Characterization and hydrogeological modelling of Gedaref Adegrat aquifer system for devising sustainable management strategies and guidelines

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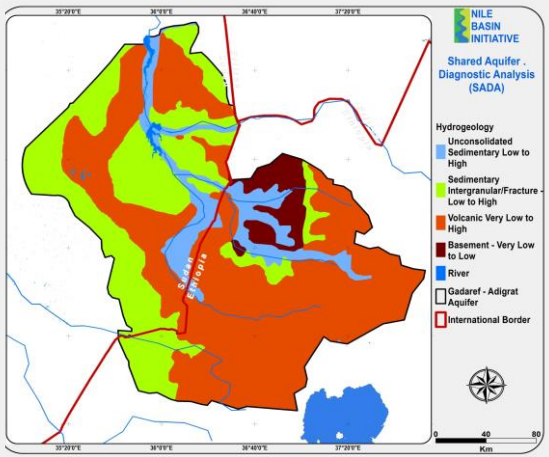
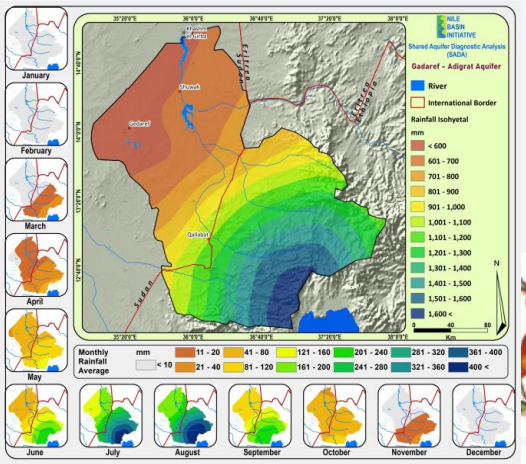
Introduction

- The aquifer is shared between Sudan and Ethiopia and represents an **invaluable resource of strategic importance** for the **socioeconomic development** in Sudan and Ethiopia.

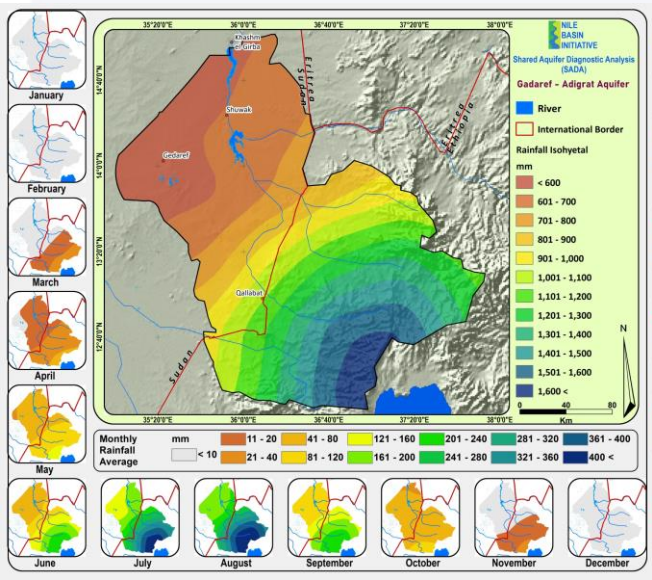
- A **SADA study** has been conducted for the basin (Sudan/Ethiopia) and a SADA report prepared which serves as a **baseline fact-based** representation of the **current status** of the aquifer. Then a modelling component has been carried out

- The SADA analysis includes geology and hydrology, hydrogeologic properties, soil and vegetation, climate analysis including climate change , water demand, socio-economic aspects , stakeholders mapping, institutional aspects and training needs

