Imprints of climate change and anthropogenic activities on groundwater resources in the Nairobi aquifer system (Kenya).

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INTRODUCTION

Groundwater importance to environment and socio-economic development is beyond reproach and to date is the main source of domestic water supply in Africa. Climate change and increased water demand is expected to shift over reliance on groundwater for both water supply and irrigation. Combination of historical and current groundwater data including exploitation is crucial to planning of sustainable management of groundwater resources or for considering remedial approaches towards reviving depleting aquifer systems for future generation. Groundwater abstraction from the Nairobi aquifer system (NAS) provides supplementary water supply to bridge the piped water supply gap for over 5 million people. Over the last years, infrastructure development land coverage has increased thereby sealing the land surface, increasing flooding during heavy rains, and potentially modifying groundwater recharge. The analyses contributes and provide insights on the effects of human activities and climate change on groundwater resource in Nairobi aquifer system-Kenya.

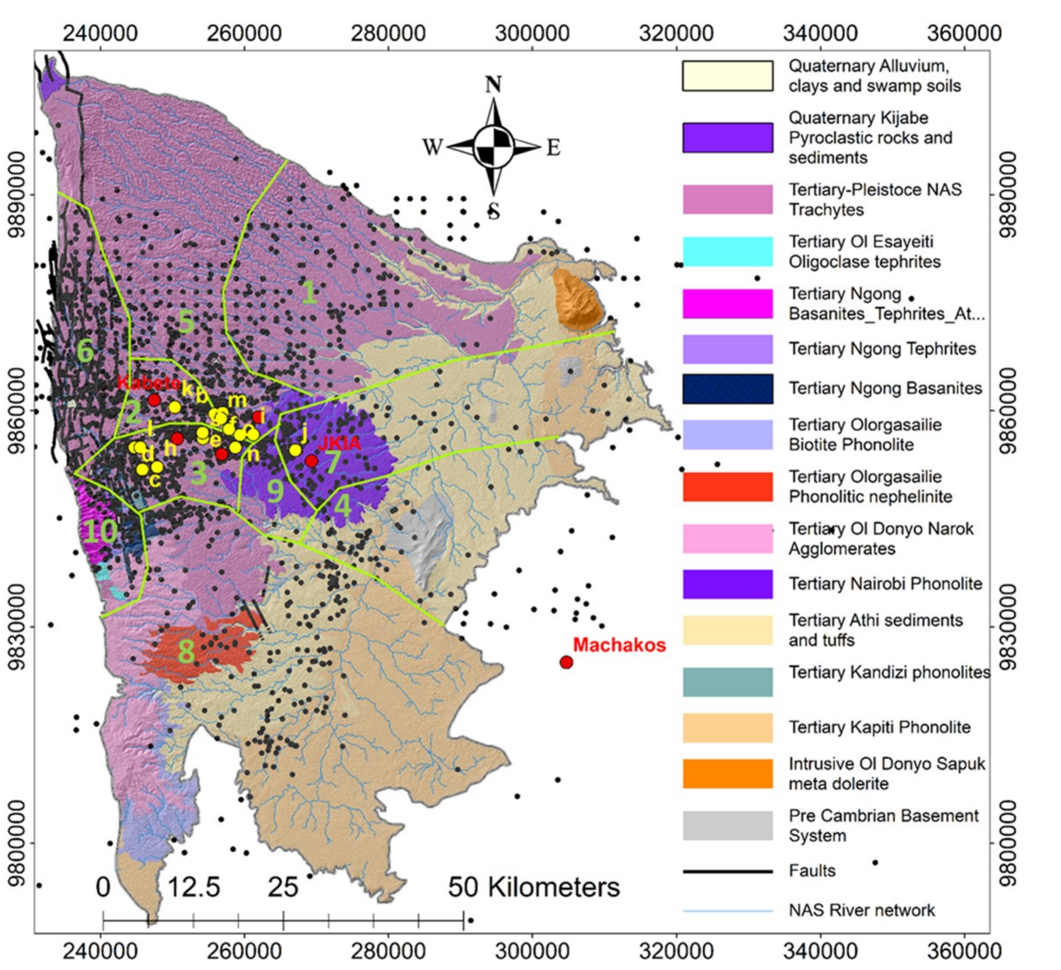
AIM

To analyse climatic and anthropogenic historical data aimed at deriving inputs for Nairobi aquifer system groundwater numerical model for policy and advisory application.

