Water budget analysis in Northern Cyprus

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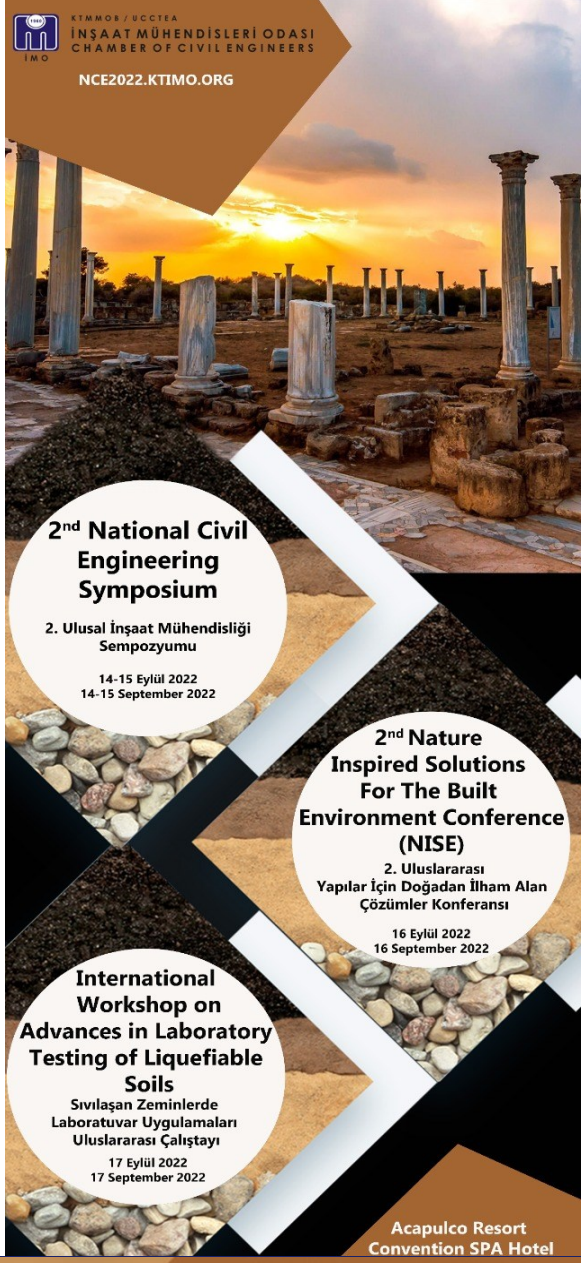
METU NCC



Outline

- Introduction
- Study Area and Data
- Background and Literature Review
- Methodology
- Results and Discussion
- Conclusion

