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TECHNISCHE UNIVERSITÄT DRESDEN

MAR Junior Research Group

IN WAS

Innovative web-based Decision Support System for Water Sustainability under a Changing Climate

Opportunities for managed aquifer recharge in Costa Rica

José Bonilla & Catalin Stefan

16th Biennial Symposium on Managed Aquifer Recharge
San Diego, USA, 07.03.18

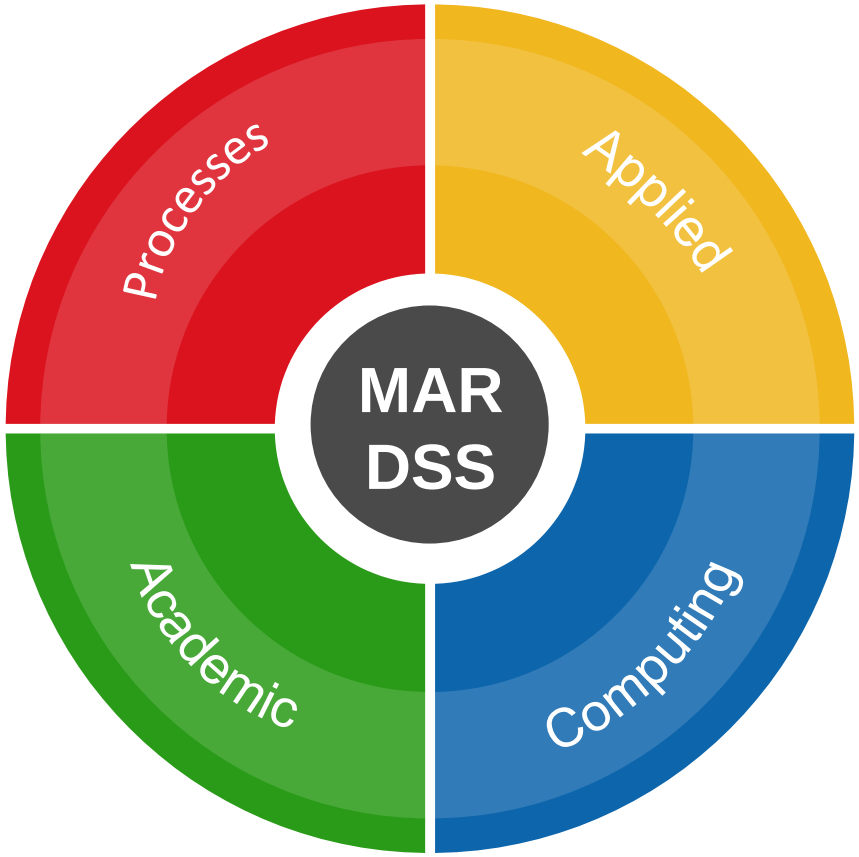
INOWAS conceptual structure

Process understanding

Understanding the influence of hydrogeological and hydrological parameters on water balance under climate change scenarios.

Academic qualification

Junior research group with multidisciplinary profile. Initiation of international MAR research network.

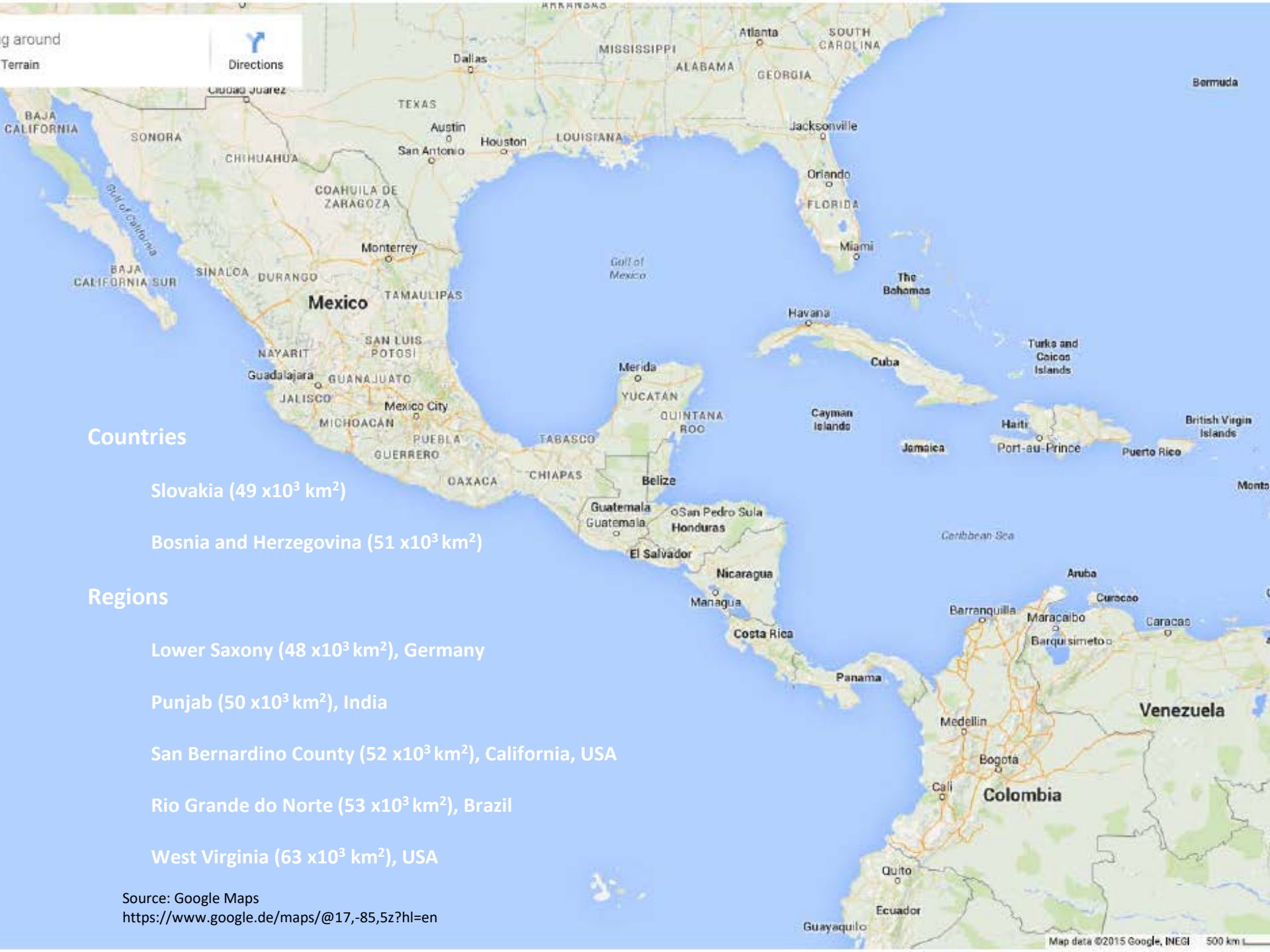


Applied research

Laboratory and test-field scale infiltration units for the prediction of the efficiency of managed aquifer recharge.

Computing

Combination of web-based technologies and GIS functionality with process-based simulations.



Countries

Slovakia (49 x10^3 km^2)

Bosnia and Herzegovina (51 x10^3 km^2)

