Rational Approach to International River Management in Different Jurisdictional Contexts of the Greater Mekong Sub-region: Water Development Vs Biodiversity Conservation

by

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ABSTRACT

Who hasn't heard of the Greater Mekong? The Southeast Asian River originated from Tibet which flows across southern province of China, Myanmar, Thailand, Laos, Cambodia and Vietnam before discharging to the South China Sea. The Mekong is a peaceful river and due to its hydrological and sedimentological regime that formed a pristine aquatic ecology and splendid watershed environment, various habitats for existence and development of endemic fish species and other wildlife occurred.

The ecological characteristics of the Mekong River are diversified following the physical conditions of its natural structures and hydrological regime, of which 4 distinguished ecosystems are empirically defined: the valley waterway system (1), the plateau watershed system (2), the reverse water system (3) and the delta system (4). The hydrological resources contributed from the four ecosystems are crucial to the whole Greater Mekong environment in terms of biodiversity development. Living and non-living aquatic resources are differentiated from one to another ecosystem and have contributed various interests to riparian communities.

Fish, forested products, edible vegetation and lands are the first commodities of the natural resource to be utilized by local people, especially at downstream where the ecology is characterized by numerous waterway corridors and various inundated vegetation. These are home of large catfish species that prevailed the capture fisheries during the past time. Unfortunately, the straggle for food through intensive commercial and subsistent fisheries during the last century together with the surge of water development for agricultural irrigation and generating electricity in recent decades were crucial consequences of the present degradation of natural environment and fish decline.

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Dispute and conflict among resource users, especially between developers and environmental conservators, dam builders and fishers, commercial fishers and subsistent fishers, agriculturists and fishers, fish farmers and fishers etc. spread throughout the region, of which the transborder issues are of great concern of this paper.

Searching for rational solution in different jurisdictional context where interest of natural resource utilization of each riparian country is different one another, an evolutionary approach with logical argument will be applied in deliberately debate. This paper describes and analyses the existing management systems and its consequences and tries to propose new rational concepts that are topics for further discussion.

Key words: different jurisdictional contexts, water development, biodiversity conservation

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Figure 1. Environmental transborder map of the Mekong River Basin

1. INTRODUCTION

The Mekong is reputed as a critical river in Asia especially Southeast Asia in term of its length, hydrological regime, sedimentological duty, landscape, ecological diversity, economic contribution and residential fitness to human. This river takes its origin from Tibetan plateau then flows 4,800 kilometers across the southern part of China, Myanmar, Thailand, Laos PDR, Cambodia and Vietnam before discharging into the South China Sea. According to Cabonnel and Guiscafre (1963), the Mekong River is one of the ten largest rivers in the world in term of its 500 billion m^3 flow annually. But in contrast, Welcomme (1985) quoted that the river ranks 14^{th} and 16^{th} in term of annual flow amount and length, respectively, as the discharge of water to the South China Sea was only 350 billion m^3, annually. However, the MRC (2003) had stated that the annual discharged volume of water of the Mekong River to the South China Sea was averaged at 475,000 m^3. The discharge of water varies seasonally by 10 to 15 percent during the dry season and 85 to 90 percent in wet season following the monsoon strength. The flood regime occurred once a year from May to October has invaded about 70,000 km^2 flood plains in which a large area located in Cambodia. The latter source also quoted that the total Mekong Basin (MB) catchment area covers 795,000 km^2 and the hydrological regime of the Mekong River is contributed by 16%, 2%, 17%, 35%, 19% and, 11% from China, Myanmar, Thailand, Laos, Cambodia and Vietnam, respectively.

Interestingly, this international river is named differently by many dialects where it based. The first 2,400 km from it origin down to the Chinese-Myanmar border is named "Lancang Jiang", which is followed by about 1,200 km "Menam Khong" that ended up at Laos-Cambodian border. It 480 kilometers passage across Cambodia territory is called "Tonle Thom" and it subordinate channel "Tonle Bassac" that forked out at the beginning of the Delta down to the Cambodia-Vietnamese border. It last part which lies on the Delta Region in Southern Vietnam is named "Song Hau", a channel continued from Tonle Bassac and "Song Tien" connected to Tonle Thom in Cambodia. This latter channel forks into 9 waterways are merely called "Song Cu Long or 9 Dragons" before reaching the South China Sea.

The population of the whole Mekong Basin catchment area has 73 million inhabitants, in which about 55-60 million inhabitants are currently living in the Lower Basin where splendid natural resources have been developed to support people livelihood for multi-millennia. The Lower Mekong Basin covers 77 percent of the total basin catchment area which extends from Myanmar-Thai-Laos border down to the South China Sea. Four countries: Thailand, Laos, Cambodia and Vietnam are part of the lower basin and shares benefit from this important river. The tangible natural resources to be benefited in the Lower Mekong Basin are arable lands, waters, forests, wildlife, fish and other aquatic animal and the intangible resource to be extracted, not only the LMB but the whole Mekong Basin are amenity. Traditionally, benefits obtained from those tangible natural resources were very different from one to another place in the old time depended upon the natural condition of geographic feature possessed.

However, the politic of economic development and population growth during the last century was driving into environmental degradation and conflict of unequal common resource benefit distribution. Perhaps, the conflicts might be started simultaneously at industrialization of fish, wildlife trade, timber for domestic consumption and sale, water damming for agricultural irrigation and electricity generation and, land for family farming and plantation. As this international river is managed by 6 jurisdictional contexts, it is really difficult to balance the natural resource benefit distribution, perhaps, it is impossible to re-distribute the benefits and to sustain the natural environment even there is effort to enact an agreement to control river development in 1995 by the four countries of the LMB and the sophisticated development plan of Greater Mekong Sub-region initiated by the 6 riparian countries and other major financial organizations. But this should not be too pessimistic with our subjective mind, perhaps we can try to use our objective mind to help improve these above solution that can be finally acceptable to all.

2. GEO-ECOLOGICAL FEATURES OF THE MEKONG RIVER

Along it course of 4,800 km the Mekong River, at it present physical feature, is one of the world youngest and high sedimentation river which has contributed tremendous extension of new lands at it delta zone for multi-millennia. In a broaden study of Rainboth (1996) on Zoogeography, The Mekong River morphology started since many million years ago following the earth eruption phenomena which made this rive a geo-ecological rich and diversity. Reportedly, at least more than 2,000 fish species have been identified and these have contributed to human diet not less than 2.6 million tonnes, annually (MRC,2003) which is about 35-6 kg/capita consumption.

There are a number of geographical and ecological studies by local and international experts to understand the uniqueness and strength of this natural creature for proper utilization the resource without dwindling the environment and social culture. Empirically, at the macro level, the whole Mekong Basin can be classified into 4 geo-ecological systems following its geo-ecological characteristics possessed: (1) the Valley Waterway system, (1) the Plateau Watershed system, (3) the Reverse Water system and, (4) the Delta system.