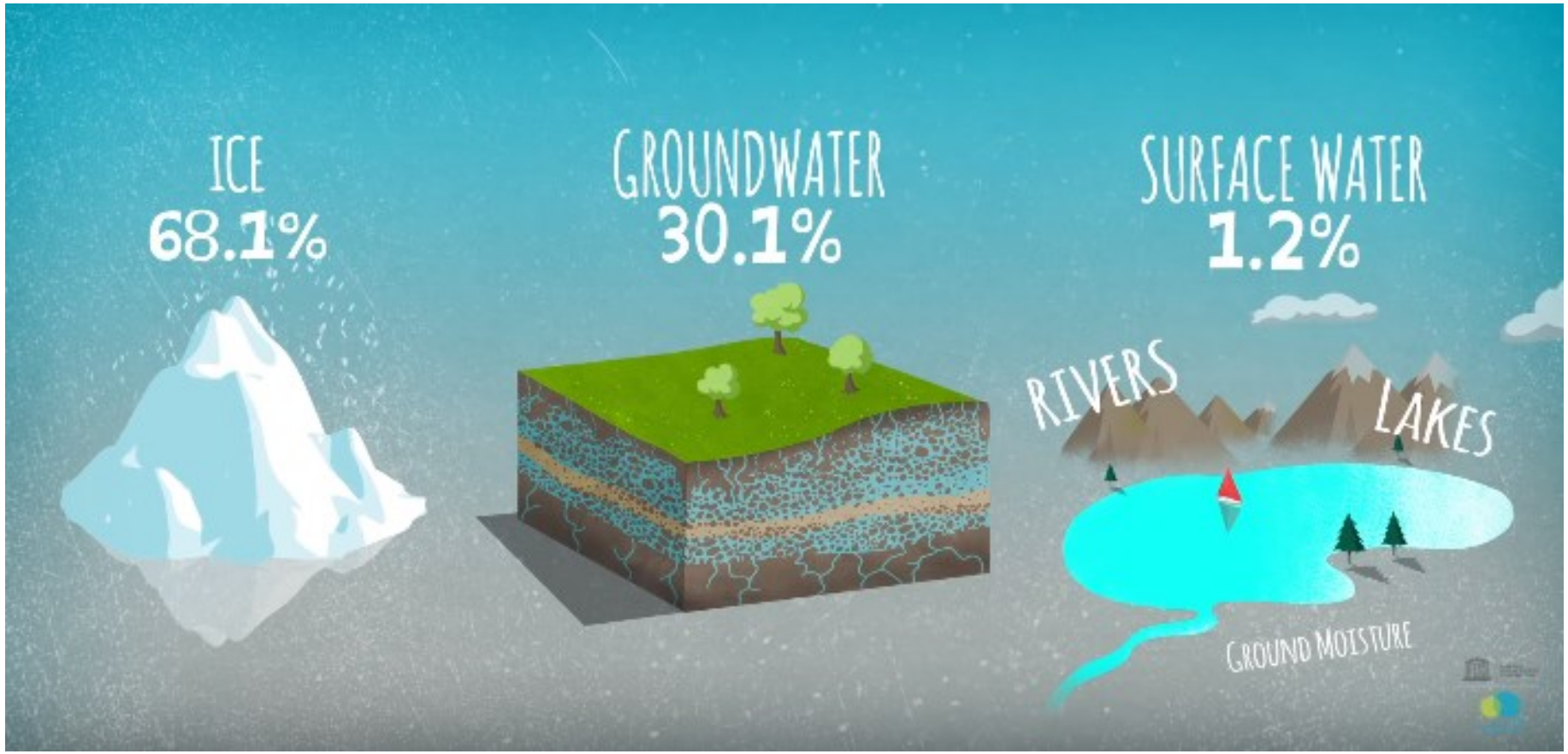


Figure 1. freshwater resources distribution

Source: http://www.unesco.org/water/wwap

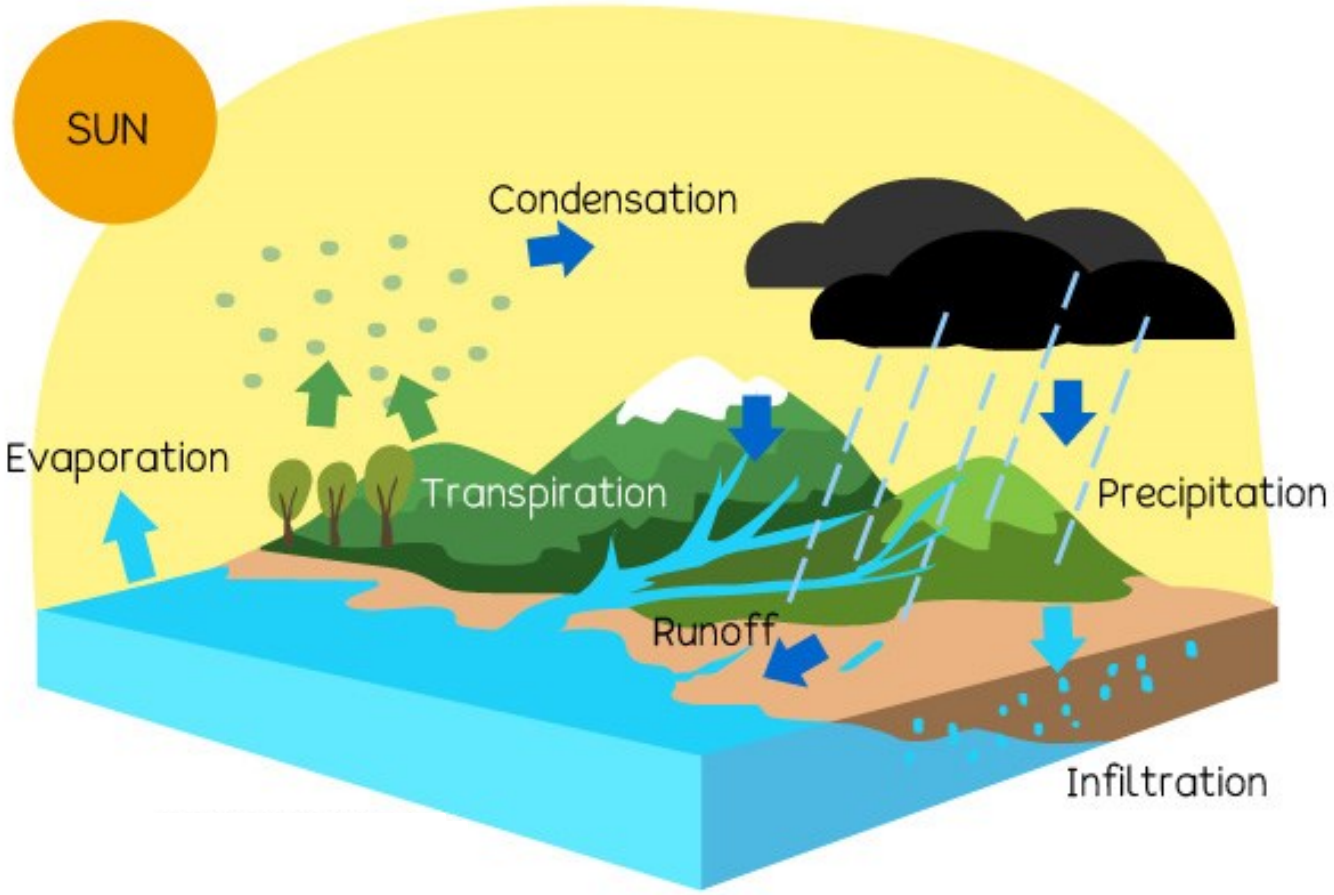
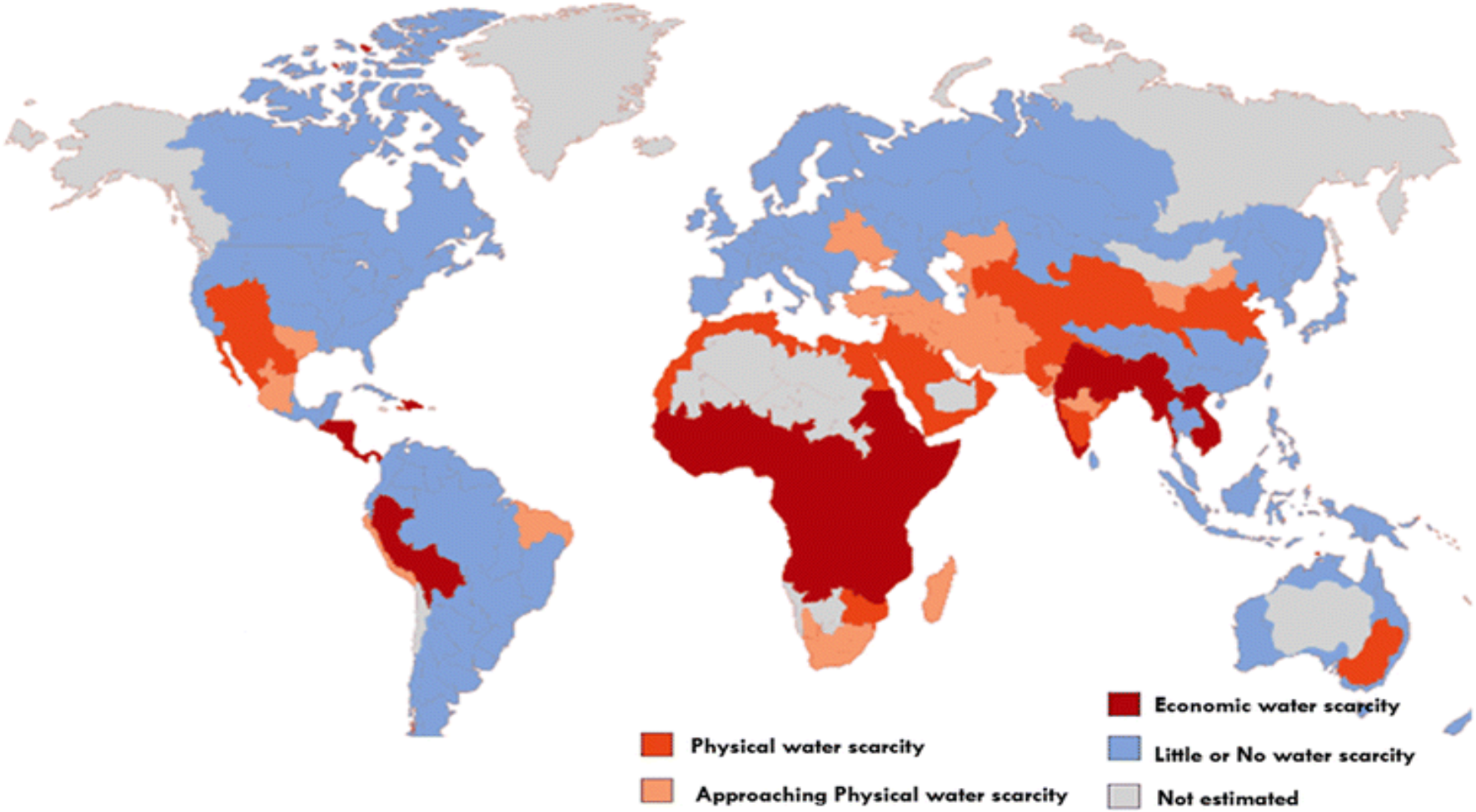


Figure 2. Hydrological cycle

Source: https://eschooltoday.com/learn/the-water-cycle



Source: Gude, 2017

Figure 3. Hydrological cycle

Literature Review

Reference	Methodology	Country
Mandal et al.(1999)	TM model	India
Nachiappan et al.(2002)	Isotope and chloride mass	Northern India
Boulet et al.(2000)	Water and energy balance	Lake/ Mexico
Jasrotia et al.(2009)	TM model and GIS	India
Xu, C. Y., & Singh, V. P. (2005)	TM model	Sweden and China
Bhattarai and Dutta (2007)	TM model and GIS	Thailand
Xu et al.(2007)	Conceptual water balance	Surface runoff China
Nugroho et al. (2019)	TM model	Indonesia
Ngongondo et al. (2015)	TM model	Malawi

Table 1. Literature review of water balance analyses

Thornthwaite and Mather Model (TM)

Five components

- Soil Storage Capacity (STC)
- Potential Evapotranspiration (PET)
- Actual Evapotranspiration (AET)
- Water Surplus (S)
- Runoff

