

## ASSESSMENT OF WATER RESOURCE VARIATION IN THE LAM RIVER BASIN FROM 1970 TO 2022

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### ARTICLE INFORMATION ABSTRACT

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The purpose of this research is to examine the change in water resources over the previous 50 years in the Lam River basin (also known as the Ca River) in Nghe An province, an important water resource basin in the North Central area. According to the findings, the amount of flow through hydrological stations on rivers and streams in Nghe An province has been falling since 2012, and the yearly flow pattern is continuously dropping. For many years following 2015, the flow has been lower than typical, owing to the drought that occurred during the dry season of 2015-2016.

**Keywords:** Lam River; Ca River; water resources.

### 1. Introduction

Water resources are particularly important since they are a vital component of life and the environment, as well as a critical factor in the country's survival and long-term growth. Research on planning for rational use of resources by river basin is an important content of integrated management of natural resources and environment by basin. The top priority in water resource management of countries is to manage water resources for long-term development.

Nghe An is a region with quite abundant water resources with a total annual surface water volume of about 25.70 billion m<sup>3</sup>, of which the amount of endogenous water is 16.25 billion m<sup>3</sup>; The amount of water flowing in from outside is 9.54 billion m<sup>3</sup> [1]. Most of which comes from Lam River. In terms of natural conditions, Nghe An province has many advantages to develop a comprehensive economy, but there are also many difficulties that hinder economic development such as: lack of water for economic sectors, surface water resources have been at risk of degradation and depletion, water quality is also degraded due to pollution, saltwater intrusion tends to increase during the dry season, and climate change has also had a major impact on water resources in the province. Irrigation and hydroelectric reservoir systems have been and are being built on the Lam river. On the main stream of Lam River, there are 11 hydroelectric reservoirs including: Ban Ve,

Nam Non, Khe Bo, Chi Khe. On Nam Mo River, there are 2 reservoirs: Nam Mo and Ban Ang. On Hieu River, there are 3 reservoirs including: Nhan Hac A, Chau Thang, Ban Mong. Among them, Ban Ve and Ban Mong reservoirs have large reservoir capacities, which have a great impact on the process of regulating Lam River flow (Figure 1). However, Ban Mong reservoir is under construction.

In early 2023, due to water shortage, Ban Ve reservoir was near dead water level, Lam River had a drought, greatly affecting the operation of power supply, production and daily life. Therefore, studying the changing trends of water resources in the Lam River basin has profound practical and scientific significance. This study would like to analyze the changes in water resources during the last 50 years, as well as the impact of the Ban Ve reservoir over the last 12 years.

## 2. Research materials and methods

### Research data

This study uses monthly and yearly average flow data at Muong Xen, Quy Chau, Dua and Yen Thuong hydrological stations in the Lam river system. In particular, Muong Xen station represents the changing trend of flow in Nam Mo river, Dua station represents the changing trend of flow in Lam river's middle reaches, Yen Thuong station represents the changing trend of flow in Lam River downstream and Quy Chau station represents the changing trend of flow in Hieu River's upstream from 1970 to 2022. This data source is provided by the North-Central Hydro-meteorological Centre.

