Southeast-Asian J. of Sciences Vol. 4, No. 2 (2016) pp. 129-138

VULNERABLE MAP OF WATER RESOURCE IN NINH THUAN

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Abstract

Water is a precious resource and affects all aspects of human activity. However, in recent years, due to population growth, economic development and in particularly the impacts of climate change, water resources got a lot of pressures. For sustainable management of water resources, it is needed to assess this resources vulnerability in order to proactively propose solutions to optimize management and minimize impacts. Calculation results show the vulnerable index of the moutainous basins is 0,38-04: average; middle basins is 0,47-0,66: high; coastal basins is 0,72-0,74: very high. The proper solutions are implemented immediately such as building lakes, dams; promulgating the suitable management policies.

Introduction

Ninh Thuan is a province in the south central region, where water resource is rarest in comparison with the other provinces in the country, although it has been added more water from the DaNhim hydropower plant. The Cai is the bigest river in this province with the catchment area of 3.043 km^2, 105 km long, which is a main water supply for socio-economic development in the province. However, the annual average flow module is less than 20 l/s.km2 while the module average is about 35 l/s.km^2 [1]. Additionally, there are some smaller rivers in coastal areas, but due to low rainfall the amount of water in these areas is inconsiderable.

Average temperature is about 27^0C, annual average rainfall is around 700mm and unevenly distributed and evaporation is 1600-1800mm per annum. The to-

Key words: Climate change, Impacts, Ninh Thuan, Vulnerability, Water Resource.

pography is very complex, over three quarters is mountainous. Most of rivers are very short with a steep gradient so that in the rainy season, water flows directly to the sea and very little infiltrates as ground water. Generally, water availability in this region is low. In the context of climate change, extreme weather events happen often. Especially, droughts have occured frequently in a series of years: 1997, 1998, 2002, 2004, 2005,2010 and 2015. The prolonged drought impacted severely on socio-economic development in the region.

In recent years, due to the impact of climate change and socio-economic development, this precious resource is facing up to challenges. Rainfall increases but mainly focused on the rainy season. A shortage of water occurs not only during the dry but also during the rainy season [2].

To manage this precious resource, especially in the context of climate change, it is neccessary to assess the vulnerability of water resources. Then, the vulnerable elements to the effects of climate change and socio-economic development can be pointed out and actively recommend optimal management solutions, minimize the impact.

Methodology

1. VULNERABILITY ASSESSMENT MODEL:

The model of vulnerability assessment of water resources has been proposed by United Nations Environment Programme (UNEP). There are two perspectives of the model: the main threats to water resources and the regions ability to cope with these threats. The threats can be assessed by three parameters: the stress on water resources (RS); pressures on water resources utilization (DP); Healthy ecological system (EH) and the ability to cope with threats can be assessed by management capacity (MC) [3] (Table 1).

Table 1: Parameters in the model of vulnerability assessment of water resources

Main parameters	Added parameters	Formula	Explaination
RS	RSs	RSs = (1700 - R)/1700	R: Total water resources per capita (m^3/person/year)
	RSv	RSv = CV/0.3 CV = S/u	CV: Coefficient of variation u: mean rainfall; S: Standard deviation of annual rainfall.
DP	DPs	DPs = Wu/W	Wu: Total water demand in the basin W: Total water resources in the basin
	DPd	DPd = Pd/P	Pd: Population without access to hygienic drinking water P: Total population of the basin
EH	EHp	EHp = Ww/W	Ww: Total amount of untreated wastewater W: Total water resources in the basin
	EHe	EHe = Ad/A	Ad: Land region without vegetation coverage A: Total land basin
MC	MCe	MCe = (WEwm - WE)/WEwm	WE: GDP value formed from 1 m^3 of water WEwm: GDP average from 1 m^3 of water in Asia
	MCe	DPs = Pd/P	Ps: Population without access to sanitation P: Total population of the basin
	MCc		MCc calculated from table 2

2. GIS:

A computer system for capturing, storing, analyzing, and displaying map data. The most powerful function of GIS is spatial analysis. Different kinds of parameter maps are overlayed to get the final vulnerable index map.