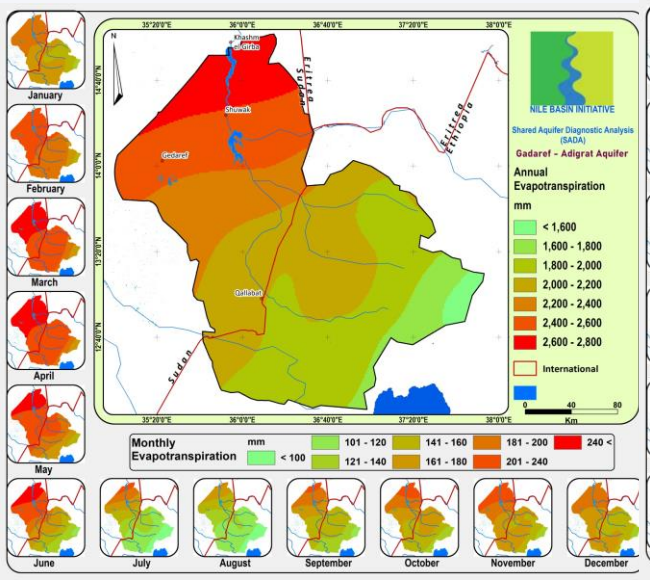




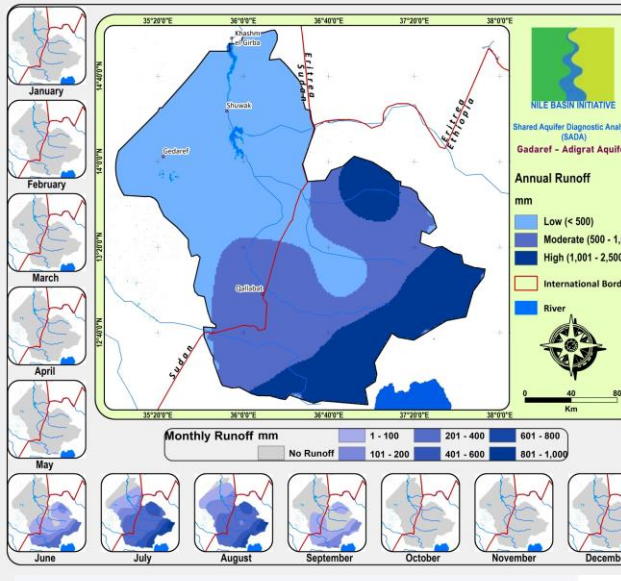
Annual Rainfall



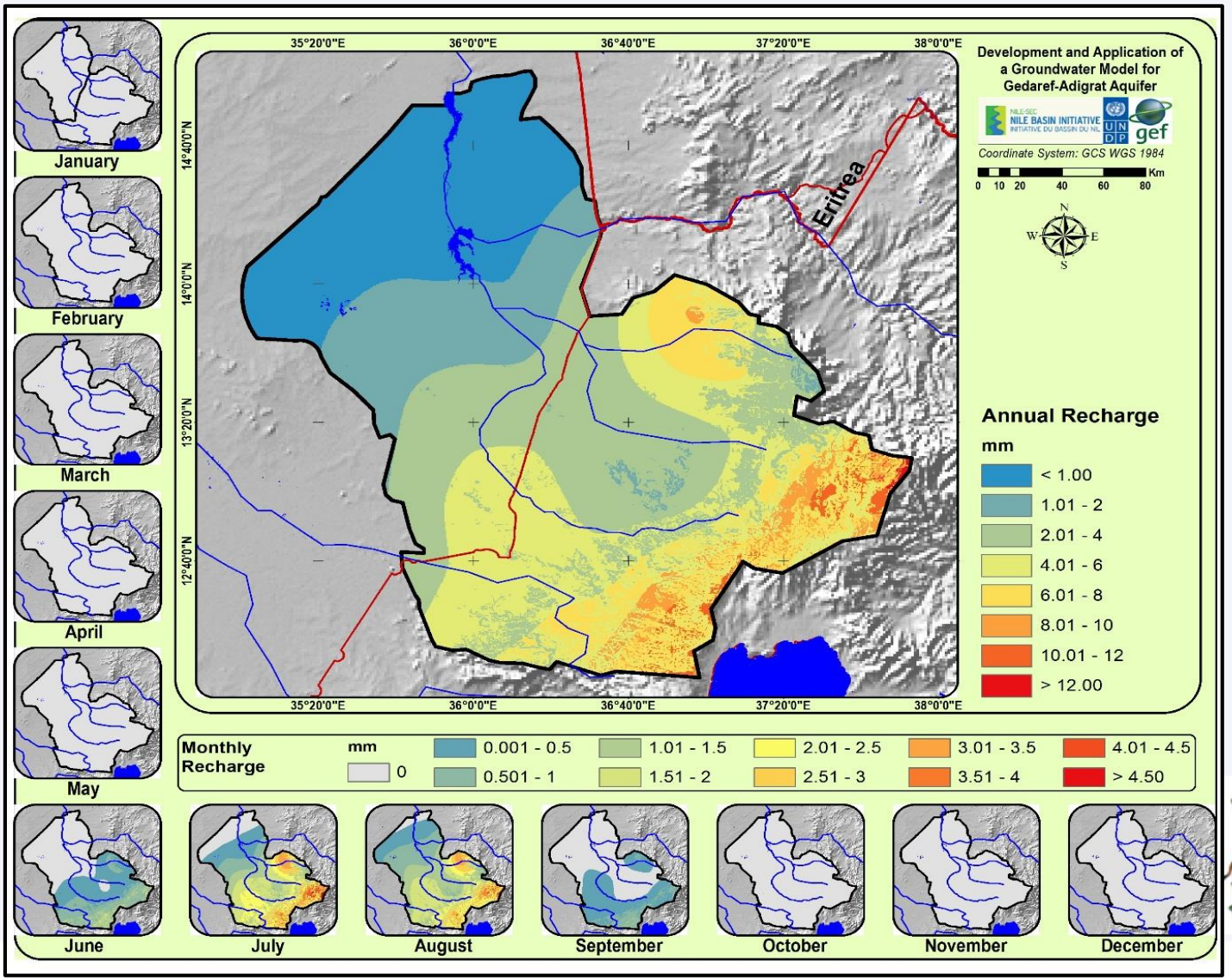
Annual Evapo-trainpiration



Annual Runoff



Annual Recharge



Recharge Analysis

Month	Recharge (MCM/month)			Recharge (MCM/month) under climate change		
	Gedaref	Adigrat	Total Aquifer	Gedarif	Adegrat	Total Aquifer
