang	38.58	37.2	45.35	44.98	42.51
Ho Chi Minh	34.91	35.88	42.41	43.78	41.98
Can Tho	39.57	38.31	46.05	45.71	42.88

Table 6. PAPI Indices in Vietnam Cities (2016-2020)
Source: The Vietnam Provincial Governance and Public Administration Performance Index (2020).

As can be seen from the data in Table 6, Vietnam cities show no gap among different levels of performance on the provincial effectiveness index. Urban governance is affected by six dimensions (2016-2017) through participation at local levels, transparency, vertical accountability, control of corruption, public administration procedures, and public service delivery. These are now combined with two more dimensions (2018-2020) added to the PAPI indices as environmental governance and E-governance that Vietnam cities implement in public sector reforms.

Results

The study uses the DPSIR (Drivers, Pressures, State, Impact, Response) framework—a causal framework for describing the interactions between society and the environment, that is, human impact on the environment and vice versa. Because of the interdependence of the components (Nguyen & Be, 2017), the framework comprises a set of indicators for evaluating surface water risk consisting of 20 indicators. It is divided into five groups such as Driving forces, for example, public administration, economic growth, historical and cultural values; Pressure, such as disaster, environmental accident, population growth, and natural conditions, State. including DO, BOD_5, SS, NH_4-N and heavy metal; Impacts, such as public health, landmark change, urban flooding; and Responses, including water processing centres, water advanced technology, water resource integrated management, public-private partnerships and eco-cities (as seen in Table 2).

There are three indicators in group 1 (named from D1 to D3), four indicators in group 2 (named from P1 to P4), five indicators in group 3 (named from S1 to S5), three indicators in group 4 (named from I1 to I3) and five indicators in group 5 (named from R1 to R5).

There are five levels of surface water risk seen as Table 7 from non-risk level to high risk level.

Classification	DO (mg/l)	BOD_5 (mg/l)	SS (mg/l)	NH_4-N (mg/l)
Non polluted	>6,5	<3,0	<20	<0,5
Low polluted	4,5÷6.5	3,0÷4,0	20÷49	0,5÷0,9
Average polluted	2,0÷4,4	5,0÷15,0	50÷100	1,3÷3,0
High polluted	<2,0	>15	>100	>3,0

Table 7. Surface water classification
Source: Sâm, 2010

The result of evaluating surface water risk for three rivers shown in Tables 8, 9, and 10, respectively as Hong, Da and Duong river.

Group (1)	Notation (2)	Name of indicator (3)	Scoring [4] (4)	WeightedIndex[5] (5)	Total Score[6] (6)=(4)x(5)
Driving forces	D1	Public Administration & Governance	7	6	42
	D2	Economic growth	5	8	40
	D3	Historical and Cultural values	6	6	36
Pressure	P1	Disaster	8	2	16
	P2	Environment Accident	6	8	48
	P3	Population growth	7	6	42
	P4	Natural Conditions	9	4	36
State	S1	DO - disolved Oxygen (mg/l)	7	5	36
	S2	BOD_5 - Biochemical Oxgen Demand (mg/l)	8	3	24
	S3	SS - Suspended compounds (mg/l)	7	2	14
	S4	NH4-N Amonium and nitrogen compounds (mg/l)	6	5	30
	S5	Heavy Metal: such as Pb, Hg, Mn, Zn, etc., and residues of chemical fertilizers and pesticides	8	5	40
Impact	I1	Public health	7	8	56
	I2	Landmark changes	6	4	24
	I3	Urban Flooding	8	8	64
Responses	R1	Water processing center	8	3	24
	R2	Water advanced technology	7	5	35
	R3	Water resource integrated management	8	5	40
	R4	Public-Private Partnership	8	3	24
	R5	Eco-city	9	4	36
Total Score				100	107

Table 8. The result of evaluating surface water risk in Hong river
Source: Author, 2020

4 The scoring of individual indicator was estimated by using the evaluating scale in column 5 in Table 10.
5 The weighted index was valued as the scale of 10
6 The value of total score, derived by each individual score multiplied values in column 4 with column 5, cumulated the value of all indicators. Its value indicated that the individual DPSIR could be a higher score than others in the group.

