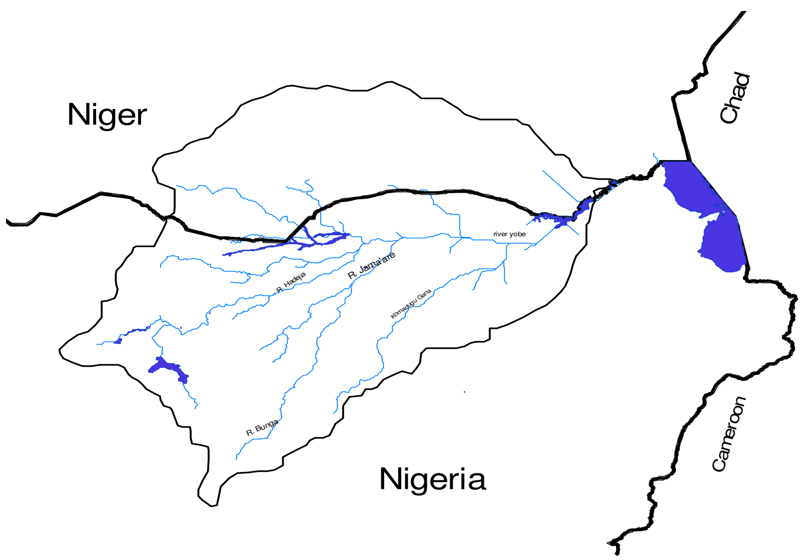
FMWR-IUCN-NCF KOMADUGU YOBE BASIN PROJECT 2006

# USER'S MANUAL

## for

# The Decision Support System (DSS)




# Annex 1 to the Water Audit for Komadugu Yobe Basin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**May 2006**

# ANNEX 1: USER'S MANUAL FOR THE DECISION SUPPORT SYSTEM FOR THE KOMADUGU YOBE BASIN



***Please reference the report as: KYBP 2006. User's Manual for the Decision Support System for the KYB*** *by Afremedev Consultancy Services Limited for FMWR-IUCN-NCF Komadugu Yobe Basin Project, Kano, Nigeria.*

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## 1.0 INTRODUCTION

The user interface of the model is presented below.


**Figure 1: The Interface of the model**

## 2.0 INSTALLATION PROCEDURE

### 2.1 System Requirement

A Personal Computer with XP operating system and full installation for Microsoft Office.

### 2.2 Procedure of Using the DSS

The data files and installation files are supplied in a directory '**backup-dss**'. The directory has two sub-directories: **dssmodel** and **dss-setup**. Create the directory **dssmodel** in your hard drive C (C:\dssmodel). Copy the contents of subdirectory dssmodel in the removable disk into C:\dssmodel. The program runs only in the directory c:\dssmodel.

The installation pack (dss-setup) has three files for installation in the setup directory. Follow the steps specified in Section 2.2.1.

### 2.2.1 Installation

**Step 1: Installation of user friendly environment**

For the program to run in a user friendly mode, follow this procedure:

- Locate the directory '**dss-setup**' in your pack (removable drive). This directory has three files. The directory must **not be** in the **c:\dssmodel**
- click **setup** and follow the installation procedure
- click **ok** to continue or **exit** to terminate installation
- click **change directory**, and change directory to c:\dssmodel which you have created.
- Click **setup icon** and answer yes to the subsequent questions.
- Go to control panel – click **start** and select **control panel**
- double click **administrative tools**
- double click **Data Sources ODBC**
- Select **system DSN** and **click Add**
- Select **Microsoft access driver** and **click finish**
- ODBC Microsoft Access setup dialogue will appear, type **gis** in the box for data source name, and click **select** under **database** (see Figure 2)**,** then choose **c:\dssmodel** as the directory for database, and select database name as **gis.mdb**. Then click **ok** to close the dialogue box**.**

You have successfully installed the user interface of the program.

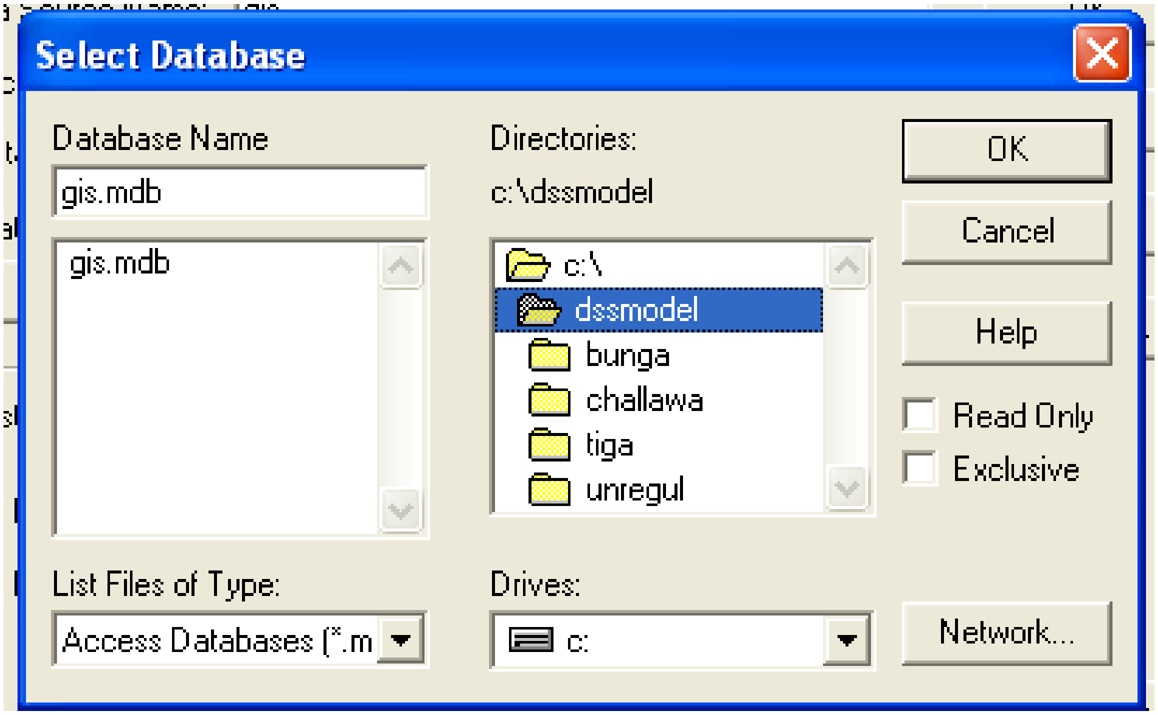



**Figure 2: Selection of Database Name**

**Step 2: Check the data files in C:\dssmodel** (This step is for verification of files copied into your system)

- The directory c:\dssmodel must have four sub-directories to keep the catchment data. These are:

  c:\dssmodel\tiga
  c:\dssmodel\challawa
  c:\dssmodel\unregul
  c:\dssmodel\bunga

- Each sub-directory must have the data files specified in Table 1.
- The executable files in each sub-directory are shown in Table 2.

### 2.2.2 Summary of input files

Table 1 shows the input files and the location of the respective files required for successful execution of the model.