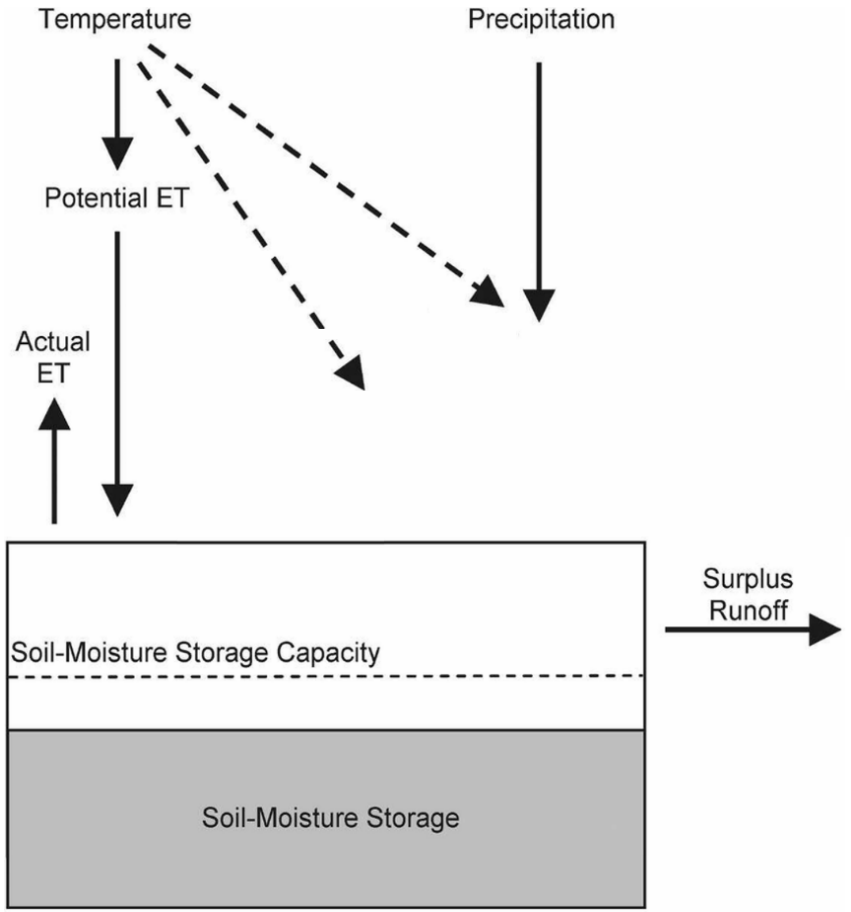
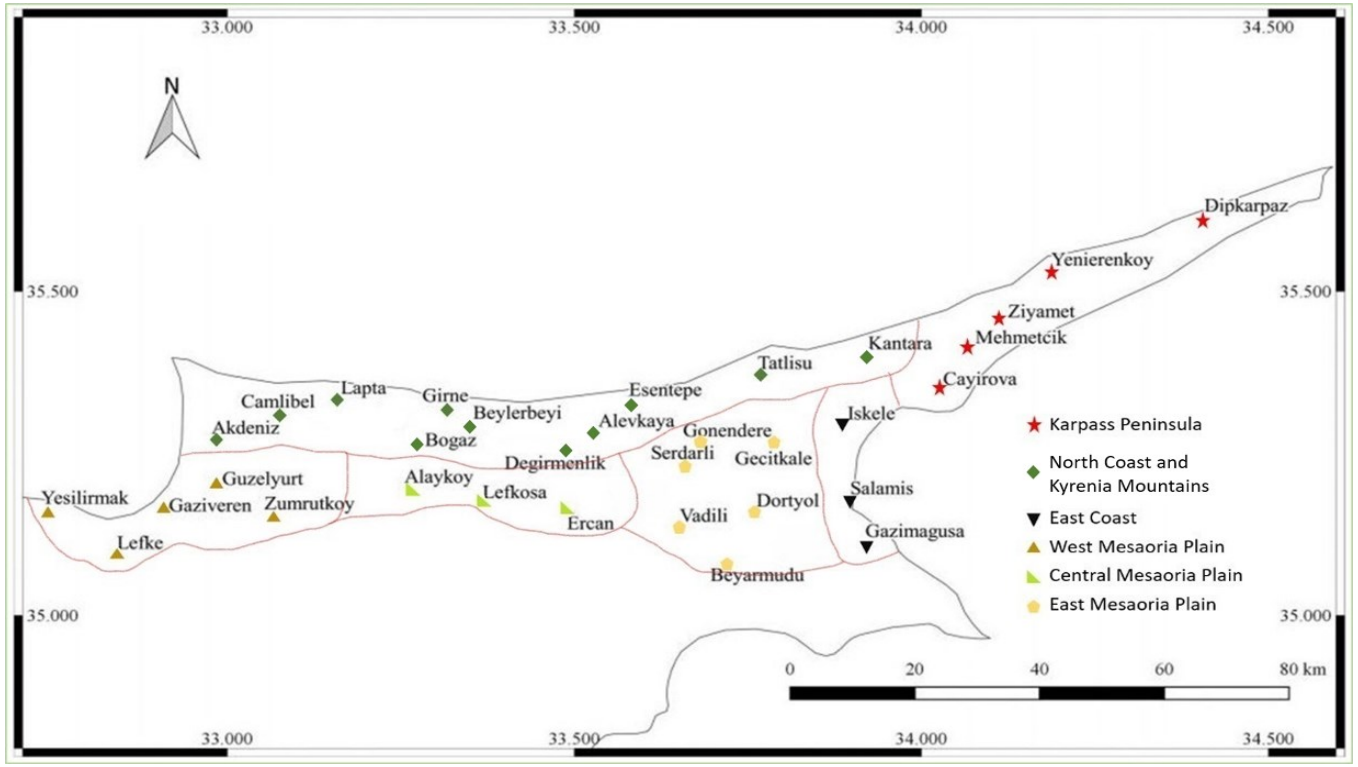


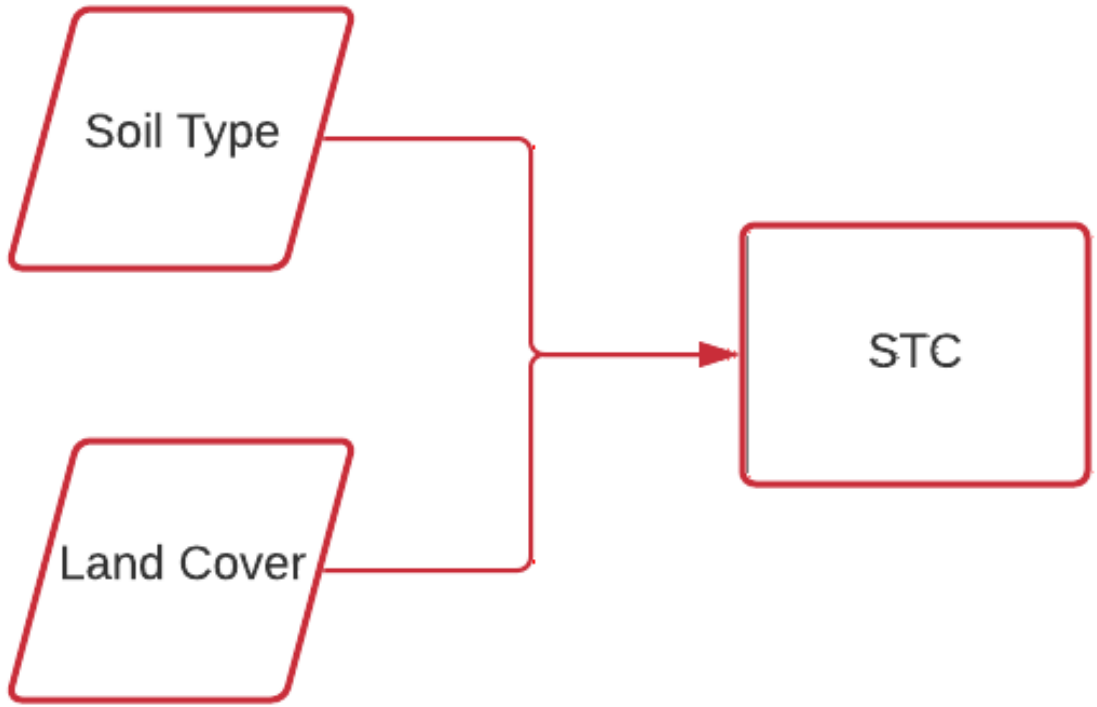
Figure 4. Water budget components in TM model