(1) The Valley Waterway system: The upper part of the Mekong River so called Lancang River by Chinese dialect has it course starting from Tibetan plateau at the 5,000 m asl elevation down to the 19th parallel at about Luong Prabang in Laos PDR where the level of elevation reduced at about 2,900 m asl. It begins by two water channels confluence where a mainstream continues along the valley of Tibetan plateau until it reaches the western watershed of Annam Highland in Laos and Thailand at about 3,400 km from it origin. This means that this system consists of the whole Lancang River plus several hundred kilometers course extended in Laos and Thai territory. The main channel is mainly rocky based which receiving waters from numerous short and small tributaries. The basin at this system is typically small and has only one small flood plain at Pak In village

of Chiang Khon, Chiang Rai province, Thailand. In general, there is only one water flow system from highest to lowest elevation but the volume and the water current fluctuated seasonally. During the wet season from late of May to October, the discharged water volume pick up to a maximum rate with high velocity of current then slows down from November to May. Even this Valley Waterway system covers a long course of about 70% of the total length of the Mekong River the volume of discharged waters has only about some 20% of the total discharged volume. Landscape including vegetation is characterized by mountainous dry grassland of the semi-temperate upland ecology which creates a great habitat for wildlife such as mammals and birds where many of them are endemic in this region. Forested flora growing in this zone is not tall and less dense but looks so beautiful and colorful that has been recently nominated together with other two parallel river basins: Nu or Salween River and Jinsha or Yangtze River as a World Natural Heritage by UNESCO (Yu Xiaogang & John Dore, 2004). Aquatic animal such as fish is negligible in the whole Lancang River as primary production is not well developed due to cold weather, strong current water that hampering the process of natural metabolism. In general food change in this aquatic system is very limited since it presents mainly small omnivorous and herbivorous species and very rare carnivorous species. But the geo-ecological feature of the last downstream of this system, especially the river course from the Myanmar-Thai-Laos border down to Luang Prabang in Laos has a unique physical structure which characterized by numerous whirling water rapid systems and pools that constituted the mere spawning grounds for giant catfish and other large size fish species that are also in omnivorous and herbivorous groups. The quality of water remains good and clear with high dissolved oxygen and low sediment rate especially at it first 2,400 km course. Based on empirical observation, the geo-ecological features of the Valley Waterway systems have already been expanded across the political border of at least four nations: China, Myanmar, Laos and Thailand (see Figure 2 below).

Figure 2. Map of the Mekong Valley Waterway system

(2) The Plateau Watershed system: The course of the Mekong River from Luang Prabang in Laos down to Kratie town in Cambodia where it reaches a large basin in Northeast Thailand before the Khon Fall and the great watershed of Bullowan Plateau and Central Highland of Vietnam. The Menam Khong channel breathes out widely as it receives a huge discharged water volume of about more than 60% of the total discharged volume from a number of long and large tributaries such as Nam Gnum, Nam Thoeun, Se Pean, Se Kong and Se San/Sre Pork of the east and Moon River of the west. The river channel of this system is characterized by long sandy and silty floor structures and a number of islands of which some are flooded during wet season. At it course above Champasak province of Laos, several large rapid systems occurred especially at the entrance of all tributaries. The most spectacular aspect of this system is the occurrence of the 4 thousand islands around the Khon Fall region so called Sipandon and the 2 water falls: Khon Papheng and Khon Bamit of Champasak province near the Laos-Cambodia border. The total length of the river channel encountering from the 19th parallel down to Kratie town is about 855 km. The greatest rapid ecosystems are found in the main-upstream of Cambodia where within about 200 km course from the Laos-Cambodia border down to Kratie town and its large tributaries numerous large rapids and deep pools associating with special

inundated forests such as Gimenila asiatica flora creates a number of pristine spawning grounds and habitats for many commercial fish species, reptiles, and specially snub-fin dolphins. Interestingly, the plateau watershed system has a largest basin with complex numerous waterway corridors within enormous rain forests where huge amount of waters are produced from. Forested flora at its origin was very diversified and consisted of most valuable timber, which created a great habitats and niches for many wildlife species such as elephant, tiger, rhinoceros, Kuprey etc. Due to the abundance of elephant in this zone, Thailand, Laos and Cambodia were named as the countries of White Elephant (Mohout, 1871-2). Flood plain areas in this zone are not significant therefore the genetic population of aquatic animals are not diversified and well developed. In contrast, fish species are very diversifies but mainly riverine and rapid species that some of them are endemic. As there are a few small flood plain areas, the population of small cyprinid and other flood plain species are very limited that makes this system less fisheries attractive. Commercial fisheries are found in all main tributaries such as Nam Gnum, Nam Thoeun, Moon River, Se Kong, Se San/Sre Pork and below the Khon Fall. Other small water channels in Northeast Thailand, Eastern Laos and Cambodia are exposed for subsistent fishing. Rather than the above described geo-ecological resources, the underneath mineral substances such as ore, lead, lime, coil, and precious stone are also available along the western watershed of Annam highland which have become much attractively targeted at the present time (see Figure 3 below).

Figure 3. Map of the Mekong Plateau Watershed system

(3) The Reverse Water System: The Mekong River so called Tonle Thom in Cambodia reaches it first large flood plain at Kratie town then turns horizontally to the west, which further continues in southwest direction until the beginning of the Delta region at the confluence of the four rivers "the Quatre-bras or ""Tonle Chaktomuk". According to the pre-historic study, the central plain of Cambodia consisting of flood plain in Kratie, Kompong Cham and the whole Great Lake Boeung Tonle Sap region was a northwestern part of the marine bay of Indo-China Peninsula during the last 6 to 5 thousand years ago (see Figure 5) where the sea level was about 8 meters lower than that of the present time (Cobanaire, 1909. p. 6-9; Auguste Pavie, 1879-95. p. 8-11). The Mekong River met the bay at a large delta of about 20 km breath (presently Kratie-Kompong Cham provincial border) and for few thousand years of siltation duties, especially during wet season a complex freshwater ecosystem was emerged to completely replace the marine ecology of the old bay since the last 25 centuries. As evidence, a number of marine species such as Dolphin, sword fish, shark, sting ray, sea snake etc. still continue to survive in this region with its mutable ability to adopt the gradual mutability of this environment. Within this system, the Mekong River has a critical job to fill the flood waters into the flood plains that are laying along side the mainstream. Flooding the Great Lake region through Tonle Sal River is it

major job which used to discharge more than 40% of the total discharged volume during the wet season from June to October (Carbonel & Guiscafre, 1963). The Great Lake Tonle Sap and other flood plains discharge the flood waters back to the Mekong River gradually following its receding water levels from November to February. The waters flow in and out between the Mekong River and its flood plain is a unique reverse water system of the whole Mekong Basin and perhaps, of the world. Even though, there are a number of tributary such as Prek Te, Prek Chhloung (eastern watershed), Stung Chinit, Stung Sen, Stung Storng, Stung Siem Reap (Dongrek chain watershed), Stung Sangke, Stung Pursat, Stung Boribo (Cadamum chain watershed) within this system also contribute waters of almost 10% of the total discharged volume to the Mekong River during the wet season. The forested watershed around this region is characterized by evergreen forests, decidous forests, secondary forests, shrublands, sawana and grassland that are critical for wildlife habitats. Many of forested floras in these above watersheds are recognized as valuable timber for excellent wood quality. The absence of rocky channel structure has caused of high degree of river bank erosion which is driving to fast river morphology. But the seasonal flood plain with reverse water system has promoted high potential of freshwater ecological evolution, which started from primary production to vegetation generation to support natural food change in this aquatic environment. Reportedly at it origin, the inundated forest consisting of gallery forests, shrublands, aquatic grass, macrophytes and algae expand almost 70% of the total 2 million ha of flood plain, which create both feeding and spawning grounds for all resident aquatic animal and many of non-resident aquatic animals from other upstream and downstream systems (see Figure 4). Carnivorous, Omnivorous and herbivorous fish species of both riverine and lucustrine habitats in this system were tremendous in the past, which made Cambodia deserved a country of everywhere fish (Chu Ta Kuan, 1297; Mohout, 1971-2; Chevey et Le Poulin, 1939). At least about 170 of the 500 fish species of the whole Cambodia have been recorded this reverse water system (Tan, Hao &Chong, 1989; Rainboth, 1996). Other aquatic animals such as crocodiles, turtles, tortoises, and reptiles that used to live in the flood plains were also

abundant. Moreover, these flood plains especially the Great Lake Tonle Sap have constituted a great seasonal nesting and feeding grounds for many water bird species and that due to it rich biodiversity resource, it is recognized by UNESCO, a World Heritage of Biosphere Reserve.