Regions

Lower Saxony (48 x10^3 km^2), Germany

Punjab (50 x10^3 km^2), India

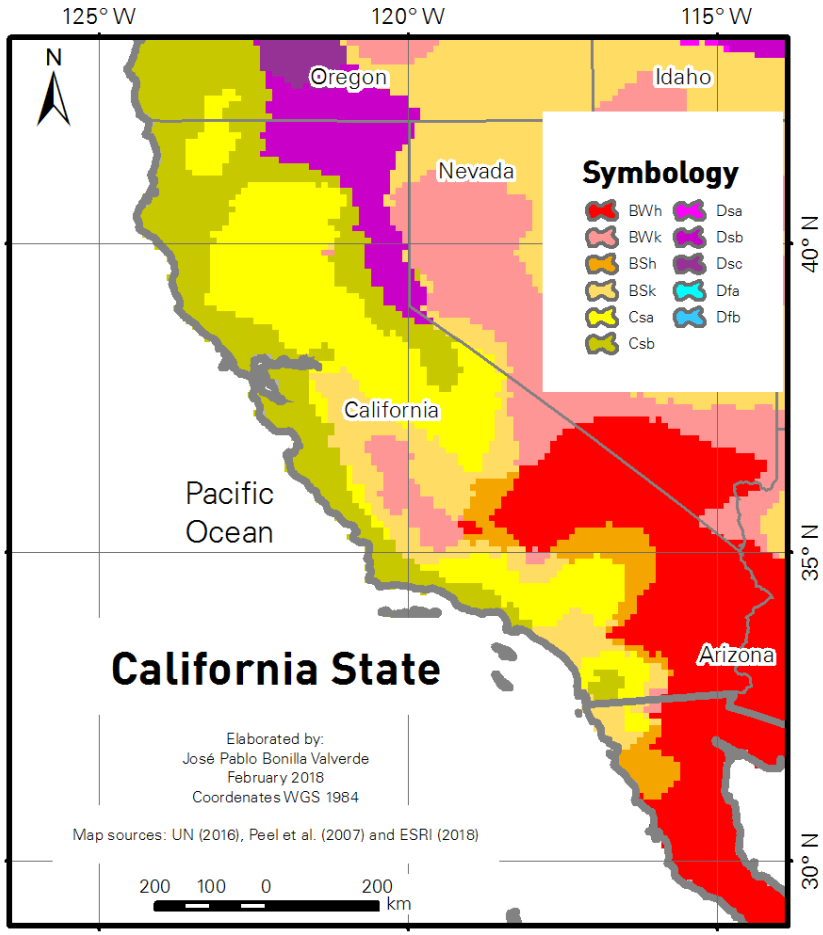
San Bernardino County (52 x10^3 km^2), California, USA

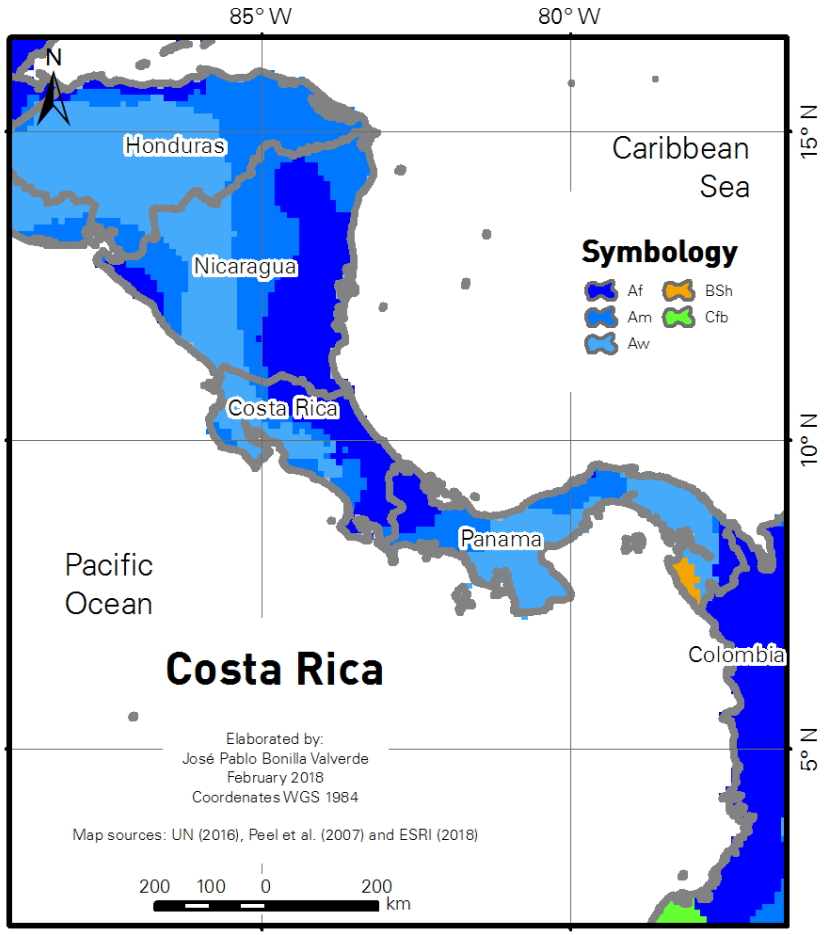
Rio Grande do Norte (53 x10^3 km^2), Brazil

West Virginia (63 x10^3 km^2), USA

Source: Google Maps
https://www.google.de/maps/@17,-85,5z?hl=en

California & Costa Rica





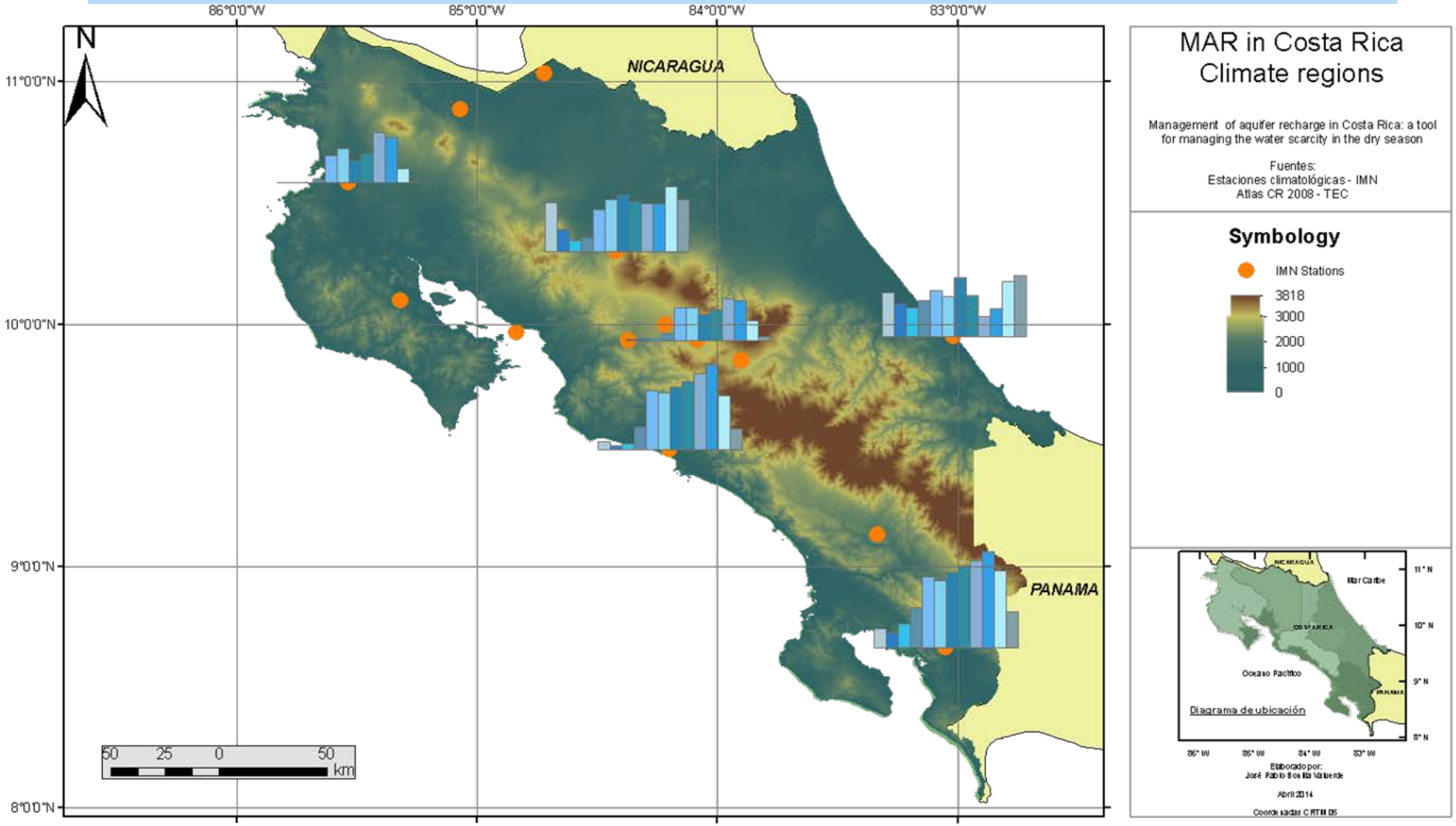
José Bonilla
San Diego, 03.07.18

General information

- Republic of Costa Rica
- Independence1821
- Army abolished 1949
- Population 4.9 mill
  - GAM half population in 5% of the territory
- Free elections 4 years
- Municipalities 81

Source: Wikimedia Commons
https://commons.wikimedia.org/wiki/Costa_Rica#/media/File:Coat_of_arms_of_Costa_Rica.svg

