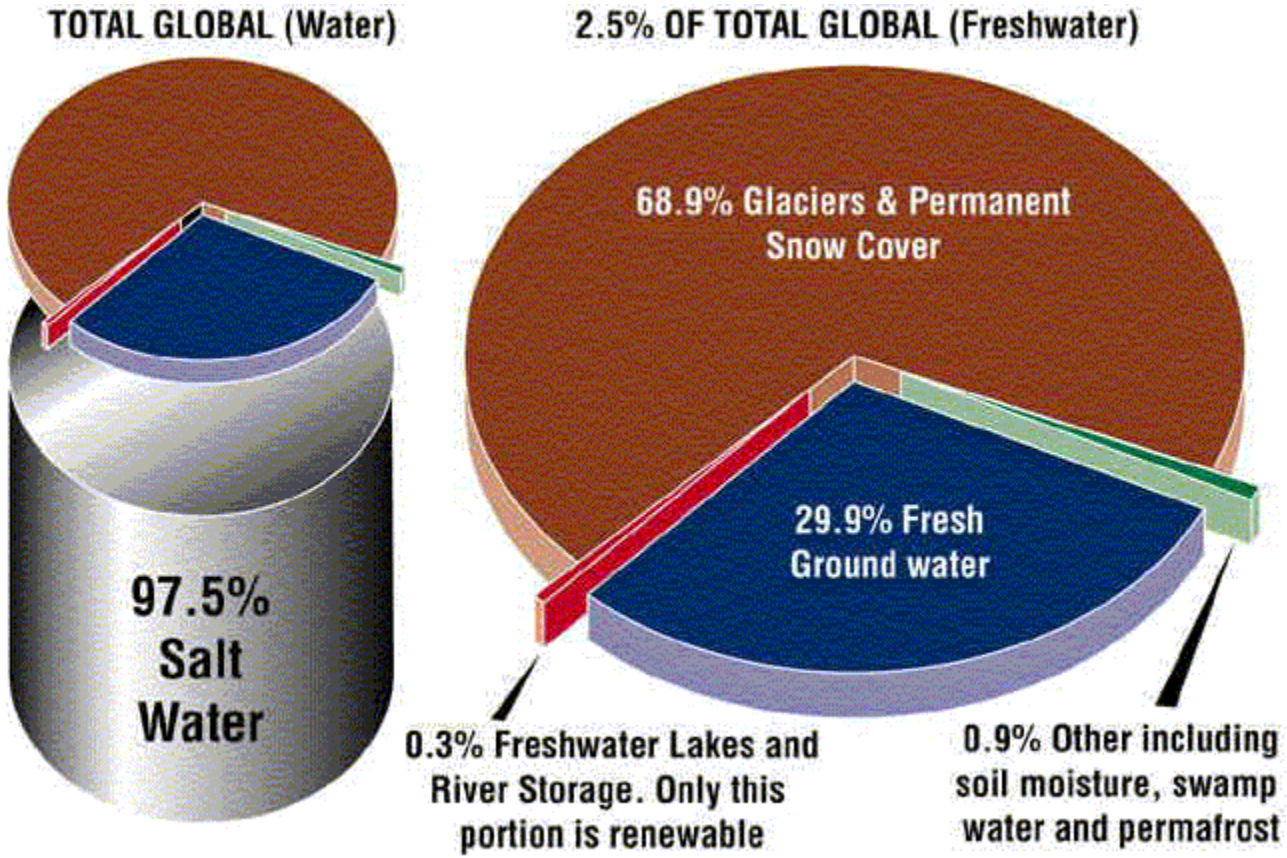
Water budget

Theoretical principle with practical example

By Mohammad Alhamed

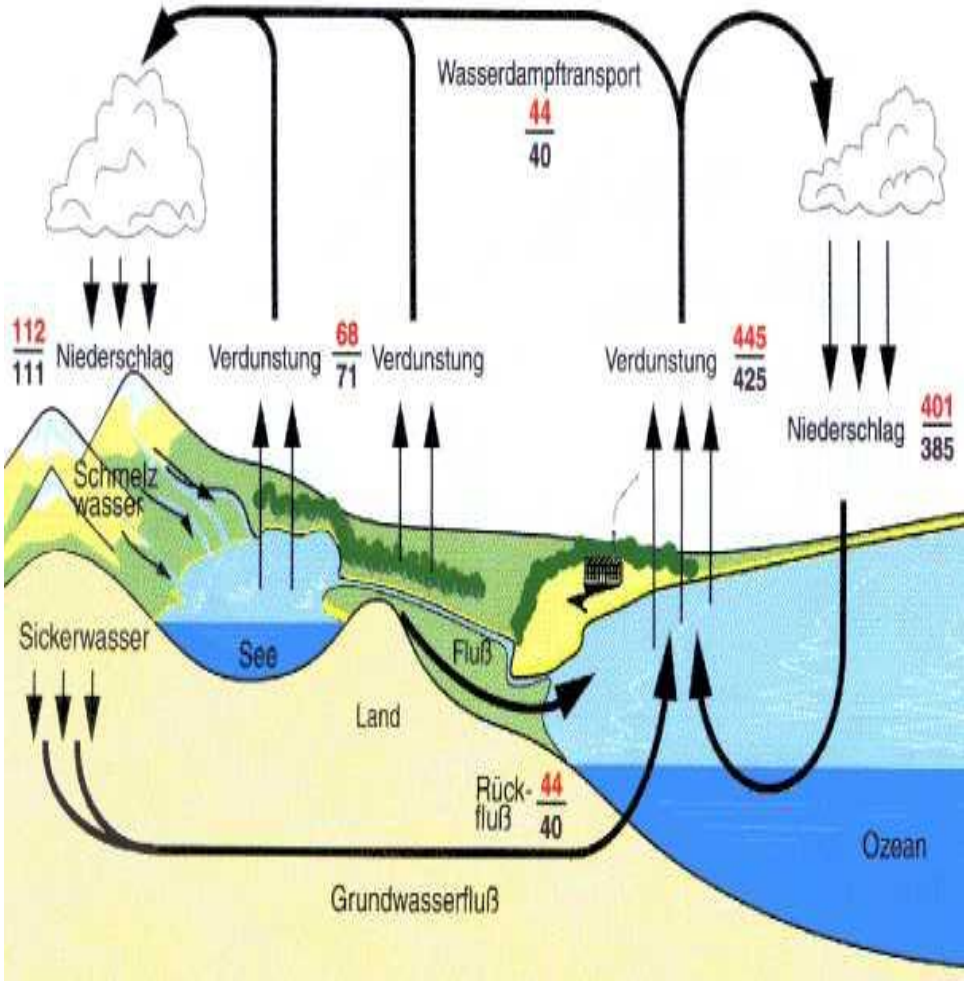
Distribution of water on the Earth



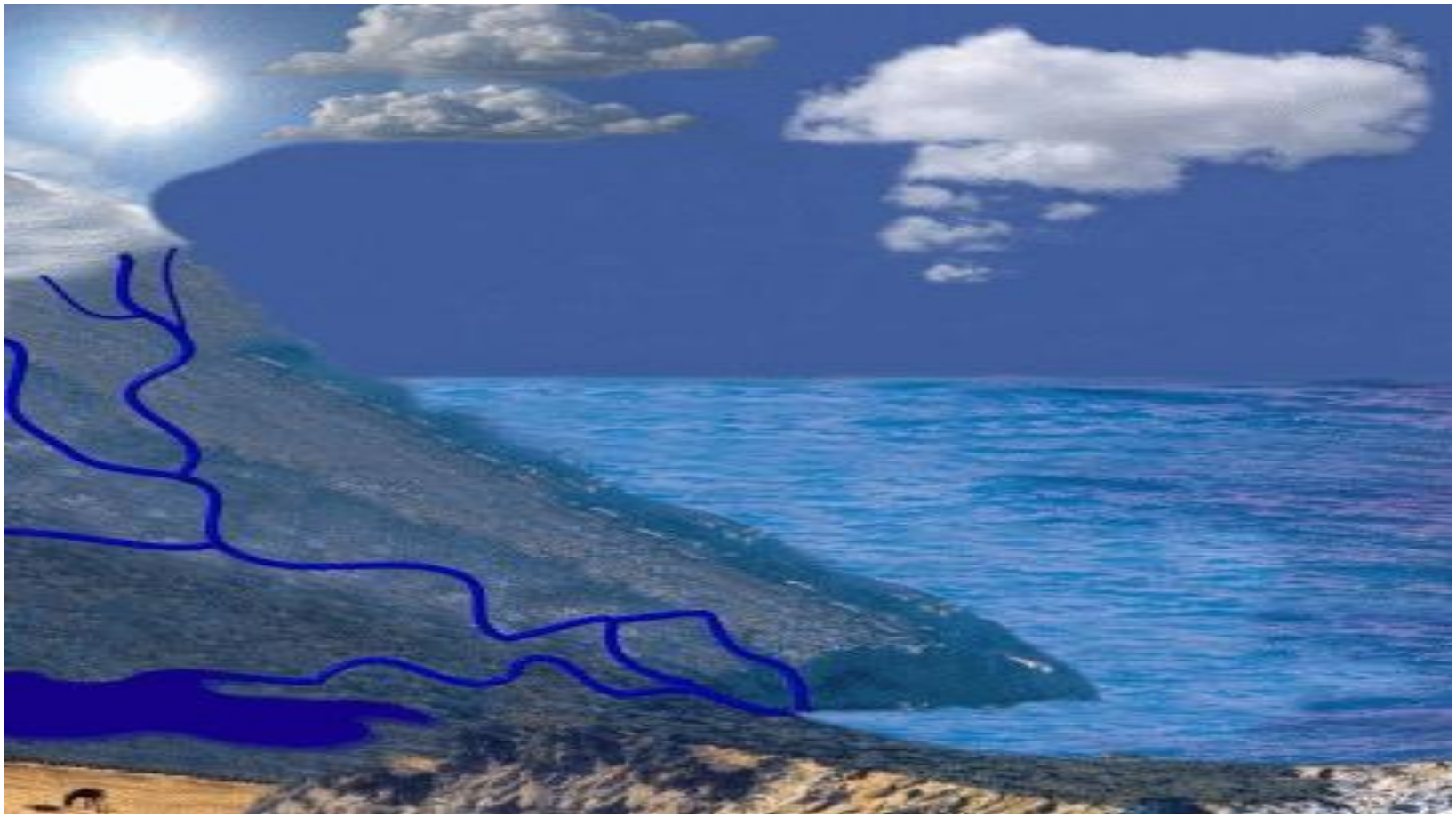
Hydrologic cycle

- Component of hydrologic cycle

1. evaporation
2. transpiration
3. surface runoff
4. inter flow
5. Ground water recharge
6. Ground water discharge