June	0.78	14.87	15.65	0.70	13.38	14.09
July	13.93	59.70	73.63	12.54	53.73	66.27
August	18.42	53.94	72.36	16.58	48.55	65.12
September	0.78	6.82	7.6	0.70	6.14	6.84
Total (MCM/year)	33.91	135.33	169.24	30.52	121.80	152.32

GMS Layout

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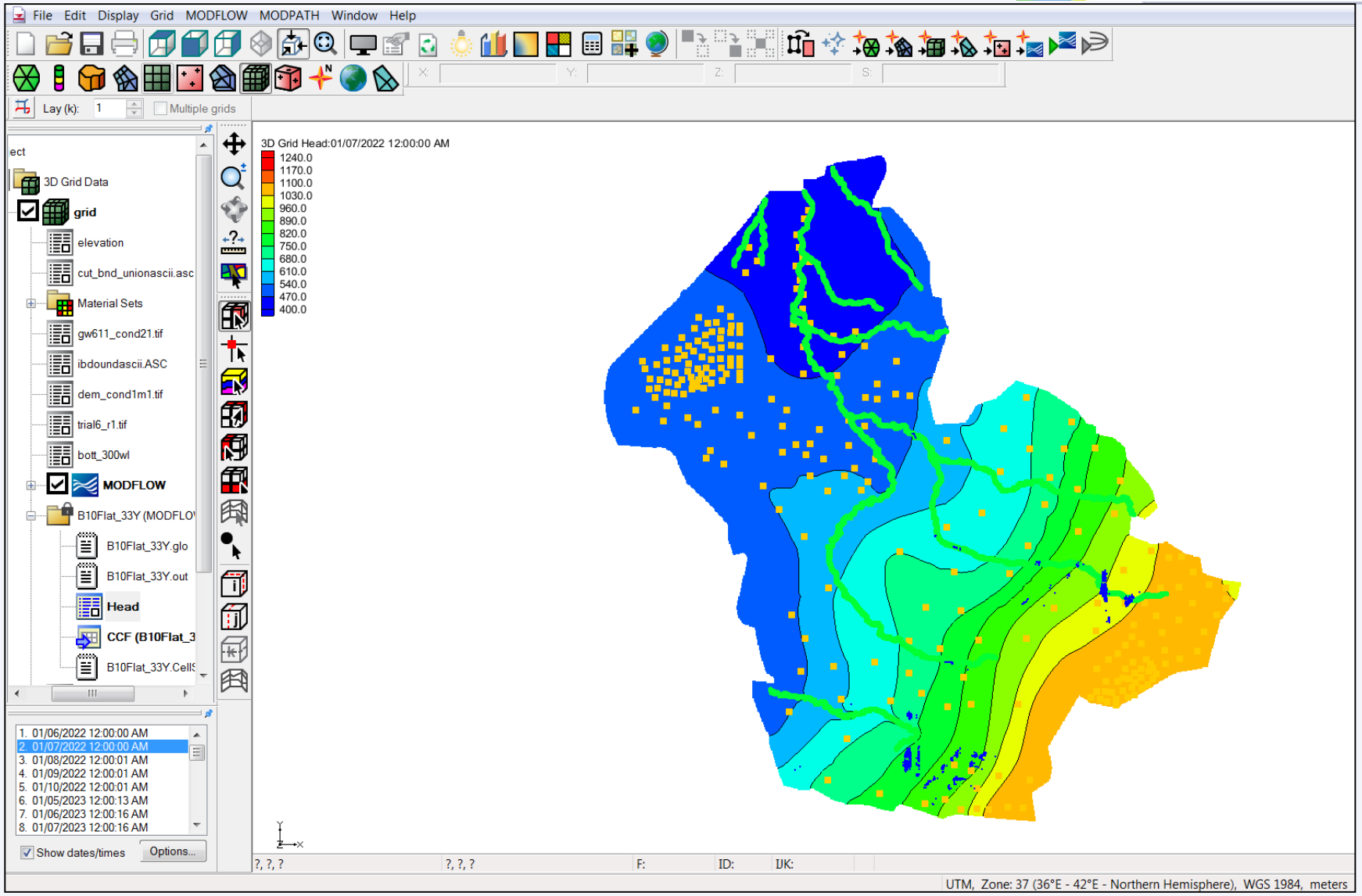