- Monthly Rainfall
- Monthly Temperature
- Soil map and land cover map
- Digital elevation map

33 stations
36 hydrological years (1978-79 and 2014-15)



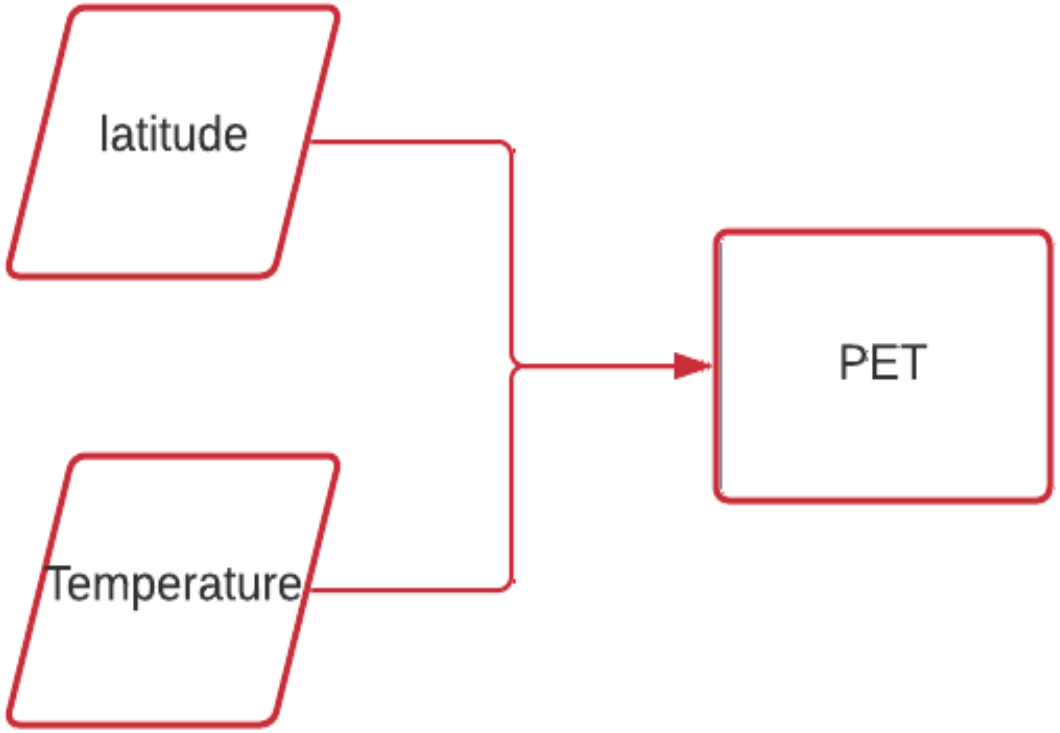
Soil Storage Capacity (STC)



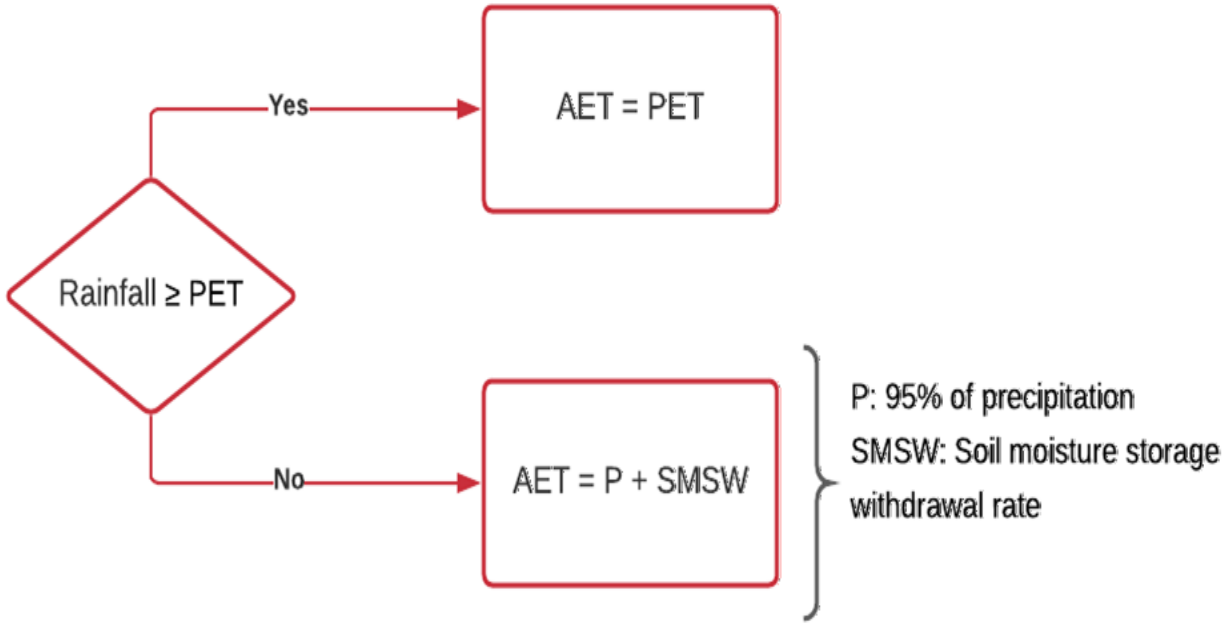
Potential Evapotranspiration (PET)

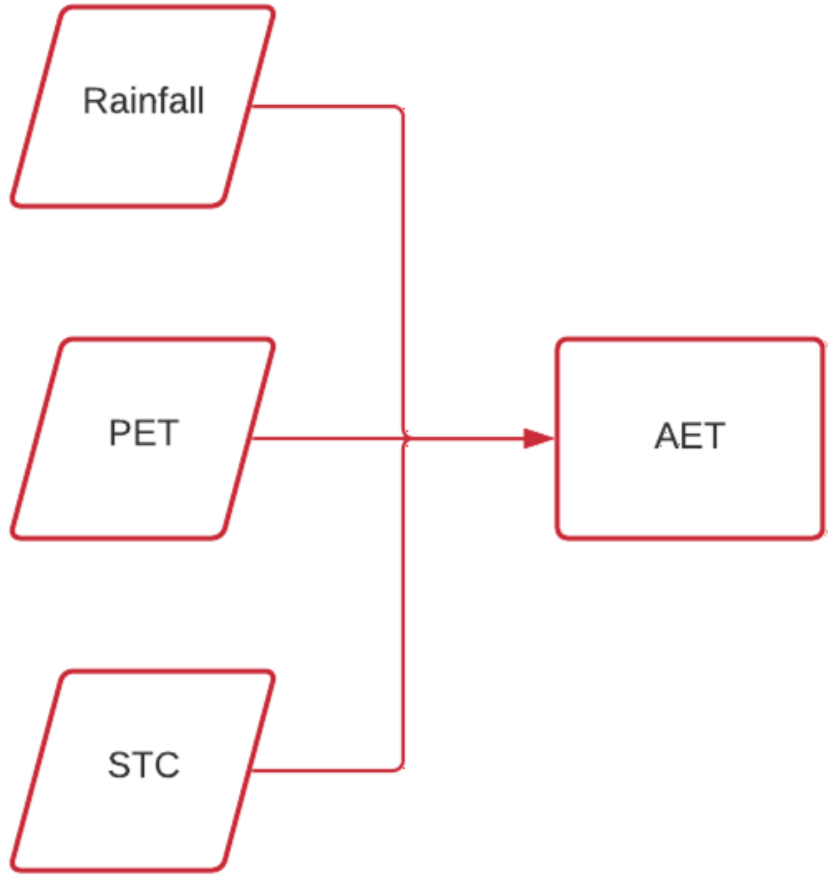
- $PET = 13.97 \times d \times D^2 \times w$
- $w = \frac{4.95 \times e^{0.062 \times T}}{100}$

d: Number of days in the month
D: Monthly daylight hours
T: Mean monthly temperature