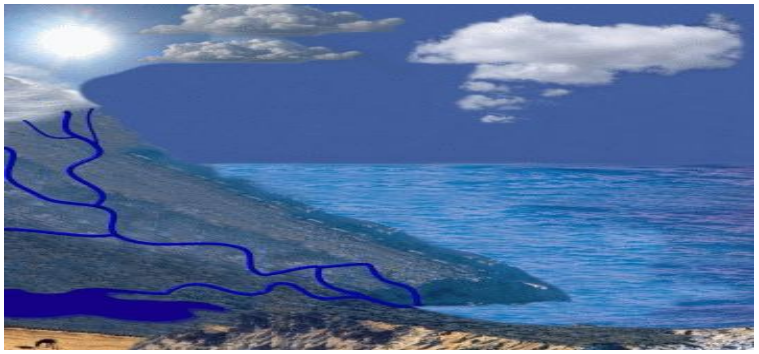
Dynamics of water cycle



Evaporation

Water evaporated from ocean, rivers and lakes or transpirated by vegetation

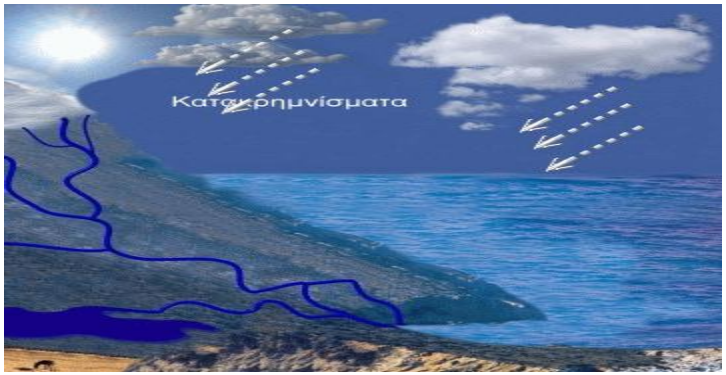
Water vapors move upward in the atmosphere and transport by air

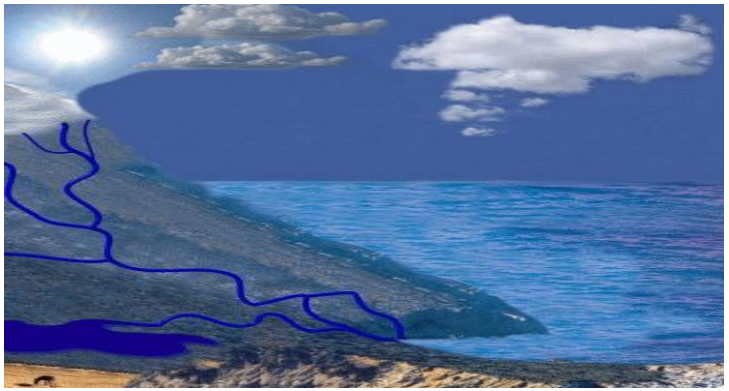


Rainfall

Formation of rainfall

- Cooling of air to dew-point temperature.
- Condensation on nuclei to form could droplets or ice crystals.
- Growth of droplets or crystals into raindrops.
- Importation of water vapor to sustain the process.

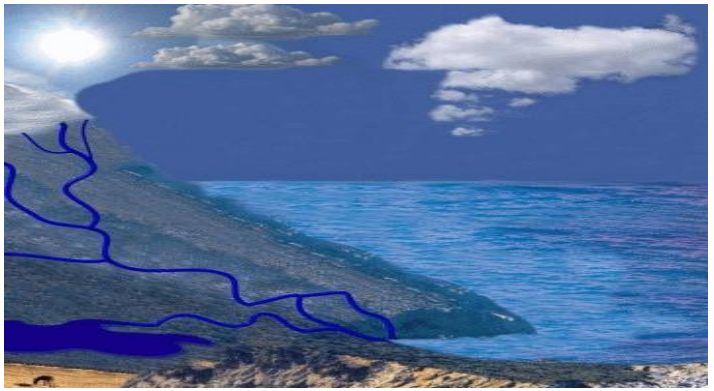




Runoff

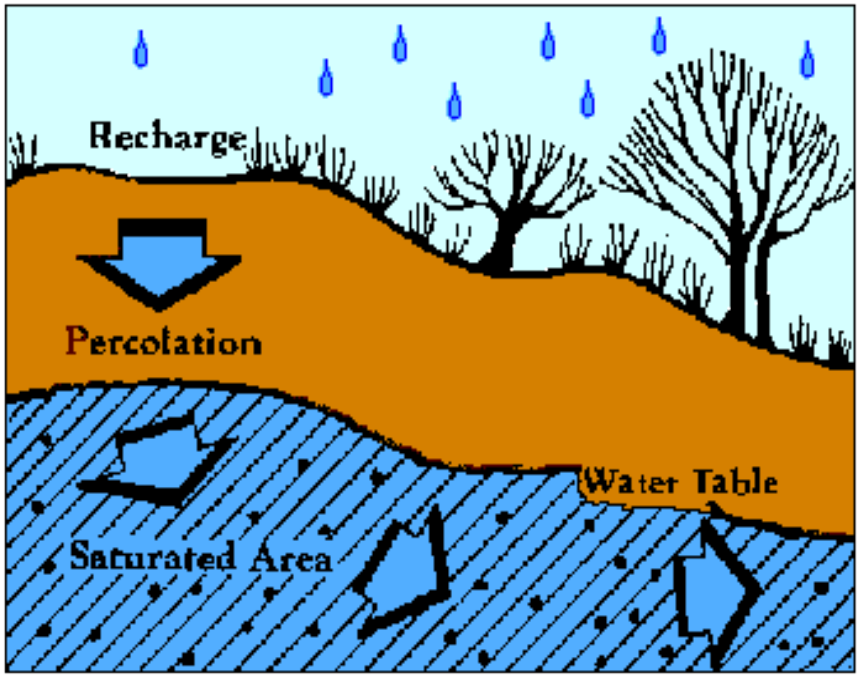
runoff

- Is apart of rainfall or snow that flow over the ground surface and concentrate to form rivers and lakes.
- Rivers and lake forms the most popular surface water bodies on the contenents



Ground water recharge & discharge

- Ground water recharge is appart of rainfall which not evaporated or flow as surface runoff . This part percolate until the ground water table .
- Ground water move laterally to appear another time as springs or seepage water to recharge stream and lakes.



reference

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- Dingman.S.L 1994 : Physical hysdrology , New jersy, 575 pp
- USGS http://ga.water.usgs.gov/edu/runoff.html
- www.cmmacs.ernet.in/~himesh/How%20Much%20is%20Fresh%20Water.gif
- http://5dim-pyrgou.ilei.sch.gr/climate/photo/water_cycle/evapotraspiration.gif

Practical example

Ruhr Universität Bochum

RUB

Estimating of direct surface runoff and ground water recharge by combine water budget , hydrological and Evapot-Transpiration models in lottental

Dipl. hydro . Mohammad Alhamed

Prof . Dr . Stefan Wohnlich

content

- Introduction
- Study area
- Theoretical Background
- Material and methods
- Results
- Problems
- Conclusion
- Reference

Definition

- Direct surface runoff

Apart of rainfall which isnt evaporated or infiltrated throw the soil profil , this part flow along the earth surface and find its way to stream to form stream flow .

- Ground water recharge

Apart of rainfall which infiltrate throw the soil profil to find its way to aquifer

- Evapotranspiration

Apart of rainfall that losse from the water bodes or soil moisture storage (evaporation) or by vegetation use (evapotranspiration)

Introduction

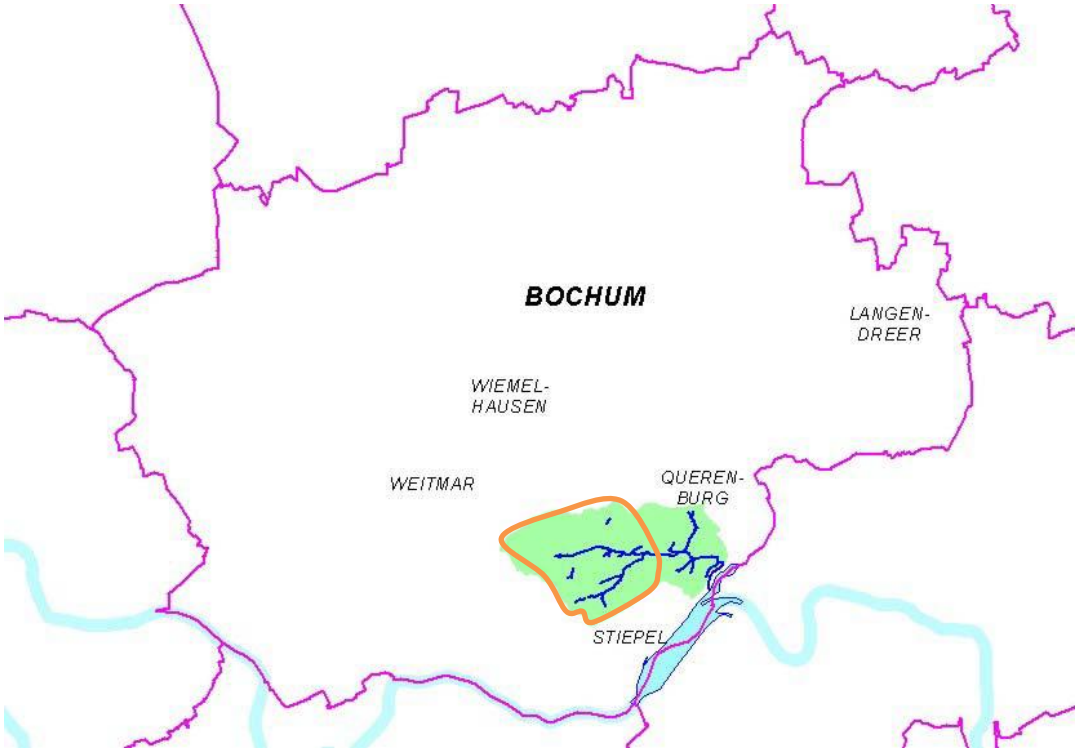
Aim of study

- Study ability of using SCS to estimate of direct surface runoff in lottental.
- Determination of the different component of hydrologic budget in study area by combine hydrologic model, evapotranspiration models and water budget model .
- Study of effect the difference of land cover on component of the hydrologic budget in this area .