Investigated Scenarios

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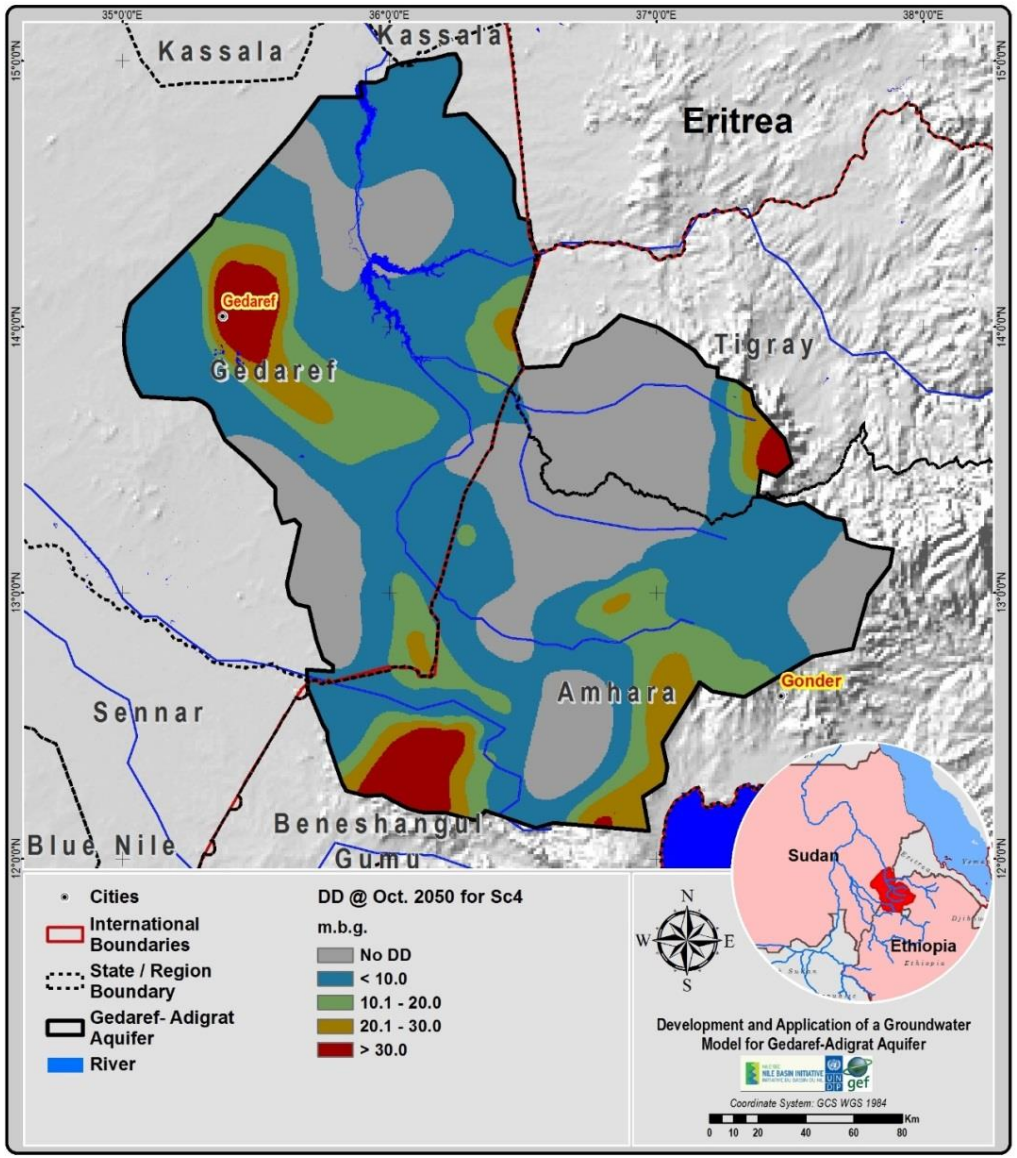
Four scenarios for the management of the aquifer up to year 2050 were investigated.

