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Research Paper

VULNERABILITY ASSESSMENT OF SURFACE WATER RESOURCE OF DONG NAI RIVER BASIN IN LAM DONG PROVINCE

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ABSTRACT

Lam Dong Province belongs to the entire upper and middle parts of the Dong Nai River system. This is a river with the third largest basin area in our country and is the river with the largest inland catchment area. Economic development is creating a significant pressure on here, in terms of environmental and resource management. This study conducted a vulnerability assessment of fresh water resources of this river basin using a method developed by UNEP and Peking University, China. The research results show that the vulnerability index of the Dong Nai River basin in the province of Lam Dong is also spatially differentiated and in general, the value of the vulnerability index is at a moderate level (VI = 0.23). It is observed that the Vulnerability Index for the Dong Nai - Lam Dong River basin comes mainly from management challenges, followed by stresses due to resource use, pressure from development. Assessing the vulnerability of basin water resources is the basis for scientists to devise appropriate management solutions towards sustainable development.

Keywords: *Vulnerability index, Water resource, Lam Dong.*

1. Introduction

CARE has proposed a community approach "Climate Vunerability and Capacity Anlysis" (Oxfam, 2009) or Oxfam proposed a method "Adaptation in the context of climate change by managing risks combined with community adaptive capacity". This method identifies the causes of community vulnerability and proposes appropriate adaptations based on community capacity and develops long-term adaptation planning strategies. To assess the vulnerability of water resources in the Orange River basin, South Africa, Sullivan used a combination of parameters from Supply driven vulnerability (SDV) and water demand parameters. The method of calculating the vulnerability index is a function of the sum of the two parameters (Sullivan et al., 2011). Similarly, Lane (1999) assessed the impact of climate change on US resources based on two environmental and social parameters (Melissa et al., 1999). Panedey, when assessing water vulnerability in Nepal, incorporated adaptive capacity into the assessment by the ratio of water

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pressure to adaptive capacity (2009) (Pandey and Bardsley, 2015). According to the IPCC, vulnerability can be expressed as a function of impact level, sensitivity and adaptive capacity (Carter et al., 1994).

Water is an important resource for life and development, water is considered one of the most valuable resources, it is not an infinite resource, this resource is being fully exploited and polluted in many parts of the world (UNEP, 2008). In order to implement an effective integrated water resources management policy, it is necessary to understand and assess the vulnerability of water resources, which is a process of investigating, surveying and analyzing the system of water resources. On this basis, it is possible to assess the sensitivity of the water resources system to changes of impacting factors to propose risk mitigation measures.

Dong Nai River plays an important role in socio-economic development, providing domestic water for about 17 million people in the basin of 11 provinces and cities. However, the process of urbanization and industrialization is happening strongly, which poses risks of water quality degradation in Dong Nai basin. Especially for Lam Dong Province, this is a locality with high socio-economic development potential, fully located in the Dong Nai River basin. Therefore, the assessment of water vulnerability in Dong Nai River basin - Lam Dong Povince to guide strategic solutions helps the locality have the most appropriate policies to exploit, use and manage water. manage water resources in the basin in the most sustainable and effective manner.

Based on the development and use of water resources, the balance of water resources in the river basin will include four main tasks, including: (1) the structure of the water source from the natural hydrological process; (2) developing and using water resources for the maintenance of human health and socio-economic development; (3) Function of water resources in maintaining the ecological environment of a river basin; and (4) management and governance competencies. UNDP has researched and applied the water vulnerability index effectively in comprehensive, multi-dimensional assessment of factors affecting water resources (UNDP, 2008; UNEP-PKU, 2009). According to this method, the assessment of the vulnerability of water resources of this river basin is based on the premise of four components of the water resources system, including: Management challenges, resource stress, Development pressure, loss ecological security.

2. Methodology and Data

2.1. Introducing the research area

Dong Nai River originates from the north of Lam Vien plateau (Lang Biang) - south of Truong Son mountain range, the height of upstream mountain peaks is over 2,000 m, including: Lam Vien peak: 2,167 m, Bi Doup peak: 2,287 m, Bơ Ra peak: 1,864 m, etc. The high slopes create a source with a steep slope of 20% - 25%, the watershed has geographical coordinates: 108°42’10”E and 12°12’10”N, the average height of the headwaters is about 1,700 m. The length from the upstream to the mouth of the Xoai Rap estuary - the Dong Nai River is about 610 km in length, the average slope across the river is 2.8‰, the section running through Dong Nai province is 220 km in length. The catchment area of the Dong Nai river system, from the upstream to Tri An station is 14,900 km^2, to Bien Hoa: 23,500 km^2, to Nha Be: 28,200 km^2, and to Soai Rap estuary about 42,600 km^2.