Group (1)	Notation (2)	Name of indicator (3)	Scoring (4)	Weighted Index (5)	Total Score (6)=(4)x(5)
Driving forces	D1	Public Administration & Governance	7	6	42
	D2	Economic growth	8	8	64
	D3	Historical and Cultural values	6	6	36
Pressure	P1	Disaster	7	2	14
	P2	Environment Accident	6	8	48
	P3	Population growth	4	6	24
	P4	Natural Conditions	8	4	32
State	S1	DO - disolved Oxygen (mg/l)	6	5	30
	S2	BOD_5 - Biochemical Oxgen Demand (mg/l)	8	3	24
	S3	SS - Suspended compounds (mg/l)	7	2	14
	S4	NH4-N Amonium and nitrogen compounds (mg/l)	8	5	40
	S5	Heavy Metal: such as Pb, Hg, Mn, Zn, etc., and residues of chemical fertilizers and pesticides	7	5	35
Impact	I1	Public health	3	8	24
	I2	Landmark changes	8	4	32
	I3	Urban Flooding	2	8	16
Responses	R1	Water processing center	9	3	27
	R2	Water advanced technology	7	5	35
	R3	Water resource integrated management	6	5	30
	R4	Public-Private Partnership	7	3	21
	R5	Eco-city	5	4	20
Total score				100	608

Table 9. The result of evaluating surface water risk in Da river
Source: Author, 2020

Group (1)	Notation (2)	Name of indicator (3)	Scoring (4)	Weighted Index (5)	Total Score (6)=(4)x(5)
Driving forces	D1	Public Administration & Governance	8	6	48
	D2	Economic growth	7	8	56
	D3	Historical and Cultural values	6	6	36
Pressure	P1	Disaster	6	2	12
	P2	Environment Accident	6	8	48
	P3	Population growth	4	6	24
	P4	Natural Conditions	3	4	12
State	S1	DO - disolved Oxygen (mg/l)	8	5	40
	S2	BOD_5 - Biochemical Oxgen Demand (mg/l)	6	3	18
	S3	SS - Suspended compounds (mg/l)	7	2	14
	S4	NH4-N Amonium and nitrogen compounds (mg/l)	6	5	30
	S5	Heavy Metal: such as Pb, Hg, Mn, Zn, etc., and residues of chemical fertilizers and pesticides	7	5	35
Impact	I1	Public health	8	8	64
	I2	Landmark changes	6	4	24
	I3	Urban Flooding	4	8	32
Responses	R1	Water processing center	6	3	18
	R2	Water advanced technology	5	5	25
	R3	Water resource integrated management	4	5	20
	R4	Public-Private Partnership	9	3	27
	R5	Eco-city	6	4	24
Total Score				100	607

Table 10. The result of evaluating surface water risk in Duong river
Source: (Authors, 2020)

Conclusions and Recommendations

Based on the DPSIR research framework (Driving force–Pressure–State–Impact–Response), the results of this study are to propose a model of PPP for the management of the Hanoi urban settlement building resilience to the environmental changes, as a pilot initiative from a case study in Hanoi. The results of compiling a set of indicators for evaluating surface water risk consist of 20 indicators. These is divided into five groups such as Driving Forces, Pressure, State, Impact, and Response indicators. There are three indicators in group 1 (named from D1 to D3), four indicators in group 2 (named from P1 to P4), five indicators in group 3 (named from S1 to S5), three indicators in group 4 (named from I1 to I3) and five indicators in group 5 (named from R1 to R5).

There are five risk levels for evaluating surface water environment, from non risk to high risk. The result was applied to three rivers running through the Hanoi urban region (border extended in 2008). Major indicators are surface water risk on Hong river as D1, P2, S5, I3, and R3 with higher scores than the other indicators. With a total score of 707, in order to manage the risk of surface water on the Hong river, Hanoi's Government should promulgate and execute legal documents on surface water as a public good. Therefore, it is necessary to prevent environmental incidents, and enforce and strictly handle violations of pollution as well as enforce compliance with regulations on the protection of surface water sources in the direction of integrated water resource management. The Hanoi urban government prioritises the necessary resources to build a synchronised water treatment plant with urban drainage systems (centre zones on the right bank of the Hong river) and encourages a mode of PPP for the plants treating surface water along the left bank of the Hong river (urban development zones).

The result as applied on the Da river in Hoà Bình province calculated 608 scores of potential risk level. D2, P2, S4, I2, and R2 are higher scores than other indicators. It is suggested that in order to manage the environmental risks of the Da's surface water in Hoà Bình province, it is necessary to promulgate the principles of polluters pay

and beneficiaries pay in order to subsidise prices for Hoà Bình's socio-economic development; building scenarios to cope with incidents and natural disasters on the basis of regional topography and geology; and inspecting, supervising, and controlling the surface water in Hoà Bình reservoir in order to coordinate the water level for electricity generation and water supply for the downstream areas. This means basically, the application of advanced water treatment technologies to maintain the ecological landscape combined with tourism-resort purposes along the Da river.

The result was calculated on the Duong river with a total score of 607 (at potential risk level). The indexes included D1, P2, S1, I1, and R4 with higher scores than others. Thus, it is shown that in order to manage environmental risks to the Duong's surface water, the Hanoi urban authorities pay more attention to surface water resources; develop/control an integrated surface water resource management using the drinking water standards (TCCP A); and encourage domestic and foreign corporations and enterprises (using the model of PPP) to invest in surface water treatment plants to ensure a clean water supply for Hanoi's urban development zones.

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