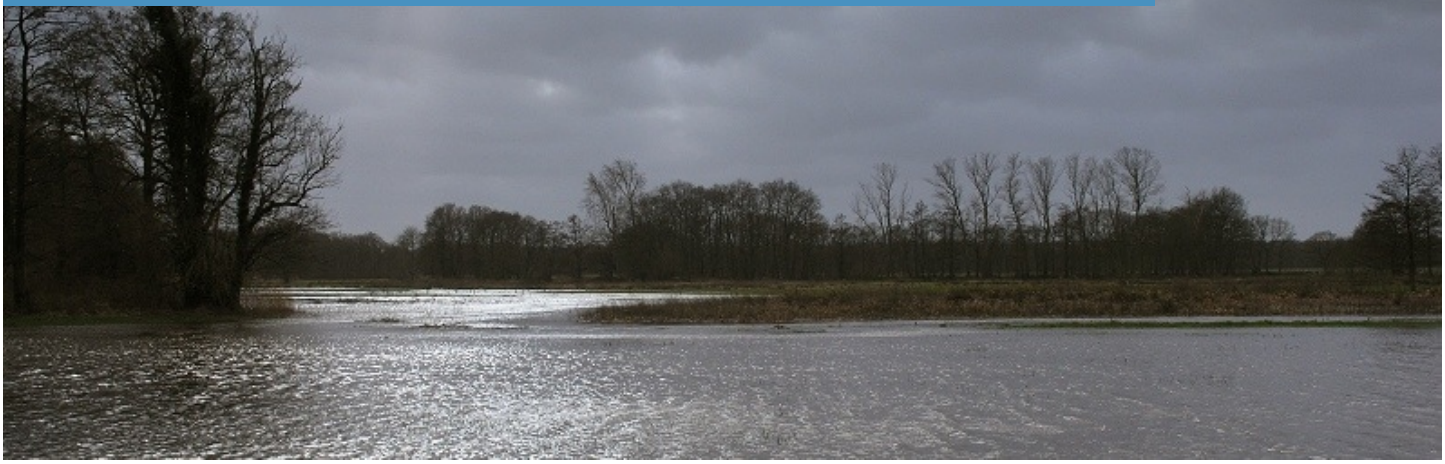
B.Sc. Thesis: International Land and Water Management



Reducing the vulnerability of crop production to extreme weather events in the Drentsche Aa Catchment Area

By

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June 2013

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Preface

This thesis is submitted in partial fulfillment of the requirements for Land and Water Management Bachelor's Degree in Van Hall Larenstein University of Applied Science for both authors. It contains work that has been done from March to August in 2013. Our supervisors are Mr. Piet Groenendijk and Mr. Robert Smit in Alterra, Wageningen UR, and Mr. Dennis de Jager in Van Hall Larenstein University of Applied Science. The thesis has been made solely by the authors, however, some of the text is based on the research of others, and we have provided reference to these sources.

Writing this thesis has been interesting since it is very relevant to our study and it provides us a much boarder view on the impacts of climate change. In addition, it is worth to be mentioned that our ArcGIS and Microsoft Excel operating levels have been improved as well. Since the thesis is written as the final thesis for Land and Water Management Bachelor Degree, the text primarily aims at the teachers and students of the Land and Water Management course in Van Hall Larenstein University of Applied Science, but we wish it would be also interesting for general environmentalists and natural scientists.

We would like to express our deepest appreciation to all those who provides us the possibility to complete the Bachelor thesis. A special gratitude we give to Mr. Piet Groenendijk and Mr. Robert Smit, who offered us the opportunity for our thesis writing and gave us great help alongside the entire process. Furthermore we would also like to acknowledge with much appreciation to Mr. Dennis de Jager, whose contribution in stimulating suggestions and encouragement, helped us to coordinate our project especially in writing this thesis.

Furthermore we would like to acknowledge much appreciation to Mr. Peter Groenhuijzen, who helped us to build up the research question and the general structure of the Plan of Approach. We would also like to thank Mr. Harry Massop and Mr. Jan Roelsma, who provided us numerous helpful data and maps that requires for modeling. In addition, the guidance and support received from all the members who contributed and who are contributing to this thesis, was vital for the complete of the thesis. We are grateful for their constant support and help.

Table of Content

Summary

The thesis investigates the vulnerability of the crop production towards extreme weather events in the Drentsche Aa Catchment Area in the future 30 years (From 2085 to 2115) and attempts to find the best solution for dealing with the vulnerability. The main method that has been used is literature study and the main instrument is the SWAT (Soil and Water Assessment Tool). The thesis started with literature reading and trial processing of SWAT model in early March 2013. The thesis proceeded orderly via model setting up, running, calibrating, and results analyzing. The main finding of the thesis is that for the crop production at the Drentsche Aa Catchment Area, there is a certain degree of risk to be impacted by peak surface water flow at present. While accompanying with the climate change and due to the climate variability, this kind of risk will become mitigatory without artificial interventions. However, the decrease of the risk doesn't mean there will be no risk anymore. Measures are still need to be taken in case of emergency. Three measures have been come up with in the thesis, but after the evaluation of these measures, it has been found that the effectiveness of the measures is very limited.

1 Introduction

People's desire to resolve the world hunger problem, or to be able to feed the world and help alleviate the suffering associated with it, is always being heard. Indeed, the world hunger is becoming an increasingly concerned issue nowadays due to many correlative reasons. Addressing the world hunger problem is an intricately combination of solving problems of natural disasters, technical restrictions, political conflicts, poverty, etc. However, there is no doubt that food and agriculture are essential for the solution. To be more simplified with food and agriculture, the world crop production is a representative signal and its worth to be investigated. "Despite tremendous improvements in technology and crop yield potential, food production remains highly dependent on climate, because solar radiation, temperature, and precipitation are the main drivers of crop growth. Plant diseases and pest infestations, as well as the supply of and demand for irrigation water are influenced by climate (Iglesias et al., 2001)."

"Crop production is generally determined by prevailing environmental conditions, i.e. by the existing complex of physical, chemical, and biological factors (Feddes et al., 1978)." The study fastens on assessing the vulnerability of crop production to extreme weather event, which is one of the most essential and unpredictable aspects within physical environmental conditions. "Extreme weather events, which occur in every agricultural region of the world, cause severe crop and livestock damage (Iglesias et al., 2001)." To investigate this topic, the Drentsche Aa Catchment has been chosen as the case study area.

The Drentsche Aa Catchment Area is an important landscape located between central Drentsche and the suburb of the city Groningen. The land cover types within the catchment area are mainly natural land (Including wetlands, forests, grassland), agricultural land (Silage maize) and residential land. It is assumed until recently that there was a natural balance between arable land, the hay land, the numbers of livestock and the area of the health for grazing.

However, accompanying with the changing of rainfall pattern and the increasing of extreme weather events caused by climate change, the natural balance of Drentsche Aa Catchment Area becomes more vulnerable to waterlogging than before and agricultural lands within the area might have a certain degree of probability of being inundated during extreme weather conditions. As a consequence, it is necessary and helpful to build up a SWAT (Soil and Water Assessment Tool) model and to analyze different scenarios by inputting existing data into the model for the Drentsche Aa Catchment Area.

The objective of the thesis is to distinguish what types of extreme weather events and to what extend that the crop production in the Drentsceh Aa Catchment is vulnerable to. And subsequently to find the most feasible measures to ensure the safety and stability of the crop production within the Drentsche Aa Catchment Area. To clarify the objective, the main research question has been established as: What is the most feasible measure to cope with the vulnerability of crop production towards extreme weather events in the Drentsche Aa Catchment Area? In order to answer the main research question, three sub-research questions have been defined as follows:

- What types of extreme weather events is the crop production in the study area vulnerable to?

Through the analysis of different scenarios, which generated by SWAT model, the exact extreme weather events, which the crop production in the Drentsche Aa Catchment Area is vulnerable to, have been defined.

- What are the possible measures that can be developed to mitigate the defined vulnerability?
- What is the most feasible measure that targeted to the crop production in the study area among all the possible measures?

Furthermore, in order to deal with the defined vulnerability, the study primarily aims at discovering possible measures, and following with confirming the most feasible one by taking multi-criteria decision analysis into consideration to evaluate, and ultimately to ensure the safety and stability of the crop production within the study area.

The methodology that has been used in the thesis is mainly the SWAT model (Soil and Water Assessment Tool). The reason the SWAT program is suitable to our study is because the SWAT model "was" specially "developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long period of time (Neitsch et al., 2009)." Which is exactly what the thesis is investigating about for the Drentsche Aa Catchment as a whole watershed.

There are five chapters following on the Introduction. Chapter 2 provides the detailed descriptions of the study area, the Drentsche Aa Catchment, including geography, climate, history, and current situation of land use information. In Chapter 3, you can find the sources of materials and the methods (mainly SWAT model) that have been used during the study. Chapter 4 comprises the analysis of SWAT model output files, scenario analysis, and model performance assessment. Chapter 5 offers the possible measures based on the output analysis in previous chapter as results. The evaluation of these measures and discussion of the results can also be found in this chapter. Chapter 6 gives the conclusion of the study by answering the research question that has been established in this chapter. Chapter 7, which is the last chapter, describes the restrictions of the study and gives recommendations for future investigation. Besides, the Reference list and the APPENDIXs are being attached at the end of the thesis.

2. Site description

As it described in the previous chapter, our study area is the Drentsche Aa Catchment Area. It is located between central Drentsche and the suburb of the city Groningen. It is a special and unique landscape among the areas in the Netherlands. And it is regarded as one of the most valuable landscapes of unspoiled sandy soil landscape in the whole Northwest European low lands and distinctive example of a pristine stream catchment. "The area of Drentsche Catchment is approximately 228 km^2 and it runs from its highest point (27m above MSL) near Grolloo to its lowest point (0m above MSL) in Groningen (Padt, 2007)." The land cover within the area is mainly natural land (Including wetland and forest), agricultural land (Maize, potato, cereal, etc.) and residential land.

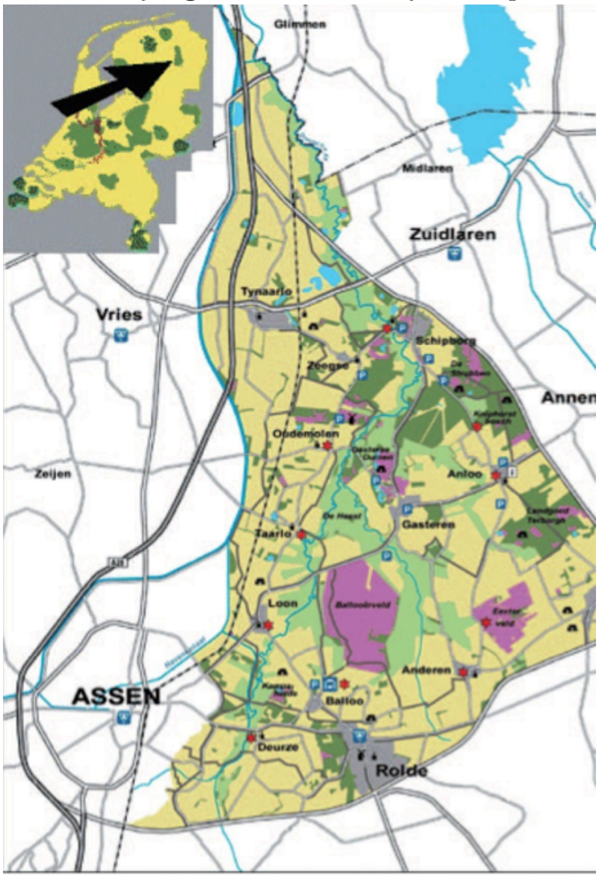


Figure 2.1 The Location of Drentsche Aa Area (S. Van Bommel, N. Röling, N. Aarts and E. Turnhout, 2009)

In addition, a large amount of the land in the study area was designated as national landscape in 2002 due to its outstanding culture and natural values. There are many streams and lowland brooks flow through the Drentsche Aa Catchment Area, each with its own headstreams and catchments. These streams formed a meandering course through the broad, peaty valleys. The streams within the Drentsche Aa Catchment Area's hydrological system are fed up by seepage, which initially comes from the ice-pushed ridges on the border of the catchment area, and also from precipitation. The seepage also contributes to an abundant flora in the catchment area. The annual precipitation of Drentsche Aa

Catchment Area is fluctuating between "553mm to 1088mm" with an average of "824mm", meanwhile, the reference potential evaporation can vary from "447mm to 615mm" (Padt, 2007). The annual discharge of the Drentsche Aa Catchment Area ranges from "118mm to 435mm" (Average "264mm") (Padt, 2007). Figure 2.2 and figure 2.3 provides the overall impression of average monthly precipitation of the Drentsche Aa Catchment in the last 30 years.

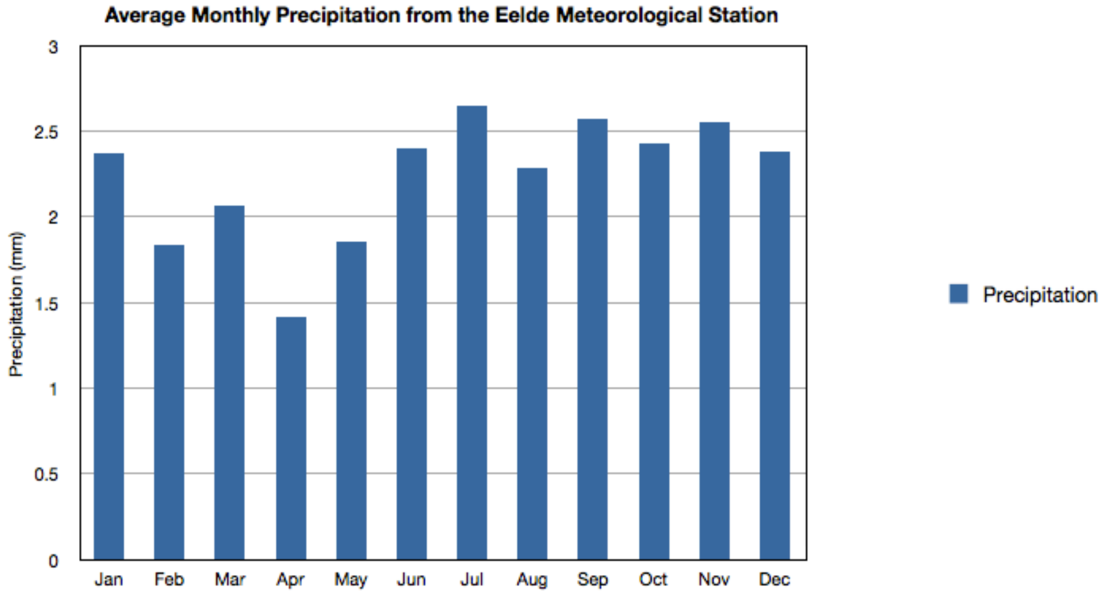


Figure 2.2 Average monthly precipitations from the Eelde Meteorological Station (1981-2010)

3 Materials and Methods

3.1 The sources of materials

During the establishment and analysis of the SWAT model for the study area, several input files and relevant data were requested. The model starts with loading the DEM (Digital Elevation Model) file for the Drentsche Aa Catchment. 'A Digital Elevation Model is a digital cartographic/geographic dataset of elevation in x,y,z coordinates (USGS Website).' In this case, our tutors in Alterra, Wageningen UR provided the DEM file for the study area from their previous project. The land cover, soil, and slope information is also required by SWAT model. The same with the DEM file, the information is provided from the tutors' previous project regarding the Drensche Aa Catchment Area. Besides those, Meteorological information is crucial since SWAT requires detailed meteological information as input data for weather data. The weather input data was completed by manually entering precipitation, maximum, minimum temperature, solar radiation, relative humidity, etc. into the database. These meteorology data was collected from the four meteorology stations within or close to the study area (The detailed information of the meteorological stations can be fond in Chapter 3.4.3).

3.2 SWAT hydrological model

To investigate the vulnerability of the crop production in the Drentsche Aa Catchment Area to extreme weather event, SWAT model was used. "SWAT", which is the acronym for Soil and Water Assessment Tool, "was developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long period of time (Neitsch et al., 2009)." Despite the complexity, water balance is the driving force behind everything that happens in the watershed no matter what are the exterior problems dealt by SWAT. And the hydrological cycle as simulated by SWAT, whose fundamental principle is the water balance to conform what is happening in the watershed, is based on the water balance equation:

$$SW_t = SW_0 + \sum_{i=1}^{t} (R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw})$$

Where SW_t is the soil water content (mm), SW_0 is the initial soil water content on day 1 (mm), t is the time (days), R_{day} is the daily precipitation (mm), Q_{surf} is the amount of surface runoff (mm), E_a is the evapo-transpiration (mm), ω_{seep} is the amount of water entering the unsaturated zone (mm) and consists of the infiltration rate minus the net percolation losses, and Q_{gw} is the amount of return flow (mm) (Figure 3.1).

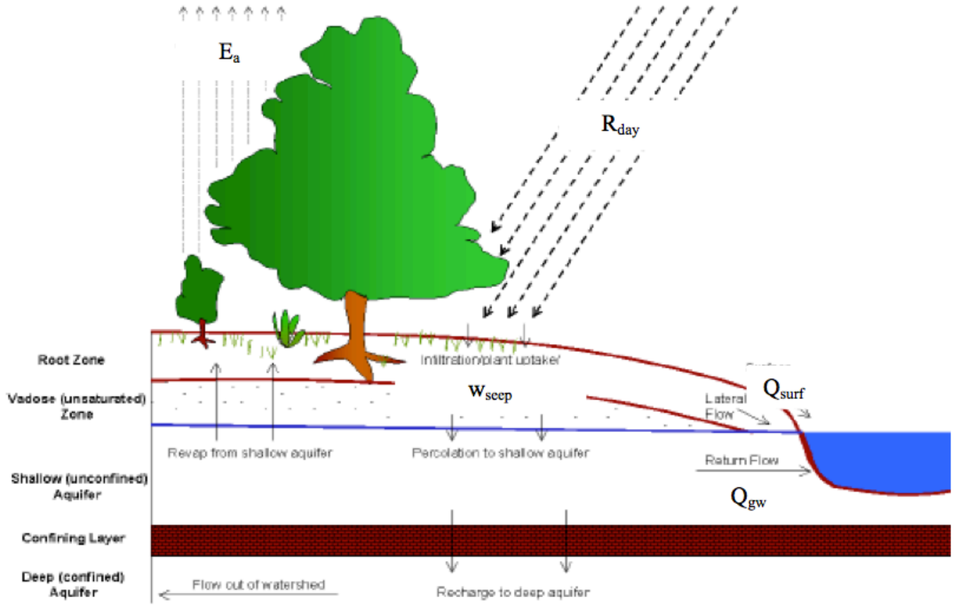


Figure 3.1 Schematic representation of the hydrologic cycle (Neitsch et al., 2009)

Simulation of the hydrological character and process for a watershed by SWAT model can be divided into two phases, the land phase and the water or routing phase. There into, the land phase controls water quantity and sediment movement, while the water phase takes charge the movement of water in the catchment.