The Dong Nai River upstream is named Da Dung, after it merges with the Da Nhim River, forming a river called Dong Nai Thuong. From there until the confluence with the Saigon River, the river officially called Dong Nai. Downstream in Ho Chi Minh City, the river is divided into two major tributaries: the Long Tau River, which flows into Can Gio, and Nha Be River, which flows into the sea through the Xoai Rap Door.

Fig. 1. Dong Nai River basin

2.2. Theoretical basis for determining parameters to assess the vulnerability of water resources

Based on UNEP and Peking University guidelines (UNEP-PKU, 2009). The vulnerability of water resources has been explored by isolating important issues related to the various functions (uses) of water resource systems in a basin. Therefore, this analysis is based on the premise of assessing the vulnerability of water resources in a river basin to be linked by four components of the water resource system, including: Total water resources, developing water resources and pressure to use water resources, ecosystems and water resources management.

According to this approach and assessment, a sustainable water resource system can only operate in an integrated operational framework that combines both natural systems and management systems.

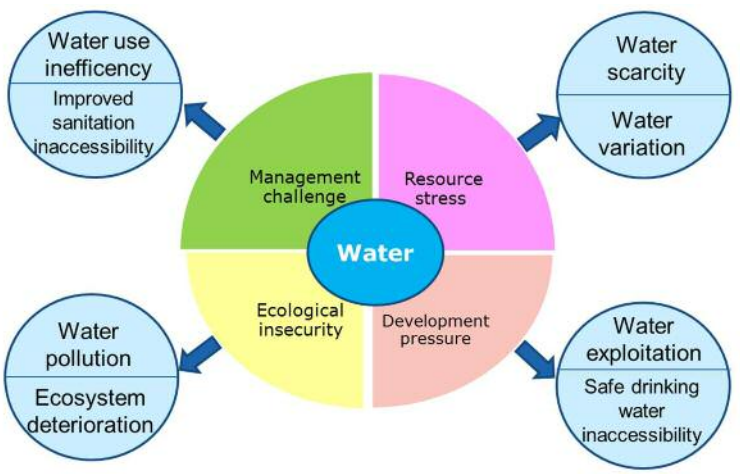

Fig. 2. Vulnerability to freshwater resources and indicators

2.3. Resource Stress (RS)

Water resources of a river basin are the total amount of fresh water available for maintaining ecosystems and socio-economic development, the water resources of a river basin may be characterized by water scarcity coefficient. and precipitation fluctuations in the basin.

Water Stress parameter (RSs): can be expressed by per capita water and compared to the average per capita water volume worldwide (1,700m^3/year) and determined as follows:

$$RS_S = \begin{cases} \dfrac{1700 - R}{1700} (R \le 1700) \\ 0 (R > 1700) \end{cases} \quad (1)$$

where R is the per capita water resources (m^3.person-1).

Water Resources Variation parameter (RS_v): The variation of the water resources can be expressed by the coefficient of variation (CV) of total annual average precipitationof whole the basinand determined by the formula:

$$RS_V = \begin{cases} \frac{C_V}{0.3} (C_V < 0.3) \\ 1 (C_V \geq 0.3) \end{cases} \quad (2)$$

where CV is the coefficient of variation (CV) of precipitation.

2.4. Water Development Pressures(DP)

Development pressures (DP_S): Freshwater resources are recharged through a natural hydrological process. Over-exploitation of water resources will disrupt the normal hydrologic process, ultimately causing difficulties for the recharge of the water resourcebase. Thus, the water resourcesdevelopment rate (i.e., per cent of water supply, compared to the total water resource), can be used to demonstrate the capacity of a river basin for a healthy renewable process. Thus:

$$DP_S = \frac{W_u}{W} \quad (3)$$

where W_u is the total water supply (capacity); W is the total water resource.