Study area

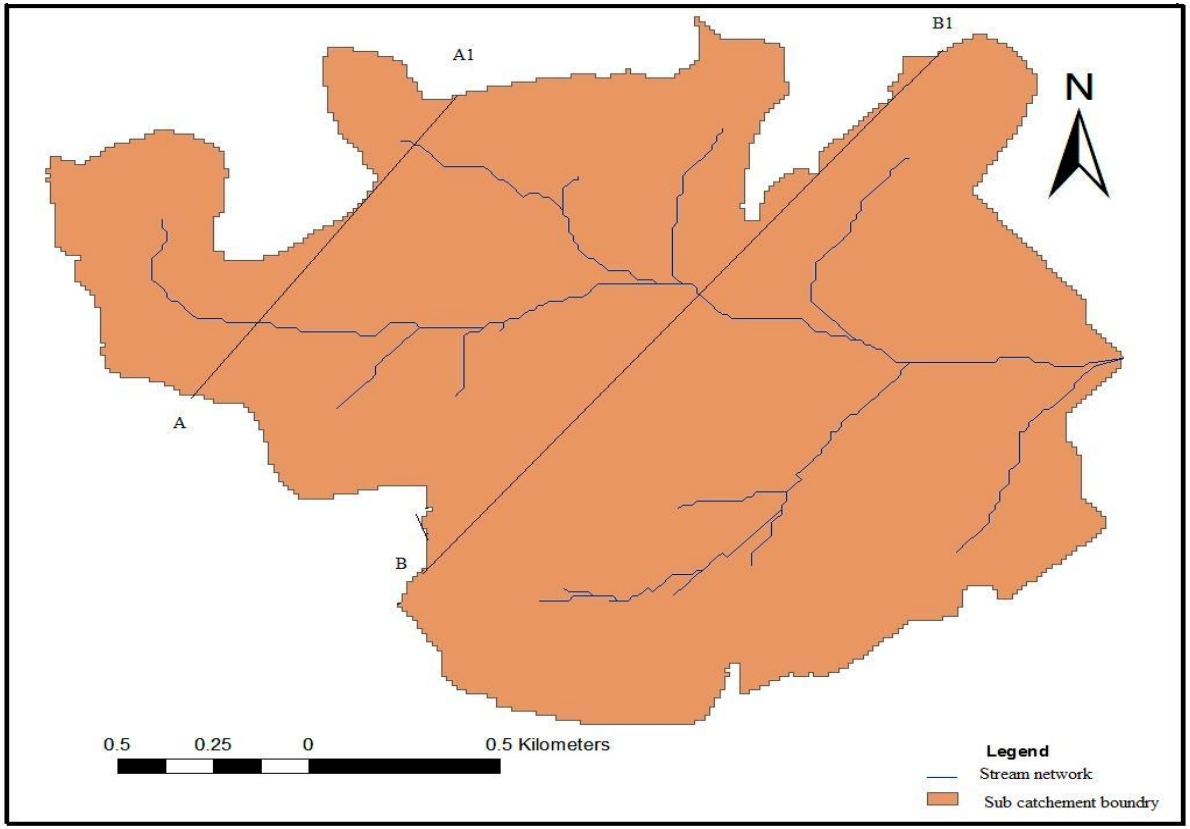
• study area located in the south east part of Bochum south bochum university

• the study area formed a western part of Lottental with total area 3.67 km2



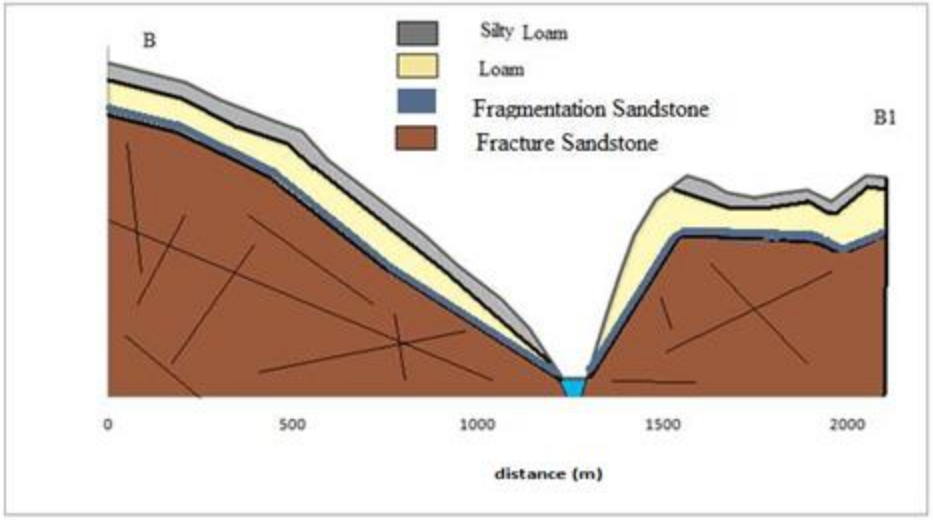
Study area

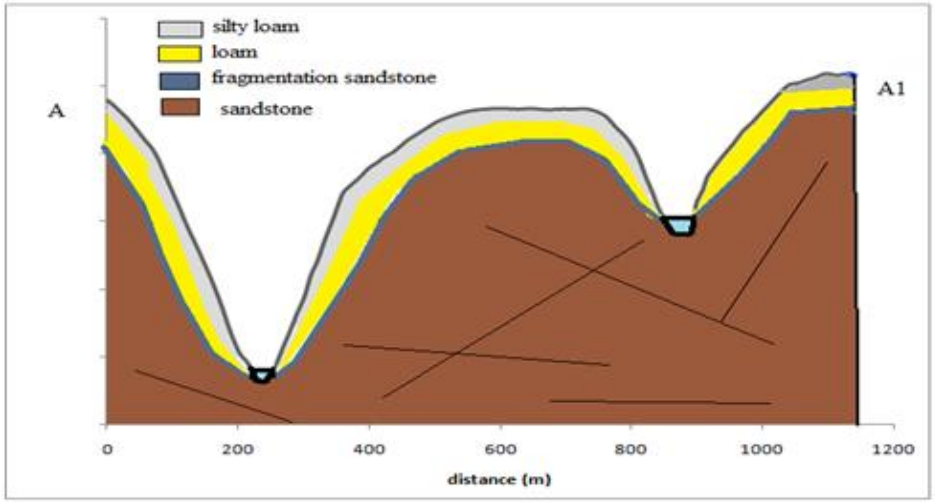
Sub catchent boundry and stream networks of study area



Study area

Topographic profil of Lottental



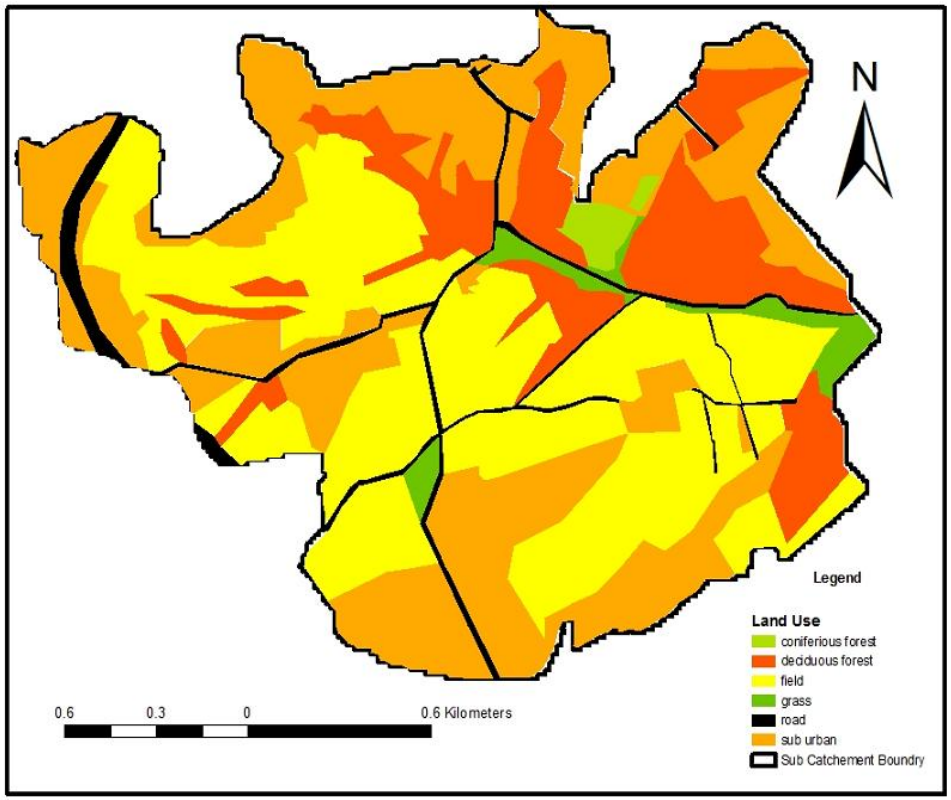


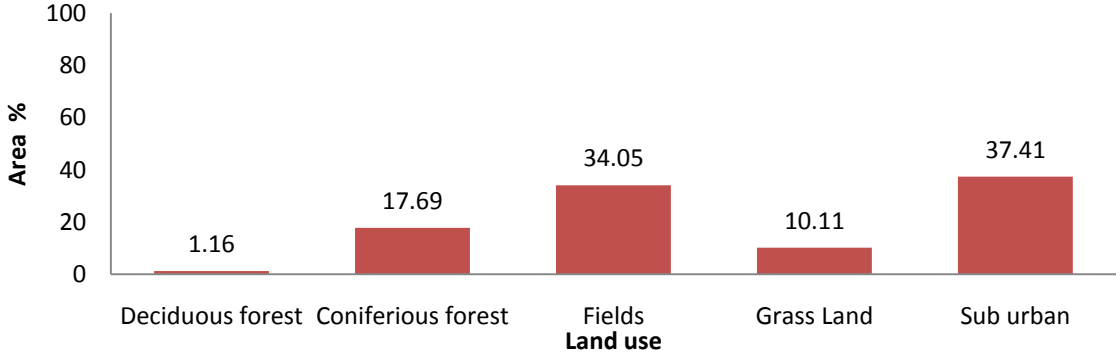
Land use

Statistcal distribution of land use in lottental

land use	area	area %
coniferous forest	0.039970	0.011651
deciduous forest	0.607840	0.177185
field	1.361201	0.396789
grass	0.072060	0.021005
road	0.143165	0.041732
sub urban	1.206307	0.351637

