

STREAM Perfume Vietnam

Updates and analyses

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Contents

Contents	i
1. Background	1
2. Data implementation	3
3. Model results with new data	9
3.1 Climate data inputs	9
3.2 Runoff results	12
3.3 Spatial Discharge and Aridity results	13
4. Conclusions and recommendations	17
References	19

1. Background

In the recent past, several river basin models have been developed by different institutes, which work on different levels of detail and address different “users”. In general, there is a growing appreciation that these models can be useful tools for planning and management, when supported by comprehensive and reliable information. This often is a problem in international river basins, and has therefore led to the development of STREAM, which requires a minimum of input data.

STREAM (Spatial Tools for River basin Environmental Analysis and Management) is developed in response to specific demands for conceptual integrated river basin and coastal management approaches. STREAM is developed around a core of a water balance model. A demonstration on the capabilities of STREAM was shown during the World Water Forum (WWF) – The Hague March 2000. The WWF2000- STREAM CD-Rom provides information on the estimation of the some of the effects of river management interventions in the upper riverine part of the basin, on the down stream - coastal part- of the river basin. STREAM modelling concept is also designed to illustrate the long-term impact of climate change on the functional uses of the river basins of the Rhine, Zambezi and Ganges/Brahmaputra/Meghna.

The concept of STREAM and the different attached modules, have been developed in the past ten years. Applications include the Ganges, Brahmaputra and Meghna (GBM), the Nile, Zambezi, Niger and Rhine basins. These applications created the context and framework for the development of an operational set of modules, which is now available.

This report is the result of an assignment by RIKZ-CZMC and describes the most recent application of STREAM to the Perfume basin in Vietnam. The previous STREAM-Perfume version has been developed in 2001 for the CZM-Centre/RIKZ, using predominantly free available data from the internet. A second edition of STREAM Perfume 2002, also initiated and commissioned by CZM-C, has been developed using new data, which was collected in by the GIS-Department of the Vietnam-Netherlands Integrated Coastal Zone Management project 2000 - 2003.

The present project resulted in the following products:

1. Two new GIS based land use and soil maps of the Perfume basin in Vietnam were acquired. The maps were reclassified and geo-referenced in STREAM format.
2. The new data layers were implemented in the model. Next, the STREAM model was run on the basis of both old model results and external data delivered by Vietnamese meteorological services which was published in the Vietnam VA report # 5., 1995. The STREAM-Perfume model (2001) will be compare with 2002 STREAM results.
3. A report, which describes old and new data layers as well as the consequences of using the new data for the modeling results, including the validation of the river discharges.

The study area of the Perfume basin is depicted in Figure 1.

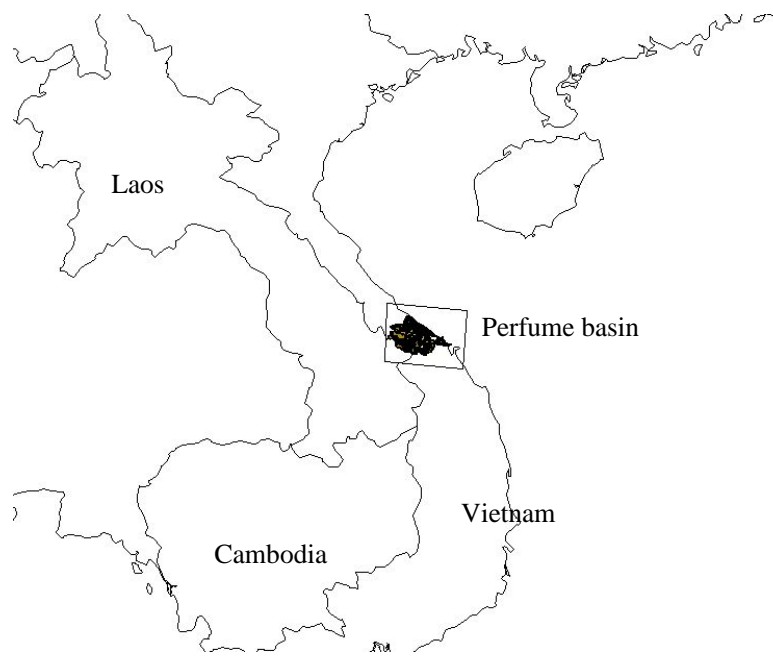


Figure 1 Location of the Perfume basin in Vietnam.

2. Data implementation

A new land use map and soil map was delivered by the GIS department of the Vietnamese-Netherlands ICZM, counterparts in ArcView / GISformat. The ArcView data is stored as polygons, which implies that the data must be converted in raster format, in order to be usable in STREAM.

The following steps are conducted to transform the Arcview data into STREAM compatible data layers. First, the data are imported in Arcview and the legend information is translated from Vietnamese into English. Figure 2a and b shows the results of this operation for both the soil map and land use map.