According to the size of the catchment area and the number of tributaries within it, SWAT model divides the entire catchment into multiple sub basins. In this case, the Drentsche Aa Catchment has been divided into 23 sub basins due to its size and stream network system. Furthermore, the sub basin is sequent divided into multiple hydrologic response units (HRUs), which are 130 in this case. The division is based on the differences in soil type, land use, and slope, but it always within the hydrological boundaries (Watershed). The details of the HRUs are in the HRUs report in Appendix 1. "The advantage of defining HRUs is that it increases the accuracy of the predicted loadings from catchment and gives a better description of water balance for each individual HRU, as it has no interaction with other HRUs (Neitsch et al., 2009)." For each HRU, four storage volumes represent its water balance: snow, soil profile ("0-2m"), shallow aquifer ("2-20m") and deep aquifer (">20m") (Neitsch et al., 2009). Each HRU in a sub basin is liable for water and sediment movement, nutrients and pesticides loadings that are routed through channels, ponds and reservoirs towards the watershed outlet.

3.3 SWAT Water Balance Components

3.3.1 Surface runoff

The SWAT model provides two approaches to estimate surface runoff; the SCS curve number method (USDA SCS, 1972) and the Green & Ampt infiltration (1911) method. The SCS curve number method was used in this study, because this method estimates the surface runoff as a function of the soil's permeability, land use and antecedent soil water conditions. It provides an accordant basis for estimating the amount of runoff under varying land use and soil types, and is easy to use when the land use is known. The SCS curve number method estimates surface runoff based on daily precipitation via using original abstractions and a retention parameter.

3.3.2 Evapo-transpiration

The SWAT model estimates values of the actual evapo-transpiration from soils and plants separately. Evapo-transpiration is the amount of evaporation from rivers, lakes and bare soil and the transpiration from vegetative surfaces. The actual evapo-transpiration is calculated by using the potential evapo-transpiration (PET); the PET is the volume of water that can be evaporated and transpired if enough water is available.

The daily PET can be estimated by SWAT through three different methods: Penman-Monteith, Hargreaves or Priestley-Talor. The different methods all require different amounts of inputs; data of relative humidity (-), solar radiation (MJ/m2/day), wind speed (m/s) and air temperature (ºC). In this study, the Priestley-Taylor method was used to calculate the daily PET; due to lack of the availability of daily meteorological data. The actual evapo-transpiration is the sum of soil water evaporation and transpiration by vegetation; soil water evaporation is estimated by using exponential functions of soil depth (mm) and water content (-), transpiration is simulated as a linear function of the PET and leaf area index (LAI (-)). The value for transpiration is the amount of transpiration that will occur on a given day when the plant is growing under its ideal conditions. The actual amount of transpiration may be less than this due to lack of water in the soil profile or nutrient deficit (Neitsch et al., 2011).

3.3.3 Soil-water interaction

The movement of water through the soil can be along various pathways; removal from the soil by evaporation or plant uptake, percolation, or lateral movement in the profile. The lateral movement through the soil is calculated by the kinematic storage model, which provided by Sloan et al. (1983). This model simulates two-dimensional subsurface flow. The SWAT model uses the storage routing methodology to calculate percolation for each soil layer in the profile.

3.3.4 Groundwater

The SWAT model incorporates shallow and deep aquifers. The shallow aquifer water balance consists of recharge entering the aquifer, groundwater flow, and the capillary rise into the vadose zone in case of low moisture contents there. It is worthwhile to be noticed that these flows are very much soil type dependent. The deep-water aquifer water balance consists of percolation from the shallow aquifer into the deep aquifer and the amount of water removed from the deep aquifer by pumping. The SWAT uses different empirical and analytical techniques to account for all these components of the ground water distribution (Neitsch et al., 2011). Water routing in the SWAT model conducted by using the Muskingum-Kunge routing (Chow et al., 1998) method provided by SWAT, which is a variation of the kinematic wave equation.

3.4 Data Processing

Data required by SWAT model for analyzing were gathered from the Drentsche Aa Catchment. And the collected data are mainly secondary data, which gathered from the meteorological stations within the catchment and the research center. However, the data have been calculated and modified by us to fulfill the requirements of SWAT model. Each step of model processing requires different types of data.

3.4.1 Watershed delineation

After setting up the initial project by ArcSWAT, the watershed ought to be delineated. "The Watershed Delineation carries out advanced GIS functions to aid the user in segmenting watersheds into several "hydrologically" connected sub-watersheds for use in watershed modeling with SWAT (Winchell et al., 2007)." In this step, the DEM file, which contains the basic data, including elevation, etc., is required. Since the DEM file has been successfully processed, the stream definition has been activated; in this section of watershed delineation, the initial stream network and sub-basin outlets are defined. There are two different alternatives to complete this section, using the DEM-based watershed dataset or using the pre-defined watershed and stream dataset. The pre-defined stream dataset is offered by the tutors, which comes from their previous project, while the DEM-based dataset is generated by SWAT based on the DEM file, which has been loaded in previously section. The extent of the stream network can be set manually via inputting the minimum size of sub-basin. In this case, 500 hector are being chose. The comparison of two alternatives is demonstrated in figure 3.2.

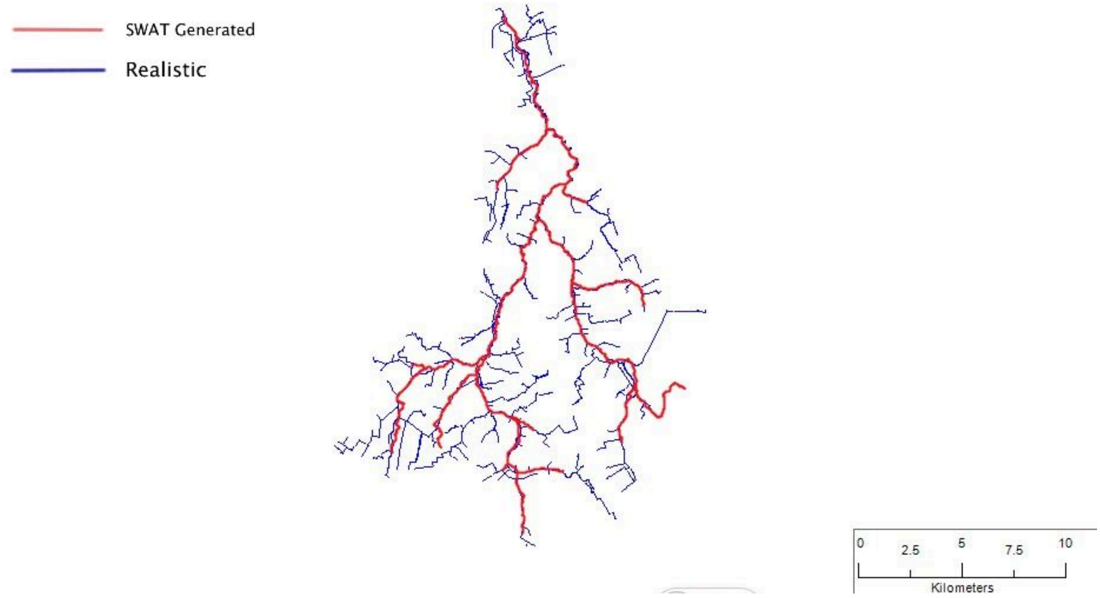


Figure 3.2 The comparision of SWAT generated and realistic stream networks

From the comparison, there are few slight differences can be found in the two alternatives, which are neglectable by SWAT. So the DEM-based stream dataset has been chosen for our project. As soon as this section finished, the streams and outlets within the Drentsche Aa Catchment Area have been created. The created outlets will be selected in the next section, watershed outlets definition and selection, which will be done by SWAT automatically. The last section for completing the watershed delineation is the calculation of sub-basin parameters, which has also been done by SWAT at backstage.

3.4.2 HRU Analysis

As mentioned in previous part of the report, HRUs are multiple hydrologic response units, which has been divided based on the land use, soil, and slope condition. In order to start this step, the custom dataset need to be input first, since the study area is out of the United States. The required data contains land cover data, soil data, and slope data, which share the equal importance for HRU analysis. The land cover and soil types are demonstrated in figures 3.3 and figure 3.4. The detailed information can be found in Appendix 2.

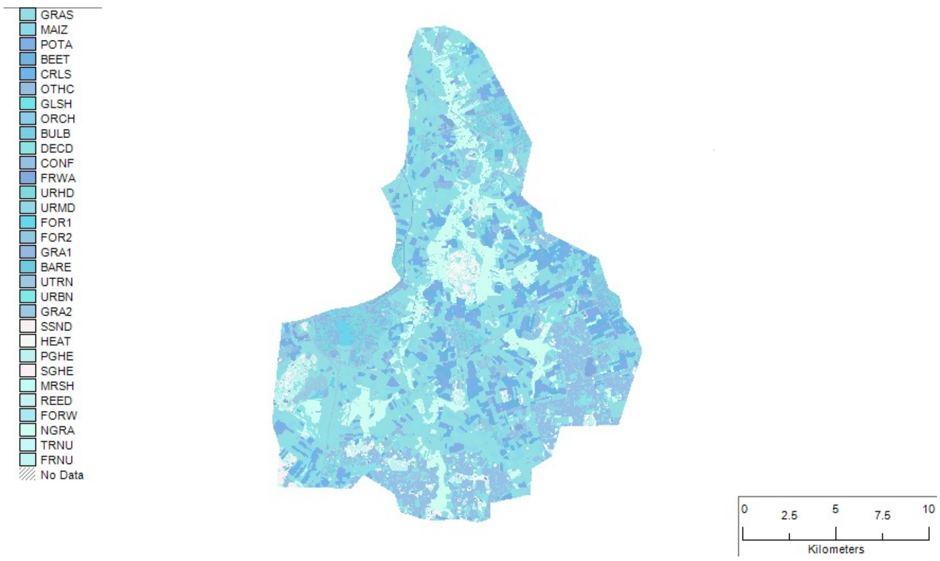


Figure 3.3 The land use type map for Drentsche Aa Catchment (Generated by SWAT)

Figure 3.4 The soil type map for Drentsche Aa Catchment (Generated by SWAT)

Once the custom database has been set up, the HRUs Analysis can begin. It starts with Land use/Soil/Slope classification and overlay. "The Land Use/Soils/Slope Classification and Overlay allows the user to load the land use and soil datasets and determine land use/soil/slope class combinations and distributions for the delineated watershed(s) and each respective sub-watershed (Winchell et al., 2007)." The land cover and soil information are shown in the figures above. And the slope definition uses the default setting of SWAT, with one single slope within the entire watershed. The land cover, soil, and slope need to be reclassified respectively before overlaying. Ultimately, the HRUs definition ends with the overlay of land cover, soil, and slope layers.

3.4.3 Climate information

Similar to the HRUs definition, the custom database for climate data needs to be input to the SWAT model before the running of the model. The weather generator data input is the prerequisite of inputting the rest weather data, namely the rainfall data, temperature data, relative humidity data, wind speed data, and solar radiation data. "The weather generator data fills in the missing data or unmeasured parameters if the custom database is being used for SWAT, since the study area is outside the United States (Winchell et al., 2007)." Once the weather generator data input has been complete, the rest weather data can be input specifically. The weather data used for our study comes from four weather stations within or next to our study area. The four weather stations are: The main station (No.280), the Eelde station (No.161), the Eext station (No.155), and the Assen station (No.140). The locations of these meteorological stations can be found in figure 3.5.

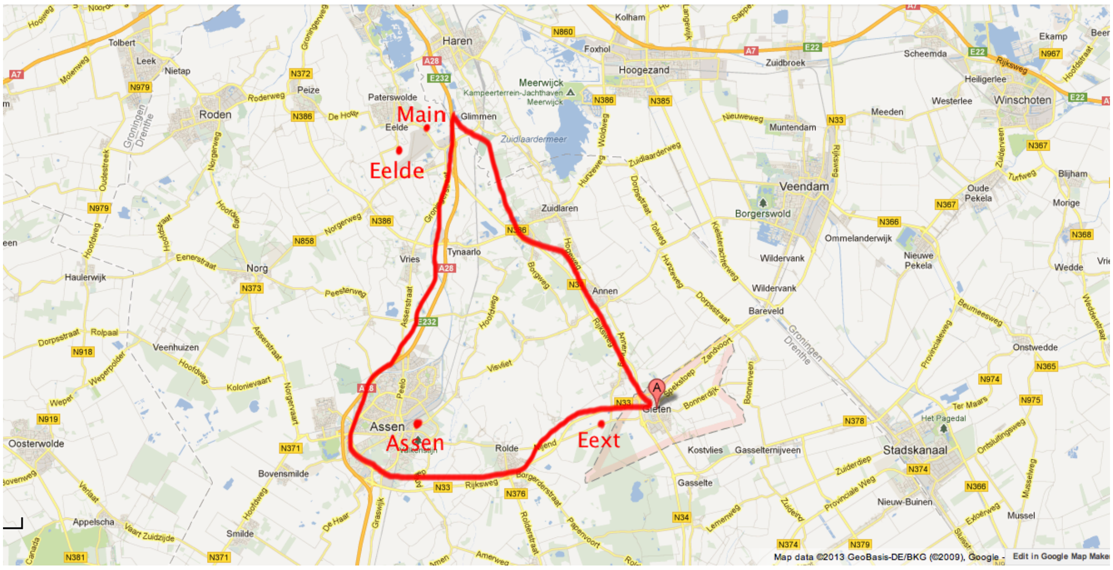


Figure 3.5. The location of weather stations

The weather generator data required by SWAT model includes not only the geographical location (Latitude, longitude, and elevation) of the weather station, but also the number of years of maximum monthly 0.5 h rainfall data (used to define values for precipitation), average or mean daily maximum air temperature for month, average or main daily minimum air temperature for month, standard deviation for daily maximum air temperature in month (Quantifies the variability in maximum temperature for each month), standard deviation for daily minimum air temperature in month (quantifies the variability in minimum temperature for each month), average or mean total monthly precipitation (mm H_2O), standard deviation for daily precipitation in month (quantifies the variability in precipitation for each month mm H_2O/Day), Skew coefficient for daily precipitation in month (quantifies the symmetry of the precipitation distribution about the monthly mean), Probability of a wet day following a dry day in the month (A dry day is a day with 0 mm of precipitation. A wet day is a day with > 0 mm precipitation.), probability of a wet day following a wet day in the month, average number of days of precipitation in month, maximum 0.5 hour rainfall in entire period of record for month (mm H_2O), Average daily solar radiation for month ($MJ/m^2/day$), average daily dew point temperature for each month or relative humidity, and average daily wind speed in month (m/s). The data sheet and calculation are provided in Appendix 3.

3.4.4 The SWAT model simulation

Once the weather data input finished, the model is ready to write the required input files. Any of the input files can be manually edited afterwards. The SWAT simulation is ready for proceeding. In the step, the information of the output file will be set up, for instance, the period of simulation, etc. SWAT can run the simulation after selecting the output, which required for further analysis.

3.5 Model assessment

Once SWAT simulation run successfully, the output files of the chosen years, which is the period from 1981 to 2010 in this case, are being generated. Since our study investigates the vulnerability towards peak flow, we compared the generated water flow out with the measured discharge for the whole watershed for calibrating the model. However, there is no water discharge measure point for the whole watershed. As a consequence, the outlet of the sub basin 22 has been chosen since there is one measure point in Schipborg within the sub basin 22 and it relatively representative (The discharge of sub basin 1 is not included) for the whole watershed. The location of the water outlet has been illustrated in the map below.

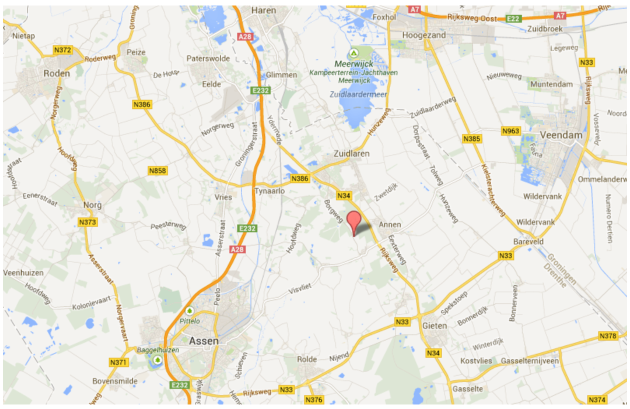


Figure 3.6 The location of the measuring point of water flow out at Schipborg

3.5.1 Sensitivity analysis

There are multiple parameters that affect the output of SWAT hydrological model, most of them are not precisely known due to spatial differentiation, measurement deviations, simplification of process description, etc. Therefore, the optimization of internal parameters of the SWAT model is crucial to establish the most representative model. This has been done by model calibration. Before calibrating a model, the most sensitive model parameters ought to be known. A sensitivity analysis determines the sensitivity of the input parameters by comparing the output variance due to the changing of the parameters. The sensitivity analysis was carried out to identify the sensitive parameters of the SWAT model. It was performed on 6 different parameters. By applying default upper and lower boundary parameter values, the parameters were tested for sensitivity for the simulation of the water flow out. After the analysis, the sensitivity situation of the parameters has been shown in the table below, and also the best value of these parameters that made the output most closely to the realistic situation can be also found in table 3.1. In table 3.1, the range of initial SSC curve number can deviate (upper or lower) the default value (100%) to 15% maximum. Additionally, for the deep aquifer percolation fraction, different values have been applied in different types of years respectively. 0.25 is used for wet years, 0.3 is used for average years, and 0.55 is used for dry years.