Safe Drinking Water Inaccessibility Parameter (DP_d): The ability to access clean water sources is also developed to indicate the status of adaptation to social factors. This is a comprehensive parameter reflecting the impact of capacity of all households using water as well as available techniques. This coefficient can be determined by the ratio of the total population able to receive clean water compared to the total population in the basin:

$$DP_d = \frac{P_d}{P} \quad (4)$$

where P_d is the population without access to improved drinking water sources; P is the total population.

2.5. Ecological Health (EH)

Ecosystem Deterioration Parameter(EH_e): As a result of the population expansion, the natural landscape was modified by the consequent urbanization and other socioeconomic development activities. Removing vegetation from landscapes changed the hydrological properties of the land surface, and can cause severe problems in supporting the functioning of ecosystems, in terms of water resources conservation, and contributed to the vulnerability of the region's water resources. Thus, the land ratio without vegetation coverage can be used to represent the contribution of ecosystemdeterioration to the vulnerability of water resources, expressed as:

$$EH_e = \frac{A_d}{A} \quad (5)$$

where A_d is the land area without vegetation coverage (i.e., total land area, except that covered with forests and wetland,expressed in km^2); A is the total land area (km^2).

Water Pollution Parameter (EH_p): Vietnam is a country with relatively abundant surface and groundwater resources. However, the management, use and protection are not good, causing surface water sources to be increasingly polluted due to a large amount of industrial and domestic waste, and the source of groundwater is contaminated with persistent organic matter. In addition to their influence on the hydrologic process, water development and use activities will produce wastes, polluting the water resources base. Thus, another very important factor influencing the vulnerability of water resources is the total wastewater produced within the basin. The contribution of water pollution to water resources vulnerability, therefore, can be represented by the ratio between the total untreated wastewater discharge and the total water resources of a river basin.

$$EH_p = \frac{W_W}{W} \quad (6)$$

where W_w is the total wastewater discharge (m^3); WR is the total water resources (m^3).

2.6. Management Capacity (MC)

This component will assess the vulnerability of freshwater by evaluation of the current man-

agement capacity to cope with three types of critical issues, including: (i) efficiency of water resources use; (ii) human health condition closely dependent on, and heavily influenced by, accessibility to freshwater resources; and (iii) overall capacity in dealing with conflicts.

Water use inefficiency parameter (MC_e): This can be represented by the GDP value of 1m^3 of water, compared to the world average for selected countries, as follows:

$$MC_E = \begin{cases} \dfrac{WE_{WM} - WE}{WE_{WM}} \left(WE < WE_{WM}\right) \\ 0 \qquad\qquad \left(WE \geq WE_{WM}\right) \end{cases} \quad (7)$$

where WE is the GDP value produced from 1 m^3 of water; WE_{WM} is the mean WE of selected countries.

Lack of information, or weak specific regulations on management, directives and human capacity institutions create a threat to the implementation of people, communities, where the public expects demand. when it comes to water supply. Water use policies and techniques determine the efficiency of water use. Therefore, the effectiveness of the water resource management system can be expressed through the difference between the water efficiency of the basin and the average water efficiency in the world.

Improved Sanitation Inaccessibility Parameter (MC_s): The ability to receive sanitation depends on the availability of clean water in the basin. Actual environmental pollution caused by community consciousness. Therefore, the best way to manage water resources is to create favorable conditions for people to receive and be aware of environmental sanitation conditions. Therefore, a management system must meet the above criteria is to strengthen the water supply to the community to meet the water demand for production life and at the same time be aware of the protection of water resources of me With the criterion on environmental sanitation parameters MCs can be used as a typical parameter to assess management capacity in terms of ensuring improvement for human livelihood activities. and is calculated by the proportion of people not receiving sanitation with the total population calculated. With Ps is the total number of people not receiving sanitation and P is the total population of the basin. The formula for calculating MCs is as follows:

$$MC_s = \frac{P_S}{P} \quad (8)$$

where P_s is the population without access to improved sanitation; P is the total population.