Climatic conditions



Source: Bonilla (2015). Unpublished

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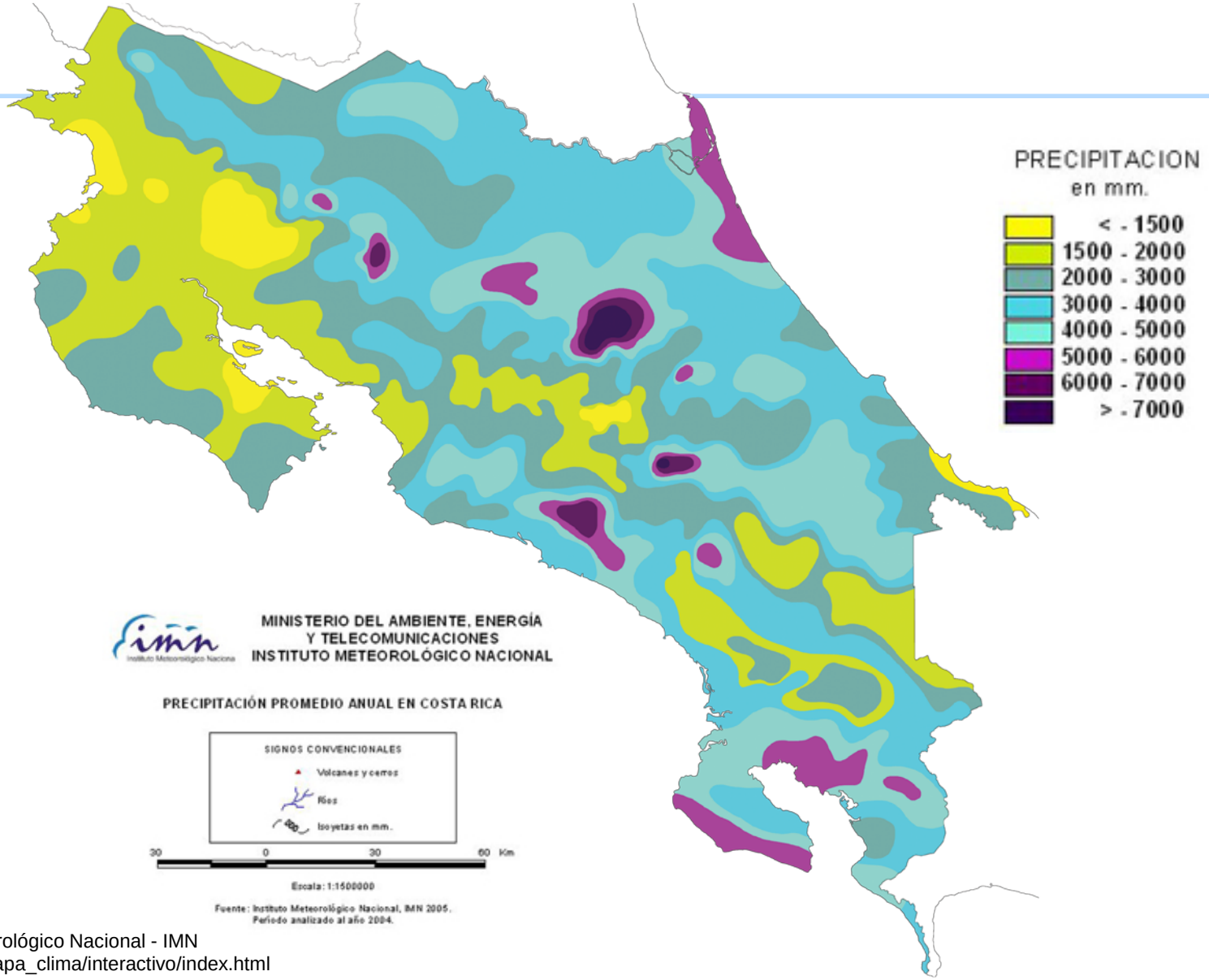
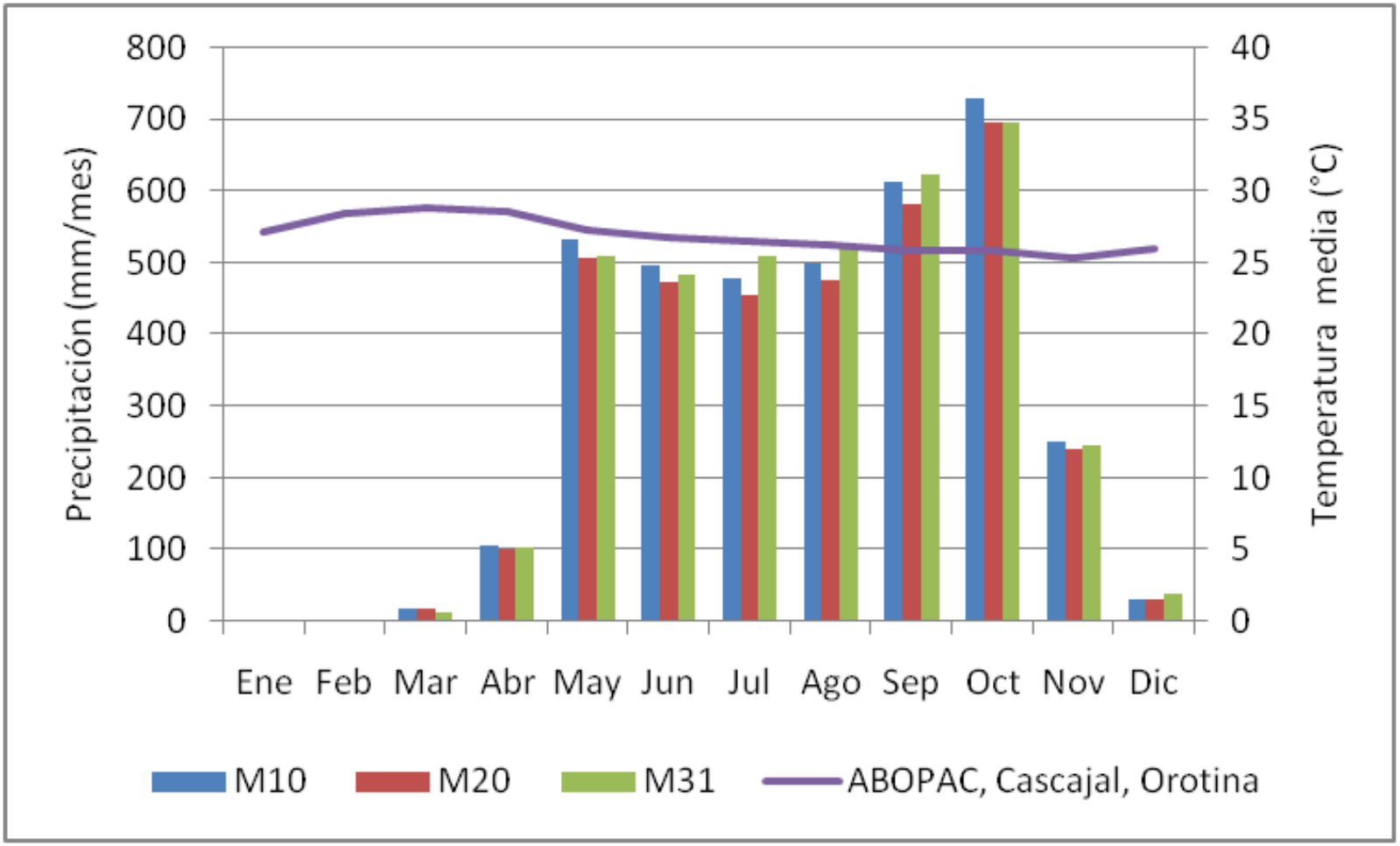


Source: Instituto Meteorológico Nacional - IMN
http://www.imn.ac.cr/mapa_clima/interactivo/index.html

Climatic conditions



Source: Bonilla V., J. P. & Barahona P., M. (2014).
Balance hídrico por el método Thornthwaite-Mather modificado en la cuenca alta del río Machuca en el Pacífico Central de Costa Rica para cuantificar el recurso hídrico superficial.