**Table 1: Data files for the DSS**

| Location | File name | Comment |
|---|---|---|
| C:\dssmodel | m_kano_r.txt | Monthly rainfall (mm) for Kano |
| | m_hade_r.txt | Monthly rainfall (mm) for Hadejia |
| | m_bun_r.txt | Monthly rainfall (mm) for Bauchi |
| | popd.txt | Population data for Kano City, Hadejia area, Yobe area, Borno area |
| | A_pd.txt | Livestock population in Yobe sub-basin |
| | HNW_D.dat | Weekly requirement Mm$^3$) for Hadejia-Nguru Wetlands |
| | Kan_us.dat had_us.dat bun_us.dat | Monthly rainfall (mm) for Kano, hadejia and Bauchi up to a maximu of 10 years required for **optional** climatic scenario |
| C:\dssmodel\tiga | In_disch.txt | Historical monthly inflow (Mm$^3$) to Tiga lake |
| | M_catch_r.txt | Monthly rainfall (mm) data for the catchment |
| | R_user.txt | Monthly rainfall (mm) up to a maximum of 10 years required for optional climatic scenario |
| | Re_tiga.dat | Characteristic data for the reservoir |
| | Ecol_q.dat | Average weekly ecological release requirement (Mm$^3$) |
| | cat-par.dat | Range of values for catchment parameters in rainfall-runoff module |
| | tempe.txt | Monthly temperature |

| Location | File name | Comment |
|---|---|---|
| | | (°C) and relative humidity (%) for the catchment |
| C:\dssmodel\challawa | In_disch.txt | Historical monthly inflow ($Mm^3$) to Challawa reservoir |
| | M_catch_r.txt | Monthly rainfall (mm) data for the catchment |
| | R_user.txt | Monthly rainfall (mm) up to a maximum of 10 years required for optional climatic scenario |
| | Re_chal.dat | Characteristic data for the reservoir |
| | Ecol_q.dat | Average weekly ecological release requirement ($Mm^3$) |
| | cat-par.dat | Range of values for catchment parameters in rainfall-runoff module |
| | tempe.txt | Monthly temperature (°C) and relative humidity (%) for the catchment |
| C:\dssmodel\unregul | M_catch_r.txt | Monthly rainfall (mm) data for the catchment |
| | R_user.txt | Monthly rainfall (mm) up to a maximum of 10 years required for optional climatic scenario |
| | tempe.txt | Monthly temperature (°C) and relative humidity (%) for the catchment |
| C:\dssmodel\bunga | In_disch.txt | Historical monthly inflow ($Mm^3$) to Bunga reservoir |
| | M_catch_r.txt | Monthly rainfall (mm) data for the catchment |
| | R_user.txt | Monthly rainfall (mm) up to a maximum of |

| Location | File name | Comment |
|---|---|---|
| | | 10 years required for optional climatic scenario |
| | Re_bung.dat | Characteristic data for the reservoir |
| | Ecol_q.dat | Average weekly ecological release requirement ($Mm^3$) |
| | cat-par.dat | Range of values for catchment parameters in rainfall-runoff module |
| | tempe.txt | Monthly temperature ($^oC$) and relative humidity (%) for the catchment |

### 2.2.3 Summary of Executable files

The following executable files must be in the specified directory.

**Table 2: Executable files for the DSS**

| Location | File name | Comment |
|---|---|---|
| C:\dssmodel | Clnorm_m.exe | Stratify monthly rainfall records into climatic patterns |
| | dagr.exe | Aggregate the demand in the basin |
| | down_dam.exe | Route flow from upper Hadejia to Yau in Yobe |
| | sumfl.exe | Summarises surface water and ground water flow |
| C:\dssmodel\tiga | Clnorm.exe | Stratify monthly rainfall record in the catchment into climatic patterns |
| | Flow.exe | The fit run for rainfall-runoff module. Determine catchment parameters |
| | Simula.exe | Use optimum parameters of the |

| Location | File name | Comment |
|---|---|---|
| | | catchment to simulate flow for desired rainfall pattern |
| | Reservoi.exe | Simulate flow and demand through the reservoir for desired climatic pattern |
| C:\dssmodel\challawa | Clnorm.exe | Stratify monthly rainfall record in the catchment into climatic patterns |
| | Flow.exe | The fit run for rainfall-runoff module. Determine catchment parameters |
| | Simula.exe | Use optimum parameters of the catchment to simulate flow for desired rainfall pattern |
| | Reservoi.exe | Simulate flow and demand through the reservoir for desired climatic pattern |
| C:\dssmodel\unregul | Clnorm.exe | Stratify monthly rainfall record in the catchment into climatic patterns |
| | Avegp.exe | Determine model parameters for rainfall-runoff model as average of Tiga and Challawa sub-basins |
| | Simula.exe | Use optimum parameters of the catchment to simulate flow for desired rainfall pattern |
| C:\dssmodel\bunga | Clnorm.exe | Stratify monthly rainfall record in the catchment into climatic patterns |
| | Flow.exe | The fit run for rainfall-runoff module. Determine catchment |

| Location | File name | Comment |
|---|---|---|
| | | parameters |
| | Simula.exe | Use optimum parameters of the catchment to simulate flow for desired rainfall pattern |
| | Reservoi.exe | Simulate flow and demand through the reservoir for desired climatic pattern |

## 3.0 EXECUTING DSS PROGRAM

The program is interactive and it requires input from user. The procedure is as follows:

- Click start, then program and click 'decision support system (GIS)'.
- The user window (Figure 3) appears.

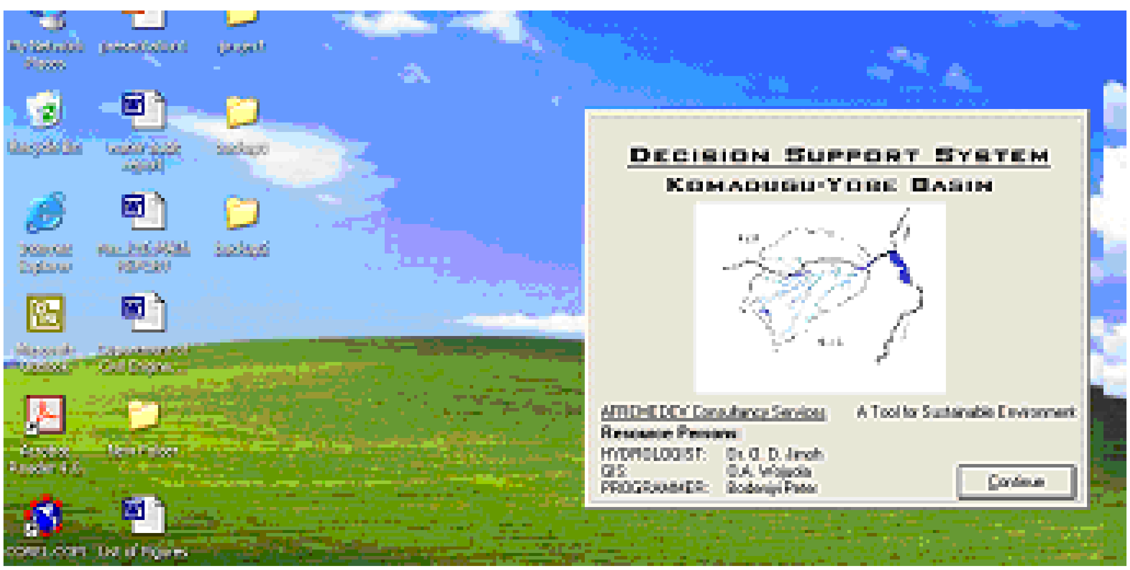



**Figure 3: Welcome interface**

- Click Continue, and the module-window (Figure 4) appears.

