Ministry of Water, Energy & Minerals

ZAWA
Zanzibar Water Authority

RAPID ASSESSMENT OF ZANZIBAR GROUNDWATER RESOURCES

A SUMMARY REPORT

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GROUNDWATER MANAGEMENT INSTITUTE

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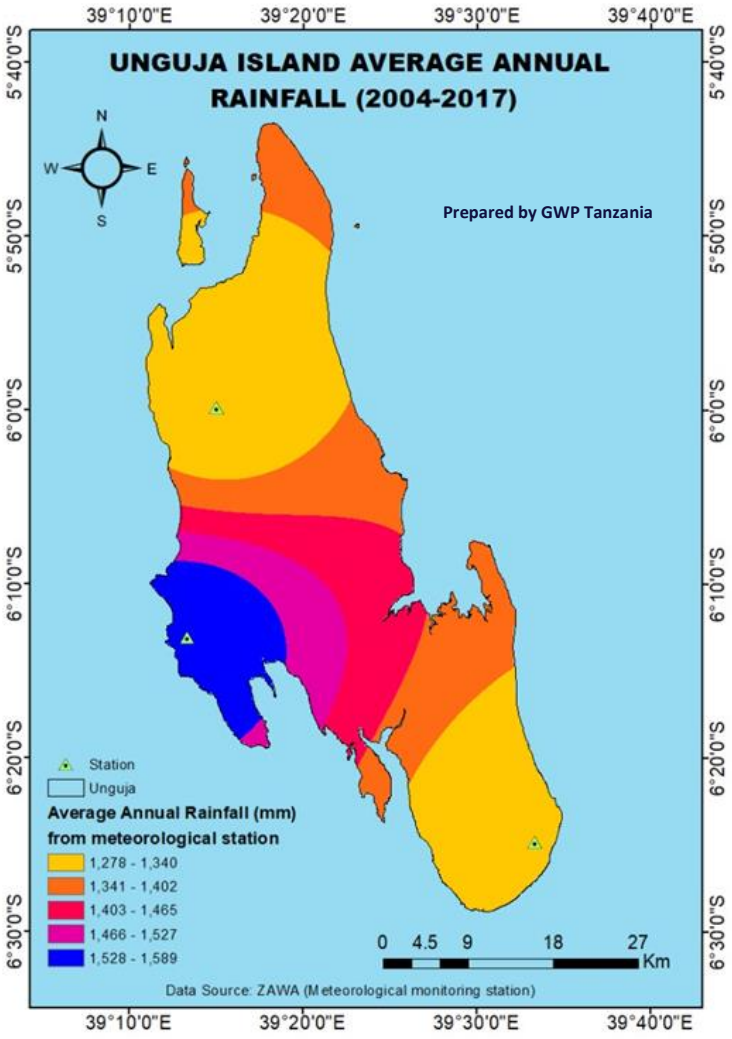
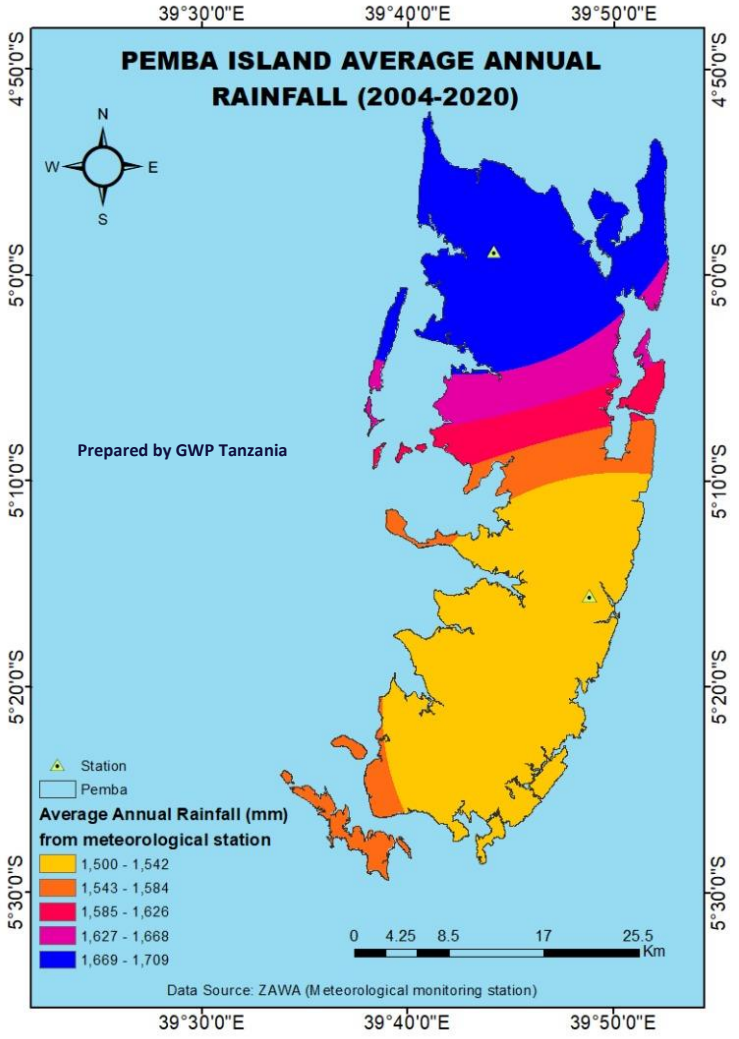
ZANZIBAR WATER RESOURCES

