ABSTRACT

The present thesis is an approach to the hydrogeography of the relatively unknown Upper Salween River Basin USRB in Yunnan and Xizhang (Tibet) province, China. Because of the few informations available about it, the overall aim of this work is to contribute to the data base and to make known the Salween river and its basin to a broader public. On the one hand, this is done by this present diploma thesis in written form and on the other hand by a web-based presentation of the findings compiled and published on www.salween.unibe.ch.

The USRB has a high relief energy. The highest point is located in the Nianqingtanggula mountains exceeding 7000 m a.s.l. and the lowest point is found near the international border with Burma somewhat below 400 m a.s.l. The overall basin has a mean elevation of somewhat over 4000 m a.s.l. and covers four different climate zones (sub-frigid, temperate, subtropical and tropical) whereby the north-western highland part is marked by predominant continental conditions with dry and cold climate and the south-eastern part in the lowlands is characterized by maritime and warm conditions. However, the planetary circulation of the monsoon with its distinct seasonality affects all parts of the USRB to a greater or lesser extent. The Salween river itself holds hydraulic gradients of up to 5‰ and its mean yearly discharge is 1659 m^3/sec in the lowlands. Unfortunately, it lies more and more in an area of conflict between different stakeholders. On the one hand, there are the plans of the government and hydro-power companies wishing to use the Salween as a source for energy and on the other hand, there are indigenous societies, environmentalists and academics who want to anticipate these plans. This is understandable, the more so as the Salween remains one of the last free flowing rivers in Asia and the world and the basin area in the northwest of Yunnan is a biodiversity hotspot of its own.

The hydrogeographical approach the USRB is based on the four phenomena discharge, precipitation, temperature and potential evaporation which are examined on different time and space scales. The time scales involve hourly, daily, monthly, seasonal (dry season from November to April, wet season from May to October, early wet season from May to June, main wet season from July to August, late wet season from September to October) and yearly dimensions. The spatial scales include the locations of the respective gaging stations, the climate zones in which the station is located and the USRB as a whole. The challenge is not only to link different spatial and temporal scales but in the endeavour to pursue such an approach, it is decisive to match a chosen time scale with the appropriate space scale and vice versa.

The data base of this present work consists of information searched in literature, numerical data of discharge, precipitation, temperature and potential evaporation as well as personal observations made during two field inspections in parts of the USRB carried out in June and September 2004. The data collection and the field inspections took place in collaboration with the Kunming Institute of Botany (KIB) and the Center for Botany and Indigenous Knowledge (CBIK) which are both based in Kunming, Yunnan province, China.

Applied methodology comprised the study of literature that deals with various aspects of the USRB, although the information found is often patchy as it does not relate to the USRB itself but to certain locations in Xizhang or Yunnan province. Data have been handled according to the concept of the *geographic data cube*. This cube spans – precisely accordant to the title of this thesis – the phenomenal, temporal and spatial dimension and helps to structure and approach data in a clear, concise way. After pre-processing the data, descriptive, exploratory and confirmatory statistical methods are applied to calculate central tendency, dispersion and distribution measures. To account for the spatial distribution of the phenomena on various temporal scales, various maps are created. In addition, a digital elevation model (DEM) is used to calculate a hypsographic curve of the basin's elevation and longitudinal section of the Salween river. Methodologies, however, also comprise the planning and carrying out of the two field inspections as well as designing and implementing the web-based presentation of findings.

The presentation of results of the phenomenal, spatial and temporal analysis are subdivided into a part that is mainly literature-based, a part that is based on the field inspection and a data-based part. The main result from literature research is – beside a physical geographical introduction to China, Yunnan and Xizhang – the spatial classification of the USRB into the four above mentioned main climate zones. The most important results from the field inspections are pictures of and around the gaging stations, the description of the landscape in north- and southwest Yunnan with special emphasis on the vertical distribution of vegetation. The most relevant results of the numerical data analysis are on the one hand summary tables of phenomena at certain gaging stations on different temporal scales involving statistical values and the indication of significant linear and Mann-Kendall trends. This is relevant against the background of the ongoing debate on potential effects of human-induced climate change. On the other hand, the numerical data eventually form the basis to create maps. For each of the phenomena, maps are created including the mean value as well as the coefficient of variation (COV) on a certain temporal dimension. Beside these maps which are supposed to visualize the dynamics of the phenomena, climate gradients are calculated to account for the four different climate zones that the USRB covers. Moreover, at each of the gaging station and on all temporal scales, a straightforward multivariate model is created that determines the influence of temperature and precipitation variance on evaporation variance. Generally, evaporation correlates negatively with precipitation and positively with temperature, but temperature and precipitation are afflicted with the problem of colinearity. The model considers this problem and identifies the best predictor for evaporation variance in a stepwise procedure. Also, data of those years are examined during which the number of the lowest and the highest mean values of any of the four phenomena is measured. The ulterior motive is to find out whether selected El Niño events in 1972-73, 1982-83 and 1997-98 had an impact on USRB stations and how the various stations within the basin responded to these events.