Seasonal excess/scarcity

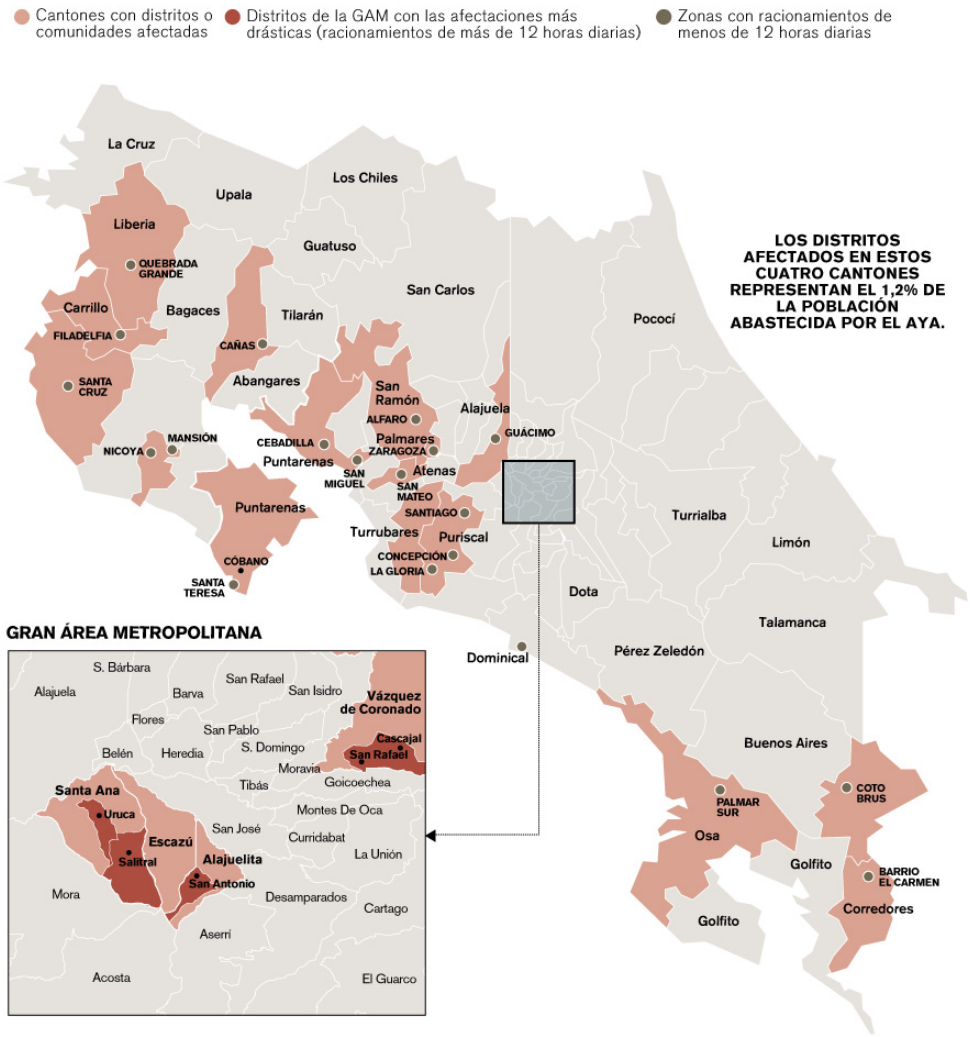
Sequía en Guanacaste es la más fuerte de los últimos 78 años (*Drought in Guanacaste is the strongest in the last 78 years*)

– Déficit de lluvia en Guanacaste es de casi un 100% mientras en Limón llovió tres veces más de lo normal (*Rainfall deficit in Guanacaste is almost 100% while in Limón it rained three times more than normal*)

Source: LA NACION 01.06.2015
https://www.nacion.com/sucesos/sequia-en-guanacaste-es-la-mas-fuerte-de-los-ultimos-78-anos/7QY5UI66MFBNFGK2JN424DYU6U/story/

Seasonal excess/scarcity

Seasonal excess/scarcity

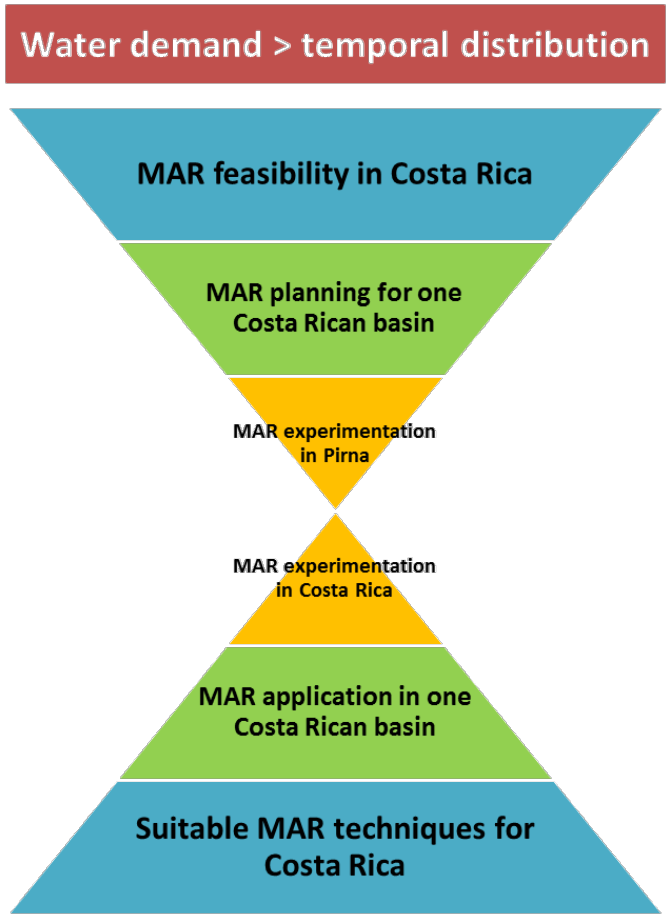


Source: LA NACION 13.01.2015 AyA inicia en 15 días cortes de agua en la GAM por sequía http://www.nacion.com/nacional/servicios-publicos/AyA-inicia-cortes-GAM-sequia_0_1463253714.html

Doctoral research

Project:

Managed aquifer recharge assessment to overcome water scarcity during the dry season in Costa Rica

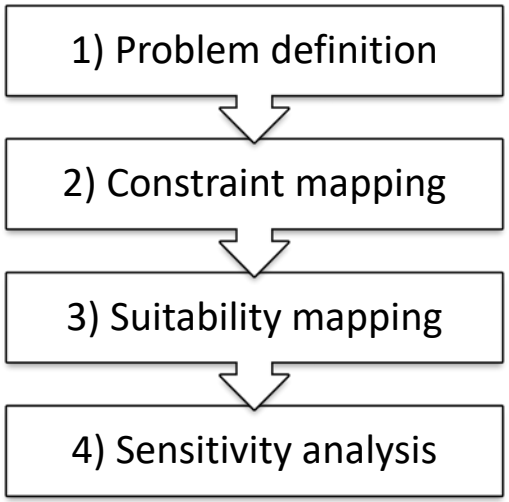


MAR in Costa Rica flow chart
Source: Bonilla *et al.*, 2016

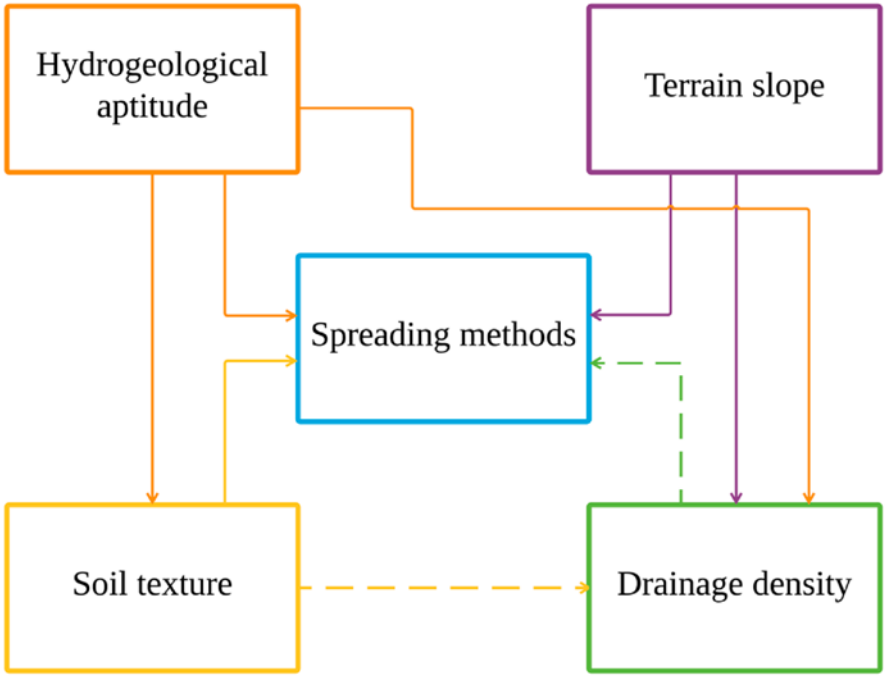
Suitable sites for spreading methods

GIS-MCDA method

- Based in 4 criteria
- Unsuitable areas:
  - Slope > 40% & protected areas
- Suitable areas > 60% country
  - Very high and high >30%