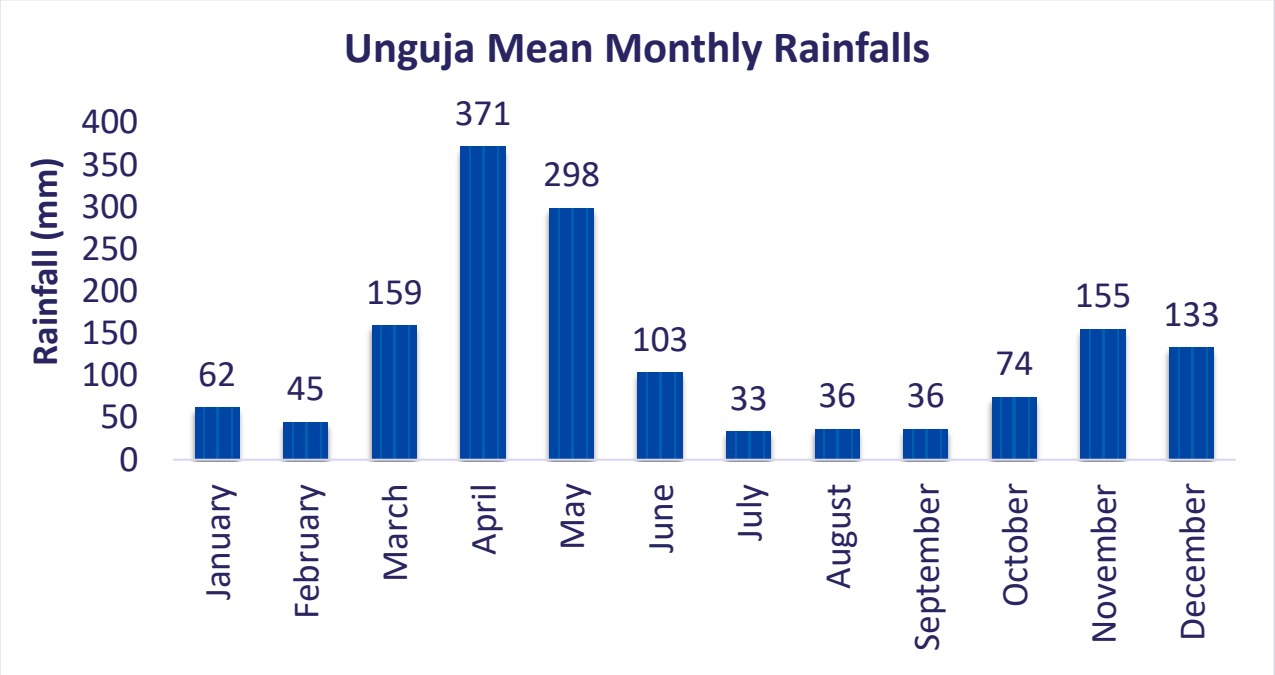
RAINFALL CHARACTERISTICS

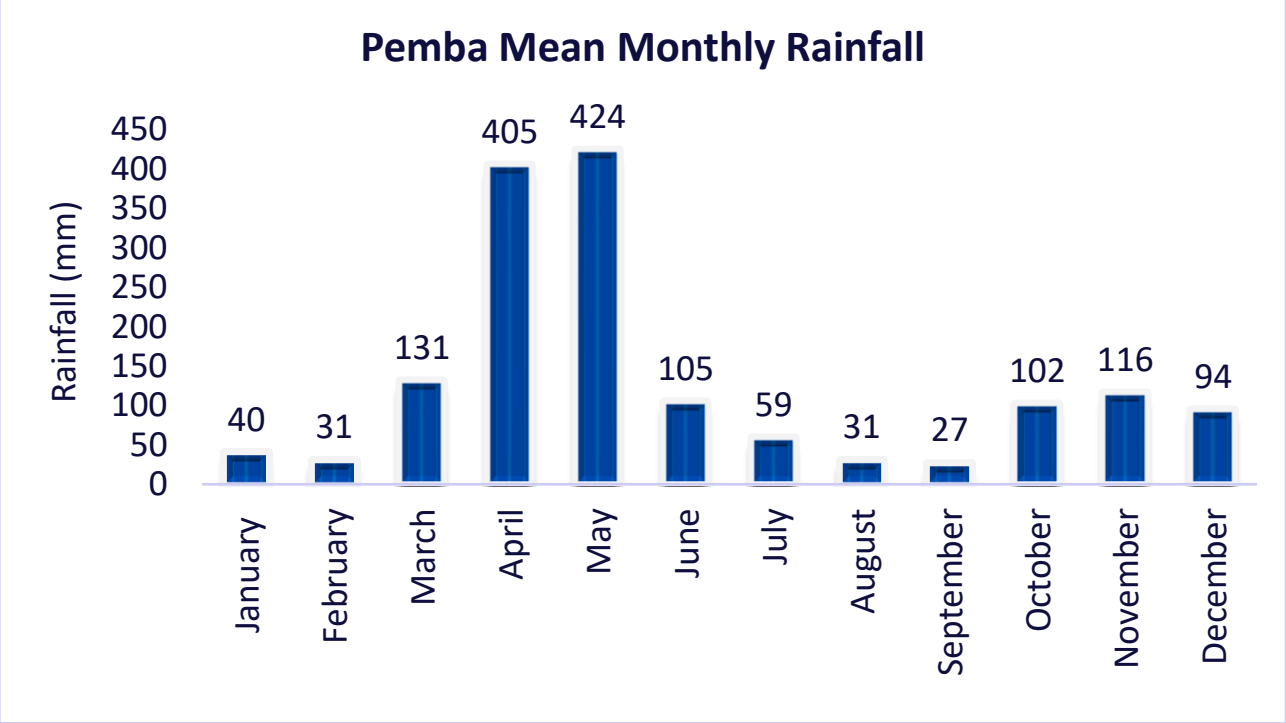
Seasonal rainfall variations in both Pemba and Unguja indicate bimodal characteristics with two distinct rainfall seasons. The heavy Masika rainfall season spanning from March to May; followed by a dry and cool season from June to September, and eventually the second light (Vuli) rainfall season from October to December. According to recent data provided, the average total annual rainfall in Unguja is 1506 and 1560mm in Pemba.





HYDRO-CLIMATIC CHARACTERISTICS

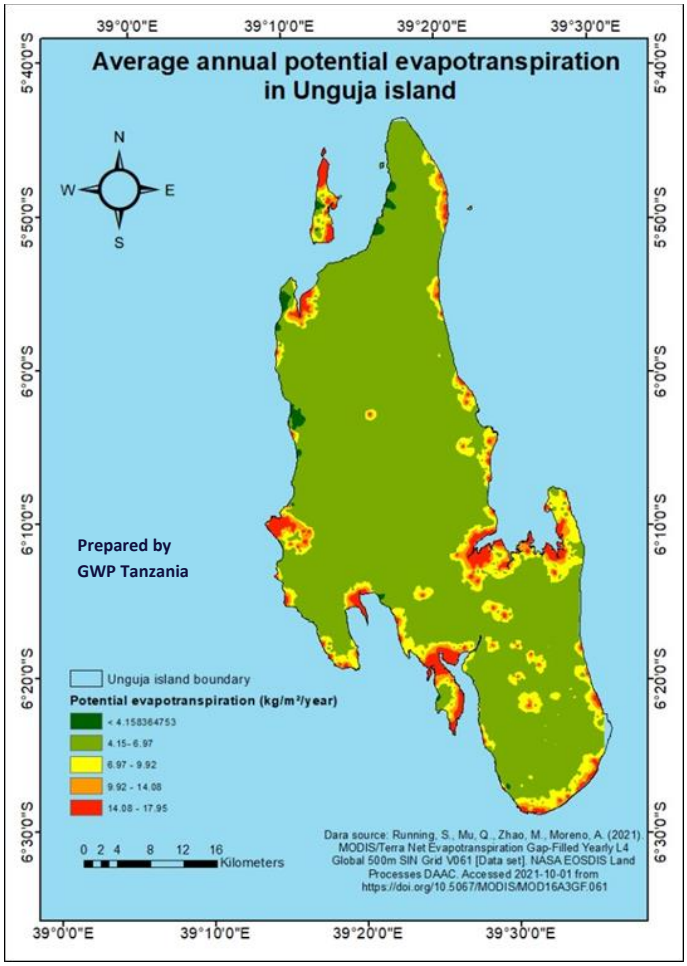


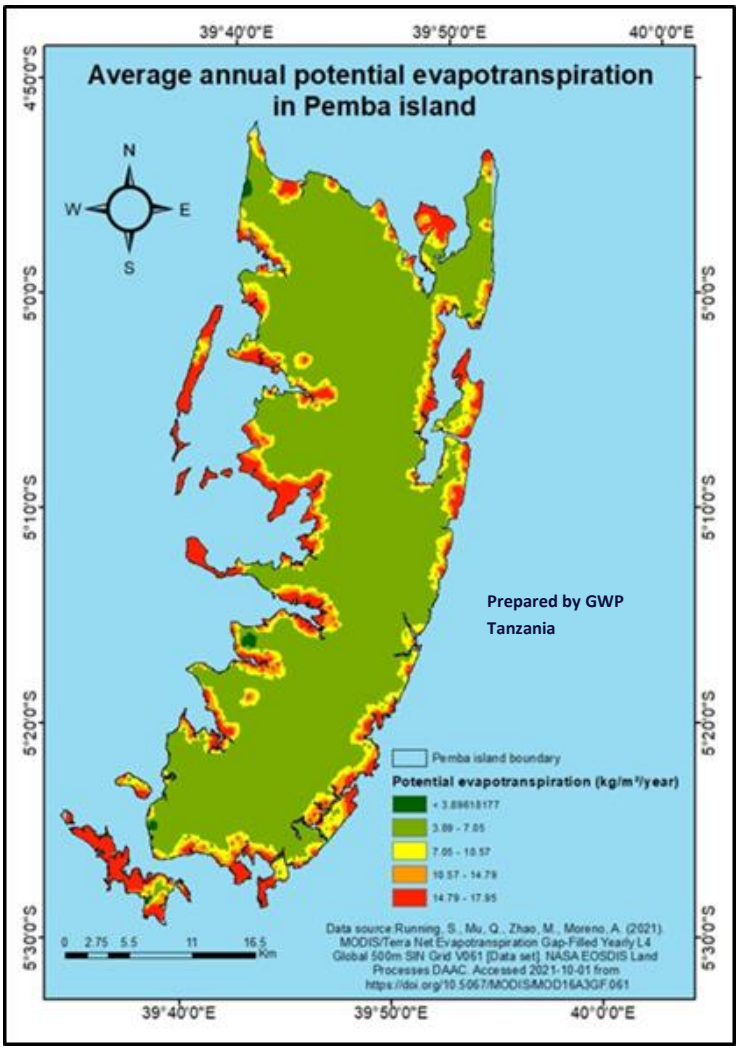


HYDRO-CLIMATIC CHARACTERISTICS

EVAPOTRANSPIRATION

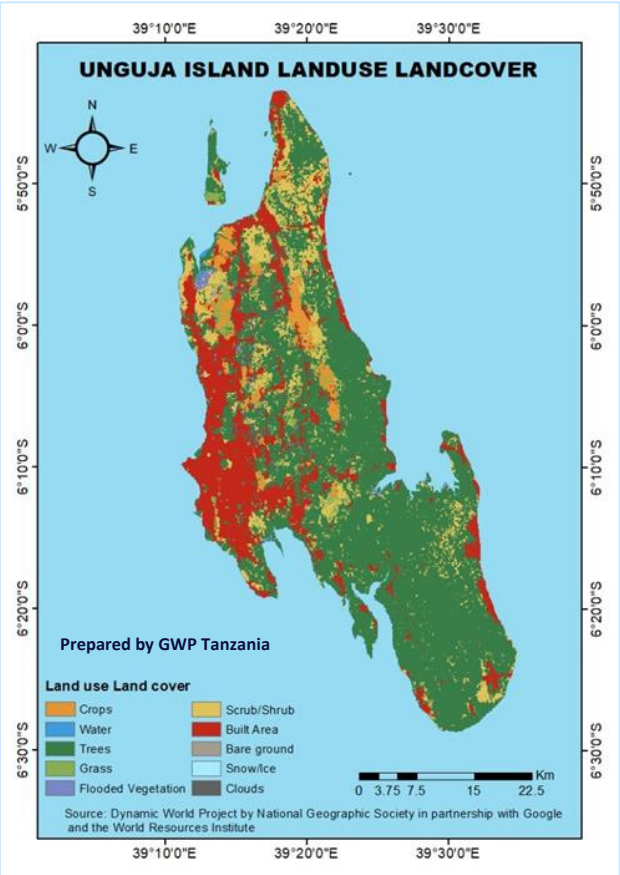
Evapotranspiration was derived from the from global MODIS ET (MOD16), product, with a resolution of 1Km.