Table 2: Conflict management parameter (MCc)

MCc	Interpretation	Score		
		0.00	0,125	0.25
Institutional capacity	Trans-boundary institution cooperation for water resource	Solid institutions	Loose institutions	No institutions
Agreement capacity	Writing/signed policy/agreement for water resource	Detail agreements	General agreements only	No agreement
Communication capacity	Communication mechanism for water resources management	Communications at policy and operational levels	Communications 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

Resource: [3]

VI is is calculated as below formula

$$VI = \sum_{i=1}^{n}(\sum_{j=1}^{m} x_{ij} \star w_{ij})\star w_i$$

where n: number of main parameters

m: number of added parameters in ith main parameters

x_{ij}: value of the jth added parameters in the ith main parameters

w_{ij}: weight of the jth added parameters in ith main parameters

w_i: weight of the ith main parameters

Table 3: VI category

Vulnerability Index	Interpretation
0,0-0,2: Low	Indicates a healthy basin in terms of resource richness, development practice, ecological state and management capacity.
0,2-0,4: Moderate	Indicates that the river basin is generally in a good condition toward realization of sustainable water resource management.
0,4 – 0,7: High	The river basin is under high stress, and great efforts should be made to design policy to provide technical support and policy back-up in order to mitigate the stress.
0,7 – 1,0: Severe	The river basin is highly degraded in water resource system with poor management set up. Management for the restoration of the river basin's water resource will need high commitment from both government and general public.

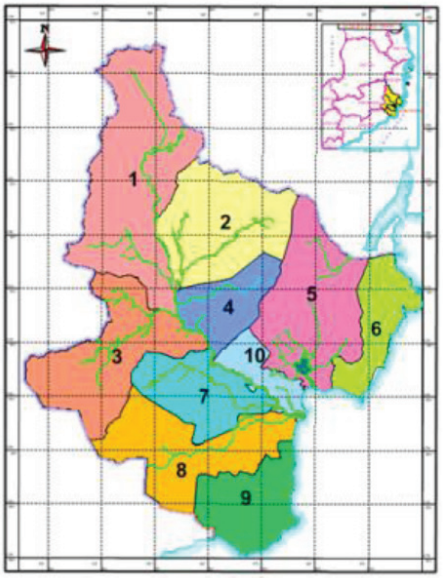
Resource: [3]

Results and Discussion

Basin division based on topography, river networks, water resource exploitation works and DEM, the basins are divided: 1 Upstream basin of the Cai river;

2 Sat - Tra Co; 3 Than; 4 Cho Mo Ngang; 5 Trau; 6 Coastal basin in the northern Cai river; 7 Quao; 8 Lu; 9 Coastal basin in the southern Cai river; 10 PR-TC basin (figure 1).

Fig 1: basin map in NinhThuan



Water stress (RS)

a. Water stress parameter (RSs)

RSs is total amount of water resource per capita per year. If RSs is less than 1.700 m^3/person/year (average of water resource per capita in the world) then water stress is high. Based on the amount of water of basins calculated from NAM model and total population in 2014, the results is: the RSs of mountainous basin (1, 2, 3 and 4) is low (0-0,18). The remain basins are high RSs (0,69-0,89). The coastal basins are the highest RSs 0,89.

b. Water variation parameter (RSv)

Series of rainfall data of 08 station from 1997-2013 are used to analyse the mean rainfall and standard deviation. The Cv and RSv are calculated as table 4.

Water development pressure (DP)

a. Water exploitation parameter (DPS)

Water demand for all sections in the province is 748,51 106 m^3/year (table 3). In which, water for agriculture is 536,47 106 m^3 (71,67%). Although total water resource of the mountainous basins is high but water demand is lower than that of others because in these basins, population density is low and

Table 4: The calculated results of RSv

No	Station	Duration	CV	RSv
1	Ba Thap	1979-2013	0,41	1
2	Phan Rang	1978-2013	0,38	1
3	Nha Ho	1978-2013	0,31	1
4	Ca Na	1984-2013	0,45	1
5	Quan The	1982-2013	0,34	1
6	Nhi Ha	1985-2013	0,35	1
7	Tan My	1977-2013	0,33	1
8	Song Pha	1979-2013	0,37	1

infrastructure for socio-economic is less development than others. Then, DPs of basins 1and 2 is low (0,13-0,22). Others are 1. It means that these basins are high pressure of water resource exploitation.

b. Hygienic drinking water inaccessing parameter (DPd)

According to report of the Vietnam national programe of rural hygenic drinking water 2013, there is 84% of rural population and 90% of urban population can get hygenic drinking water [4]. This statistic data shows living conditions recently are considered and highly improved compared to the past. Based on the provincial statistic data of population, the DPd calculated is low in all basins from 0,14-0,36.

Ecological system (EH)

a. Water pollution parameter (EHp)

Total untreated waste water is difficult estimation. Then, some authors assum the amount of waste water is 30% of that for agriculture and forestation and 80% of that for domestic and industry [6].

