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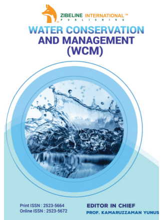

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RESEARCH ARTICLE

THE HARMFUL OF THE HYDROELECTRIC DAMS IN MEKONG RIVER UPSTREAM ON THE ECOSYSTEMS AND LIVELIHOODS IN THE MEKONG DELTA, VIETNAM

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ABSTRACT

The hydro-electric of the upstream Mekong (China) has been and will greatly impact on the down-stream areas, in which the Mekong Delta (Viet Nam) is suffering a lot of losses Drought due to water trapped by dams upstream together with Climate Change, Sea Level Rise are present, its impact on Vietnam Mekong Delta and given scenarios for the specialist units to propose. 12 dams in the Chinese division, they accumulate too large water; even causing floods for the people, for many years, causing drought in the downstream, especially the Mekong Delta of Vietnam: drought, lack of water for crops, livestock, for human livelihoods. Alluvium of the river stream is also retained (formerly 160,000,000.00 tons / year, this year, only 80,000,000.00 tons / year, so not only the loss of crop but also erosion of the shoreline and coastline. and saline intrusion, under the impact of climate change is rapidly increasing and very high, in addition, the Sulfate Acidification process also becomes fierce. Characteristics of the ecological system of acid sulfate soil in the Mekong Delta, it contains more than 1.7 million Ha with S content about 1.0-.8%. in normal condition, they are not toxic, but when dry, dehydrated, and air penetrates, they will sulfate acidification very strong, produces highly toxic (Al^{3+}> 3000ppm), kills aquatic organisms and rice, and other agricultural crops. Drought due to water resources by upstream countries, mainly by China, will be increasingly fierce: 6 processes simultaneously occurring in this Ecosystem: 1- Drought, 2: sulfate acidification, 3. Saltwaterization, 4. Lack of alluvium and nutrition, 5- riverbank erosion, sedimentation of estuaries and seaports; and 6 - Coastal landslide (which in the past, accreted to the sea 100m /year, now, in contrast, erosion and sea intrusion 25m/year. Productivity of rice and fisheries has been and will continue to decrease.

KEYWORDS

hydroelectric dams build; Upstream of Mekong River, Mekong Delta Viet Nam; damage; drought- Salinization: ecosystem; livelihood; landslide.

1. INTRODUCTION

In the past 3 years to now, The Mekong Delta region plays a particularly important role in socio-economic development, ensures the national security and defense for the whole Vietnam country and is a key region for economic development; Especially, there is the greatest potential for developing tropical agriculture, food production, and cultivation, especially for aquaculture, fishing and exporting seafood. The Mekong Delta plays a decisive role in ensuring national food security and creates the competitiveness of Vietnam's agricultural and fishery products with the world, bringing great export value to the whole country, expanding exchanges with region and world. According to the statistics, Me Kong Delta provides more than 53% of rice production, 65% of fishery production, 75% of fruit production and more than 90% of Vietnam's export rice. About fisheries, this has contributed a large part to the US $ 7 billion of seafood exports (2017). In addition, the Cuu Long Delta is also a "barn" of the nation's largest fruit, providing fruit for the whole country and for export. But When 12 dams have been built, more than 50% of the water is trapped in the Lancang River (China). They have accumulated too much water, causing the risk of rupture of the Three Gorges Dam, which has been causing floods and inundations in the provinces of HO Nam, Ho Bac, Tu xuyen, and Van Nam. Shortage for Cambodia, Vietnam, causing drought, sulfate acid dification, salinization. In the past two years, salinity has penetrated deep into the field (for example, Vam Co River, 4g/L salinity goes into the field > 160 km. It's dangerous! Losing the Livelihood of 20 million people , crop yields decrease, riverbank erosion, coastal erosion, depletion of aquatic products.

1.1 An overview

The Cuu Long River Delta belongs to Vietnam and situated in the Mekong River basin. The Mekong River is 4,200 km long, flowing through 6 countries: China, Myanmar, Thailand, Laos, Cambodia and Vietnam, with a basin area of 795,000 km^2, including the 49,367 km^2 delta. The Cuu Long River Delta is the end of the Mekong Delta, including 13 provinces and cities: Long An, Tien Giang, Vinh Long, Ben Tre, Dong Thap, Tra Vinh, Can Tho, Hau Giang, Bac Lieu, Soc Trang, An Giang, Kien Giang and Ca Mau; has

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a natural surface of about 4,058,046 ha (accounting for 12% of the Vietnam natural area); The population is more than17.5 million people (equal to 21% of the national population); density of 430 people / km^2; There are about 1.3 million Khmer people(Cambodian origin), concentrated in the provinces of Tra Vinh, Soc Trang, Vinh Long, An Giang and Kien Giang.

The Cuu Long Delta region plays a particularly important role in socio-economic development, ensures the national security and defense for the whole Vietnamcountry and is a key region for economic development; Especially, there is the greatest potential for developing tropical agriculture, food production, and cultivation, especially for aquaculture, fishing and exporting seafood. The Cuu Long Delta plays a decisive role in ensuring national food security and creates the competitiveness of Vietnam's agricultural and fishery products with the world, bringing great export value to the whole country, expanding exchanges with region and world. According to the statistics,Cuu Long Delta provides more than 53% of rice production, 65% of fishery production, 75% of fruit production and more than 90% of Vietnam's export rice. About fisheries, this has contributed a large part to the US $ 7 billion of seafood exports (2016). In addition, the Cuu Long Delta is also a "barn" of the nation's largest fruit, providing fruit for the whole country and for export (Ba et al., 2016).

But, due to the impact of hydro-power development, water use in up-stream countries, combined with Climate Change, Sea Level Rise, has posed great challenges for the Cuu Long Delta. This chapter briefly presents the risks facing the Cuu Long Delta due to the impacts of hydro-power dams on the Mekong main-stream; From there, propose solutions. Cuu Long is the Vietnamese name of Mekong River for the part flowing on Vietnamese territory (Cuu Long means 9 dragons –the simile meaning this river flowing into the East Sea through 9 estuaries, but Ba Thac (Bassac) estuary now is mud-filled, "9 Dragons" are only on 8 estuaries). The Mekong Delta get on most of the Mekong down-stream plains,while the Cambodian part of this delta is very small, so the Mekong Delta can be used to identify the Cuu Long Delta ([1]) (chapter 2).

1.2 Characteristics of up-stream Mekong waters

Due to the impact of El Nino phenomenon in 2015, the rainy season came late but ended soon, the total rainfall in the basin is short of the many years average as 20-50%. Therefore, the flood season in 2015 –one of the years with small floods, resulting in the transitive flow early in the dry season from the up-stream to the Mekong Delta at extremely low level (at historical level) compared to the average annual document list (AMY) since 1980 until now. During the middle of the dry season 2015-2016, the up-stream flow has increased fluctuation and is predicted to have an impact on the Saline Intrusion [1.9]in the Mekong Delta estuaries. Two important up-stream factors for water resources, saline intrusion in the Mekong Delta are the fresh water reserves in Tonle Sap (Tonle Sap) and flow to Kratie (entering part of Mekong Delta). The contents as below describing theactual status of these 2 elements.

1.2.1 Water regime in Tonle Sap (Lake)

Figure 1 shows the updated water level until April 4, 2016 at Prek Kdam station (near Tonle Sap). From the chart, the sea level changes in the extremely low state (average of about 1.41m) compared to the average data series of many years in the period 1980-2013 and lower than the same period in 2014-2015, about 0.75m. Therefore, it is possible to predict the very poor flow from the Tonle Sap to the Delta in the near future.

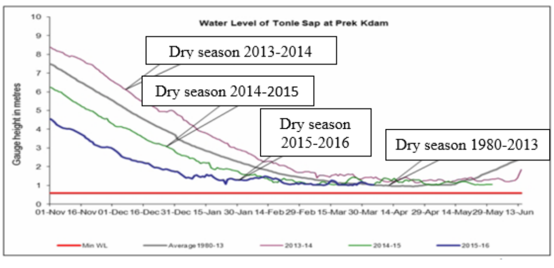

Figure 1: Dry season water level at Prek Kdam station in recent years (Scale: 1/5, 000)

1.2.2 Flows in the Mekong main-stream

This year, the flow in the beginning of the dry season to the Mekong Delta is small, but at the end of January to the beginning of February 2016, the up-stream flow to the delta increased sharply, then the flow decreased rapidly until early March; and from this time to the middle of March, there is the regulation of the up-stream reservoirs of the Mekong river main-stream, specifically at Chiang Sean station, the water level started to rise from 12-14 March and remained quite stable from 14 th / 3 to April. 2016. Figure 2 and Figure 3 show situations of dry season water level at Kratie station (a station near the delta) and Chiang Saen station on the Mekong main-stream to the Delta in the 2015-2016 updated (on April 4, 2016) (Ba, 2000).