OBJECTIVES

- To analyse climatic data and map out land use changes over last 30 years
- To scrutinise the implication of the changing climate and anthropogenic activities on NAS groundwater resource.

STUDY SITES



Scrutinised sub-sections

1. Juja, Thika, Roysambu, Kasarani, Ruaraka
2. Parklands, Westlands, Kabete
3. Langata
4. Athi River, Mlolongo, Syokimau
5. Muthaiga, Kiambu, Red Hill, Roslyn, Runda
6. Muguga, Thogoto, Kikuyu
7. Embakasi
8. Isinya, Kiserian, Kitengela
9. Industrial area
10. Ngong, Ongata Rongai

Monitoring wells

a. KICC
b. Riverside Park
c. Karen Country Club
d. Jorgen Ladaforged
e. Uchumi Supermarket
f. Hindu Temple
g. Anthony
h. Hillcrest School
i. Trufoods
j. Kabansora Millers
k. Kabete
l. St. Lawrence University
m. Boulevard Hotel
n. Unilever
o. TUK men's hostel

Figure 1: Simplified Geological map of Nairobi aquifer system (NAS) with inscription of Meteorological weather stations in red, production wells in black dots, Observation/monitoring wells in yellow, and subdivisions of areas within NAS for specialized dynamic water rest level analyses in light green numbered from 1-10 for understanding areas undergoing abstraction stress.

METHODS

- Geological map production and land use image classification map using GIS (ArcGIS, 2015)
- Purchase, collection, analyses and synthesis of climatic data
- Compilation, analyses and synthesis of hydrogeological and groundwater abstraction data

RESULTS

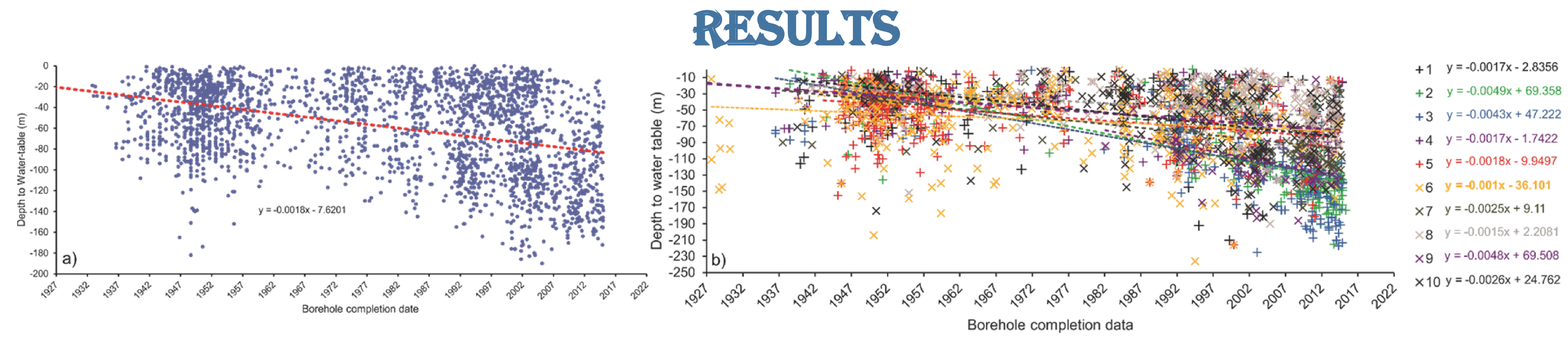


Figure 2: (a) A plot of all recorded NAS boreholes water rest levels with reference to ground level plotted against respective borehole completion dates, (b) sub-divisions plots of water rest levels against their specific borehole completion dates. Both providing regional depth to water table trend over period of abstractions and sub-regional trends for identifying hot spot areas which are under stress of exploitation.