- **Scenario 1 (SC1): Baseline scenario with the current pumping and recharge rates.**
- **Scenario 2 (SC2): Current pumping rates plus recharge rates impacted by climate.**
- **Scenario 3 (SC3): Increase in pumping rates due to population growth and**
- **Scenario 4 (SC4) : Impact of climate change on recharge plus increase in pumping (worst case scenario)**


35°0'0"E
36°0'0"E
37°0'0"E
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Kassala
Kassala
Eritrea
Gedaref
Gedaref
Tigray
Amhara
Gonder
Sennar
Blue Nile
Beneshangul Gumu
Sudan
Ethiopia
Cities
International Boundaries
State / Region Boundary
Gedaref- Adigrat Aquifer
River
DD @ Oct. 2050 for Sc4
m.b.g.
No DD
< 10.0
10.1 - 20.0
20.1 - 30.0
> 30.0
N
W
E
S
Development and Application of a Groundwater Model for Gedaref-Adigrat Aquifer
Coordinate System: GCS WGS 1984
0 10 20 40 60 80
Km

Water Balance for Adegrat for SC4 at 2050

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Months	IN (MCM)		OUT (MCM)			Net (MCM)
	Recharge	From Gadaref	Wells	Baseflow	To Gadaref	
May	0.0	1.0	2.3	6.9	2.9	-11.2
June	13.3	0.9	2.3	6.8	2.8	2.4
July	53.2	1.0	2.3	8.5	2.9	40.5
August	48.1	1.0	2.3	8.8	2.9	35.0
September	6.1	0.9	2.3	7.4	2.8	-5.4
October - April	0.0	6.6	15.9	47.7	19.6	-68.6
Total	121.8	11.3	27.4	86.1	33.7	-7.2

Potentiality Map for Water Harvesting Structures

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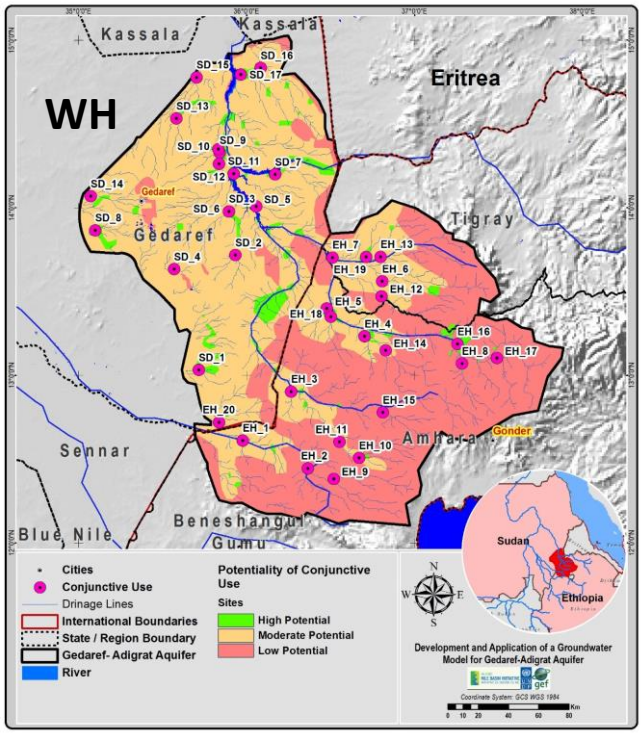
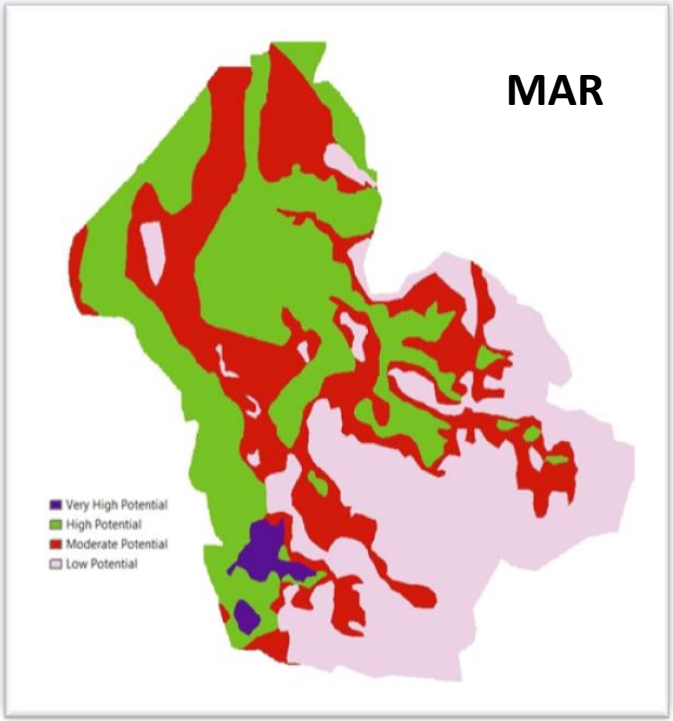
Thematic maps were used for the identification of rainwater harvesting potential areas for both artificial recharge and water supply structures (dams), which are Geology, rainfall, catchment slope, flow accumulation, drainage density, Lineament density, LU/ LC , Soil texture. Weight to the layers and rates to each category within the layers for study area were assigned