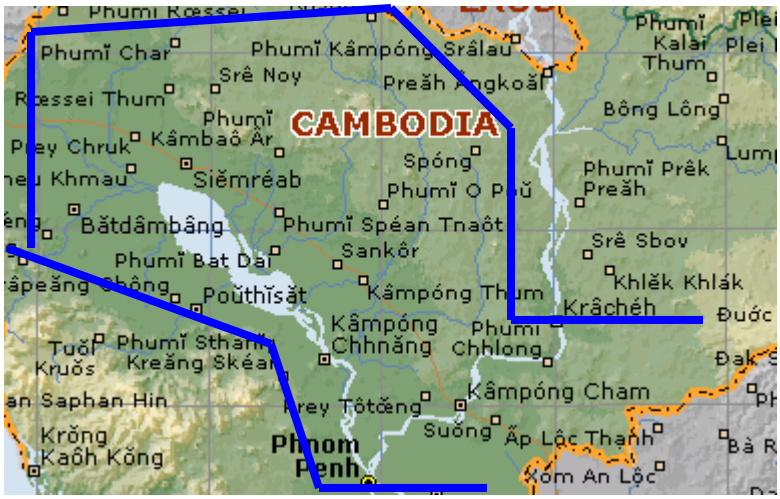
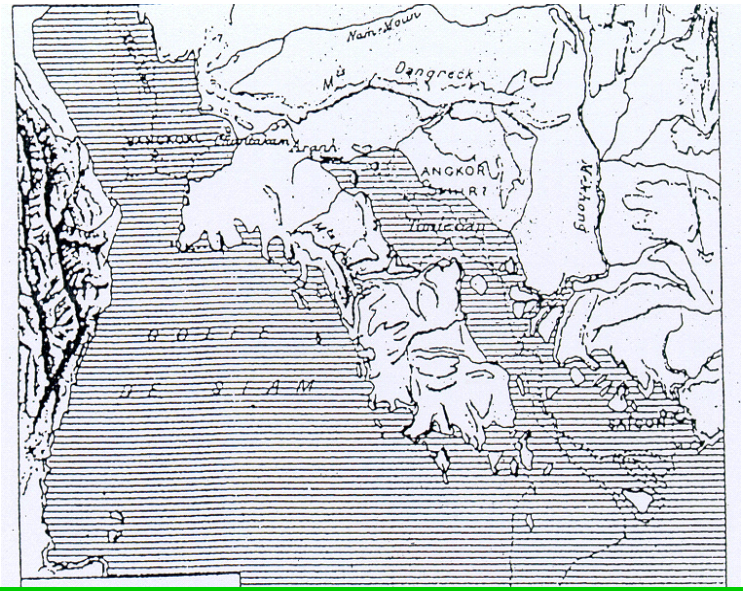


Figure 4. Map of the Mekong Reverse Water system



Pre-historic Map of the Present Mekong Delta showing that the central plain of Cambodia down to Southern Vietnam was the marine bay in around 5,000-6,000 years ago

(4) The Delta System: This system started from the confluence Chaktomuk or "Quatre-Bras" at Phnom Penh capital city of Cambodia where the Mekong River forked out into two main channels: Mekong downstream and the Bassac River flowing down to the South China Sea. These two river channels are characterized by silty and sandy soil due to high degree of sinking sediment caused by slow water current near to the sea. Most part of this basin is flooded for a long period of time every year from 3 to 9 months with no significant reverse water system. In relation to the high sediment deposit, the delta has continued to extend out to the sea, which created a large estuary covering by dense mangrove forests. River morphology was extremely evolved with sedimentology and the sea movement that westward shifted the 2 river channels for more than 100 km within the period of 2,500 years. Reportedly, the mouths of the 2 river channels were originated at Kompong Trach in Kampot province (presently at the Vietnam-Cambodia border). The flood plain within this basin was, according to the French studies in the old time covering by a huge inundated gallery forest from the above stretch of the delta down to Mangrove forest at the estuary (see Figure 6). Several large deep pools of about 30 to 50 meters that most fish used them as their shelters during dry season have been detected only in the Mekong downstream channel in Cambodian territory. Soil is generally acidic, except the areas where flood waters resist about four months a year. Even it is a very lowland region the Mekong and Bassac Rivers still receives waters from it tributary and catchment areas of about at least 15% of the total discharged volume to the South China Sea. Lucustrine fish species such as snake head and small cyprinid occur fairly in the swamps where the water retained more than 6 months a year. Pure riverine fish species are not so abundant at the lower part due to the effect of brackish acidic waters but the estuarine species such as freshwater prawn, Pangasius Krempfi, Pangasius kugnit etc that their life cycle patterns involved three different habitats: the estuary, the flood plain and the rapid for feeding and spawning is fairly interested. The most important fisheries resources are the estuarine species inhabited in the large mangrove forests such as mud crabs, shrimps, fish and mollusc.

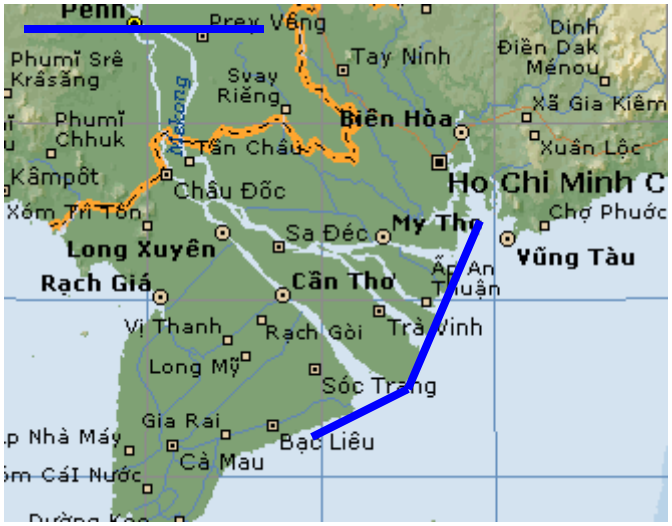


Figure 5. Map of the Mekong Delta system

In order to compare and distinguish the different features of geo-ecology of the defined systems within the Mekong River Basin, a summary Table of important information should be provided (see Table 1 below).