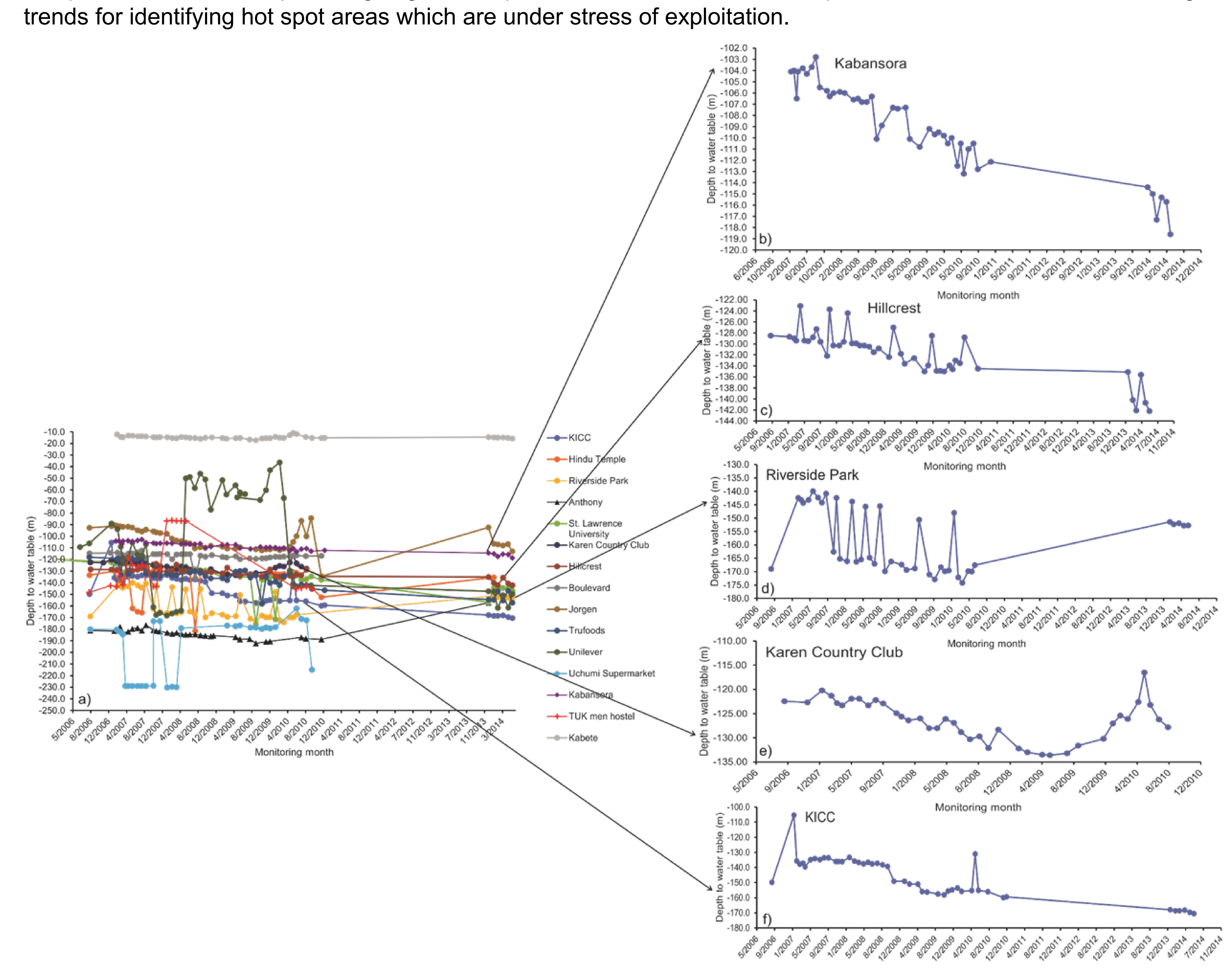


Figure 3: (a) Plot of observed monthly dynamic water rest levels from dedicated monitoring boreholes within NAS vs monitoring dates, b—f) are chosen few to represent trends of observation made from year 2007— 2014. (b, c, & f) shows declining groundwater level with time, (d) shows pumping effects on wrls with recovery in between the declining trends, and e) shows recovery from a declining water rest level (wrl).