Conclusions and Recommendations

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- **There is a serious problem of lack of monitoring and data availability. Therefore the results should be considered as indicative model at this stage. Efforts should be made for more data collection through the establishment of a monitoring system.**
- **Climate change analysis shows that groundwater recharge will decrease by about 10% up to year 2050. It was found from the modelling results that this reduction in recharge has little or no impact on the groundwater levels in the aquifer. It can therefore be concluded that the impact of climate change on the aquifer levels up to 2050 is not significant.**
- **The current and future pumping rates in the aquifer are much smaller than the groundwater recharge. Therefore there is a big potential for the aquifer development to satisfy the increased demands in the future.**
- **There is also a very high outflow from the aquifer as base flow to rivers and streams running in the aquifer area. This outflow could be intercepted through water harvesting structures to contribute to meeting the demand both in Gedarif and Adegrat.**

- **Drawdown maps at 2050 for all scenarios showed that there are still large areas within the aquifer with little or no drawdown that can be developed either through increasing pumping from existing wells or introduction of additional wells.**
- **It is also noted that up to 2050, there will be no significant drawdown at the trans-boundary area even with the worst case scenario SC4 of increased pumping and recharge reduction due to climate change. However, care should be taken after 2050 since climate change may have a significant impact on recharge.**
- **The developed suitability map for water harvesting projects reveal that there is a high potential of using excess surface water in conjunction with groundwater through construction of small dams. 37 potential sites for small dams have been proposed in Gedarif and Adegrat areas.**

- **Also the potentiality map for managed aquifer recharge (MAR) showed that there is high potential for increasing groundwater recharge. Various artificial recharge techniques are available that could be utilized for this purpose.**
- **In summary, the Gedarif Adegrat aquifer still has great potentials for development. In view of the high population growth and frequent occurrence of droughts, conjunctive use of surface and groundwater is expected to play greater role in meeting the future demand for water.**
- **One of the great challenges that are facing proper management of the aquifer is lack of information due to absence of monitoring. Therefore there is a need for the eestablishment of a monitoring system with focus on trans-boundary monitoring as well as groundwater data and information exchange platform between Sudan and Ethiopia at national and local levels. There is also a need for introducing adequate administrative institutions for data collection and information dissemination.**

Areas of Priority

- Establishment of local and trans-boundary monitoring systems
- Identification of aquifer development plans in consultation with authorities
- Aquifer use is to be limited to supply of domestic water supply and animal watering
- Protection of the aquifer from contamination (agricultural and mining activities)
- Establishment of a groundwater data and information exchange platform between Sudan and Ethiopia at national and local levels.
- Introducing adequate administrative institutions for data collection and information dissemination.
- Field work for more data collection for adequate model calibration.
- Training on GMS modelling and recalibration and use of the model for analysis of more scenarios. National experts should work together on this to ensure sustainability.
- Identification of priority areas for projects by authorities on both sides.


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THANK YOU!