### NETWORK MAP OF HYDRO-METEOROLOGICAL STATIONS AND RESERVOIRS



Figure 1: Location of hydrological stations and reservoirs

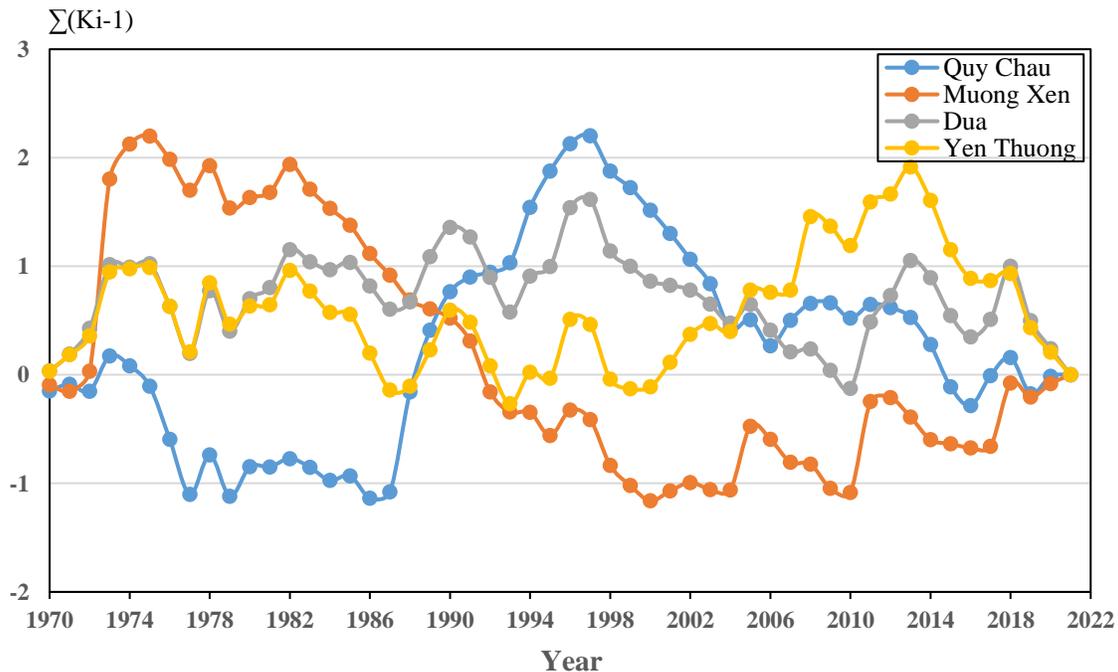
*Research Method*

The study uses the standard error cumulative curve for the annual average flow series ( $\sum(K_i-1) \cdot t$ ;  $K_i=Q_i/Q_{tb}$ ;  $Q_i$  is the average flow in  $i^{th}$  year;  $Q_{tb}$  is the average flow rate over many years) at hydrological stations to analyze flow changes.

**3. Results and Discussion**

**3.1. Changing trend of average annual flow**

Creating a cumulative curve with standard deviation for the yearly average flow series at the following hydrological stations: Nam Mo (Muong Xen station); Lam River (Dua, Yen Thuong station); and Hieu River (Quy Chau station) to determine the changing trend of the average annual flow on the Lam river system. The evaluation period is 1970 to 2022, which corresponds to the time of synchronized data series at hydrological stations. The results of average annual flow fluctuation trends in regions and rivers are shown in Figure 2.



**Figure 2:** Cumulative curve with standard deviation of annual flow at some hydrological stations on Lam River

**Muong Xen Station**

From 1970 to 2000 (31 years), a relatively long cycle with one high water phase and one low water phase developed, with the low water period being quite long. During the 1970-1982 period, the flow was higher than the average, while the 1982-2000 period was significant low water time, representing a 19-year trend of water resource loss on the Nam Mo river branch.

2001-2010 cycle (10 years): The flow was higher than usual for many years during the 2001-2005 period, although this period only lasted 5 years. Low water levels

prevailed from 2006 to 2010.

From 2010 to 2012, there was a period of high water; however, from 2012 to 2022, the flow was lower than the average flow for many years.

Thus, the flow on the Nam Mo River tends to shift in a cycle of roughly (10-11) years, with one high water phase and one low water phase. With this tendency, the flow on the Nam Mo River is projected to be in the low water phase in the 2021-2025 period and to begin new cycles between 2025-2030; 2031-2040. At that time, the forecast of the natural resources scenario in the Nam Mo river basin for the planning periods (2025 and 2030) is a period of low water.

#### **Dua Station:**

- From 1973 to 1997 there were two low cycles (from 1973 to 1988 and from 1988 to 1997), however the amplitude of yearly flow changes in high water and years with low water is small.

- From 1997 - now is a cycle, in which from 1997-2010 (13 years) is a time of low water, whereas from 2010 to 2013 there are only 4 years of high water, and since 2015 the flow has been on a downward trend.

#### **Yen Thuong Station:**

The flow at Yen Thuong station is a combination of the flow on the main flow of the Lam River and the tributary flow of the Giang River.

- The flow at the station showed fluctuation water regime from 1973 to 2000, however the cycle was unclear. In total, the tendency of this period is one of low water.

- From 2000 to 2013, the flow at Yen Thuong station was higher than the average flow for many years, but since 2015, the flow has tended to be lower.

#### **Quy Chau Station:**

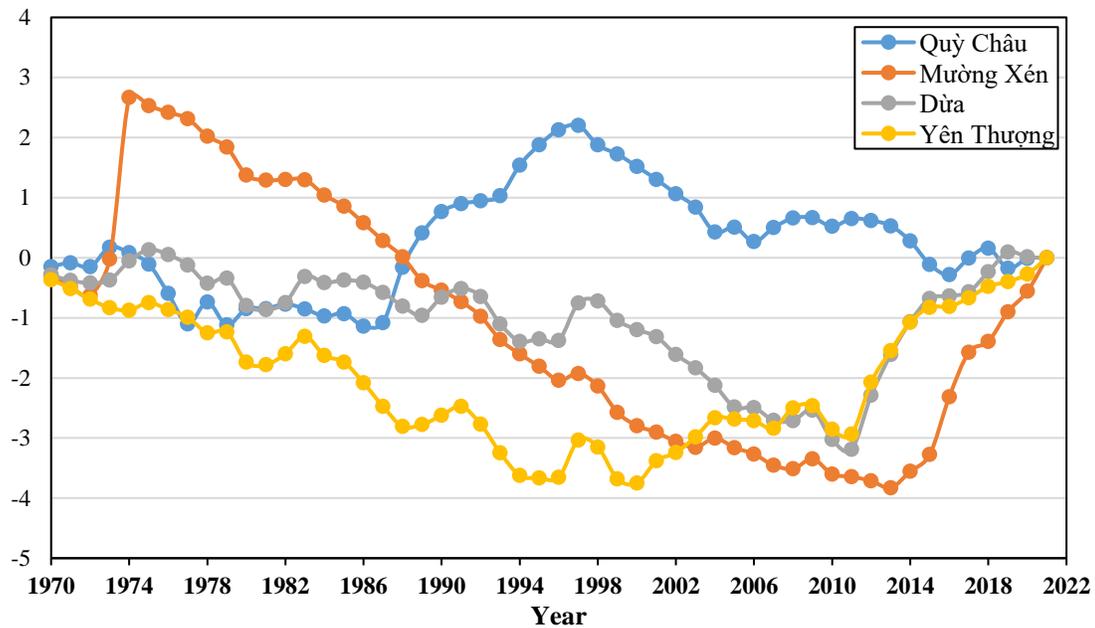
According to the cumulative chart of average annual flow, there was a cycle from 1987 to 2012, with a sequence of years with high water from 1987 to 1997, followed by a period of low water from 1997 to 2006. These are the two longest periods of high and low water in the flow data record measured at Quy Chau station, each lasting 11 years. The flow tended to be greater than the average flow for many years from 2006 to 2012, however the fluctuation amplitude was not substantial.