Climatic condition since 1970s

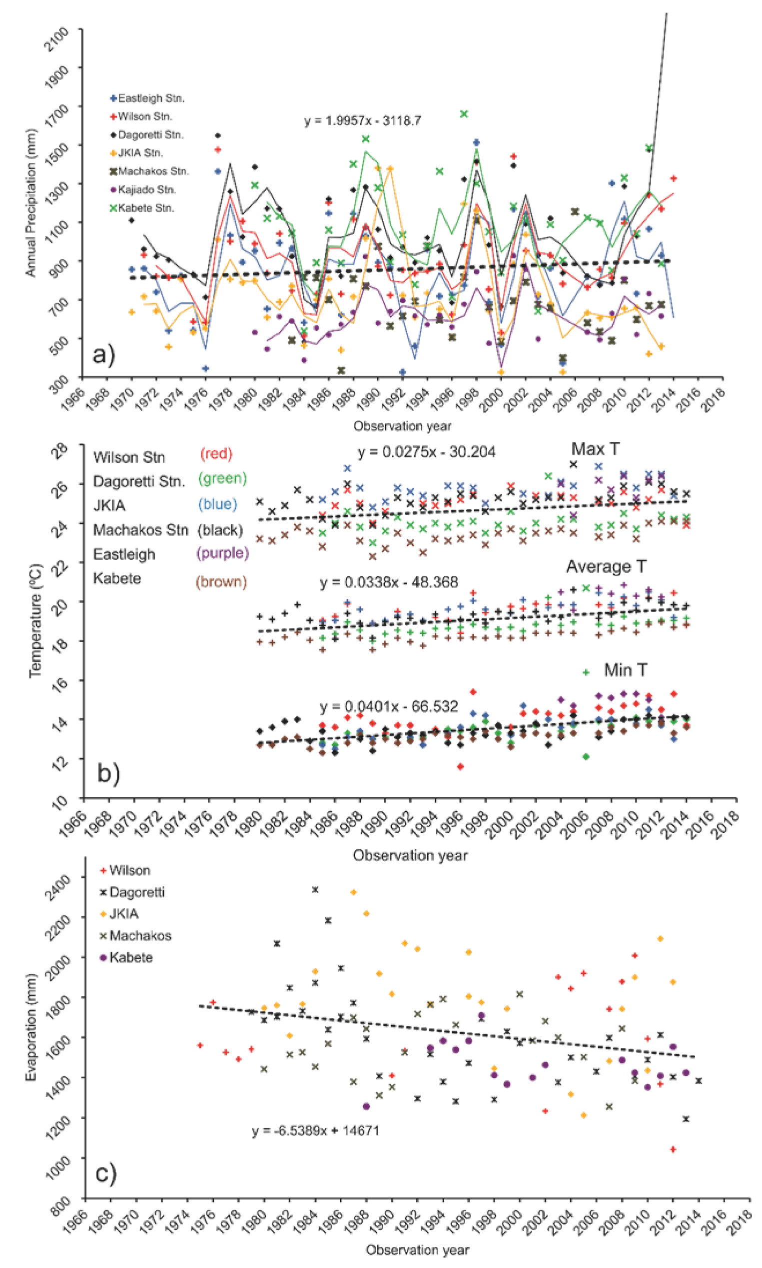


Figure 4: (a) Annual precipitation against observation year plot of seven weather stations with a regional precipitation trend-line,(b) annual minimum, average, and maximum temperature (°C) plot for six stations with specific category regional trend-line, and c) annual evaporation (mm) plot of five stations with a regional trend-line.