Study area

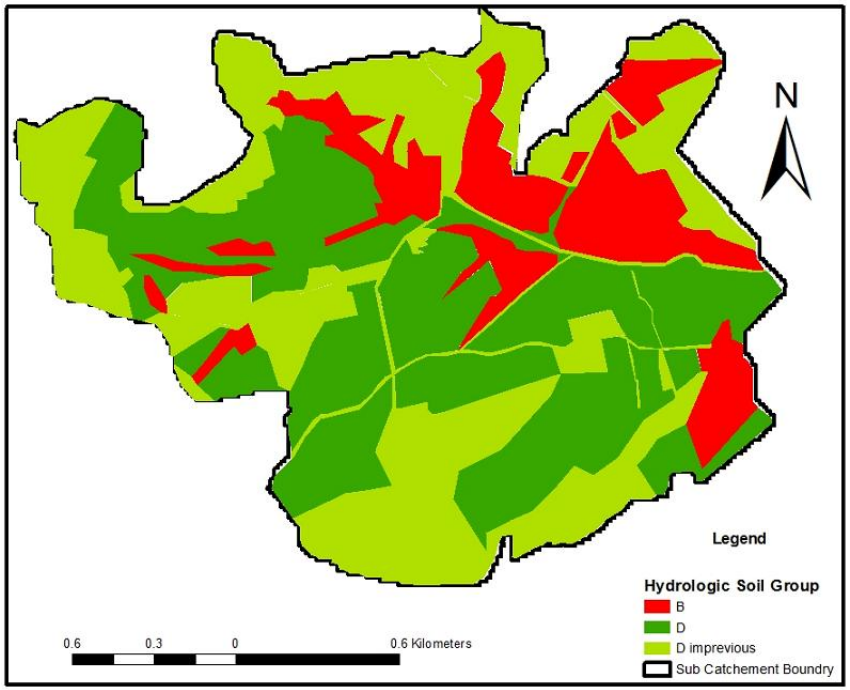


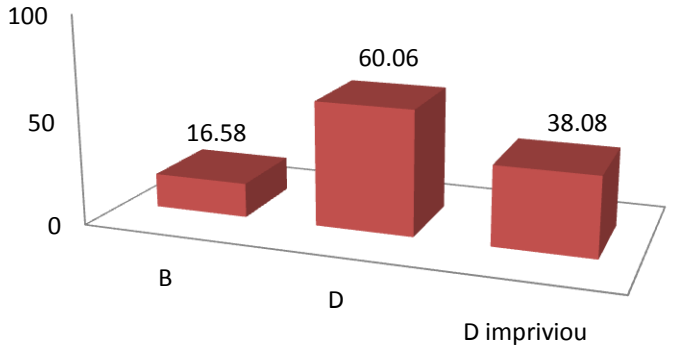


Study area

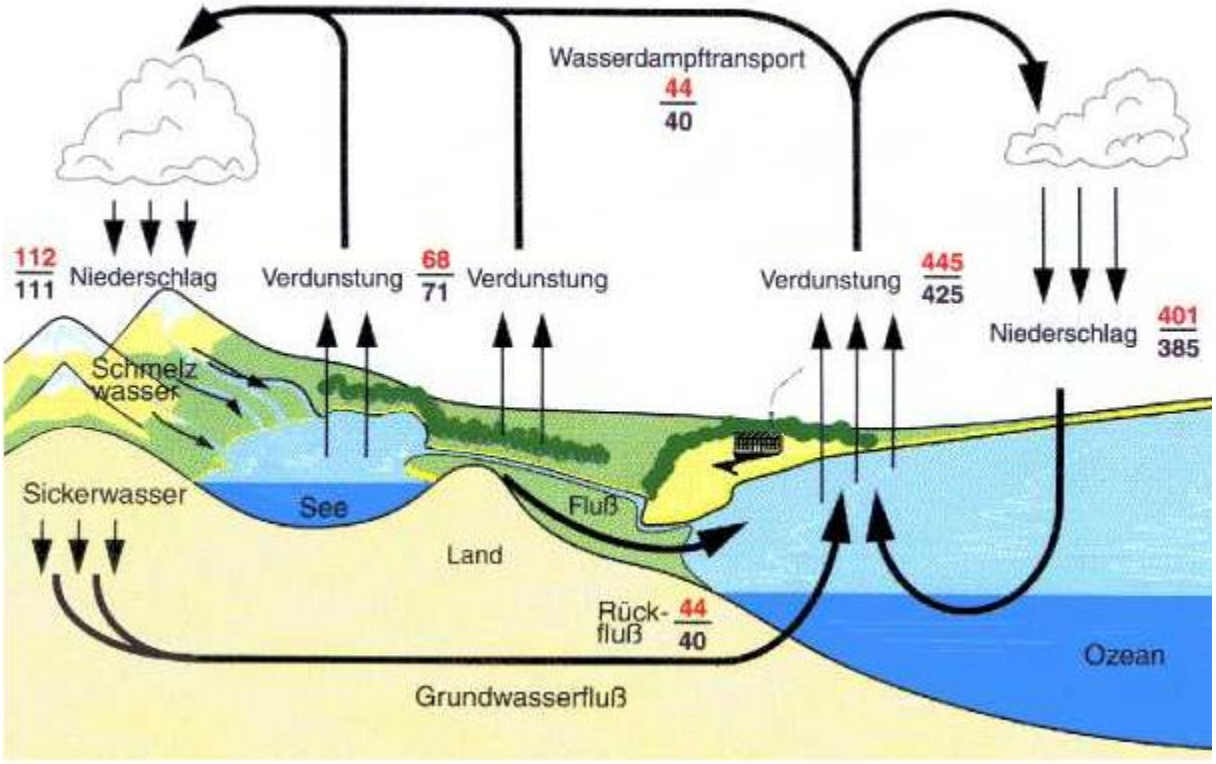
Hydrologic Soil Gruop

Soil Type	HSG	Area %
Silty loam	B	16.58
loam	D	60.06
impervious	D impervious	38.08





Water cycle


Wasserdampftransport
44
40
112
111
Niederschlag
Verdunstung
68
71
Verdunstung
Verdunstung
445
425
Niederschlag
401
385
Schmelz
wasser
Sickerwasser
See
Fluß
Land
Rück-
fluß
44
40
Ozean
Grundwasserfluß

Water budget model

$$P - R - G - E - T = \Delta S$$

Where:

P: precipitation

R: surface runoff

G: ground water recharge

E: evapotranspiration

T:transpiration

: change in storage

Ground water recharge model

$$G = P - R - E - T \mp \Delta S$$

Where:

G: ground water recharge

P: precipitation

R: surface runoff

E: evapotranspiration

T:transpiration

: change in storage

Evapo-Transpiration

- potential evapotranspiration Haude

$$ETP_{Haude} = k \cdot e_s \cdot \left(1 - \frac{F}{100}\right) \ [\mathrm{mm/d}]$$

K: Haude factor [-].

es: saturated vapor pressure at 14:00 O'clock (= Tmax) [hPa].

F: relative air humidity [%].

Evapo-Transpiration

- Potential Evapotranspiration FAO Penman Monteith model

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

- ET_o reference evapotranspiration [mm day^{-1}],
  R_n net radiation at the crop surface [MJ m^{-2} day^{-1}],
  G soil heat flux density [MJ m^{-2} day^{-1}],
  T mean daily air temperature at 2 m height [°C],
  u_2 wind speed at 2 m height [m s^{-1}],
  e_s saturation vapor pressure [kPa],
  e_a actual vapor pressure [kPa],
  $e_s - e_a$ saturation vapor pressure deficit [kPa],
  Δ slope vapor pressure curve [kPa $°C^{-1}$],
  psychometric constant [kPa $°C^{-1}$].

Runoff

- SCS model

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Q runoff.
P rainfall.
S potential maximum retention after runoff begins.
Ia initial abstraction

CN curve number

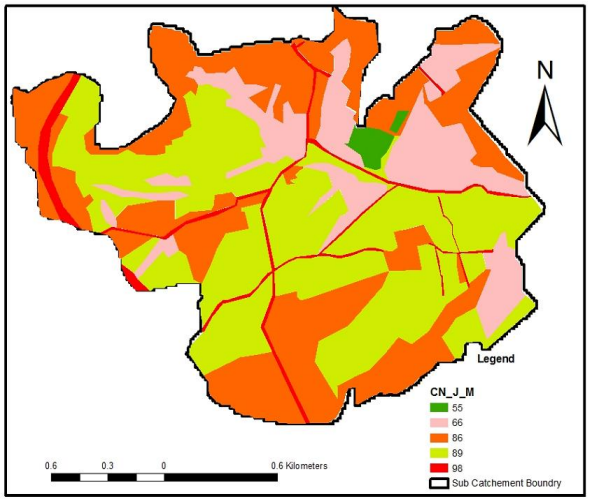
$$S = \frac{1000}{CN} - 10$$

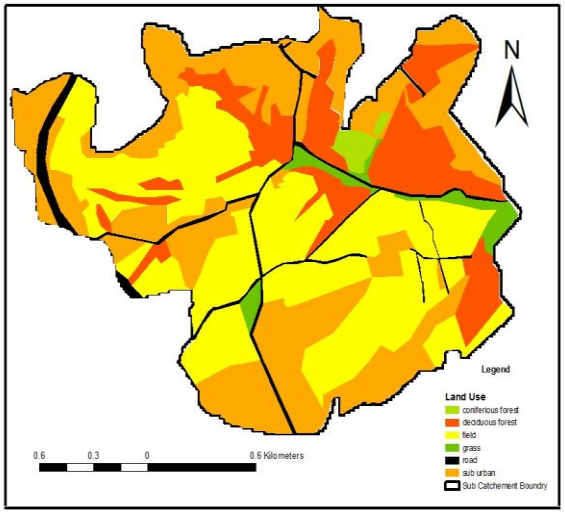
Ia= a S

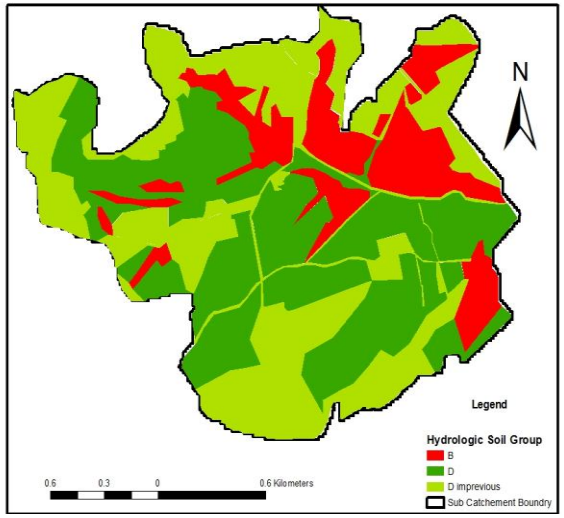
.a = 0.05

Detremenation of CN

CN = Land use & hydrologic soil group







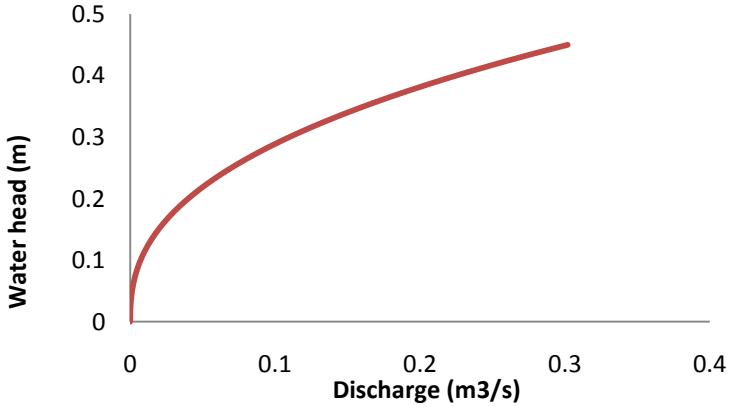
Material and methods

Runoff

Runoff discharge measurements

- V-notch weir plate

Daily reading of the water head beyond weir plate and discharge value obtained From the theoretical curve.