Parameter	Description	Range	Optimal value
CN2	Initial SSC curve number	85%-115%	100%
EPCO	Plant uptake compensation factor	0.01-1.00	1.0
ESCO	Soil evaporation factor	0.01-1.00	0.1
GW_DELAY	Delay time of groundwater discharge	1-31(day)	21 (day)
GW_REVAP	Groundwater "revap" coefficient	0.02-0.2	0.2
RCHRG_DP	Deep aquifer percolation fraction	0-1	0.25/0.3/0.55

Table 3.1 The parameters of SWAT model for sensitivity analysis

3.5.2 Model calibration

Model calibration is done to improve the result of the model simulation, to adjust uncertainties. The calibration is support by sensitivity analysis to prevent performing on non-sensitive parameters. In this case, for the SWAT model for the Drentsche Aa Catchment Area, as it mentioned in preceding part of this chapter, the comparison of water flow out between the SWAT output and measurement has been used for calibration. To be more precise with the comparison, first we defined dry years, wet years and average years among the entire period of 30 years.

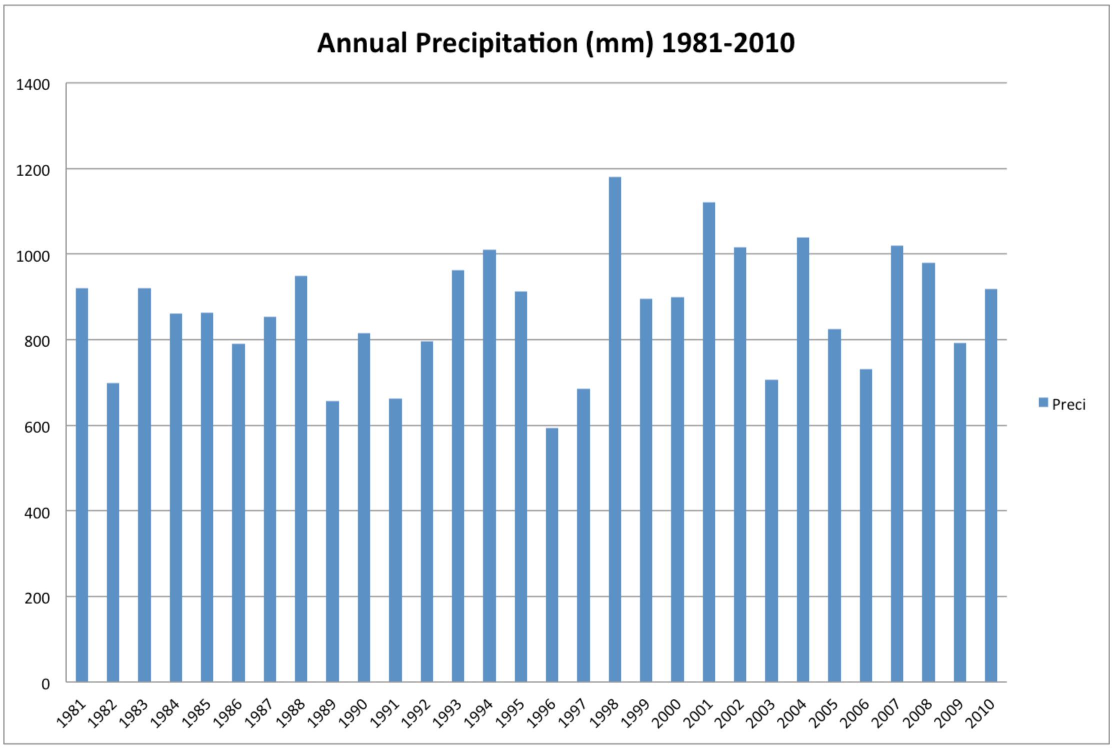


Figure 3.7 The annual precipitation of the Netherlands from 1981 to 2010

And then we chose one representative year for each group. These representative years are 1985 for average years, 1996 for dry years, and 1998 for wet years. It is worth to mention that the extreme are taken for the wet and dry years and the average year has been chosen by the median of the precipitation. We run the model again for the selected years and the year before (for a correct initialization) and do the calibration respectively. There's a tricky situation during the model calibration. For SWAT model, there are two different methods to calculate potential evapotranspiration, the Penman-Monteith method and the Hargreaves method. The Penman-Monteith method is more accurate since it requires the information of precipitation, maximum and minimum air temperature, relative humidity, wind speed and solar radiation at daily bases. However, the Hargreaves method only requests the information of daily precipitation, maximum and minimum air temperature. The scenario analysis, which has been done for future forecasting, can only use the Hargreaves method since the climate scenario from KMNI provides the information of precipitation and air temperature. In older to minimize the error caused by different calculating method. We used the Hargreaves methods for current situation as an intermediary between the current situation model, which used the Penman-Monteith method, and the future scenario model, which used the Hargreaves method. The calibrations have been done for the three different situations respectively. And we use the trend line, accumulative graph, and percentile graph of the discharge data from the sub basin 22nd for demonstrating the results of the calibrations. The optimal situations after comparisons are showing in the graphs below.

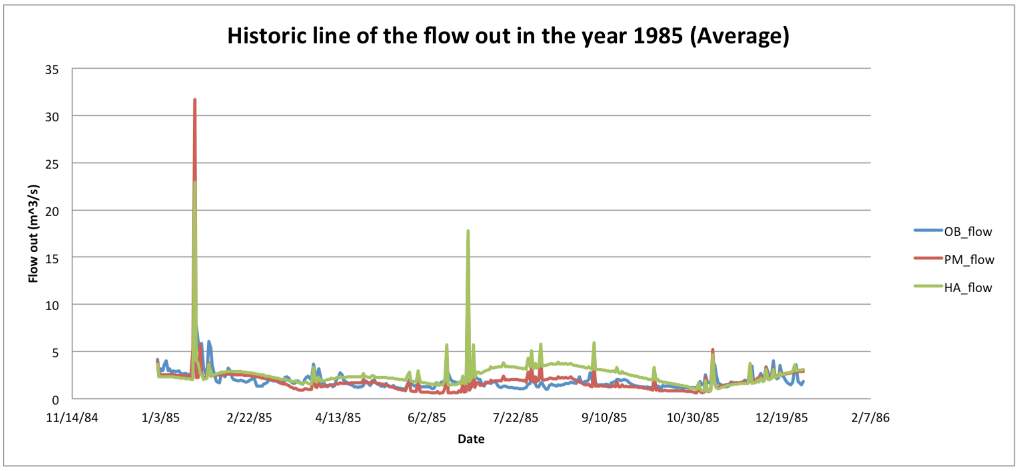


Figure 3.8 The historic line of the flow out of the 22nd sub basin in 1985

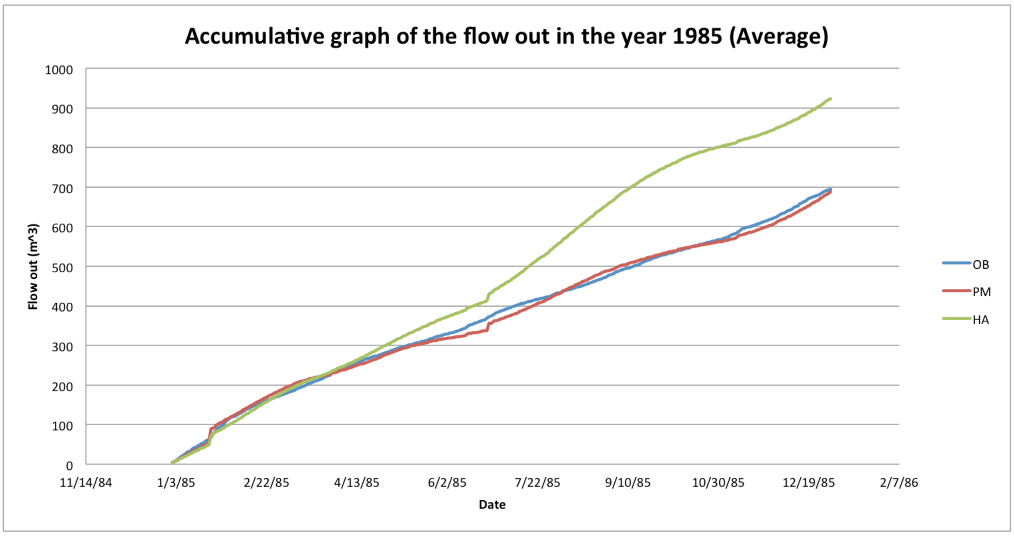


Figure 3.9 The accumulative graph of the flow out of the 22nd sub basin in 1985

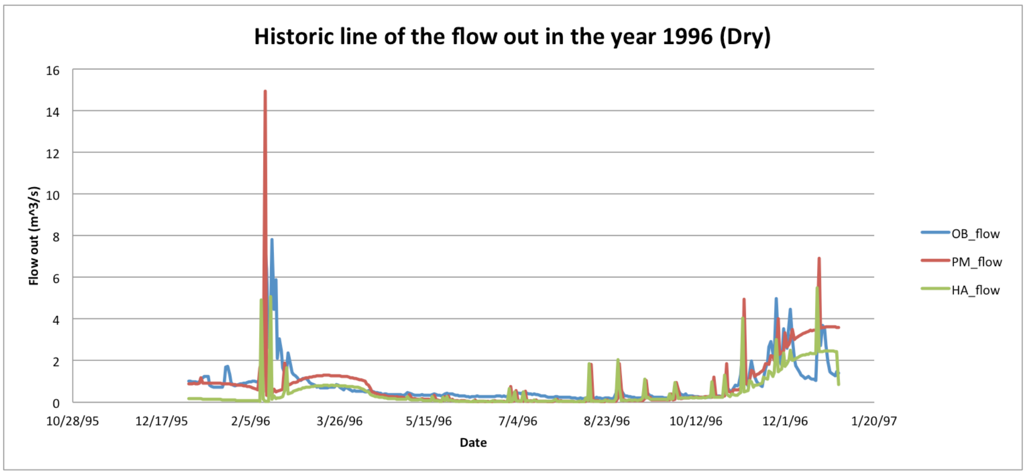


Figure 3.10 The historic line of the flow out of the 22nd sub basin in 1996

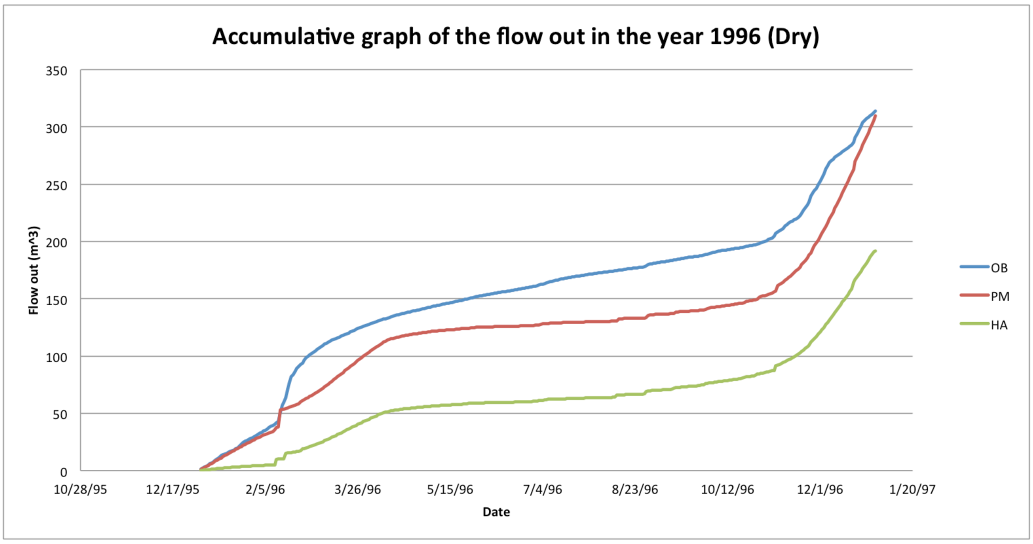


Figure 3.11 The accumulative graph of the flow out of the 22nd sub basin in 1996

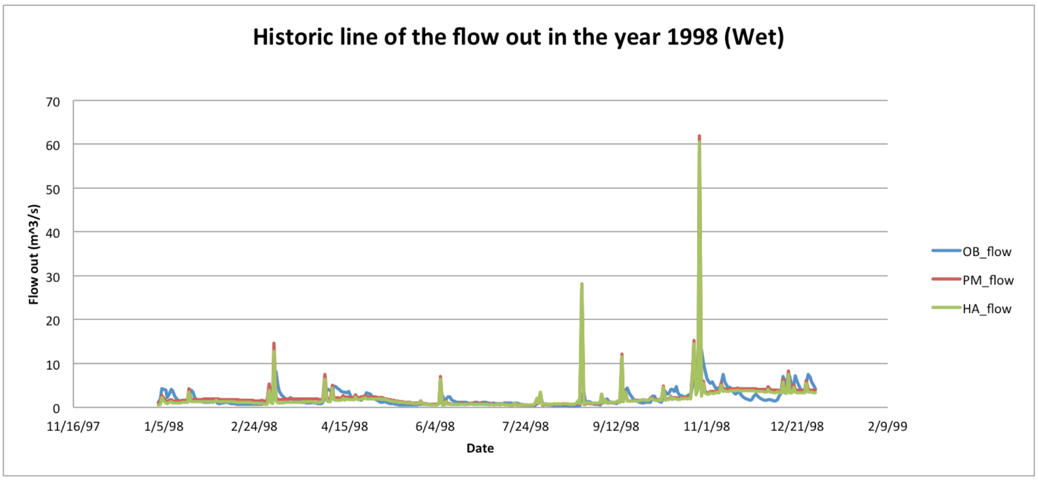


Figure 3.12 The historic line of the flow out of the 22nd sub basin in 1998

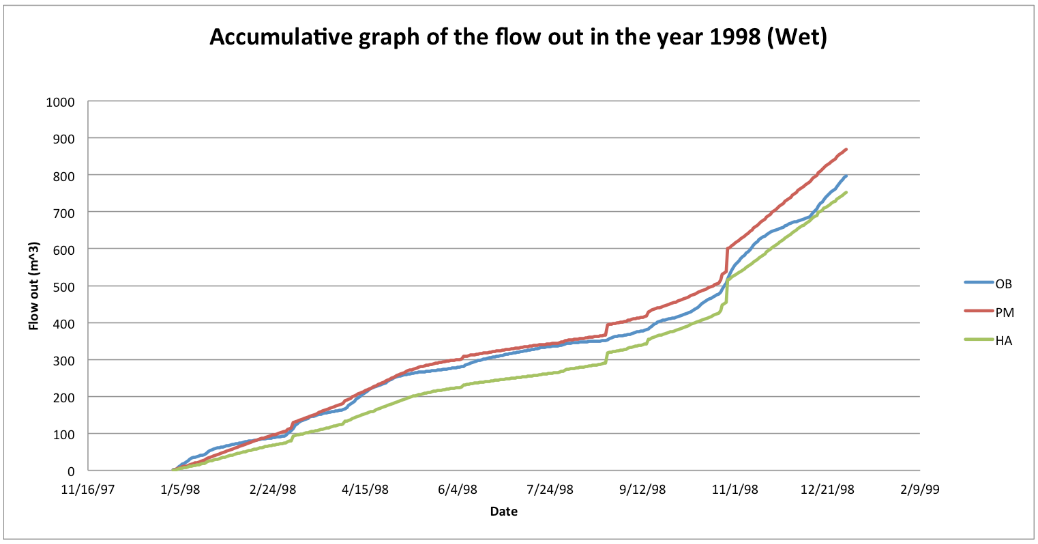


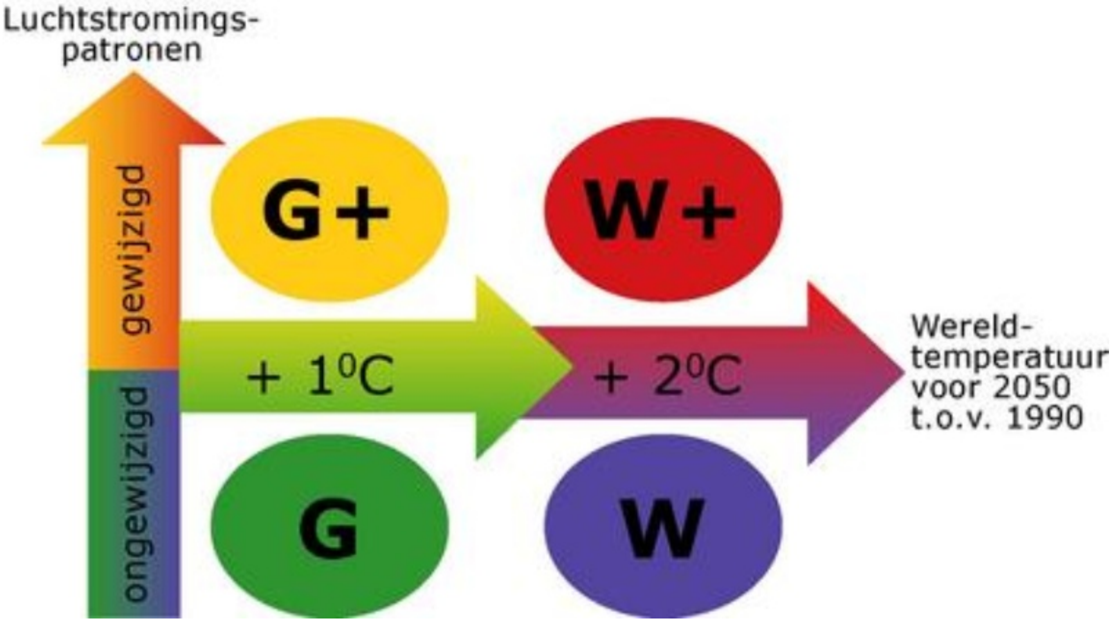
Figure 3.13 The accumulative graph of the flow out of the 22nd sub basin in 1998

The figures above were generated based on the results come from the SWAT model. The SWAT analyses the input information mentioned in previous chapters, and gives its own results. From the figures, it is evident that the extreme weather events that affect the study area the most is peak surface water flow. In the six figures above, the blue lines indicate the observed flow out; the red lines indicate the flow out simulated by SWAT when using Penman-Monteith method for calculating evapotranspiration, while the green lines indicate the flow out simulated by SWAT when using Hargreaves method for calculating evapotranspiration. Since peak flow is essential for our study, according to the comparison in the figures above, we can draw the conclusion that the result using the Hargreaves method is more close to the realistic situation, especially for the wet year.