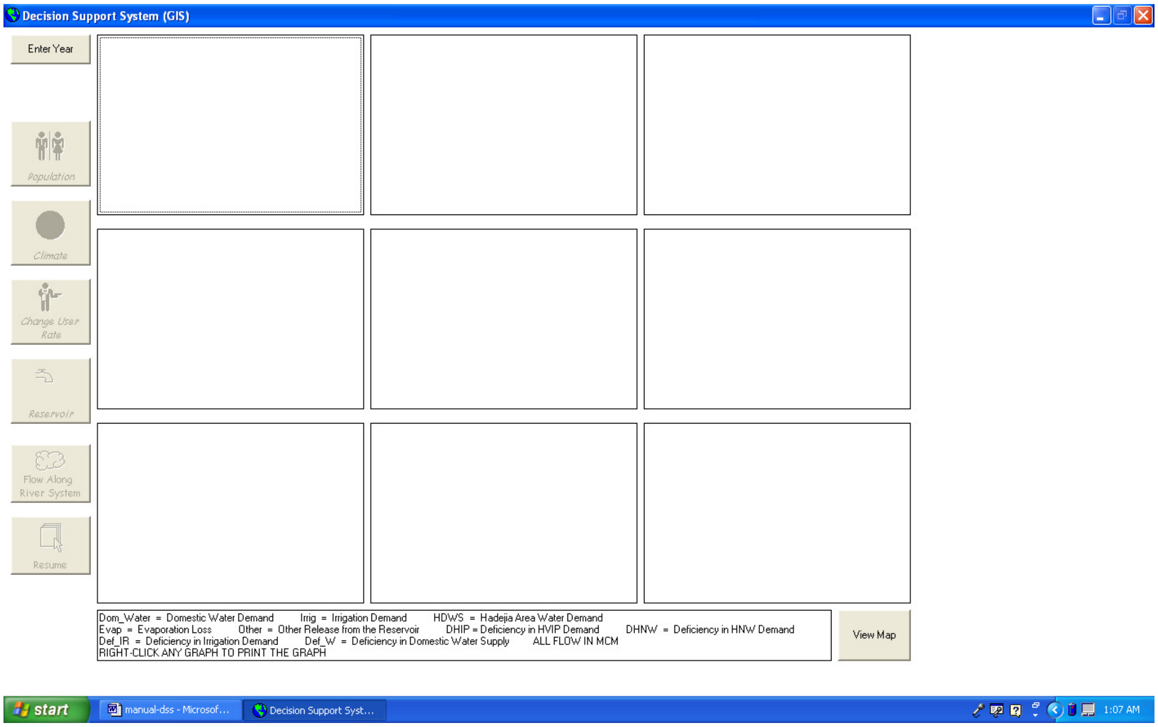



**Figure 4: Module window**

The window shows the various modules. The meanings of the abbreviations that come up in the course of execution of the model are shown. You can also view the KYB river system.

- Click enter year. This will request for year (four digit e.g. 2005) desired for execution. The program can execute for one year or multiple of years up to 10 years. For multiple years, enter the last year (for 2006 to 2010, enter 2010). NB: you must have the necessary rainfall data for multiple years (r_user.txt).

- Then click population icon to select the rate of increase for the population of Kano City, Hadejia area (all informal users around Wudil to Hadejia), area from Hadejia to Damasak, and Damasak to Yau area. There are three options – constant rate, linear rate and exponential rate. You are also required to edit the population base data (Figure 5). Click edit population, then the population data for 1995 is displayed. Modify the population data, if desired (or if new information is available). Then click 'safe and close' this takes you to dialogue for modifying the livestock data in Yobe sub-basin. Modify the data (if desired) then click 'safe and close". Then click 'ok'.

- Click climate icon to select the climatic pattern of the year. This could be normal, wet, extra wet, dry, extra dry and prolong dry years as well as optional code. There are rainfall patterns for the six climatic patterns in the directory C:\dssmodel, but user has to enter the rainfall pattern for optional case. See format of entering 'r_user.txt' (Table 3). Each of the four sub-directories has example of the r_user.txt. Also the root directory c:/dssmodel has three files bun_us.txt, kan_us.txt hav_us.txt for Jama'are sub-basin, Kano area and Jigawa area, respectively, for user to supply.

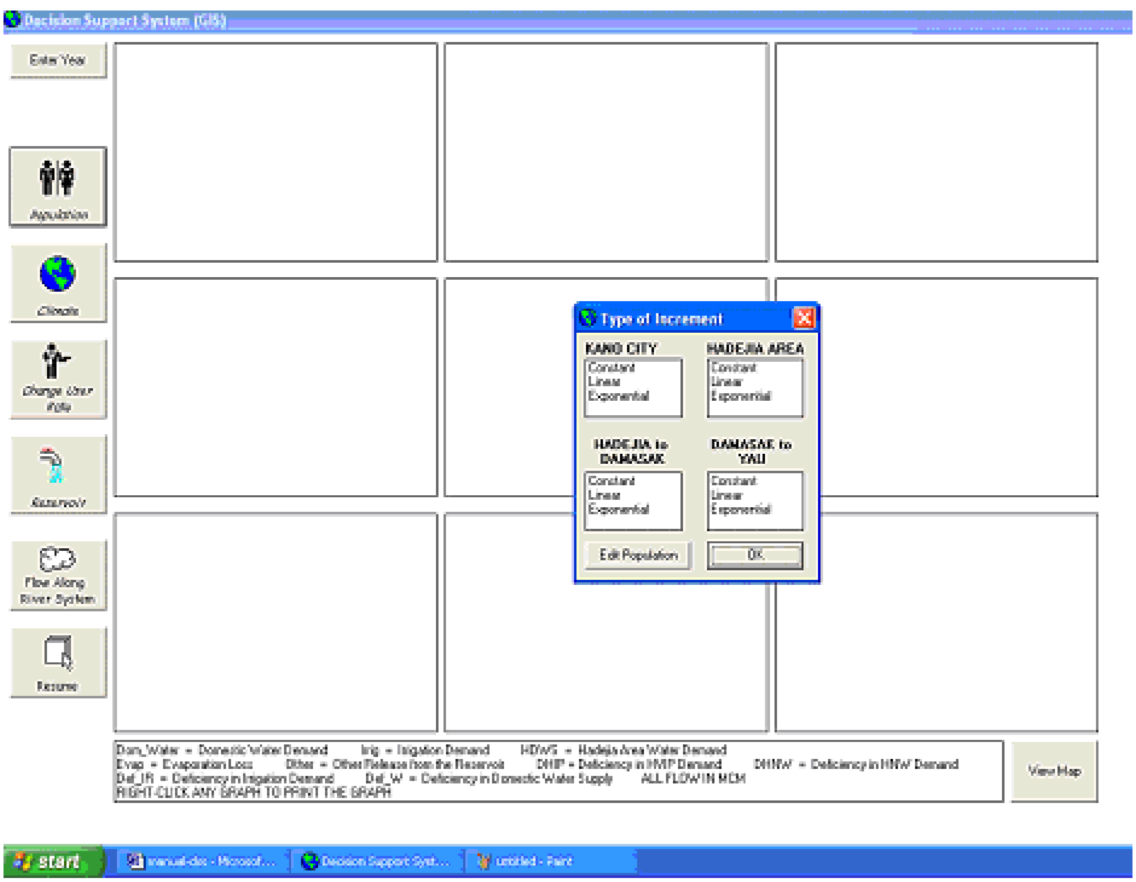



**Figure 5: Population dialogue window**

**Table 3: Standard for providing rainfall file (Tiga Unit) for Optional Code**

```
TIGA-CATCH
1986  1992
      1     2     3     4     5     6     7     8     9     10    11    12
1986  0.0   17.7  1.8   32.5  84.9  140.1 302.8 215.4 147.7 8.2   0.0   0.0
1987  0.0   0.0   24.1  7.4   86.7  159.3 239.9 237.6 112.5 45.0  0.0   0.0
1988  0.0   3.9   13.6  89.5  98.0  159.1 207.8 328.0 189.6 44.1  0.0   0.0
1989  0.0   0.0   0.1   50.3  65.2  134.4 185.7 315.6 109.7 53.7  0.0   4.4
1990  0.0   0.0   0.0   15.7  158.3 132.7 224.8 210.5 144.4 7.3   0.0   1.0
1991  0.0   0.3   21.4  86.0  172.0 175.5 274.1 346.0 64.5  22.7  0.0   0.0
1992  0.0   2.1   29.2  83.5  136.6 148.7 233.4 292.1 191.1 34.8  2.3   0.0
```

- Then click on change user icon' and enter the proportion of the demand from a specified user you wish to analyse. You can enter an integer from 0 to 100 for each user. For example, a user rate of 100 for KCWS implies the current rate (year 2005 value) of water demand for Kano City should be assessed. Click ok when you have selected the rate (in percentage) for all users. Then click ok again for a summary of annual water demand for each user to be displayed. Click continue.