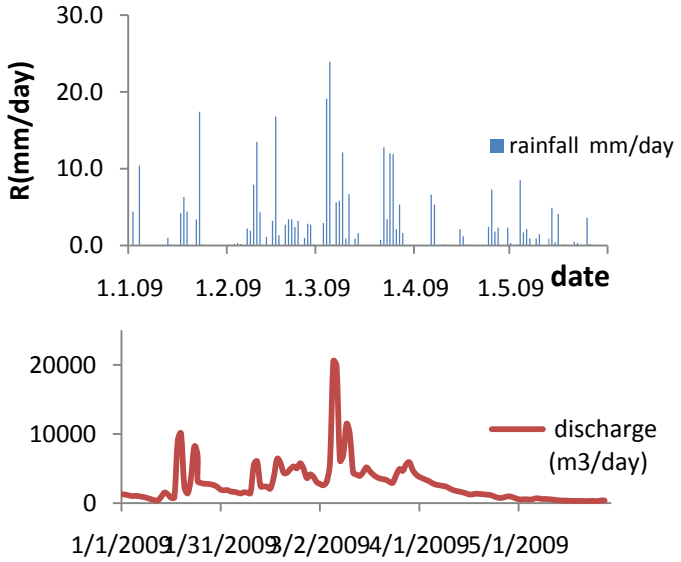
Material and methods

Runoff

Runoff discharge measurements

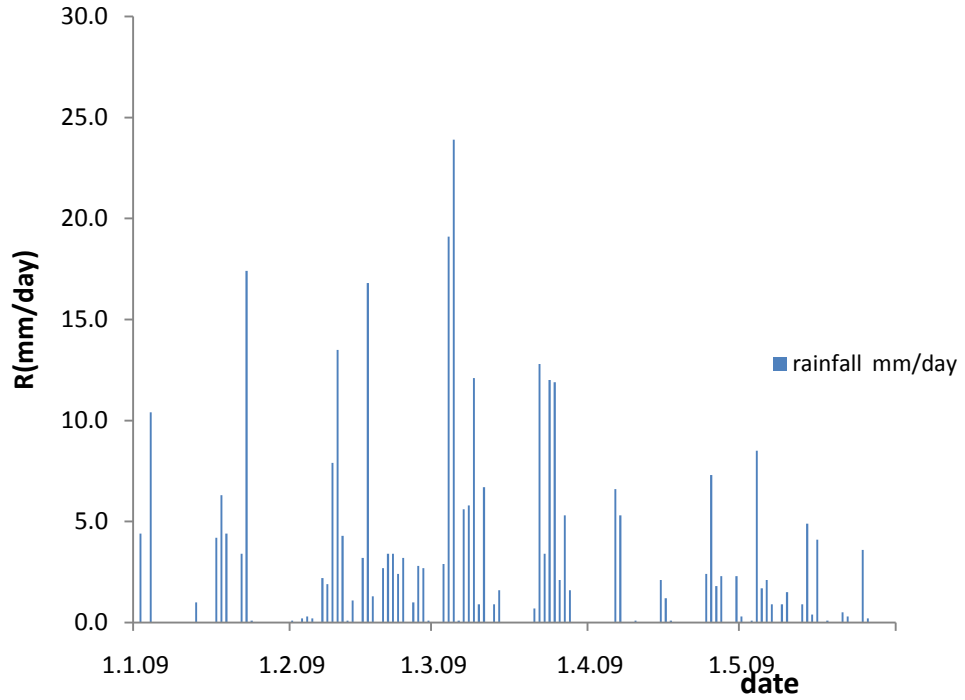
- **Current meter measurements**

This measurements used when the weir plate damaged by flooded event



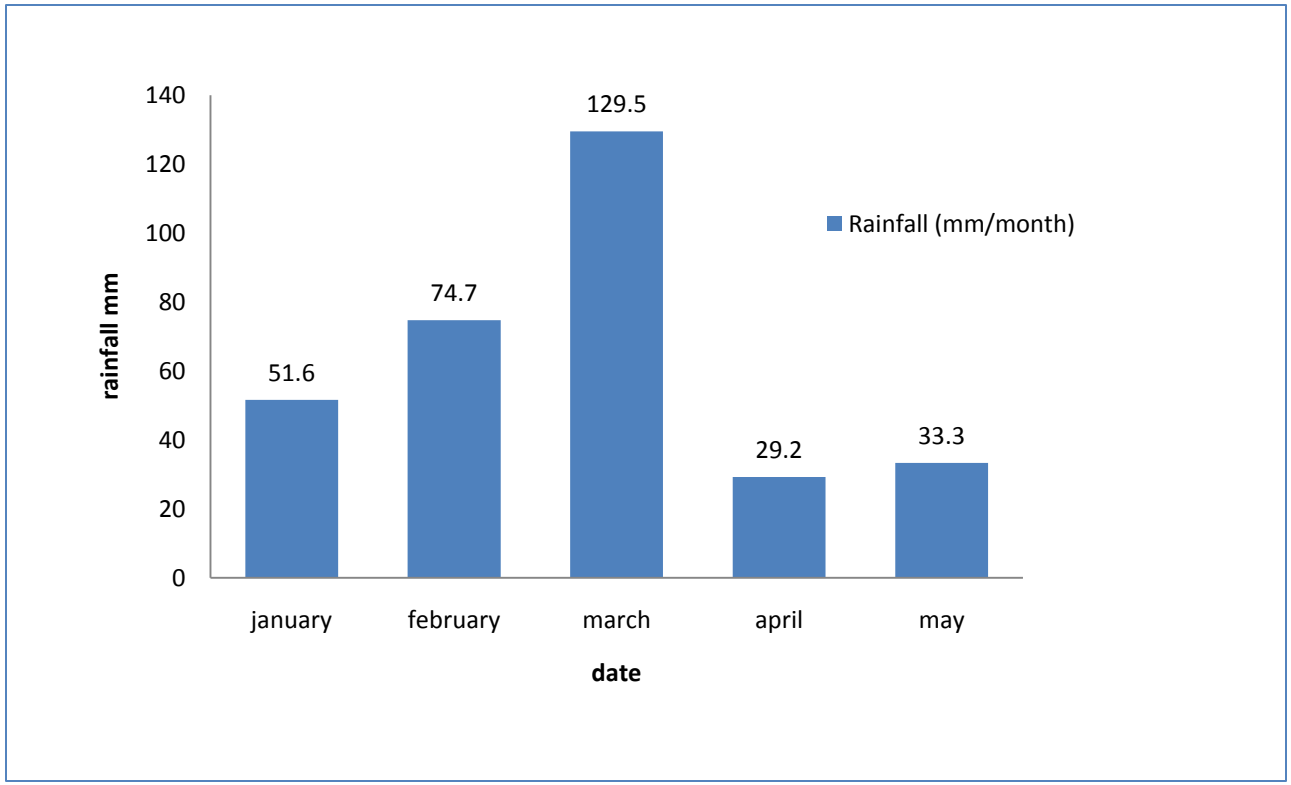
Precipitation

- daily value



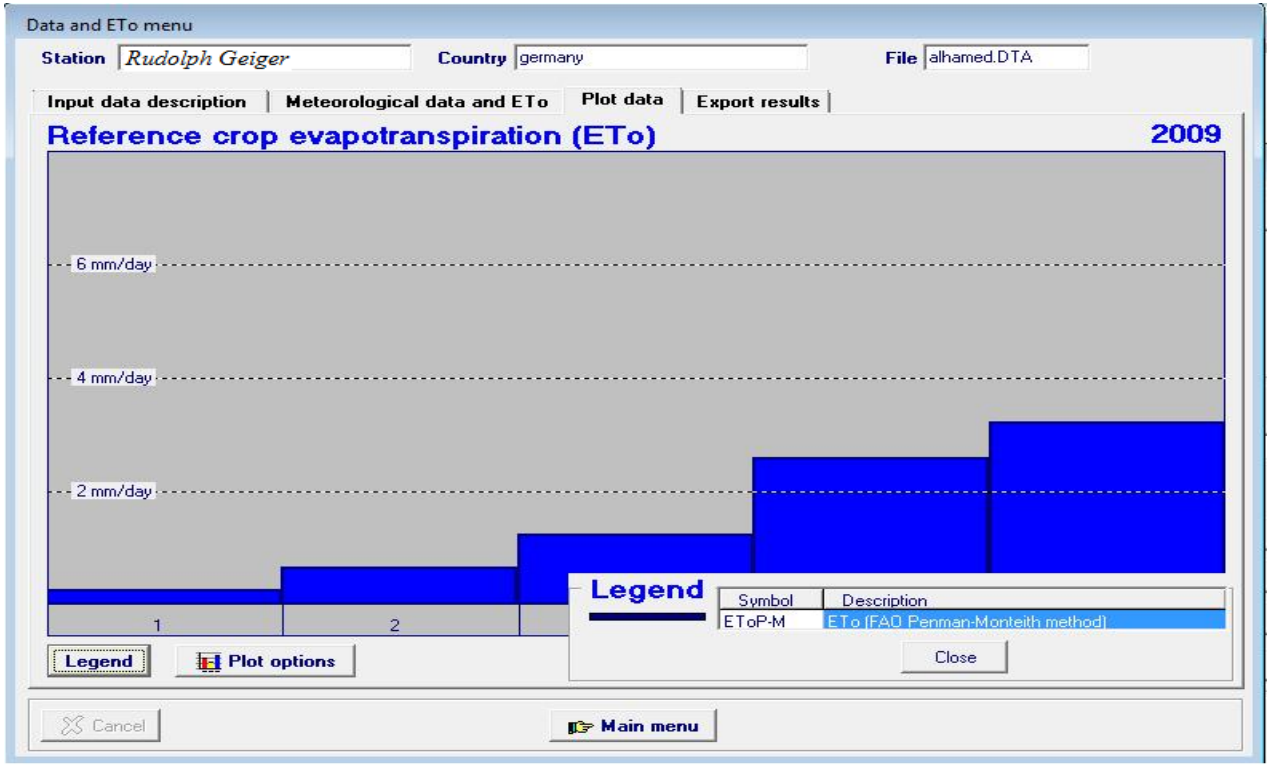
Precipitation

- Monthly value



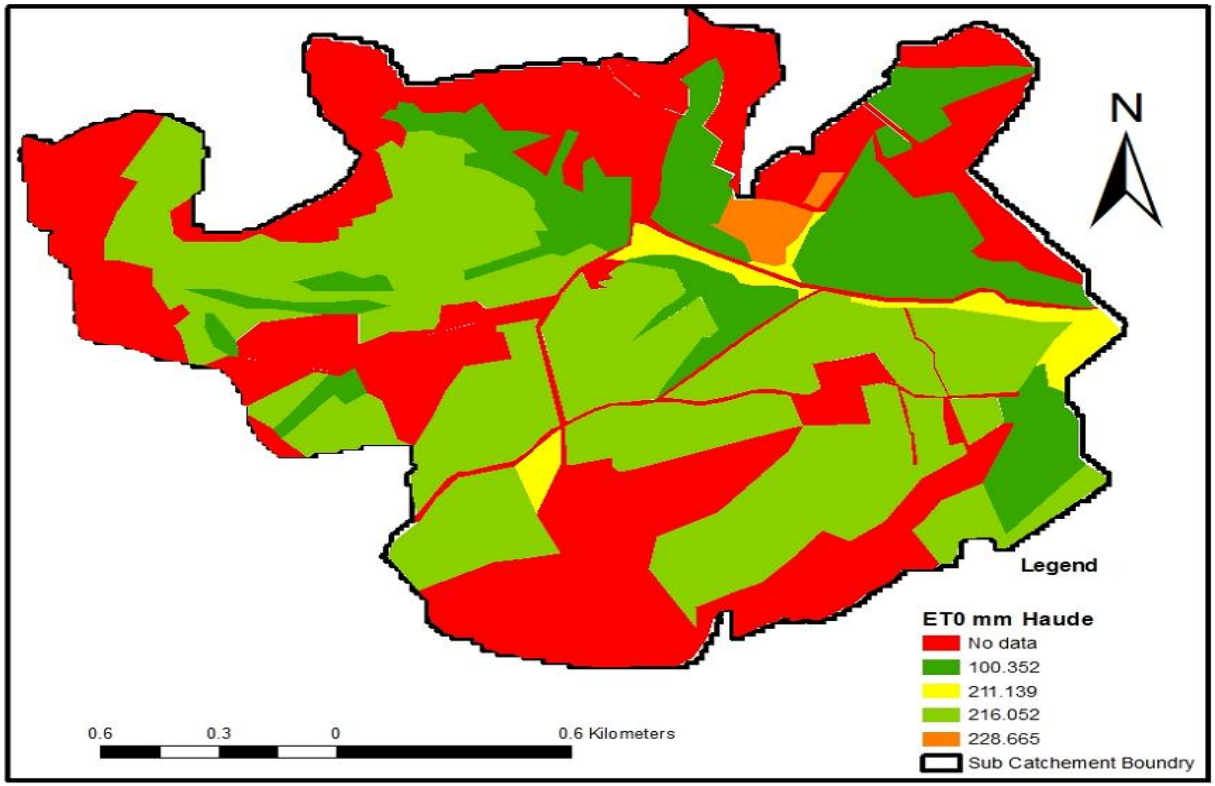
Evapo-transpiration

Potential monthly reference crop Evapo-transpiration (FAO Penman Monteith model)