Because discharge data was available only to a limited extent, discharge of Salween was analyzed at one station in the highlands (Naqu) and at one in the lowlands (Daojie). While in the highlands snow and glacial melt dominates the runoff production in summer (around 70 m^3/sec by the end of August / beginning of September), the discharge regime in the lowlands can be attributed tropical-subtropical which is dominated by precipitation. The mean yearly runoff coefficient of Salween in Daojie amounts to 85%. The mean yearly discharge of 1659 m^3/sec corresponds to a theoretical mean yearly precipitation amount over the whole USRB upstream of Daojie of around 477 mm. The mean yearly specific discharge of Salween in Daojie is 15 liter/sec*km^2 for the period from 1957 to 2001. A tributary of Salween in the lowlands holds a mean yearly specific discharge of 12 liter/sec*km^2 between 1971 and 2001.

It is found that on certain temporal dimensions, discharge, precipitation, evaporation and temperatures hold significant linear and Mann-Kendall trends. Conspicuous, for example, are the positive trends of temperatures (2.3°C) and precipitation (4 mm or 96%) and the negative trend of evaporation (-30 mm or -27%) between 1958 and 2001 during the dry season in Naqu, a representative USRB gaging station in the sub-frigid semi-arid highlands above 4500 m a.s.l. Significant trends are also observed at stations of the tropical lowlands where, for example, Yongde gaging stations attracts the attention with a decrease of mean yearly evaporation (-431 mm or -23%) between 1957 and 2001. Although it is advised against over-interpreting these trends, the cause of them might most likely be in connection with the emission of carbon dioxide from the transport and industry sector in China. Climate change may ultimately influence the USRB highlands by accelerating glacier and snow melt and have effects on its lowlands by the increased number of tropical rainstorms. Moreover, the analysis of the three El Niño events shows that their effect on the phenomena was irregular and differed considerably as to the four phenomena. 1972-73 may be viewed as the most “typical” event out of these three as it lead to dry conditions with low discharge of the Salween, high temperatures and evaporation amounts and – at some stations – to low precipitation. The precipitation data of the USRB during the event of 1997-98 does not mirror the devastating effects precipitation had in the adjacent Yangkzhe basin.

The spatial analysis of the phenomena reveals that the monsoon circulation is the determining factor for their spatial pattern and distribution. The humid air masses form clouds which considerably influence the amounts of precipitation, evaporation and temperature. Generally, precipitation and temperatures increase from the humid lowlands to the semi-arid highlands, however, these so-called climate gradients are varyingly high or not even significant, depending on what temporal dimension is examined. Mean monthly precipitation during the dry season, proves to have a significant gradient of -0.9 mm as per 100 m ascending altitude while in July the gradient is much higher with -40.6 mm/100 m. Temperature gradients are, as expected, influenced by the topography and increase from the lowlands to he highlands. The gradient in January is -0.70°C/100 m and -0.40°C/100 m in July. Evaporation is a special case to this respect as in January, the gradient is negative with -13.1 mm/100 m and positive in July with 2.8 mm/100 m. The analysis of the evaporation model suggests that in January, temperature is the main factor that explains evaporation variance at highland stations. In July, however, temperature is the best predictor at the stations in the lowlands and precipitation explains evaporation variance best at stations in the sub-frigid highlands. Beside these gradients, the spatial analysis show that the north and the south of the transition area (between highlands and lowlands) have an extremely reverse climate although the topography in both areas is stamped by deep valleys: the north is a “dry island” within the USRB throughout the year (Basu with 258 mm mean yearly precipitation) as it lies on the lee side of the Assam Himalayas. While these mountains receive abundant south-west monsoon precipitation on their southern slope (outside of the USRB), they cause Foehn effects with dry downslope winds on the northern lee side that belongs to the USRB. The southern part of the transition area receives a multiple of the precipitation that occurs in the northern transition area (Gongshan with 1740 mm and Fugong with 1440 mm mean yearly precipitation). The sharp contrast within a relatively short horizontal distance combined with the great differences in altitude certainly accounts for the high biodiversity found in this area.