4 Scenario Analysis

4.1 Climate Scenarios

As soon as the model calibration finished, the preconditions of scenario analysis are ready. Scenario analysis is used for predicting the future status regarding peak flow risk for the Drentsche Aa Catchment Area by inputing the climate scenarios. Since our study fastens on measures to cope with the vulnerability that comes from climate change, we used the extreme climate scenario for the Netherlands, which is the W+ Scenario of KNMI (Royal Netherlands Meteorological Institute). The climate scenarios from KNMI are demonstrating in Figure 5.1. The W+ is the abbreviation of the warm plus climate scenario. This scenario presume there will be '2 degree temperature rise on earth in 2050 compared to 1990 with milder and wetter winters due to more westerly winds and warmer and drier summers due to more easterly winds' (KNMI Official Website).



Fighre 4.1 The different climate scenarios from KNMI (KNMI Official Website)

To be more realistic for analyzing, the meteorological data from the KNMI W+ climate scenario (including the temperature and precipitation data under the scenario) has been input to the SWAT model witch established and calibrated in foregoing process. Please note that the land use change hasn't been taken into consideration due to the lack of information on relevant policies for the study area. Accordant to the analysis with the current data for model calibration, the forecast period (from 2085 to 2115) is also being divided into wet years, dry years, and average years. And we use one year for each group to represent the future prediction for the whole period. The classification of the years is shown in Figure 4.2.

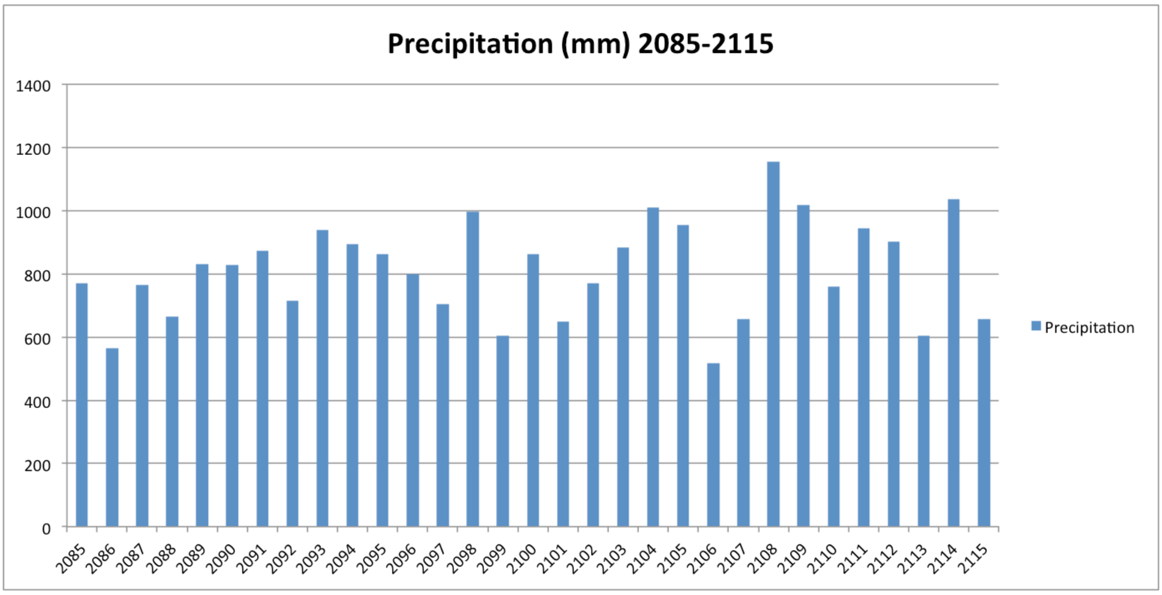


Figure 4.2 The annual precipitation of the Netherlands from 2085 to 2115 under the W+ climate scenario

The year 2108, 2089, and 2106 have been chosen as the representative year for wet years, average years, and dry years respectively. The SWAT model has been run separately for the three selected years and the year before them for warming up.

4.2 Results analysis

To be coherent with the model calibration, the discharge value of the sub basin number 22nd has been used for representing the whole watershed for future scenarios. The results have also been shown including trend line, accumulative graph, and percentile graph as it in the model calibration phase.

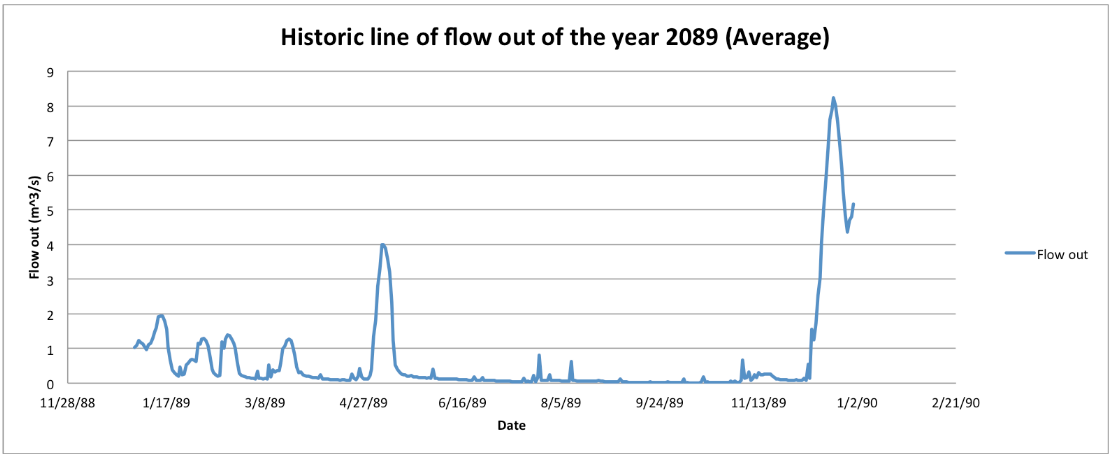


Figure 4.3 The historic line of the flow out of the 22nd sub basin in 2089

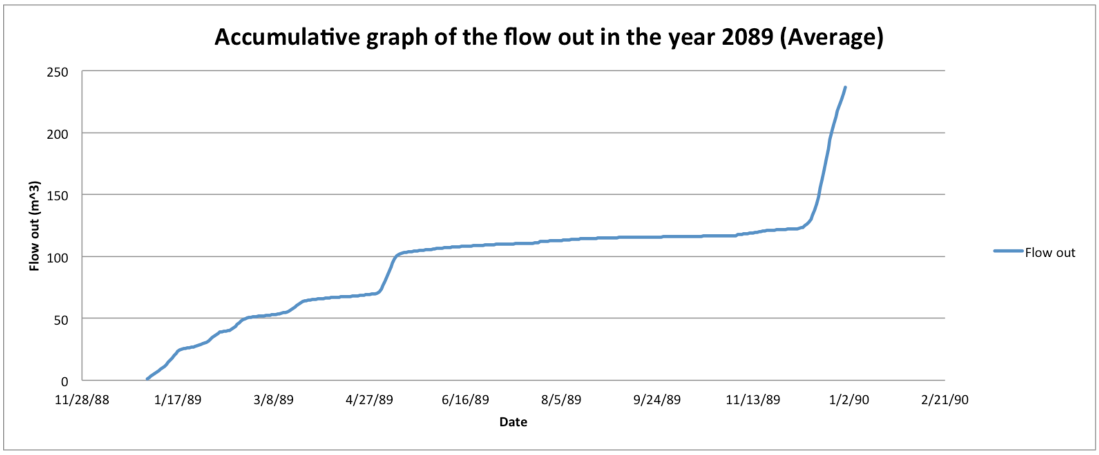


Figure 4.4 The accumulative graph of the flow out of the 22nd sub basin in 2089

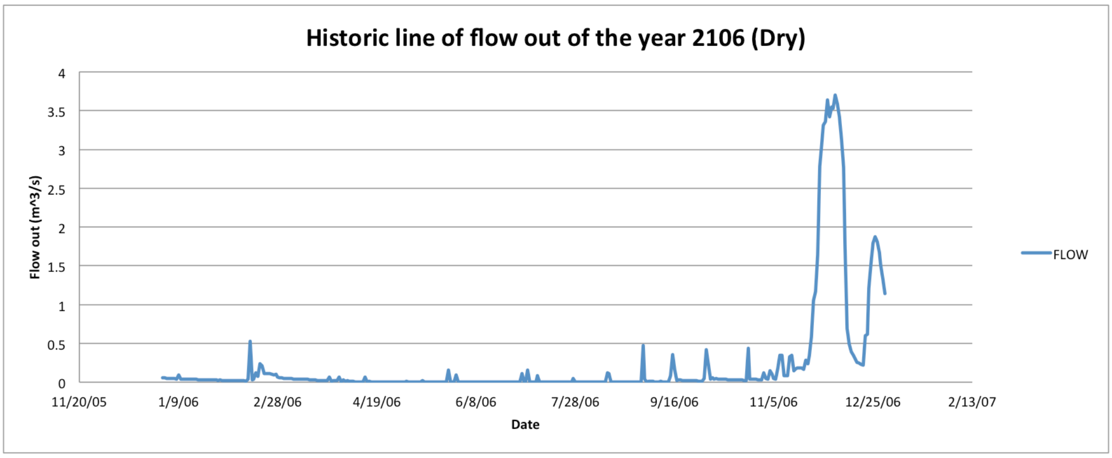


Figure 4.5 The historic line of the flow out of the 22nd sub basin in 2106

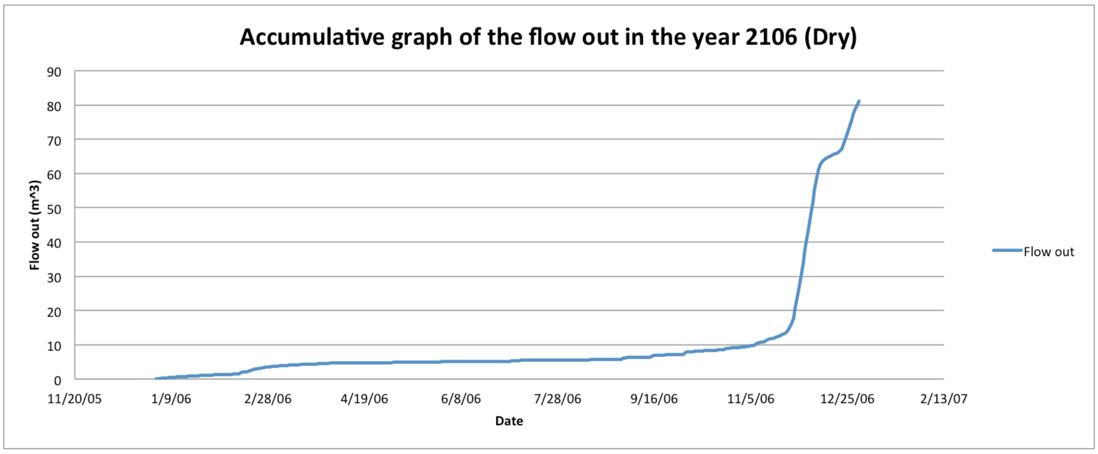


Figure 4.6 The accumulative graph of the flow out of the 22nd sub basin in 2106

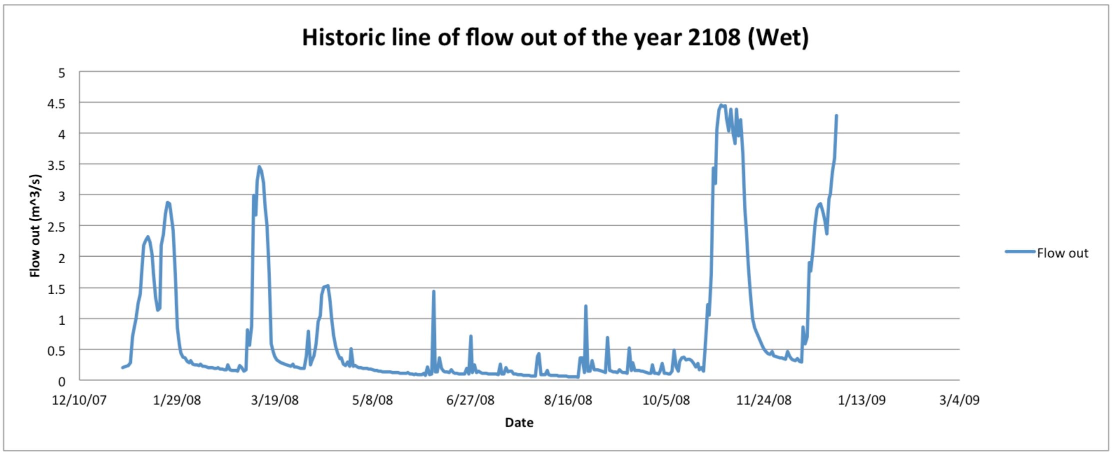


Figure 4.7 The historic line of the flow out of the 22nd sub basin in 2108

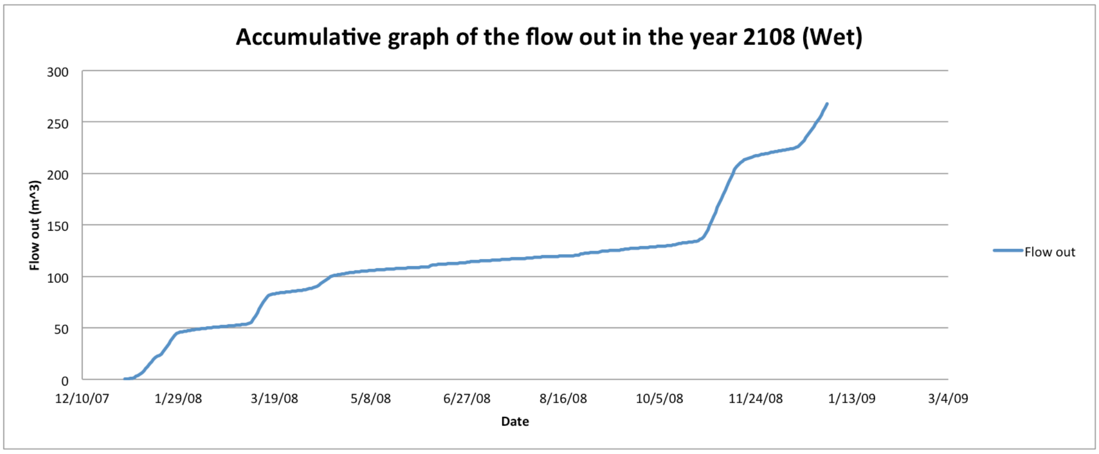
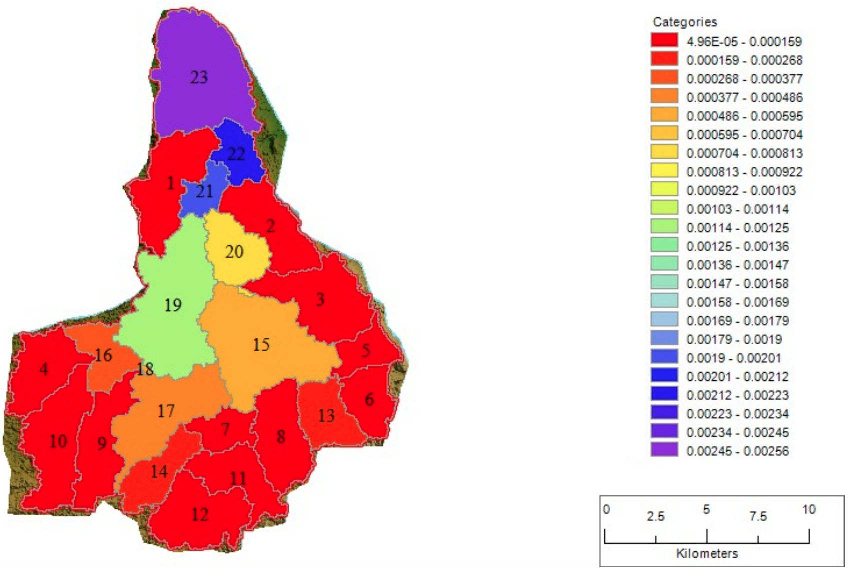


Figure 4.8 The accumulative graph of the flow out of the 22nd sub basin in 2108

These six graphs above visually illustrate the forecast of future situation under the extreme climate scenario, which is the w+ scenario. It is evident that the peak flow problem is much milder than in the current situation. While it still has certain degree of peak flow risk during the wet years. Additionally, according to the description of different climate scenario, we can predict that the peak flow risk will still be a severe problem for the study area. However, it is deficient that we didn't apply other climate scenarios in SWAT model due to time limit, but it is worthwhile to do so in further study.

To me more visualize with the forecast, the vulnerability map has been generated by VIZSWAT. Since the main focus of our study fastens to Peak surface flow, so the map uses this parameter to indicate the vulnerability.



Firgue 4.9 The vulnerability map regarding peak flow for the Drentsche Aa Catchment Area

The vulnerability map above is generated by VIZSWAT based on the daily flow out data, whose unit is m^3/s, during the whole forecast period (30 years). Different colors indicate different values of surface water flow out in sub basin level. The color red in the figure means relatively lower value and the color purple means relatively higher value. To be more specific with the vulnerability map, the red-orange area illustrates the areas have a lower probability of inundation due to lower surface water runoff, while the blue-purple areas have a high probability of inundation due to high surface water runoff.

5 Possible Measures

As it said in previous chapter, the crops production in the Drentsche Aa Catchment Area is still vulnerable to peak flow to some degree in the coming 30 years. Measures, which can be taken for the purpose of reducing this kind of vulnerability, have been investigated and developed during the case study process.