### **3.2. Change trend of flow during 3 dry months (II - IV)**

The dry season flow, like the annual flow, tends to decrease as a result of factors such as:- Climate: Because of the different distribution of rain in each zone, but where there is little rain, the low flow is quite low such as the upstream of Ca River and the middle and lower reaches of Hieu River. In rainy places such as the upstream of Hieu River and Giang River, the low flow is quite high, some flows in dry months ranging from (20 - 27) l/s.km<sup>2</sup> with the driest month of the year.

- Buffer surface factor: As the extent of forest exploitation increases, the forested area is increasingly shrinking and the buffer surface is being destroyed. Decreased forest cover leads to a decreasing ability to retain water and regulate water, resulting in depletion during the flood season and increased flood concentration during the rainy season.

- Ability to exploit water resources: As the demand for water for agriculture, industry, and people's livelihoods grows, the seasonal structure necessitates an increasingly large source of irrigation water per unit area, resulting in more intense exploitation of water resources, particularly during the dry season. Heavy irrigation exploitation in the high and middle sections of the river will have a direct impact on water use in the lower reaches of the river.



**Figure 3:** Cumulative curve with standard deviation of flows in 3 months of dry season (II - IV) at some hydrological stations on Lam River

Figure 3 shows that the flow pattern of three dry months in the Lam River's downstream has tended to increase since 2010. The cause for this is due to improved water supplies from the Nam Mo River and control of the Ban Ve reservoir. The Ban Ve reservoir has been operational since 2010. Table 1 shows the average flow statistics for three dry months at the Yen Thuong hydrological station. After 2010,  $Q_{tb}$  of three dry months (II - IV) are all greater than in prior years.

**Table 1:** Statistics of average flow for 3 months at Yen Thuong hydrological station

No.	Period	$Q_{tb}$ of 3 dry months (II - IV) ( $m^3/s$ )
1	1970-1974	132
2	1975-1979	156
3	1980-1984	155
4	1985-1989	110
5	1990-1994	130
6	1995-1999	181

No.	Period	Q <sub>th</sub> of 3 dry months (II - IV) (m <sup>3</sup> /s)
7	2000-2004	180
8	2005-2009	154
9	2010-2015	188
10	2016-2019	194
11	2020-2022	249

#### 4. Conclusion

The annual flow volume at hydrological stations on rivers and streams in Nghe An province has been dropping since 2012, and the annual flow trend is continuously declining. After 2015, the flow tends to be lower than the long-term average. This is well demonstrated by the drought that occurred during the dry season of 2015-2016. At the time, the natural resource scenario of Nghe An province was predicted to have low water for the years 2025 and 2030. The impact of Ban Ve hydropower plant is clear; the average flow in the three months of the dry season (II - IV) has grown significantly since 2010.

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## TÓM TẮT

### ĐÁNH GIÁ SỰ THAY ĐỔI TÀI NGUYÊN NƯỚC TRÊN LƯU VỰC SÔNG LAM GIAI ĐOẠN TỪ NĂM 1970 ĐẾN 2022

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Nghiên cứu này nhằm phân tích về sự biến đổi của nguồn nước trong hơn 50 năm qua trên lưu vực sông Lam (hay còn gọi là sông Cả) trên địa bàn tỉnh Nghệ An, một lưu vực quan trọng về tài nguyên nước tại khu vực Bắc Trung Bộ. Kết quả cho thấy, từ năm 2012, lượng dòng chảy qua các trạm thủy văn trên các sông suối thuộc địa bàn tỉnh Nghệ An đang trong thời kỳ ít nước, xu thế dòng chảy năm đang giảm dần. Dòng chảy đang có xu hướng nhỏ hơn dòng chảy trung bình nhiều năm sau 2015, đặc biệt tình trạng khô hạn diễn ra trong mùa khô năm 2015-2016.

**Từ khóa:** Sông Lam; Sông Cả; tài nguyên nước.