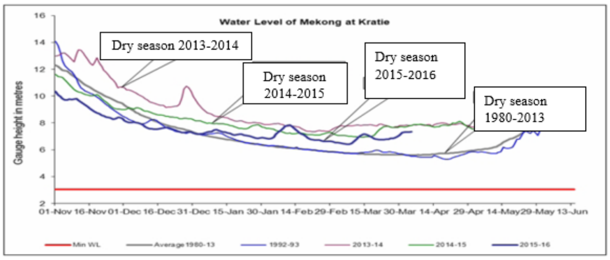

Figure 2: Dry season water level at Kratie station in recent years, Scale: 1/500, 000

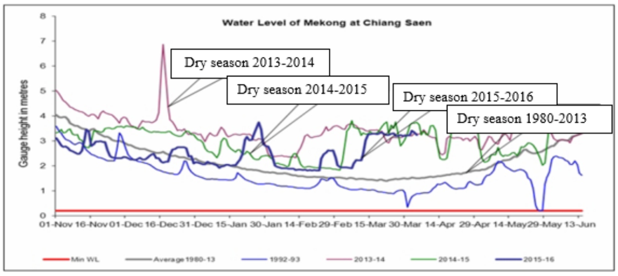

Figure 3: Dry season water level at Chiang Saen station in recent years Scale: 1:500, 000

Thus, with the data of the Mekong River up-stream (Chiang Saen station) increased and maintained from the middle of March until now; At Kratie station (a station near the delta), the flow starts to increase from the end of March to April 1 and tends to maintain stability after April 1st to April. 4th. 2016. The China and Laos open dam to discharge water into the Mekong River that contributes an additional part of water. Therefore, saline intrusion in estuaries in the Mekong Delta region in April (updated in this forecast) will likely decrease compared to previous forecasts; However, if there is no rain in May, the flow to the Delta is expected to remain low.

2. Overview of Hydro-power Planning and Development in Mekong River

2.1 Hydro-electricity potential in the Mekong basin

The hydro-power potential of the Mekong River basin is very large, reaching about 53,900 MW,concerning:
* China: 23,000 MW
* Down-stream: 30,900 MW
+ On the main stream: 13,000 MW
+ On branch stream: 17,900 MW
- Branches in Laos: 13,000 MW
- Branches in Cambodia: 2,200 MW
- Branches in Thailand: 700 MW
- Branches in Vietnam: 2,000 MW

2.2 Hydro-power planning on the Mekong main-stream

2.2.1 General introduction

The Mekong River is the only river that still flows freely to the sea through 5 of the 6 riparian countries of Myanmar, Laos, Thailand, Cambodia and Vietnam. The main-stream in China has been blocked by the primary 5

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dams in a series of 8 steps expected for dam construction. Since 2006, interest in hydro-power has increased in the Mekong down-stream basin (MDB) region, with increasing private investment in electricity infrastructure. Most of the tributaries of the Mekong already have natural steps, and as a result, they are also built dams, or are planned to be built, with about 71 projects expected to be operated by 2030.

Figure 4: Hydropower plan on the Mekongmain-Stream (Scale: 1:10, 000, 000)

2.2.2 Planning and plan implementation of hydro-power in China

The Mekong River originates in Tibet and flows through Yunnan hiland province to the countries in the Mekong down-stream basin, with many different names. In China it is called Lan Cang. In other countries, it is called the Mother River or the Cai River. The Mekong River in China has great potential for hydro-electricity. In the planning of hydro-electric ladder in 1980, there are 25 steps on the main stream with total installation capacity of 25,870 MW; 120 hydro-electric positions on branch lines with a total installed capacity of 2,600 MW. See figure graphic 6.4: According to the plan, some factories are planned to be built by China by 2020 as follows:

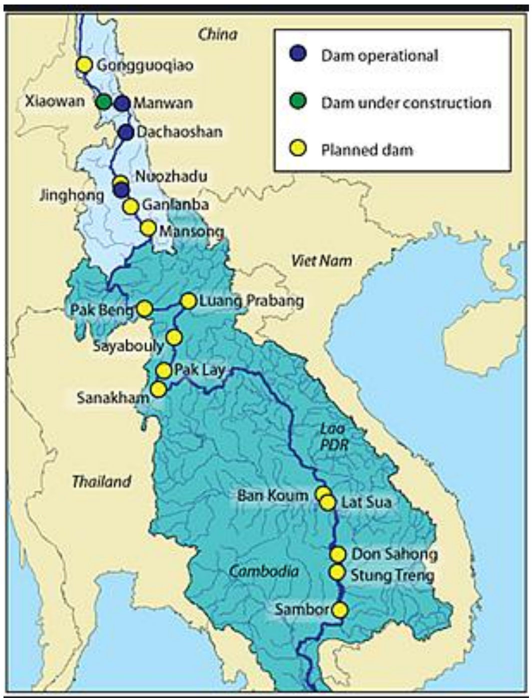

Figure 5: Upper Mainstream dams of Mekong River (Scale: 1:10,000,000)

Table 1: Hydro-power works on the Mekong main-stream in China

No	Project Name	Aim	Basin surface (km^2)	Dam style Height	Lake Volume (10^6 m^3)	Useful volume (10^6 m^3)	Warranty Power (MW)	Installed Power (MW)	Yearly Energy (GW)	Plan Duration
1	Mengsong	P	160.000	C/28		0	373,9	600	3.740	2013-2020
2	Ganlanba	P	152.800	Lock/10		0.	100,8	150	1.010	2013-2020
3	Jinghong	P	149.100	C/107	1.230	230	847,4	1.500	7.606	2009
4	Nuozhadu	P	144.700	R/260	22.700	12.400	2.267,1	5.500	23.700	2013-2020
5	SichiaG- ang	P	123.000	C/260	550	140	510	1.100	5.730	PF/S?
6	Dacha- oshan	P	121.000	C/118	890	240	709,5	1.350	5.931	2003
7	Manwan	P	114.500	C/132	920	258	787	1.250/1.500	7.870	1993
8	Xiaowan	P	113.300	A/290	15.130	9.800	1,803,3	3.600/4.200	19.170	2012/2015
9	Gongguo- qiao	P	97.300	C/130		120	4.674	750	4.711	2011
10	TieMenKan	P	93.400	C/	2.150	960	827,1	1.780	8.270	PF/S?
11	Hyang- Deng	P	92.000	C/	2.290	1.110	849,6	1.860	8.500	PF/S?
12	Tuoba	P	88.000	R/	5.150	3.400	762,3	1.640	7.630	PF/S?
13	Wulong Long	P	85.500	-/-	980	340	270	800	4.890	Desk Study
14	JiaBi	P	84.000	-/-	320	90	131	430	2.650	Desk Study
15	Liutan Jiang	P	83.000	-/-	500	170	162	550	3.360	Desk Study
Total					52.810	29.258	15.074,8	22.860 -23.710	114.768	

(Source: Mekong River Committee, 2015)

Based on this plan, China has been completing the construction and planning of construction and installation of hydro-electric plants as follows:

Already and will complete 5 works including:

- 1993: Man Wan (Man Wan): H dam: 132 m, W: 920 million m^3, Power: 1,500 MW
- 2003: Dai Trieu Son (Dachaoshan): H dam: 118 m, Wh: 940 million m^3, Power: 1,350 MW,
- 2009: Canh Hong (Jinghong): H dam: 108 m, Power: 1,500 MW completed,
- 2011: Gongguaqiao (Gongguaqiao) is 105 m high,
- 2012: Tieu Loan (Xiaowan): 292 m high, Wh: 15 billion m^3, Power: 4,200 MW (2nd largestafter Tam Hiep - on the Yangtze River).

Continue to complete in 2020
The other 3 dams under construction are Nua Trat Do (Nouzhadu), Cam Lam (Ganlanba) and Manh Tong (Mensgong), located in the lower section of the Lancang River (Chinese name of Mekong up-stream).

2.2.3 Planning and implementing the planning for hydro-power development in the down-stream Mekong countries

In the 1960s and 1970s, the Mekong Committee outlined plans for a series of 7 major dams for the lower basin. In the 1980s, the countries in the DMB rejected the possibility of constructing dams with large reservoirs, including the Pa Mong dam, which was controversial. Later, in 1994, the Mekong Secretariat published a study proposing a series of dams at 12 locations from Pak Beng, Oudomxay Province in Laos to Tonle Sap in Cambodia with a height of 20 - 50 m from the bottom of the river. Projects are defined as not considering the impact on the environment when they are put into operation. Now, with the encouragement of up-stream governments, different companies have taken these ideas and built-up similar concepts then submitted them to the regional governments' energy agencies. Up-stream 12 hydro-power projects on the Mekong main-stream have been proposed belongs to the countries of Laos, Thailand and Cambodia, of-which 10 will be located in Laos and 2 in Cambodia (See Table 1).