5.1 Possible Measures to response to the vulnerability

5.1.1 Advanced Agriculture System

To reduce the vulnerability of crop production towards extreme weather events to minimize, an advanced agriculture system comprises monitoring and alerting system could be implemented. Comparing with conventional agriculture system, the advanced system focuses on the instant detection and reaction to the undesirable growing condition for crops. The present invention provides a highly automated agricultural production system, which consists of essential components as follows:

1. A sensing subsystem comprising direct and indirect sensing points in the agricultural production area, in this case, is the agricultural area in the Drentsche Aa Catchment. The function of the sensing subsystem is to detect the growing environment of the crops, such as temperature, soil moisture, and air moisture. The subsystem is used for collecting the information of the growing condition for crops. The monitoring and alerting functions are included in this subsystem. Once the unexpected weather condition occurred, the information will be instantly collected and transmitted to computing subsystem through the data transmit subsystem;
2. A data transmit subsystem is used for forwarding data that generated by the direct and indirect sensing subsystem to computing system and for transmitting instructions from the computing system via interfacing subsystems to various devices (field effectors) in the agricultural area to perform various functions;
3. A computing subsystem linked by the data transmitting subsystem to the indirect and direct sensing subsystem in a pattern of many feedback loops. The computing subsystem is programed to enable correlation of data received from the indirect and direct sensing subsystem and to generate appropriate instructions to accomplish a substantive number of functions required for the operation of the automated agricultural production system.
4. A fluid delivery subsystem, which provides: pathways for delivering water, chemicals in liquid or gaseous form, air, and should be set in various parts of the agricultural production area. And pathways for providing power to various peripheral devices, which utilize the power of moving liquid and/or gases are also included in this subsystem.

5. A field operation subsystem which, in a highly preferred embodiment, comprises means to harvesting agricultural products, convey the agricultural products, grade the agricultural products, store the agricultural products, and pack the agricultural products. Meanwhile, the field operation system consists of the devices of reacting on extreme weather condition for agricultural area. The operation subsystem includes the peripheral devices to handle the unwished situation as well. The peripheral devices such as discharging system. Once the sensing subsystem detected the peak flow or inundation in the field, the discharging system starts working.

5.1.2 Green roof in urban area

Another measure that might help to alleviate the threats caused by peak surface runoff is the green roof technology. It has become increasingly popular during the last decades due to rapid worldwide urbanization. This rapid urbanization includes an unsustainable use of natural systems and creates numerous problems both within and outside cities. 'One of the major environmental problems of urbanization is that the urban hydrological system has to cope with a highly fluctuating amount of surface runoff water which may become extremely high during periods during rainfall. (Mentens et al., 2006)' Climate change exacerbates this situation to some extent. In particular, the flood risk will further increase. 'Green roofs basically consist of vegetation layers, a substrate layer (where water is retained and in which the vegetation is anchored) and a drainage layer (to evacuate excess water) (Mentens et al., 2003).' There are two basic types of green roof, the intensive green roof and extensive types. The main difference between intensive and extensive green roofs is the depth of the substrate layer. In our case, it is wise to choose the extensive type due to its low weight, low capital cost, low plant diversity and minimal maintance requirements.

In order to make the green roof more sustainable and to extend the service life, the structure of the green roof should including growing medium for the plant, filter membrane for the rainwater collection, drainage layer to prevent flooding on the roof during rainy seasons, and also the vapour control layer in case the unexpected evapotranspiration in high temperature periods. The figure below shows the schematic of the green roof system.

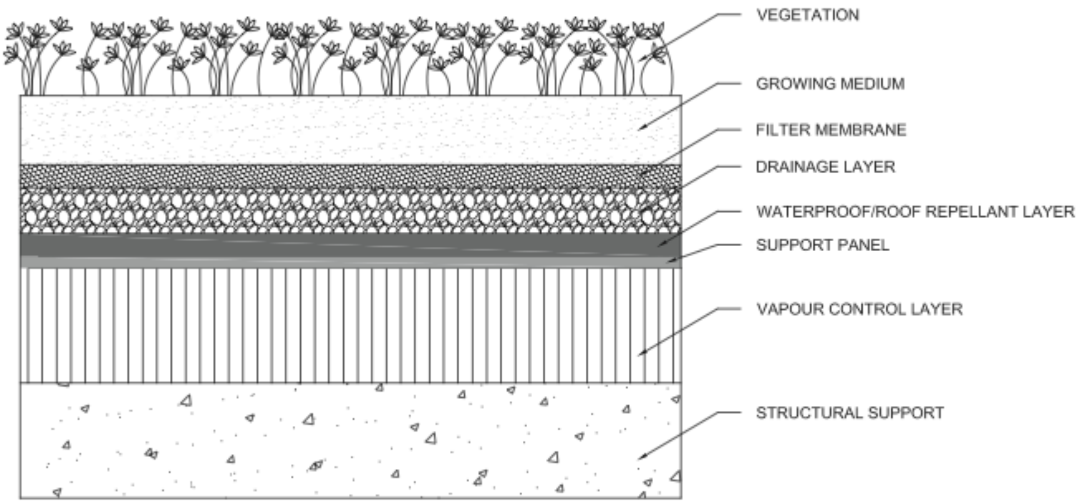


Figure 5.1 The schematic of the green roof system (www.charlesriver.org)

The local species of plant are recommended to choose for green roof due to their high adaptability to the local climatic condition (Temperature, Amount of Precipitation, Wind Speed, and Soil type). The ability of plants to survive on the green roof is directly impact on the amount of time and cost for the maintenance. Since we chose the extensive green roof system, it relies on a mixture of grasses, mosses, sedums, sempervivums, festucas, irises, and wildflowers. (Steven Peck and Monica Kuhn, 2003)

5.1.3 Change of Land Use Pattern

Although land use is becoming a force of global importance, but it still has generally been considered as a local environmental issue. For a certain area, land use pattern changes for many reasons, such as policy requirements, economic/technological factors, demographic factors, and natural variability. Conversely, Land change impacts on them in return. As it mentioned in previous chapters, the current land use pattern of the Drentsche Aa Catchment Area is a natural balance that results from hundreds years of exploration, experiment, and development. However, from the results of the SWAT model, it is apparent that the natural balance is experiencing a gradually deteriorating. More intensive and extreme precipitation will occur in the coming years. To be more localizing in the Drentsche Aa Catchment Area, some agricultural lands within the study area might be no longer suitable as agricultural land during certain seasons. In order to resolve the problem, those agricultural lands can be temporally changed into natural lands or reservoirs. To make this approach more realistic, the seasonal-changed lands ought to be defined in the first place. Then the crops grown on these lands should be carefully chosen, the crop planted on these lands should be water-resistant and with relatively short endogenous growth cycle. There are two specific land use change scenarios have been tested with SWAT model, these two measures are to change majority of arable land within the study area into grass land and to change majority of arable land into forest. The majority of arable land means lands for maize, potato, and cereal, since the area of the rest arable lands is too less to take into account. The table below illustrates the information of different types of land use in the Drentsche Aa Catchment Area and their proportions of the whole watershed.

Land use type	Area (ha)	Percentage of the whole watershed
GRAS (Grass)	9229.72	35.91%
NGRA (Natural grass)	4307.50	16.76%
CONF (Coniferous)	3441.53	13.39%
DECD (Deciduous)	3428.65	13.34%
MAIZ (Maize)	1404.21	5.46%
POTA (Potato)	1289.37	5.02%

Table 5.1 The area and proportion of different land use types in the study area

We chose these two extreme measures since we are dealing with the most extreme climate scenario. To be coherent with preceding results, when applying these land use change scenarios in SWAT model, the flow out of the 22nd sub basin has been chosen for analysis.

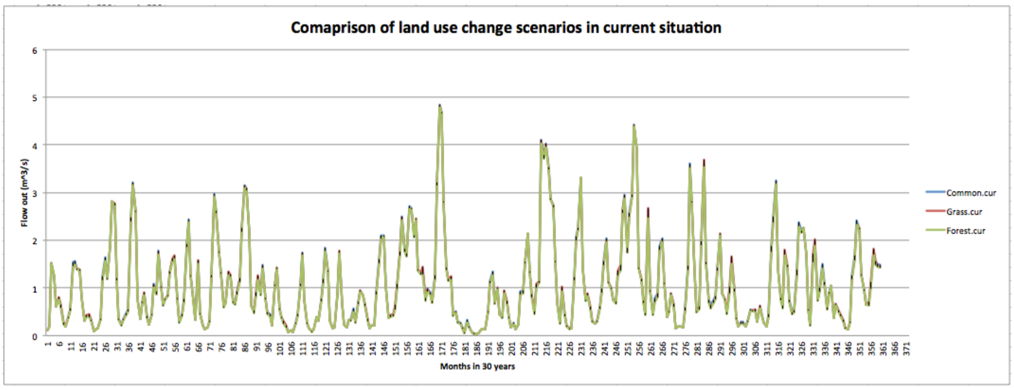


Figure 5.2 Comparison of land use change scenarios in current situation

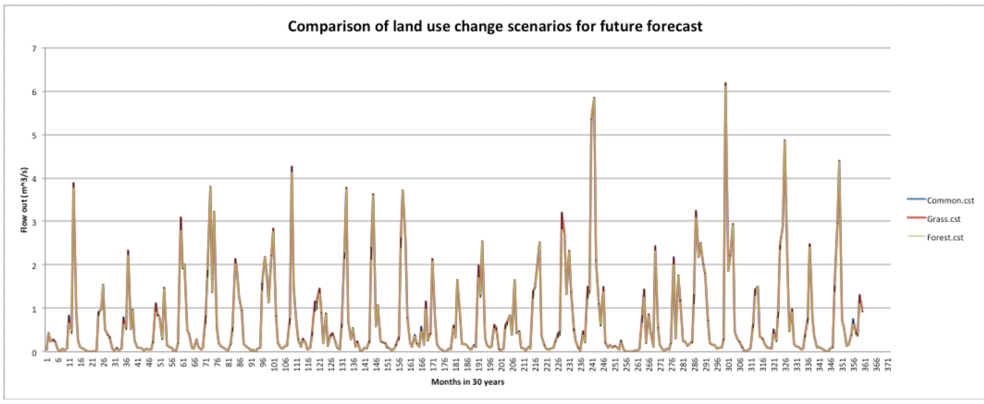


Figure 5.3 Comparison of land use change scenarios for future forecast

In Figure 5.1 and Figure 5.2, the blue lines represent the flow out that for the original situation (without land use change), the red line represents the flow out under the first land use change scenario, and the green line represents the flow out under the second land use change scenario. According to the two figures above, it is evident that even two of the most extreme land use scenarios have been applied; the effect of reducing the peak flow risk is very limited. It is worthwhile to be noticed here is that the method SWAT used for calculating evapotranspiration doesn't take transpiration coefficient of different crops into consideration. That is one of reasons why the result didn't change that much.

5.2 Multi-criteria decision Analysis for the measures

For the purpose of finding the most feasible solution for the Drentsche Aa Catchment, the Multi-criteria Decision Analysis framework has been used in this thesis. The principle and general concept of Multi-criteria Decision Analysis are described below.

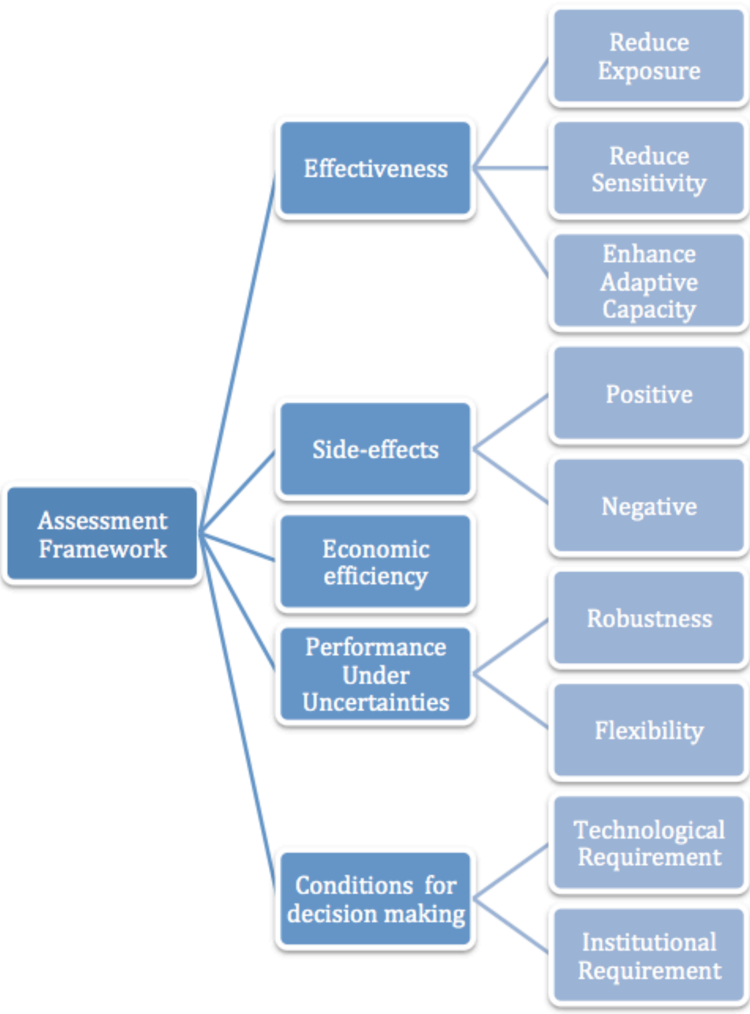


Figure 5.4 The Multi-criteria Analysis Framework

Effectiveness is the first, and probably the most important for evaluation and selection of the possible measures. Effectiveness is understood as the extent to which adaptation options can reduce systems' vulnerability to climate change impacts. According to (UNFCCC, 2010a), vulnerability comprises three main components: Exposure, Sensitivity, and Adaptive Capacity.

Broadly speaking, side-effects criterion looks at the secondary effects (Both positive and negative ones), which are directly related to the primary purpose of reduce vulnerability. Side-effects criterion also pays attentions to the negative impacts that adaption measures can have on societies once they are implemented.

Economic efficiency pays attentions to the economic viability of adaptation measures by considering their costs and benefits. In brief, an adaptation measure is considered cost-efficiency if it brings higher benefits comparing its implement costs. Costs attached to an adaptation measure consist of construction or Implementation costs, maintenance costs and transaction costs. "Transaction cost is defined by as costs associated with searching for information, searching for partners in collective action, drawing up and enforcing contracts, and social capital (Adger et al., 2006)."

The requirement of Performance under uncertainties is that adaptation measures should be able to maintain their performance under a wide range of changes in climatic and socio-economic conditions. Measures that meet this requirement are either robust to uncertainties or flexible in designing and implementation.

Conditions for decision-making: In the phase of decision-making, not only the adaptation measure itself is important, but the framework conditions in which the measures are selected and implemented play a crucial role. The technological and institutional requirements judge this criterion.

The detailed evaluation of the three measures mentioned in the section above is shown in the table below. Each measure has being evaluated by each criterion from 0 point (Not correspond to the description of the criterion at all) to 5 point (Completely correspond to the description of the criterion). Additionally, the proportion of criterions has been defined according to their importance as: Effectiveness (40%), Side-effects (10%), Economic efficiency (15%), Performance under uncertainties (20%), and conditions for decision making (15%).

Measures		4.1.1	4.1.2	4.1.3
Effectiveness	Reduce exposure	1	1	3
	Reduce sensitivity	4	5	5
	Enhance adaptive capacity	5	5	5
Side-effects	Positive (5)	5	5	3.5
	Negative (0)			
Economic efficiency		2	3.5	3.5
Performance under uncertainties	Robustness	2.5	4	4
	Flexibility	1	4.5	4
Condition for decision making	Technological requirement	1.5	4	4
	Institutional requirement	2	1	1.5
Overall score		2.02	3.73	3.97

Table 5.2 Detailed scores of Multi-criteria analysis

From the table above, although the three measures are not ideal for the problem in our study area, it is obvious that the third measure, which is change of land use pattern, gained a relatively higher score due to its high effectiveness and relatively low technological requirements.

6 Conclusion

Based on the analysis results of the SWAT model, there is a certain degree of vulnerability for the crop production in the Drentsche Aa Catchment Area towards extreme weather events at present. The vulnerability mainly comes from peak water flow due to intensive precipitation. However, the vulnerability for the study area will have a dramatically decrease in the future. The decrease of the vulnerability doesn't mean there will be no vulnerability. To be more specific, there will be a very high possibility of the occurrence of peak surface flow in November 2108. In order to manipulate this vulnerability to the minimize, three possible adaptation measures, i.e. constructing advanced agriculture system, applying green roof technology in urban area, and changing of land use pattern, have been developed in the thesis. The development of possible adaptation measures followed by the evaluation of these measures so that the most feasible one for the Drentsche Aa Catchment Area can be determined. The evaluation has been done through multi-criteria decision analysis.

Within the evaluation process, the analysis took effectiveness, side-effects, economic efficiency, performance under uncertainties, and condition for decision making into consideration as its criterions. From the evaluation, it is not arduous to find that the changing of land use pattern is the most feasible measure for the study area since it got the highest score during the evaluating process. To be more specific with the evaluation, for the effectiveness criterion, all three measures gained very high score since effectiveness is the main target for developing these measures. Although the third measure (changing land use pattern) has the weakness in side-effects at socio-economic aspects and huge demand of institutional requirements, it wins in the relatively high economic efficiency, and better performance under different climatic and socio-economic conditions. The result of the evaluation has been presented in scores. So it is obvious that the most feasible measures to reduce the vulnerability is to change land use pattern within the study area due to its relatively higher score in the multi-criteria decision analysis.