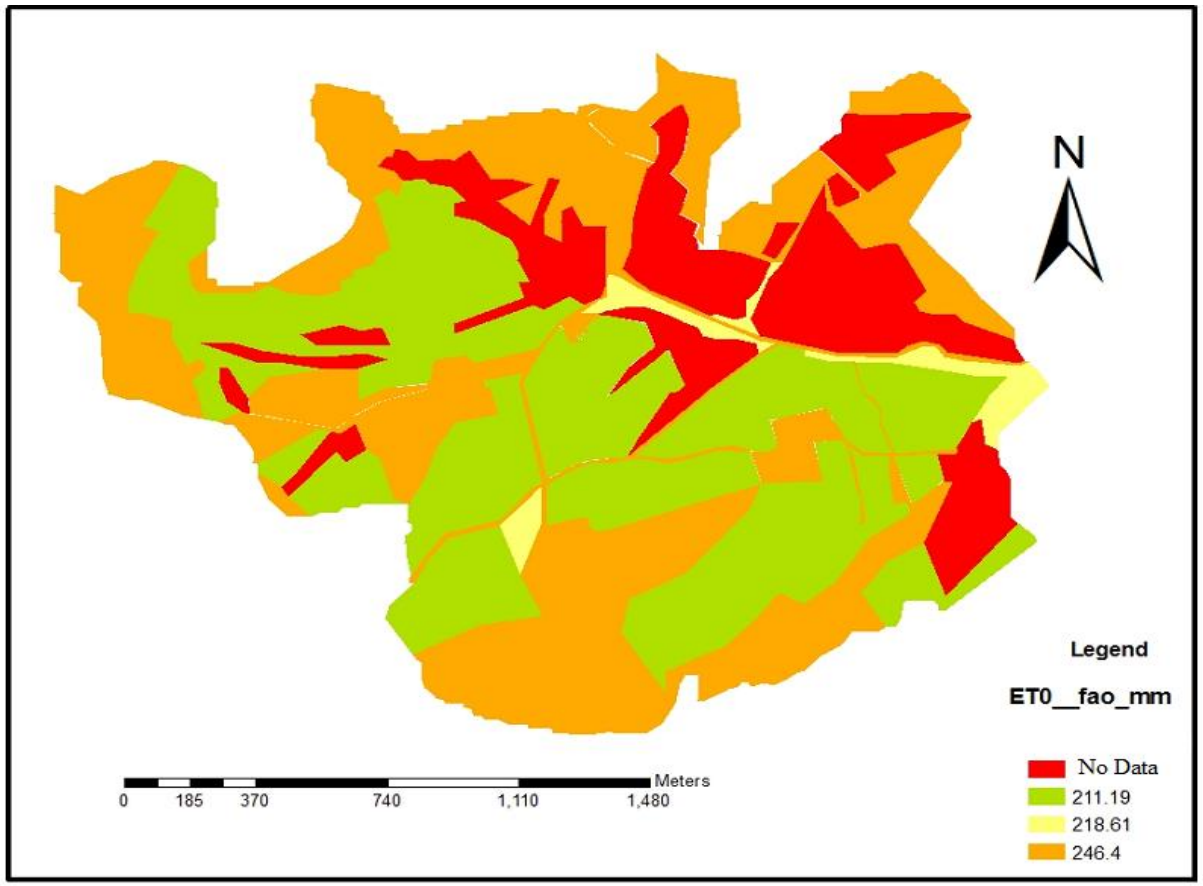
Evapo-Transpiration

- Spatial distribution of potential Evapotranspiration (Haude method)



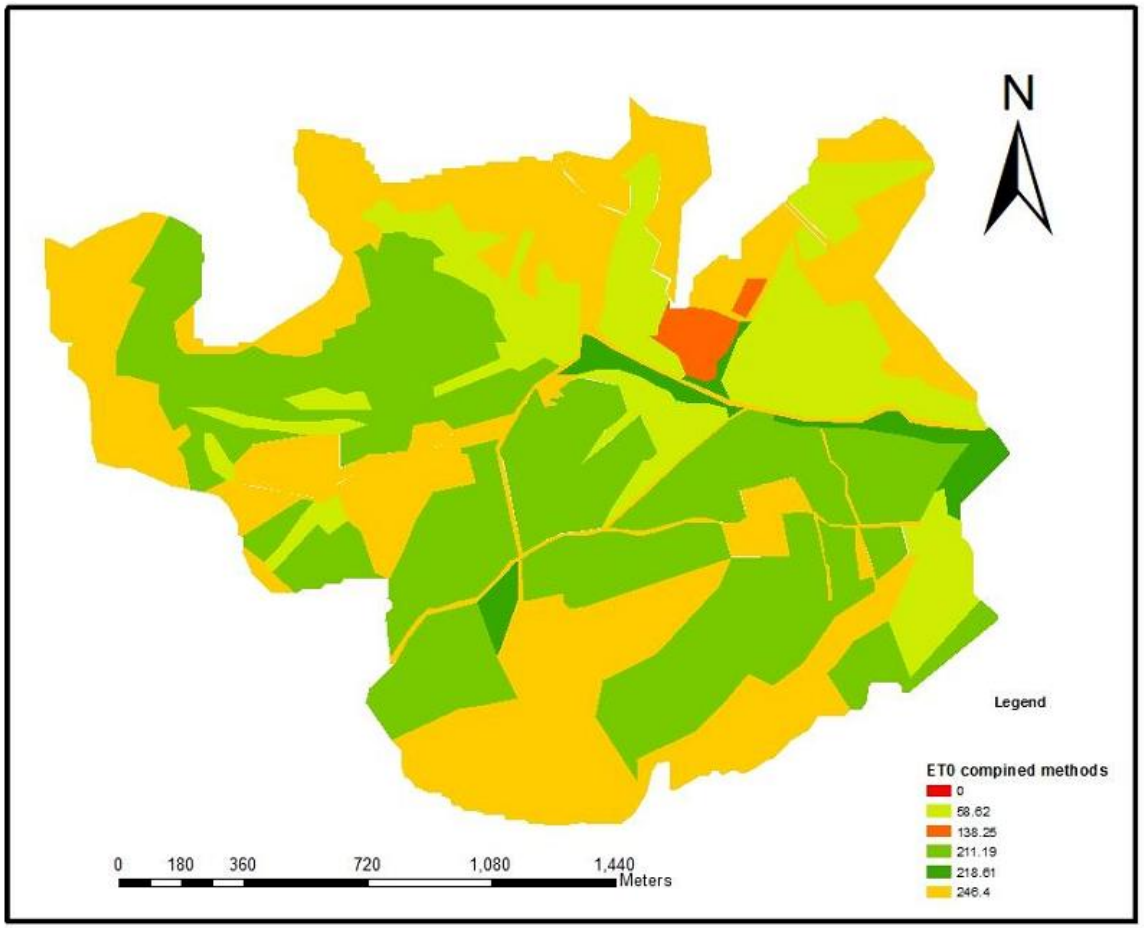
Evapo-Transpiration

Sapital distribution of potential evapotranspiraton FAO model



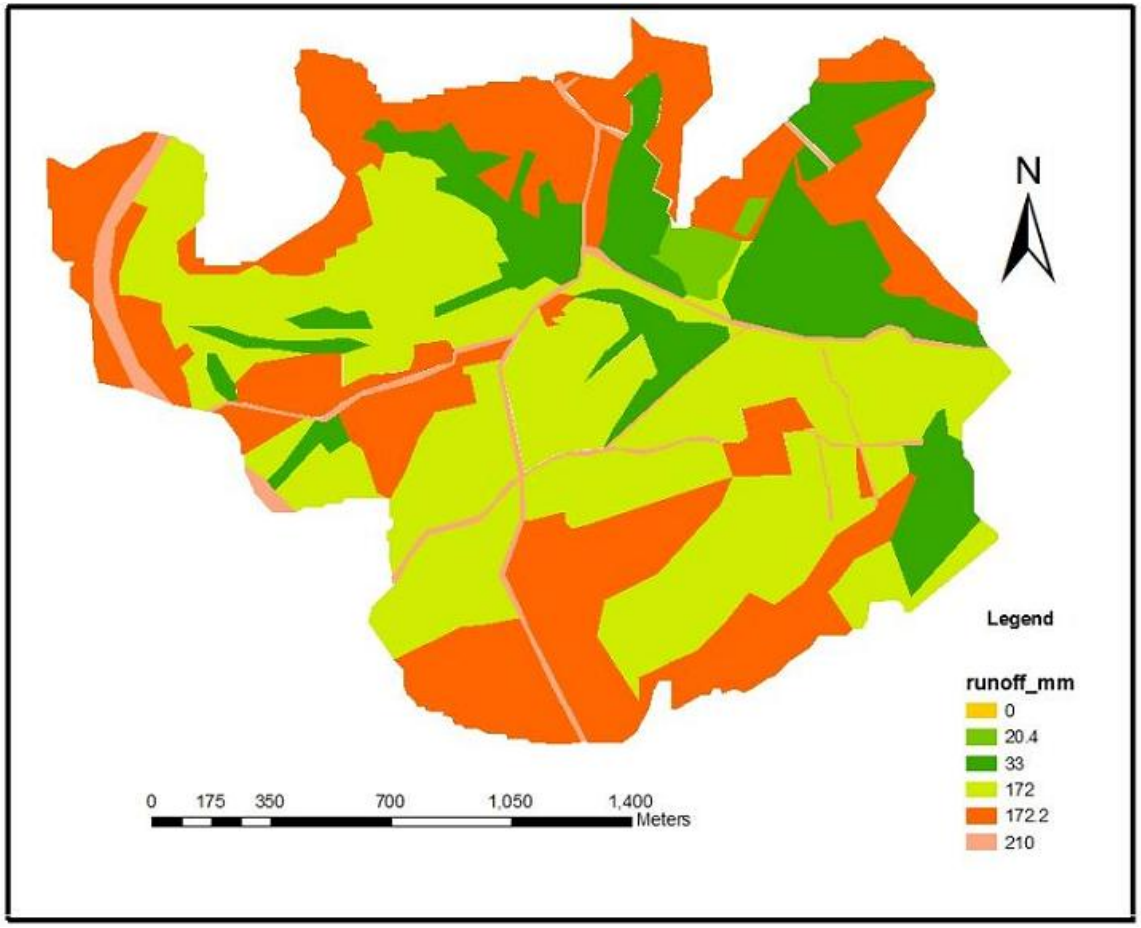
Evapo-Transpiration

Spatial distribution of potential evapotranspiraton combine FAO model & Haude method



