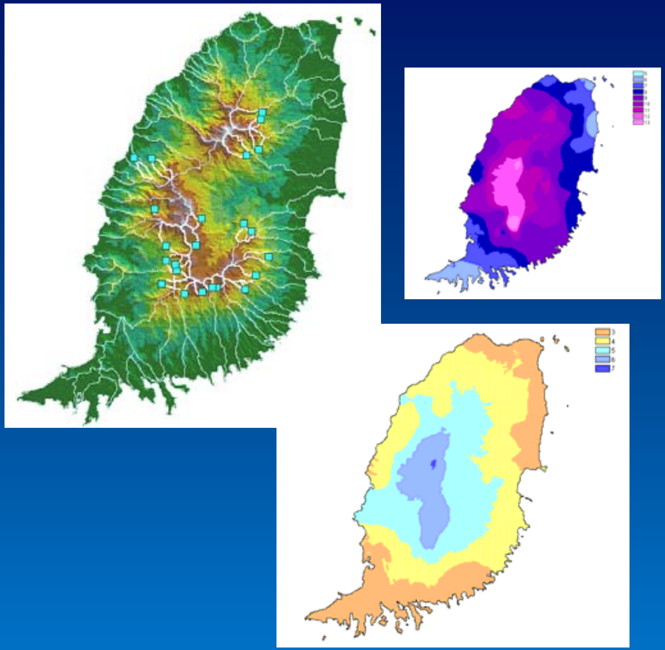
Promoting Rainwater Harvesting in Caribbean Small Island Developing States



Water Availability Mapping for Grenada

Preliminary findings

National Workshop

Pilot Project funded by
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Executed by
The Caribbean Environmental Health Institute
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Tropicana Hotel, Grenada

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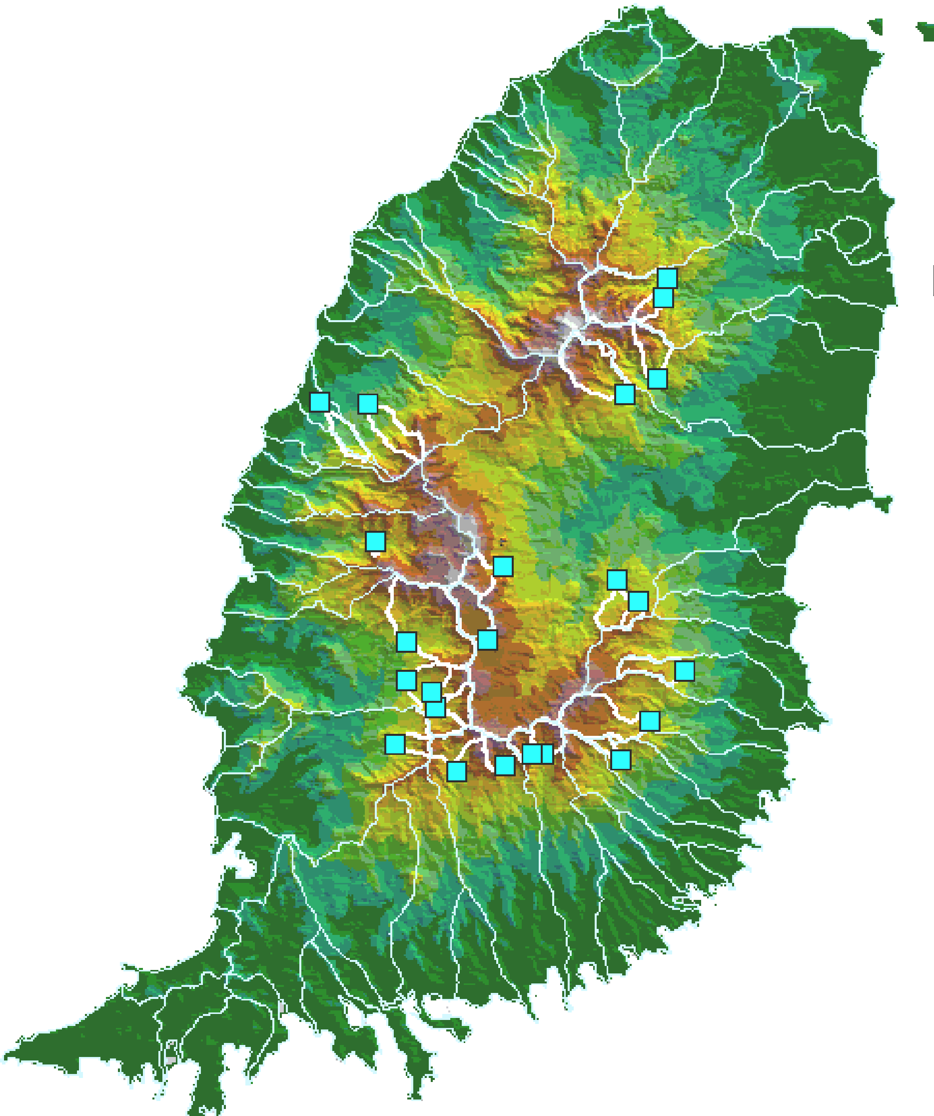
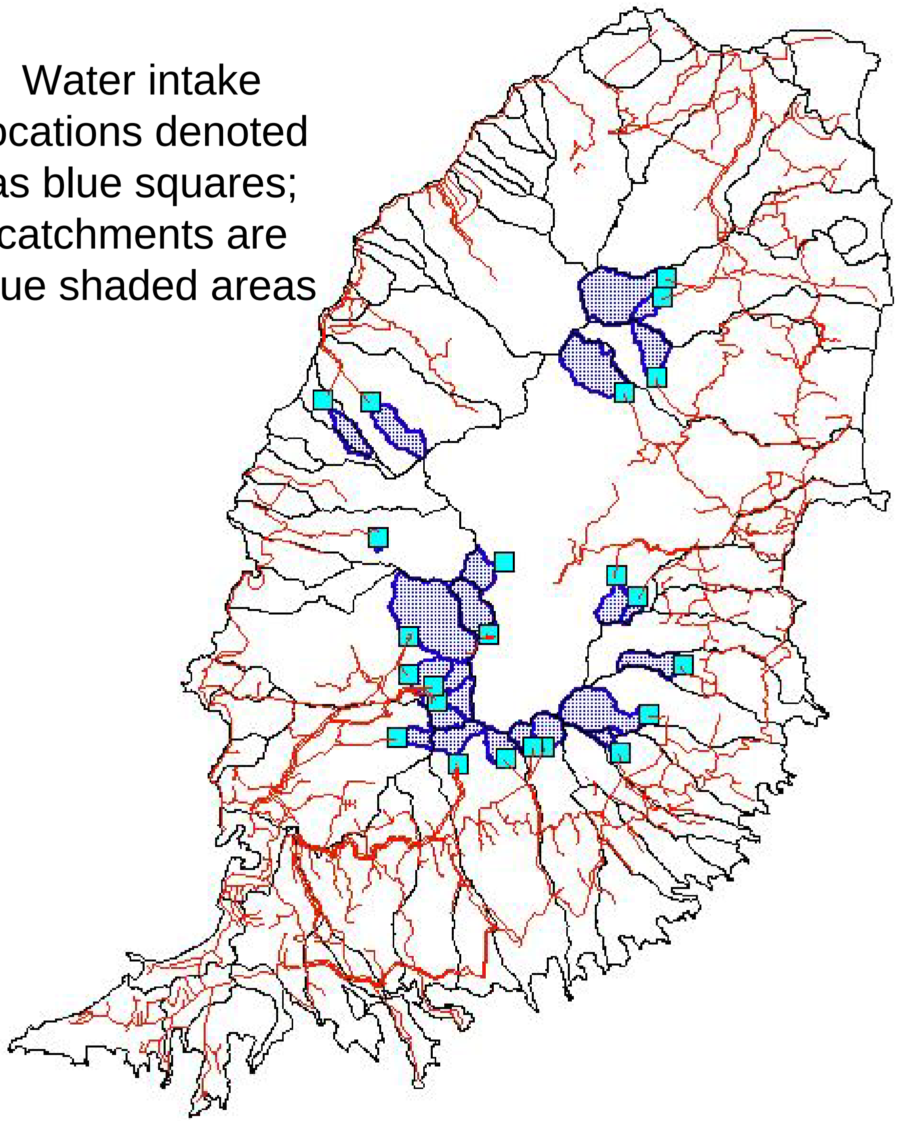
Procedural outline