Land-use changes from 1990-2017

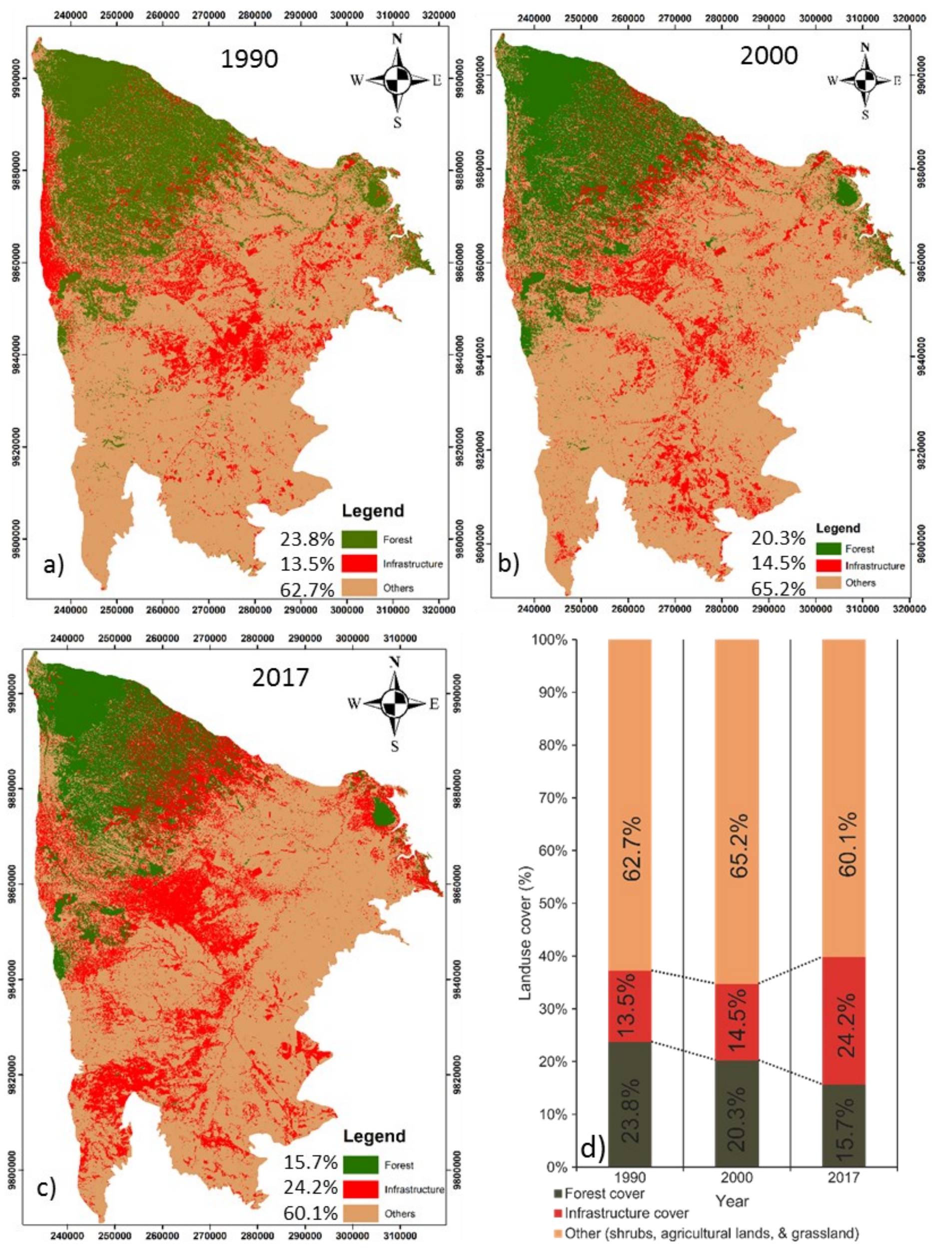


Figure 5: Classified percentage land –use coverage map of 1990, 2000, and 2017, (a) 1900 map shows the least land cover under infrastructure and most under forest cover, (b) 2000 map shows slight infrastructure land cover increment by 1% from 1990 and a reduced forest cover by 3% from 1990, c) 2017 shows tremendous increment on infrastructure land coverage by 10% from year 2000 and associated with the least forest cover, and (d) illustrates summarised land-use coverage over the considered years.