Here is the parameters of these Dams:

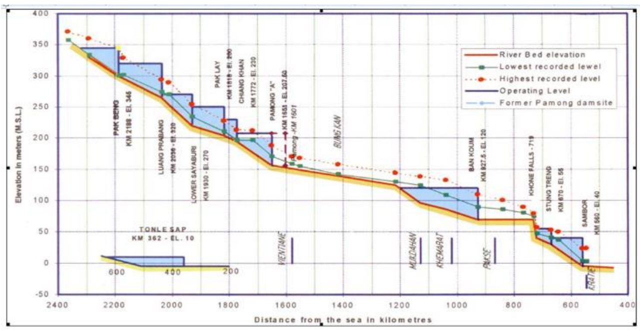

Figure 6: Hydro-power ladder on the Mekong mainstream (Laos-Thai-Cambodia)

Table 2: Basic information on parameters and current status of 12 dams

Project	Nation	Water level for Power(m)	Power rate installed (MW)	Yearly power (GWh)	Invester
Pak Beng	Laos	31	1230	5517	China
Luang Prabang	Laos	40	1410	5437	Vietnam
Xayabori	Laos	24	1260	6035	Thailand
Paklay	Laos	26	1320	6460	China
Sanakham	Laos	16	700	5015	China
Pak Chom	Thai – Laos	22	1079	5318	Thailand – Laos
Ban Koum	Laos	19	1872	8434	Thailand
Latsua	Laos	10	800	3504	Thailand
Thakho	Laos	15	50-60	360	Thailand
Don Sahong	Laos	17	240	2375	Malaysia
Stung Treng	Cambodia	15	980	4870	
Sambor	Cambodia	33	2600	11740	China
Total			14.111	64.706	

(Source: Mekong River Committee)

Based on this plan, Laos is currently building 2 works: Xayabury and Don Sa hong (Khone Fall)

2.2.4 Requirements for water using from up-stream Mekong countries

At the present moment, in the Mekong up-stream countries, surface water resources are used mainly for irrigation, hydro-electricity, domestic activities and industrial development. In the dry season, when less flow of the Mekong River, the use of water for Mekong down-stream socio-economic activities will be affected.

2.2.4.1 Development of lake reservoirs

Table 3: Major reservoir works in the Mekong basin (as of 2009)

Nation	Number of reservoir	Effective capacity (million m^3)
China (22%)	3	718
Myanmar (3%)	0	0
Laos (25%)	3	5.408
Thailand (23%)	9	5.462
Cambodia (19%)	0	0
Vietnam (8%)	5	4.000
Total	20	15.596

According to the Mekong River Committee's report, the reservoir capacities will be as follows:

- The total capacity of 6 lakes in China side has and will reserved 21 billion m^3 (4.6%);
- The total of 40 existing reservoirs on all branches of the lower Mekong basin holds 22 billion m^3(4.7%);
- By 2030, with the construction of an additional 70 reservoirs on Mekong down-stream tributaries, another 20 billion m^3 (4.2%) will be stored
- In addition, the total capacity of 11 dams on the lower Mekong main-stream will also store 2.5 billion m^3 (0.5%)

The total capacity of all hydro-electric reservoirs in the basin get for 14.0% of the flow of the Mekong River.

2.2.4.2 Water requirements for agriculture

The agricultural development and water use of countries in the Mekong basin are as follows:

- China (Yunnan Province): irrigation water demand for agriculture may increase from 1.92 to 2.08 billion m^3 in 2000 to 2.25-2.44 billion m^3 in 2020. Water demand for industry will increase from 518 million m^3 in 2000 to about 750 million m^3 in 2020. China has also proposed a plan to transfer water from the Mekong River to serve its East provinces.

- Myanmar: has a short-term development plan of 3-5 years, taking agriculture development as a basis, and comprehensively developing other economic sectors. Agriculture is currently only about 9 million hectares (of-which 4.5 million hectares of rice) exploited out of a total of 18 million hectares of arable land.

- Laos: It is expected to stabilize the rice cultivation on an area of about 800,000 ha (450,000 ha for main seasonal crop, 370,000 ha for Winter-Spring crop), produce 2.2 million tons of food, focus on intensive farming and increase irrigation surface, therefore, the water demand from 3.0 billion m^3 currently increases to 4.5 billion m^3 in 2030.

- Thailand: Total area of actual irrigation is 747,000 hectares, of which 133,800 hectares are in the Mun River basin, 224,200 hectares are in the Chi River basin and 188,900 hectares are in the basin of the Mekong tributaries. and other small irrigate works for about 200,000 ha. The irrigated area may increase by 485,900 ha in the condition that all irrigation works are planned to be built. Total water demand will increase from the current 12.3 billion m^3 to 23.0 billion m3 in 2030 (# twice). Thailand has made some proposals and profound studies of 8 projects related to water transfer into the basin. When these plans are implemented, the irrigation area in the basin can be up to 1,223,000 ha and will remove about 7-10% of the Mekong total flow, affecting the dry season and the down-stream ecosystem (Cambodia and the Mekong Delta).

- Cambodia: At present, the irrigation area is only 11% and the area cultivated by out-going flood-waters is 4% of the total cultivation area of 563,000 ha in Mekong down-stream (Summer - Autumn crop 290,000 ha, Winter - Spring 273,000 ha). Expected to 2030, in Mekong down-stream, Cambodia will raise the Summer - Autumn area to 487,400 ha and the Winter - Spring crop to 398,800 ha. Total water demand from 3.3 billion m^3 in 2007 to 4.9 billion m^3 in 2030.

Thus, the total water demand of the up-stream countries, in 2010 increased compared to 2000 was 10.9%, by 2030 will increase to 117% and 2050 to 160%.

2.2.4.3 Water requirements for other industries

Table 4: Demand for water for the Mekong Delta's industry and people

Country	Year 2000	Year 2007	Year 2030	Year 2060 Average development	Year 2060 Very high development
Cambodia	64,29	563,37	754,29	1.271,78	1.271,78
Laos	111,83	111,83	482,48	887,89	888,12
Thailand	874,28	1.088,13	1.753,35	2.351,24	2.342,73
Vietnam	52,30	51,82	141,02	264,39	264,39
Total	1.602,70	1.815,15	3.131,14	4.775,30	4.767,02

(Source: Mekong Committee-Note: Vietnam only counts the Se San and Srepock basins)

3. IMPACT ASSESSMENT OF THE HYDRO-POWER DAMS ON THE MEKONG RIVER MAIN-STREAM UNDER CONDITIONS OF CC AND SI

3.1 Assess the impact of the hydro-power construction on the Mekong main-stream to the alluvial in the Mekong Delta

3.1.1 General assessment of alluvial transport in the Mekong

Like similar river basins in the world, Mekong alluvium nourishes flooded plains, Deltas and lakes and contributes to the creation of mud-flats encroaching into the sea. The amount of sediment deposited is closely related to the amount of alluvium carried in the river and the topography of the river bed. The redistribution of alluvium in a river system for a long time has been identified as one of the key factors for the development of a river basin, especially in flood-plains, sunken areas and deltas, the environment is very sensitive to changes in the carried alluvium balance. According to a research report on suspended alluviumcarriage and sediment issues (PO Harden and A. Sundborg - 1992), the Mekong Interim Committee concluded that: the total amount of yearly suspended alluvium is 180 million tons and the total amount of alluvium in the Pakse region (Laos) is 200 million tons.

Pakse down-stream, due to the entry of some tributaries, there is also a change in the sediment in the flooded and irrigated areas, especially in the Delta. Therefore, only less than 200 million tons (maybe 100 - 150 million tons) of alluvium are dumped into the sea. According to an evaluation conducted by the International Mekong Commission in 1987, the annual sediment load of the Mekong River to its esturies and discharges into the sea is from 150 to 200 million tons / year, which is an additional source of fertile sediment. For the Mekong Delta of Vietnam, accretion and make the Mekong Delta encroachment into the sea at the rate of 1-2m / year. At the same time, the amount of silt along with the plankton is a source of nutrition for the down-stream fish population, especially the Tonle Sap Lake and the Mekong Delta of Vietnam. Previous studies show that every year, the Mekong River moves into the Mekong Delta about 150 million tons of alluvium, of-which 138 million tons for Tien River and 12 million tons for Hau River, mainly in the flood season.