- **Objective: map areas on mainland Grenada subjected to moisture deficit**
- Based on simplified water balance
  - Determine the depth of runoff from water catchment areas (areas upstream of NAWASA intakes)
- Three analytical steps
  1. Determine spatial variability in monthly rainfall
  2. Determine spatial variability in evapotranspiration (ET)
  3. Determine spatial variability in water deficit
- Catchments with low yield/runoff (during dry months) – downstream communities expected to experience shortfalls

Most catchments located at high elevations; high rainfall
Water yield is function of catchment area and effective rainfall (balance after ET)



Water intake locations denoted as blue squares; catchments are blue shaded areas



Procedure

- Water balance – partitioning of components of the hydrological cycle
- $P = R + ET + S$ (simplified)
  - P = rainfall
  - ET = evapotranspiration
  - S = storage
- In small island environments the storage component is negligible (relative to other components)
- Hence, after estimating losses to ET; remainder from precipitation input is runoff; available for use

Procedure

- STEP1: Rainfall spatial variability estimation
  - Interpolation method; means of extrapolating rainfall estimates over unsampled areas
  - In GIS, is automated procedure as alternative to conventional isohyetal (manual) method
  - Limitation: Does not account for elevational influences at unsampled locations; with conventional method one can approximate influence of elevated terrain

Procedure

- STEP2: Evapotranspiration spatial variability estimation
  - The FAO Penman-Monteith combination equation
  - FAO guidelines for computing crop water requirements (Allen et al., 1998)
  - Method recommended as the sole method for predicting ET_o; most closely estimates ET_o where data parameters are missing (FAO Irrigation and Drainage Paper 56)
  - Estimate for potential evapotranspiration is referenced from a well-watered grass surface

Procedure

FAO Penman-Monteith combination equation

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

ET_o = reference evapotranspiration (mm/day)
R_n = net radiation at crop surface (MJ/m²/day)
G = heat flux density to the soil (MJ/m²/day)
T = air temperature at 2 m height (°C)
u_2 = wind speed at 2 m height (m/s)
e_s = saturated vapor pressure (kPa)
e_a = actual vapour pressure (kPa)
e_s - e_a = saturation vapour pressure deficit (kPa)
Δ = slope of vapour pressure curve (kPa/°C)
γ = psychrometric constant (kPa/°C)