Management Capacity (MC_c): In fact, any problems have any conflicts. Solution is always an important issue to determine the effectiveness of a job. Conflict management capacity parameters (MC_c) represent river basin management capacity for different types of conflicts. A good management system can be assessed through its effectiveness in aligning mechanisms and establishing effective management policies. Conflict management capacity, can be assessed through the matrix of contradictory management capacity parameters:

Table 1. Conflict management capacity parameter assessment matrix

Category of capacity	Description	Scoring Criteria →		
		0.0		0.25
Institutional capacity	Transboundary institutional arrangement for coordinated water resources management	Solid institutional arrangements	Loose institutional arrangements	No existing institutions
Agreement capacity	Writing/ signed policy/ agreement water resources management	Concrete/ detailed agreement	General agreement only	No agreement
Communication capacity	Routine communication mechanism for water resources management	Communication at policy and operational levels	Communication only at policy level or operational level	No communication mechanism
Implementation capacity	water resources management cooperation actions	Effective implementation of basin – wide river projects/programs	With joint project/program but poor management	No joint project/program

2.7. Vulnerability Index (VI)

To determine the vulnerability index of water resources (VI), it is necessary to determine the above parameters by weight. In each type of parameters their weights must have a sum equal to 1.

$$VI = 0.25RS + 0.25DP + 0.25EH + 0.25MC \quad (9)$$

Once the vulnerability index of the water resource has been identified, it is necessary to assess the situation of water resources based on the following criteria:

Table 2. Reference sheet for interpretation of Vulnerability Index

Vulnerability Index	Interpretation
Low($VI \leq 0.2$)	This indicates a healthy basin, in terms of resource richness, development practices, ecological state, and management capacity. No serious policy change is needed.
Moderate ($0,2 < VI < 0,4$)	This indicates the river basin is generally in a good condition in regard to realization of sustainable water resources management. It may still face major challenges, however, in regard to either technical support or management capacity-building. Thus, the basin's policy design should focus on the main challenges identified after examining the VI structure, and strong policy interventions should be designed to overcome key constraints for the river basin.
High ($0,4 \leq VI < 0,7$)	This indicates the river basin is experiencing high stresses, and great efforts should be made to design policy to provide technical support and policy backup to mitigate the pressures. A longer-term and appropriate strategic development plan should be made, with a focus on rebuilding management capacity to deal with the main threatening factors.
Severe ($0,7 \leq VI \leq 1,0$)	This indicates the river basin is highly degraded in regard to being a water resources system with a poor management structure. Restoration of the river basin's water resources management will require major commitment from both government and general public. Restoration will be a long process, and an integrated plan should be made at the basin level, with involvement from international, national and local level agencies.

3. Results and discussion

In order to better manage the challenges of water resources in the Dong Nai river basin in Lam Dong province, it is important to understand the pressures arising such as: rapid population growth, urbanization, and climate change. climate, environmental pollution, migration to urban areas ... Through hydrological data results from measurement stations of Da Lat, Lien Khuong, Cat Tien, Bao Loc; water needs of the sectors; land use planning; socio-economic development orientation of Lam Dong Province. The study has calculated and determined water vulnerability parameters as follows:

3.1. Resource Stress (RS)

According to previous studies, every year, the Dong Nai river system provides a total flow of about 36.6 billion m^3, of which about 32 billion m3 arise in the territory (accounting for 89%), per capita. in 1990 it was 4,105 m^3/year, equaling 51% of the world average and equal to 34.2% of the average of the whole territory of Vietnam. If the distribution of surface water is evenly divided among the total population in the region (2015: 12.7 million people), each person gets 2,520 m^3/year. The reality shows that surface water resources in the province of Lam Dong are abundant and abundant, or it can be said that Lam Dong is a gathering place in the Central Highlands (more than the other 4 provinces in the Central Highlands); However, the exploitation and use still lack of water, the reason is that the rivers and streams in Lam Dong province are short and steep, the flood season has a large amount of concentrated water causing floods, but the dry season is very exhausted. Large river is far away from residential areas so exploitation and use are still very difficult. Besides, based on the actual survey, it shows that some irrigation works in Lam Dong province are now seriously degraded, almost do

not serve any purpose of use. That irrigation works mostly used in the rainy season.

