

2 HYDROLOGICAL REFERENCE SERIES

The hydrological analyses are based on observed discharges, made available by the Ministry of Industry and Handicrafts (MIH), by the Mekong River Commission and by the NTPC.

The information comprises the gauging stations in the Mekong main river as listed below (see small map in Figure 2). In addition, discharge information was available for Xe Bang Fai and Nam Theun at Ban Signo/Thalang. The latter is however a computed series (by correlation with other hydrological information), presented in the NT2 EIA.

Table 1 Hydrological Reference Series

	Name	River	Period	Time Unit	Comment
1	Chiang Saen	Mekong	1950-2000	Monthly	
2	Vientiane	Mekong	1925-2000	Monthly	
3	Nakhon Phanom	Mekong	1925-2000	Monthly	
4	Mukdahan	Mekong	1925-2000	Monthly	
5	Pakse	Mekong	1925-2000	Monthly	
7	Kratie	Mekong	1925-2000	Monthly	Established by correlation with Pakse.
8	Kompong Cham	Mekong	1960-2000	Daily	For calibration of hydraulic model
9	Prek Kdam	Tonle Sap	1960-2000	Daily	For calibration of hydraulic model
10	Neak Luong	Mekong	1960-2000	Daily	For calibration of hydraulic model

The Mekong flow data were examined in order to assess the consistency. It was found that with the exception of Nakhon Phanom (at Thakek) series, there was good consistency between the series. In the case of Nakhon Phanom, since the 1980's the data display a pattern that is likely to indicate sedimentation problems in the gauging station area, which affect the discharge-stage relationship and thereby may give incorrect discharges. To compensate for this, an alternative series was calculated for Nakhon Phanom, based on the correlation with Mukdahan/Savannakhet station shortly downstream.

Discharge data from Luang Prabang were available but discarded because it appeared to have an unrealistic increase towards the late 1990's, so that discharges were larger than downstream Vientiane. This pattern was rejected as erroneous since it was incompatible with data from other stations. It is likely to be associated with sedimentation at the gauging station.

2.1 Hydrological trends in the Reference period 1950-2000

Historical trends in the hydrological data were investigated in order to project historical hydrological records to the scenario period until 2025. In order to project the historical record most correctly, it is important to establish whether observed trends in the historical records can be expected to continue, or opposite are caused by a series of single once-for-all events, such as large dams and large-scale irrigation schemes. Therefore the trend investigation considered three periods:

- 1925-2000 (i.e. the entire observation period)
- 1925-1970

- 1950-2000.

The second period considered, 1925-70, is a period before the major construction of hydropower dams and large irrigation schemes. Trends found in this period would **not** be a result of dams and irrigation. The third period, 1950-2000, is dominated by the period with intensive expansion of irrigation and hydropower constructions. A comparison of trends in the two sub-periods may indicate to what degree eventual trends are related to such water management constructions.

When considering annual Mekong flows in the entire period **1925-2000**, a decreasing trend is found, see Figure 1. This trend is consistent for the gauging stations downstream Chiang Saen on the Lao-Thai-Burma border, i.e. the four stations in Lao PDR/Thailand. For Chiang Saen however, this trend is not seen, meaning that runoff from Yunnan has been constant.

For the 75 years period the decrease is 13-18% of the average flow at the four stations, which is a significant reduction. At e.g. Pakse, the runoff reduction during these 75 years is from an average flow of 10,700 m³/s in 1925 to 9400 m³/s in 2000, i.e. around 1300 m³/s less. The runoff hydrographs are shown on Figure 1.

The fact that Chiang Saen appear to be stable, indicates that the decreasing runoff is caused by factors located mainly in Laos and/or Thailand. Theoretically, the decreasing runoff might be caused by a decreasing rainfall. It is however assumed as a working hypothesis that the long term rainfall is constant.