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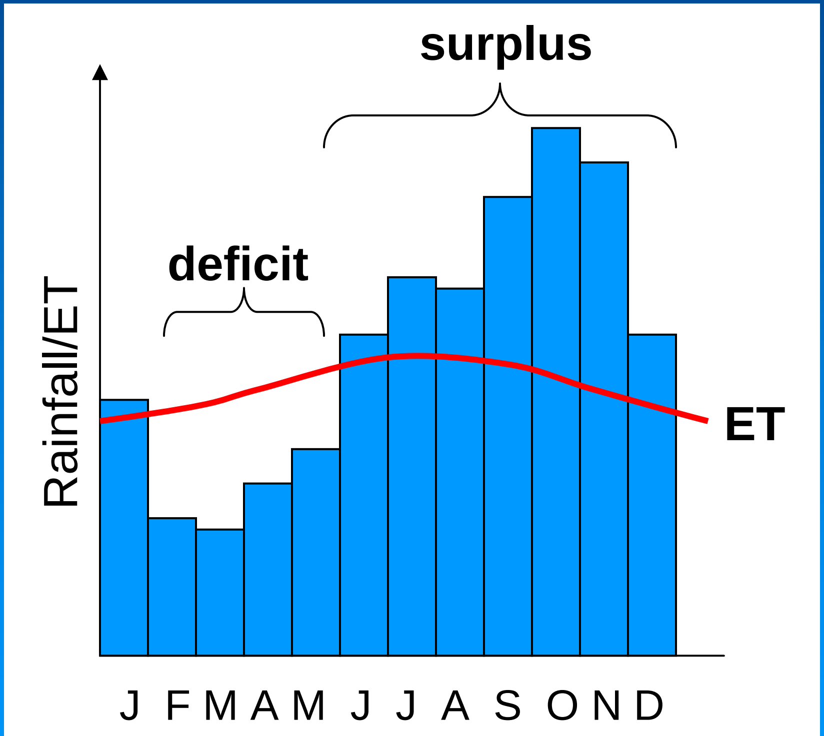
Assumptions
Estimating ET

- Temperature (mean daily min, max) data across island not available; values derived from GIS map source. Adiabatic lapse rate to account for decrease in temps with elevation used
- Windspeed data across island not available; assumed at 2 m/s over island surface (FAO, 1998)

Procedure

- STEP 3: Estimating water deficit
  - Simply the difference between rainfall input and ET losses
  - Also referred to as effective rainfall
    - Water available for abstraction – potable (domestic) water; irrigation, livestock watering



Data quality

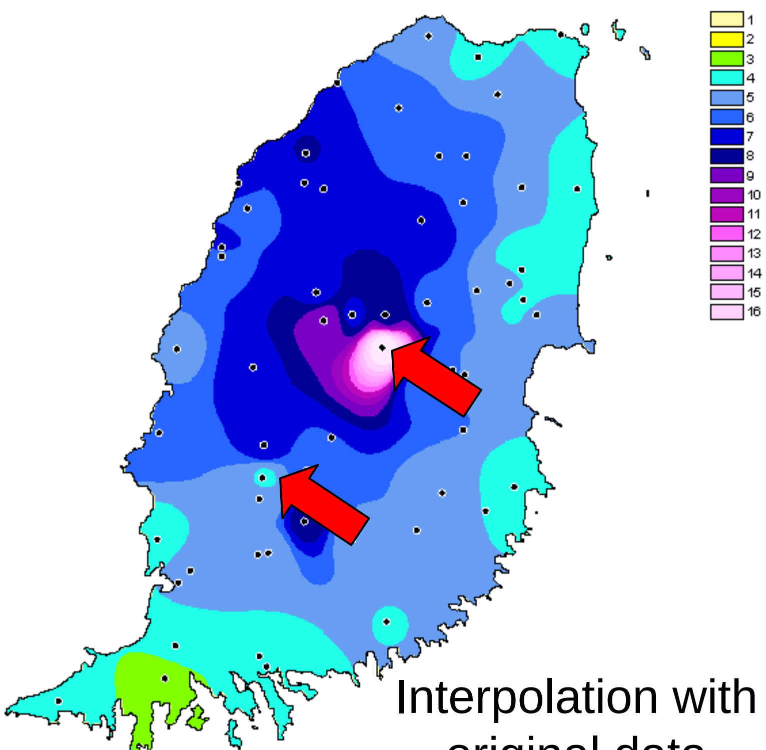
Monthly rainfall data observations

Interpolation revealed <u>inconsistencies</u> in rainfall monthly observations

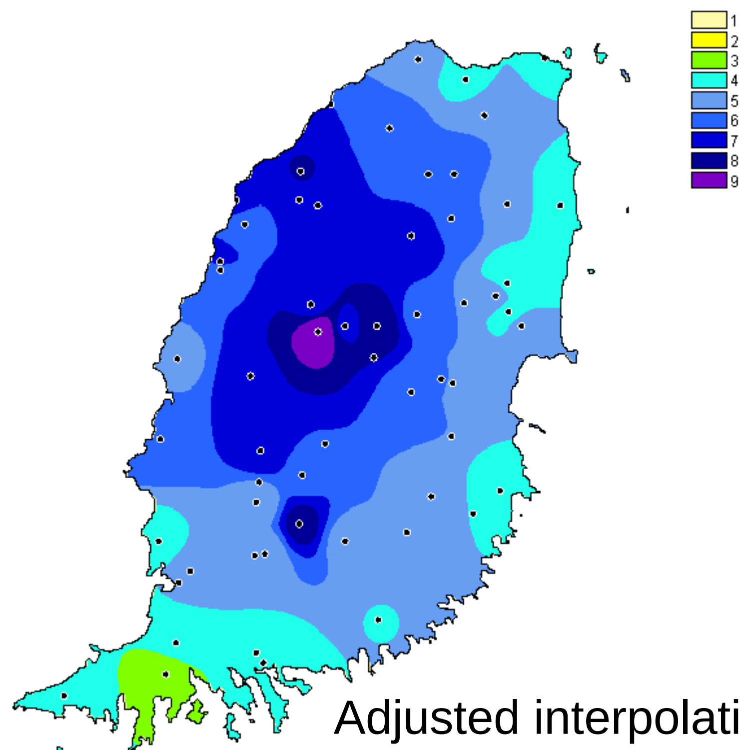
Vendome WTP station – consistent under-reporting for all months

Nianganfoix station - large deviation for September (excess of 800 mm!)