- Click reservoir icon. Three reservoirs will be active – Tiga, Challawa, and Kafin Zaki. Click on each icon in order of appearance (top to bottom). A plot of inflow to each reservoir as estimated in the rainfall-runoff model is displayed. If you have selected 0 for Kafin Zaki, a plot of inflow at Bunga is displayed since the reservoir is still proposed. Click continue and then ok, to display a summary of water available from the four sub-basins. A summary of the demand from each sub-basin is also displayed. Click continue to display decision dialogue. The dialogue requested for information on the proportion of the demand that should be satisfied from available surface water. The decision is expected to be based on the summary of demand and supply of water in KYB. This summary is displayed behind the decision dialogue (Figure 6). The decision dialogue can be moved with the aid of mouse to view the summary of demand and supply (Figure 7).

Enter value between 0 and 100 for sector: Tiga sub-unit, Challawa sub-unit, area from Wudil to Hadejia, Hadejia to Damasak and Damasak to Yau. A value of 100 means 100% of the estimated demand should be satisfied from surface water resources. Click ok, then click yes to plot graphs showing simulated storage, spillage, demands and level of deficiency.

- Click on the icon: flow along river system. The flow from upper section of Hadejia River system through the Hadejia barrage to Hadejia-Nguru Wetland and to Yau is displayed. The volume of flow at critical section along the river system is plotted.

- Click resume to start again, otherwise terminate.

Right click on any graph to print.

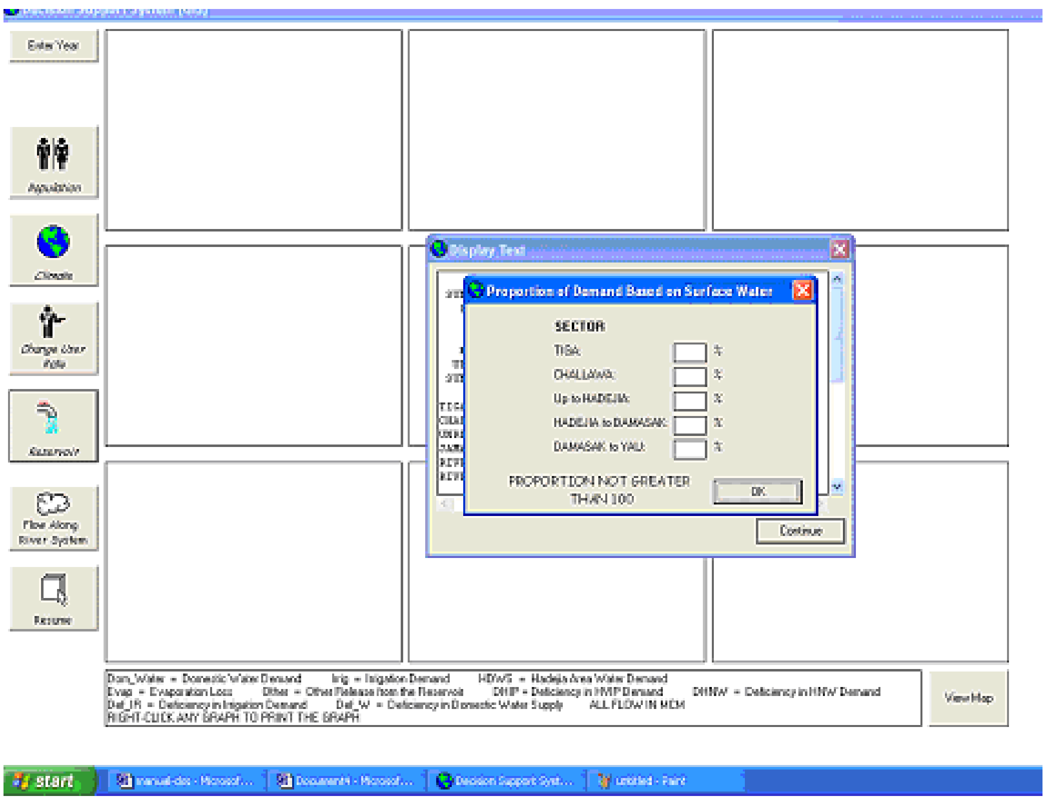



**Figure 6: Summary of demand and supply behind decision dialogue**

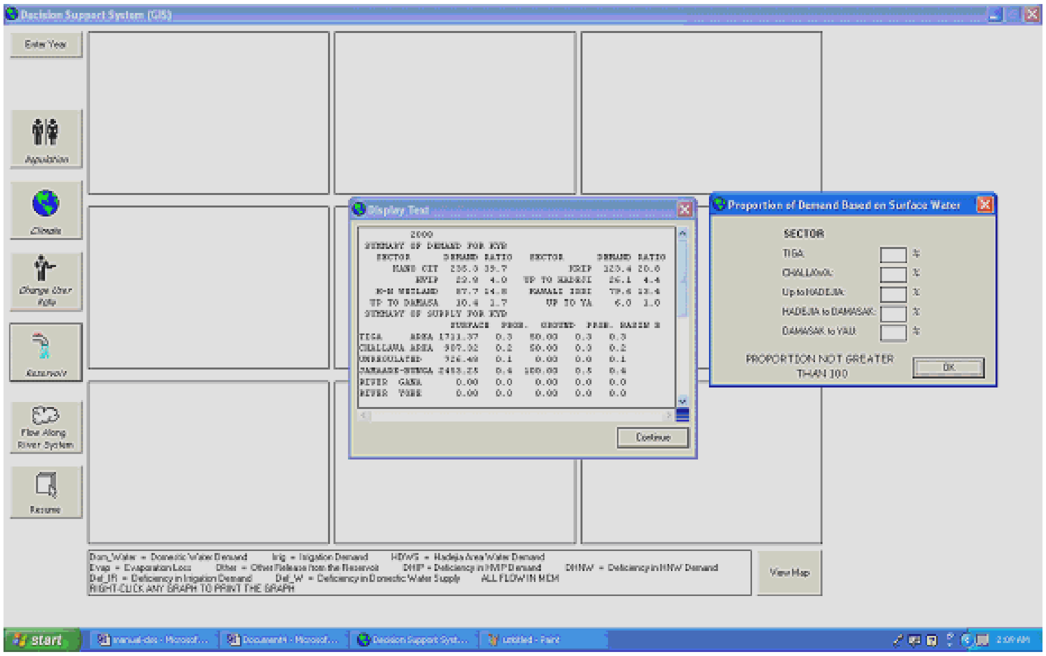



**Figure 7: Dialogue window for selecting surface water rate**

The output files during execution are summarised in Table 4. Some of these files serve as input for graphical display of results, while others can be accessed using a notepad or text editor.

**Table 4: Output files from the program**

| Location | File name | Comment |
|---|---|---|
| C:\dssmodel | Seq_01.txt | Summary of flow at critical nodes from Wudil to Yau in the basin including deficit level to Hadejia-Nguru Wetlands and Hadejia Valley Irrigation. |
| | Seq_out.txt | Summary of flow at critical nodes from Wudil to Yau in the basin including deficit level to Hadejia-Nguru Wetlands and Hadejia Valley Irrigation for Graphical Display. |
| | Demd_sum.txt | Summary of demand from KYB |

| Location | File name | Comment |
|---|---|---|
| | Supl_sum.txt | Summary of water resources in the basin |
| C:\dssmodel\tiga | Parame.txt<br><br>A_simu.txt<br><br>Res_01.txt<br><br>Res_out.txt | Optimum parameter for rainfall-runoff<br><br>Weekly observed and estimated flow for Graphical Display<br><br>Output from reservoir operation<br>.<br>Output from the reservoir for Graphical Display |
| C:\dssmodel\challawa | Parame.txt<br><br>A_simu.txt<br><br>Res_01.txt<br><br>Res_out.txt | Optimum parameter for rainfall-runoff<br><br>Weekly observed and estimated flow for Graphical Display<br><br>Output from reservoir operation<br>.<br>Output from the reservoir for Graphical Display |
| C:\dssmodel\unregul | Parame.txt<br><br>A_simu.txt | Optimum parameter for rainfall-runoff<br><br>Weekly estimated flow |
| C:\dssmodel\bunga | Parame.txt<br><br>A_simu.txt<br><br>Res_01.txt<br><br>Res_out.txt | Optimum parameter for rainfall-runoff<br><br>Weekly observed and estimated flow for Graphical Display<br><br>Output from reservoir operation<br>.<br>Output from the reservoir for Graphical Display |

Output files for graphical display might not be self explanatory

## 4.0 BASIS OF MODELING

### 4.1 The Rainfall-Runoff Model

#### 4.1.1 Basis of the rainfall-runoff model

The basis of the model is a water balance between the following:

(i) Input to the catchment as rainfall.