Table 1. Summary of the Geo-ecological featuring systems of the Mekong Basin

Geo-ecological features	Valley Waterway system	Plateau Watershed system	Reverse Water system	Delta system
Political location	Southeast China-Mayanmar-Laos PDR-Thailand	Thailand-Laos PDR-Cambodia	Cambodia	Cambodia-Vietnam
Geographic location	Between 32nd and 19th parallels	Between 19th and 13th parallels	Between 13th and 11.5 Parallels	Between 11.5 and 9th parallels
Degree of elevation	Between 5,000m and 2,900m asl.	Between 2,900m and 80m asl.	Between 80m and 40m asl.	Between 40m and 0m asl
Basin area based on total 795,000 km^2	about 27%	about 54%	about 14%	about 5%
Length of river course	3,400 km	855 km	215 km	330 km
Discharged water volume based on total 475 billion m^3	about 20%	about 60%	about 11%	about 9%
Landscape of Basin	Hilly zone with dry grassland vegetation	Watershed-plateau with rain forest	Rainfed plain of Cadamum and Dongrek chains and Annam Highland with rain forest and inundated forest	Swamp and estuary with inundated forest and mangrove forest
Important wildlife	Monkey and other small mammals	Elephant, tiger, rhinoceros, Kuprey	Elephant, tiger, rhinoceros, Kuprey, water bird	Migrated and water bird
Flood plain based on the total of 70,000 km^2	Absence	20%	about 30%	50%

Degree of erosion	Negligible	High	Very high	Negligible
Sediment deposit	Negligible	High	Very High	Extremely high
Aquatic vegetation	Small plant and algae at the stretch end	Small plant and algae at the above fall and inundated trees especially Gimenila asiatica flora and algae at the below fall	Inundated gallery forest, shrubland, grass, small plant flora, macrophytes, algae	Inundated gallery forest, shrubland, grass, small plant flora, macrophytes, algae and mangrove forest
Important habitats	Water whirling rapid and pools at the last stretch end	Large riverine feeding ground and watershed spawning grounds and great rapid spawning precinct at the below fall	Extreme feeding and spawning grounds of resident and non-resident fish	Residence of lucustrine fish and home of estuarine species
Aquatic fauna trend	Small sized fish; a short visit of Giant catfish and other large species at the last stretch end during spawning period	High fish species diversity with limited genetic population diversity and its dynamic, except the below fall region where fish and other marine species in origin develop very well	Both species and genetic diversity are high with extreme dynamic population. Other aquatic animals such as crocodile, reptile, turtle, tortoise and also water birds	Lucustrine fish and estuarine species are fairly developed

3. RELATIVITY OF ENVIRONMENTAL BIO-ECOLOGICAL TRANSBORDER OF THE DEFINED SYSTEMS

Based on the dynamic of hydrological regime that flows down from a 5,000 m elevation across numerous catchment areas, the Mekong River has created a diversified natural environment and bio-ecology throughout it whole basin. As consequence, fish and forest resources were well developed to support the economy and socio-economic of the reparian states and its population for a long period of time. But among these two resources, fish was the only one necessary commodity for human food to be firstly exploited. As fish is a common source of protein for human consumption that is prevailing in the aquatic environment, a critical understanding on natural bio-ecology phenomena of this river basin is needed. Four geo-ecological systems are already defined and described but there still need to know how the bio-ecology works in each defined system and what is the relativity linking those systems in dynamic terms for the existence and development of all aquatic animals in the Mekong Basin.

- Fish was not significant in the Valley Waterways system but this not means that there are no fish at all. Fish is available in scarcity condition throughout

the first 2,800 km mainstream and its tributaries. They are endemic and adapted to local environment that relied on algae and detritus to feed for survival. These species are generally small size and living in small population. But most of them are strength and looked very beautiful. This system is steadily changed at the last 600 km course (passing across Mayanmar, Thai and Laos territory) with the presence of some large sized fish such as Giant catfish, other catfish, *Siluriforms, Probarbus sp., Mystus sp*. etc. These species are so rare and found them throughout the year, except two giant catfish species: *Pangasionodon gigas* and *Pangasius sanitwongsei* that take only a short visit along this course from May to July for spawning purpose. These giant catfishes spend several months feeding in the basin catchment of the plateau watershed system before retreating to the deep pools in Mekong mainstream in around November-December. They continue to live in around the deep pool for a few month to develop their gonad with little feeding then migrate upstream to their proper spawning ground at the whirling water rapid and pools at Chiang Khon. Big fish needs strong current to stimulate hormone for mating and laying eggs. After coupling of male and female the process of hormone stimulation is taking place at the whirling pool for sometimes. Mating to fertilize the eggs laying in undertaking at a complex whirling rapid in order to make more eggs stick on the rocky substrates. After mating, the male moves immediately to the feeding ground at downstream but once in a while there may have someone moves to upstream for many hundred kilometers for the same purpose. This latter is finally returned back to the rich feeding at downstream after sometimes. While the female retreats to somewhere nearby to ripe up the eggs in the gonad with little feeding on local algae available in the area and also waiting for a new male. Coupling with new male for second spawning may be about 15 to 20 days after the first one and the whole process is similarly undertaken. The couple is immediate move to feeding grounds after spawning and the rest of eggs in the gonad have been released out along the way. Sometimes in case that male is not available, overripe eggs in the gonad are naturally released out without fertilization, so

this is a great lost of reproduction. The new hatchlings from natural hatcheries flow down by the water current toward their feeding grounds in the basin catchment and the flood plains where they can enter through the tributaries by the strong force of water current. Most of hatchlings of the species spawned around Chiang Khon are usually entering the basin catchment located above the Khon fall especially the western catchment in Northeast Thailand if there is no obstacle at the entrance. Despite though, there still have some hatchlings move further downstream passing by the Khon Fall then enter the Great Lake Tonle Sap flood plain for feeding and growing up within the Reverse Water system. It is very rare to find them pass over the Cambodia-Vietnam border to the lower delta region. In summary, the evidence from empirical observation in the above system can provide a high degree of corroboration to argument of relativity of environmental bio-ecological transboder of the defined system (sea figure 8)

- The Plateau Watershed system is the biggest system of the Mekong River Basin where pristine forested watershed is the interested resource for both state and people. Due to the absence of flood plain the abundance of fish is seconded in this region as it is generally exploited in family scale for local consumption. The mainstream and tributaries, especially the deep channel the rapids and deep pools are the mere habitats of all fish species, especially during dry season. Other small Cyprinid species can live in the shallow water areas throughout the suitable waterways channels within the basin catchment. Above the Khon Fall, most small and medium sized fish species live throughout the existing waterway corridors where feed is available throughout the year. Some fish spawn at the flooded river bank and some other required a particular spawning ground along the watershed canal or creek where they can spawn in the small rapid system. Except for the giant species that required a long migration to the suitable criteria matching their spawning pattern. At the below Khon Fall, the condition is a bit difference from the former one even it has been classified in one system. Empirical observation can prove that the

below Khon Fall habitat can connect it bio-ecological pattern to the above habitat through the Sekong channel of which a number of fish species can move up and down between Attapeu watershed and the rapid system of the upstream in Cambodia. Perhaps some among those fish such as small Cyprinid species that it life cycle is less restricted to any specific environment like *Mekongina erythrospila* fish can move further upstream to associate with other fish species in the above habitats. It can be happened the same pattern for the above fish species. However, the below fall bio-ecology consists of a very specific characteristic in terms of complex habitat for tremendous types of aquatic animals such as marine origin species, reptile, turtle, tortoise, and all group of freshwater fish from plankton feeder to see top predator. It is good to speak that the combination of large rapids, deep pools, specific inundated flora, sandy beaches, complex waterway corridors and hydrological regime of the Mekong River and the Sekong, Sesan and Sre Pork tributaries has formed a great home for resident species and suitable temporary maternity of many non-resident breeders from the Great Lake Tonle Sap and other flood plain regions. Despite though, until today there is neither evidence nor information to convince that this precious habitat can be able to assist the reproduction pattern of both greater catfish: the giant catfish and *P. sanitwongsei*. All these above contemporary knowledge are of great argument to insert into the assumption that the relativity of environmental and bio-ecological transborder of the 3 defined systems relatively true in its content (see Figure 8).