The calculation results show that EHp in the plain basin is high (0,56-0,8), while it in the mountainous basins is (0,04-0,29).

b. Ecosystem degradation parameter (EHe)

This parameter is calculated by ratio of uncovered vagetation areas and total area in the basin. Due to economic development and urbanization, deforestation happened seriously in the past, especially in the urban areas. Currently, being aware of the key role of forest, the provincial government had stopped deforestation and encouraged reforestation. Therefor, the uncovered vegetation areas have decreased regularly [7]. Based on the statistic data and map of forest, EHe is calculated as follow: the moutainous basins are from 0,2-0,34.

Table 5: The amount of untreated waste water (Unit: m^3/year)

	Water demand	Ratio	Waster water
Aquaculture	48.909.781	80%	39.127.824
Industry	57.243.315	80%	45.794.652
Breeding	39.077.885	80%	31.262.308
Agriculture	536.474.928	30%	160.942.47
Forest	38.197.250	30%	11.459.175
Domestic	15.430.740	80%	12.344.592
Tourism	13.173.184	80%	10.538.547

The remain basins are from 0,4-0,68. The PR-TC basin has the highest 0,86 due to no forest.

Management capacity (MC)

a. Water use inefficient parameter (MCe)

This parameter is estimated by the ratio of the GDP formed from 1 m^3 water used with the GDP average produced from 1 m^3 in the world [3]. NinhThuan is a agricultural province with 6 districts in where over 70% of population is farmer. Special agricultural products are rice, grape, jujube, garlic, onion... The traditional irrigation method is by flooding. This method shows water use is inefficient. According to Al-Kalbani [8], MCe of the basins locating in these districts is 1. Except PR-TC city its economic sections are more development than other. Industrial GDP is 1.566,6 billion VND with amount of water use 37,84 106 m3 [5], hence MCe is 0,41.

b. Sanitation inaccessing parameter (MCs)

According to report of the Vietnam national programe of rural hygenic drinking water 2013, there is 65% of rural population can access sanitation [4]. Calculation result of MCs of the basins is 0,4. Except, basins 5 and 6 are 0,3 and 0,6 correspondingly.

c. Conflict management parameter (MCc)

This parameter is ability to manage water resources involving trans-boundary. A well-managed system can be shown as term of the institutional capacity, agreement capacity, communication capacity and implementation capacity. To determine these parameters, all agencies in NinhThuan relative to management and use of water resources such as the Department of Natural Resources and Environment, Department of Agriculture and Rural Development, Department of Industry, Department of Trade and Tourism, Natural resources division in

districts are investigated with the contents as table 2. The results show the basins 3, 7 and 8 are 0,5-0,51; the coastal basins are l 0,6 and the mountainous basins are 0,6-0,7.

Vulnarable index

Determination of the weights can be biased and then difficult to compare the parameters. Therefor, 0,25 is given as weights for RS, DP, EH and MC; 0,5 as weights for RSs, RSv, DPs, DPd, EHe, EHe and 0,33 as weights for MCe, MCs and MCc [3]. The results of vulnerable index as (figure 7).

Fig 2: vulnerability index graph

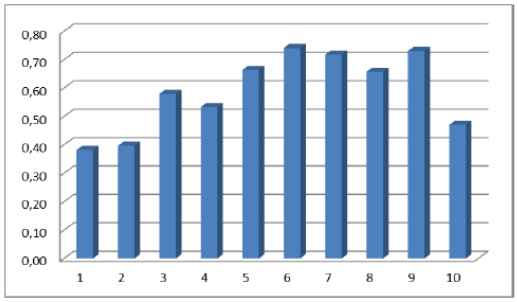


Fig 3: Map of RS

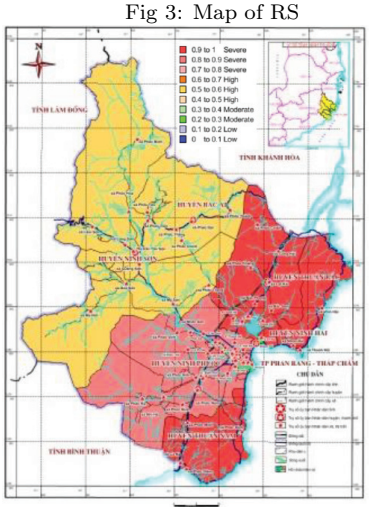
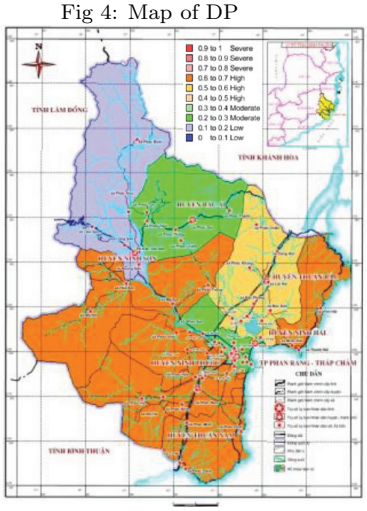