Actual data measured in some years shows that the average sediment content in flood season is about 500 g / m^3 on Tien River and 200 g / m^3 on Hau river. However, the alluvium content in the river varies greatly in time and space. On yearly average, during the beginning months of the flood season (July → September), the alluvium content at Tan Chau (Tien River) is from 500-600 g /m^3 and Chau Doc (Hau river) is from 250-300 g /m^3. In the middle of the flood season, the alluvium content decreases at 100-150 g /m^3 for both rivers. The alluvium content gradually decreases from up-stream to down-stream. In August, at Tan Chau it was 380 g /m^3, Cao Lanh was 330 g /m^3 and My Thuan was 210 g /m^3. However, because Hau river is supplemented with water from Tien River to Vam Nao, so sometime the alluvium content in Long Xuyen is higher than Chau Doc: in August, Chau Doc is 140 g /m^3 and Long Xuyen is 185 g /m^3. According to the above study too, although the contribution of China's Lan Cang flow to Mekong total flow is not much (16% as Mekong River Commission data), the amount of China sediment contribution can be up to 50%, so the flow bringing alluvium from China plays an important role for the MDB (Mekong Down-stream Basin).

3.1.2 Assess the impact of hydro-power development on alluvium in the Mekong downstream region and the Mekong Delta

3.1.2.1 Evaluation of international organizations

The amount of alluvium will be reduced by 75 - 81% in the Lan Cang River due to 8 hydro-electric dams in the up-stream Basin. The average amount of alluvium to Chiang Saen will decrease from 90 million tons /year to 20 million tons /year. For the river down-stream, the reduction of medium-sized alluvium carriage will take place first because this size of this-one will be exhausted first from the lake reservoir and river bed / side. The decrease in alluvium will cause land-slides near Chiang Saen and then gradually move to lower down-stream. The down-stream movement of the landslide will slow down due to the deep holes in Zone 2 and it will take at least a year to pass, so it will take about 1-2 decades before the raw sediment cease sing to come down to the lower section, 40km North from Vientiane. Reducing the sediment load (principally due to projects in the up-stream basin) will increase the mid-sized alluvial landslides currently remained along river banks and river bottoms in Zones 3 and 4. This will take place first in the Vientiane vicinity and it will take about 15-30 years to move down to Kratie. Thereafter river-bank instability will begin to take place in Kratie and Phnom Penh. There will be no significant movement of raw alluvium below its lower basin on Phnom Penh.

Deep holes: According to investigators, there are at least 355 deep holes along the Mekong main-stream, playing an important role in regulating sediment carriage and creating flow characteristics such as islets and sand dunes and other important habitats for fisheries productivity.

In the absence of the MDB main-stream hydro-power dams, a significant amount of alluvium and length connection will allow deep holes to continue normal operation in the short and medium term. The reduction of sediment load will affect the medium and long-term function of deep holes, because of sediment 11,000 million tons are stored in the Mekong.

At the moment, there is a continuous movement of medium and raw materials to down-stream -from Zone 2 to Zone 5. Zones 3 and 4 are the carriage zones and Zone 5 is the main accumulation place of medium and raw materials (middle). About 80% of the alluvium from the Mekong original source will be kept by hydro-electricity in China and increase current landslides at the head of Zone 3. When river bottom medium-sized materials are mobilized, the raw material will remain in the river bed. Further down-stream, the river will reestablish a balance between landslides and sedimentation and a new balance will likely reduce sedimentation in Zone 5 in the next 5-20 years (below). The rest sediment in the river will be depleted in the next 50 years and the medium-sized sediment material source to Zone 5 will be reduced to 0 mg / m^3. Erosion effects will occur throughout the Zone 3 with river-bank instability. In all stages of the near future, there will be no carriage of sand materials to the Mekong Delta because the flow energy will not be sufficient to maintain the suspension of this material to overpass the Zone 5.

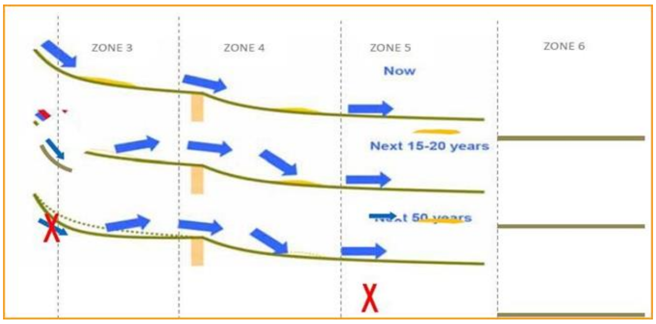

Figure 7: Schema of Sediment Loss in Flow to Mekong Delta down-stream

Thus, the current tendency is to significantly reduce the movement of fine alluvium, due to the operation of large reservoirs in China and its tributaries. In the 20-year future scenario, the sediment load in Zone 2 will be reduced by 80%, while down-stream in Kratie (Cambodia) this amount will be halved. The estimated alluvium is 90 million tons /year in Chiang Saen (Chang Rai); Amount of 84 million tons /year in Vientiane plus an additional 25 million tons /year in Se San, Sekong, Srepok and 56 million tons /year from the basin between South Binboun and Se Done, totaling about 165 million tons coming in Kratie. With hydro-power on tributaries and up-stream basin, these amounts will be reduced by about 20 million tons /year (in Chiang Saen and Vientiane), 88 million tons /year (in Kratie). With the tendency of 2030 without more main-stream dams, the sediment load will be halved to be smooth and nutritious to the Mekong Delta (Table 5).

Table 5 shows that: Changes in sediment destination below Kratie: The 20-year scenario predicts a 50% reduction in sediment to Kratie due to dams in Zone 1 and 3S basins (Se San, Sekong, Srepok).

Table 5: The average annual amount of sediment deposition in records

Sediment place	By BDP alluvial basic scenario (millionTs/year)	After 20 years, with dams, the alluvial quantity (million Ts/year)
At Kratie -The annual sediment carriage speed.	165	88
Cambodian Plain	25	13
Tonle SapPlain	9	5
Mekong Delta	26	14
Mekong estuaries	5	3
Cà Mau penisula	< 1	0
Continental shelf (20km from shore)	100	53

This impact will affect 18,000 km^2 in the Cambodian Delta and 5,000 - 10,000 km^2 in the Mekong Delta and reduce nutrient in the Mekong Delta. The river energy is gradually lost as it moves along the river bed and due to the stream morphology. This variation are arisen from the seasonal flowing nature of the Mekong; Therefore, there is a big difference between the dry and flood seasons. River energy is important for all aspects of the river, including the transportation of course and fine sediments, the development of deep holes in river bed rock, geomorphology, river bank erosion, the creation of islands in the middle of the rivers. The tendency for the 20-year scenario is that flow peak energy will be reduced by about 10-30%, due to a flow peak decrease in the flood season and a flow increase in dry season due to the flow regulation of dams with large reservoirs. 8 proposed dams in the up-stream basin are the main cause of the decrease in flow energy because they regulate flood flow to provide additional flow during the dry season. As a result, the largest reduction occurs in the up-stream basin (10-30%, in Zone 2) and as further to the down-stream as lower the impact (5-10% in the Zone 3,4,5. and about 5% in Zone 6). This reduction is estimated to reduce the efficiency of geographic-morphological processes such as sediment carriage, the season cycle in deep holes and the impact of sediment carriage to the marine environment, but it will cannot prevent these processes from happening as below:

+ The reduction of current velocity and sediment deposition of fine alluvium in the lake. This fine alluvium retention will be an impact in the first decade of the main-stream dams operation and the sedimentation will quickly reach the long-term equilibrium (in 1 or 2 decades) because the reservoir is quite small.

+ The reduction of sediment concentration in the river down-stream of the dams; this sediment reduction will have an impact on the nutrient carriage and stability of the Mekong Delta.

Table 6 shows that: Average annual estimates of nutrient accretion and Mekong sediments. Under basic conditions, about 20% of the alluvial load in Kratie will be deposited in the Cambodian plain (including Tonle Sap Lake), 16% in the Mekong Delta, 3% in the estuary and 60% are transported to the marine environment mainly within 20km from the coast. The sediment decrease in Kratie will result in a corresponding decrease in sediment load at these down-stream points.