Vendome WTP station excluded from analysis; Nianganfoix station excluded from September analysis only

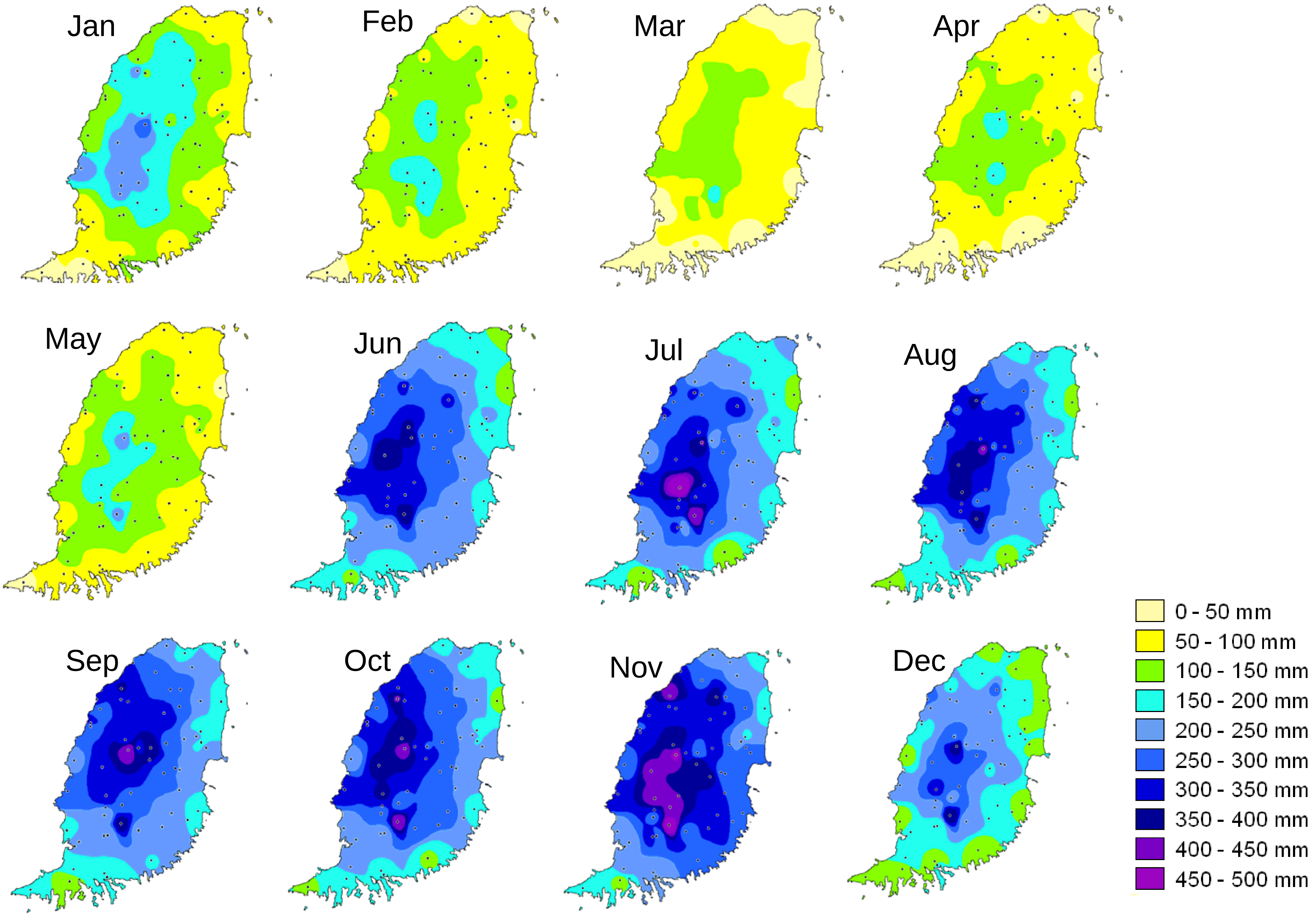


Interpolation with original data

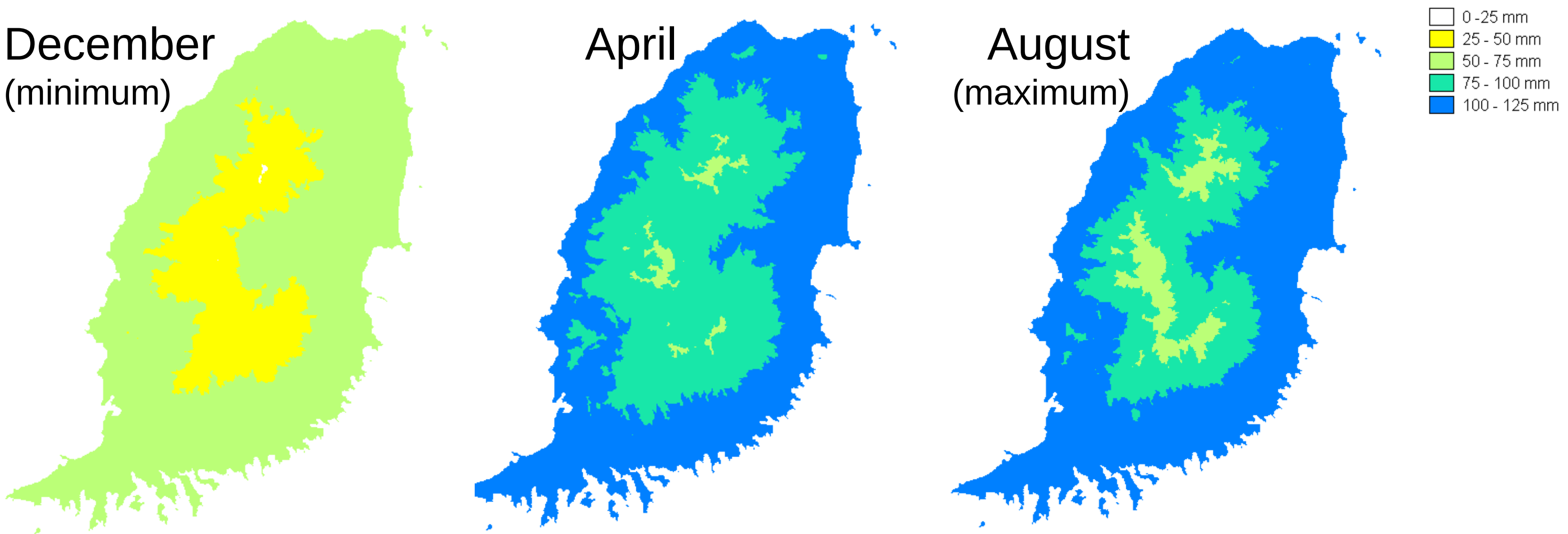


Adjusted interpolation “suspect” stations excluded