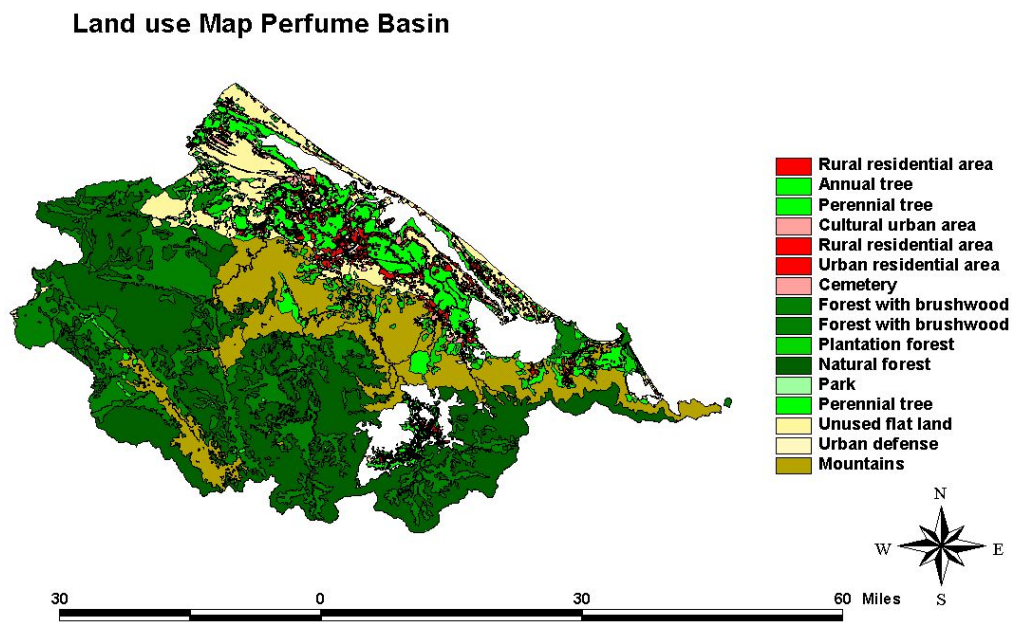


Figure 2a New land use map with legend shown in Arcview format (see Appendix 1 for large map).

Soilmap Perfume Basin

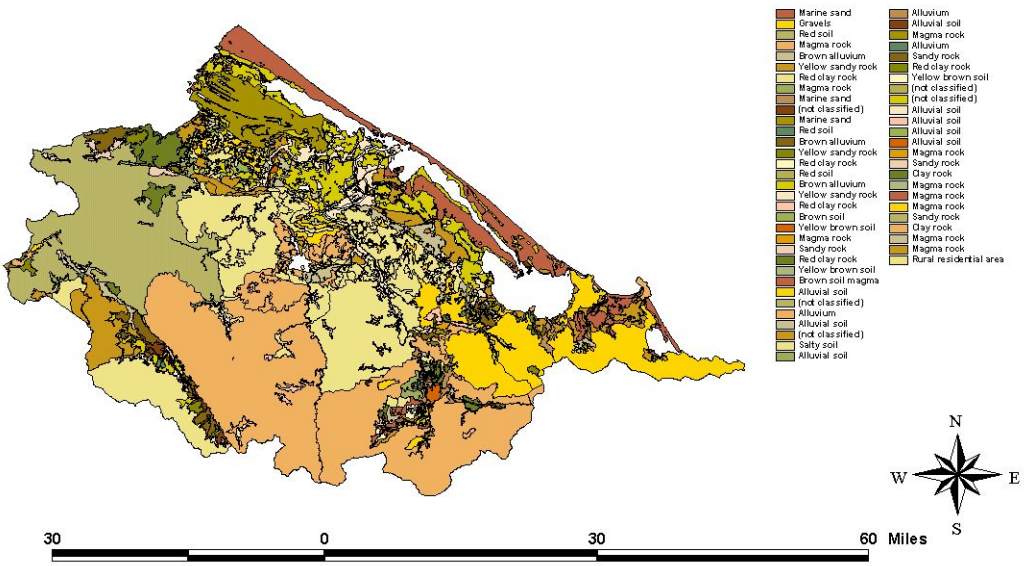


Figure 2b New soil map with legend shown in Arcview format (see Appendix 2 for large map).

Next, these maps are converted in Arcview from polygon to raster format, having exactly the same numbers of rows and columns as the maps that are currently used in the STREAM perfume model. The number of rows is 113 and the number of columns is 162. The surface of one cell is km² in the current model.

Thereafter, the old soil and land use maps are superimposed to see where possibly information is missing. Figure 3a and b shows the missing information in the new soil and land use maps.

Next, the new soil and land use maps are reclassified to the same legend as used in the STREAM model, using Table 1. That is, the soil map is reclassified to a ‘waterholding capacity map’ with values in millimetres. The waterholding capacity value typically range between 50 and 300 mm. The new land use map is reclassified in a cropfactor map, which is used in the model to calculate the potential evapotranspiration. The value for the cropfactor varies between 0.8 and 1.1.

Table 1. Soiltypes and maximum water holding capacity (after Groenendijk 1989)

No.1	Soiltype	Waterholding capacity [mm/m]
0	Rock	50
1	Sand	102
2	Loamy sand	127
3	Sandy loam	161
4	Fine sandy loam	212
5	Loam	271
6	Silt loam	296
7	Silt	305
8	Clay loam	305
9	Sandy clay loam	313
10	Silty clay loam	313
11	Sandy clay	322
12	Silty clay	322
13	clay	330

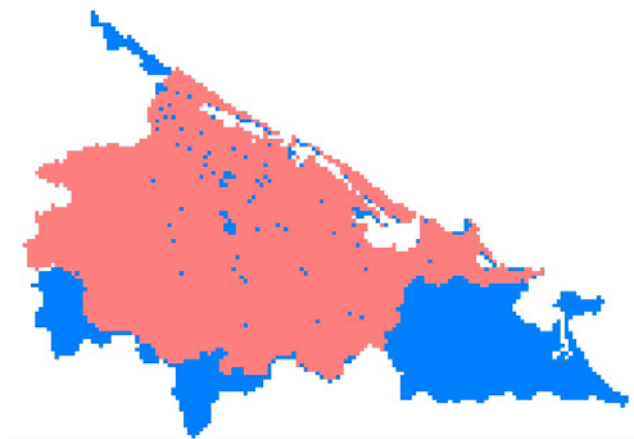


Figure 3a Missing information in the new soil map is depicted in blue. The red colour shows the areas that are covered by the new soil map information.

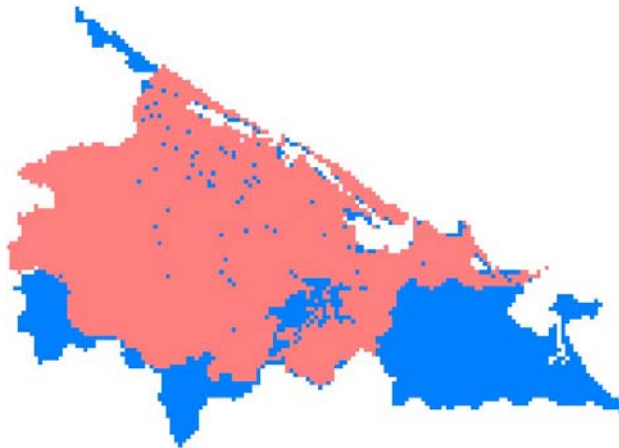


Figure 3b Missing information in the new land use map is depicted in blue. The red colour shows the areas that are covered by the new land use information.