Table 6: Estimated annual average of Mekong sediment and nutrient deposition

PLACE OF SEDIMENT	ANNUAL SEDIMENT VOLUME					
	BDP BASIC INFORMATION		No mainstream dam		Dam existence on down-stream basin (exp.: effect of max net alluvia retainingof down-stream basindams as 10%) TE (total)=75%	
	Alluvial (Million tons / year)	Nutrient (total P) (million tons /year)	Alluvial (Million tons/year)	Nutrient (total P) (million tons/ year)	Alluvial (Million tons / year)	Nutrient (total P) (million tons/ year)
At Kratie -The annual sediment carriage speed.	165	26,376	88	14,061	41	6,594
Cambodian Plain	25	3,958	13	2,111	6	989
Tonle SapPlain	9	1,439	5	768	2	360
Mekong Delta	26	4,157	14	2,210	7	1,039
Mekong estuaries	5	800	3	427	1	200
Cà Mau penisula	<1	32	<1	14	~0	8
Continental shelf (20km from shore)	100	15,990	53	8,533	25	3,998

3.1.2.2 Assessment of Vietnamese organizations and experts

Until now, Vietnam's assessment on the hydro-power development impact in the main-stream of Mekong up-stream to the Mekong Delta alluvium is very limited. The evaluation results are still cited based on the evaluation results of foreign experts or are still not very specific. The collection process has the following statements:

3.1.2.3 Evaluation of Southern Institute of Water Resources Planning

Reduction of sediment on Down-stream Delta and Mekong Delta: This is one of the impacts that many environmentalists worry about. The consequences of alluvial depletion create many economic, social and environmental impacts on down-stream:

- The decline in nutrient resources for the fisheries system, especially in the down-stream areas of the dam, leads to a decline in the down-stream fish quantity, which is one of the important livelihoods of millions of people living in the Mekong Down-stream basin;
- Losing a large amount of natural fertilizer to the delta, affecting the Mekong Delta agriculture;
- For the Mekong Delta, the accretion of the coastal areas will decrease, possibly increasing the process of sea going forward;

Sediment depletion changing the river dynamics, increasing the possibility of erosion in the down-stream river side and bottom,causing land loss, destabilizing the lives of many communities, including destroying public works and large infrastructures along the coast.

3.1.2.4 Evaluation of Mekong River Commission of Vietnam

The Vietnam Mekong Committee organizes a national consultation seminar at Can Tho City on the hydro-power projects on the Mekong main-stream. Standing Vice Chairman of the Committee, Mr Nguyen Thai Lai Deputy Minister of Natural Resources and Environment on the seminar, declaring: "If many dams are planned as expected, the Mekong Delta may disappear".

According to the Strategic Environmental Assessment of International Center for Environmental Management (Research by proxy of Mekong Commission), The building of dams on the main-stream can "destroy the Mekong ecosystem. The Chinese up-stream dams have some what affected the ecosystem", if a series of dams down-stream appears, the threat is hard to imagine !!!.

As per data in the strategic environmental assessment report, the total amount of sediment decreased by 75% (the annual sediment load in the Mekong Delta from 26 million tons to 7 million tons and the nutrient content of alluvium every year from over 4,000 tons to more than 1,000 tons). About 2.3 to 2.8 million hectares of agricultural land (mainly of Vietnam and Cambodia) will be barren.

When hydro-electric dams rise, the use and transfer of water from the Mekong River out of the basin is more likely. The flow of the Mekong Delta decreases, erosion increases, plus sea level rise due to Climate Change leading to "Mekong Delta may disappear after a few hundred years" as Deputy Minister Nguyen Thai Lai said.

3.1.2.5 Evaluation of the scientists

Scientists warn that in the problem of Climate Change (CC) and Sea Level Rise (SLR), the widespread development of hydro-electricity on the Mekong River will put the Mekong Delta region under double impacts from both up-stream and sea.

- Because it is located in down-stream, at the end of the Mekong River, the Mekong Delta has long benefited many advantages from the alluvial fertility of this river, which accretes and receives all the river flow after passing through the up-stream countries. But due to the location at the end of the flow, the Mekong River water has reached and will be affected by all natural fluctuations and human activities on up-stream.

- One of these impacts due to the construction of hydro-power dams on the Mekong main-stream is that the retention of sediment and nutrients by the dam will cause the down-stream river to reduce sediment load and nutrients. As a result, the negative impact on aquatic species, especially reducing the amount of fish in the down-stream which is the source of livelihood of millions of people living in the basin. Like similar river basins in the world, the Mekong alluvium fills flooded fields, deltas, and lakes as well as contributing to the creation of Flood plains far out to sea.

In other words, the amount of deposited sediment is closely related to the sediment amount transported in the river and the topography of the river bed. According to an evaluation of the International Mekong Commitee, the annual volume of alluvial flow of the Mekong River to its estuaries and sea is from 150-200 million tons. This huge amount of alluvium is a fertile addition to the Mekong Delta, accreting and causing the Mekong Delta to encroach into the sea at the rate of 1-2 m /year.

The reduction of sediment can lead to deterioration of the river bed, change of river bed ecology, degeneration of coastal plains and all of these return, causing sea-water to penetrate deeper into the field, eroding river-side and coast-line. Affronting the biggest river-bank erosion are the provinces in the head area of the delta such as An Giang and Dong Thap, which is particularly worrying in Tan Chau town - An Giang provine. Similarly, the strongest coastal erosion occurs in the coastal provinces of Ca Mau, Bac Lieu, Soc Trang, Ben Tre and Tien Giang.

Perhaps that is why Vietnamese river network experts frankly recommend that the ladder hydro-electricity on the Mekong main-stream does not bring any benefits to the Mekong Delta, but directly threaten to the lives of nearly 20 million people in the Mekong Delta today and future generations, even threatening national and regional food security.

4. Assessing the Impact of The Construction of Hydro-power Projects on The mekong Main-stream in The Context of Cc, Slr -causing Si in The Mekong Delta

4.1 Current situation of SI in the Mekong Delta

Saltiness is an attribute of estuarine and coastal areas. In the interaction between the river and the sea, 2 saline &fresh waters meet. During ebb tide, disturbance and salinity previously recede during ebb tide create regular salinity in the region, over time under the effectuation of 2 basic factors: fresh water flow from the source and the tide within amplitude and intensity. Saline Intrusion (SI) has occurred in many Mekong Delta provinces. Salt water [1.9]intrudes into many regional fields in the Mekong Delta. Currently, the situation of SI is complicated and seriously affects the production and daily life of people in the Mekong Delta provinces (lacked clean water, dead Shrimp, Crops ...). In which the 2015 rainy season late arrival and early termination, the Mekong River had the lowest water level in the past 90 years and SI occurred nearly 2 months earlier than the traditional period, damaged the regional production and life.

4.2 Forecast of SI in the Mekong Delta under condition of the impact of up-stream hydro-electric works and CC, SLR

4.2.1 Research results of Can Tho University

Research results of the Faculty of Technology, Can Tho University on Saline Intrusion (SI) in the Mekong Delta are simulated for different scenarios of Sea Level Rise (SLR) and down-stream decreased flow by MIKE11 paradigm. In this study, Saline Intrusion in the Mekong Delta is predicted on base of 4 scenarios –compared to original scenario, as per diverse script : (1) SLR 14cm / decrease ratio 11% and (2) SLR 14cm / decrease ratio 22% of 2020; then (3) SLR 20cm / decrease ratio 15% and (4) SLR 20cm / decrease ratio 30% of 2030... that are formed from SLR values under the B2 Climate Change scenario.

4.2.1.1 Research results

The largest SI distance on the main rivers of the Mekong: In this study, the salinity value of 2.5g / liter selected by the limit value can adversely affect the crop productivity, reducing 25%. rice yield. The depth of SI on the main-streams of Tien and Hau rivers indicates that in the future (in 2030), if the SLR by 20cm and the dry season flow decreases by 22%, SI on the main river of the Mekong Delta is 14km deeper than the original scenario and the SI area extends to most of the freshened areas under SI projects.

Saline intrusion area: The results of SI in the original scenario show that in 1998, salinity affected most of Ca Mau peninsula, Tra Vinh province, part of Vinh Long and Ben Tre provinces. The area ofSI in scenarios 1 and 2 is reduced, although in these scenarios the SLR and the flow in the dry season decreases, this can be explained by the fact that since 1999 the system of SI prevention works from the East Sea and the West Sea have been implemented to prevent salinity for 534,860 ha, including projects of South Mang Thit, Quan Lo - Phung Hiep and O Mon-Xa No (World Bank, 2008). More-over, the results in scenarios 3 and 4 indicate that even if all existing SI prevention systems were operating as designed, SI penetrated deeply into the land-field and affected almost all areas are protected by SI project.

However, in this study, the SI paradigm does not include all the factors affecting SI in the Mekong Delta in the present as well as in the future such as monsoon (especially in the "Bizarre wind" -Northeast monsoon), demand of water using...for the changes in the Mekong River basin, timing and intensity of floods...etc.