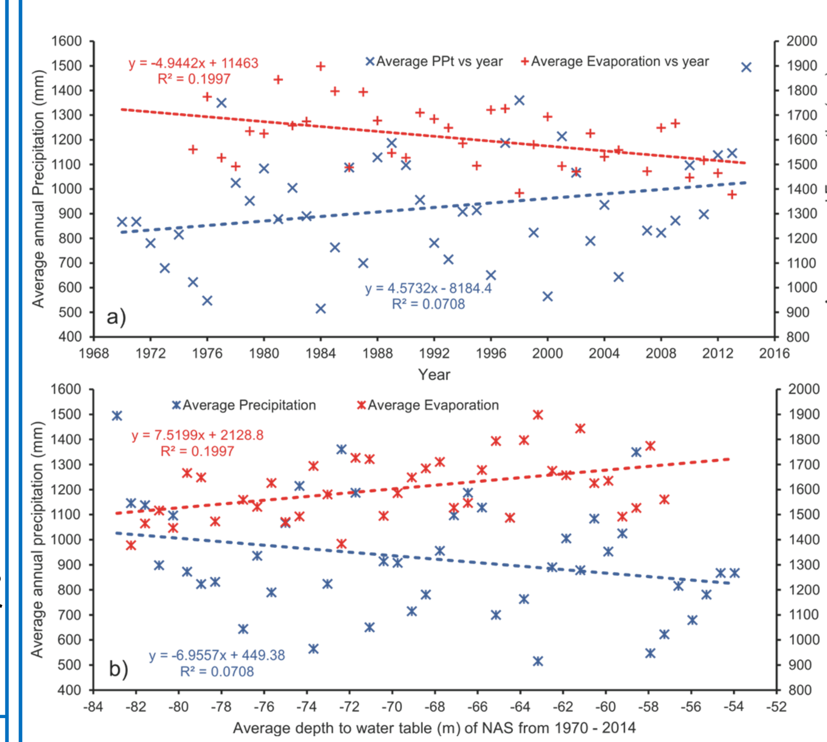


Figure 6: (a) Average annual precipitation (PPT) and average annual evaporation vs observation year plot shows an increasing rainfall and a decreasing evaporation, (b) average annual precipitation and evaporation vs average yearly depth to water table reveals negative relation with PPT and vis versa with evaporation

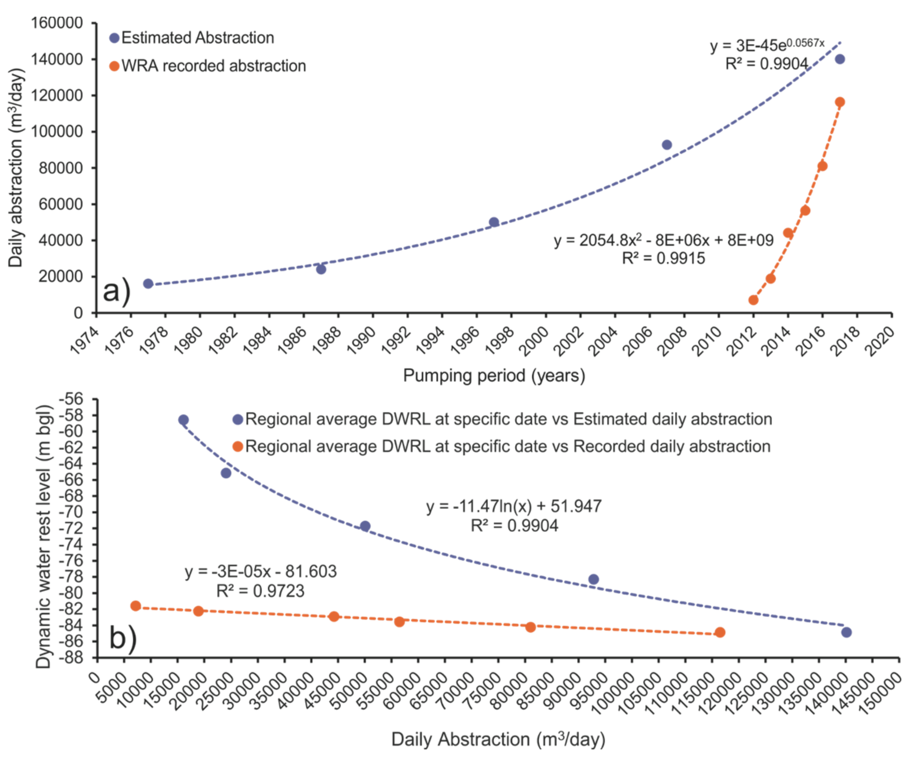


Figure 7: (a) Estimated (using boreholes) and recorded (Water Resources Authority) daily abstraction of groundwater vs fiscal year of abstraction showing exponential increase with time, (b) Regional dynamic water rest level vs daily abstraction over time showing negative relationship.