Next, the missing parts in the new water holding capacity map (WHOLD) and the new cropfactor map (CROPF) are filled with old information, which together results in a final new WHOLD (Figure 4) and CROPF map (Figure 5).

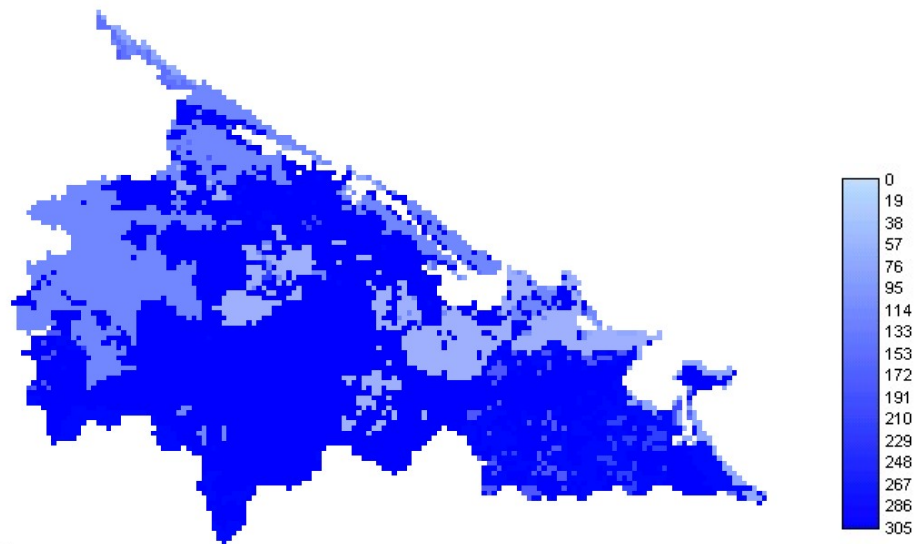


Figure 4 New Water Holding capacity map, with values in [mm / m].

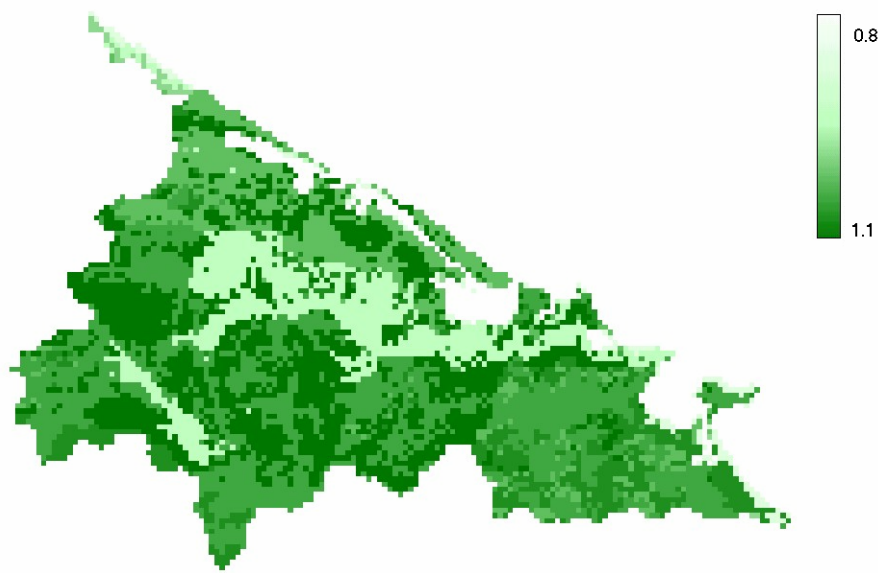


Figure 5 *New Crop factor map, with values ranging from 0.8 to 1.1. These values are used to calculate the potential evapotranspiration.*

3. Model results with new data

3.1 Climate data inputs

This chapter describes the model results using the new input data as presented in chapter 2. The model has been executed using two different climate datasets: (1) climate data of the present situation and (2) climate data for the period 2070-2099. Both data sets are shown in figures 6 and 7, which depict the current and future temperatures as well as current and future precipitation rates per month for the Perfume basin. These are monthly average numbers, which are derived from the IPCC Global data set (Intergovernmental Panel on Climate Change 1996). This data set contains a climate database for the entire world, for both the present situation and future scenarios at a resolution of 0.5 x 0.5 degrees (approximately 50 x 50 km²). The climate change scenarios were based upon predicted climate change by a global circulation model (GCM). These results are freely available through the Internet.

The STREAM water balance model is driven by monthly average climate conditions, such as temperature and precipitation. The IPCC scenario's similarly consist of monthly average precipitation and temperature figures, and are thus relatively easy to implement in STREAM.

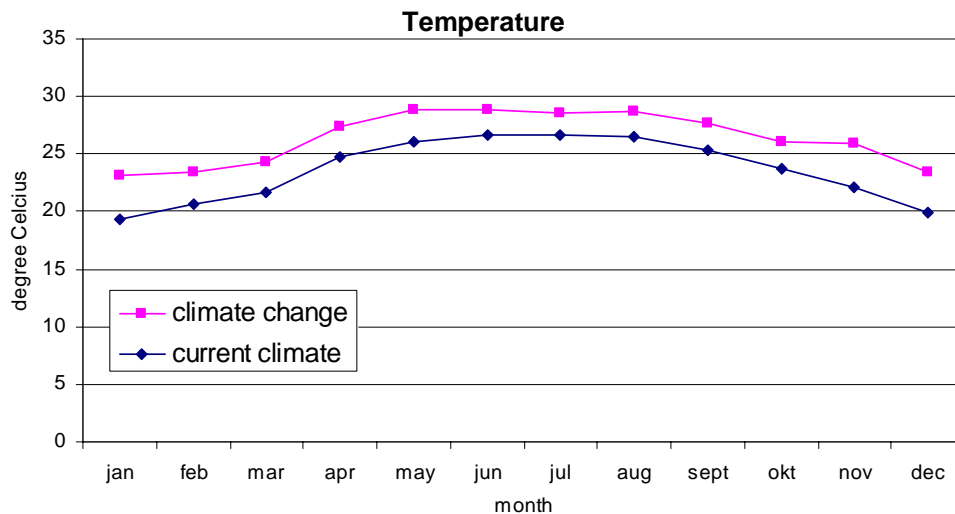


Figure 6 Monthly average temperatures for the present situation, and the situation in the period 2070-2099, as predicted by a Global Circulation Model, for the entire Perfume river basin (IPCC 1996).