- The recognition of freshwater fish abundance in the Reverse Water system of the Mekong River basin that claimed by a number of people has become a routine matter for all. The ecosystem diversity of the flood plain especially the Great Lake Tonle Sap constituted the wonderful niche for tremendous aquatic life, in which they reproduce and feed on a very rich food chain throughout (see Figure 7). Feeding in the flood plain is very common for aquatic animal including mammal, except for several riverine fish and estuarine species such

as *Pangasius bocourti, Pangasius Krempfi and Pangasius Kugnit, Scombridae sp., Anguila sp*. etc. These fishes rarely entered the flood plain and in a very short time when they are fingerling, so the rest of their life is merely in the river channels and estuaries. Species and genetic population diversity of aquatic animals in the Reverse Water system are adequately disseminated worldwide but biological truth knowledge of them is very limited. Some recent efforts to discover these mysterious life cycles of a number of important species have been released to a small mass of the public. In this comprehensive way of description, some important resident and non-resident fish species often found in the flood plain like Shevron snake head (*Channa triatus*), giant snake head (*Channa micropeltis*), *Gobiidae sp. Clariidae sp., Siluridae sp., Pangasidae sp., Cyprinidae sp., Belontiidae sp*. etc. should be roughly cited. Chevron snake head, Giang snake head, *Gobiidae sp., Clariidae sp., Belontiidae sp., Bagridae sp.* are prolific and purely lucustrine species with short movement within the flood plain as they can resist in the harsh environment but the most withstanding one is Chevron snake head, which followed by *Clariidae, Belotiidae, Gobiidae, Notopteridae,* and Giant snake head fish species. Those fish feed and spawn in the flood plains almost year round with 2 peek periods: May-June and August-September, except for Giant snake head that spawns only time a year in August and requires a deep and clear water areas to live. *Siluridae sp*. have a longer movement are more active that the former groups as they shift back and forth between the river channel and the flood plain for feeding but their spawning ground is merely in the flood plain. While large *Pangasidae sp*. that prevail the natural stock use flood plain for just feeding only but they move to the below Khon Fall rapids for spawning at the specific substrate of the *Gimenila asiatica* flora concentration zone. Hatchlings of these species from the substrate together with hatchling of other fish species from the near above and below the Khon Fall regions have pushed by the Mekong current to flood plain areas especially the Great Lake Tonle Sap to enjoy feeding throughout the wet season. Interestingly, there may have about almost a half of the above

hatchlings have pushed more downstream to the Delta system by 3 channels: The Tonle Toch River, which flows across Kompong Cham and Prey Veng province, Mekong downstream and the Bassac River. At the lower part of the Delta system where the water current is relatively slow, the latter group of hatchlings of about 15 days old can be able to enter the nearby flood plains and so some of them take its way back to the flood plain in the Reverse Water system. According to these above empirical observation of pragmatic scientists, just the Reverse Water system alone cannot make this region a world productive in fisheries. It is surely needed the support in many aspects from other systems of the whole Mekong Basin such spawning grounds for some specific species at the upstream rapid systems, substrate for nesting, safe rescue pools for natural brood-stock, supplementary feed etc. Now it is clear to advocate the relativity of the environmental and bio-ecological transborder of the 3 defined system of the Mekong Basin with logical arguments of the scientific observation (see Figure 8).

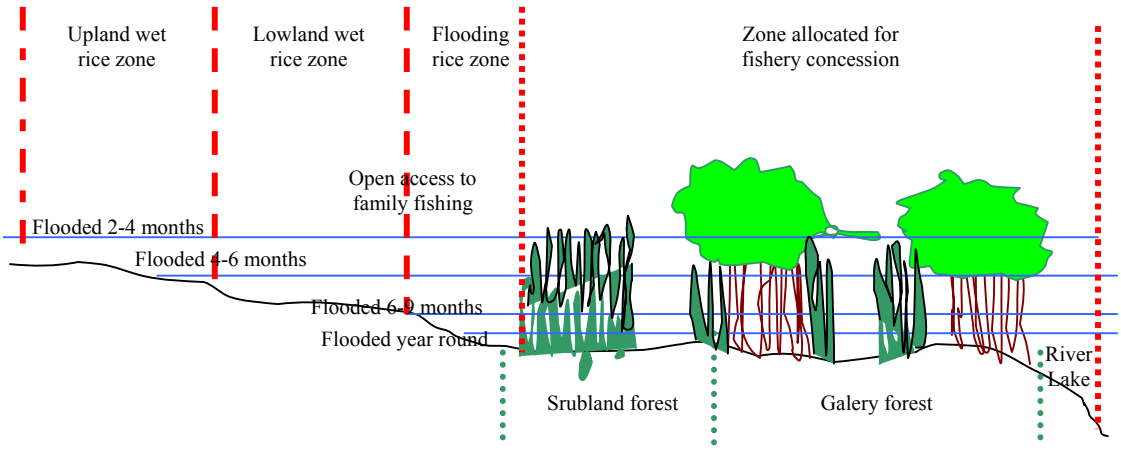


Figure 7. Lateral view of the flood plain of the Reverse Water system

- The bio-ecology strength of the Delta system is characterized by the approach of freshwater swampy ecology to the estuarine ecology and it temporary host for visitor species from the above systems and from estuarine or marine waters. Even though, there are also a number of resident species, especially the freshwater swampy species that strongly withstood in the acidic waters. They are mainly snake head fish group, walking catfish, *Anabantidae sp*., Swampy eel, *Siluridae sp.*, *Belontiidae sp., Gobiidae sp., Cobitidae sp.,* etc together with small *Cyprinidae sp*. to fulfill the food chains in the swampy region, of which the first and the last one are the dominant groups. Other resident species in the estuarine waters such as Sea bass, *Dorosomatinae sp. Leiognathidae sp., Scatophagidae sp*., Mud crab, mangrove shrimp etc. use the mangrove forests as their appropriate habitats for feeding and some of them use it for spawning too. Most visitors from the upstream such as fry and adult *Pangasidae sp*. and other large *Cyprinidae sp*. entered the swampy areas in short period then move back to the mainstream and rarely passed over the brackish water system near the estuary except for *Chanidae sp*. Normally, these short visitors used to return back to upstream in the Reverse water and the Plateau Watershed systems for substantial feeding and reproduction. In contrast, the estuarine species such as *Anguila* eel, *Scombridae, Pangasius Kremfi, Pangasius Kugnit*, giant prawn (*Macrobrachium rogenbergi*) etc. have made a short visit in the upstream throughout the below Khon Fall region for enjoying feeding and spawning, except for the giant prawn that they use to go back to the estuarine waters for spawning. This latter system is empirically proved the complexity of relativity of the environmental and bio-ecological transborder of the Mekong Basin as the whole and between one to another defined system in particular that are very useful to develop a holistic rational approach for harmony development management (see Figure 8).