Actual Evapotranspiration (AET)

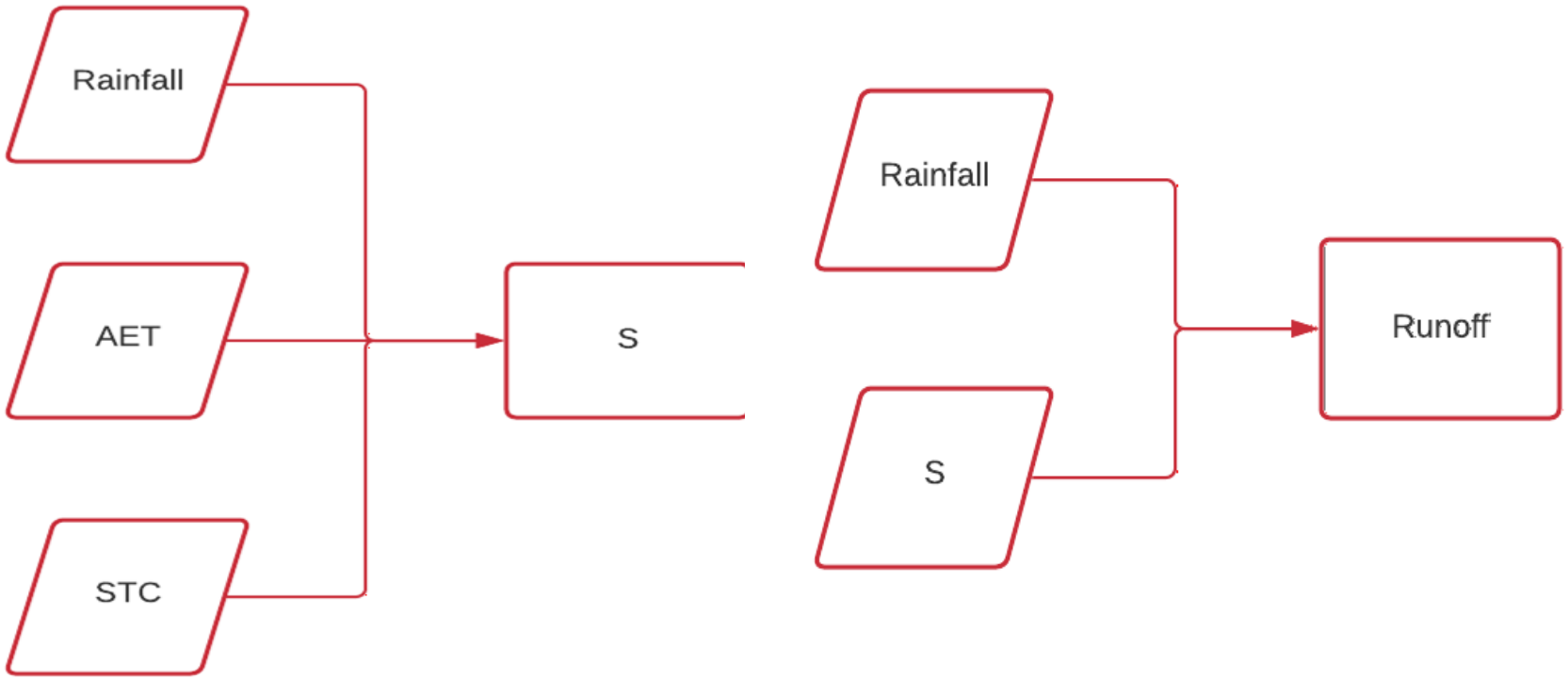




Water Surplus (S) and Runoff (RO)

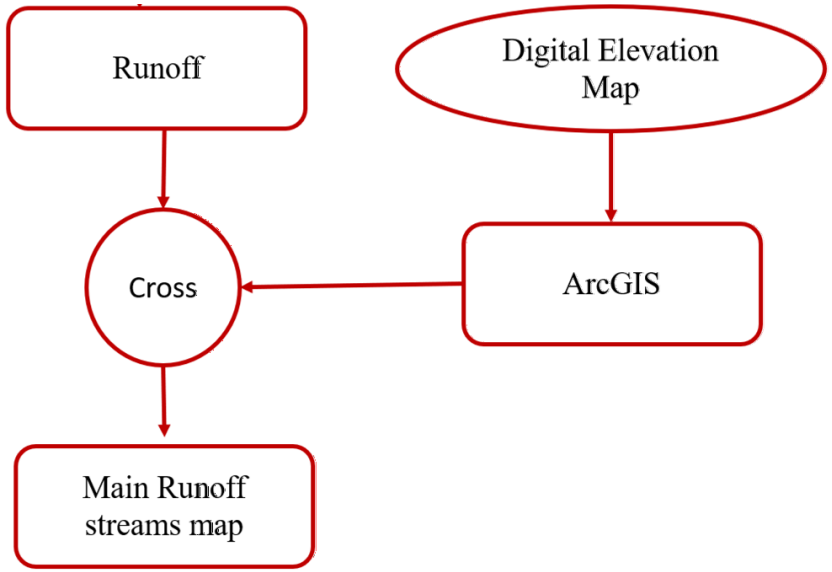
- $RO_{total} = 0.05 \times P_{total} + 0.5 \times S + RS$

P_{total}: Monthly total rainfall
S: Surplus
RS: Remaining surplus



Runoff streams map

- Create a Runoff streams map from DEM in ArcGIS
- Combining Runoff depth with the Runoff streams



Actual Evapotranspiration (AET) % Heat Map

- Low AET% on the northern coast
- High AET% in the southern part of the study area