Figure 6 shows the differences in temperatures between the current situation and the predicted future climate for the period 2070-2099 (IPCC 2001). It appears that temperatures are approximately 2 to 3 deg. Celsius higher in the period 2070-2099, and temperature changes are expected to be constant over the year

Figure 7 shows the expected precipitation changes in the period 2070-2099. According to these figures, no real differences in precipitation rates are expected. This is, though, in contradiction to some reports by the IPCC, which predict an increase in precipitation in South East Asia. More detailed research on the application of precipitation scenario's is needed.

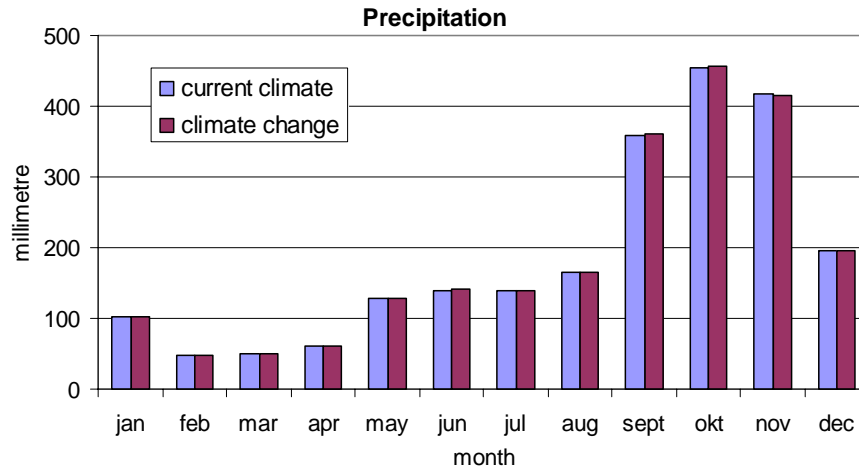


Figure 7 Differences in precipitation rates between the current situation and the predicted precipitation rates in the period 2070-2099.

The changes in temperature and precipitation will result in a change in Actual Evapotranspiration rates. In the STREAM model, moisture will evaporate from the soil rapidly when the soil moisture is near the maximum water holding capacity value. As the soil moisture decreases in spring and summer months, an increasingly greater force is required for evapotranspiration to occur; hence the rate of evapotranspiration from the soil moisture decreases exponentially. The actual evapotranspiration (AET) will equal the sum of precipitation and the absolute change in soil moisture, in the months when a soil moisture deficit occurs. In the months when a soil moisture surplus occurs (soil is saturated with water), the actual evapotranspiration will equal potential evapotranspiration.

Figure 8 shows the change in AET in the period 2070-2099. It appears that AET numbers will be much higher in the period 2070-2099, mainly due to much higher temperatures. Because precipitation numbers seems to remain similar in the future, these higher AET numbers are not compensated by higher precipitation, thus the soil humidity will decrease.

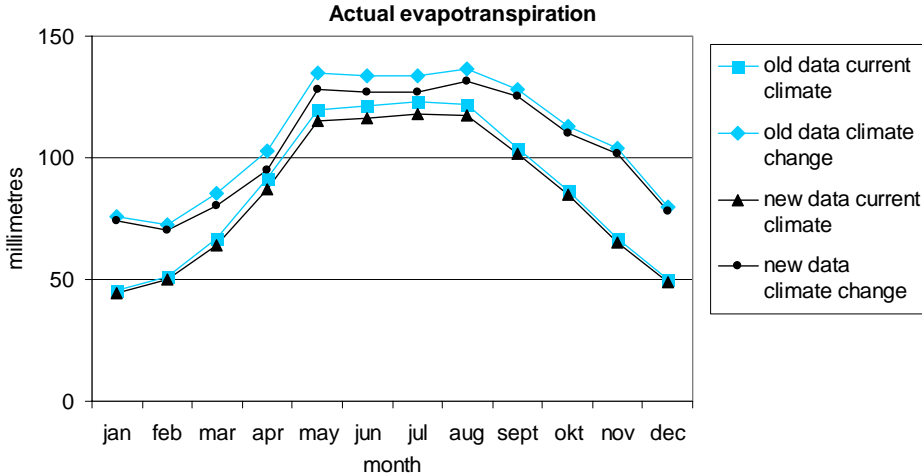


Figure 8 Actual Evapotranspiration rates for the present situation and the period 2070-2099, for the whole Perfume basin.

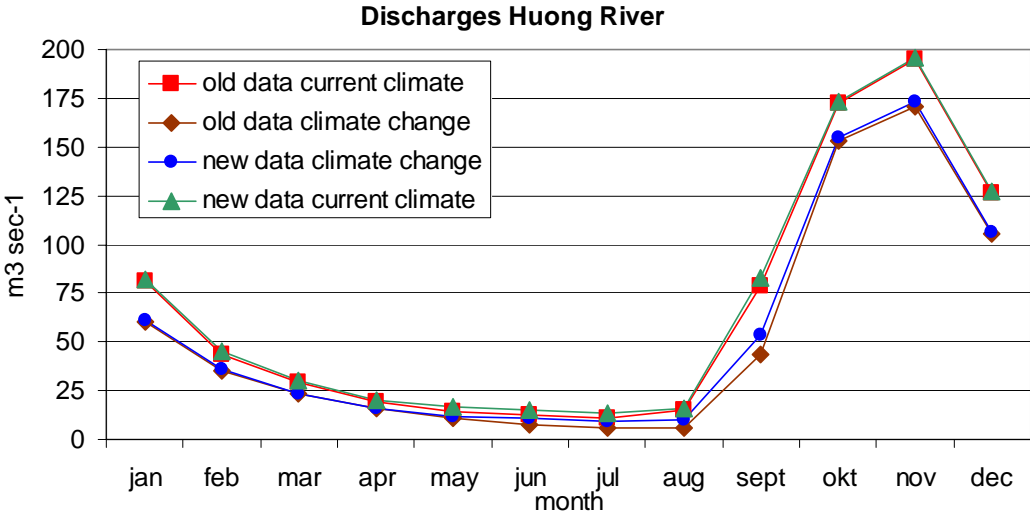
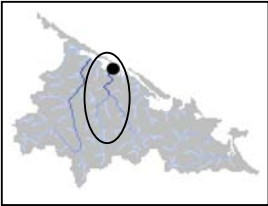