Future activity

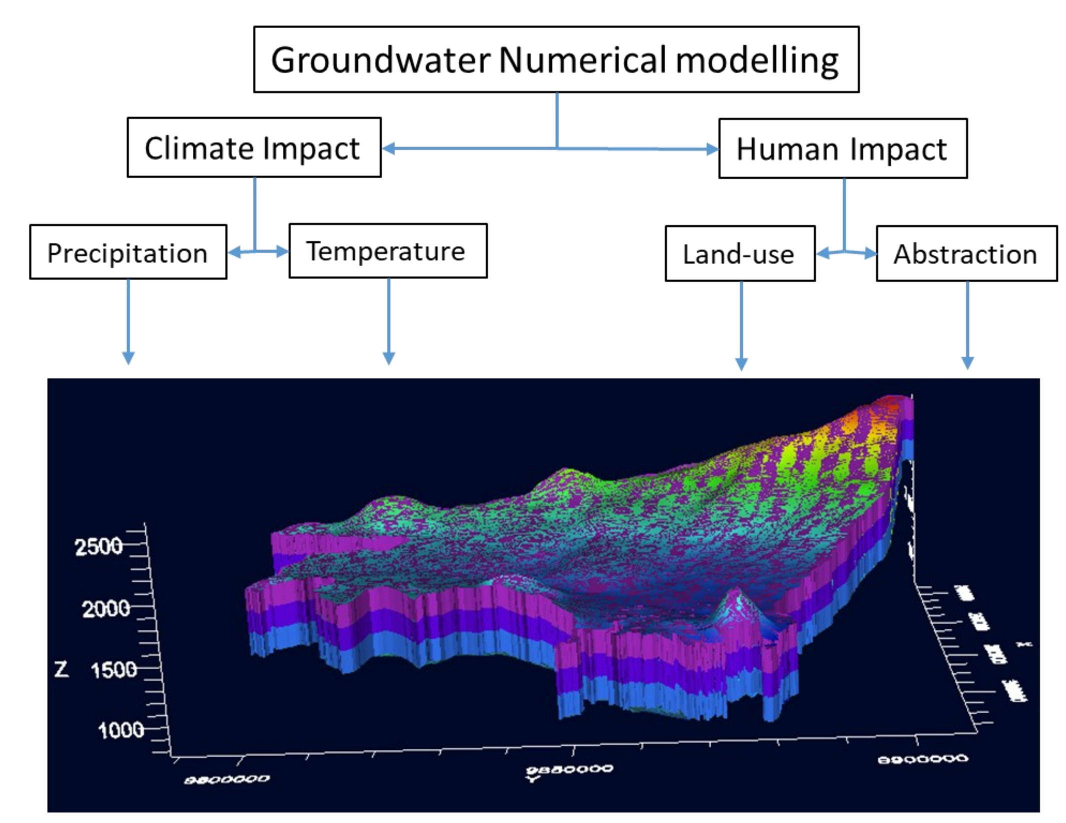


Figure 8: (a) Graphical and pictorial image of expected application of the resulting information derived from the data analyses and synthesis. Results will be used as inputs for groundwater numerical modelling.

CONCLUSIONS

- Regional dynamic water rest level is declining at 6.6 m/decade
- Annual rainfall and temperature trend is increasing at 4.25 mm and 0.3 °C/decade respectively while evaporation is decreasing at 6.5 mm/decade
- Land surface sealing due to infrastructure development has increased by 10% from 1990 - 2017 (13.5% - 24.2%).
- Groundwater abstraction is increasing exponentially over the last 10 years
- Both climate change and infrastructure development potentially modifies groundwater recharge and flooding scenarios in NAS
- There is a higher correlation between groundwater level decrease and abstraction than with climate change

References

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