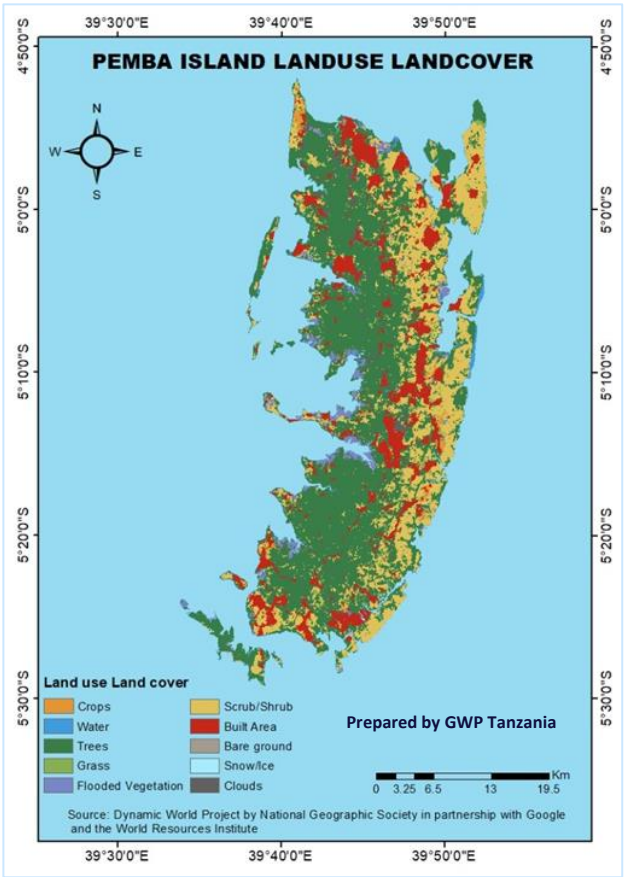


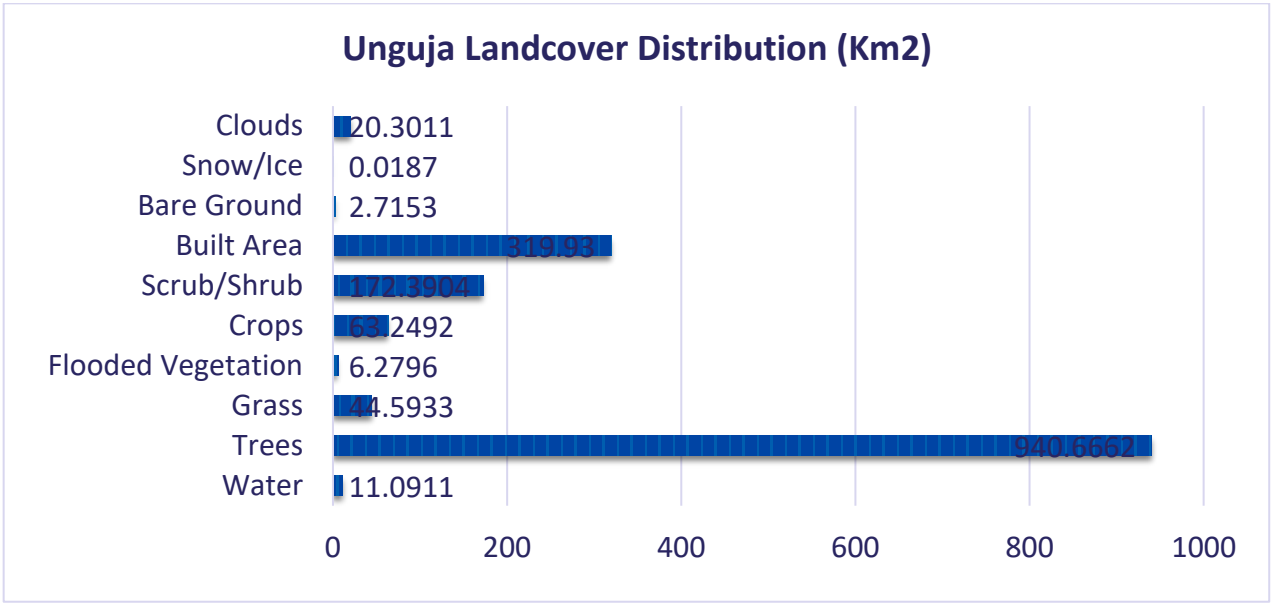


Evapotranspiration is relatively low due to large number of high vegetation.