Figure 9 Monthly average discharge curves for Hue in m3/sec, based upon current climate data and a climate change scenario for the period 2070-2099. The black dot in the upper left map shows the location of the modelled discharges depicted in the graph.

3.2 Runoff results

Figure 9 shows the model results for the Huong river at the city of Hue. The model uses both the current climate conditions and the climate change scenario, as well using both the old- and new waterholding capacity and cropfactor maps. It appears that running the model with the new data results in somewhat higher discharge curves. This can be explained by the fact that in general, the average water holding capacity has been lowered through using the new soil map. Hence the new soil map indicates soil types with less water holding capacity. Moreover, the cropfactor map, which was derived from the new land use map, generates higher potential evapotranspiration rates. The impact of climate change, indicate a decrease in run off during peak flow period with 10 to 35%.

Figure 10 shows the validation results of the STREAM model for the Thoung Nhat station, in the upstream Huong river. This was the only station mentioned in the Vietnam VA report (1995), which provided mean monthly average discharge numbers. All the other discharge numbers were either minimum or maximum peak discharges.

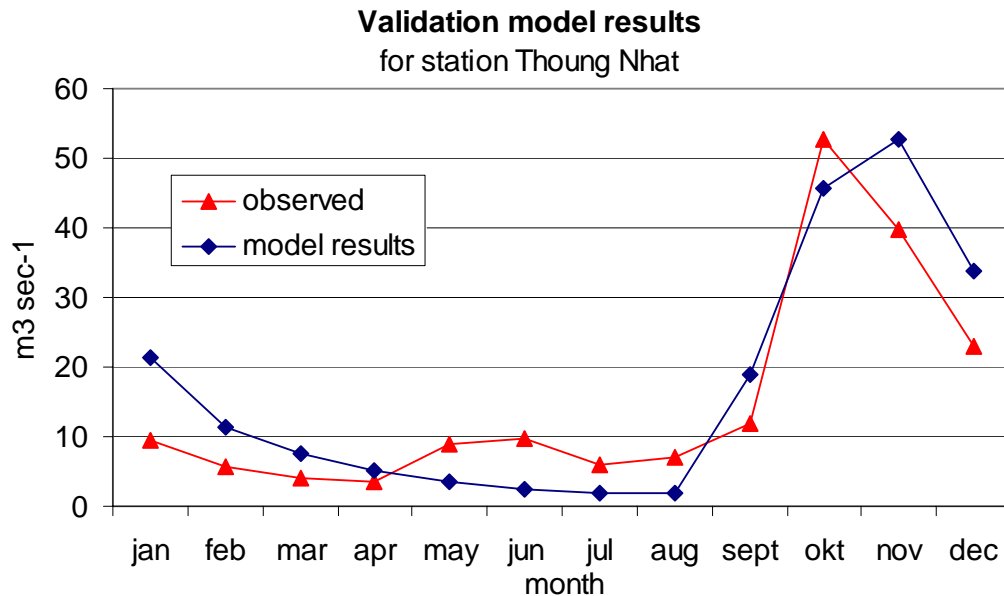


Figure 10 Validation of the model results, using the Thoung Nhat station.

For a reliable validation and calibration of the model, long term mean discharges are needed for low lying locations such as the city of Hue. The discharges provided for Hue in the Vietnam VA 1995 report, however, were not considered as reliable, because the report shows tables with an average peak of 700 m³/sec in November for Hue. These numbers are very well possible for a period of several days, but not as an average for one month.

Table 2 shows why the Hue discharges show some discrepancies. According to the STREAM model, the yearly discharge in km³ per year is about 2.07. If we compare this with the number calculated by subtracting rainfall from our climate database with the AET produced by STREAM, then this calculation results in an annual runoff of 1.85

km³. These two runoff numbers match relatively close, and it can be assumed that the model calculates realistic discharges.

Table 2 Comparison of STREAM model results with results from Vietnam VA report n#5, 1995.

Huong River approximate mean annual water balance			
		millimetres	Total runoff in km ³ /year
STREAM MODEL (IPCC data)	Precipitation	2257.7	3.46
	Actual evapotranspiration	1048.7	1.61
	P – AET	1209.0	1.85
	Runoff by STREAM model		2.07
VA REPORT	Precipitation	2860	
	Actual evapotranspiration	1000	
	P – AET	1860	2.84
	Runoff in Table 5.2.6 (Ta Trach + Huu Trach)		2.76

The yearly runoff numbers, for the whole Perfume basin, provided in the Vietnam VA (1995) report vary from 2.76 to 2.84 km³ per year, which are also close to each other. However, they are significantly higher as compared to the numbers provided by STREAM and the meteorological dataset used by STREAM

It is virtually impossible to reach an annual discharge of 2.76 – 2.84, using the climate data as provided by STREAM. Suppose, the report is correct, then it is expected that rainfall numbers are much higher as opposed to the rainfall data used by STREAM. Compare in this context the total annual precipitation of 2257 mm in Hue used in STREAM to the 2860mm as provided in the Vietnam VA (1995) report.