7 Recommendation

The thesis was being written accompanying with the finishing of SWAT hydrological model for the Drentsche Aa Catchment Area. Although the study completed successfully, there are still several restrictions and inadequacies in perspective of academic, scientific research. First of all, even though the SWAT model is specialized for the analyzing of hydrological process of catchment area and the data we used comes from localized monitoring stations, still, there is quite a gap between the ideal model and realistic. Second, it was a pity that we haven't had the chance to interview different stakeholders in the study area, the consequence of this is that the thesis was being written in a point of view of the researchers, to put it in other word, us. The conclusion will be more comprehensive if the opinions of different stakeholders had been taken into consideration. Third, the multi-criteria decision analysis we used for determining the most feasible measure is very subjective in giving scores for different criterions. Again, it would be improved by involving different stakeholders into the research. The multi-criteria decision analysis ought to be a questionnaire for participants. At last, the limits of time has a big impact on our study, for instance, during the scenario analysis phase, the results will be more accurate and repetitive if we took the four different climate scenarios of KNMI. And when developing the measures for the problem, there are abundant of measures that are effective for reducing the vulnerability, such as build secondary channel in the high vulnerable area, but the research for that is missing in this thesis due to time limits. The restrictions mentioned above are worthwhile to be paid attention to, and worthy to be investigated in future study.