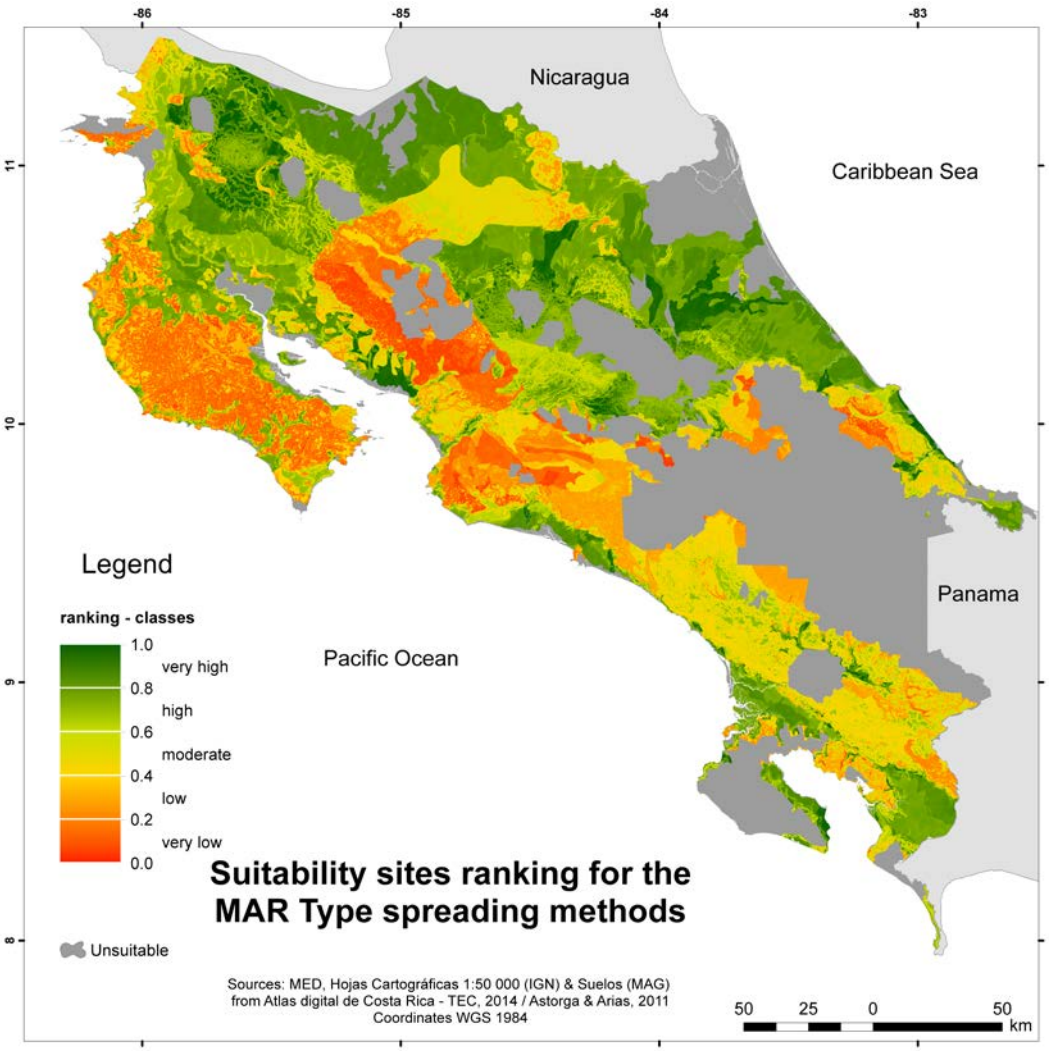


GIS-MCDA methodology for MAR
Source: modified from Rahman *et al.*, 2012.



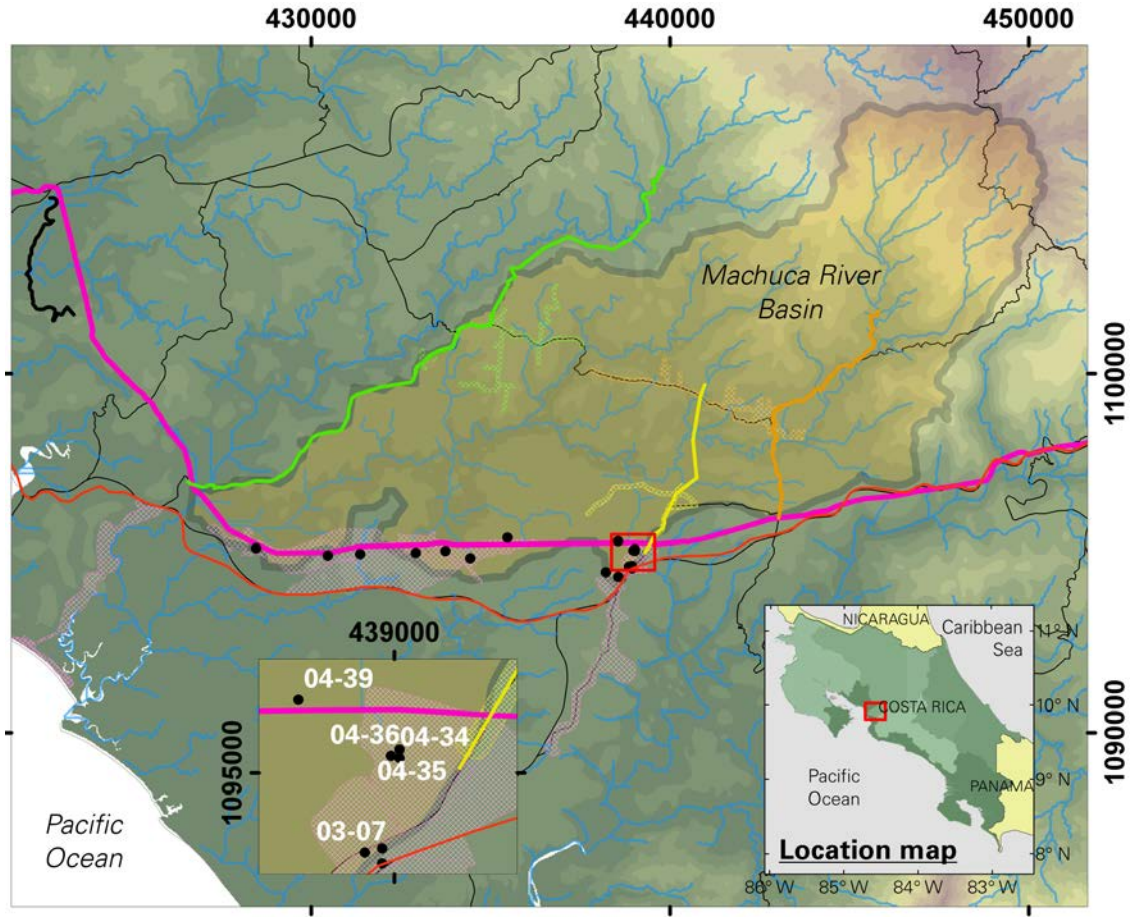
Weight assignment by multi-influence factor method (MIF).
Source: Bonilla *et al.*, 2016