Water stress RSs > 1,700 (m^3/capita). According to the calculation of the water scarcity parameters, RSs = 0. Water coefficient of water fluctuation is calculated from the Cv coefficient at gauges Da Lat, Lien Khuong, Bao Loc, Cat Tien respectively for the three sub-basins, and Cv coefficients at four stations are respectively 0.11; 0.12; 0.14; 0.15. According to the results of calculation of water pressure index for sub-basins (Table 3), it is found that Da Lat basin has greater pressure, this index also reflects the high demand for water use for the sub-basin, due to higher socio-economic development and population concentration needs.

Table 3. Calculation parameters of RS water pressure

Sub-basin	Rain Station	RSs	RSv	RS
Da Lat	Da Lat	0	0.37	0.063
Bao Loc	Bao Loc	0	0.47	0.044
Duc Trong	Lien Khuong	0	0.4	0.03
Di Linh	Bao Loc	0	0.47	0.02
Cat Tien	Cat Tien	0	0.5	0.01
Lac Duong	Da Lat	0	0.37	0.005
Don Duong	Da Lat	0	0.37	0.02
Dam Rong	Da Lat	0	0.37	0.02
Lam Ha	Da Lat	0	0.37	0.042
Bao Lam	Bao Loc	0	0.47	0.015
Da Teh	Cat Tien	0	0.5	0.02
Da Huoai	Bao Loc	0	0.47	0.0095

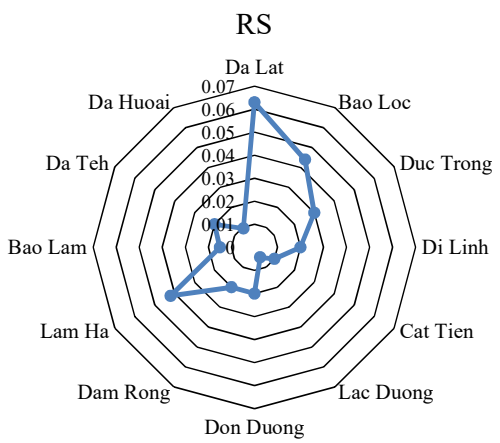

Figure 3. Diagram showing Resource Stress parameters on the sub-basins

In general, the water pressure in the basins of Lam Dong province is highly variable, among densely populated places like Da Lat - the center of Dalat, where economic and tourism activities take place. strong, so the demand for water is high. Next is Bao Loc City, the second most densely populated city in the province, also a developing city, resulting in an increasing amount of water for people's daily life and production needs. Da Te and Cat Tien are the areas with the lowest water pressure, this is a place where few people live, farming activities, annual rainfall is low. There is a high difference between the area of high pressure and the area of low pressure of 6.68 times.

3.2. Water Development Pressures (DP)

Lam Dong currently has about 401 irrigation works in service of irrigation, with 200 reservoirs and 04 inter-reservoir systems, 85 spillways, 85 temporary dams, 15 irrigation pumping stations and 12 drainage canals. The total number of existing canals is 973.15 km, including the main channel of 236.15 km and the branch canal of 737 km. Among them were 565.5 km solidified, including the main channel is 145.36 km, branch canal is 424.76 km. Total area of arable land irrigated from irrigation works is about 42,864 ha, of which rice area is about 13,761 ha; seedlings, vegetables, vegetables, short-term industrial plants are about 4,736 ha; fruit trees, long-term industrial trees of about 24,185 ha and used for fisheries of about 182 ha.

In Lam Dong Province, the statistics of 2016, the total area of arable land in the province is about 308.499 ha, including the area of perennial industrial crops (coffee, tea, pepper, cashew ..) accounting for 193,812 ha (of which coffee area accounts for about 155,172 ha, tea accounts for about 21,961 ha, cashew accounts for about 16.197 ha, pepper accounts for about 482 ha), rice area accounts for about 32,415 ha, fruit trees account for about 11,698 ha and other crops (maize, vegetables, sugarcane, etc.) account for about 70,574 ha, with the current state of exploitation using surface water and underground water estimated at 605 million m3/year, of which the main source is Agriculture is mainly used from groundwater (bore wells, dug wells). Based on the results of water balance on the sub-basins and the percentage of the population with access to clean water, the DP_e and DP_d coefficients are determined as in Table 4.