3.3 Spatial Discharge and Aridity results

Figures 11a and b show discharge maps in m³/sec for the month November. The model uses the new data (WHOLD and CROPF maps, see chapter 1). The two discharge maps in Figure 11 maps are the result of both current climate data and climate data for the period 2070-2099. Comparing the river discharges, a decrease in river discharge can be observed for the for the Huong River (figure 9) during the period of peak flow: September 25%, October 13%, November 12%, December 20% and January 25% under influence of the IPCC climate change scenario used. The indication of decrease in river discharge can also be observed comparing the two maps 11a and 11b.

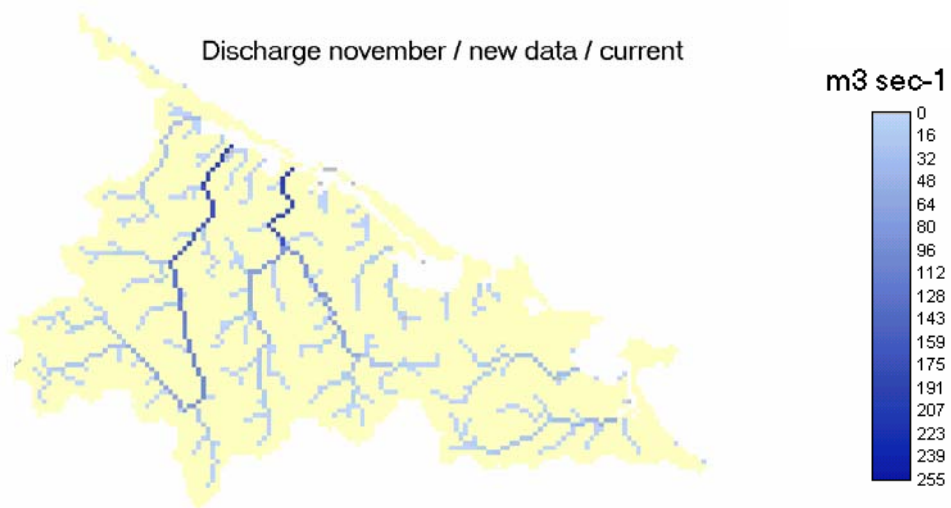


Figure 11a Discharge numbers in November calculated by STREAM using new data and current climate data.

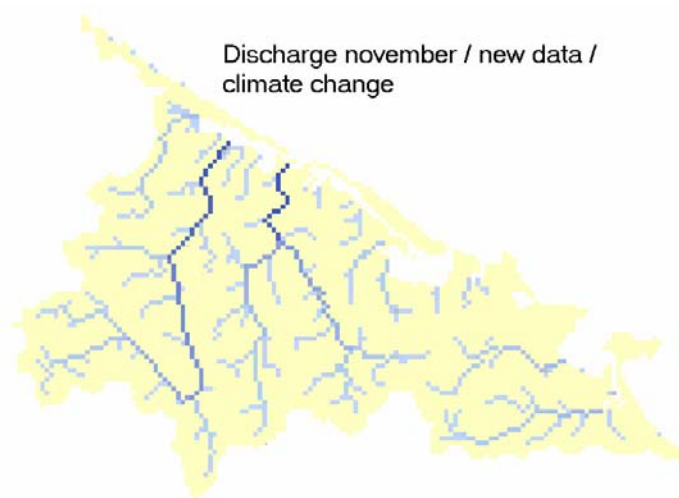


Figure 11b Discharge numbers in November calculated by STREAM using new data and climate change data.

Finally, Figures 12 and 13 show the soil aridity index for the STREAM model results. Figure 12 shows the aridity index for the current situation, for both STREAM results using old data and new data. Figure 13 depicts the aridity index for the climate situation in the period 2070-2099, comparing again STREAM results using old data and new data.

From Figure 12 and 13, it can be concluded that the soil aridity in the Perfume basin has increased, in particular in the southern part, using the new input data. It also shows the low resolution of the climate database, since big squared blocks largely determine the aridity patterns. Also, the aridity appears to be higher under influence of climate change, especially in the middle and North Eastern part of the basin.