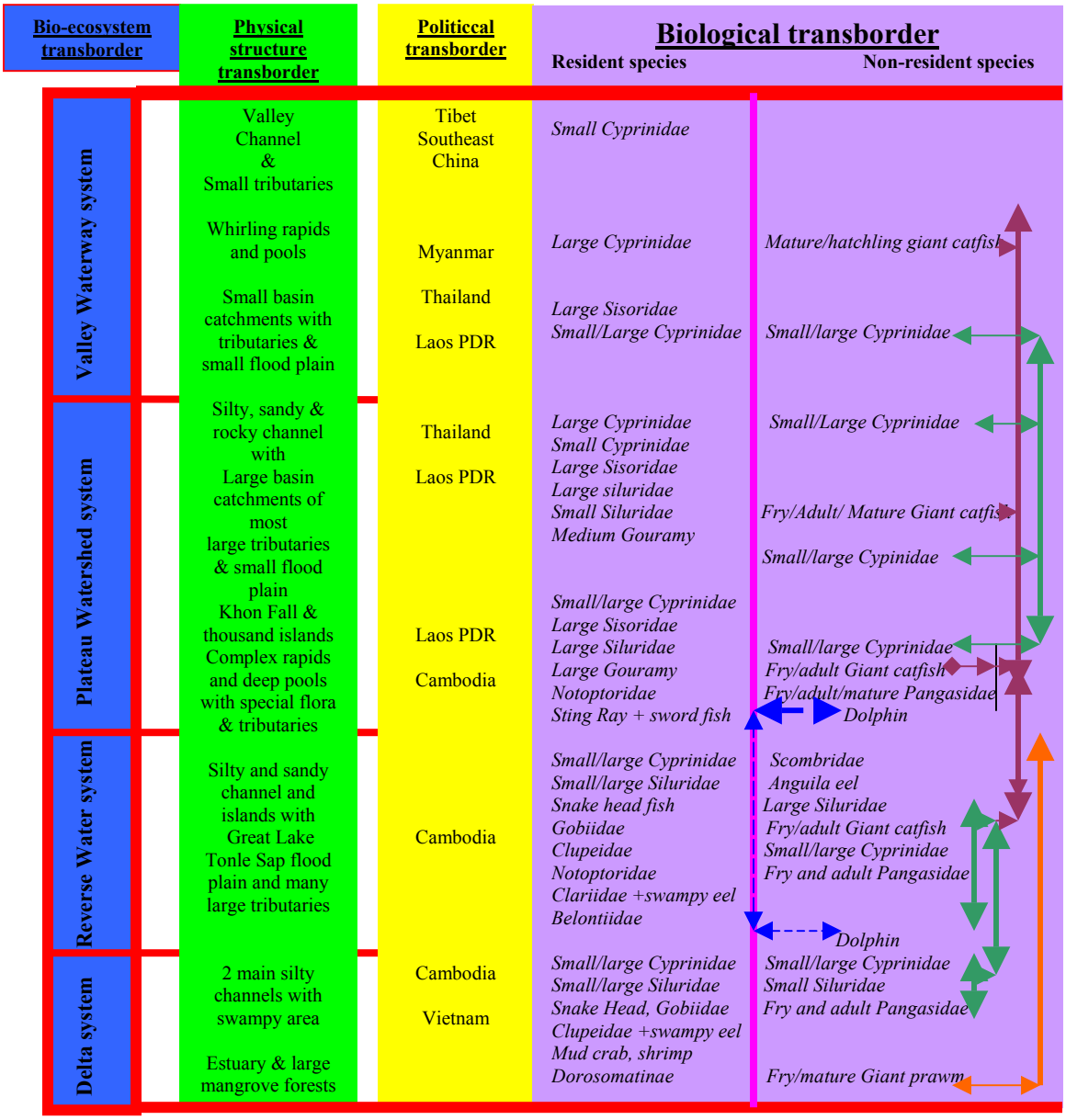


Figure 8. The Relativity of Environmental and Bio-ecological Transborder of the Mekong River

4. PAST, PRESENT AND FUTURE DEVELOPMENTS: BENEFITS AND IMPACTS

Throughout the history of the Mekong River or the Great Mekong Sub-region and even during it pre-historic time the natural resources to be exploited and utilized were firstly fishery then followed by lands and waters and, lastly negligible forests on the family-scale and traditional form. The level of exploitation and utilization of those resources increased overtime with growth of population and socio-economic evolution. The

exploitation and utilization of resource on the traditional manners are the sole satisfaction of all stakeholders that every one benefits without any sigh of adverse impact on the environment. However, these above harmonized activities have no longer existed when the economic ambition concept invaded the modern society around one and a half century ago. Due to the freshwater fishery resource rich in the Reverse Water system in Cambodia, the French colonial authority had convinced the Cambodian monarchy to commercially exploit this resource in 1883 for ensuring it existence. Thailand and Vietnam had partially applied this concept in some small places around the 50s. Water development concept for agriculture irrigation and generate electricity power for industrial development was introduced by the developed countries and firstly adopted by Thailand in around the 50s. These developments have become one of the most beneficiary investments at the beginning and continue to boom up with political and financial support of local government and international financial institutions. And finally the forested resource exploitation took place around late of the 50s in accordance to deforestation for large reservoirs building and land claimed for agriculture development in industrial scale for both export and domestic use. Water development was adopted by Vietnam, Cambodia and Laos PDR since the 60s for improving agricultural crops. The forested product exploitation has split to Vietnam, Cambodia and Laos PDR from late 70s until today. The latest issues concerning the hydropower dam construction on the Mekong mainstream and the navigation channel development are under way to finish in the hear future. Past, present and future developments as described above were perceivably aware that benefits and adverse impacts to environmental sociology are sharply occurred in the whole GMS stakeholders and need to bring all concerned issues and problems to deliberately debate in order to obtain the rational solution that can be reduced negative impacts and create reliable and equitable resource benefit re-distribution to all.

- **(i) Fisheries development: Benefits and impacts**: Historically, the industrialization programme of Cambodian economy was firstly started with the Reverse water system fisheries at the pre-colonial period in 1863 for the benefit of

feudal patronage system and then the French protectorate authority in Cambodia (Vincent, 1870-1). The commercial fisheries was arbitrarily under taken throughout the Reverse Water system for export purpose due to local consumption relied mainly on self-subsistence (Loys Petillot, 1911.p. 140). There were only the Chinese corporations who devoted to buy the fisheries concession right (represented by the burden book) for further sub-leasing for many other small enterprises with very good price. According to the rule, sub-leasers also have right to divide their sub-leased areas for sub-sub-lease to many other fishermen in order to allow poor people to generate some benefit from the fisheries (Loys Petillot, 1911. p. 112-113). Most skill labors were imported from Vietnam for fishing and processing to satisfy export. The management was typically classical as the resource just allocated for exploitation under the title of general fishing farm monopolizing by 5 or 6 and some time 7 rich corporate who were played the role of workless, non-risk and huge benefit intermediaries (Loys Petillot, 1911. p. 112-113). Revenue from this natural resource exploitation that supposed to be a substantial source of finance of the state administration was completely under the hand of the monopoly corporate due to the weakness of administration and finance of the feudal patronage system. The surge of conflict of benefit distribution among resource users and a series peasantry rebellions (Kiernan 1982a:1-3) are the matters of political, administrative and financial reform in 1884s by cutting off all provincial monopoly intermediaries for alleviating social pressure (Loys Petillot, 1911. p.113-117). Numerous restrictions and regulations for sustaining this industry activity were developed and enforced during the period 1930-1940 (Chevey et Le Poulin, 1940). More over, by the end of it rule in Cambodia, the French protectorate had established a strong state bureaucracy through which the creation of national fisheries research institute was also been deployed. But fish is claimed to have decline over time due to unrest intensification of exploitation (Chevey et Le Poulin, 1939. p.116-118; Blanc, 1958.p.41-42). Based on the fisheries administration, regulation and restriction formulated during the protectorate period, the fisheries legislation was completely prepared and promulgated in 1956 (Tan Kim Huon, 1971). The