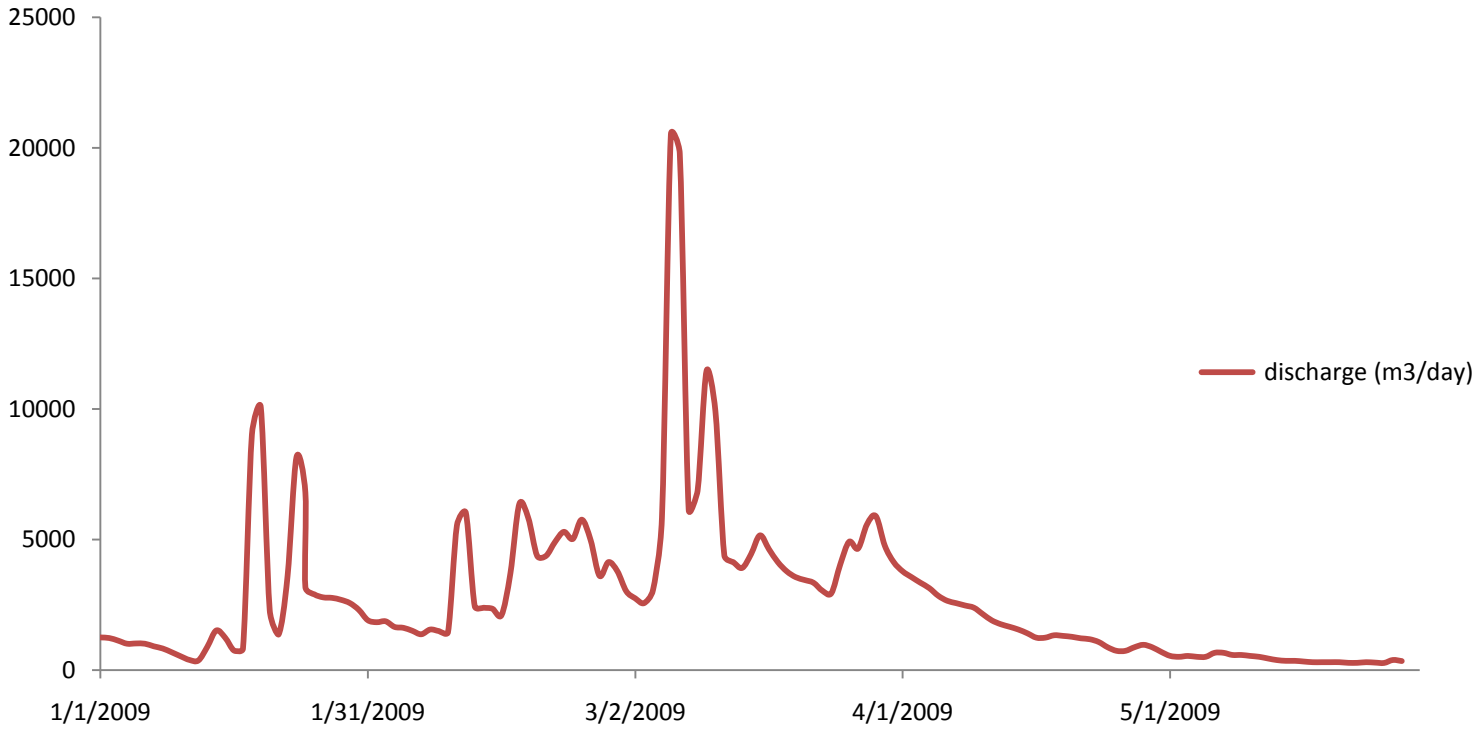
Runoff

Spatial distribution of direkt runoff generation



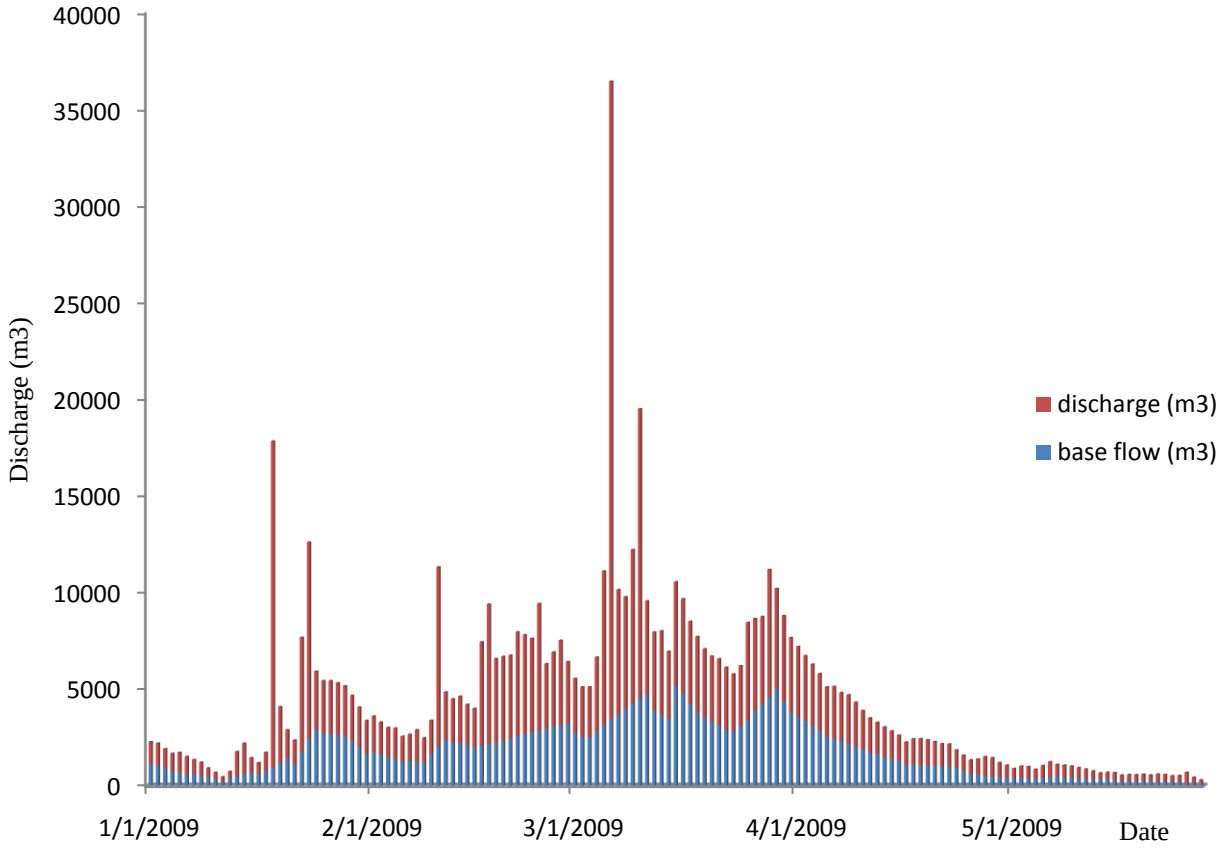
Runoff

Measuring runoff in lottental



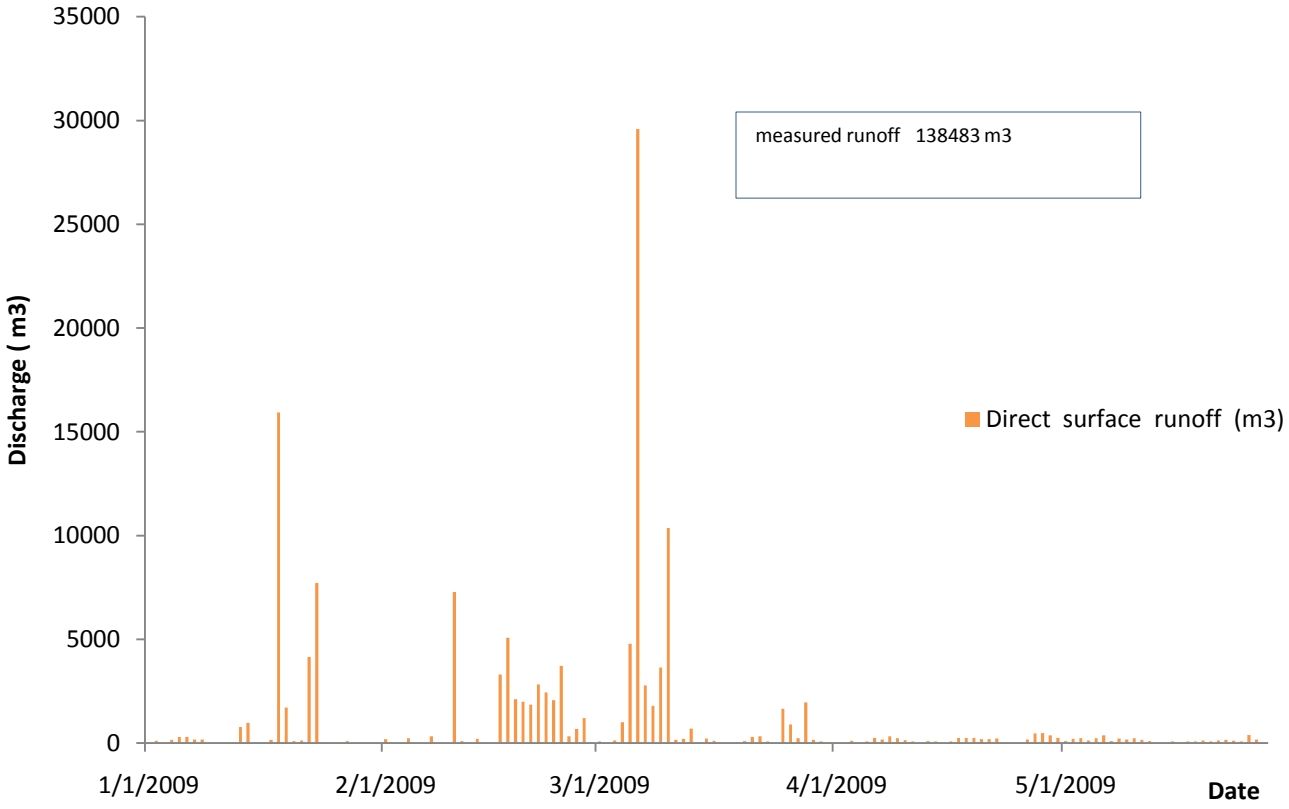
Runoff

Separating of direct surface runoff from base flow (Inter flow)