Suitable sites for spreading methods

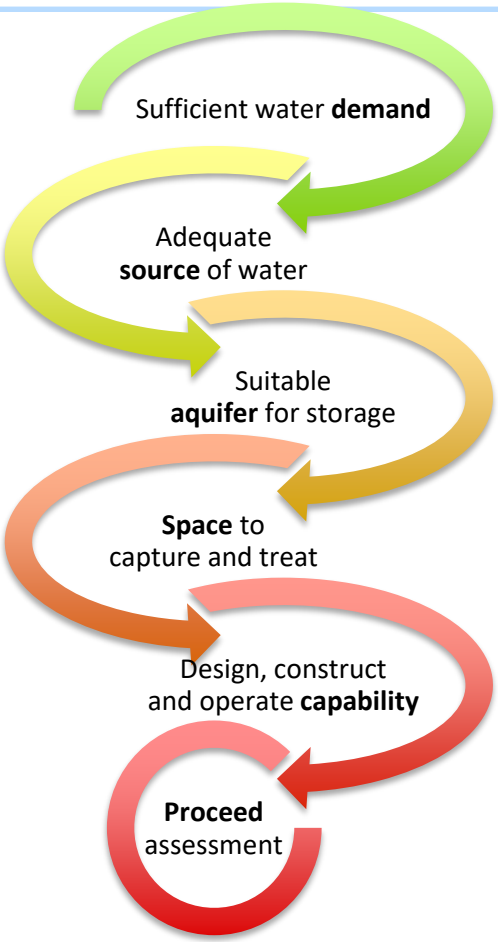


Suitability ranking for MAR through spreading methods in Costa Rica
Source: Bonilla *et al.*, 2016. *Water* **2016**, *8(9)*, 391; doi:10.3390/w8090391

MAR at a regional level

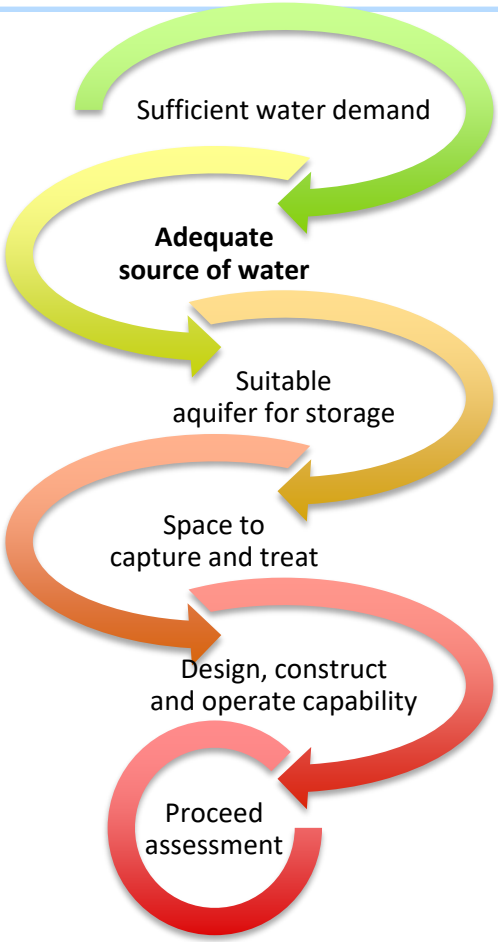


Machuca river basin, spatial distribution of water supply wells and the potential available water supply sources.
Source: Bonilla *et al*, 2017.



Modified viability assessment scheme for MAR projects.
Source: Australian Guidelines for Water Recycling: Managed Aquifer Recharge, 2013.

MAR at a regional level



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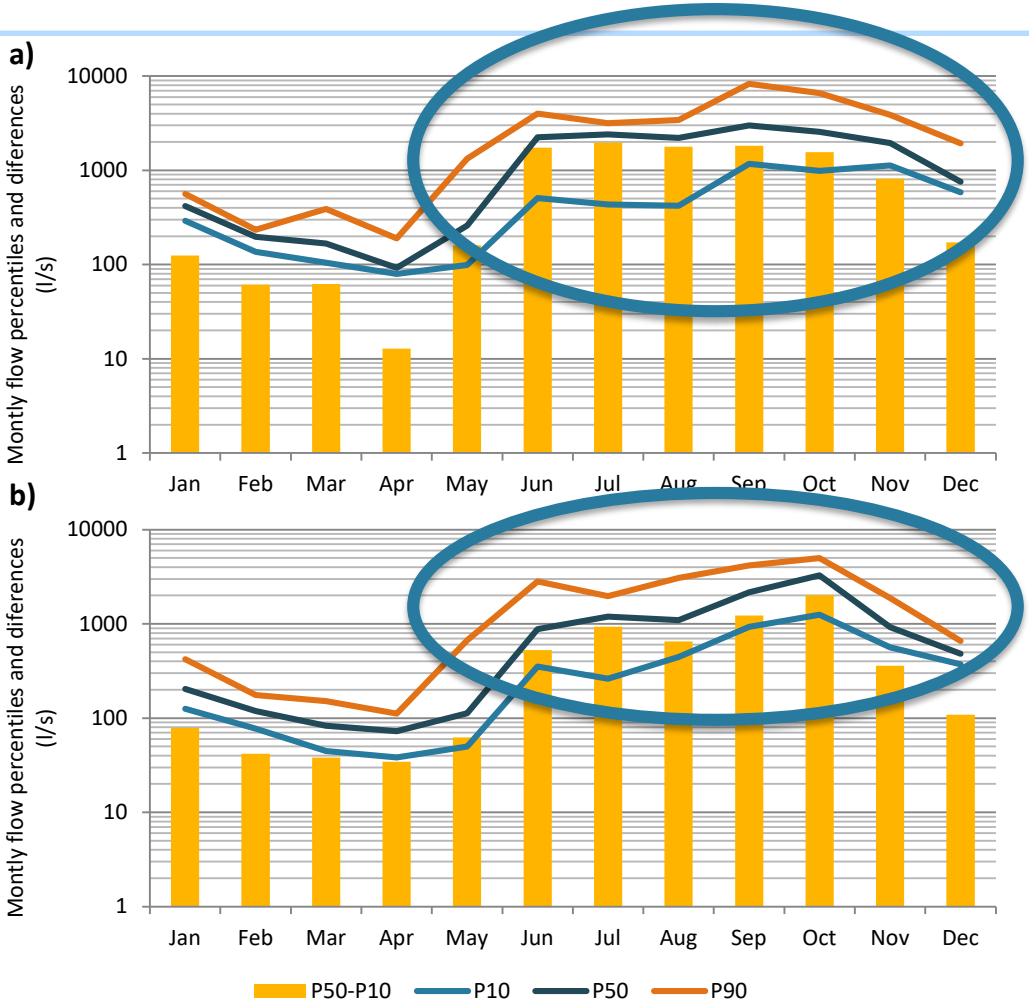
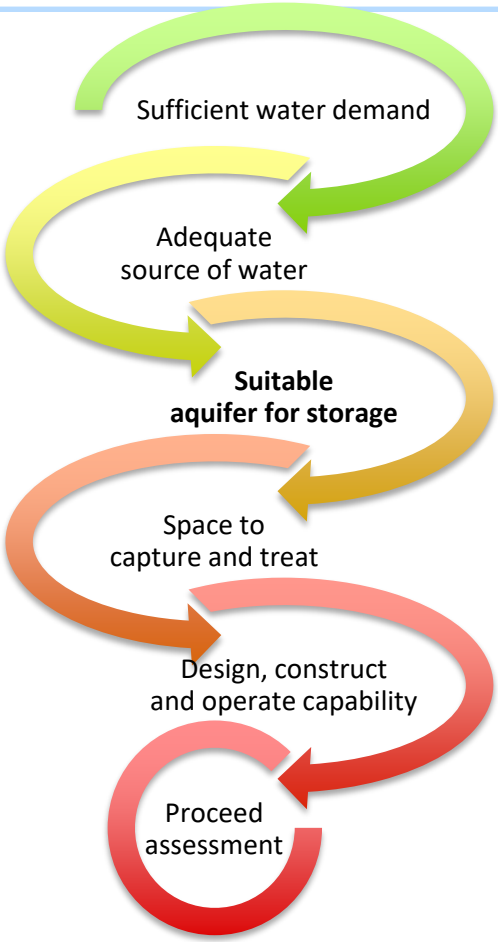


Monthly hygrograms (percentiles 10, 50 and 90 from 2004-2016) for the rivers a) Jesús María and b) Machuca.
Source: Bonilla *et al.*, 2017.