(ii) Output from the catchment as evapotranspiration loss, surface runoff and sub-surface flow.

(iii) Change in the volume of water stored in the catchment. This is summarized in the equation.

$$P = E_t + Q_i + Q_s + DS \qquad \text{.......................... (1)}$$

where P is rainfall, $E_t$ is evapotranspiration loss, $Q_i$ is Surface runoff, $Q_s$ is subsurface flow, and DS is the change in storage (positive or negative).

#### 4.1.2 Structure of the model

The model is conceived as a linear combination of four storage elements identified as:

(i) Surface storage

(ii) Channel storage

(iii) Soil moisture storage

(iv) Groundwater storage

**Surface Storage:** This unit is augmented by rainfall and artificial inflow (if any), and depleted by evapotranspiration loss and infiltration to the soil moisture zone. Channel inflow will occur when the storage in the unit exceeds a threshold value, and a simple budget yields the amount of the channel inflow. The average monthly evapotranspiration loss was computed by the Baney-Morin-Nigeria model. The Baney-Morin-Nigeria model accepts daily temperature, relative humidity and ratio of maximum possible radiation to the annual maximum radiation as inputs to give the average daily/monthly evapotranspiration.

The average monthly evapotranspiration is given by the model as:

$$E_{tp} = nr_f\,(0.45\,T + 8)(520 - R^{1.31})/100 \qquad \text{.......................... (2)}$$

where $E_{tp}$ is the average monthly potential evapotranspiration in mm, n is the number of days in the month, T is the mean monthly temperature in $^{O}C$, R is the average monthly relative humidity (%) and $r_f$ is the ratio of maximum possible radiation to the annual maximum.

The rate of infiltration which depends on the type and intensity of rainfall, and the present state of soil moisture was evaluated by the following equation given as:

$$f_i = f_o e^{-kt} \qquad \text{.......................... (3)}$$

where $f_i$ is the potential infiltration rate in mm. $f_o$ is the maximum infiltration rate in mm. k is the infiltration coefficient and t is the time unit.

**Channel Storage:** The channel storage is augmented by channel inflow and depleted by surface runoff. The surface runoff is conceived as a linear function of the storage. The constant of proportionality depends on the soil type and cover.

**The Soil Moisture Storage:** The movement of water into the unit is controlled by infiltration and capillary rise. Evapotranspiration and deep percolation controls the movement of water out of the unit. Deep percolation occurs when the soil moisture storage exceeds a threshold value. Capillary rise will cease whenever there is deep percolation. Both capillary rise and deep percolation depends on the storage level of the moisture and groundwater storage.

**Groundwater storage:** This is augmented by deep percolation, and depleted by capillary rise and flow. When the ground water storage exceeds the threshold value, the soil moisture storage is capillary rise and deep percolation will cease to occur, while evapotranspiration loss will act directly on the groundwater.

### 4.1.3 The model parameters

The water budget model has nine parameters, and they are listed in Table 5. The codes used for the parameters in the computer program, and their units are also indicated. The actual values of the parameters are given with the results printout.

**Table 5: The model parameters**

| s/n | Parameter | Code name | Unit |
|---|---|---|---|
| 1. | Threshold value of surface storage | TVSS | Metre |
| 2. | Maximum infiltration rate | FMAX | Metre |
| 3. | Infiltration Coefficient | HINFEL | Per unit time |
| 4. | Channel storage constant | CHSTK | Fraction |
| 5. | Threshold value of soil moisture storage | TVSM | Metre |
| 6. | Maximum capillary rate | CMAX | Fraction |
| 7. | Rate of evaporation from subsurface zone | PCUS | Fraction |
| 8. | Groundwater storage constant | GWSC | Fraction |
| 9. | Threshold value of Groundwater storage | TVGW | Metre |

## 4.2 The Demand-Allocation Model

### 4.2.1 DAGR.EXE

This module aggregates the water demand for both major and minor users. In order to determine domestic water demand, the module estimates the population based on the POPD.DAT and the desired rate of increase in population (constant, linear or exponential). The weekly water demand is computed based on average consumption rate of 150 litres per capita per day for city, 100 litres per capita per day for urban area and 60 litres per capita per day for rural area. The average consumption rate was converted to weekly rate based climatic ratio shown in Figure 8.

The water required by a given population P is expressed as the product of the population and rate of consumption. Similarly, the water required for livestock is expressed as a product of the livestock population and its consumption rate.

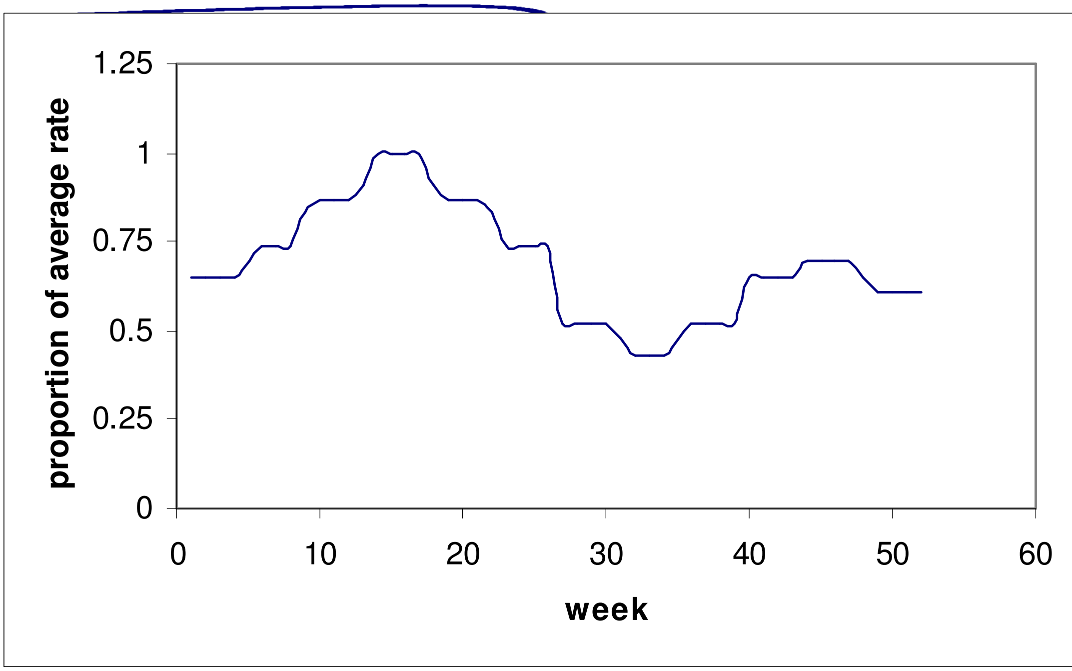



**Figure 8: Variation in domestic water demand for KYB**

Irrigation water requirement:

Area under irrigation for a particular crop = total command area * proportion of area for the crop

Water required = area under irrigation * $C_{wr}$ * irrigation efficiency

The crop water requirement, $C_{wr}$ was based on evapotranspiration data, crop factor and stage of growth of the particular crop. An irrigation efficiency of 50% was assumed for each irrigation scheme. The irrigation canals (secondary and tertiary) are unlined thus a minimum water level in the canal must be maintained throughout the year to reduce effect of cracking and seepage. For supplementary irrigation during rainy season, water required was reduced by effective rainfall (rainfall less evaporation loss).

### 4.2.2 RESERVOI.EXE

The routing procedure is summarised below.