RESULTS: Spatial variation in mean monthly rainfall

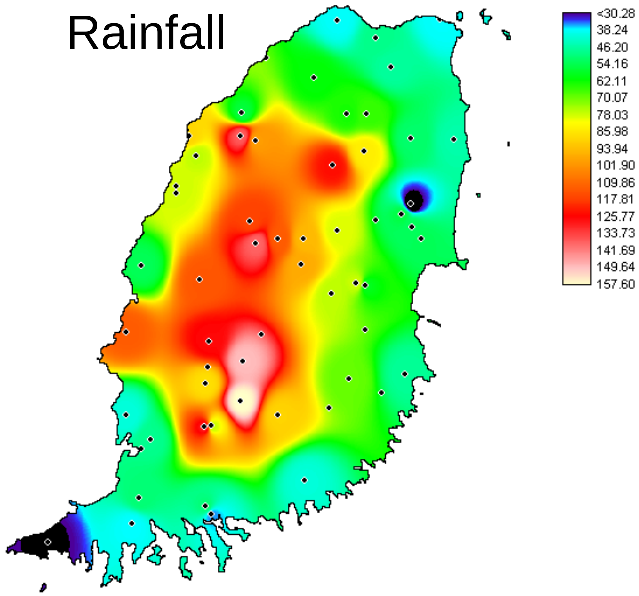


RESULTS: Spatial variation in monthly evapotranspiration

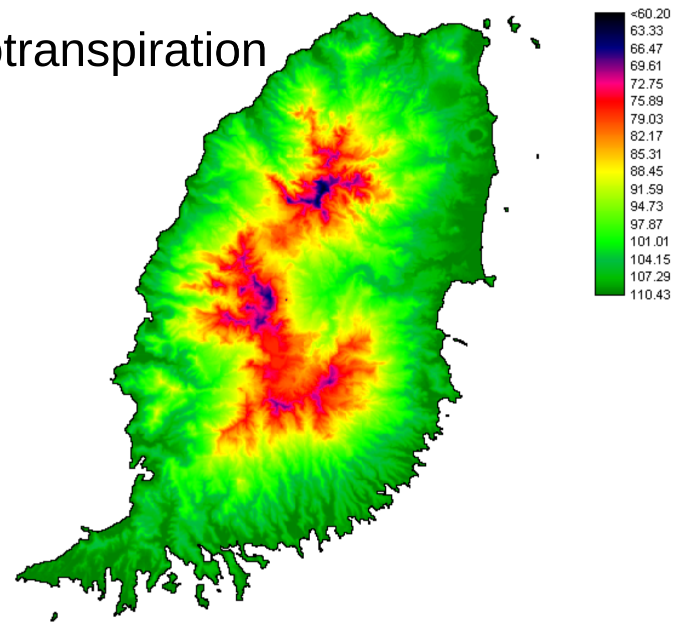


ET is primarily a function of temperature (seasonal variation and elevation)