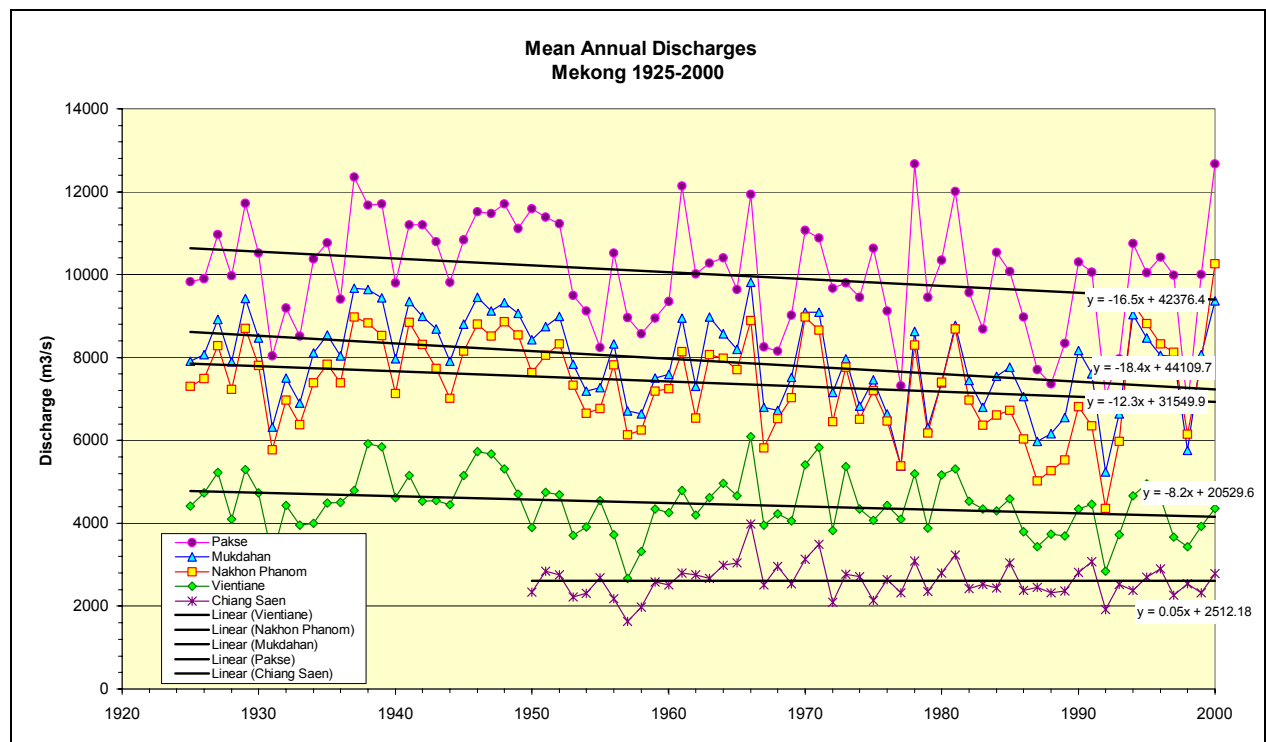


Figure 1 Trends in Mekong Discharges 1925-2000.

When the early sub-period **1925-1970** (45 years) is considered, the decreasing trends are approximately the same as in the entire 75 years period. This sub-period is mainly *before* the construction of large hydropower dams and large irrigation schemes, so it is clear that these constructions cannot be the explanation for the decreasing trend in the early sub-period.

Also the late sub-period **1950-2000** was considered. Again, the trend confirms the trends found from the other periods. The construction of large irrigation schemes was significant in

this period; so if dams and large irrigation had an impact on the annual runoffs, one would expect the trend to be stronger in this sub-period. Since the trends are approximately identical in all periods, it is concluded *that the large water management construction works starting from around 1970 are not the main reason for the decreasing runoff*. It is expected that the cause – if man-made at all - must be found in activities that have been on-going during most of the 20th century.

The conclusion that dams are not the cause to the declining runoffs, can also be evaluated by estimating the possible water consumption from the reservoirs built in the second half of the 20th century. The reservoirs in Thailand have a total surface of around 1000 km², and including Nam Ngum in Lao PDR the total surface area is around 1440 km². Assuming an average evaporation rate of 6 mm/day (or 2 m/year), this water surface can evaporate an equivalent of around 100 m³/s, which is far less than the decrease of 1300 m³/s, which was found for Pakse discharge over the 1925-2000 period.