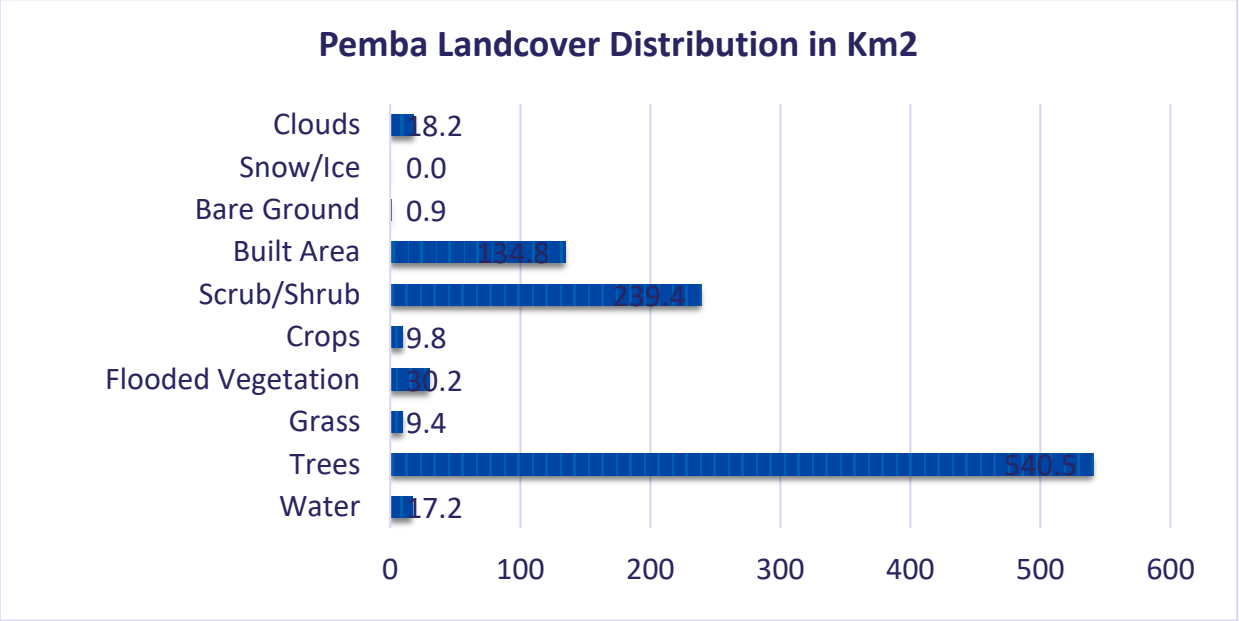
LAND COVER CHARACTERISTICS







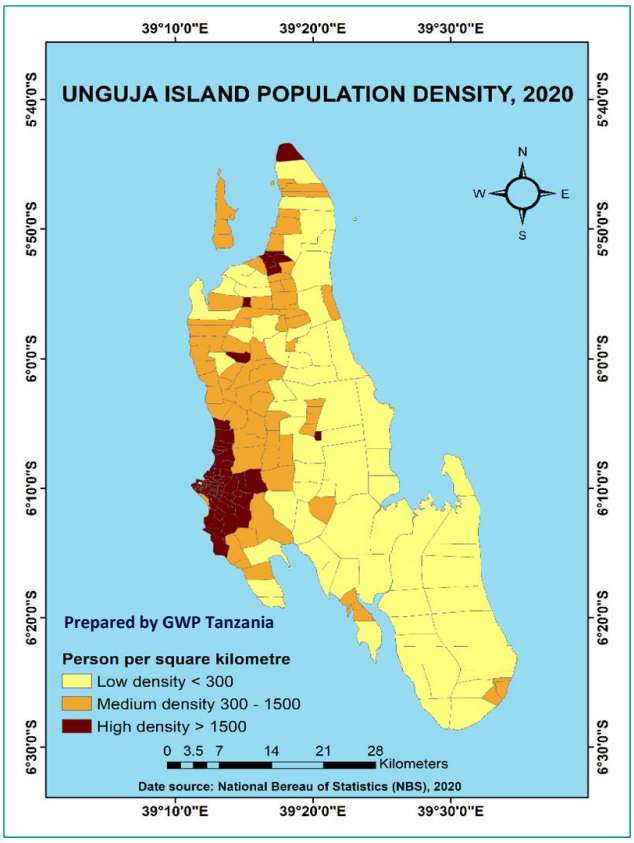
LAND COVER CHARACTERISTICS

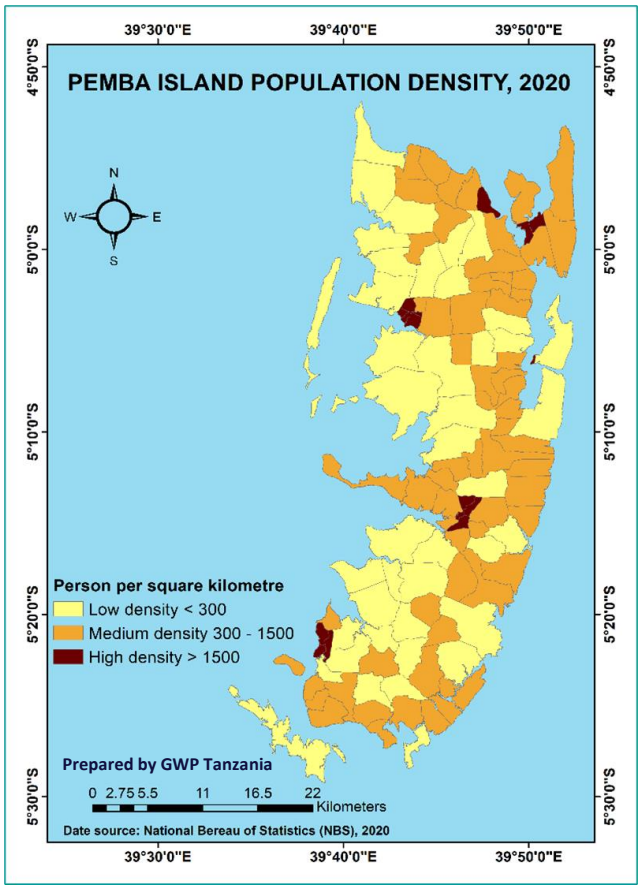


The greater part of Unguja and Zanzibar still lies pristine with forest and tree plantations. Natural forest reserves include Jozani forest and Masangini forest in unguja and Ngezi forest reserve in Pemba. Zanzibar main economic activity is agriculture. This may not be well represented in the figures above due to the fact that, the nature of plantation is commercial and small-scale forest plantations. Major tree plantations in both islands are cloves, cinnamon, and other spices as well as coconut palm trees, classified in this landcover mapping as trees. Unguja and Pemba is therefore largely covered by trees as the mapping indicates.

Urban Built-up areas are concentrated on the Urban west region of Unguja island and relatively medium concentrated in other parts of the islands. Shrub/Scrubs land covers also forms a large part of the island as these are sometimes utilized for shifting cultivation.

POPULATION & WATER DEMAND

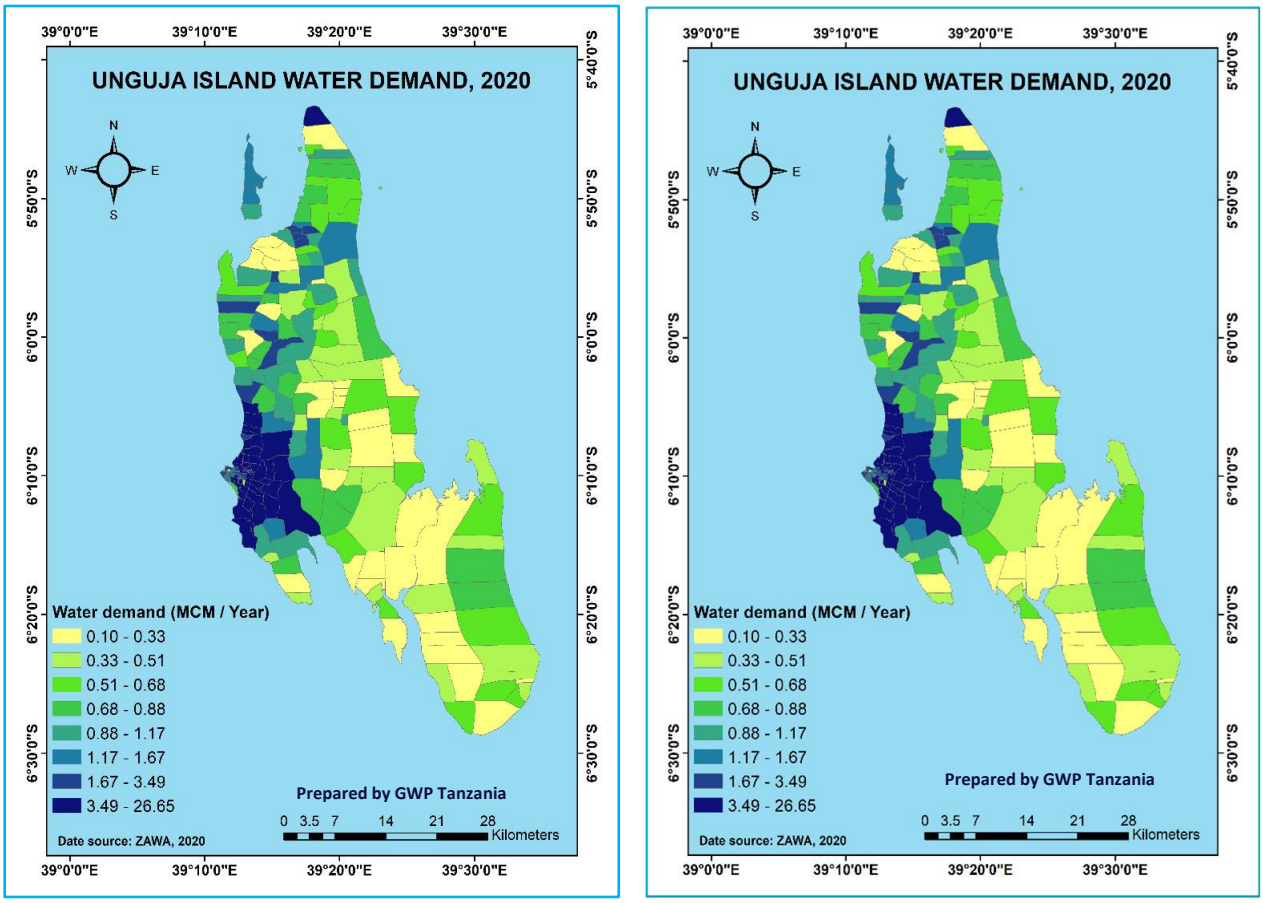




Zanzibar Population by 2012 was 1,303,569 as per 2012 Tanzania Population and Housing Census while the population growth rate was 2.8% per annum. However, 2019 estimates show that population density has already increased from 530 person/sq.km in 2012 to 603 person/km^2.

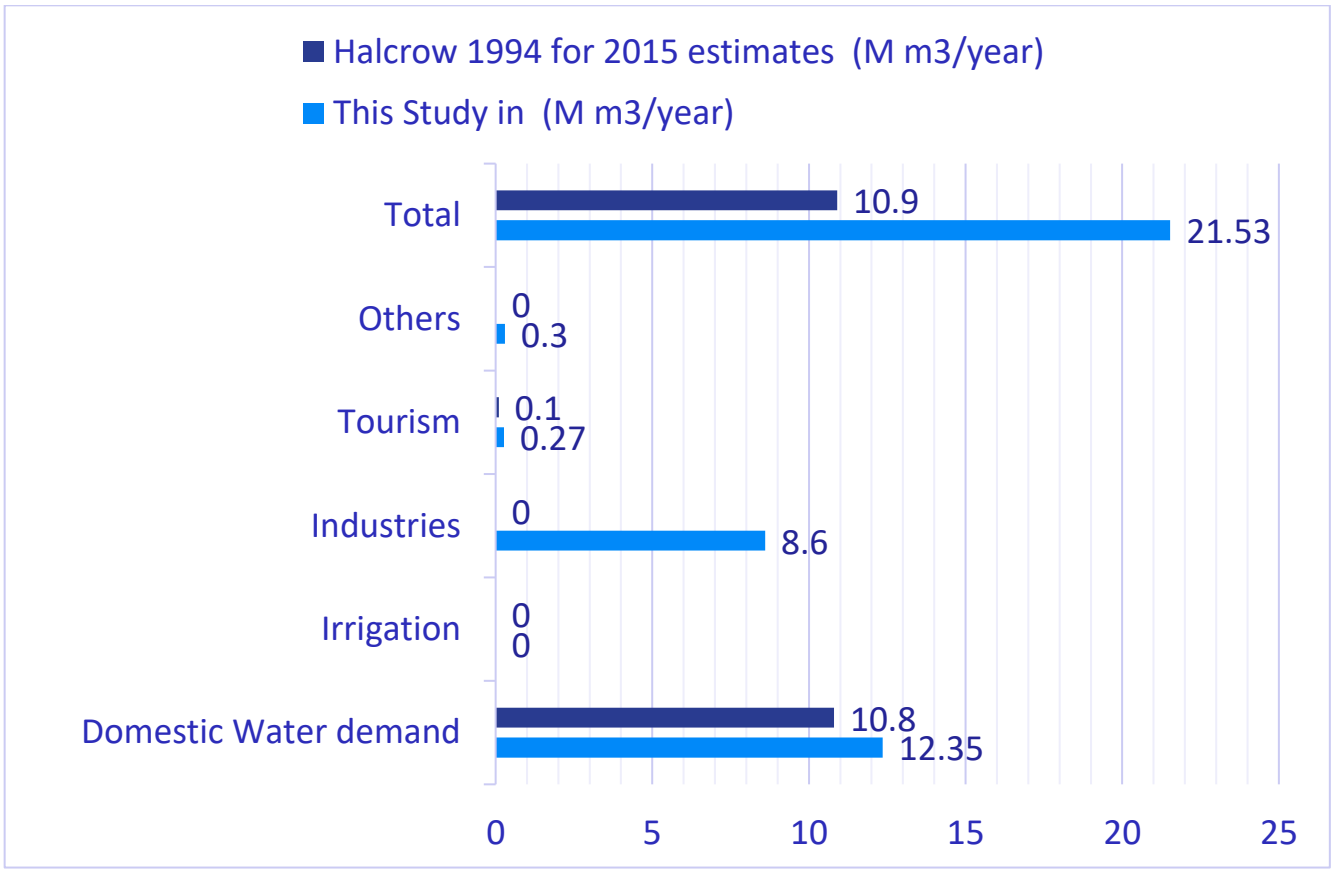
According to Zanzibar Statistical Abstract 2019, Office of the Chief Government Statistician, it is also estimated that half of the Zanzibar population currently live in Mjini Magharibi.