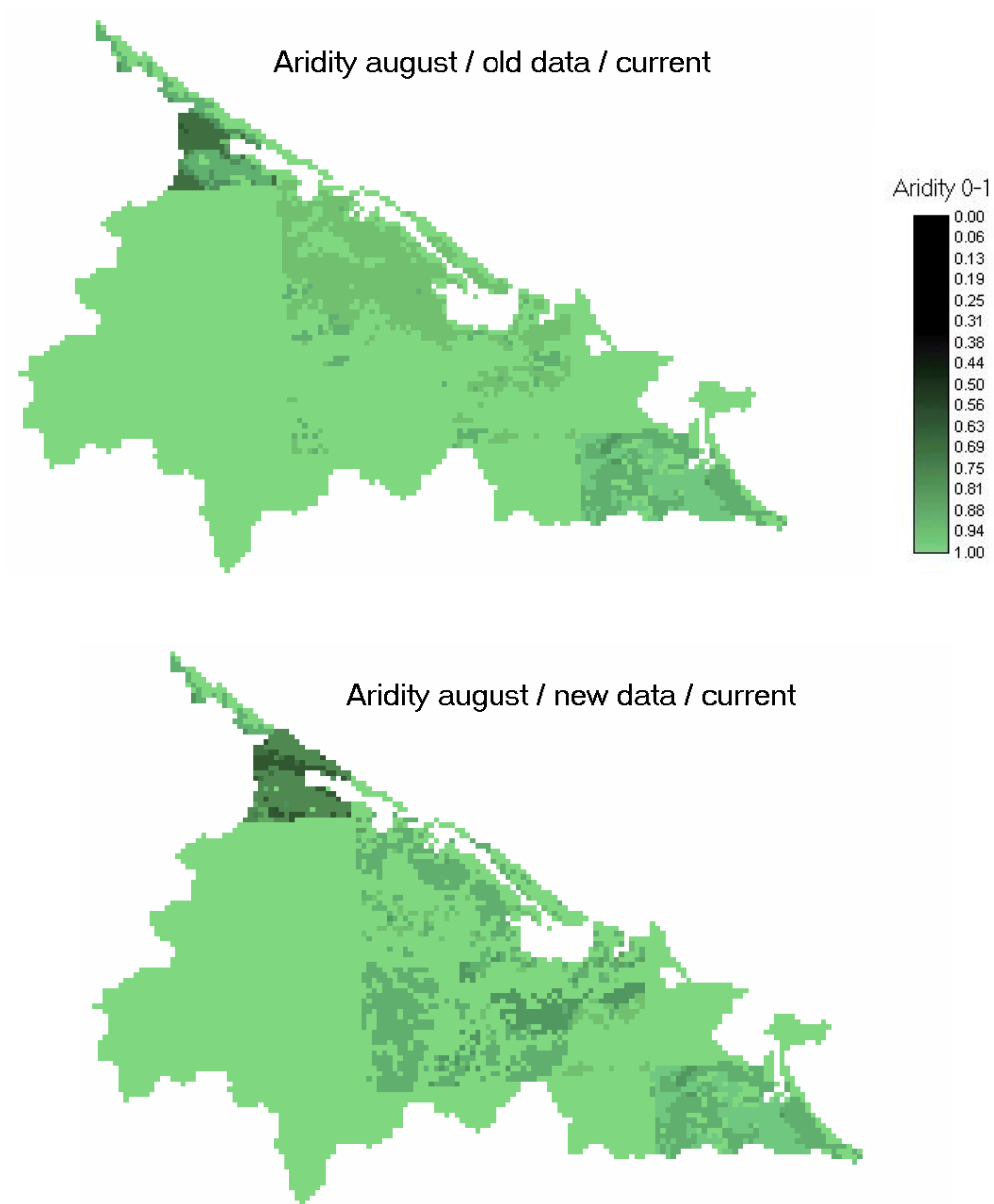


Figure 12 Aridity index for the current climate situation, comparing STREAM results using old data and new data (0 = water deficit, 1 = no water deficit).

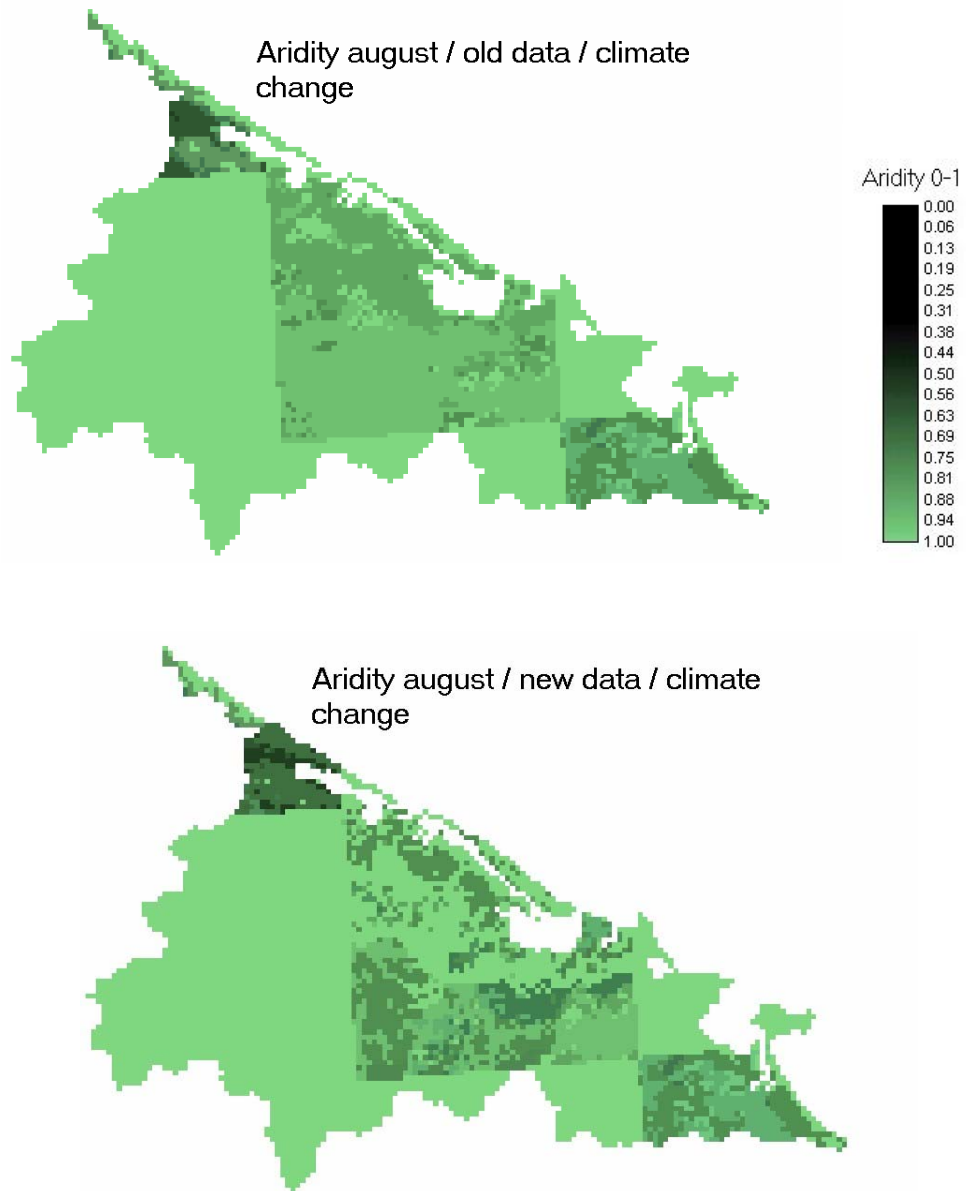


Figure 13 Aridity index for the climate situation in the period 2070-2099, comparing STREAM results using old data and new data (0 = water deficit, 1 = no water deficit).

4. Conclusions and recommendations

The new input data derived from a new soil map and a new land use map, has been successfully inserted in the STREAM model. These two maps were converted in a water holding capacity map and a crop factor map. Efforts have been made to validate the model on the basis of discharge numbers, which are presented in the Vietnam VA report of 1995. Some of these reported data, need further investigation. In general no clear information is given in the report whether these discharge numbers are monthly minimum, maximum or mean values. Better discharge numbers and longer records are needed to improve the reliability of the modelled results

Another recommendation is to update the meteorological data input with more detailed data. Hence, the STREAM model must be remodelled using time steps of one week, in order to better cope with sudden discharge peaks.