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Appendix 1 – HRUs Report

```
Detailed Landuse/Soil/Slope Distribution       Monday, 17 June 2013 16:32:54

Multiple HRUs Landuse/Soil/Slope option        Minimum area: 100.00 ha
Number of HRUs: 130
Number of subbasins: 23

---------------------------------------------------------------------------
                                    Area [ha]
Watershed                            25704.06
---------------------------------------------------------------------------
                                    Area [ha]     %Watershed

Landuse
                          NGRA        4307.50          16.76
                          FOR1         183.61           0.71
                          URHD         735.93           2.86
                          PGHE         191.97           0.75
                          HEAT         250.49           0.97
                          CONF        3441.53          13.39
                          DECD        3428.65          13.34
                          CRLS         789.05           3.07
                          POTA        1289.37           5.02
                          MAIZ        1404.21           5.46
                          GRAS        9229.72          35.91
                          GRA1         452.02           1.76

Soil
                    loamy sand         823.95           3.21
    loamy sand on boulder clay        8309.37          32.33
              slightly lmy snd        9454.55          36.78
                loam poor sand        1308.71           5.09
                     dune sand         124.99           0.49
sandy top on peat on sandy sub         396.63           1.54
 peaty earthy top on pt on snd        3493.23          13.59
 peaty earthy top on peaty sub         421.07           1.64
                 built-up area        1371.56           5.34

Slope
                        0-6379       25704.06         100.00
---------------------------------------------------------------------------
---------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 1                            1380.63           5.37

Landuse
                          POTA         178.96           0.70          12.96
                          MAIZ         281.92           1.10          20.42
                          GRAS         749.06           2.91          54.26
                          DECD         170.68           0.66          12.36

Soil
              slightly lmy snd        1193.49           4.64          86.45
                    loamy sand         187.13           0.73          13.55

Slope
                        0-6379        1380.63           5.37         100.00

HRUs:
1    DECD/slightly lmy snd/0-6379         170.68           0.66          12.36
2    POTA/slightly lmy snd/0-6379         178.96           0.70          12.96
3    MAIZ/slightly lmy snd/0-6379         281.92           1.10          20.42
4       GRAS/loamy sand/0-6379       187.13           0.73          13.55
5    GRAS/slightly lmy snd/0-6379         561.93           2.19          40.70
---------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 2                            1149.06           4.47

Landuse
                          GRAS         348.82           1.36          30.36
                          CRLS         128.14           0.50          11.15
                          POTA         131.98           0.51          11.49
                          NGRA         263.83           1.03          22.96
                          DECD         276.30           1.07          24.05

Soil
              slightly lmy snd         734.32           2.86          63.91
    loamy sand on boulder clay         414.75           1.61          36.09

Slope
                        0-6379        1149.06           4.47         100.00

HRUs:
6    NGRA/slightly lmy snd/0-6379         133.89           0.52          11.65
7    NGRA/loamy sand on boulder clay/0-6379         129.94           0.51          11.31
8    DECD/loamy sand on boulder clay/0-6379         149.84           0.58          13.04
9    DECD/slightly lmy snd/0-6379         126.46           0.49          11.01
10   CRLS/slightly lmy snd/0-6379         128.14           0.50          11.15
11   POTA/slightly lmy snd/0-6379         131.98           0.51          11.49
12   GRAS/loamy sand on boulder clay/0-6379         134.97           0.53          11.75
13   GRAS/slightly lmy snd/0-6379         213.85           0.83          18.61
---------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 3                            1471.31           5.72

Landuse
                          GRAS         263.54           1.03          17.91
                          POTA         311.70           1.21          21.19
                          CRLS         278.54           1.08          18.93
                          CONF         128.29           0.50           8.72
                          NGRA         169.28           0.66          11.51
                          DECD         319.96           1.24          21.75

Soil
              slightly lmy snd         460.54           1.79          31.30
                loam poor sand         305.94           1.19          20.79
    loamy sand on boulder clay         704.83           2.74          47.91

Slope
                        0-6379        1471.31           5.72         100.00

HRUs:
14   NGRA/loamy sand on boulder clay/0-6379         169.28           0.66          11.51
15   CONF/loam poor sand/0-6379         128.29           0.50           8.72
16   DECD/slightly lmy snd/0-6379         142.31           0.55           9.67
17   DECD/loam poor sand/0-6379         177.65           0.69          12.07
18   CRLS/slightly lmy snd/0-6379         146.01           0.57           9.92
19   CRLS/loamy sand on boulder clay/0-6379         132.53           0.52           9.01
20   POTA/slightly lmy snd/0-6379         172.21           0.67          11.70
21   POTA/loamy sand on boulder clay/0-6379         139.49           0.54           9.48
22   GRAS/loamy sand on boulder clay/0-6379         263.54           1.03          17.91
---------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 4                            1012.69           3.94

Landuse
                          URHD         208.45           0.81          20.58
                          PGHE         191.97           0.75          18.96
                          GRAS         372.22           1.45          36.76
                          GRA1         240.05           0.93          23.70

Soil
              slightly lmy snd         118.92           0.46          11.74
sandy top on peat on sandy sub         114.50           0.45          11.31
 peaty earthy top on pt on snd         191.97           0.75          18.96
                 built-up area         448.50           1.74          44.29
    loamy sand on boulder clay         138.80           0.54          13.71

Slope
                        0-6379        1012.69           3.94         100.00

HRUs:
23   PGHE/peaty earthy top on pt on snd/0-6379         191.97           0.75          18.96
24   GRA1/built-up area/0-6379         240.05           0.93          23.70
25   URHD/built-up area/0-6379         208.45           0.81          20.58
26   GRAS/loamy sand on boulder clay/0-6379         138.80           0.54          13.71
27   GRAS/slightly lmy snd/0-6379         118.92           0.46          11.74
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28   GRAS/sandy top on peat on sandy sub/0-6379         114.50           0.45          11.31
----------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 5                             519.44           2.02

Landuse
                          GRAS         170.79           0.66          32.88
                          CONF         233.16           0.91          44.89
                          DECD         115.49           0.45          22.23

Soil
                loam poor sand         348.65           1.36          67.12
    loamy sand on boulder clay         170.79           0.66          32.88

Slope
                        0-6379         519.44           2.02         100.00

HRUs:
29   CONF/loam poor sand/0-6379         233.16           0.91          44.89
30   DECD/loam poor sand/0-6379         115.49           0.45          22.23
31   GRAS/loamy sand on boulder clay/0-6379         170.79           0.66          32.88
----------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 6                             685.06           2.67

Landuse
                          CONF         558.73           2.17          81.56
                          DECD         126.33           0.49          18.44

Soil
              slightly lmy snd         115.14           0.45          16.81
                loam poor sand         208.66           0.81          30.46
    loamy sand on boulder clay         361.26           1.41          52.73

Slope
                        0-6379         685.06           2.67         100.00

HRUs:
32   CONF/slightly lmy snd/0-6379         115.14           0.45          16.81
33   CONF/loam poor sand/0-6379         208.66           0.81          30.46
34   CONF/loamy sand on boulder clay/0-6379         234.93           0.91          34.29
35   DECD/loamy sand on boulder clay/0-6379         126.33           0.49          18.44
----------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 7                             522.69           2.03

Landuse
                          MAIZ         155.85           0.61          29.82
                          GRAS         366.84           1.43          70.18

Soil
    loamy sand on boulder clay         522.69           2.03         100.00

Slope
                        0-6379         522.69           2.03         100.00

HRUs:
36   MAIZ/loamy sand on boulder clay/0-6379         155.85           0.61          29.82
37   GRAS/loamy sand on boulder clay/0-6379         366.84           1.43          70.18
----------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 8                            1138.94           4.43

Landuse
                          GRAS         455.93           1.77          40.03
                          POTA         117.27           0.46          10.30
                          MAIZ         111.60           0.43           9.80
                          CONF         234.54           0.91          20.59
                          DECD         219.59           0.85          19.28

Soil
              slightly lmy snd         302.25           1.18          26.54
                loam poor sand         123.50           0.48          10.84
    loamy sand on boulder clay         713.19           2.77          62.62

Slope
                        0-6379        1138.94           4.43         100.00

HRUs:
38   CONF/loam poor sand/0-6379         123.50           0.48          10.84
39   CONF/loamy sand on boulder clay/0-6379         111.04           0.43           9.75
40   DECD/slightly lmy snd/0-6379         101.90           0.40           8.95
41   DECD/loamy sand on boulder clay/0-6379         117.69           0.46          10.33
42   POTA/loamy sand on boulder clay/0-6379         117.27           0.46          10.30
43   MAIZ/loamy sand on boulder clay/0-6379         111.60           0.43           9.80
44   GRAS/loamy sand on boulder clay/0-6379         255.59           0.99          22.44
45   GRAS/slightly lmy snd/0-6379         200.35           0.78          17.59
----------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 9                            1138.81           4.43

Landuse
                          GRAS         469.64           1.83          41.24
                          MAIZ         180.96           0.70          15.89
                          NGRA         488.22           1.90          42.87

Soil
 peaty earthy top on pt on snd         474.45           1.85          41.66
    loamy sand on boulder clay         664.36           2.58          58.34

Slope
                        0-6379        1138.81           4.43         100.00

HRUs:
46   NGRA/peaty earthy top on pt on snd/0-6379         364.19           1.42          31.98
47   NGRA/loamy sand on boulder clay/0-6379         124.03           0.48          10.89
48   MAIZ/loamy sand on boulder clay/0-6379         180.96           0.70          15.89
49   GRAS/peaty earthy top on pt on snd/0-6379         110.26           0.43           9.68
50   GRAS/loamy sand on boulder clay/0-6379         359.38           1.40          31.56
----------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 10                           1476.88           5.75

Landuse
                          GRAS         903.94           3.52          61.21
                          MAIZ         107.60           0.42           7.29
                          NGRA         177.11           0.69          11.99
                          DECD         288.23           1.12          19.52

Soil
              slightly lmy snd         117.56           0.46           7.96
 peaty earthy top on pt on snd         626.97           2.44          42.45
    loamy sand on boulder clay         732.34           2.85          49.59

Slope
                        0-6379        1476.88           5.75         100.00

HRUs:
51   NGRA/peaty earthy top on pt on snd/0-6379         177.11           0.69          11.99
52   DECD/loamy sand on boulder clay/0-6379         179.10           0.70          12.13
53   DECD/peaty earthy top on pt on snd/0-6379         109.12           0.42           7.39
54   MAIZ/loamy sand on boulder clay/0-6379         107.60           0.42           7.29
55   GRAS/loamy sand on boulder clay/0-6379         445.64           1.73          30.17
56   GRAS/slightly lmy snd/0-6379         117.56           0.46           7.96
57   GRAS/peaty earthy top on pt on snd/0-6379         340.74           1.33          23.07
----------------------------------------------------------------------------
                                    Area [ha]     %Watershed      %Subbasin

Subbasin 11                            915.63           3.56

Landuse
                          GRAS         510.18           1.98          55.72
                          MAIZ         140.38           0.55          15.33
                          CONF         119.24           0.46          13.02
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                      DECD        145.82          0.57         15.93

Soil
 peaty earthy top on pt on snd        147.99          0.58         16.16
    loamy sand on boulder clay        767.63          2.99         83.84

Slope
                    0-6379        915.62          3.56        100.00

HRUs:
58   CONF/loamy sand on boulder clay/0-6379         119.24          0.46         13.02
59   DECD/loamy sand on boulder clay/0-6379         145.82          0.57         15.93
60   MAIZ/loamy sand on boulder clay/0-6379         140.38          0.55         15.33
61   GRAS/loamy sand on boulder clay/0-6379         362.19          1.41         39.56
62   GRAS/peaty earthy top on pt on snd/0-6379         147.99          0.58         16.16
---------------------------------------------------------------------------
                                   Area [ha]     %Watershed      %Subbasin

Subbasin 12                          1297.13          5.05

Landuse
                      CONF        744.61          2.90         57.40
                      NGRA        242.36          0.94         18.68
                      DECD        310.16          1.21         23.91

Soil
             slightly lmy snd        455.80          1.77         35.14
 peaty earthy top on pt on snd        242.36          0.94         18.68
    loamy sand on boulder clay        598.96          2.33         46.18

Slope
                    0-6379       1297.13          5.05        100.00

HRUs:
63   NGRA/peaty earthy top on pt on snd/0-6379         242.36          0.94         18.68
64   CONF/loamy sand on boulder clay/0-6379         438.39          1.71         33.80
65   CONF/slightly lmy snd/0-6379         306.22          1.19         23.61
66   DECD/loamy sand on boulder clay/0-6379         160.57          0.62         12.38
67   DECD/slightly lmy snd/0-6379         149.58          0.58         11.53
---------------------------------------------------------------------------
                                   Area [ha]     %Watershed      %Subbasin

Subbasin 13                           794.69          3.09

Landuse
                      CONF        635.59          2.47         79.98
                      DECD        159.10          0.62         20.02

Soil
             slightly lmy snd        411.67          1.60         51.80
               loam poor sand        110.93          0.43         13.96
    loamy sand on boulder clay        272.08          1.06         34.24

Slope
                    0-6379        794.69          3.09        100.00

HRUs:
68   CONF/loamy sand on boulder clay/0-6379         272.08          1.06         34.24
69   CONF/slightly lmy snd/0-6379         252.57          0.98         31.78
70   CONF/loam poor sand/0-6379         110.93          0.43         13.96
71   DECD/slightly lmy snd/0-6379         159.10          0.62         20.02
---------------------------------------------------------------------------
                                   Area [ha]     %Watershed      %Subbasin

Subbasin 14                           803.69          3.13

Landuse
                      GRAS        277.68          1.08         34.55
                      CONF        393.55          1.53         48.97
                      DECD        132.47          0.52         16.48

Soil
sandy top on peat on sandy sub        156.32          0.61         19.45
    loamy sand on boulder clay        647.37          2.52         80.55

Slope
                    0-6379        803.69          3.13        100.00

HRUs:
72   CONF/sandy top on peat on sandy sub/0-6379         156.32          0.61         19.45
73   CONF/loamy sand on boulder clay/0-6379         237.22          0.92         29.52
74   DECD/loamy sand on boulder clay/0-6379         132.47          0.52         16.48
75   GRAS/loamy sand on boulder clay/0-6379         277.68          1.08         34.55
---------------------------------------------------------------------------
                                   Area [ha]     %Watershed      %Subbasin

Subbasin 15                          2434.94          9.47

Landuse
                      GRAS        802.09          3.12         32.94
                      POTA        183.56          0.71          7.54
                      CRLS        157.40          0.61          6.46
                      CONF        393.83          1.53         16.17
                      MAIZ        157.62          0.61          6.47
                      NGRA        491.09          1.91         20.17
                      DECD        249.34          0.97         10.24

Soil
             slightly lmy snd       1561.85          6.08         64.14
               loam poor sand        211.03          0.82          8.67
 peaty earthy top on pt on snd        555.25          2.16         22.80
    loamy sand on boulder clay        106.82          0.42          4.39

Slope
                    0-6379       2434.94          9.47        100.00

HRUs:
76   NGRA/slightly lmy snd/0-6379         141.55          0.55          5.81
77   NGRA/peaty earthy top on pt on snd/0-6379         349.54          1.36         14.36
78   CONF/slightly lmy snd/0-6379         182.80          0.71          7.51
79   CONF/loam poor sand/0-6379         211.03          0.82          8.67
80   DECD/slightly lmy snd/0-6379         249.34          0.97         10.24
81   CRLS/slightly lmy snd/0-6379         157.40          0.61          6.46
82   POTA/slightly lmy snd/0-6379         183.56          0.71          7.54
83   MAIZ/slightly lmy snd/0-6379         157.62          0.61          6.47
84   GRAS/loamy sand on boulder clay/0-6379         106.82          0.42          4.39
85   GRAS/slightly lmy snd/0-6379         489.57          1.90         20.11
86   GRAS/peaty earthy top on pt on snd/0-6379         205.71          0.80          8.45
---------------------------------------------------------------------------
                                   Area [ha]     %Watershed      %Subbasin

Subbasin 16                           685.38          2.67

Landuse
                      FOR1        183.61          0.71         26.79
                      URHD        289.79          1.13         42.28
                      GRA1        211.97          0.82         30.93

Soil
                built-up area        685.38          2.67        100.00

Slope
                    0-6379        685.38          2.67        100.00

HRUs:
87   GRA1/built-up area/0-6379        211.97          0.82         30.93
88   FOR1/built-up area/0-6379        183.61          0.71         26.79
89   URHD/built-up area/0-6379        289.79          1.13         42.28
---------------------------------------------------------------------------
                                   Area [ha]     %Watershed      %Subbasin

Subbasin 17                          1616.06          6.29

Landuse
                      GRAS        869.31          3.38         53.79
                      POTA        238.32          0.93         14.75
                      MAIZ        132.49          0.52          8.20
                      NGRA        219.71          0.85         13.60
                      DECD        156.23          0.61          9.67
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Soil
            slightly lmy snd        177.77          0.69         11.00
 peaty earthy top on pt on snd        375.62          1.46         23.24
   loamy sand on boulder clay       1062.67          4.13         65.76

Slope
                       0-6379       1616.06          6.29        100.00

HRUs:
90   NGRA/peaty earthy top on pt on snd/0-6379         219.71          0.85         13.60
91   DECD/loamy sand on boulder clay/0-6379         156.23          0.61          9.67
92   POTA/loamy sand on boulder clay/0-6379         238.32          0.93         14.75
93   MAIZ/loamy sand on boulder clay/0-6379         132.49          0.52          8.20
94   GRAS/slightly lmy snd/0-6379         177.77          0.69         11.00
95   GRAS/peaty earthy top on pt on snd/0-6379         155.92          0.61          9.65
96   GRAS/loamy sand on boulder clay/0-6379         535.62          2.08         33.14
---------------------------------------------------------------------------
                              Area [ha]     %Watershed      %Subbasin

Subbasin 18                        24.94          0.10

Landuse
                         GRAS       24.94          0.10        100.00

Soil
            slightly lmy snd        24.94          0.10        100.00

Slope
                       0-6379       24.94          0.10        100.00

HRUs:
97   GRAS/slightly lmy snd/0-6379          24.94          0.10        100.00
---------------------------------------------------------------------------
                              Area [ha]     %Watershed      %Subbasin

Subbasin 19                      2446.69          9.52

Landuse
                         POTA      127.58          0.50          5.21
                         URHD      115.40          0.45          4.72