MAR at a regional level



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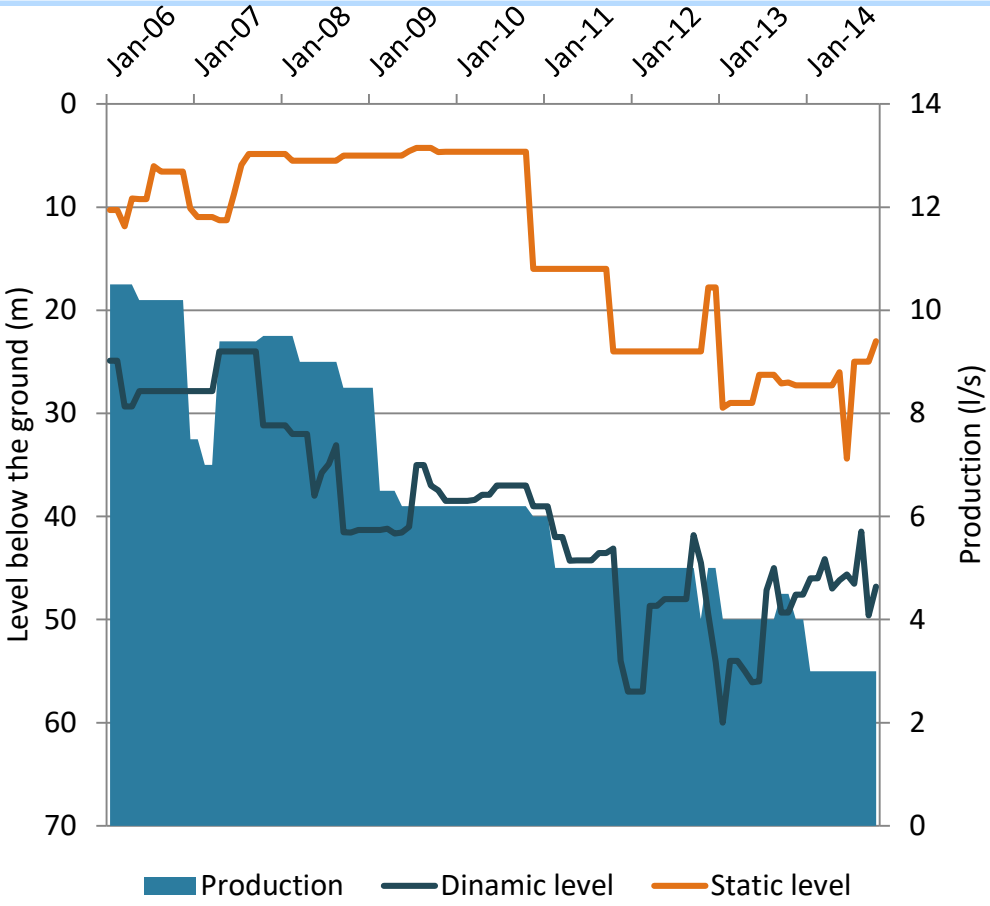
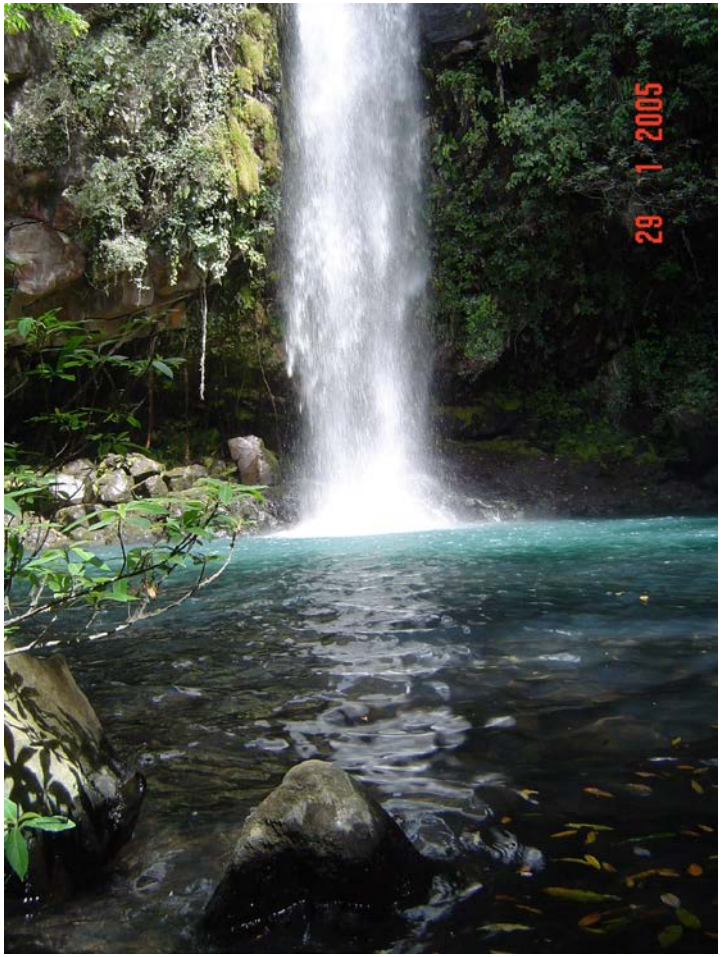


Monthly production, dynamic and static level for Well 04-35 in the Machuca river basin.
Source: Bonilla *et al.*, 2017.

MAR opportunities in Costa Rica

1. to overcome the temporal water scarcity at the end of the dry season;
2. to prevent saltwater intrusion; and
3. as an alternative source for water supply systems (WSS).

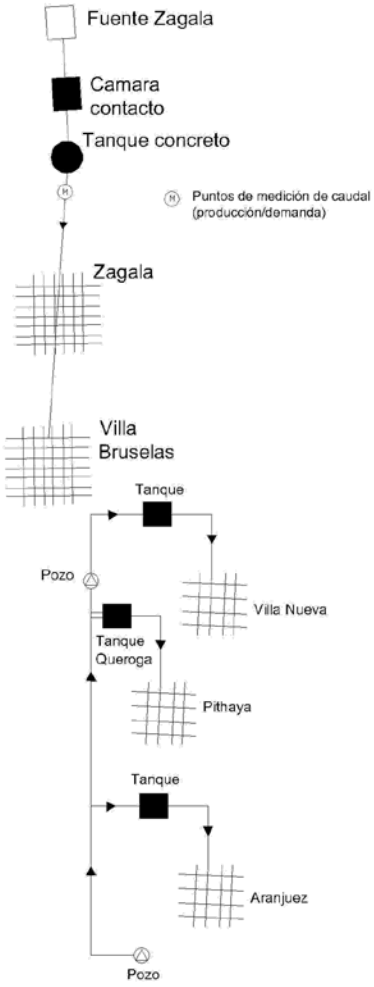


MAR opportunities in Costa Rica

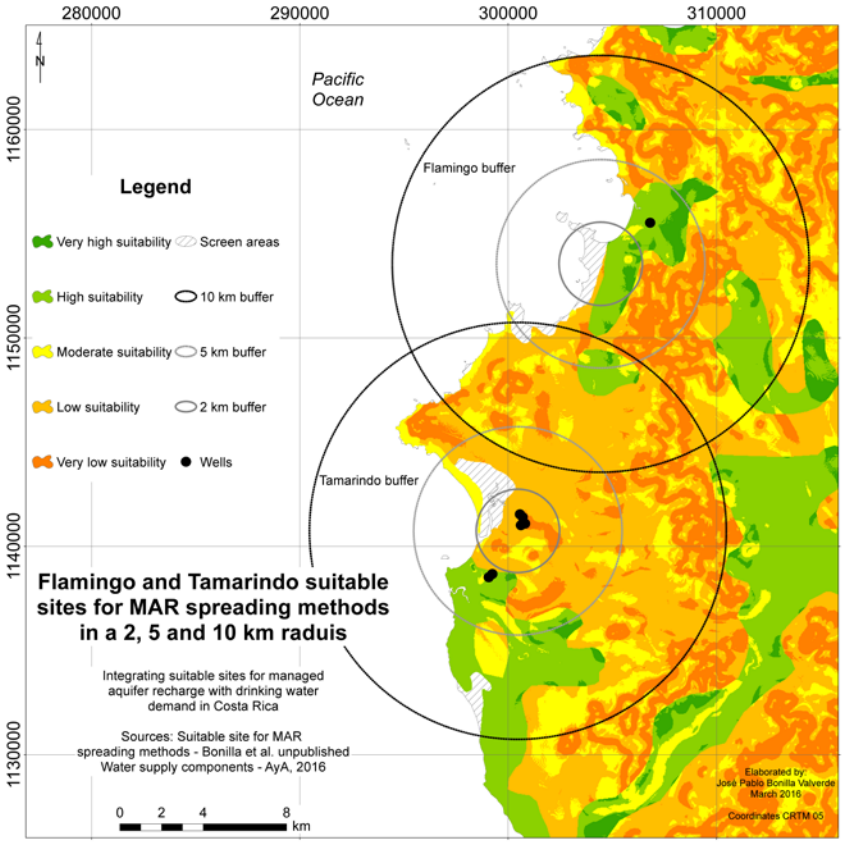
1. to overcome the temporal water scarcity at the end of the dry season
   a) Coyolar and Zagala in the Central Pacific Region; and
   b) Nicoya in the Nicoya Peninsula

Table: Population per drinking water supply system (WSS) by 2017.