In general, both the new datasets as well as the climate data set result in an increase in soil aridity in the Hue catchments, and a decrease of river discharges during peak flow period.

The following summary of recommendations can be given:

Short term CCP activities for the year 2002:

- Rainfall and temperature measurements: monthly, weekly averaged values during many years
- The exact position of rainfall and temperature stations.
- Reliable and long time series of discharge measurements for validation and calibration
- The exact position of the discharge measuring stations
- An assessment of the discharge tables provided in the Vietnam VA report 1995:
 - Where are the gauging stations located?
 - Which numbers are mean monthly values?
 - Recalculate yearly averages.
- A better description of the soil types in the Soil type map recently provided by the VN_ICZM project, in terms of water holding characteristics: a measure for permeability, clay, sandy, etc.
- A spatially more detailed digital elevation model in GIS raster or vector format (better than 1x1 km²) and a good topographical map outlining the river network

Long term (2003 and beyond):

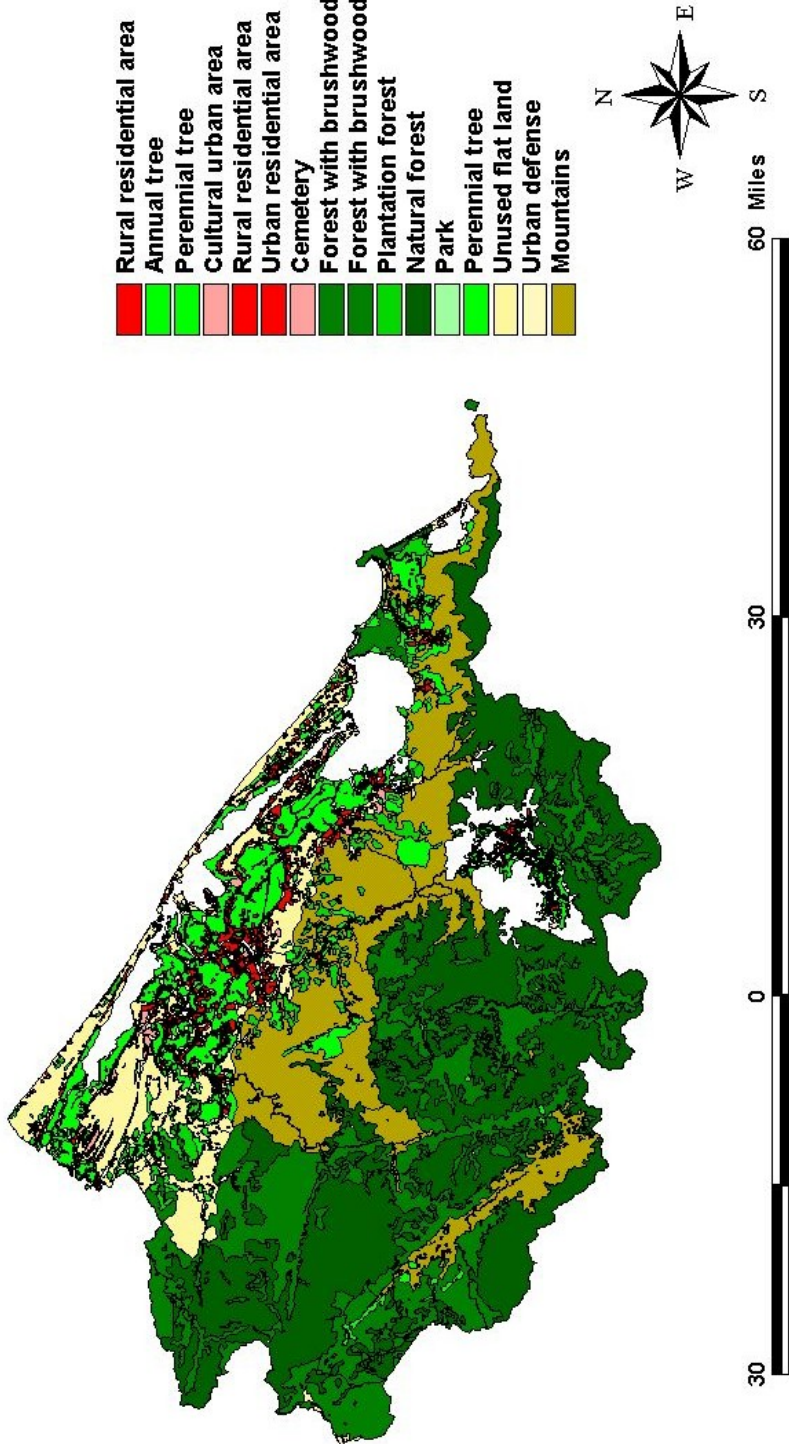
- STREAM results can be used, after serious validation and calibration, as boundary conditions for more detailed lagoon models.
- Implement dam and barrage module in the STREAM model
- First steps in the development of a sediment module in STREAM
- Development of water demand (for agriculture, industry, drinking water and for nature) and water availability maps for the Hue province for the present situation, 2025 and 2050, provided that demographic and economic development scenarios are available.

References

- Groenendijk, H., (1989). *Estimation of the waterholding-capacity of soils in Europe. The compilation of a soil dataset*. Simulation Report CABO-TT nr. 19. A joint publication of Centre for Agrobiological Research, Dept. of Theoretical Production Ecology (Agricultural University) and International Soil Reference and Information Centre (ISRIC).
- IPCC (1996). *Global Climate Dataset*. Online at <http://ipcc-ddc.cru.uea.ac.uk/>
- Vietnam VA (1995). *Vietnam Coastal Zone Vulnerability Assessment and First Steps Towards Integrated Coastal Zone Management*. Report no.5. Pilot study flooding and lagoon management Thua Thien Hue Province.

Appendix I. New land use map

Land use Map Perfume Basin



Appendix II. New soil map

Soilmap Perfume Basin