Convert Storage to Area using Reservoir Characteristic equation

**For Tiga Reservoir:**

AREA = VOLUME*ms + c

Ms = 0.21, c = 0.0 for VOLUME ≤ 190

Ms = 21.838, c = 0.0889 for 190 < VOLUME ≤ 1429

AREA = 148.79 for VOLUME > 1429

(Volume in $Mm^3$ and Area in $km^2$)

**For Challawa Reservoir:**

AREA = VOLUME*ms + c

Ms = 0.09, c = 0.0 for VOLUME ≤ 100

Ms = 0.09, c = 13.79322 for VOLUME > 100

**For Bunga Reservoir:** Use either the equation for Challawa or Tiga.

MODIFIED INFLOW = INFLOW*(1-AREA/CATCHMENT AREA)

Determine Reservoir Storage less Demand

STORAGE = PREVIOUS RESERVOIR STORAGE + MODIFIED INFLOW – DEMAND – DOWNSTREAM RELEASE

Convert Storage to AREA using Reservoir Characteristic equation

Determine SPILLAGE

FINAL RESERVOIR VOLUME = STORAGE – SPILLAGE – EVAPORATION + RAIN on reservoir area

Convert Final Reservoir Volume to RESERVOIR LEVEL using reservoir characteristic equation

**For Tiga Reservoir:**

LEVEL = VOLUME*ms + c

Ms = 0.4994, c = 490.96 for VOLUME ≤ 25

Ms = 0.0578, c = 500.23 for 25 < VOLUME ≤ 100

Ms = 0.0268, c = 503.57 for 100 < VOLUME ≤ 300

Ms = 0.0141, c = 507.76 for 300 < VOLUME ≤ 800

Ms = 0.0083, c = 512.6 for 800 < VOLUME ≤ 1500

(Volume in $Mm^3$ and Level in m)

**For Challawa reservoir:**

$LEVEL = A*(VOLUME)^3 + B*(VOLUME)^3 + C*(VOLUME) + D$

where A = 0.0069, B =-0.225, C=2.6194, D =487.81 for VOLUME ≤ 20

A = $5*10^{-8}$, B =$-9*10^{-5}$, C=0.068, D =501.06 for 20 < VOLUME ≤ 10 20

(VOLUME in $Mm^3$, LEVEL in m)

Use RESERVOIR LEVEL to determine DISCHARGE TO IRRIGATION CANAL or RIVER CHANNEL FOR WATER SUPPLY as appropriate. The calculation is also based on Characteristic equation

**For Tiga Reservoir:**

(a) Canal -

| | |
|---|---|
| DISCH = 0 | for LEVEL < 508.4 m |
| DISCH = 9.0143 * LEVEL - 4586 | 508.4 m ≤ LEVEL < 509.6 m |
| DISCH = 3.0078 * LEVEL - 1520.6 | 509.6 m ≤ LEVEL < 513.86 m |
| DISCH = 25 | LEVEL ≥ 513.86 m |

(discharge in $m^3/s$)

(b) River Channel -

| | |
|---|---|
| DISCH = 0 | for LEVEL < 502.0 m |
| DISCH = 0.089 * LEVEL - 41.269 | 502.0 m ≤ LEVEL < 507.0 m |
| DISCH = 0.0768 * LEVEL - 34.994 | 507.0 m ≤ LEVEL < 509.0 m |

DISCH = 0.0768 * LEVEL - 34.994 + LEVEL * 0.1262 – 62.234

for LEVEL ≥ 509.0 m

**For Challawa Reservoir**

DISCH = ms * LEVEL + c

| | |
|---|---|
| where ms =12.38, c = -6,140.5 | for LEVEL ≤ 498.0 |
| ms =2.4998, c = 1,214.1893 | for 498.0 < LEVEL ≤ 514.0 |
| ms =1.6442, c = -775.4073 | for LEVEL > 514.0 |

(DISCH in $m^3/s$ and LEVEL in m)

Determine whether the discharge could meet the demand (DEFICIENT in IRRIGATION OR WATER SUPPLY)

#### 4.2.3 DOWN_DAM.EXE

This module route the flow from Upper Hadejia to Yau. The routing was based on historical flow records and mathematical relationship between the flows.

### 4.3 The Complete DSSModel

The acronym of the model developed is termed DSSModel. The model was built in modules. The flow structure of the model is presented in Figure 9.

#### 4.3.1 Data preparation

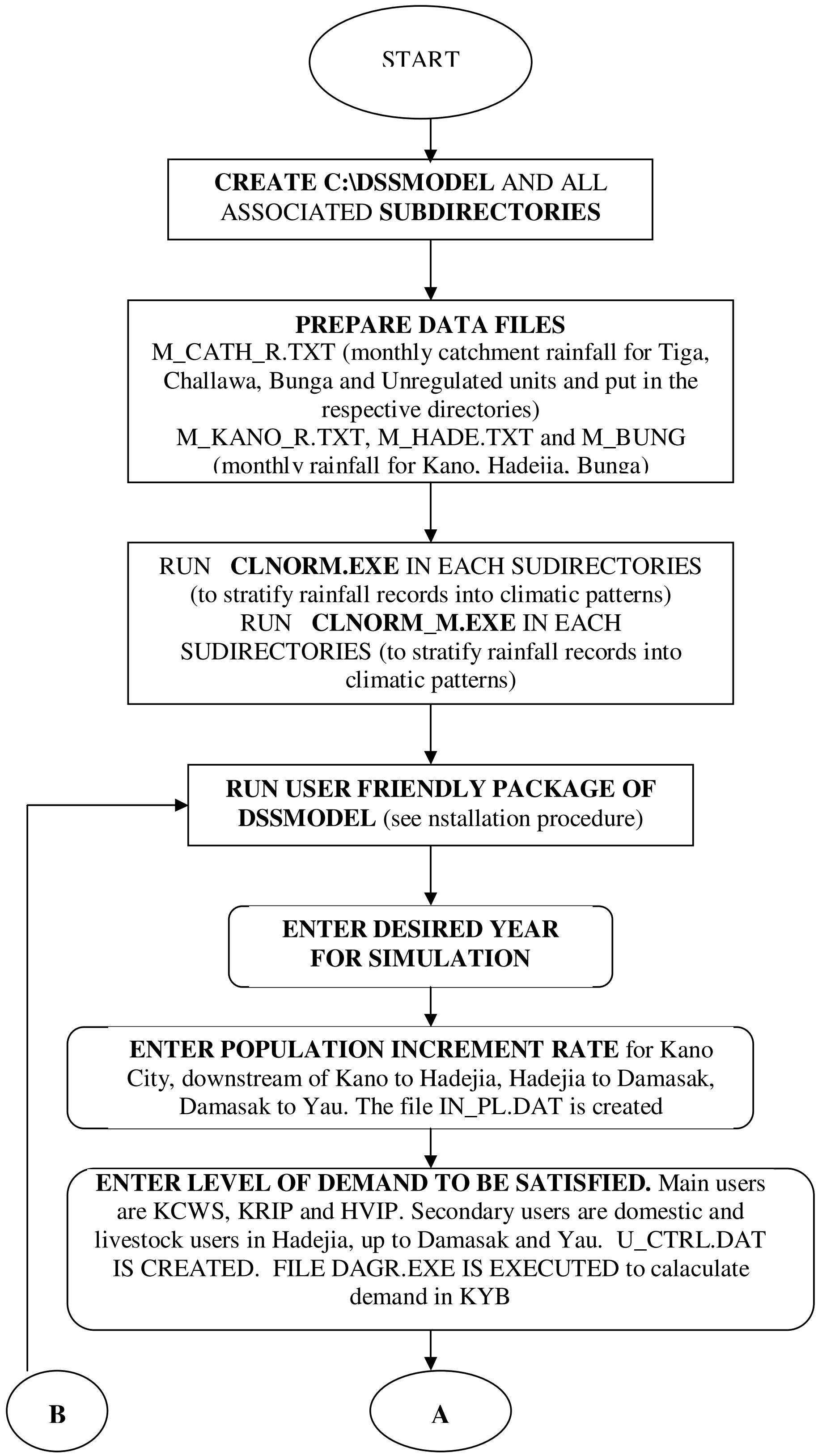
The formats for data preparation are expressed below.