Rainfall

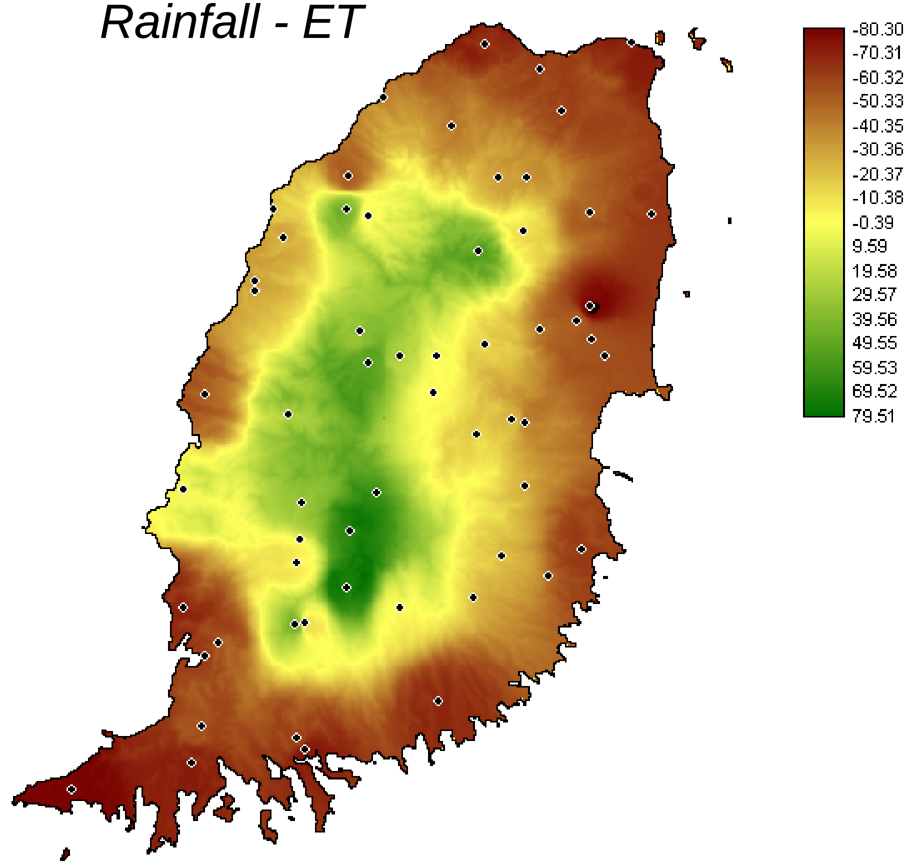


Evapotranspiration

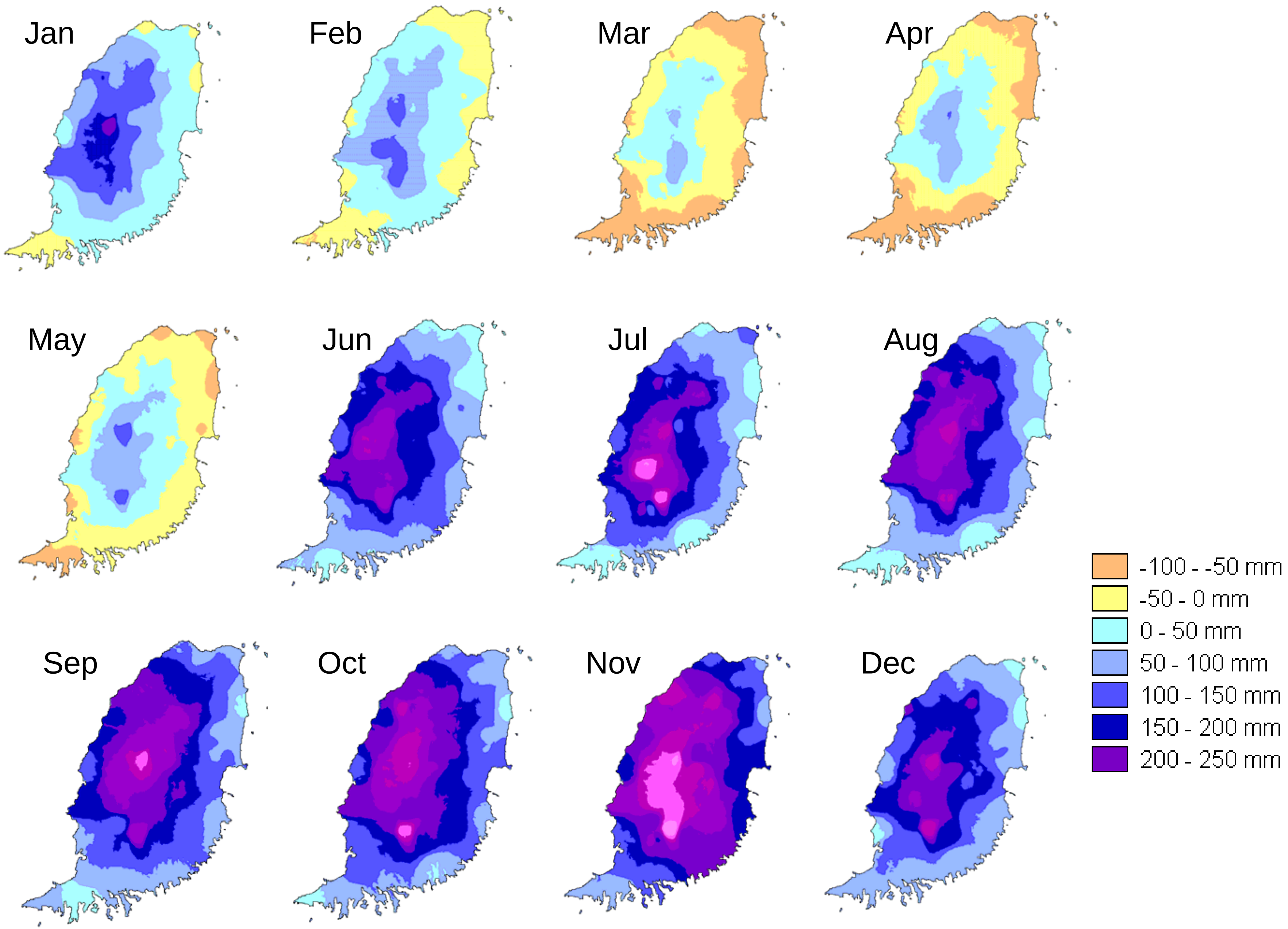


March Water deficit

Rainfall - ET

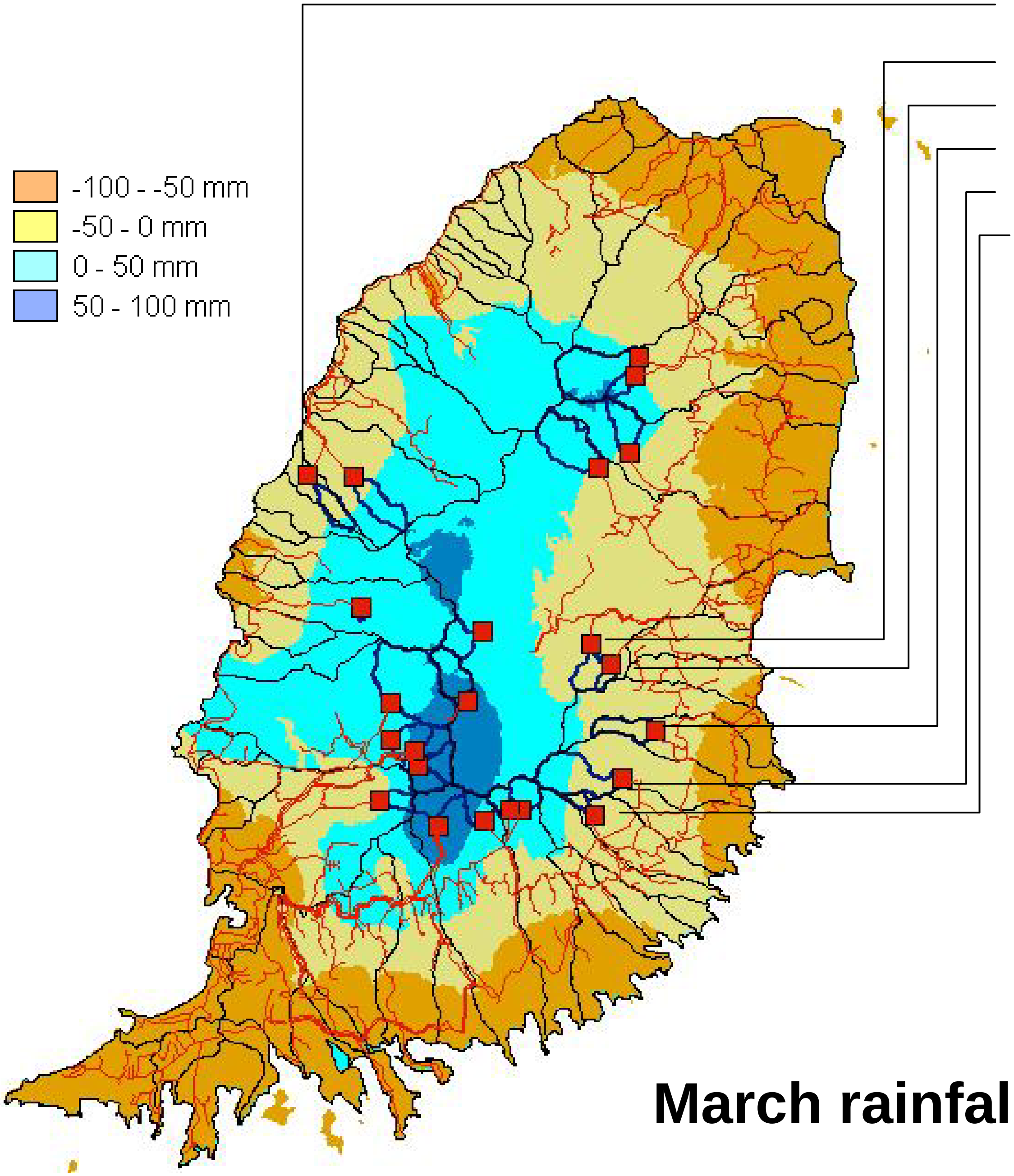


RESULTS: Spatial variation in mean rainfall deficit



Vulnerable Catchments (runoff depth)

Mount Nesbit	-7.4 mm
Birch Grove	-7.5 mm
Belle Vue	-4.4 mm
Minich	-12.3 mm
Mamma Cannes	1.5 mm
Pomme Rose	-8.1 mm