POPULATION & WATER DEMAND

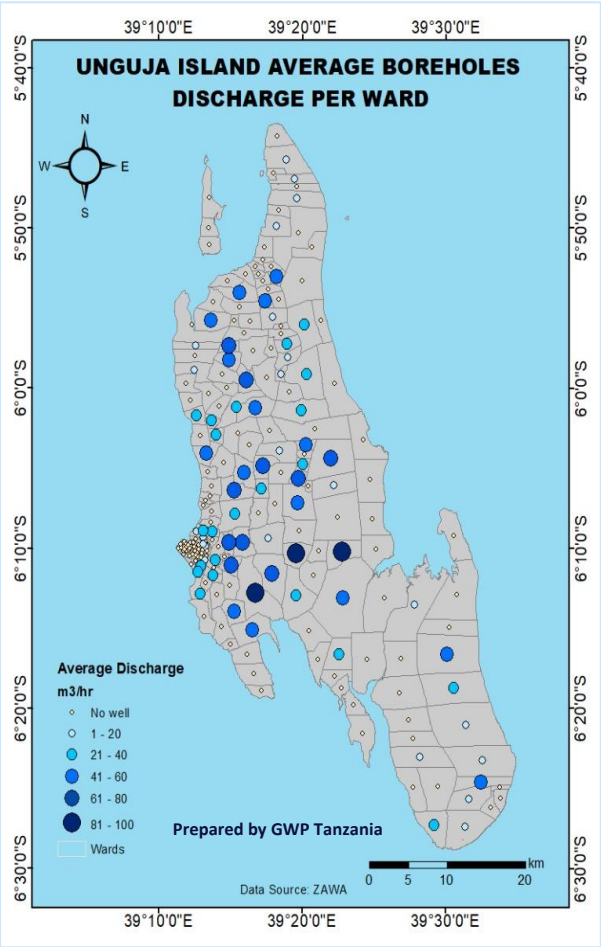


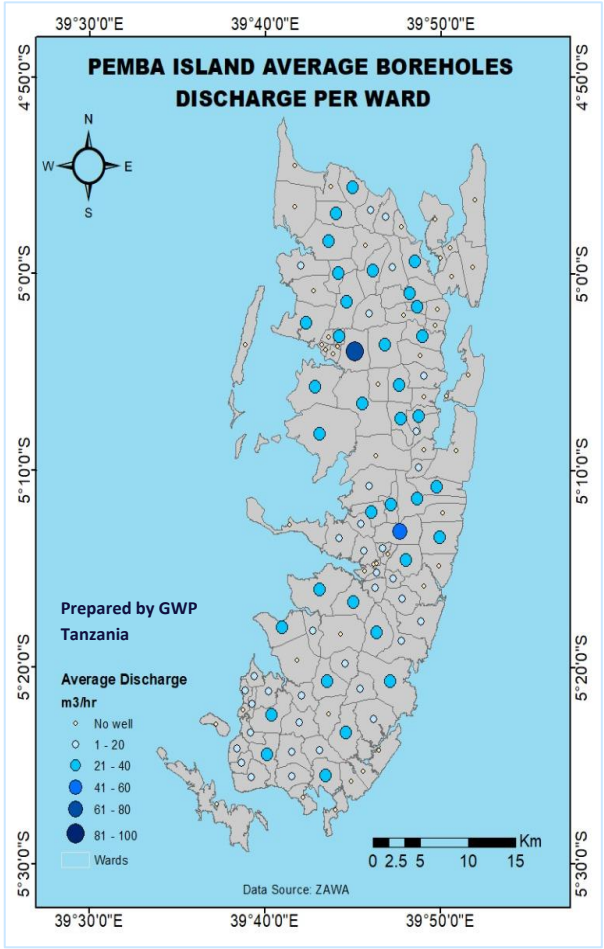
In Unguja Urban west region had the largest water demand and some wards such as Nungwi ward in the North region. The South region had relatively moderate water demand largely concentrated in the coastal wards of Paje. In Pemba, a few wards were characterized as high-density wards that included Utaani ward in Wete district North region and Chachani in Chakechake district south region.

POPULATION & WATER DEMAND



GROUNDWATER DISCHARGE





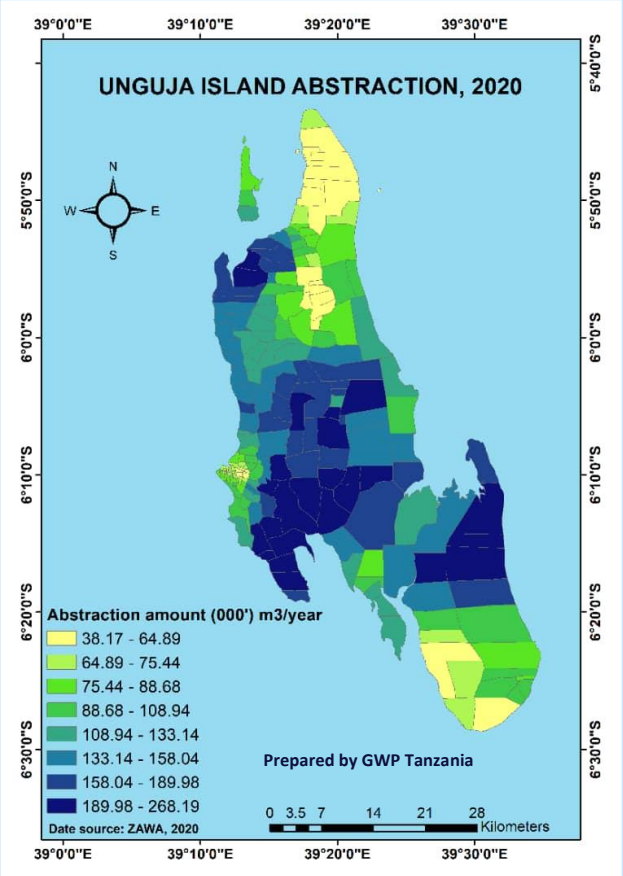
Currently Unguja relies on

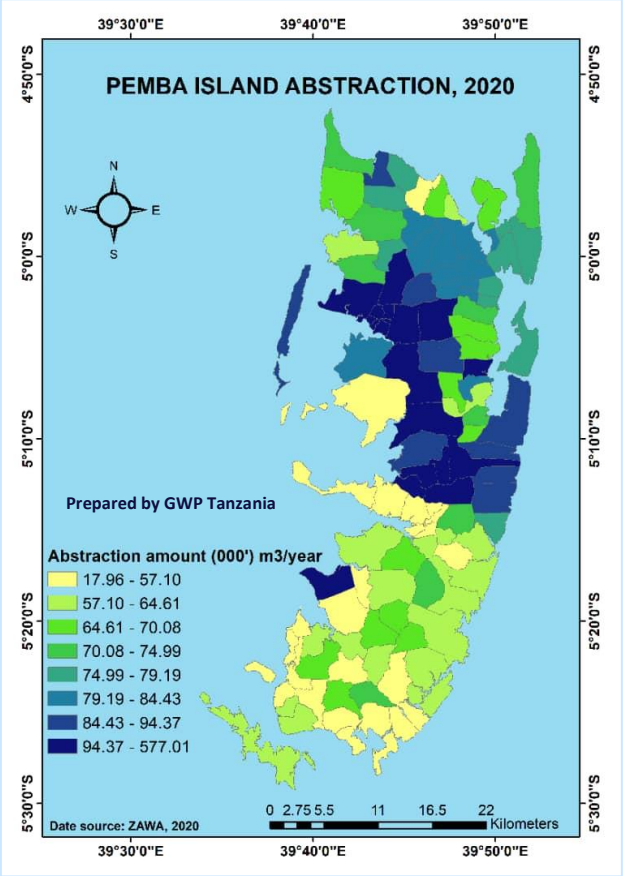
- Two (2) springs,
- Eight (8) caves and
- One hundred and seventy-nine (179) boreholes

Pemba gets its water from

- one hundred and forty-four (144) production boreholes and t
- Two (2) springs.