**POPD.DAT ---- population data file**

Example:

```
1995
4230000  3.0
750000  2.5
56586    2.5
67660    2.5
```

Line 1: year of record
Line 2: population of Kano City for the year of record, annual growth rate
Line 3: population of community downstream of Kano up to Hadejia (informal user), annual growth rate
Line 4: population downstream of Hadejia up to Damasak (informal user), annual growth rate
Line 5: population from Damasak to Yau (informal user), annual growth rate


START
CREATE C:\DSSMODEL AND ALL ASSOCIATED SUBDIRECTORIES
PREPARE DATA FILES
M_CATH_R.TXT (monthly catchment rainfall for Tiga, Challawa, Bunga and Unregulated units and put in the respective directories)
M_KANO_R.TXT, M_HADE.TXT and M_BUNG (monthly rainfall for Kano, Hadejia, Bunga)
RUN CLNORM.EXE IN EACH SUDIRECTORIES (to stratify rainfall records into climatic patterns)
RUN CLNORM_M.EXE IN EACH SUDIRECTORIES (to stratify rainfall records into climatic patterns)
RUN USER FRIENDLY PACKAGE OF DSSMODEL (see nstallation procedure)
ENTER DESIRED YEAR FOR SIMULATION
ENTER POPULATION INCREMENT RATE for Kano City, downstream of Kano to Hadejia, Hadejia to Damasak, Damasak to Yau. The file IN_PL.DAT is created
ENTER LEVEL OF DEMAND TO BE SATISFIED. Main users are KCWS, KRIP and HVIP. Secondary users are domestic and livestock users in Hadejia, up to Damasak and Yau. U_CTRL.DAT IS CREATED. FILE DAGR.EXE IS EXECUTED to calaculate demand in KYB
B
A

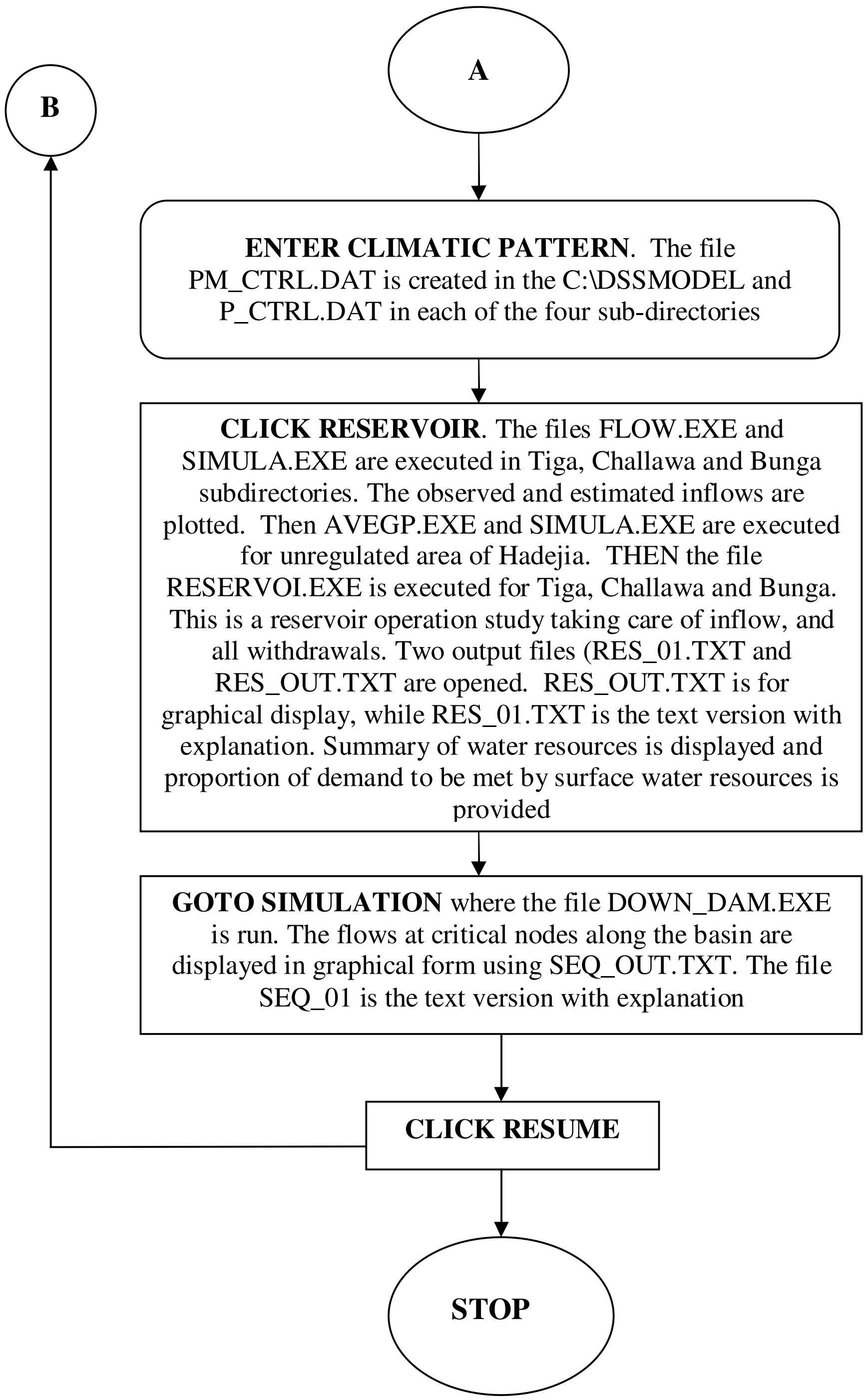



**Figure 9: Flow structure of the DSSModel**

**IN_DISCH.TXT**
Line 1: title of station
Line 2: starting year of record, ending year of record, catchment area in $km^2$
Line 3: month code 1 to 12
Line 4: starting year, monthly flow in $Mm^3$
Line 5: next year, monthly flow in $Mm^3$
..
..
Last line: ending year, monthly flow in $Mm^3$

**M_CATH_R.TXT**
Line 1: name of station
Line 2: starting year of record, ending year of record
Line 3: month code 1 to 12
Line 4: starting year, monthly rainfall depth
Line 5: next year, monthly rainfall depth
..
..
Last line: ending year, monthly rainfall depth

**R_USER.TXT** --- monthly rainfall record for user optional code
Line 1: name of station
Line 2: starting year of record, ending year of record
Line 3: month code 1 to 12
Line 4: starting year, monthly rainfall depth
Line 5: next year, monthly rainfall depth
..
..
Last line: ending year, monthly rainfall depth

**M_HADE_R.TXT**
Line 1: name of station
Line 2: starting year of record, ending year of record
Line 3: month code 1 to 12
Line 4: starting year, monthly rainfall depth
Line 5: next year, monthly rainfall depth
..
..
Last line: ending year, monthly rainfall depth

**M_BUNG_R.TXT**
Line 1: name of station
Line 2: starting year of record, ending year of record
Line 3: month code 1 to 12
Line 4: starting year, monthly rainfall depth
Line 5: next year, monthly rainfall depth
..
..
Last line: ending year, monthly rainfall depth

**M_KANO_R.TXT**
Line 1: name of station
Line 2: starting year of record, ending year of record
Line 3: month code 1 to 12
Line 4: starting year, monthly rainfall depth
Line 5: next year, monthly rainfall depth
..
..
Last line: ending year, monthly rainfall depth

**RE_TIGA.TXT** --- reservoir characteristics data
Example:
*TIGA*
*523.7 1945.0 1100.0*
*0.0 190.0 0.21 0.0*
*190.0 1429.0 0.0889 21.838*
*0.0 25.0 0.04994 490.96*
*25.0 100.0 0.0578 500.23*
*100.0 300.0 0.0268 503.57*
*300.0 800.0 0.0141 507.76*
*800.0 1500.0 0.0083 512.6*
*508.4 509.6 509.6 513.86 513.86 9.0143 -4586 3.0078 1520.6 0.0 25.0*
*502.0 507.0 507.0 509.0 509.0 0.089 -41.269 0.0768 -34.994 0.0768 -34.994*
*0.1262 -62.234*
Line 1: station name
Line 2: maximum reservoir level, maximum storage volume, average storage volume at the end of year
Line 3 and Line 4: Parameters for volume- area equation (area = coef*vol + constant). Thus, line 3 and line 4 show lower limit of volume, upper limit, coefficient and constant.
Line 5 to Line 9: parameters for volume-elevation equation (level=coef*vol + constant). Thus, each line should have the lower limit of volume, upper limit, coefficient and constant.
Line 10: parameters for converting reservoir level to canal discharge-KRIP (discharge = coef*level+const). The first 5 values show the lower limit, upper limit, lower limit, upper limit and lower limit of the three segments of the equation, then, the coefficient and constant of the respective segments.
Line 11: parameters for converting reservoir level to river discharge-KCWS (discharge = coef*level+const). The first 5 values show the lower limit, upper limit, lower limit, upper limit and lower limit of the three segments of the equation, then, the coefficient and constant of the respective segments.