It should however be noted that the estimated evaporation from reservoir surfaces should be compared with the *natural* evaporation/transpiration from the original land-use prior to dam construction, which would in many cases have been a natural forest. The evapo-transpiration from a natural forest is difficult to estimate accurately and may vary a lot depending on a variety of conditions. However it is important to note that the evapo-transpiration from a forest will often be of approximately same magnitude as an open water surface, due to trees' ability to transpire water from a large leaf area. This is especially true if the forest is evergreen, and thus transpiring also in the dry season. The result of these factors is that the evaporation from reservoirs is likely to differ *less* from the natural pre-dam evapo-transpiration than the above mentioned figure of 100 m³/s. In other words, the figure 100 m³/s as evaporation *introduced by reservoirs* is likely to be exaggerated.

It may be argued that one more important water consuming activity in the Basin is slash-and-burn cultivation. The reason is that the new forest which is regenerating in the fallow areas (which may be 90% of the cultivated area), have a very large water consumption in order to produce maximum biomass, as opposed to mature (say, 30 years old) forest that mainly is surviving and maintaining existence. As shown in the Table 2 below, the forest cover has declined dramatically in Lao PDR, during the last 40 years. Although a large part of the deforestation is due to logging, there is reason to assume that also swidden cultivation has expanded during the reduction of the forest cover. It is therefore possible that deforestation is one of the main factors for explaining the decreasing Mekong flows.

Table 2 Deforestation History and Forecast in Lao PDR in terms Forest Cover (Percentage of he total Surface of Lao PDR).

Period	Forest Cover
Mid 60ies	70 %
Late 80ies	54%
1996	47%
2003	42%
2020	30%

The likelihood of this hypothesis can be evaluated by some simple calculations. According to Table 2, the forest cover has been reduced from 70% to around 45% from the mid-60ies to 2000, i.e. a reduction of 25% of the area of Lao PDR, around 60,000 km². This area should be divided into what has been deforested due to slash-and-burn and what has been deforested due to logging, a distribution that is not well known. It is probably not unrealistic to assume that around one-third of the area is deforested due to slash-and-burn (i.e. around 20,000 km²) and the rest being due to logging.

In the same period the discharge at Pakse has been reduced by around 600 m³/s. These two figures correspond to $600 \text{ m}^3/\text{s} / 20,000 \text{ km}^2 = 1000 \text{ mm}/\text{year} = 2.6 \text{ mm}/\text{day}$. This is a relatively modest water consumption compared to open water evaporation (typically 6 mm/day). It is therefore not difficult to imagine that the observed discharge reduction can be related to the reduction of the forest cover through slash-and-burn.

The above estimations disregarded the water balance of the logged areas. Regrowth in logged areas will to some extent also cause increased water consumption, but the period will be shorter than in slash-and-burn areas, where regular slashing is re-initiating the period with high water consumption. It is however not possible to quantify it more accurately.

In order to reach a firmer conclusion about the reasons for the decreasing Mekong runoff, at least the following should be carried out: 1) a thorough analysis of evapo-transpiration from different forest/vegetation types as well as a study of the actual land-use changes in Lao PDR in the period 1900-2000; and 2) an analysis of long-term trends in rainfall and climate. Such an analysis would have indicated whether the runoff trends were caused by climate changes or rather by land-use changes. This was outside the scope of the CIA study.

2.2 Projected Reference Series

The simulation of hydropower, water balance and hydraulic impacts in Tonle Sap are based on the reference series 1950-2000. It is concluded that mean flows have been declining in the past 50 years or more. It is assumed that this trend will continue. This assumption is based partly on the fact that the processes that have been going on throughout the 20th century are likely to continue (slash-and-burn) for some more decades, even though the Government has a anti-slash-and-burn policy.

A continued declining trend, means that the average discharges in the period 2005-2025 would be around 8% smaller than in the reference period 1950-2000. *The catchment runoffs downstream Yunnan have therefore been reduced by 8%.* The Yunnan runoff has been left unchanged, since no decreasing trend was detected at Chiang Saen. Since the Yunnan runoff was not changed, that leaves the reductions of the Mekong discharges a little less than 8%. The resulting reduction of the Mekong flow at Thakek (Nakhon Phanom), Savannakhet (Mukdahan) and Pakse is around 6%.