# Appendix

Equations used in model.

## Water resources and supply Sub-model

Water resources:

* Water resources = Inflow (SW,GW) – Consumption – Outflow (SW,GW)
* Inflow (SW,GW) = GW inflow (from other basins) + SW inflow (from other basins) + Runoff + Infiltration + Return flow
* RUNOFF =RAINFALL\*BASIN AREA\*RUNOFF COEFFICIENT
* INFILTRATION=BASIN AREA\*INFILTRATION COEFFICIENT\*RAINFALL
* Return flow = (Agricultural water consumption\*Agricultural Return Flow Coefficient) + (Industrial Return Flow Coefficient\*Industrial water consumption) + (Urban and Services Return Flow Coefficient\*Urban and services water consumption
* Outflow (SW,GW) = GW outflow coefficient + SW outflow coefficient
* WATER CONSUMPTION = AGRICULTURAL WATER CONSUMPTION + INDUSTRIAL WATER CONSUMPTION + URBAN AND SERVICES WATER CONSUMPTION

Water supply:

* TOTAL SUPPLIED CAPACITY = GROUNDWATER SUPPLIED CAPACITY+SURFACE SUPPLIED CAPACITY
* AVAILABLE WATER= MIN (TOTAL SUPPLIED CAPACITY, WATER RESOURCE
* SURFACE SUPPLIED CAPACITY= INCREASE IN SURFACE SUPPLIED-DECREASE IN SURFACE SUPPLIED
* INCREASE IN SURFACE SUPPLIED CAPACITY= RESERVOIR(TIME)
* Decrease in surface supplied capacity = Sediment
* Sediment = (Sediment in Bustan station(Time)+Sediment in Golestan station(Time)+Sediment in Kosar station(Time)+Sediment in Voshmgir station(Time))

Water use allocation:

* Water for consume = min(Availabe water, Need)
* Urban consumption = IF THEN ELSE (Water for consume>0, min((Urban Water need) ,Water for consume) , 0 )
* "Water for consume- urban" = IF THEN ELSE (Water for consume>0 , Water for consume-Urban consumption ,0)
* Services water consumption = IF THEN ELSE("Water for consume- urban">0, min("Water for consume- urban", Services Water need ) ,0)
* "water for consume -urban-services" = IF THEN ELSE("Water for consume - urban">0,"Water for consume- urban" - Services water consumption , 0)
* Industrial water consumption = IF THEN ELSE("water for consume -urban-services">0,min(((1+waste of water in industrial consume)\*Industrial Water need) , "water for consume -urban-services" ) , 0 )
* "water for consume -urban-services-industry"=IF THEN ELSE( "water for consume -urban-services">0 , "water for consume -urban-services"-Industrial water consumption , 0)
* Agricultural water consumption=IF THEN ELSE("water for consume -urban-services-industry">0, min(Agricultural water Demand, "water for consume -urban-services-industry" ) , 0)

Land use-Flood sub-model

* Vegetation area= Agricultural area to Vegetation area + Bare to veg-veg to agri - veg to bare land - veg to indust - Veg to urban
* Urban and Services area= agri to urban + Veg to urban + Bare land to Urban and Services
* Bare Land area to Industrial area=IF THEN ELSE(Difference between desired and real industrial area>0: AND: Bare land>0, min(( (c1\*Difference between desired and real industrial area)),(Bare land/40000)),0)
* Agriculture to Industry=IF THEN ELSE(Difference between desired and real agricultural area<0: AND: Difference between desired and real industrial area>0: AND: Agricultural area>0, min((c3\*Difference between desired and real industrial area),(-e1\*Diffrence between desired and real agricultural area)),0)
* Industrial area=agri to indust+Bare Land area to Industrial area+veg to indust
* Bare land to agricultural area=IF THEN ELSE(Difference between desired and real agricultural area>0: AND: Bare land>0, min( (d1\*Diffrence between desired and real agricultural area), (Bare land/40000)), 0 )\*Different between cultivable and agricultural land
* Different between cultivable and agricultural land=IF THEN ELSE(Cultivable land area>Agricultural area, 1, 0 )
* Agricultural area=Bare land to agricultural area+veg to agri-agri to urban-agri to indust-Agricultural area to vegetation area
* Bare land=veg to bare land-Bare to veg-Bare land to Urban and Services-Bare land to agricultural area-Bare Land area to Industrial area
* Flood hazard=Look up function veg ver flood hazard(Vegetation area/1.3061e+010)-(Surface supplied capacity)

## The Economic activities Sub-system

Services:

* Services Water need=Urban and Services area/1500
* Services water consumption = IF THEN ELSE ("Water for consume- urban">0 ,min("Water for consume- urban", Services Water need ) ,0 )
* Services GDP=(Look up function services area versus GDP(Urban and Services area))+(look up function services consume versus GDP(Services water consumption) )
* Services employment=Increasing in services employment-Decreasing in services employment
* Increasing in services employment=IF THEN ELSE(Difference between desired and services employment>0,Difference between desired and services employment , 0 )
* Decreasing in services employment=IF THEN ELSE(Difference between desired and services employment<0, -Difference between desired and services employment , 0 )

Industry

* Industrial water consumption=IF THEN ELSE("water for consume -urban-services">0,min(((1+waste of water in industrial consume)\*Industrial Water need) , "water for consume -urban-services" ) , 0 )
* Industrial GDP=0.6\*Look up function consume versus GDP(Industrial water consumption)+(0.6\*Look up function area versus GDP(Industrial area))
* Industrial employment = Increasing in industrial employment - Decreasing in industrial employment
* Percent of industry area=( Look up function area versus employment(Percent of industry employment)+(Look up function GDP versus area(Industrial GDP/GDP)))/100

Agriculture

* Total Agricultural water need=Agricultural area\*((Beans(Time)\*Beans water need)+(Cereals(Time)\*Cereals water need)+(Forage plants(Time)\*Forage plants water need)+(Industrial plant water need\*Industrial plants(Time))+(Other plant(Time)\*Other plants water need)+( herb(Time)\* herb water need)+(Vegetables(Time)\*Vegetables water need)
* Agricultural water Demand=(Total Agricultural water need)\*(1-Rainfed(Time))\*(1/Efficiency)
* Agricultural water consumption=IF THEN ELSE("water for consume -urban-services-industry">0, min(Agricultural water Demand, "water for consume -urban-services-industry" ) , 0 )
* Ratio of agri water satisfaction = (Agricultural water consumption+1)/ (Agricultural water Demand+1)
* Agricultural GDP=(Look up function ratio of agri water satisfaction versus GDP(ratio of agri water satisfaction))\*(Agricultural GDP per area)\*Agricultural area
* Agricultural employment=increasing in employment-decreasing in employment
* Desired Agricultural area=Percent of agri area\*Economic area
* Percent of agri area=(Look up function employment versus agri area(Percent of agri employment)+Look up of function of GDP versus agri area(Agricultural GDP /GDP))

## Social Sub-system

* Population=increase in population-decrease in population
* *Increase in population=((Increase net Rate/100)\*population)+Migration to basin*
* *Decrease in population=((Migration from basin))\*population*
* Workforce population=Job coefficient\*population
* Urban Water need=urban need per capital(Time)\*population
* *Urban consumption= min((Urban Water need) ,Water for consume)*
* *Desired Regional utility=(GDP per capital/100000)+(Increase in surface supplied capacity/1e+007) -Flood hazard + (Total employment/population) +(Vegetation area/1.3061e+010)*
* Regional utility=increase in Regional utility-decrease in Regional utility