4.2.2 Research results of the Southern Institute of Water Resources Planning

As a result of the hydraulic paradigm VRSAP of the late Assoc Prof Nguyen Nhu Khue was built in the 1980s and documents were continuously revised, supplemented, upgraded and updated by the Hydraulic Group (Division of Technology and International Cooperation, SIWRP). Calculation results of SI in actual situation and year 2050:

Table 7: Combining maximum surface of Saline Intrusion in February, March and April according to salinity

Smax (g/l)	Actual status (ha)			Year of 2050 (ha)		
	February	March	April	February	March	April
0 – 1	1.599.641	1.650.377	1.478.580	1.452.789	1.425.452	1.311.993
1 – 4	575.280	576.725	527.594	553.611	509.859	489.184
4 – 8	452.614	418.415	431.741	543.078	532.545	502.178
8 – 12	230.722	219.322	227.672	305.688	256.475	341.097
12 – 16	209.850	149.480	203.106	175.545	186.587	197.840
16 – 20	199.253	153.172	187.692	160.931	198.951	153.369
20 – 24	86.380	92.803	137.759	170.323	197.270	154.479
24 – 28	334.924	96.014	97.138	371.134	178.815	238.200
28 – 32	126.199	455.825	483.922	86.152	333.625	414.435
> 32	5.138	7.867	44.796	750	420	17.224
Total Surface	**3.820.000**	**3.820.000**	**3.820.000**	**3.820.000**	**3.820.000**	**3.820.000**

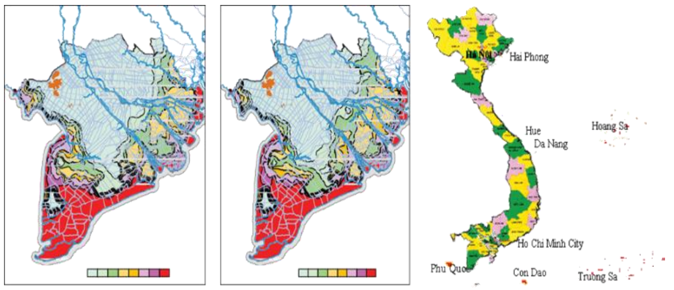

Figure 8 & 9: Mekong Delta Saline Intrusion 2016 and Map 3: Viet Nam Overview

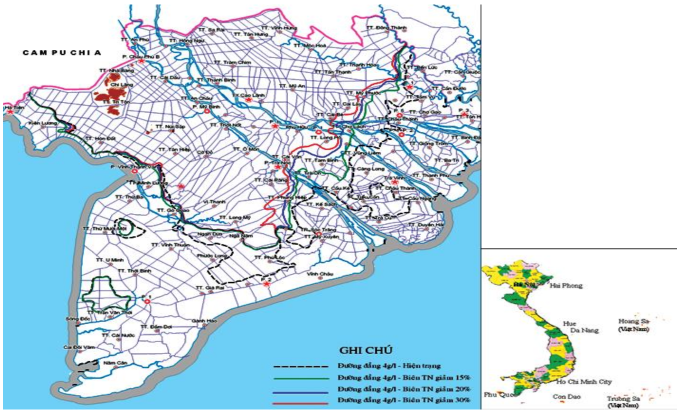

Figure 10: Boundary of SI up to 2050 with different upstream flow exhaustion scenarios.

Table 8: Combining Max saline intrusion area in February - April with salinity of 1 & 4 g/ liter

Smax (g/l)	Actual status			Year of 2050		
	February	*March*	*April*	*February*	*March*	*April*
Total surface (ha)	3.820.000	3.820.000	3.820.000	3.820.000	3.820.000	3.820.000
Surface >1gr /liter (ha)	2.220.360	2.169.623	2.341.420	2.367.212	2.394.547	2.508.006
Ratio per total area (%)	58,12	56,80	61,29	61,97	62,68	65,65
Surface >4gr /liter (ha)	1.645.080	1.592.898	1.813.826	1.813.601	1.884.688	2.018.822
Ratio per total area (%)	43,06	41,70	47,48	47,48	49,34	52,85

Table 9: The difference of SI (> 4g / liter) increases between scenarios of reducing the exhausted flow compared to the situation when the SLR by 30 cm, (unit: km)

River	Reduced upstream flow at Kratie		
	-15%	-12%	-30%
Tien	19,9	25,7	29,9
Hau	14,4	16,8	21,6

Table 10: Change of SI area > 4 g / l between scenarios of reduction o exhausted flow compared to the situation when SLR by 30 cm (unit: 1,000 ha)

Surface	Actual status	Reduced up-stream flow at Kratie					
		-15%		-20%		-30%	
		Total	Increase	Total	Increase	Total	Increase
> 4g/l	1.691	1.987	+296	2.072	+381	2.146	+455
Total surface	3.820	3.820	7.7%	3.820	10,0%	3.820	11.9%

(V=12%, p <0.95)

4.3 Assessing the impact of the construction of hydro-power works on the Mekong main-stream to fisheries development in the Mekong Delta under condition of CC, SLR

4.3.1 Impact of the hydro-power dams construction on the Mekong main-stream on the aqua-production in Mekong Delta

With the impact of CC -SLR, the Mekong Delta aqua-production will also be affected by the construction of hydro-power dams on the Mekong main-stream. According to the strategic environmental assessment (SEA), under natural conditions, the Mekong River get the second class in the world thank toits highest bio-diversity, has provided fluvial materials for the domestic aqua-product industry in the region, becoming the world-wide biggest with about 2.6 million tons of wild fish and other aquatic animals worth at more than US $ 7 billion per year.

The dam is built like a wall, the fish cannot across it for seasonal migration. Even constructing a ladder for fish to overpass but not feasible for the vast, complex Mekong main-stream (There are currently only 3 projects with a fish traffic ladder design). If the dam is built, 35% of the total fish migration will be obstructed, with a risk of 0.7 - 1.6 million tons / year. By 2030, the total direct loss of fish will be 550,000 - 880,000 tons / year (excluding the loss of field and marine fish), which is equivalent to the total cattle production of Laos and Cambodia added and equal to the total fish quantity of 15 West African countries.

If only Xayaburi dam is built with a height of 32 m, exceeding the height of the ladder step for migratory fish, it will not only destroy the fish migration pathway but also muddle the flow, breaking the ecosystem, impossible to resave and leading to the extinction of 41 species of fish or other aquatic species, which will finally cause catastrophe in both food security and nutrition. The SEA report shows that the total fish production at risk from dams in the Mekong main-stream is up to 1.4 million tons, while reservoir fisheries only compensate for 1/10 of the natural fisheries quantity loss. Vietnam particularly loses 220 - 440 thousand tons of white fish migrating each year, causing losses of about US $ 0.5-1 billion per year. More-over, the white fish is the bait of the black fish, if the white fish is gone then the black fish will follow. In addition, some species of fish only in the Mekong River (endemic species) are in danger of extinction such as: giant Pangasius Catfish, Irrawadi Dolphin, Siamese Crocodile, fresh-water Ray, giant yellow Scutum Cantor Turtle. Lack of fish for food, so other animals such as Birds, Storks, Turtles, Snakes... are also reduced. This loss is eternal, irreversible and lonely could bigger than the energy benefits of these dams.

Marine fisheries in the Mekong Delta are also affected. In the past, a large coastal water of the Mekong Delta depended on the nutrition of the Mekong River every year for food for marine fisheries. In 2009, the coastal seafood production of the Mekong Delta was 606,500 tons (attaining 50% of the Vietnam country's marine fishing output). Under conditions where sediment load is only equal to 25% of the previous quantity, coastal-estuarine fishery production will significantly decrease in the future. However, to date there has been no study to estimate the loss of marine fisheries to the Mekong Delta due to the reduction of Mekong sediments. The decrease in coastal fishery productivity will greatly affect the marine fishing industry and the life of the Mekong Delta fishermen; At the same time, it affects the inland aqua-culture industry by reducing the source of marine fishmeal as feed for livestock. Decreased production of fresh-water and marine fisheries has led to a decline in the aqua-product processing and export industry, where people living on traditional profession being jobless. In addition, the shortage of aquatic products for consumption of people must be compensated by livestock and poultry products –which make difficulty for the state.

4.3.2 Impacts of CC -SLR on the Mekong Delta aqua-culture (Le Huy Ba, book, 2013)

The shortage of fresh water in Tien and Hau River, together with SLR and SI increase, will lead to the following consequences:

- Saline water intrudes deeply, causing loss of suitable habitat of some fresh-water aquatic species;
- Increased temperature causing a phenomenon of temperature stratification in stagnant waters, affecting the life of organisms; Some species move North or deeper to change the distribution structure of aquatic organisms with depth;
- For fishery and aqua-culture resources, SLR makes the physical, chemical and aquatic regimes worse.