                         CRLS      224.97          0.88          9.19
                         HEAT      146.69          0.57          6.00
                         GRAS      881.77          3.43         36.04
                         NGRA      780.65          3.04         31.91
                         DECD      169.63          0.66          6.93

Soil
            slightly lmy snd       1026.15          3.99         41.94
 peaty earthy top on pt on snd       268.12          1.04         10.96
               built-up area       115.40          0.45          4.72
                  loamy sand       636.82          2.48         26.03
 peaty earthy top on peaty sub       143.61          0.56          5.87
   loamy sand on boulder clay       256.59          1.00         10.49

Slope
                       0-6379      2446.69          9.52        100.00

HRUs:
98      NGRA/loamy sand/0-6379        128.13          0.50          5.24
99   NGRA/slightly lmy snd/0-6379        240.78          0.94          9.84
100  NGRA/peaty earthy top on pt on snd/0-6379        268.12          1.04         10.96
101  NGRA/peaty earthy top on peaty sub/0-6379        143.61          0.56          5.87
102  HEAT/slightly lmy snd/0-6379        146.69          0.57          6.00
103  URHD/built-up area/0-6379        115.40          0.45          4.72
104  DECD/slightly lmy snd/0-6379        169.63          0.66          6.93
105  CRLS/slightly lmy snd/0-6379        106.28          0.41          4.34
106     CRLS/loamy sand/0-6379        118.69          0.46          4.85
107     POTA/loamy sand/0-6379        127.58          0.50          5.21
108     GRAS/loamy sand/0-6379        262.41          1.02         10.73
109  GRAS/loamy sand on boulder clay/0-6379        256.59          1.00         10.49
110  GRAS/slightly lmy snd/0-6379        362.77          1.41         14.83
---------------------------------------------------------------------------
                              Area [ha]     %Watershed      %Subbasin

Subbasin 20                       855.25          3.33

Landuse
                         GRAS      166.66          0.65         19.49
                         HEAT      103.80          0.40         12.14
                         NGRA      584.79          2.28         68.38

Soil
            slightly lmy snd       531.57          2.07         62.15
 peaty earthy top on pt on snd       197.22          0.77         23.06
 peaty earthy top on peaty sub       126.46          0.49         14.79

Slope
                       0-6379       855.25          3.33        100.00

HRUs:
111  NGRA/slightly lmy snd/0-6379        261.11          1.02         30.53
112  NGRA/peaty earthy top on pt on snd/0-6379        197.22          0.77         23.06
113  NGRA/peaty earthy top on peaty sub/0-6379        126.46          0.49         14.79
114  HEAT/slightly lmy snd/0-6379        103.80          0.40         12.14
115  GRAS/slightly lmy snd/0-6379        166.66          0.65         19.49
---------------------------------------------------------------------------
                              Area [ha]     %Watershed      %Subbasin

Subbasin 21                       410.81          1.60

Landuse
                         GRAS      257.99          1.00         62.80
                         NGRA      152.82          0.59         37.20

Soil
            slightly lmy snd       410.81          1.60        100.00

Slope
                       0-6379       410.81          1.60        100.00

HRUs:
116  NGRA/slightly lmy snd/0-6379        152.82          0.59         37.20
117  GRAS/slightly lmy snd/0-6379        257.99          1.00         62.80
---------------------------------------------------------------------------
                              Area [ha]     %Watershed      %Subbasin

Subbasin 22                       533.31          2.07

Landuse
                         NGRA      255.17          0.99         47.85
                         DECD      278.14          1.08         52.15

Soil
            slightly lmy snd       282.52          1.10         52.97
                   dune sand       124.99          0.49         23.44
sandy top on peat on sandy sub       125.81          0.49         23.59

Slope
                       0-6379       533.31          2.07        100.00

HRUs:
118  NGRA/slightly lmy snd/0-6379        129.36          0.50         24.26
119  NGRA/sandy top on peat on sandy sub/0-6379        125.81          0.49         23.59
120  DECD/slightly lmy snd/0-6379        153.16          0.60         28.72
121      DECD/dune sand/0-6379        124.99          0.49         23.44
---------------------------------------------------------------------------
                              Area [ha]     %Watershed      %Subbasin

Subbasin 23                      2390.06          9.30

Landuse
                         URHD      122.29          0.48          5.12
                         GRAS     1338.31          5.21         55.99
                         MAIZ      135.79          0.53          5.68
                         NGRA      482.48          1.88         20.19
                         DECD      311.18          1.21         13.02

Soil
            slightly lmy snd      1529.24          5.95         63.98
               built-up area       122.29          0.48          5.12
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 peaty earthy top on pt on snd        413.28          1.61         17.29
 peaty earthy top on peaty sub        151.00          0.59          6.32
    loamy sand on boulder clay        174.25          0.68          7.29

Slope
                        0-6379       2390.06          9.30        100.00

HRUs:
122  NGRA/slightly lmy snd/0-6379         197.28          0.77          8.25
123  NGRA/peaty earthy top on pt on snd/0-6379         134.21          0.52          5.62
124  NGRA/peaty earthy top on peaty sub/0-6379         151.00          0.59          6.32
125  URHD/built-up area/0-6379        122.29          0.48          5.12
126  DECD/slightly lmy snd/0-6379         311.18          1.21         13.02
127  MAIZ/slightly lmy snd/0-6379         135.79          0.53          5.68
128  GRAS/loamy sand on boulder clay/0-6379         174.25          0.68          7.29
129  GRAS/slightly lmy snd/0-6379         884.99          3.44         37.03
130  GRAS/peaty earthy top on pt on snd/0-6379         279.08          1.09         11.68
---------------------------------------------------------------------------
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Appendix 2 – Land use information

OBJECTID	ICNUM	CPNM	IDC	CROPNAME	BIO_E
1	1	GRAS	6	NL Agricultu	35
2	2	MAIZ	4	NL Maize	39
3	3	POTA	4	NL Potatoes	25
4	4	BEET	4	NL Beet	30
5	5	CRLS	4	NL Cereals	30
6	6	OTHC	4	NL Other cro	33.5
7	7	FRSD	7	Forest-Decid	15
8	8	GLSH	6	NL Glass hou	0
9	9	ORCH	7	NL Orchards	15
10	10	BULB	4	NL Bulbs	30
11	11	DECD	7	NL Deciduous	15
12	12	CONF	7	NL Coniferou	15
13	13	SPAS	6	Summer Pastu	35
14	14	WPAS	6	Winter Pastu	30
15	15	RNGE	6	Range-Grasse	34
16	16	FRWA	6	NL Freshwate	0
17	17	SWRN	6	Southwestern	34
18	18	URHD	6	NL Urban are	0
19	19	URMD	6	NL Urban are	0
20	20	FOR1	7	NL Forest	15
21	21	SCRN	4	Sweet Corn	39
22	22	FOR2	7	NL Forest	15
23	23	GRA1	6	NL Grass	34
24	24	BARE	6	NL Bare soil	34
25	25	UTRN	6	NL Roads	0
26	26	URBN	6	NL RuralHous	0
27	27	SWHT	5	Spring Wheat	35
28	28	GRA2	6	NL Grass	34
29	29	DWHT	5	Durum Wheat	30
30	30	RYE	5	Rye	35
31	31	BARL	5	Spring Barle	35
32	32	OATS	5	Oats	35
33	33	RICE	4	Rice	22
34	34	PMIL	4	Pearl Millet	35
35	35	SSND	6	NL Shifting	34
36	36	HEAT	6	NL Heather	34
37	37	PGHE	6	NL Poor gras	34
38	38	SGHE	6	NL Strong gr	34
39	39	BLUG	6	Kentucky Blu	18
40	40	BERM	6	Bermudagrass	35
41	41	MRSH	6	NL Other mar	47
42	42	REED	6	NL Reed Vege	47
43	43	FORW	7	NL Forest in	15
44	44	RYEG	5	Italian (Ann	30
45	45	NGRA	6	NL Natural g	34
46	46	RYEA	6	Altai Wildry	30
47	47	SIDE	6	Sideoats Gra	11

HVSTI	BLAI	FRGRW1	LAIMX1	FRGRW2	LAIMX2
.9	4	.15	.01	.5	.95
.9	4	.15	.05	.5	.95
.95	4	.15	.01	.5	.95
2	5	.05	.05	.5	.95
.54	4	.05	.05	.45	.95
.45	3	.15	.05	.5	.95
.76	5	.05	.05	.4	.95
0	0	0	0	0	0
.1	4	.1	.15	.5	.75
1.25	1.5	.15	.01	.5	.95
.76	5	.05	.05	.4	.95
.76	5	.15	.7	.25	.99
.9	4	.05	.05	.49	.95
.9	4	.15	.01	.5	.95
.9	2.5	.05	.1	.25	.7
0	0	0	0	0	0
.9	1.5	.05	.1	.25	.7
0	0	0	0	0	0
0	0	0	0	0	0
.76	5	.05	.05	.4	.95
.5	2.5	.15	.05	.5	.95
.76	5	.05	.05	.4	.95
.9	2.5	.05	.1	.25	.7
.9	1.5	.05	.1	.25	.7
0	0	0	0	0	0
0	0	0	0	0	0
.42	4	.15	.05	.5	.95
.9	2.5	.05	.1	.25	.7
.4	4	.15	.01	.5	.95
.4	4	.15	.01	.5	.95
.54	4	.15	.01	.45	.95
.42	4	.15	.02	.5	.95
.5	5	.3	.01	.7	.95
.25	2.5	.15	.01	.5	.95
.9	1.5	.05	.1	.25	.7
.9	2.25	.05	.1	.25	.7
.9	2	.05	.1	.25	.7
.9	2	.05	.1	.25	.7
.9	2	.05	.05	.3	.7
.9	4	.05	.05	.49	.95
.9	6	.1	.2	.2	.95
.9	6	.1	.2	.2	.95
.76	5	.05	.05	.4	.95
.9	4	.2	.32	.45	.95
.9	2.25	.05	.1	.25	.7
.9	3	.35	.02	.62	.95
.9	1.7	.05	.05	.3	.7

DLAI	CHTMX	RDMX	T_OPT	T_BASE	CNYLD
.85	.8	2	25	8	.0234
.7	2.5	2	25	8	.014
.6	.6	.6	22	7	.0246
.6	1.2	2	18	4	.013
.9	.9	1.3	18	0	.025
.64	1	2	30	11	.0199
.99	6	3.5	30	10	.0015
0	0	0	0	0	0
.99	3.5	2	20	7	.0019
.6	.5	.6	19	7	.0206
.99	6	3.5	30	10	.0015
.99	10	3.5	30	0	.0015
.99	.5	2	25	12	.0234
.8	1.5	2	15	0	.0234
.35	1	2	25	12	.016
0	0	0	0	0	0
.35	1	2	25	12	.016
0	0	0	0	0	0
0	0	0	0	0	0
.99	6	3.5	30	10	.0015
.5	2.5	2	24	12	.0214
.99	6	3.5	30	10	.0015
.35	1	2	25	12	.016
.35	1	2	25	12	.016
0	0	0	0	0	0
0	0	0	0	0	0
.6	.9	2	18	0	.0234
.35	1	2	25	12	.016
.8	1	2	15	0	.0263
.8	1	1.8	12.5	0	.0284
.6	1.2	1.3	25	0	.021
.8	1.5	2	15	0	.0316
.8	.8	.9	25	10	.0136
.85	3	2	30	10	.02
.35	1	2	25	12	.016
.35	1	2	25	12	.016
.35	1	2	25	12	.016
.35	1	2	25	12	.016
.35	.2	1.4	25	12	.016
.99	.5	2	25	12	.0234
.7	2.5	2.2	25	12	.016
.7	2.5	2.2	25	12	.016
.99	6	3.5	30	10	.0015
.5	.8	1.3	18	0	.022
.35	1	2	25	12	.016
.8	1.1	1.3	15	0	.023
.35	.4	1.4	25	12	.016

CPYLD	BN1	BN2	BN3	BP1	BP2
.0033	.0314	.0137	.0103	.0038	.0025
.0016	.047	.0177	.0138	.0048	.0018
.0023	.055	.02	.012	.006	.0025
.002	.055	.02	.012	.006	.0025
.0022	.0663	.0255	.0148	.0053	.002
.0032	.044	.0164	.0128	.006	.0022
.0003	.006	.002	.0015	.0007	.0004
0	0	0	0	0	0
.0004	.006	.002	.0015	.0007	.0004
.0032	.04	.03	.002	.0021	.002
.0003	.006	.002	.0015	.0007	.0004
.0003	.006	.002	.0015	.0007	.0004
.0033	.06	.0231	.0134	.0084	.0032
.0033	.056	.021	.012	.0099	.0022
.0022	.02	.012	.005	.0014	.001
0	0	0	0	0	0
.0022	.02	.012	.005	.0014	.001
0	0	0	0	0	0
0	0	0	0	0	0
.0003	.006	.002	.0015	.0007	.0004
.0037	.047	.0177	.0138	.0048	.0018
.0003	.006	.002	.0015	.0007	.0004
.0022	.02	.012	.005	.0014	.001
.0022	.02	.012	.005	.0014	.001
0	0	0	0	0	0
0	0	0	0	0	0
.0033	.06	.0231	.0134	.0084	.0032
.0022	.02	.012	.005	.0014	.001
.0057	.06	.0231	.013	.0084	.0032
.0042	.06	.0231	.0134	.0084	.0032
.0017	.059	.0226	.0131	.0057	.0022
.0057	.06	.0231	.0134	.0084	.0032
.0013	.05	.02	.01	.006	.003
.0028	.044	.03	.01	.006	.0022
.0022	.02	.012	.005	.0014	.001
.0022	.02	.012	.005	.0014	.001
.0022	.02	.012	.005	.0014	.001
.0022	.02	.012	.005	.0014	.001
.0022	.02	.01	.006	.0014	.001
.0033	.06	.0231	.0134	.0084	.0032
.0022	.035	.015	.0038	.0014	.001
.0022	.035	.015	.0038	.0014	.001
.0003	.006	.002	.0015	.0007	.0004
.0028	.066	.0254	.0147	.0105	.004
.0022	.02	.012	.005	.0014	.001
.0037	.0226	.018	.014	.004	.004
.0022	.02	.01	.006	.0014	.001

BP3	WSYF	USLE_C	GSI	VPDFR	FRGMAX
.0019	.9	.003	.005	4	.75
.0014	.9	.2	.007	4	.75
.0019	.95	.2	.005	4	.75
.0019	1.1	.2	.007	4	.75
.0012	.2	.03	.0056	4	.75
.0018	.25	.2	.005	4	.75
.0003	.01	.001	.002	4	.75
0	0	.001	0	0	0
.0003	.05	.001	.007	4	.75
.0019	.95	.2	.006	4	.75
.0003	.01	.001	.002	4	.75
.0003	.6	.001	.002	4	.75
.0019	.9	.003	.005	4	.75
.0019	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
0	0	.001	0	0	0
.0007	.9	.003	.005	4	.75
0	0	.001	0	0	0
0	0	.001	0	0	0
.0003	.01	.001	.002	4	.75
.0014	.3	.2	.007	4	.75
.0003	.01	.001	.002	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
0	0	.001	0	0	0
0	0	.001	0	0	0
.0019	.2	.03	.006	4	.75
.0007	.9	.003	.005	4	.75
.0019	.2	.03	.006	4	.75
.0019	.2	.03	.01	4	.75
.0013	.2	.01	.008	4	.75
.0019	.175	.03	.005	4	.75
.0018	.25	.03	.008	4	.75
.0012	.1	.2	.014	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0019	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0003	.01	.001	.002	4	.75
.0024	.9	.03	.005	4	.75
.0007	.9	.003	.005	4	.75
.0024	.9	.03	.005	4	.75
.0007	.9	.003	.005	4	.75

WAVP	CO2HI	BIOEHI	RSDCO_PL	OV_N	CN2A
8	660	45	.05	.1	31
7.2	660	45	.05	.14	67
14.8	660	30	.05	.14	67
10	660	35	.05	.14	67
6	660	39	.05	.14	62
8.5	660	36	.05	.14	67
8	660	16	.05	.1	45
0	0	0	0	1	92
3	660	20	.05	.15	45
10	660	35	.05	.14	67
8	660	16	.05	.1	45
8	660	16	.05	.1	25
10	660	36	.05	.15	49
8	660	39	.05	.15	49
10	660	39	.05	.15	49
0	0	0	0	.01	92
10	660	39	.05	.15	39
0	0	0	0	1	92
0	0	0	0	1	92
8	660	16	.05	.1	45
7.2	660	45	.05	.14	67
8	660	16	.05	.1	45
10	660	39	.05	.15	49
10	660	39	.05	.15	39
0	0	0	0	1	92
0	0	0	0	1	92
8	660	46	.05	.14	62
10	660	39	.05	.15	49
7	660	45	.05	.14	62
7	660	45	.05	.14	62
7	660	45	.05	.14	62
10	660	45	.05	.14	62
5	660	31	.05	.14	62
8	660	40	.05	.14	62
10	660	39	.05	.15	39
10	660	39	.05	.15	44
10	660	39	.05	.15	39
10	660	39	.05	.15	39
10	660	31	.05	.1	31
10	660	36	.05	.1	31
8.5	660	54	.05	.05	49
8.5	660	54	.05	.05	49
8	660	16	.05	.05	45
6	660	39	.05	.1	31
10	660	39	.05	.15	44
8	660	46	.05	.1	31
10	660	21	.05	.1	31

CN2B	CN2C	CN2D	FERTFIELD	ALAI_MIN	BIO_LEAF
59	72	79	0	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
73	81	84	1	0	0
77	83	87	1	0	0
66	77	83	0	.75	.3
92	92	92	0	0	0
66	77	83	1	.75	.3
77	83	87	1	0	0
66	77	83	0	.75	.3
55	70	77	0	.75	.3
69	79	84	0	0	0
69	79	84	0	0	0
69	79	84	0	0	0
92	92	92	0	0	0
61	74	80	0	0	0
92	92	92	0	0	0
92	92	92	0	0	0
66	77	83	0	.75	.3
77	83	87	1	0	0
66	77	83	0	.75	.3
69	79	84	0	0	0
61	74	80	0	0	0
92	92	92	0	0	0
92	92	92	0	0	0
73	81	84	1	0	0
69	79	84	0	0	0
73	81	84	1	0	0
73	81	84	1	0	0
73	81	84	1	0	0
73	81	84	1	0	0
73	81	84	1	0	0
73	81	84	1	0	0
61	74	80	0	0	0
65	76.5	82	0	0	0
61	74	80	0	0	0
61	74	80	0	0	0
59	72	79	0	0	0
59	72	79	0	0	0
69	79	84	0	0	0
69	79	84	0	0	0
66	77	83	0	0	0
59	72	79	0	0	0
65	76.5	82	0	0	0
59	72	79	0	0	0
59	72	79	0	0	0

MAT_YRS	BMX_TREES	EXT_COEF	BM_DIEOFF
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
10	1000	.65	.1
0	0	0	0
0	0	.65	.1
0	0	.65	.1
10	1000	.65	.1
30	1000	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.33	.1
0	0	0	0
0	0	.33	.1
0	0	0	.1
0	0	0	.1
0	0	0	0
0	0	.65	.1
0	0	0	0
0	0	.33	.1
0	0	0	0
0	0	0	.1
0	0	0	.1
0	0	.65	.1
0	0	.33	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.45	.1
0	0	.35	.1
0	0	.65	.1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	1.4	.1
0	0	1	.1
0	0	.65	.1
0	0	.65	.1
0	0	0	0
0	0	.65	.1
0	0	0	0
0	0	.65	.1
0	0	1.12	.1

OBJECTID	ICNUM	CPNM	IDC	CROPNAME	BIO_E
48	48	BBLS	6	Big Bluestem	14
49	49	LBLS	6	Little Blues	34
50	50	SWCH	6	Alamo Switch	47
51	51	INDN	6	Indiangrass	34
52	52	ALFA	3	Alfalfa	20
53	53	CLVS	3	Sweetclover	25
54	54	CLVR	2	Red Clover	25
55	55	CLVA	3	Alsike Clove	25
56	56	SOYB	1	Soybean	25
57	57	CWPS	1	Cowpeas	35
58	58	MUNG	1	Mung Beans	25
59	59	LIMA	1	Lima Beans	25
60	60	LENT	1	Lentils	20
61	61	TRNU	7	NL Tree Nurs	15
62	62	FRNU	7	NL Fruit Nur	15
63	63	PEAS	2	Garden or Ca	25
64	64	SESB	1	Sesbania	50
65	65	FLAX	5	Flax	25
66	66	COTS	4	Upland Cotto	15
67	67	COTP	4	Upland Cotto	15
68	68	TOBC	4	Tobacco	39
69	69	SGBT	4	Sugarbeet	30
70	70	POTA	5	Potato	25
71	71	SPOT	4	Sweetpotato	15
72	72	CRRT	5	Carrot	30
73	73	ONIO	5	Onion	30
74	74	SUNF	4	Sunflower	46
75	75	CANP	4	Spring Canol	34
76	76	CANA	4	Spring Canol	34
77	77	ASPR	6	Asparagus	90
78	78	BROC	5	Broccoli	26
79	79	CABG	6	Cabbage	19
80	80	CAUF	5	Cauliflower	21
81	81	CELR	6	Celery	27
82	82	LETT	5	Head Lettuce	23
83	83	SPIN	5	Spinach	30
84	84	GRBN	1	Green Beans	25
85	85	CUCM	4	Cucumber	30
86	86	EGGP	4	Eggplant	30
87	87	CANT	4	Cantaloupe	30
88	88	HMEL	4	Honeydew Mel	30
89	89	WMEL	4	Watermelon	30
90	90	PEPR	4	Bell Pepper	30
91	91	STRW	6	Strawberry	30
92	92	TOMA	4	Tomato	30
93	93	APPL	7	Apple	15
94	94	PINE	7	Pine	15

HVSTI	BLAI	FRGRW1	LAIMX1	FRGRW2	LAIMX2
.9	3	.05	.1	.25	.7
.9	2.5	.05	.1	.25	.7
.9	6	.1	.2	.2	.95
.9	3	.05	.1	.25	.7
.9	4	.15	.01	.5	.95
.9	4	.15	.01	.5	.95
.9	4	.15	.01	.5	.95
.9	4	.15	.01	.5	.95
.31	3	.15	.05	.5	.95
.42	4	.15	.01	.5	.95
.31	4	.15	.01	.5	.95
.3	2.5	.1	.05	.8	.95
.61	4	.15	.02	.5	.95
.1	4	.1	.15	.5	.75
.1	4	.1	.15	.5	.75
.3	2.5	.1	.05	.8	.95
.31	5	.15	.01	.5	.95
.54	2.5	.15	.02	.5	.95
.5	4	.15	.01	.5	.95
.4	4	.15	.01	.5	.95
.55	4.5	.15	.05	.5	.95
2	5	.05	.05	.5	.95
.95	4	.15	.01	.5	.95
.6	4	.15	.01	.5	.95
1.12	3.5	.15	.01	.5	.95
1.25	1.5	.15	.01	.5	.95
.3	3	.15	.01	.5	.95
.23	3.5	.15	.02	.45	.95
.3	4.5	.15	.02	.45	.95
.8	4.2	.25	.23	.4	.86
.8	4.2	.25	.23	.4	.86
.8	3	.25	.23	.4	.86
.8	2.5	.25	.23	.4	.86
.8	2.5	.25	.23	.4	.86
.8	4.2	.25	.23	.4	.86
.95	4.2	.1	.05	.9	.95
.1	1.5	.1	.05	.8	.95
.27	1.5	.15	.05	.5	.95
.59	3	.15	.05	.5	.95
.5	3	.15	.05	.5	.95
.55	4	.15	.05	.5	.95
.5	1.5	.15	.05	.5	.95
.6	5	.15	.05	.5	.95
.45	3	.15	.05	.5	.95
.33	3	.15	.05	.5	.95
.1	4	.1	.15	.5	.75
.76	5	.15	.7	.25	.99

DLAI	CHTMX	RDMX	T_OPT	T_BASE	CNYLD
.35	1	2	25	12	.016
.35	1	2	25	12	.016
.7	2.5	2.2	25	12	.016
.35	1	2	25	12	.016
.9	.9	3	20	4	.025
.75	1.5	2.4	15	1	.065
.75	.75	1.5	15	1	.065
.75	.9	2	15	1	.06
.6	.8	1.7	25	10	.065
.8	1.2	2	28	14	.0427
.9	1.5	2	30	15	.042
.9	.6	2	26	18	.0368
.9	.55	1.2	20	3	.0506
.99	3.5	2	20	7	.0019
.99	3.5	2	20	7	.0019
.6	.6	1.2	14	5	.041
.9	2	2	25	10	.065
.9	1.2	1.5	22.5	5	.04
.95	1	2.5	30	15	.014
.95	1	2.5	30	15	.019
.7	1.8	2	25	10	.014
.6	1.2	2	18	4	.013
.6	.6	.6	22	7	.0246
.6	.8	2	24	14	.0097
.6	.3	1.2	24	7	.0135
.6	.5	.6	19	7	.0206
.62	2.5	2	25	6	.0454
.5	.9	.9	21	5	.038
.5	1.3	1.4	21	5	.038
1	.5	2	24	10	.063
1	.5	.6	18	4	.0512
1	.5	.6	18	1	.0259
1	.5	.6	18	5	.0411
1	.5	.6	22	4	.0199
1	.2	.6	18	7	.0393
.95	.5	.6	24	4	.0543
.9	.6	1.2	19	10	.0299
.6	.5	1.2	32	16	.0219
.6	.5	1.2	26	15	.0218
.6	.5	1.2	35	15	.0138
.6	.5	1.2	35	16	.0071
.6	.5	2	35	18	.0117
.6	.5	1.2	27	18	.0188
.6	.5	.6	32	10	.0116
.95	.5	2	22	10	.0235
.99	3.5	2	20	7	.0019
.99	10	3.5	30	0	.0015

CPYLD	BN1	BN2	BN3	BP1	BP2
.0022	.02	.012	.005	.0014	.001
.0022	.02	.012	.005	.0014	.001
.0022	.035	.015	.0038	.0014	.001
.0022	.02	.012	.005	.0014	.001
.0035	.0417	.029	.02	.0035	.0028
.004	.065	.028	.0243	.006	.0024
.004	.065	.028	.0243	.006	.0024
.004	.06	.028	.024	.006	.0025
.0091	.0524	.0265	.0258	.0074	.0037
.0048	.06	.0231	.0134	.0049	.0019
.004	.0524	.0265	.0258	.0074	.0037
.0046	.004	.003	.0015	.0035	.003
.0051	.044	.0164	.0128	.0074	.0037
.0004	.006	.002	.0015	.0007	.0004
.0004	.006	.002	.0015	.0007	.0004
.0051	.004	.003	.0015	.003	.002
.0091	.05	.02	.015	.0074	.0037
.0033	.0482	.0294	.0263	.0049	.0024
.002	.058	.0192	.0177	.0081	.0027
.0029	.058	.0192	.0177	.0081	.0027
.0016	.047	.0177	.0138	.0048	.0018
.002	.055	.02	.012	.006	.0025
.0023	.055	.02	.012	.006	.0025
.001	.045	.016	.009	.0045	.0019
.0036	.055	.0075	.0012	.006	.003
.0032	.04	.03	.002	.0021	.002
.0074	.05	.023	.0146	.0063	.0029
.0079	.044	.0164	.0128	.0074	.0037
.0079	.044	.0164	.0128	.0074	.0037
.0067	.062	.05	.04	.005	.004
.0071	.062	.009	.007	.005	.004
.0031	.062	.007	.004	.005	.0035
.0059	.062	.007	.004	.005	.0035
.0049	.062	.015	.01	.006	.005
.0049	.036	.025	.021	.0084	.0032
.0058	.062	.04	.03	.005	.004
.0039	.004	.003	.0015	.004	.0035
.0043	.0663	.0075	.0048	.0053	.0025
.0041	.0663	.0255	.0075	.0053	.002
.0017	.0663	.0255	.0148	.0053	.002
.001	.007	.004	.002	.0026	.002
.0011	.0663	.0075	.0048	.0053	.0025
.003	.06	.035	.025	.0053	.002
.0023	.0663	.0255	.0148	.0053	.002
.0048	.0663	.03	.025	.0053	.0035
.0004	.006	.002	.0015	.0007	.0004
.0003	.006	.002	.0015	.0007	.0004

BP3	WSYF	USLE_C	GSI	VPDFR	FRGMAX
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.0007	.9	.003	.005	4	.75
.002	.9	.01	.01	4	.75
.0024	.9	.003	.005	4	.75
.0024	.9	.003	.006	4	.75
.0025	.9	.003	.005	4	.75
.0035	.01	.2	.007	4	.75
.0011	.05	.03	.005	4	.75
.0035	.01	.2	.005	4	.75
.0015	.22	.2	.005	4	.75
.0023	.01	.2	.005	4	.75
.0003	.05	.001	.007	4	.75
.0003	.05	.001	.007	4	.75
.0015	.22	.2	.005	4	.75
.0035	.01	.2	.005	4	.75
.0023	.4	.2	.005	4	.75
.0025	.4	.2	.009	4	.75
.0025	.3	.2	.009	4	.75
.0014	.55	.2	.005	4	.75
.0019	1.1	.2	.007	4	.75
.0019	.95	.2	.005	4	.75
.0015	.4	.05	.006	4	.75
.002	.9	.2	.006	4	.75
.0019	.95	.2	.006	4	.75
.0023	.18	.2	.008	4	.75
.0023	.01	.2	.006	4	.75
.0023	.01	.2	.006	4	.75
.002	.95	.2	.006	4	.75
.003	.95	.2	.006	4	.75
.002	.95	.2	.006	4	.75
.002	.95	.2	.006	4	.75
.003	.95	.2	.006	4	.75
.0019	.01	.01	.003	4	.75
.0035	.95	.2	.006	4	.75
.0015	.1	.2	.008	4	.75
.0012	.25	.03	.003	4	.75
.0015	.25	.03	.006	4	.75
.0012	.25	.03	.006	4	.75
.0017	.25	.03	.006	4	.75
.0012	.25	.03	.006	4	.75
.0012	.25	.03	.005	4	.75
.0012	.25	.03	.006	4	.75
.0025	.15	.03	.008	4	.75
.0003	.05	.001	.007	4	.75
.0003	.6	.001	.002	4	.75

WAVP	CO2HI	BIOEHI	RSDCO_PL	OV_N	CN2A
10	660	39	.05	.1	31
10	660	39	.05	.1	31
8.5	660	54	.05	.1	31
10	660	39	.05	.1	31
10	660	35	.05	.06	31
10	660	30	.05	.06	31
10	660	30	.05	.06	31
10	660	30	.05	.06	31
8	660	34	.05	.14	67
8	660	39	.05	.14	67
10	660	33	.05	.14	67
5	660	34	.05	.14	67
10	660	33	.05	.14	67
3	660	20	.05	.15	45
3	660	20	.05	.15	45
5	660	34	.05	.14	67
10	660	60	.05	.14	67
10	660	33	.05	.14	62
3	660	19	.05	.14	67
3	660	19	.05	.14	67
8	660	44	.05	.14	67
10	660	35	.05	.14	67
14.8	660	30	.05	.14	67
3	660	19	.05	.14	67
10	660	35	.05	.14	67
10	660	35	.05	.14	67
32.3	660	59	.05	.14	67
10	660	39	.05	.14	67
10	660	40	.05	.14	67
5	660	95	.05	.3	63
5	660	30	.05	.16	67
5	660	25	.05	.14	67
5	660	25	.05	.14	67
5	660	30	.05	.14	67
8	660	25	.05	.14	67
5	660	35	.05	.14	67
5	660	34	.05	.14	67
8	660	39	.05	.14	67
8	660	39	.05	.14	67
3	660	39	.05	.14	67
3	660	39	.05	.14	67
3	660	39	.05	.14	67
8	660	39	.05	.14	67
8	660	39	.05	.14	67
8	660	39	.05	.14	67
3	660	20	.05	.14	45
8	660	16	.05	.14	25

CN2B	CN2C	CN2D	FERTFIELD	ALAI_MIN	BIO_LEAF
59	72	79	0	0	0
59	72	79	0	0	0
59	72	79	1	0	0
59	72	79	0	0	0
59	72	79	0	0	0
59	72	79	0	0	0
59	72	79	0	0	0
59	72	79	0	0	0
78	85	89	0	0	0
78	85	89	0	0	0
78	85	89	0	0	0
77	83	87	0	0	0
77	83	87	0	0	0
66	77	83	1	.75	.3
66	77	83	1	.75	.3
77	83	87	0	0	0
77	83	87	0	0	0
73	81	84	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
74	82	85	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
77	83	87	1	0	0
66	77	83	0	.75	.3
55	70	77	0	.75	.3

MAT_YRS	BMX_TREES	EXT_COEF	BM_DIEOFF
0	0	.36	.1
0	0	.36	.1
0	0	.33	.1
0	0	.36	.1
0	0	.65	.1
0	0	.55	.1
0	0	.55	.1
0	0	.55	.1
0	0	.45	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.9	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
0	0	.65	.1
10	500	.65	.1
50	1000	.65	.1

Appendix 3 – The weather information

Month Average	TMPMX	TMPMN	TMPSTDMX	TMPSTDMN	PCPMM	PCPSTD	PCPSKW	PR_W1	PR_W2	PCPD	RAINHHMX	SOLARAV	DEWPT	WNDAV
1	4.630	−0.476	4.435	5.080	2.369	4.205	3.240	0.338	0.769	0.594	6.600	2.121	0.905	5.419
2	5.386	−0.552	4.109	4.683	1.833	3.366	2.739	0.319	0.714	0.527	3.975	4.428	0.881	5.034
3	8.893	1.396	3.941	3.731	2.068	3.746	2.896	0.317	0.730	0.540	6.825	7.879	0.851	5.046
4	13.342	3.336	4.551	3.477	1.417	2.969	3.329	0.270	0.659	0.442	7.650	13.546	0.793	4.334
5	17.406	6.781	4.679	3.364	1.852	4.065	4.309	0.255	0.659	0.428	12.675	17.279	0.786	4.038
6	19.851	9.474	4.280	3.045	2.405	4.586	2.962	0.311	0.688	0.499	16.500	17.704	0.807	3.862
7	22.086	11.820	4.140	2.764	2.647	5.194	3.407	0.348	0.653	0.501	21.975	17.288	0.817	3.721
8	22.113	11.588	3.879	2.905	2.290	4.944	3.989	0.307	0.670	0.482	22.800	14.679	0.825	3.608
9	18.595	9.260	3.203	2.995	2.576	5.197	3.946	0.297	0.728	0.522	13.125	10.112	0.863	3.701
10	13.884	6.094	3.336	3.913	2.427	4.334	2.909	0.316	0.737	0.545	9.750	5.778	0.887	4.250
11	8.687	2.878	3.632	4.006	2.551	4.266	2.797	0.374	0.782	0.632	5.925	2.627	0.913	4.563
12	5.350	0.187	4.214	4.777	2.379	4.071	2.773	0.361	0.747	0.588	4.350	1.604	0.921	4.910