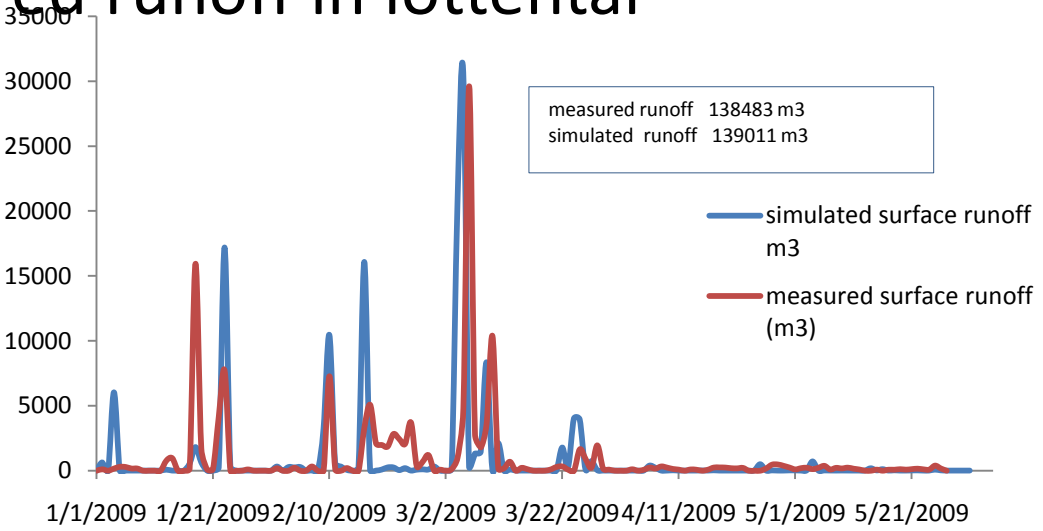
Runoff

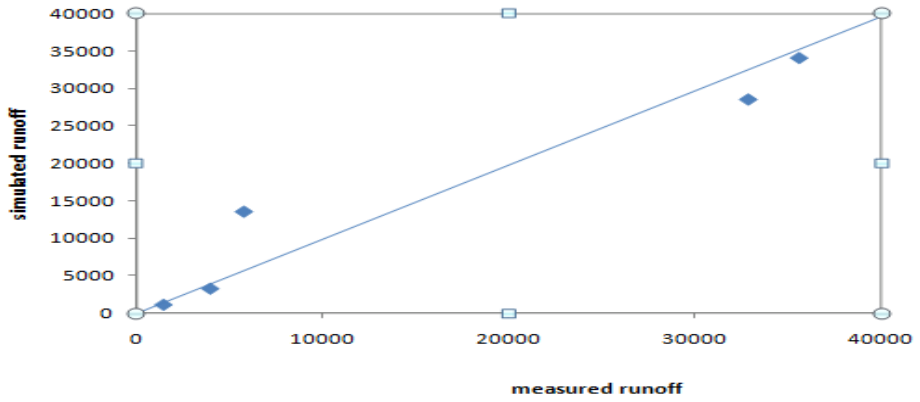
Direct surface runoff



Runoff

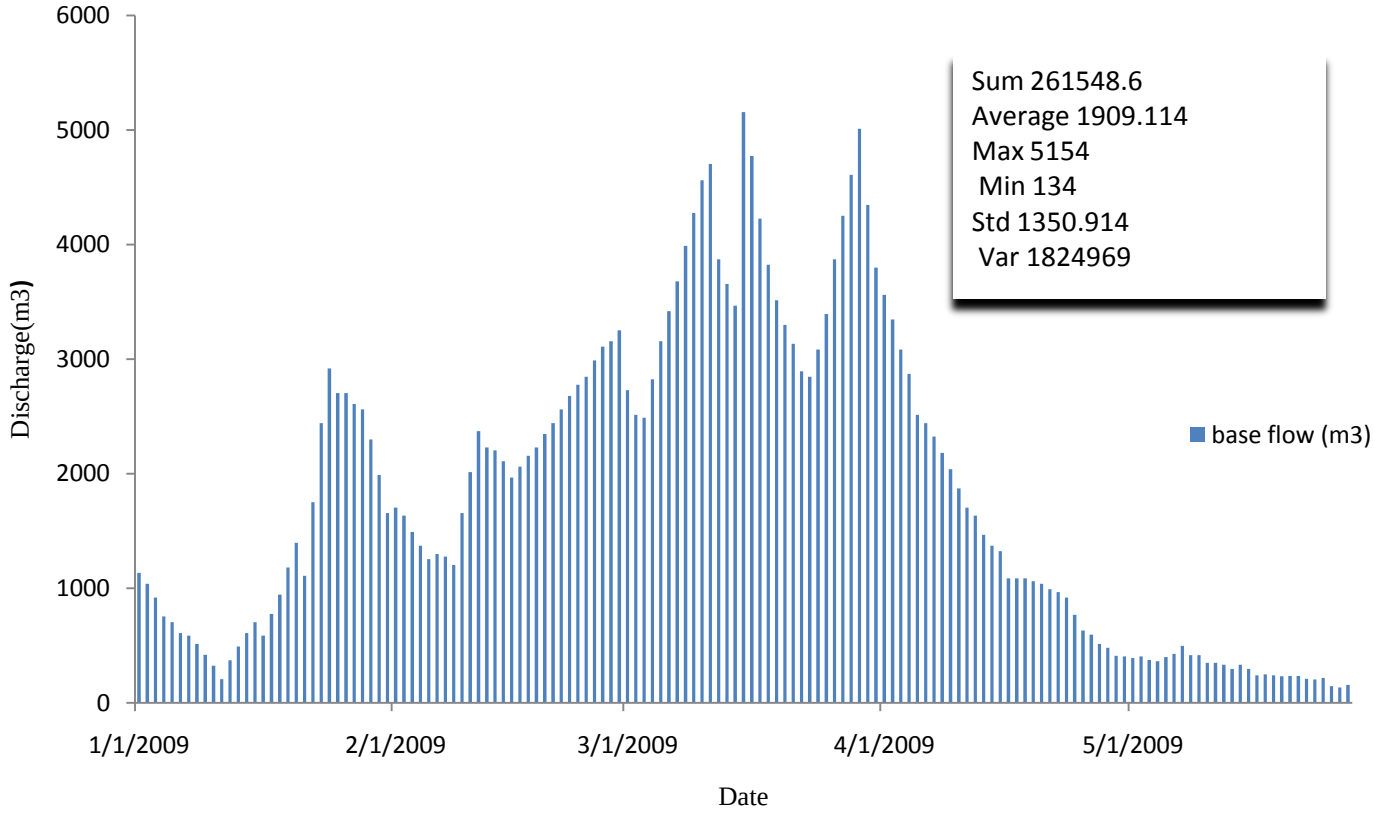
Simulated vs. measured runoff in lottental





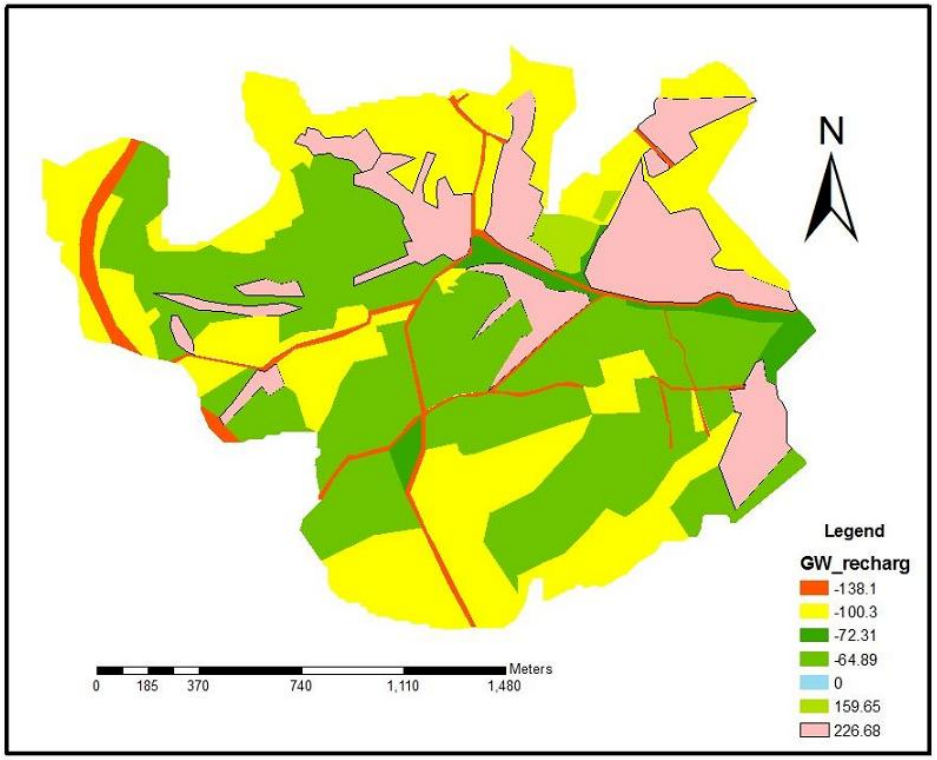
Ground water recharge

Base flow (inter flow)



Ground water recharge

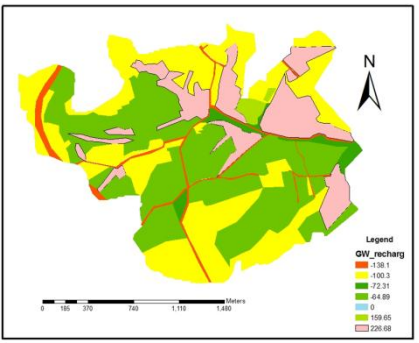
Spatial distribution of groundwater recharge

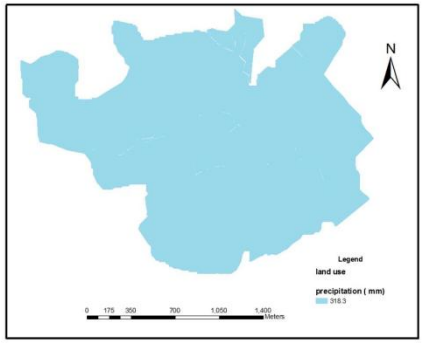


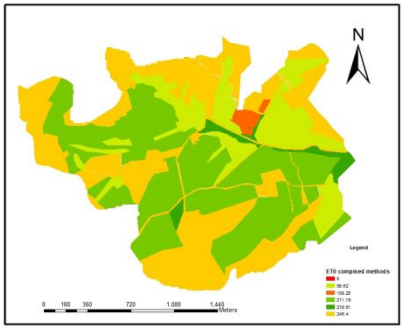
Ground water recharge

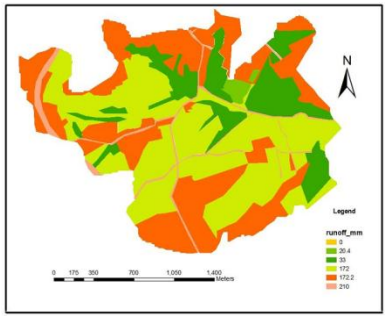
Result

G = P - ET - R









Ground water recharge

Result

Land use	Area ratio %	precipitation	Direct Runoff	apart direct runoff	ET0	apart ET0	GWR	apart GWR
sub urban	0.011651217	318.29	172.19	2.006223009	246.4	2.87086	-100.3	-1.16861704
road	0.177184778	318.29	210	37.20880339	246.4	43.65833	-138.1	-24.4692178
field	0.396788788	318.29	172	68.24767158	211.19	83.79782	-64.89	-25.7476245
grass	0.021005421	318.29	172	3.612932413	218.61	4.591995	-72.31	-1.51890199
deciduous forest	0.04173246	318.29	33	1.377171194	58.62	2.446357	226.68	9.45991413
coniferious forest	0.351637336	318.29	20.39	7.173401294	138.25	48.61386	159.65	56.13890062
			sum	119.6262029	sum	185.9792	sum	12.6944534

Problems

- Absence of the permentant measurement of the stream discharge
- Absence of tansiometer
- Absence of actual measurement of evapotranspiration
- Absence of ability to take soil sample

Conclusion

This study give

- ability to use scs method to simulate the direct surface runoff
- ability to estimate ground water recharge in study area
- Ability to show effect of differences in land use on component of hydrologic cycle

Reference

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