Fig 4: Map of DP



The moutainous basins such as the upstream basin of Cai river, Sat-Tra Co basin have average vulnerable index from 0,38 to 0,4. Although water resources of these basins are exploited and used sustainably but still facing technical pressure as well as management policies. So it is needed to promulgate new

Fig 5: Map of EH

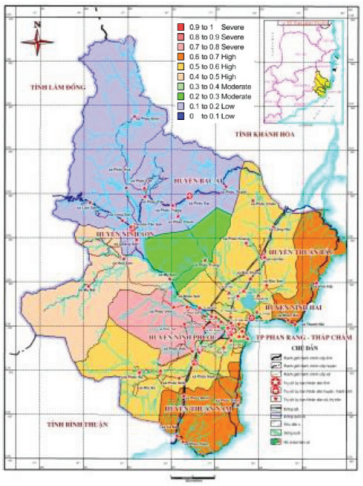


Fig 6: Map of MC

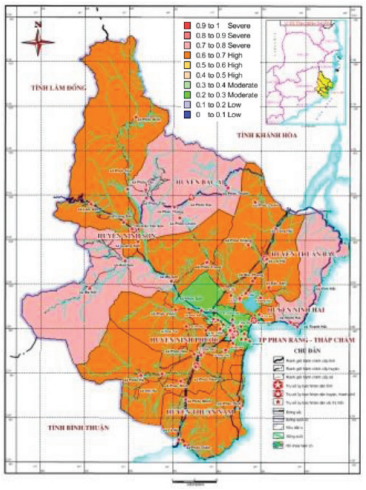
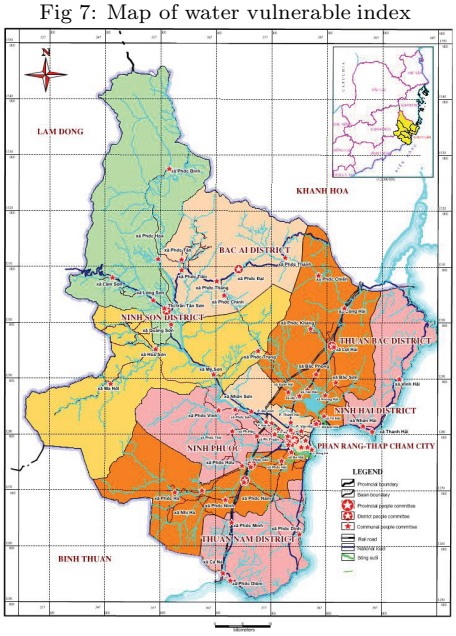


Fig 7: Map of water vulnerable index



management policy to cope with the challenges of water resource use.

The basins of Cho Mo, Trau, Lu have high vulnerability index from 0,47 to 0,66. It is necessary to develop policies for technical assistance to reduce the pressure as well as to build the long-term strategic to develop management capacity to deal with challenges of water resources.

The Quao basin and the coastal basins such as northern and southern Cai river basin have very high vulnerable index from 0,72-0,74. Water resources in these basins are seriously deteriorated. Technical infrastructure and management systems can not meet the needs. These basins need the long term strategy to rebuild technical infrastructure as well as promulgate the proper management policies with the agreement of people, governments and relevant organizations.

Conclusion

Ninh Thuan is a southern province where water resource is rarest in comparison with the other provinces in the country. In recent years, due to the impacts of socio-economic development and climate change, water resources got a lot of pressures. The drought and shortage of water happen frequently often. It makes water resources more vulnerability.

The model of vulnerability assessment of water resources has been proposed by UNEP. There are 04 main parameters such as stress on water resources (RS); pressures on water resources utilization (DP); Healthy ecological system (EH) and management capacity (MC). Applying this model to calculate the vulnerable index in NinhThuan and the results of the moutainous basins is 0,38-04: average; the middle basins is 0,47-0,66: high; and the coastal basins is 0,72-0,74: very high.

The proper solutions are needed to implemen immediately such as building lakes, dams... to store water for the dry season; saving water use as well as promulgating the integrated water resource management.

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