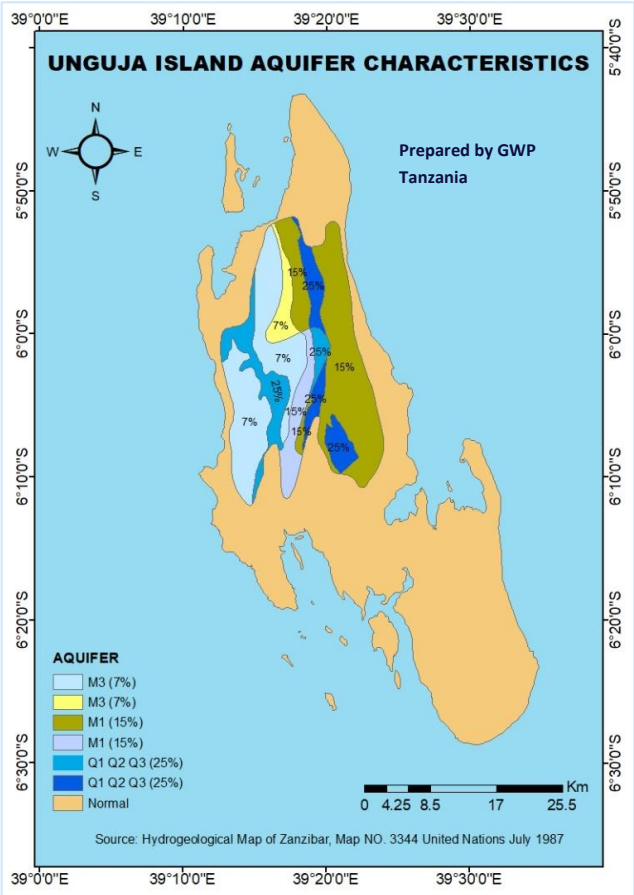
GROUNDWATER ABSTRACTIONS

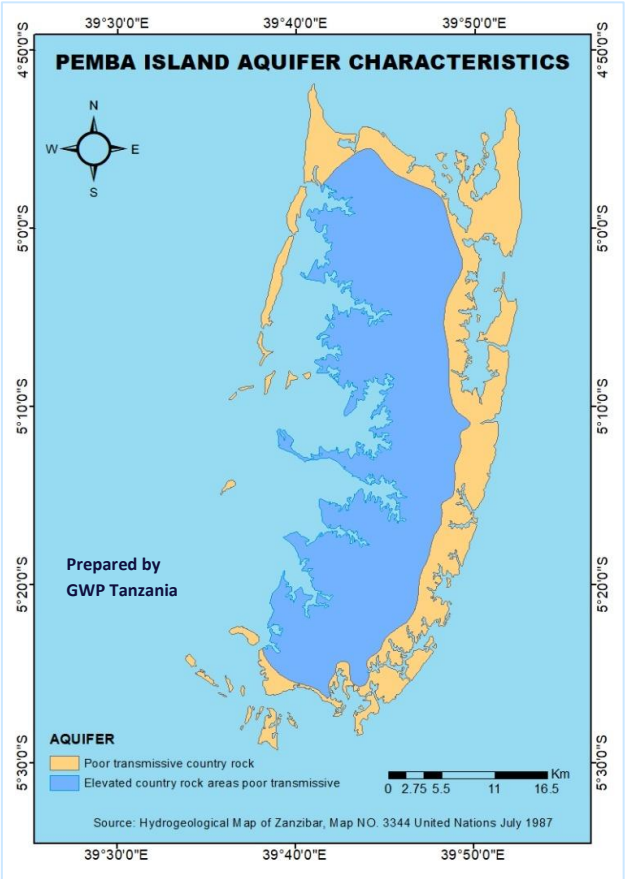




Variations in groundwater abstractions across Unguja and Pemba

ZANZIBAR AQUIFER CHARACTERISTICS





UNGUJA AQUIFERS

1. The vastest aquifer Coralline Reef limestone is the Quaternary limestone (Q2) Occupies (67%)
    - Q2 is also where most cave wells are located.
2. The dense crystalline reef Miocene Limestone (M1)
    - M1 supplies water to springs and lakes at Bambi.
3. Q3 is Main aquifer in the corridor zones.

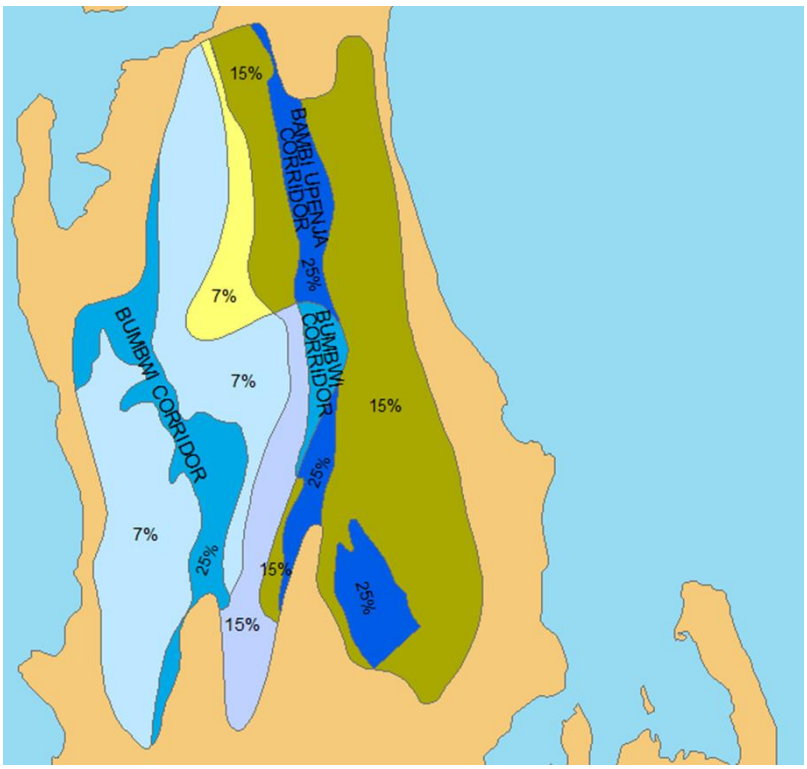
- The coral rag limestone is karstic and except for the caves in it, they are thin and of no hydrogeological significance

THE ORRIDOR ZONE AQUIFERS

A significant feature of Unguja Geology is the ‘geological corridors’ (shoestring sand channels), which are a thick sand sediments deposits of Rufiji meandering channels.

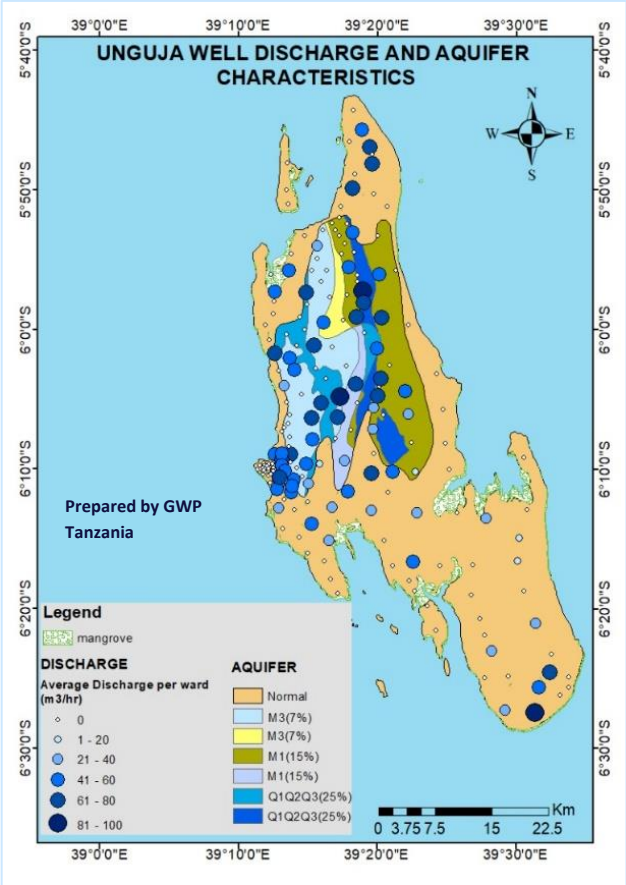
These corridor channel zones are notable for their high-water potential as indicated in the figure above as.