4.4 Assess the impact of hydro-power construction on the Mekong main-stream in the context of CC, SLR to Mekong Delta food security

4.4.1 The negative impact of dam construction on the Mekong main-stream on rice production and food security

The construction of hydro-power dams on the Mekong main-stream will directly threaten the lives of nearly 20 million people in the Mekong Delta today and future generations, threatening national and regional food security. If 12 hydro-electric ladder steps were built in addition to China, 33% of the water retained in the up-stream would be adjusted to the will of the Chinese, resulting in a severe shortage of water down-stream, which would change the flow regime, causing up-stream alluvial deposits and in the reservoir bed. Although in August 2020 there is an agreement of MLC (Mekong-Lan Cang Comittee) that China shares the data and water resources of the Mekong River with the down-stream countries, there is no guarantee that this promise will be sincerely done and the Mekong River in danger of exhaustion is still there.

Currently, the Mekong Delta has 1-2m forward sea invasion per year, when blocked, the amount of alluvium in the Mekong Delta will decrease from 26 million tons /year to 7 million tons /year, causing erosion of river-side and coast-line, subsidence in the delta, halting sedimentation, the nutrient amount reduced by ¼ will reduce agricultural productivity. Not to mention the CC and SLR plus a large water amount being held up-stream in the Mekong Delta, causing the Mekong Delta not to be inundated, water shortages are forced to face the situation of SI, causing great damage to fisheries, declining food, fruits production.

4.4.2 The negative impacts of CC and SLR on rice production and food security

According to World Bank (WB) research, Vietnam with a coastline of 3,260 km and 2 large plains, when the SLR from 0.2-0.6m, there will be 100,000-200,000 ha of land inundated and agricultural production area will be narrowed. If the SLR to 1m, it is likely to affect 12% of the area and 20% of the Vietnamese population, flooding about 0.3 to 0.5 million hectares in the Red River Delta (North Vietnam RRD) and 1.5 to 2 million hectares in Mekong River Delta (South Vietnam MRD) and a hundred thousand hectares of coastal Vietnam central. It is estimated that Vietnam will lose about 2 million hectares of paddy land in a total of over 4 million hectares today, seriously threatening national food security and affecting tens of millions of people. CC disorganizes the living conditions of species, leading to the disappearance of some species and the risk of increasing natural enemies. Over the latest 2 years, the epidemic of yellow dwarf plant pests, dwarf leaf... in the Mekong Delta have become more and more complicated, affecting the ability of intensive farming, increased crops and reducing rice yields. About SI, the observation results in recent years of the research agencies show that the factors affecting the SI on each river branch and canal in the whole region of Mekong Delta have different happenings, but increasing trend.

5. Solutions For Coping With Up-stream Countries' Developments and Cc& Si in The Mekong Delta

Aim to cope with up-stream dam construction in the context of CC, SI, the domestic and foreign studies have given the following solutions:

5.1 Constructional solutions against the flow deficiency of Mekong River, and the Saline Intrusion in the Mekong Delta (Le Huy Ba at al, 2016)

In order to adapt to CC-SLR and up-stream developments, the overall solution for irrigation development is by the constructional works system in order to proactively respond to the 3 main aspects of CC, concerning: the up-stream CC, the CC right in the Mekong Delta. and SLR, in which; The up-stream developments is considered the most important factor, strong impact, rapid and create the largest mutation; The next-one is the SLR, which has the consequent SI. The combination of reducing the exhausted flow due to up-stream developments and increasing SI from the sea are probably the 2 key factors of proposed solutions. Because the interaction between exhausted flow and SI is unified and successive, therefore, the proposed solution is also synchronous and systematic, inseparable and heritable without conflict of present and future.

With the impact of reduced exhausted flow and SI: The basic and proactive solution is to store and retain in large volumes of water parallely with the control of deep SI on the inland. As we know, the area between Tien and Hau rivers with 4 independent estuaries does not affect the 2 adjacent regions of left of Tien and right of Hau river (including Long Xuyen Quatrangle and Ca Mau Penisula), including estuaries of Ba Lai, Ham Luong, Co Chien and Cung Hau. The impact on these 4 estuaries will create a fresh water axis in the middle of the Mekong Delta and with the high-water level in the middle, low on both sides, fresh water will thereby proactively provide more for the of left of Tien and right of Hau riverregions. Ba Lai estuary was prevented in 2004.

Due to difficulties and awareness at that time, Ba Lai sluice way was designed too small compared to the width of the river (84/300 m, less than 30%), the rest was the earthen dam. Therefore, despite the system completion, Ba Lai sluice gate also has defects that are difficult to repair and overcome. The sluice gates of Ham Luong, Co Chien and Cung Hau will be designed with a large aperture, ensuring the flood drainage and not affecting the hydrological / hydraulic regime of the seasonal exhausted flow in non-operational years. More-over, to avoid the very sensitive impact on estuaries, the sluices will be pulled back quite deeply.

To support the sluices of Ba Lai, Ham Luong, Co Chien and Cung Hau, Cai Lon - Cai Be sluices in the Ca Mau penisula and Vam Co areas of the of left of Tien River region will also be built to take advantage of the water from the Tien – Hau rivers. However, in terms of feasibility, these sluices can all be built earlier than the Ham Luong, Co Chien and Cung Hau sluices. In Ham Luong, Co Chien and Cung Hau large sluices, Ham Luong sluice gate is more efficient so it will be the next priority. With the influence of SLR and natural disasters from the sea, the dyke system from Quang Ngai to Kien Giang approved by the Government will continue to be priorly implemented, but with consideration for suitable improvement as per tidal peak

With the impact on flood flow and SLR: Due to CC and up-stream development can increase or decrease floods, creating a high difference between the years of big and small floods. Therefore, the common solution is to ensure control of big floods but not eliminate small floods. From this point of view, for the Long Xuyen Quatrangle, which has been invested quite well in the flood control system, it only needs to increase the possibility of flood drainage to the West Sea by expanding the axial canals in the central region, upgrading the drainage system on West Sea coast and possibly more flood control sluices along the Hau River (they also increase the ability to supply fresh water for the region)

For the Dong Thap Muoi area of the Left Tien River, recent Flood events have shown that flooding overflows border less and less. The Cambodian side is promoting flood control projects and other own work lines of So Ha - Cai Co - Long Khot and Tan Thanh - Lo Gach also help reduce floods entering the Dong Thap Muoi center. In addition, the work lines Hong Ngu, An Phong - My Hoa, Dong Tien - Lagrange, Nguyen Van Tiep also create the ladder for flood prevention, storage and slow flood steps quite effectively. More-over, within small flood years, this system also helps to regulate floods in the no flood areas of Nguyen Van Tiep canal down-stream and the clamped area between 2 rivers Vam Co West - Vam Co East, especially in Bo Bo – Bac Đong - Binh Thanh (Ba, et al., 2009).

With such developments, the flood control line on the Tan Thanh - Lo Gach canal (10 sluices) proposed in the short-term flood control planning to 2010 and listed in Decision 84 / TTg. The same for the 4 sluices along the Tien river. However, in order to reduce the flood pressure on land-field of the flood years, 4 axes of flood drainage back to the Tien River are also proposed. Engineering works in the region and in the fields proposed in Decision 84 / TTg (of Vietnam Government PM) are still of high significance and efficiency, so they continue to be implemented. However, some works that are deemed ineffective and no longer suitable may not be proposed. Besides, after considering the feasibility of each project with the provinces, the Project will also propose a number of priority work items for each period.

When constructing works for large river-blocking, the most important effectuation is that fresh water will be retained then added to both sides, including Tien and Hau rivers, helping to improve SI on these 2 rivers for many years after. However, depending on the progress of the construction of large sluice gates as well as after 2030, if the salinity on the Tien and Hau rivers is high, it is surely considered to build the sluice gates to control gradually the salinity from the estuary of the river up, suitable for each stage and each period of SLR. Internal region water drainage will also be considered in parallel with water supply by expanding axial canals and building a combined irrigation / drainage electric pump system.

With the impact of CC-SLR and up-stream developments, the regime of flooded-exhausted flows on the main-stream, canals and even the coast has many changes, leading to destabilizing the river beds, canal banks and sea-coast. Solutions to protect the most important areas / sectors will also be checked, combining embankments and breakwaters planting (for coastal areas). In order to prevent forest fires due to increased temperatures, the dry season is accelerative harder, the water management solutions by the works system in Cajuput forests, especially on Peat land, will also be considered. The combination of sea dykes with coastal roads, river dykes / embankments to control Floods and habitat basement elevation ... will also be improved more closely. Irrigation solutions for aqua-culture (both fresh and brackish / salt-water), especially solutions for fresh-water supply / salt-water drainage, waste-water sewage... have been studied and proposed.