Table 4. Calculation results of DP parameters

No	District	DP_s	DP_d	DP
1	Da Lat	0.453	0.05	0.25
2	Bao Loc	0.110	0.28	0.19
3	Dam Rong	0.527	0.40	0.46
4	Lac Duong	0.361	0.08	0.22
5	Lam Ha	0.034	0.20	0.12
6	Don Duong	0.281	0.14	0.21
7	Duc Trong	0.256	0.50	0.37
8	Di Linh	0.490	0.40	0.44
9	Bao Lam	0.413	0.54	0.52
10	Da Hoai	0.085	0.30	0.19
11	Da Teh	0.080	0.50	0.29
12	Cat Tien	0.077	0.13	0.10

3.3. Ecological Health (EH)

Water Pollution Parameter (EH_p): According to the calculation experience, the amount of waste water from living will be 80% of the amount of water used, the amount of wastewater from livestock production will depend on the animals. From the calculation of water use demands of all sectors, the coefficient of water pollution is calculated. The amount of wastewater generated in each sub-basin is proportional to the number of industrial production facilities in each region, Da Teh is the region with the highest amount of wastewater generated, followed by Di Linh and Da Lat, particularly in Lac Duong, has the lowest amount of wastewater generated compared to the whole basin.

Ecosystem Deterioration Parameter (EH_e): The population increase has led to urbanization and socio-economic development activities, thereby leading to changes in the natural landscape. Changes in crop structure also lead to changes in surface flow characteristics, and can cause problems that affect the functioning of the ecosystem to conserve water, and also increase vulnerability of water resources. Based on Lam Dong's land use map, land mainly used for agriculture, non-agricultural land and ecosystem degradation coefficients in the basin is shown in Table 5.

Calculation results show that ecological coefficients tend to increase more downstream, showing that the environmental stress here is mainly concentrated in densely populated areas, in high production areas and also in where there are many industrial zones, potential environmental risks are unavoidable.

Table 5. Calculation of EH eco-coefficient results of the basin

District	EHp	EHe	EH
Da Lat	0.16	0.1	0.13
Bao Loc	0.08	0.1	0.09
Dam Rong	0.06	0.02	0.04
Lac Duong	0.02	0.05	0.01
Lam Ha	0.12	0.05	0.09
Don Duong	0.05	0.04	0.04
Duc Trong	0.07	0.09	0.08
Di Linh	0.04	0.04	0.04
Bao Lam	0.01	0.04	0.02
Da Hoai	0.02	0.03	0.02
Da Teh	0.04	0.03	0.04
Cat Tien	0.01	0.03	0.02

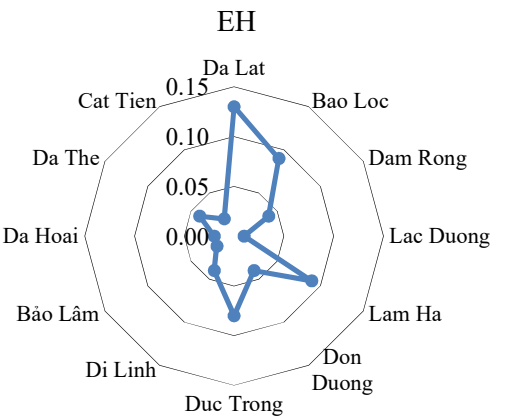

Figure 4. Comparison chart of EH for localities in the upstream of Dong Nai River

3.4. Management Capacity (MC)

Water Use Inefficiency parameter MCe: Lam Dong province has a GDP per capita of about 58.5 - 59 million VND (in 2017, 1USD = 23,200 VND). The gross national product (GDP) in 2017 reached VND 6,750 billion in the Dong Nai river basin. Total amount of water used 877.33x106 m^3. Water productivity, calculated according to the GDP produced per m3 of water used is 3.34 USD/m^3. Worldwide average value WEm = 19.24 USD/m^3 (World Bank, 2018). Water usage efficiency parameter in the basin are: MC_e = 0.82.

Improved Sanitation Inaccessibility Parame-

ter MC_S: The statistics show that the population with access to sanitation on the total of the sub-basins in Lam Dong province is: $MC_S = 0.1$.