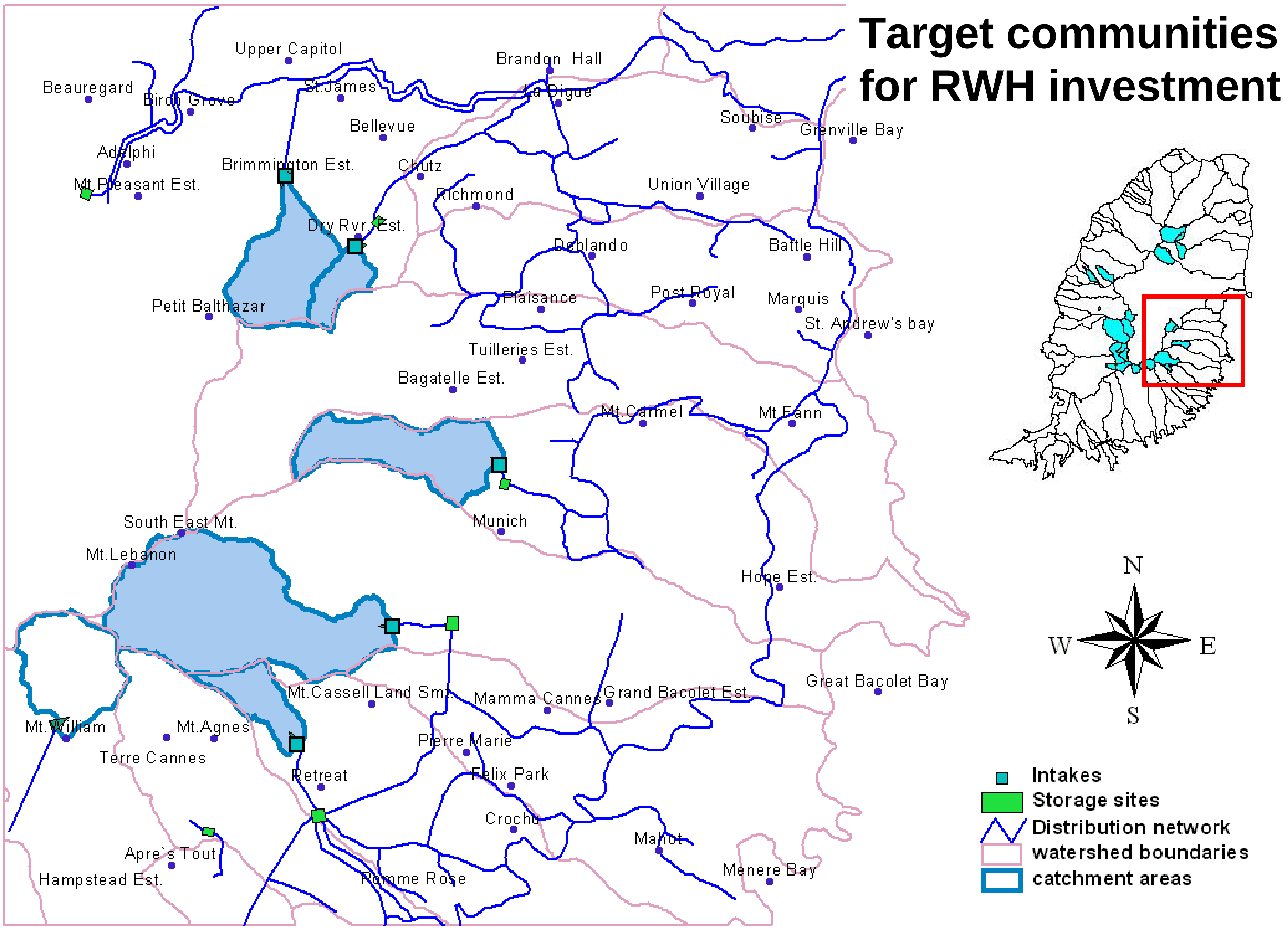


By extension, communities exclusively dependent on these sources will be relatively vulnerable to water stress during dry months. Water supply augmentation strategies highly recommended

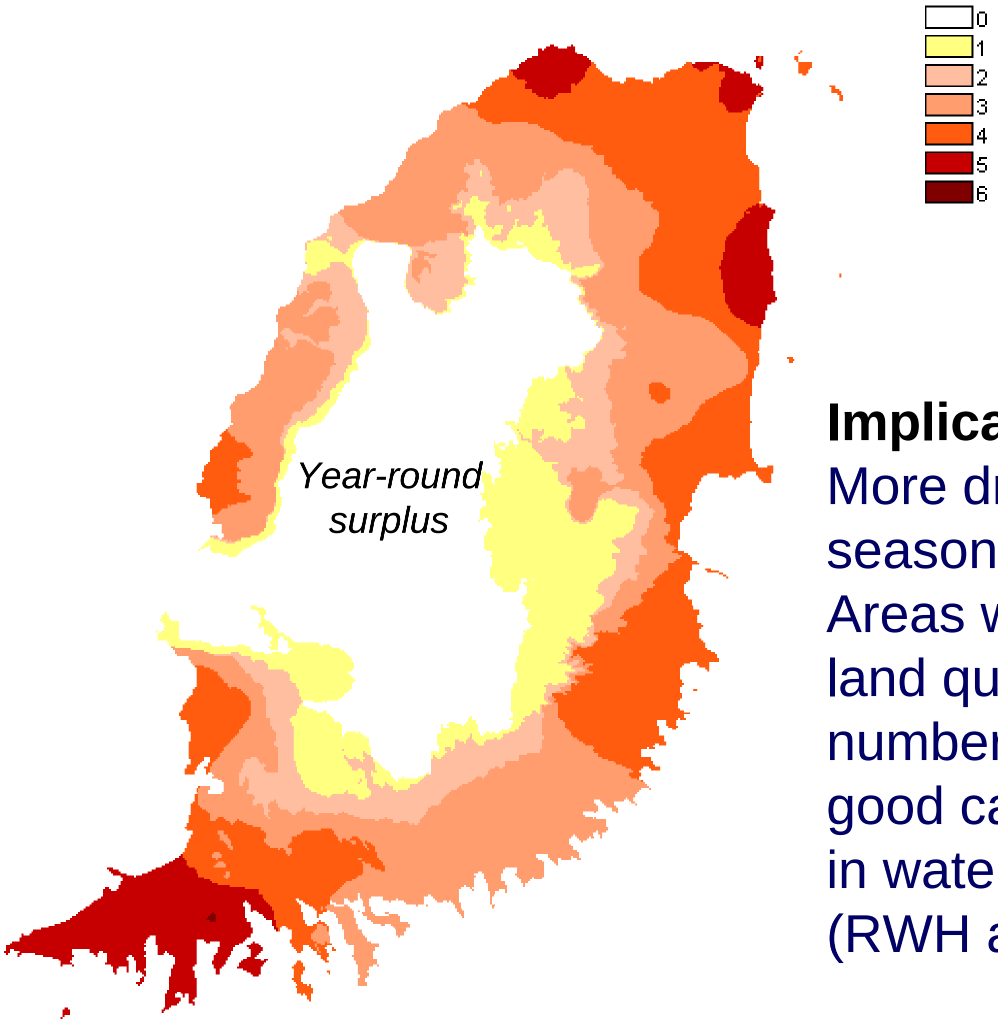
(NOTE: there may be other abstraction sources not analyzed at this time; verification needed)

March rainfall deficit

Target communities for RWH investment



Number consecutive months where mean rainfall < ET



Implications for rain-fed agriculture

More dry months; shorter growing season; limits rain-fed production. Areas with high land capability (good land qualities) but severe deficit (high number consecutive dry months) are good candidate areas for investment in water augmentation measures (RWH and irrigation)

Planning

- Process permits objective spatial allocation (zoning) of resource distribution
  - Investment in water abstraction and distribution systems
  - Agriculture production zoning (crops, livestock)
    - Build on previous FAO-supported initiative

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Considerations

- Analysis is based on mean rainfall data observations
  - May be wide variation around the mean. Should be further investigated in context of frequency analysis
- ET analysis may be improved with better parameter estimation
- Feedback from stakeholders on whether methodology is a suitable guide
  - Are communities identified using methodology really at risk?

Thank You!

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