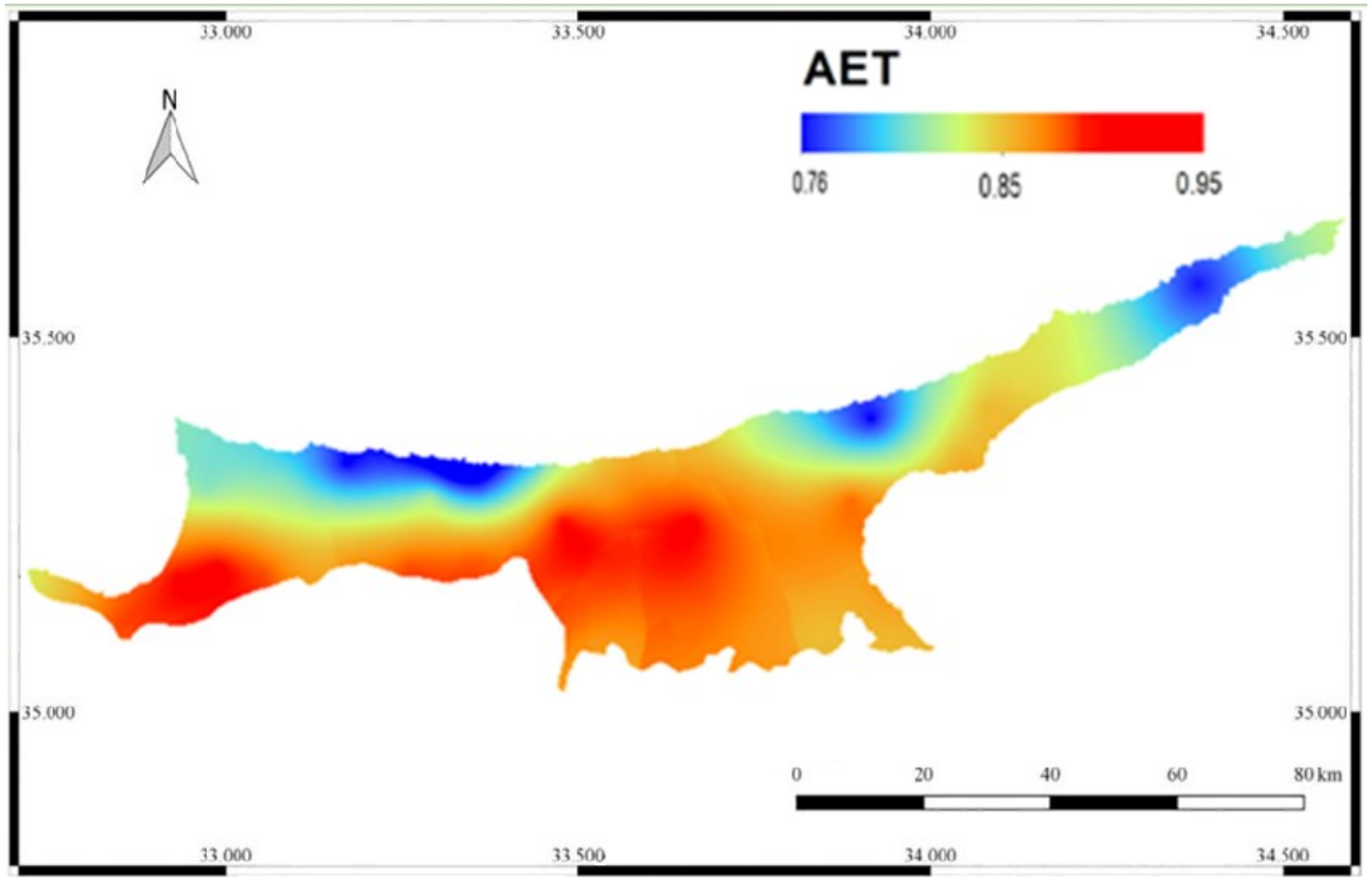


Figure 8. Spatial distribution of AET across Northern Cyprus

Runoff Depth Heat Map

- High Runoff depth on the northern coast
- Low Runoff depth in the southern part of the study area

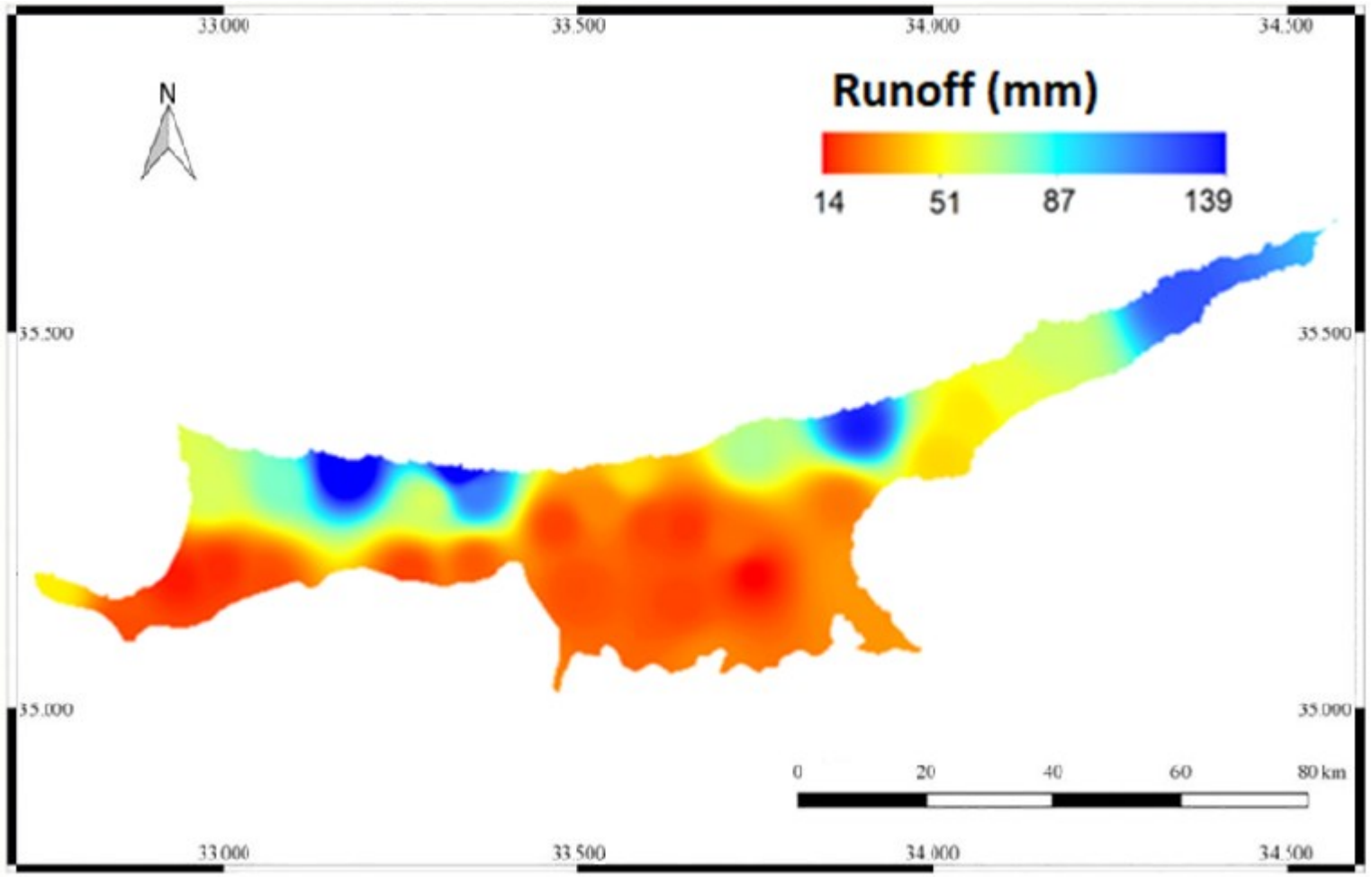


Figure 6. Spatial distribution of Runoff across Northern Cyprus

Main Runoff Streams

- The eastern region has the most significant 2 streams
- The Northern Coast has only small streams