Management Capacity MC_c: The results show that Lam Dong Province achieved the average indicators in management, as follows:

Table 6. Management challenges in the Dong Nai river basin

District	MC_s	MC_e	MC_c	MC
Da Lat	0.04	0.82	0.16	0.34
Bao Loc	0.07	0.82	0.16	0.35
Dam Rong	0.12	0.82	0.2	0.38
Lac Duong	0.13	0.82	0.2	0.38
Lam Ha	0.11	0.82	0.2	0.41
Don Duong	0.10	0.82	0.2	0.37
Duc Trong	0.15	0.82	0.2	0.38
Di Linh	0.13	0.82	0.2	0.39
Bao Lam	0.12	0.82	0.2	0.38
Da Hoai	0.13	0.82	0.2	0.38
Da Teh	0.11	0.82	0.3	0.41
Cat Tien	0.11	0.82	0.3	0.37

The management capacity of the state is reflected clearly in the calculated data, the Dong Nai River through Lam Dong province is strictly controlled in the basins, the calculated indices do not have high disparities. The Government has implemented many policies to improve the ability to receive environmental sanitation. The highest is in Da Teh and Da Hoai 0.41 and the lowest is Dalat 0.34 with the difference is 1.2 times lower (Table 7).

Table 7. Calculations of vulnerability indicators for the Dong Nai River basin in Lam Dong

District	RS	DP	EH	MC	VI
Da Lat	0.185	0.252	0.13	0.34	0.23
Bao Loc	0.235	0.195	0.09	0.35	0.22
Dam Rong	0.185	0.445	0.04	0.39	0.27
Lac Duong	0.185	0.221	0.01	0.37	0.20
Lam Ha	0.185	0.527	0.09	0.38	0,29
Don Duong	0.185	0.378	0.04	0.38	0.25
Duc Trong	0.2	0.464	0.08	0.38	0.28
Di Linh	0.235	0.221	0.04	0.38	0.22
Bao Lam	0.235	0.193	0.02	0.38	0.21
Da Hoai	0.235	0.104	0.02	0.37	0.18
Da Teh	0.25	0.29	0.04	0.41	0.25
Cat Tien	0.25	0.117	0.02	0.41	0.20
Total	**0.21**	**0.28**	**0.05**	**0.38**	**0.23**

Results of the assessment of the vulnerability index of water resources in Dong Nai river basin are shown in the Table 7, showing that Duc Trong and Lam Ha are the subregion with the next highest water vulnerability index, Dam Rong with VI value = 0.27. The locality with the lowest water vulnerability index of the main basin is Da Hoai 0,18; ensuring water management parameters at screening.

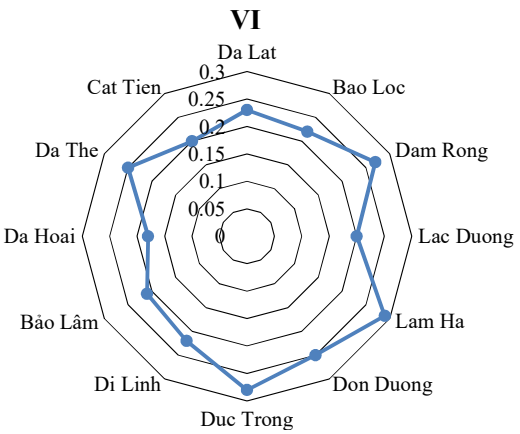

Figure 5. Diagram of Vulnerability Index of Dong Nai River basin in Lam Dong area

4. Conclusion

The Dong Nai River system provides an important source of water for the livelihood and economic development needs of Lam Dong province and many other provinces. In addition to the potential for hydroelectricity development, the Dong Nai River also provides irrigation water for agriculture and domestic water supply in the basin. In addition to the rapid population growth, along with the pace of urban and industrial development, there have been and will be increasing pressures on the entire Dong Nai river basin, especially ecosystems. forests, land resources, water resources here. The construction of industrial parks, hydroelectric dams on the upstream and urbanization has increased rapidly, leading to increased hazardous waste and pollution, coastal degradation, causing conflicts in downstream water allocation.

The vulnerability value for the Dong Nai river basin in Lam Dong province is in the part of the river basin with the average water vulnerability index, meaning that the basin has good conditions for sustainable management of its resources. However, there is still technical pres-

sure as well as management policies. In order to reduce the vulnerability of river basins, it is necessary to encourage the development of new policies to reduce tensions and develop a long-term strategic plan, focusing on water management capacity, to be appropriate. with the challenge of using water resources.

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