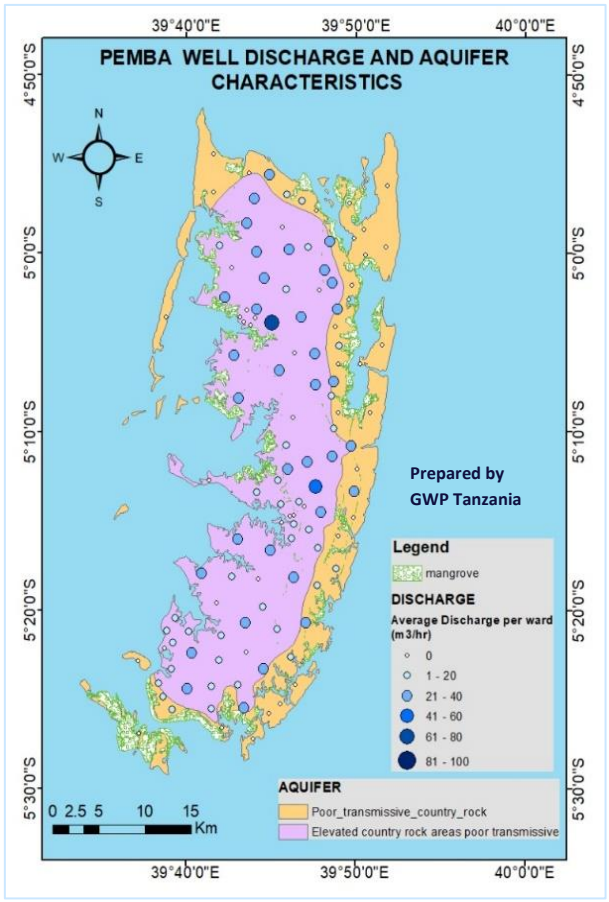
- Mahonda - Bumbwi - Mwera Valley (Bumbwi Corridor);
- Kisima Mchanga Corridor,
- Cheju-Bambi-Upenja-Kibokwa-chaani areas (Bambi-Upenja Corridor).
- Other corridors are located around the coast at Kiwani Bays, Kombeni Bay, Pete Inlets, Chwaka Bay



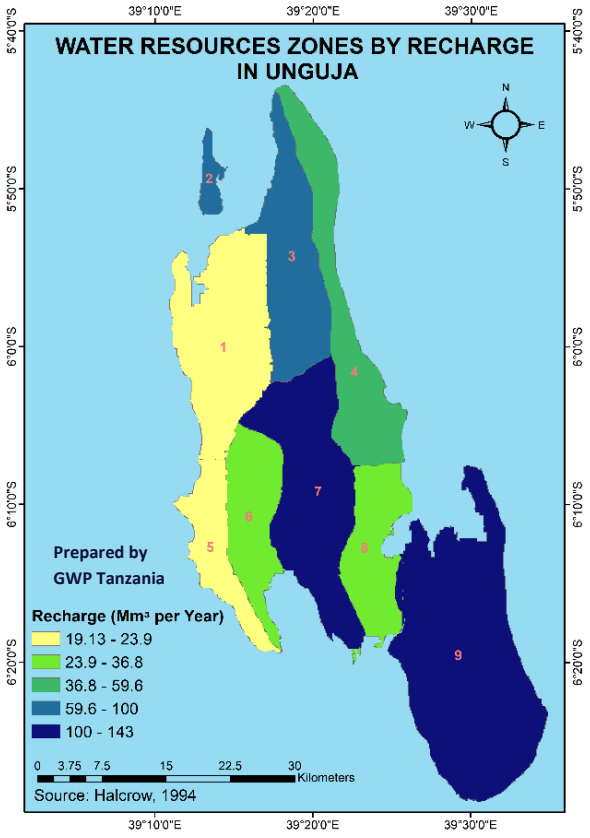
BOREHOLE LOCATION

BOREHOLE LOCATION AS PER AQUIFER CHARACTERISTICS





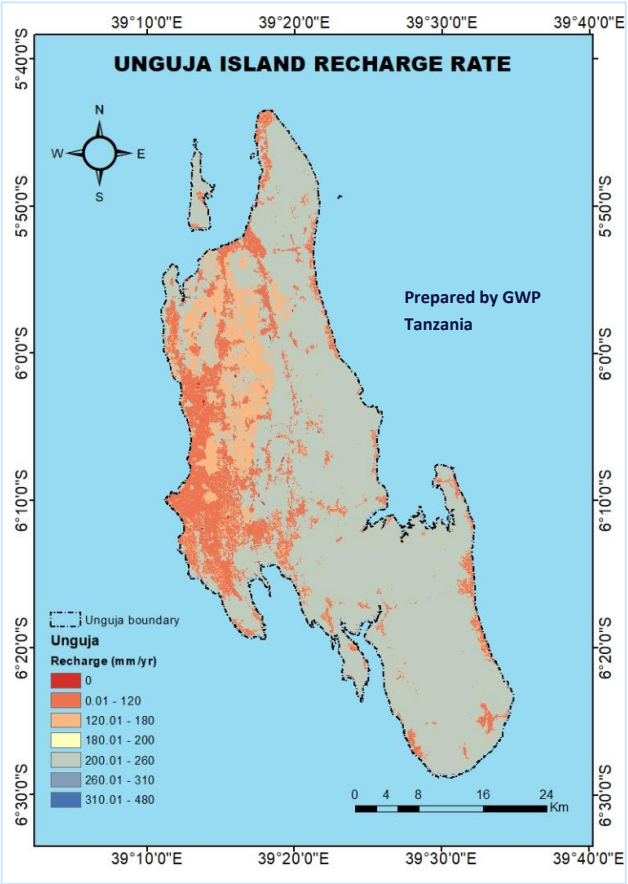
ANNUAL RECHARGE VOLUME

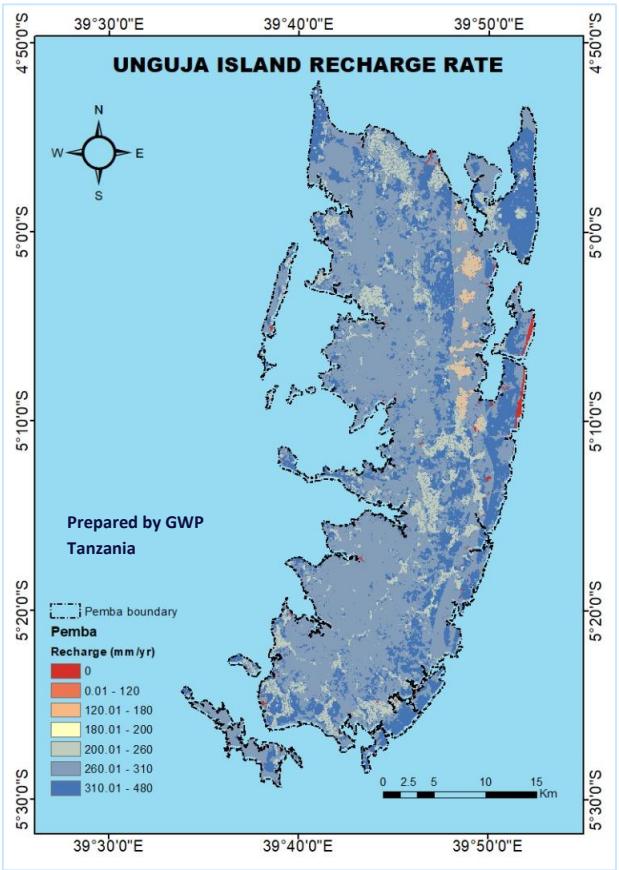


Resource Zone (Unguja)	Groundwater Recharge 1994 Halcrow (Well Hydrograph Method)
1	23.99
2	68.53
3	72.4
4	59.64
5	19.13
6	35.27
7	130
8	36.75
9	143
Total	564.73

Notably, the recharge volume for corridor zone were estimated as indicated in the table below. The UNDP (1987) aquifer storages were used to derive the volumes indicated. However, it was not possible to do the same of the rest of the area since the aquifer extent are not yet known.

ANNUAL RECHARGE VOLUME

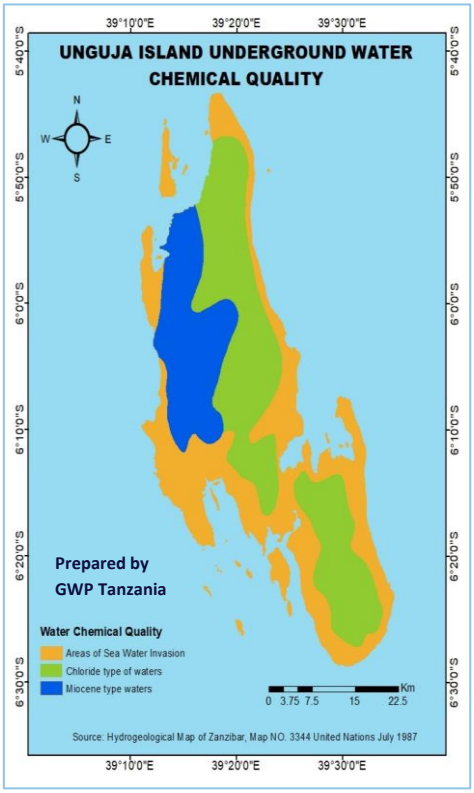


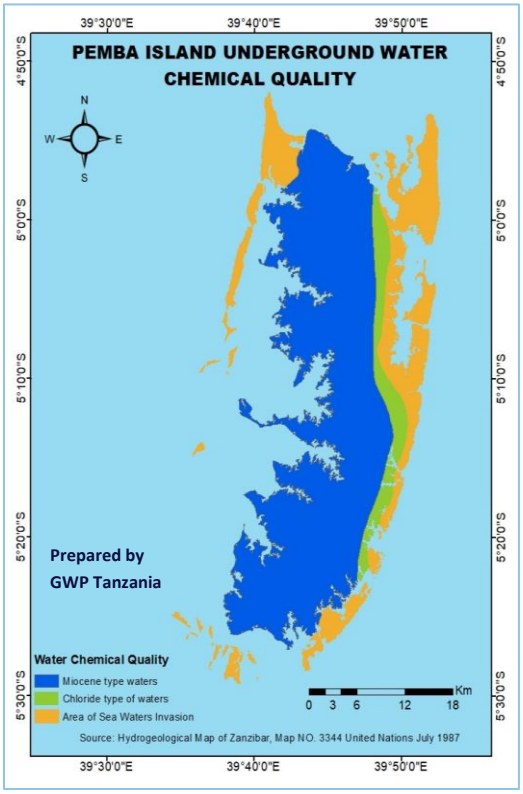


Unguja Corridor Zone	Johnson 1983 (Mm^3/yr)	Halcrow 1994 (well Hydrograph Method) (Mm^3/yr)	FINNIDA 1991 (Pump Tests) (Mm^3/yr)
Overall	348	422	
West Corridor	102	104	
East Corridor	170	202	
Remaining Areas	76	116	
Total	**696**	**844**	**600**