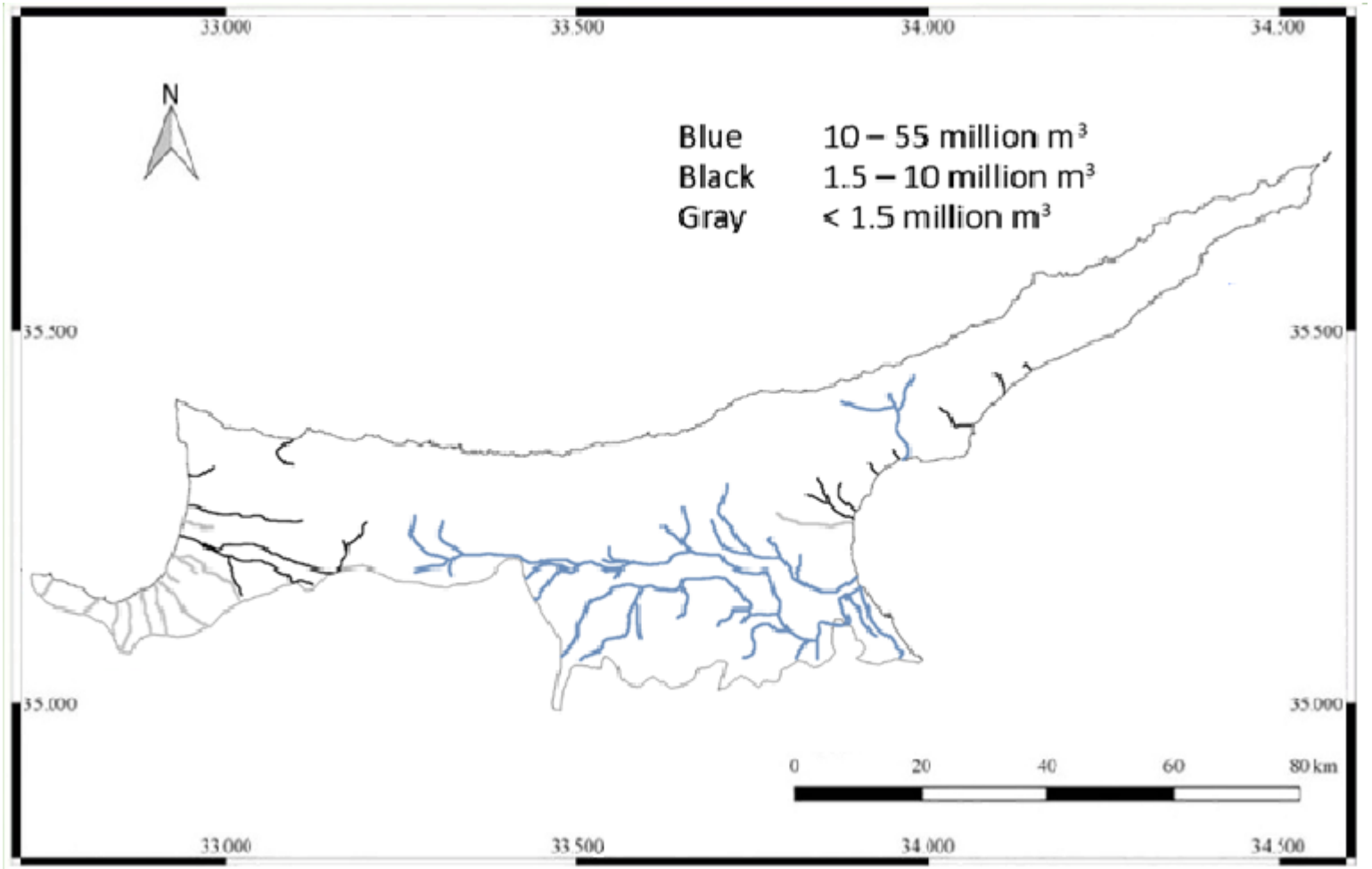


Figure 8. Spatial distribution of Runoff streams across Northern Cyprus

Runoff in the Main Cities

- 8.1 million m^3 /year
- Significant variation in annual runoff values

Polygon name	Average annual runoff (mm)	Maximum annual runoff (mm)	Minimum annual runoff (mm)	Dense urban area (km^2)	Average annual available water for harvesting (m^3)
Lefkosa	78.7	247.3	5.2	27.5	2,164,250
Gazimagusa	120.7	373.7	9.2	25	3,017,500
Girne	222.4	573.2	28.5	13.1	2,913,440

Highlights of Northern Cyprus Water Balance

- Rainfall ~ 1.2 billion m^3 annually on average
- Most of the rainfall is lost due to AET ⟶ 84%
- A significant temporal variation has been observed in runoff
- However, there is a chance of a significant rainfall harvesting
  - From the main runoff streams ⟶ 1.43%
  - From the main cities ⟶ 0.13%

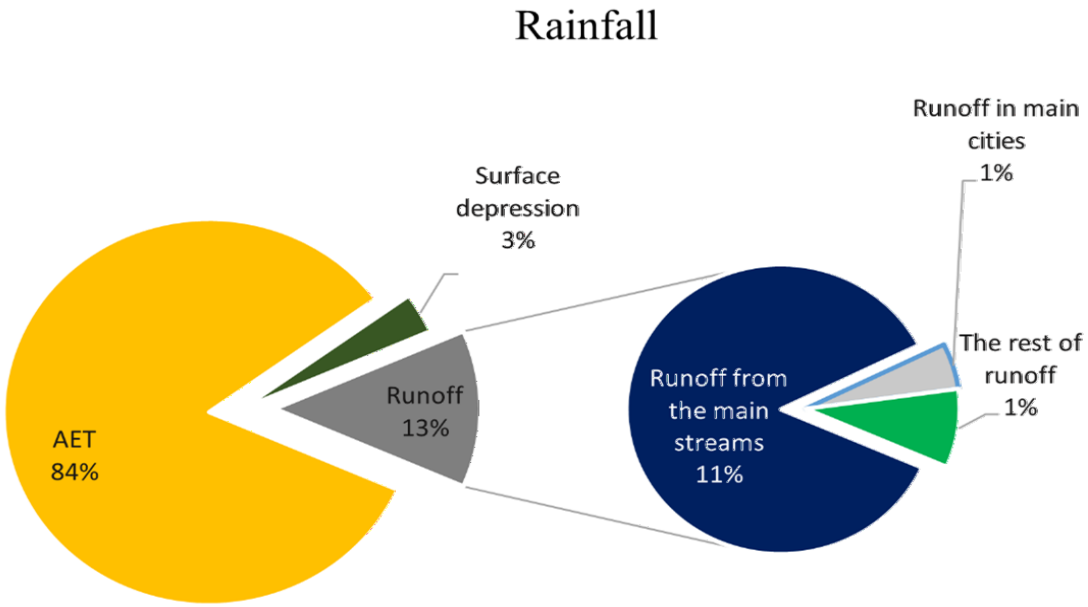


Figure 9. Pie chart of the water balance results in Northern Cyprus

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Thank you for your attention

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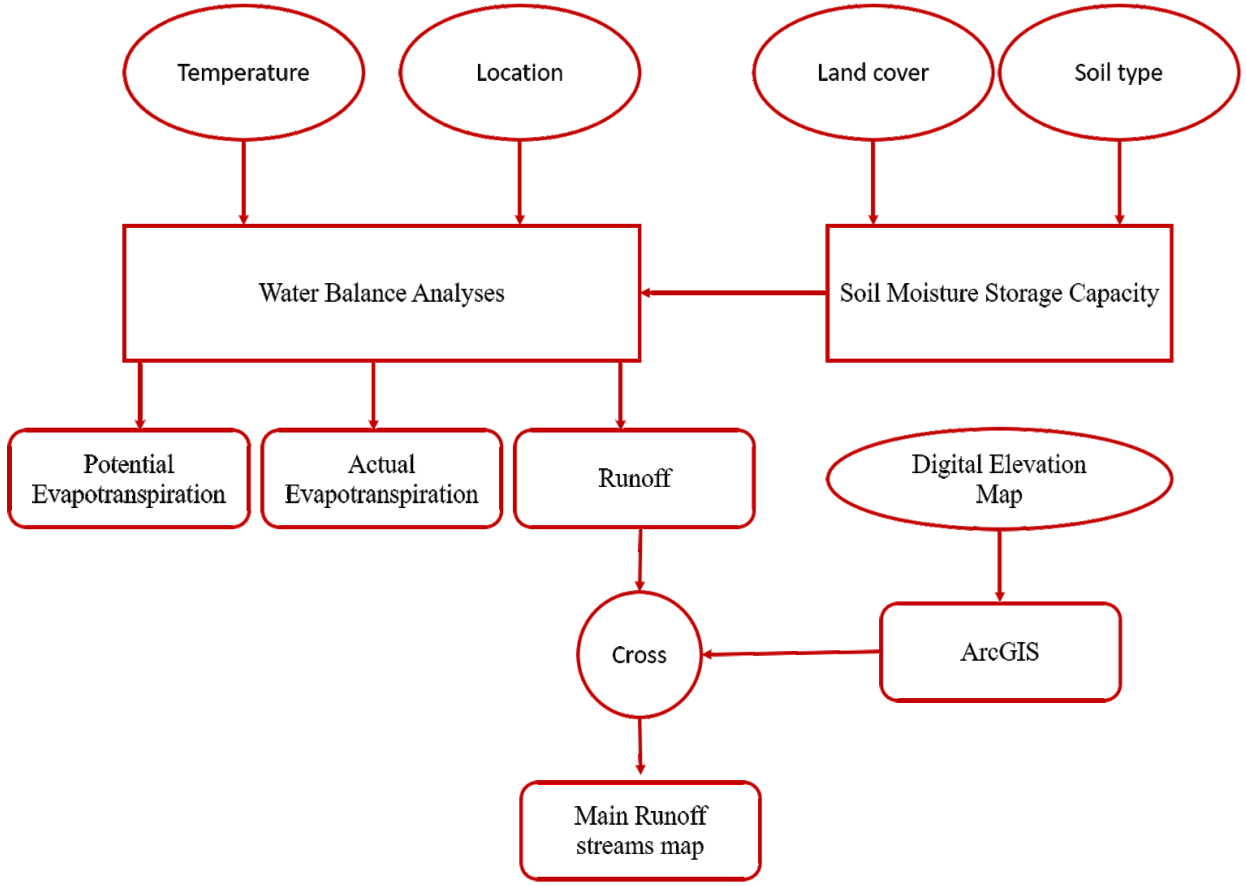
Temperature
Location
Land cover
Soil type
Water Balance Analyses
Soil Moisture Storage Capacity
Potential Evapotranspiration
Actual Evapotranspiration
Runoff
Digital Elevation Map
Cross
ArcGIS
Main Runoff streams map