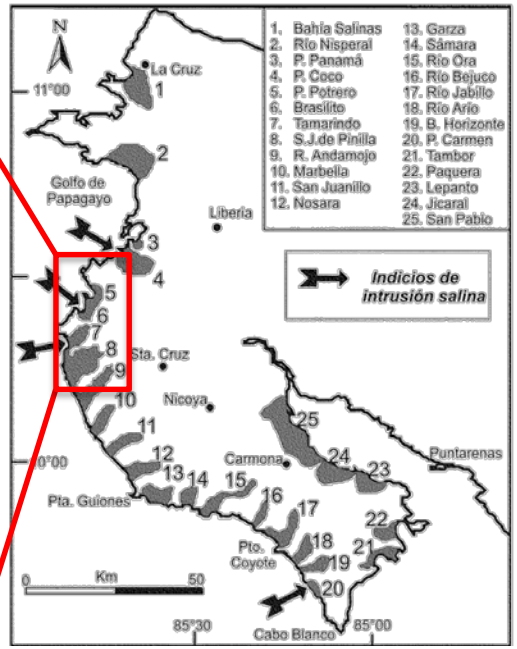
Drinking WSS	Population ($x10^3$)
Coyolar	6.1
Zagala	1.9
Nicoya	22.6



MAR opportunities in Costa Rica



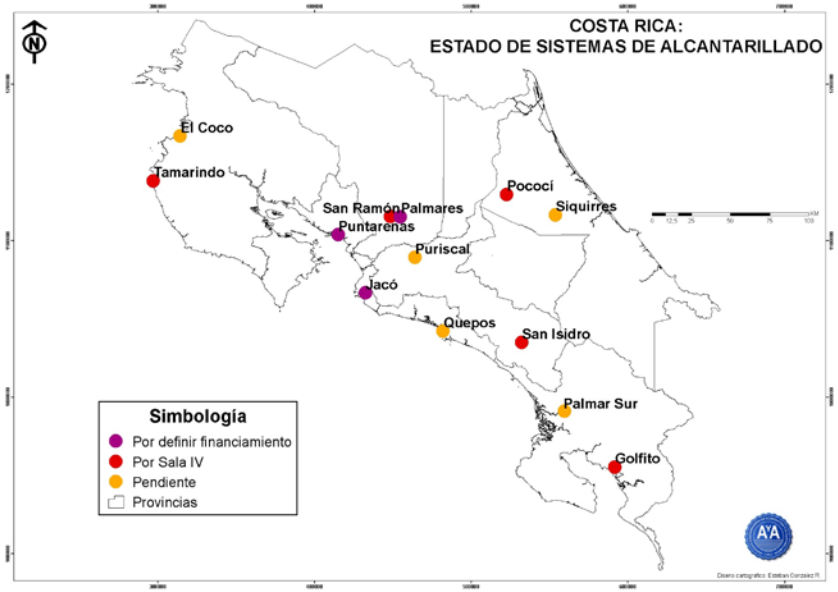
Suitable site for MAR through spreading methods around the Flamingo and Tamarindo wells
Source: Bonilla *et al.*, 2016.



Costal aquifers in the Nicoya Peninsula of Costa Rica and signs of saline intrusion
Source: Arellano & Vargas, 2001.

2. to prevent saltwater intrusion:
   a) playa Panama (3) and Potrero (5) wells were abandoned due to high electrical conductivity. The same practice has been applied at playa Tamarindo (7).

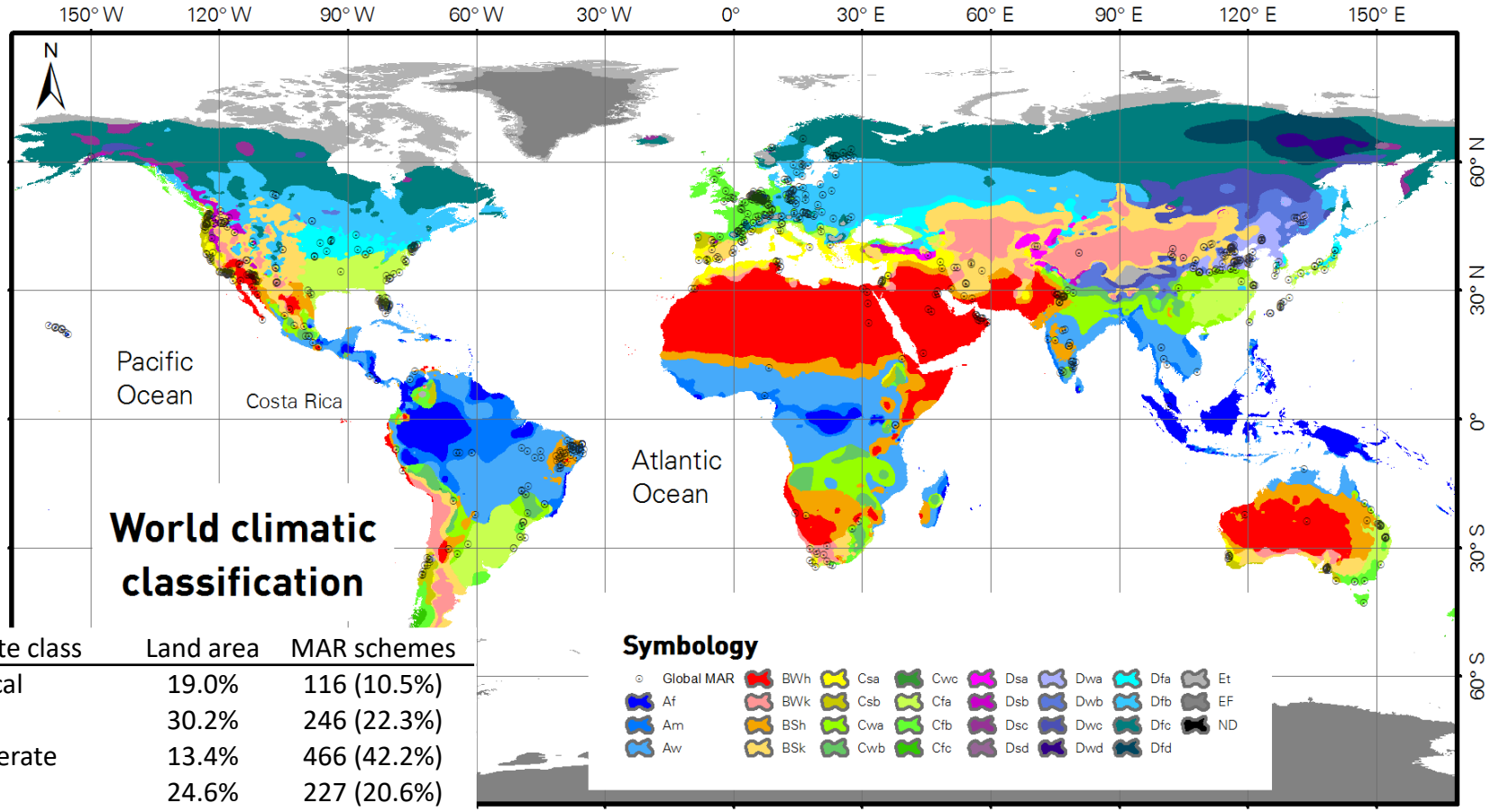
More MAR opportunities in Costa Rica



Projected new wastewater treatment plants in Costa Rica
Source: AyA, 2010.

- Interest of the agro-industrial sector in investigating opportunities to implement MAR in the Caribbean Region as compensation of the extracted water for irrigation.
- AyA is interest in looking into MAR as an alternative for indirect treated wastewater reuse.

MAR opportunities in the tropics



Climate class	Land area	MAR schemes
Tropical	19.0%	116 (10.5%)
Arid	30.2%	246 (22.3%)
Temperate	13.4%	466 (42.2%)
Cold	24.6%	227 (20.6%)
Polar	12.8%	
No data		49 (4.4%)
Total general		1104 (100.0%)

Contact

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