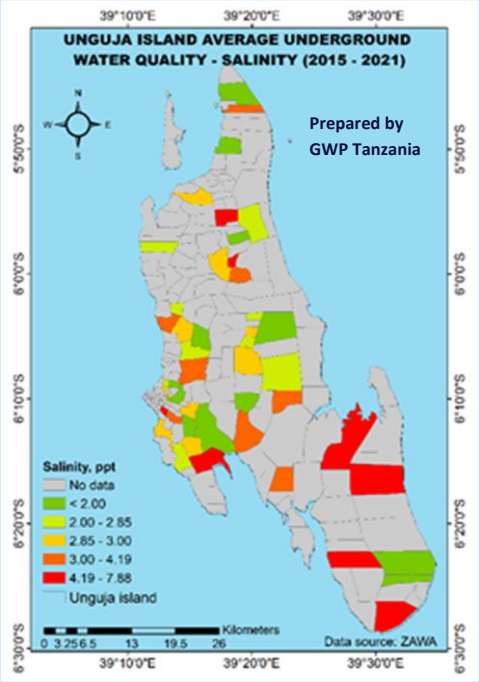
GROUNDWATER QUALITY

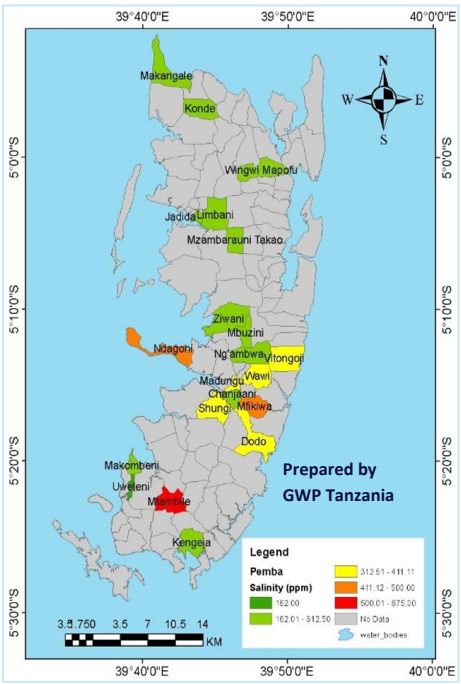
GROUNDWATER CHEMISTRY (DIGITIZED FROM UN, 1987)



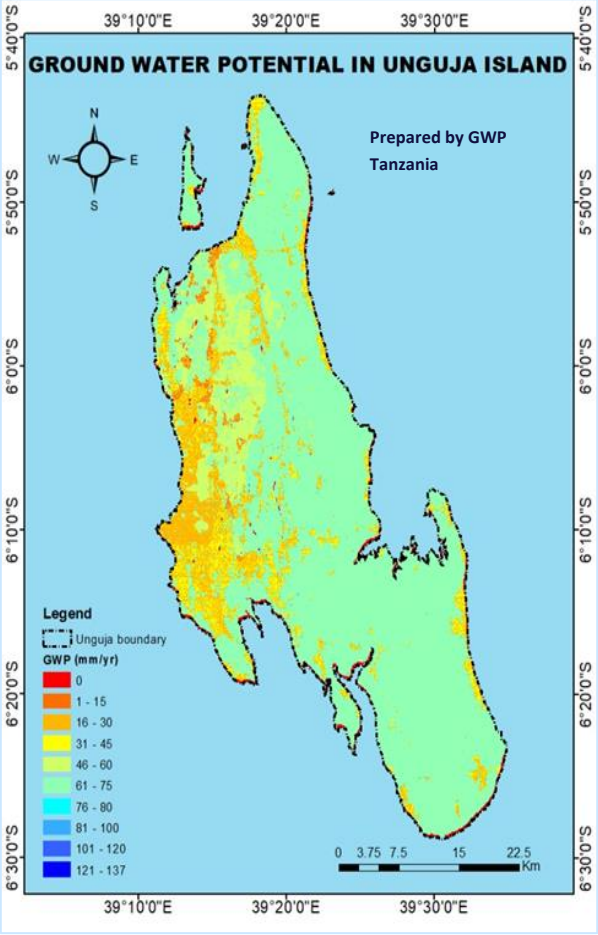


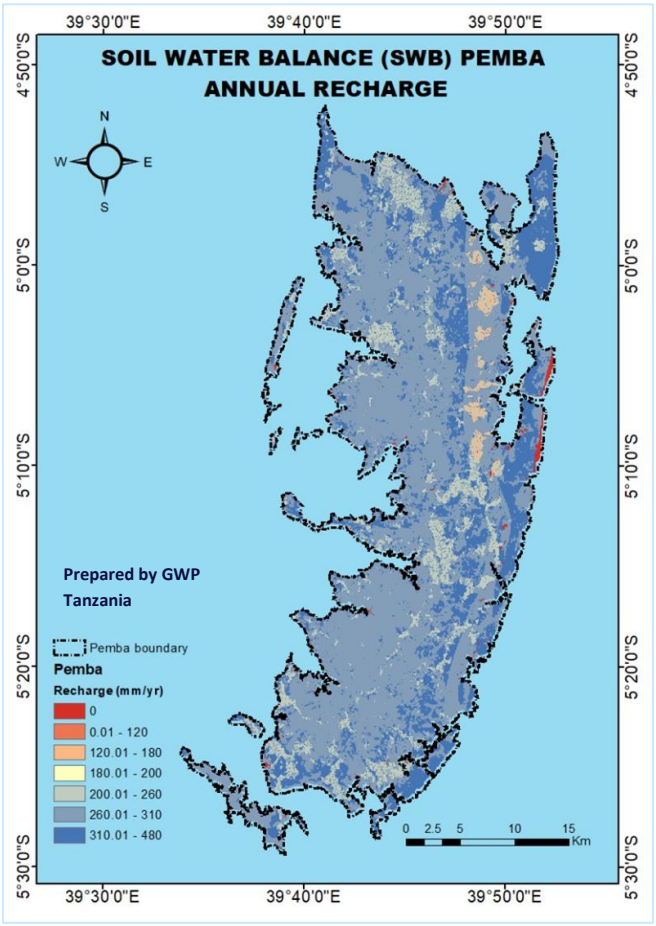
GROUNDWATER SALINITY *(This study)*





GROUNDWATER POTENTIAL





	Annual GW Potential Mm^3/yr	Daily potential Mm^3/day
Bumbwi Corridor	4.44	0.0122
Bambi Upenja corridor	4.52	0.0124
Kisima Mchanga	3.47	0.0087
	12.43	**0.0333**

CONCLUSION

- Past studies showed that the available groundwater resources in Zanzibar was to sufficient to cater for need up until 2015. However, accurate estimation of the water resources is limited by data inadequacy i.e., hydrometeorological, hydrogeological and abstractions amounts.
- The demand for water is approximately 88.24 Mm^3/year for Unguja and 21.43 Mm^3/year, while the major aquifers potential is less than 13 Mm^3/year. Indicative abstraction amounts and locations were mapped showing high variations across both Unguja and Pemba. There are indications of excessive abstractions in some locations, as expressed during personal interviews and indicated in high salinity levels mapped in this study.
- The increased in drying wells and reduction of the well yield in some of the public wells located most especially in urban areas of the islands indicates the reduction groundwater in the aquifers. Moreover salt water intrusion in the aquifers of the coastal areas of the Islands threaten to degrade the water quality of the Islands
- The threat of climate change in increasing sea water levels that have a greater potential to reduce both the quality and quantity of groundwater in Zanzibar Islands
- Population pressure is noted in few locations that are also encroaching high groundwater potential zones and recharge zones, which is a threat to future quantity and quality of the wells in Unguja.
- Pemba has poor groundwater aquifers that limit more groundwater development in this area.

RECOMMENDATIONS

1. There is a need for a thorough groundwater exploration studies to improve understanding of aquifer extents, availability, accessibility, and distribution.
2. Collect well logs of ongoing drilling of boreholes across Unguja and Pemba
3. Undertake Marine geo-electromagnetic studies purposely for delineation of freshwater extension of the coastal sub-aquifers beneath the sea.
4. Install observation wells in order to monitor groundwater use and replenishment trends.
5. Establishment of data repository for proper storage and sharing of data of groundwater.
6. Tracer studies are to be undertaken to thoroughly map the karst system of the Islands i.e., to identify and map the recharge areas and zones.
7. Pemba should aggressively opt for rainwater harvesting due to high rainfall amounts but poor aquifers.
8. The need for development of IWRMD Plan for Unguja and Pemba that will bring different sectors together in planning for water resources.
9. Establishment of a National multi-sectoral Platform for Water Resources Management purposely to discuss threats and opportunities to different water users and stakeholders.