Polygons

Figure 6. Boundaries of the 33 polygons in the study area (Cakal, 2016)

Runoff streams map - Catchment

Multi flow direction

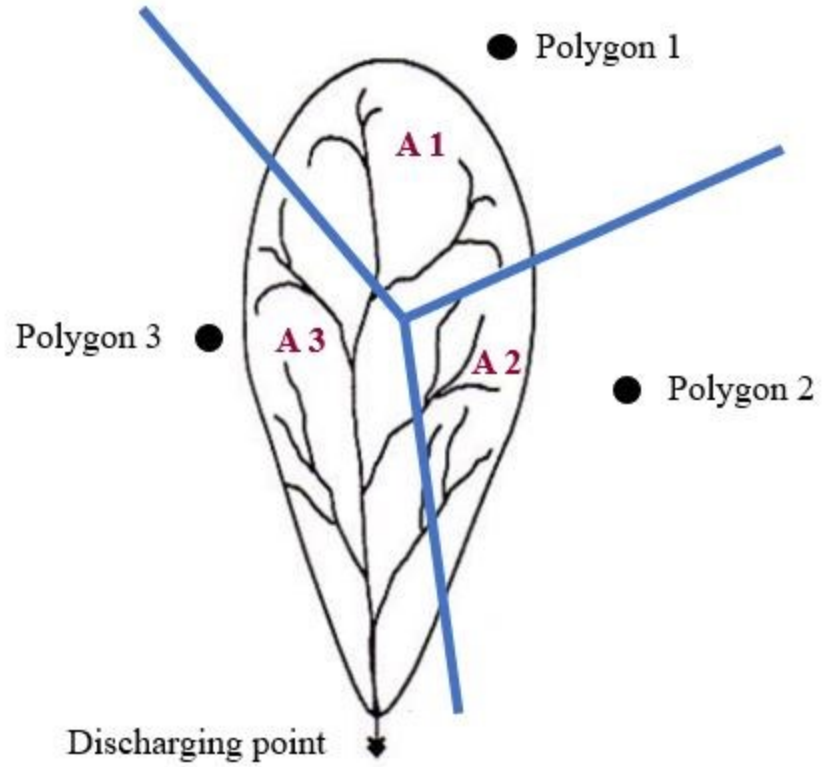

Figure 7. Runoff discharge from a catchment

Northern Cyprus Water Balance

- Rainfall ~ 1.2 billion m^3 an[illegible]

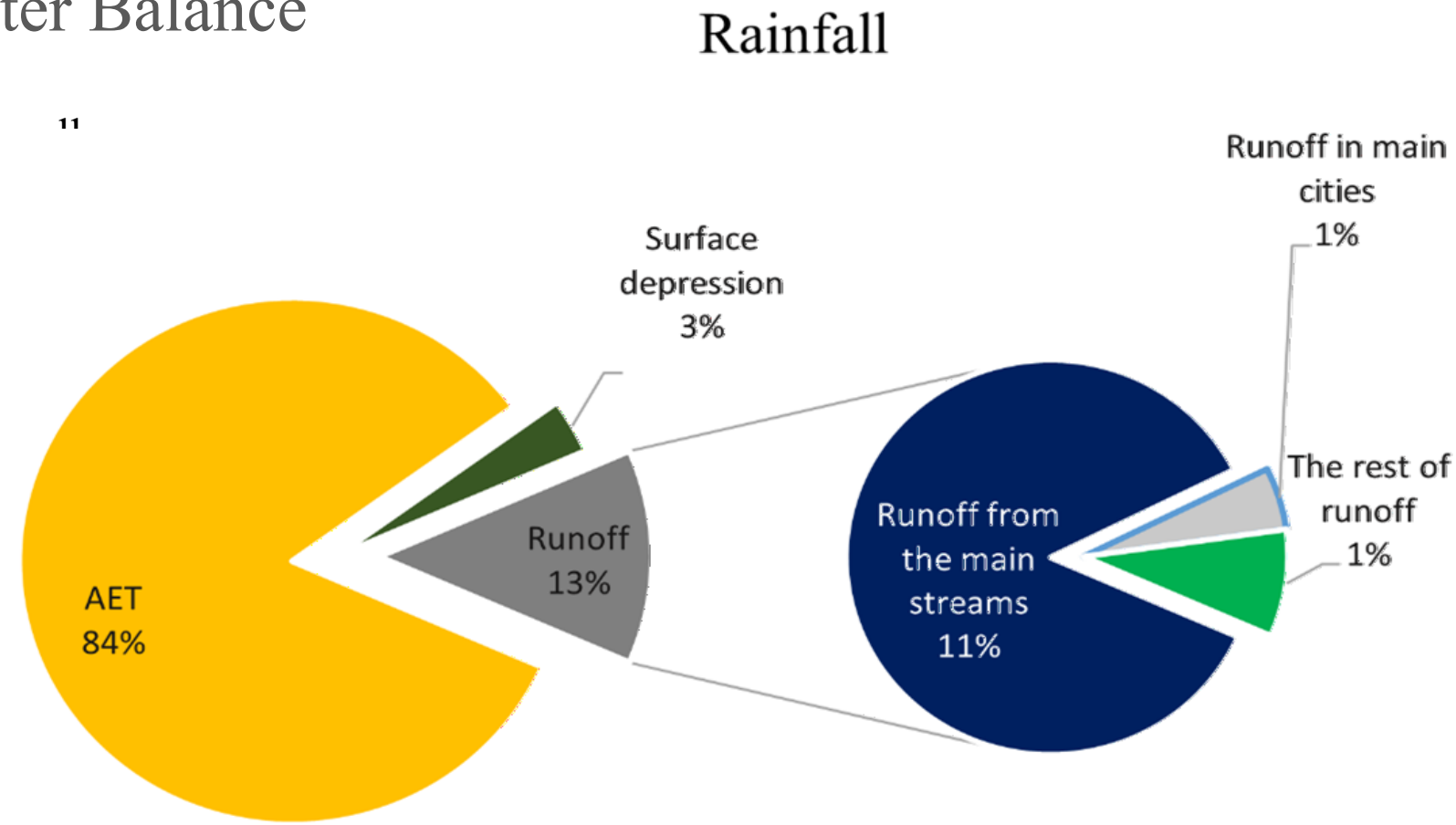

Figure 9. Pie chart of the water balance results Northern Cyprus