**RE_CHAL.TXT** --- reservoir characteristics data
Example
*CHALLAWA*
*524.0 948.0 850.0*
*0.0 100.0 0.22799 0.0*

*100.0 948.0 0.09 13.79322*
*0.0 20.0 0.0069 -0.225 2.6194 487.81*
*20.0 1020.0 0.00000005 -0.00009 0.068 501.06*
*0.0 498.0 498.0 514.0 514.0 12.38 -6140.5 2.4998 -1214.1893 1.6442 -775.4073*

Line 1: station name
Line 2: maximum reservoir level, maximum storage volume, average storage volume at the end of year
Line 3 and Line 4: Parameters for volume- area equation (area = coef*vol + constant). Thus, line 3 and line 4 show lower limit of volume, upper limit, coefficient and constant.
Line 5 to Line 6: Parameters for volume-elevation equation (Level = $ax^3 + bx^2 + cx$ + constant, where x is volume). Thus, each line should have the lower limit of volume, upper limit, coefficient and constant.
Line 7: parameters for converting reservoir level to river discharge (discharge = coef*level+const). The first 5 values show the lower limit, upper limit, lower limit, upper limit and lower limit of the three segments of the equation, then, the coefficient and constant of the respective segments.

**RE_BUNG.TXT** --- reservoir characteristics data
BUNGA
524.0 948.0 850.0
0.0 100.0 0.22799 0.0
100.0 948.0 0.09 13.79322
0.0 20.0 0.0069 -0.225 2.6194 487.81
20.0 1020.0 0.00000005 -0.00009 0.068 501.06
0.0 498.0 498.0 514.0 514.0 12.38 -6140.5 2.4998 -1214.1893 1.6442 -775.4073

Line 1: station name
Line 2: maximum reservoir level, maximum storage volume, average storage volume at the end of year
Line 3 and Line 4: Parameters for volume- area equation (area = coef*vol + constant). Thus, line 3 and line 4 show lower limit of volume, upper limit, coefficient and constant.
Line 5 to Line 6: Parameters for volume-elevation equation (Level = $ax^3 + bx^2 + cx$ + constant, where x is volume). Thus, each line should have the lower limit of volume, upper limit, coefficient and constant.
Line 7: parameters for converting reservoir level to river discharge (discharge = coef*level+const). The first 5 values show the lower limit, upper limit, lower limit, upper limit and lower limit of the three segments of the equation, then, the coefficient and constant of the respective segments.

**CAT_PAR.DAT**
Example:
0.01 0.05
0.2 0.35
0.1 2.
0.1 0.25
0.04 0.1

0.1   2.0
0.02  0.2
0.075 0.5
1.    1.0
Line 1: minimum and maximum value of tvss
Line 2: minimum and maximum value of fmax
Line 3: minimum and maximum value of hinfl
Line 4: minimum and maximum value of chstk
Line 5: minimum and maximum value of tvsm
Line 6: minimum and maximum value of cmax
Line 7: minimum and maximum value of pcus
Line 8: minimum and maximum value of gwsc
Line 9: minimum and maximum value of tvgw

**TEMPE.TXT** --- monthly temperature and relative humidity
Line 1: name of station, subtitles (TEMP, REL.HUM)
Line 2: starting year of record, ending year of record
Line 3: month 1 (of starting year), temperature, relative humidity
Line 4: month 2 (of starting year), temperature, relative humidity
..
..
Line 14: month 12 (of starting year), temperature, relative humidity
Line 15: month 1 (of subsequent year), temperature, relative humidity
..
Last line: month 12 (of ending year), temperature, relative humidity

**ECOL_Q.DAT** --- Ecological release requirement
Line 1: name of station
Line 2: subtitle 9wk, release)
Line 3: wk 1, flow in $Mm^3$
Line 4: wk 2, flow in $Mm^3$
..
..
Line 54: wk 52, …, flow in $Mm^3$

## 6.0 OUTPUT

Flow along KYB river system for a wet year with full development at Kafin Zaki and Kawali Irrigation Scheme and all demand based on surface water resources is shown in Figure 10 as an example of a typical output from the DSS (i.e. DSSModel).

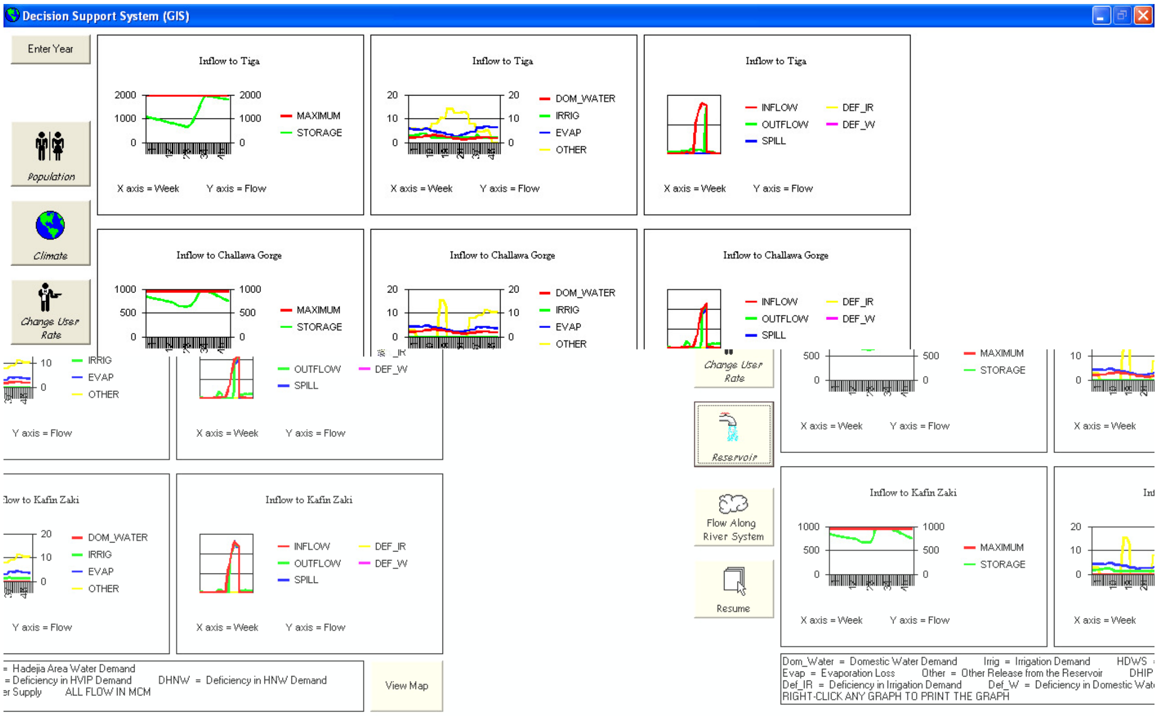



**Figure 10: Flow along KYB river system (Wet year, full development at Kawali Irrigation Scheme)**