Fisheries administration and management was completely structured and fully executed its role in fisheries management administration since 1963 after the first batch of recruited staffs finishing the ad-hoc training. The fishery law was properly enforced until the spread of devastated war between 1970 and 1993. Revenue from this development was not excess US$ 3 million/year but the fishing activities intensified overtime. As result, valued fish stock was drastically declined along side with the increase of rampant illegal and destructive fishing throughout the fishery sector.

In contrast, conflict among fishermen in Thailand and Vietnam were not much serious as the fisheries resources were not so important but the sound of resource depletion such as the decline of Giant catfish fisheries in Thailand and over-fished, especially the fry fisheries in Vietnam had been claimed in recent years. General speaking, the fisheries resources of the whole Mekong River Basin are under threat of drastic decline after the introduction of economic development with the surge of conflicts amongst interested stakeholders. The cause and effect are doubtful and only the critical contribution of the fisheries resources to human diet remains in every one mind of the people in this region.

- **(ii) Past, present and future of water development: benefits and impacts**: Importance of irrigation and hydropower dam for agriculture development and electricity generation for industry development have been taken into consideration by international development and financial agencies and United Nation Development Programme in around the 50s. The Mekong River Basin was one of the targeted river development of which Thailand was the first country to be involved in the region in late of the 50s around the time of the establishment of the Secretariat of Interim Committee of the Lower Mekong Basin representing four countries: Thailand, Laos, Cambodia and Vietnam under supervision of the UN. Reportedly, about 6,000 medium and small dams associating with reservoir and irrigation schemes were built since 1950s in which about 4,000 in Thailand, 700 in Cambodia, more than 600 in Laos PDR, and more than 600 in Vietnam

(MRCS data, Thai country paper, 1996). Damming the Mekong River Basin was a major objective for generating electric power of the Interim Mekong Committee, in order to control the flood and mitigation, of which a number of hydropower dam projects on many tributaries have been studied and planned throughout the basin especially in Thailand, Laos PDR and Vietnam. Cambodia is the least dam developed country due to disturbance war. Experience of benefits contributed from damming in the region and the lesson from the first world countries have had accumulated with a number of social and environmental crisis like a vicious circle. As such, the Mekong River Commission who represented the 4 countries of the Lower Mekong Basin have had modified it policy from water development in it origin into "match the needs, keep the balance" for each individual country in terms of equitable and sustainable use the Mekong resources for the benefit of all. According to the 1995 agreement, any development on the Mekong mainstream is prohibited unless the consensus of the 4 riparian countries, except for the tributaries. Even though, local and transborder conflicts remained unsold due to under-minding the importance of consensus on the international tributaries. Concomitant to the effort to match the needs and keep the balance of the 4 countries, the 8 large hydropower dams on the Mekong or Lancang mainstream in China were already planned to substitute 24% of China hydropower potential by the end of 2020. Manwan dam was impounded in 1992 and operated in 1996 then started the second dam, Dachaoshan, which was operated in 2001. The 2 other dams are being constructed, which one was the world's tallest dam of 290 m high (Yu Xiaogang & John Dore, 2004). However, the reduction of flood regime and uneven flood during monsoon was already affected since the last decade. Reportedly, at least 15% of natural flow was decline during 17 years period from 1982 to 1998 if compare to the previous period of 1923–56 (MRC/ORSTOM/BCEOM 1993 and MRCS hydrological data base). The Flood regime change by the upstream development of both mainstream and tributaries has caused a number of serious impacts at the downstream region, especially the drastic mutation of fisheries ecology, and damage agriculture crop and infrastructure. Future hydropower development plan shows that a number of

dam projects in the region may reduce flow at Phnom Penh as much as 15% in the wet season resulting of 20% less flow into the Great Lake, which may cause the flood plain reduction of about 20% of the total 1.2 million ha of the above region (MRC 1998, Flo cover data). However, suspicious impact on fisheries from the past and the present water development are seriously stick in every local fishermen at the downstream as they put their concerns on 3 big issues: the decline of giant catfish fisheries at Chiang Khon (1), the decline of Pangasidae fry fisheries in Cambodia (2) and, the decline of flood plain fish species throughout the Lower Mekong Basin (3). Suspect of the first issue may be implicated with the block of Moon River gate while the second and the third issues must be related to damming in Lancang River upstream most of the Mekong River. Concomitant to the latter issues, 2 times uneven floods in 1996 and 2000 must be suspiciously caused by the reducing of overloaded waters in the dam reservoir to avoid the collapse of the dam structures.

- **(iii) Logging and land claimed for agriculture: Benefits and Impacts**: Industrialization of forest exploitation and logging at the forested watershed started around the 60s and 70s in Thailand. This might be partially implicated with water development for both irrigation and power generation as establishment of reservoir required to clear the forest. Logging in Laos PDR and Cambodia was intensified around the 90s when forested resource in Thailand declined to an alarming stage. In Vietnam, the forested resource was strongly destroyed during the war time so the remaining forest along within the Mekong Basin is not widely opened for large-scale logging. Empirical survey in recent years found out that most rain forests in the Lower Mekong Basin were drastically depleted, which is, perhaps, consequence to the present long lasting draught in this region. On the other hand, the lost of huge forest areas may also cause the reduction of natural waters produced from the forested watershed system and lost its ability to store and adjustment the flow the waters from heavy precipitation at the high elevation zones. Perception on risk-laden of deforestation was difficult to adopt in the developing and undeveloped countries where poverty is major burden of the

society. The benefit from logging and land claims which accumulated with natural calamities was already appeared in the whole region but the acceptance to give it up is hard as ecological recovery is the most complicated activities and cost a lot of money.

- **(iv) Navigation channel development: Benefits and Impacts**: This development embeds 3 concepts: navigation and transport service feasible to international trade and tourism (1), optimal use of regulated water flow from the hydropower development in the upstream (2) and, alleviating the intense environmental pressure of downstream communities through economic substitution contributed by oversea trade activities. Even though, the development without critical environmental research has frustrated the achieved plan as many of protest against the project intensifies overtime from the civil societies and downstream communities. Therefore, the destruction of rapid to clear the water channel was temporary ceased before the rapid in Chiang Khon and wait for the new consensus that may allow the project to continue. Impact on fisheries is unavoidable, especially the lost of the mere spawning ground of giant catfish and other large fish species. However, people complain of Mekong water current change with the present boom of strength algae remained for all the time.