5.2 Non-structural solutions against the shortage of Mekong river flow and SI in the Mekong Delta (Ba, 2016)

Management of disastrous areas (particularly the most hardly affected areas of CC-SLR) including the division of areas in saline intrusion, flooding and carry-out the management and exploitation of them scientifically, reasonably, including land use, development management in saline, flood areas, changing crop structure in accordance with rule of tides, saline and flood, and to find measures for agricultural, residential settlement safe and stable in flooded areas.

- Implement the measures to forecast and warn natural disasters such as increased SI, Drought, SLR, storms, major tides, Floods, heavy rain... rescuing and organizing temporary evacuation, well doing this work in all 3 periods before, during and after natural disasters.

- Through relief, recovery and disaster insurance to share the loss caused by natural disasters for people in coastal, flooded areas ..., especially care to those who are vulnerable to natural disasters. like women and children. Strengthen community education in disaster prevention.

- Responding to CC - SLR by non-structural measures can change the sensitivity of natural disasters, through the adjustment of land use structure and production models, exploitation policies and financial help for victims, changing the cultivation environments, minimizing the consequences of SI and flooding. In essence, non-structural solutions are solutions that organize and manage scientifically in a positive but flexible way, fully understand the rules and the course of natural disasters to cleverly wriggle and avoid them.

- For residents of coastal and flooded areas, it is necessary to make them adapt to SI and flood, to live with salinity and floods, and to emphasize the appropriate controls for the industrial / agricultural development on coastal and flooding regions

Management of development and reasonable exploitation on saline and flooded areas is demonstrated in the following main activities: (Ba, et al., 1982).

+ Managing the socio-economic development in coastal SI and flooded areas so as not to cause adverse and negative impacts on the environment, to try to obey natural rules, in which, special attention has been paid to infrastructure developments such as salt-water control works (sluices, water supply canals...), flood control (embankments, dykes...etc.), traffic works (roads, waterways, ports...) because these are the works that have the strongest impact on salinity and floods.

+ Exploiting rationally and wisely the sources of salt water and flooding seasons, products from estuarine, coastal and flooded areas, including using salt-water for aqua-culture and the diversity enrichment of estuaries, using flood water for cleaning fields, disinfecting the environment, exploiting flood water resources such as alluvium, aquatic resources and products from floods.

+ Shifting and hastening the dry / droughty season crops in flood areas, rainy / flood seasons in saline areas is a wise way to adapt to SI and deep inundation. The application of new short-term but high-yield rice varieties is an important step to serve the target of shifting the crop structure in the flooded areas, the same applies for coastal areas by rice varieties with salinity tolerance above 4 g /liter.

+ Fishing and exploiting the natural aquatic resources beside the management is also one of the good approaches in coastal saline affected and flooded areas.

+ Propagating the information to the community is an important factor of risk awareness due to CC - SLR and up-stream adverse development.

6. Discussion

With the studies and information as mentioned above, we can easily find:

The development of hydro-electric projects of the up-stream Mekong countries has been and will be inevitable and greatly impact on the down-stream areas, in which the Mekong Delta is suffering a lot of losses.

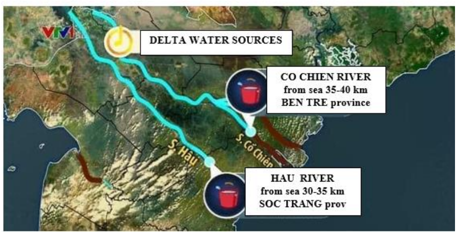

Figure 11: Vietnam Television VTV (Source: 13) (Map Scale: 1/250, 000)

Climate Change, Sea Level Rise are present, its impact on Vietnam in general and the Mekong Delta in particular has been warned by international and Vietnamese organizations and given scenarios for the specialist units to propose the response solutions which are actual affairs. The Mekong Delta is located in down-stream of the Mekong River, doubly affected by 2 sides: up-stream development and the impact of CC, SLR causing SI is quite serious. As a developing country, although we have already the necessary solutions, but they cannot be done at the same time. Therefore, finding the right solutions and steps to cope with these impacts is an extremely important mission.

After that, in beginning days of September of this year 2020, an online discussion organized by American Institute of Peace and Singapore's Lee Kuan Yew School of Public Policy, argues that China poses "an urgent challenge" in the Mekong dow-stream region by "manipulating Mekong River flow" for its own benefit while the down-stream countries have to pay the high price. This problem has actually happened over the past 25 years, in which the most severe natural flow disruption occurred concurrently with the construction and operation of large dams. And the up-stream reservoirs are not only used for electricity generation but also for storing excess water compared to the irrigation requirements of the area (Yunnan).

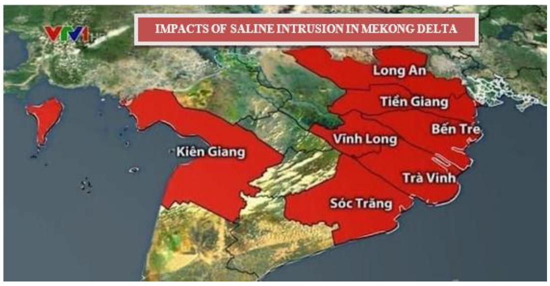

Figure 12: Vietnam Television VTV (Source: 12) (Map Scale: 1/500, 000)

For that reason, the Mekong River is currently suffering from record water loss, devastating crops, threatening food security and regional water resources. As aforesaid in the end of August 2020, at the Lan Thuong-Mekong forum, China promised to share annual hydrological data for this river to other members. But between the promise and the reality it is unlikely correct and the Mekong River will be dwindling gradually to draw the prospect of Mekong down-stream arid fields in a closed day.

On May 20th, 2020, the European Commission (EC) approved the biodiversity strategy to 2030, of which the most important is the rest orating acceleration of at least 25,000 km of European rivers by removing most of the dams-whether or not to generate electricity, to restore flood-plains and wet-lands. The World-Wide Fund for Nature (WWF) declares that the release of natural flows as a breakthrough action to revitalize the step-by-step dying rivers. At the moment, 4,984 dams have been demolished according to the European Union Framework Directive on Water (DCE) that by 2027, EU countries must take measures to restore rivers into good ecological condition.

In the United States, a tendency that is quietly growing is also the demolition of old or degraded dams to protect the ecology and ensure safety. According to American Rivers, in 2019, 26 US states destroyed 90 dams in total, and there will be a wave of speeding up dam destruction in the future to address more than 15,000 dams, large and small with high risk all over the U.S A country. The unsafe old dams demolition seems to be the primary choice for developed countries to uphold an environmental role and is also an effective way to meet their commitment to sustainable development (Ba et al., 2017).

Recently, on the end of August 2020, Mekong River Committee co-operates with Facebook to open 1 FB warning information page of Mekong down-stream Flood and Drought for the punctual news & alarm signs of Mekong down-stream flow observed by 22 alongside stations to regional people. According to MRC estimation, the annual Flood of Mekong down-stream causes big damage equivalent 60-70 million USD to them. As soon as possible, Government haves to apply 1 effective strategy for this calamity.

There is a small and happy signal that in mid-September 2020, the possibility of the Mekong River problem will be discussed at the ASEAN Regional Forum (ARF), scheduled to take place with the participation of the Foreign Ministers of 10 ASEAN countries plus USA, China, Russia, India. Hopefully there will be moves positively to resolve the lethal scenario of the Mekong River down-stream sunset (Ba, 2016).

7. Conclusion

The Warn that, upstream countries to build too many hydroelectric dams on the same Mekong River, China alone has 12 dams. They have retained excess water according to demand. This is damaging to downstream fields and villages such as Vietnam. Please remember to say: a- Characteristics of Ecosystem of acid sulfate soil in the Mekong Delta will be changed strongly, b- 1,700,000 ha of acid sulfate soil in its heart. Here, if there is a lack of water will be harmful for livelihood, c- the drought will cause saltwaterization of saltwaterization in near future, d - Lack of alluvium and nutrition, e- riverbank erosion, sedimentation of estuaries and seaports; This has given: - Coastal landslide (which in the past, accreted to the sea 80-100m / year, now, in contrast, erosion and sea intrusion 20-25m / year decrease. Together with climate change and Sea rise, livelihood of 20 million people in Mekong Delta in Viet Nam becomes very difficult. Nowadays, The Mekong Delta is a wetland. It will be destroyed in case of getting drier. This is a powerful warning to the upstream countries and to the world.

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