5. NATURAL MUTABILITY OF THE MEKONG BASIN ENVIRONMENT

Rather than the benefits and impacts of human-nature interface, the natural mutability of the environment is also a key factor of change such as natural sedimentation and erosion, and population growth.

- **Natural sedimentation:** Natural sedimentation has been one of the greatest environmental concerns during the last decade. Many alleged claims that the Great Lake and a number of inland wetland in Cambodia will be dried up in the near future. The FAO's fishery consultancy group stated in 1992 that according to

acceleration of high sedimentation of the Mekong River the Great Lake will be possibly dried up in one decade. This claim has repeated again and again by extreme naturalist and officials, in order to persuade fund for re-deepening the lake. However, scientific evidence from empirical survey during King Sihanouk regime by Carbonel and Guiscafre (1963) on Hydrology, river morphology and sedimentology of the Mekong River and the Great Lake was clear enough for explaining this natural phenomenon. According to the sedimentological regime from the Mekong Rivers and the surrounding tributaries the Great Lake can be possibly dried up in 1,400 years, if in extreme calculation with additional erosion from its watershed system, it may take at least 500 years. Therefore, pressure from natural erosion is not a vital problem for the inland wetland environment at the present time.

- **Present and future population growth**: It is one of the most logical arguments when talking about environment degradation. MRC, 2004 noted that the population inhabited throughout the Mekong River Basin from Southwest China down to Vietnam has increased up from 55 million to 73 million inhabitants within the period of about 10 ten years time. So it is a remarkable figure to be taking into consideration. In the sense of "population growth, the natural resource decline" the problems and conflicts of resource benefit distribution is the usual case. But if these resources have been taken away on a large-scale base development for one or two parties of the interested stakeholder, the protest for equitable resource benefit re-distribution must taking into account. A real example in Cambodia, Blanc (1958) wrote that Cambodian population were 2.403.000, 2.806.000, 3.046.000, 3.195.000, 3.748.000, 4.074.000, 4.359.000 and, 4.740.000 in 1921, 1931, 1936, 1939, 1948, 1950, 1956 and, 1958, respectively, by which growth rate within 37 years was almost the same in the previous time. These population growth figures already represented threat of intensified exploitation on natural resources overtime that requires a political inputs for improving the administration and management conservation together with

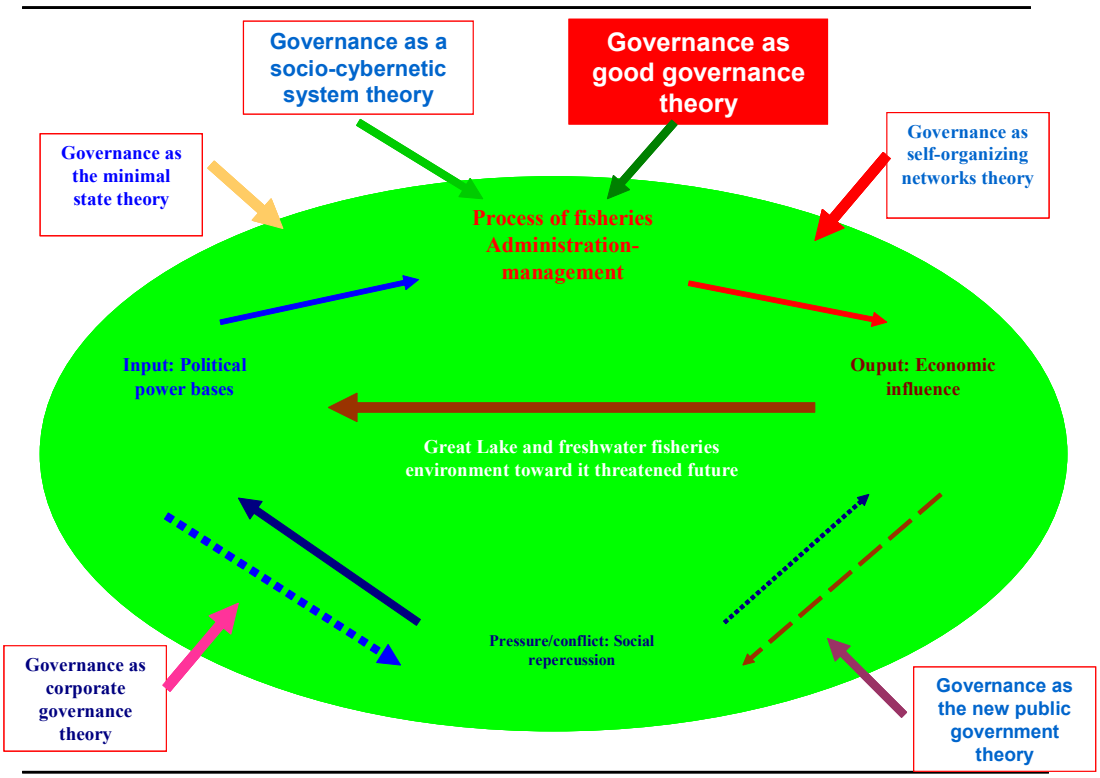
diversification of other job opportunities for alleviating pressure on the limited natural resources.

6. COLLABORATIVE CONCEPTS FOR RATIONAL REGIONALIZATION

Challenging the policies of the world new millennia, a number of regional and sub-regional collaborative projects were initiated and developed to sustain and harmonize the development for achieving the equitable benefit sharing of all stakeholders. The politics of fish, agricultural crop, irrigation, hydropower and other development are more or less opened for deliberately debate among interested groups to find the most rational solution. It is very different from the past experience that the responsible government prepared only it logical response to the question of the proposed development. Logical term in this respect is revenue that state can benefit from each of these activities because for its existence the state needs to maximize national revenues with little consideration on environmental deterioration. The state may compare the official production figure and revenue generated from the fisheries and the economic efficiency of agricultural crop and hydropower. And the decision will prioritize to the most valuable and beneficial outcome for the state. These absolute attitude and behaviour of the state in decision-making are steadily changed into participatory involvement of all interested groups in development decision-making. As result, some mistake development has been modified following the suitable suggestion.

Moreover, at the regional level, many efforts to tie up cooperation among reparian countries are under tough process, in order to create trust and belief among each other. The cooperation is mainly based on economic, trade, tourism, transport development in relation to social, environmental and cultural value, which has expressed into a number of regional projects such as Asia Highway, Asian Railway, Emerald triangle etc. And the Mekong navigation channel project should be taking part with these above cooperation too. Interestingly, these above regional projects were strongly committed by each individual country and international financial institution such as ADB, World Bank etc.

There still have some more bilateral projects are undertaken effectively to help build a fair and reliable transborder development cooperation. However, doubt on inequitable benefit sharing and future impact of large-scale development, especially large hydropower dam are not removable from disadvantageous group of people in the region. In reality, those groups of people may need more than an EIA to ensure their livelihood and social sustainability (see figure 9).



7. CONCLUSION AND RECOMMENDATION

7.1 Individualism in development on natural system relativity in the past created a vicious circle in politic, social, environmental and cultural for generation as in the case of the whole Greater Mekong Sub-region.

7.2 The present solutions initiated by the effort of many interested groups are partially convincible but there need more than that to ensure that the resource benefit can be redistributed on an equitable way.

7.3 Resource lost should be compensated to the less priority group of people and nation and their future should be strongly protected.

7.4 There is need a reliable insurance with full responsibility to all issues around large-scale development rather than an EIA that just only predict the impact without commitment.

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