Identifying Feasible Areas in California's Central Valley that Would Benefit from Flood-MAR Actions

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Abstract

In response to California's multiyear droughts many sustainable practices are being explored, one of them being Flood-MAR. Although the benefits associated with Flood-MAR are attractive to landowners, groundwater management agencies, and local water agencies, there's still data, information, and guidance needed to proceed with the implementation of Flood-MAR projects. The objective of this study was to identify feasible areas throughout California that would benefit from Flood-MAR actions and propose potential Flood-MAR source water for a selected study site.

Introduction

The California State Legislature passed the Sustainable Groundwater Management Act (SGMA) in 2014 (Ercan et al., 2016). SGMA requires local and regional authorities to form Groundwater Sustainability Agencies (GSAs) to develop Groundwater Sustainability Plans (GSPs). The objectives of these GSPs are to avoid groundwater level declines, land subsidence, seawater intrusion, groundwater storage reductions, interconnected surface water depletions, and water quality degradation. In response to SGMA many sustainable practices are being explored, one of them being Flood-MAR. Flood-MAR is a voluntary management strategy aimed to recharge aquifers (California, 2021). This strategy is structured to utilize floodwater primarily on agricultural lands, floodplains, and flood bypasses. Benefits associated with Flood-MAR include drought preparedness, aquifer replenishment, subsidence mitigation, and water quality improvement. In 2019 the Flood-MAR Research Advisory Committee released a Flood-MAR Research and Data Development Plan. Within this plan priority actions for expanding flood-MAR projects throughout California are listed. Under the "People and Water Priority Action Summary," the committee identified the need to classify areas that could substantially benefit from Flood-Mar projects. Such areas would be highly dependent on groundwater and are susceptible to groundwater shortages.

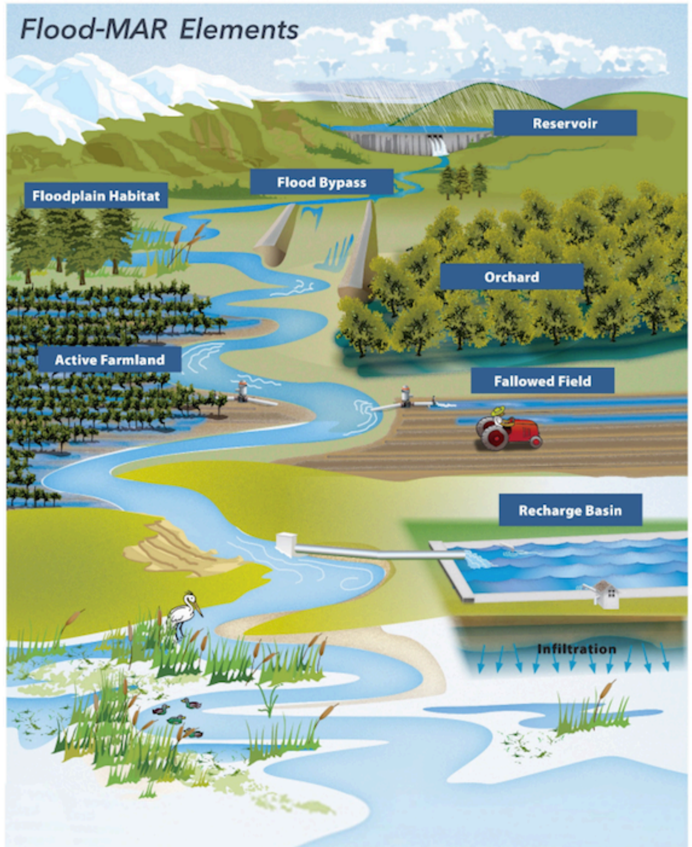

Figure 1. Example Flood-MAR Projects (California, 2021).

Objective

This study aimed to identify regions across California's Central Valley that would significantly benefit from Flood-MAR projects based on a predetermined selection criterion. These regions were identified using tools provided by the DWR, such as the Groundwater Level Percentile Statistics Tool, the Soil Agricultural Groundwater Banking Index (SAGBI) tool, and the Disadvantaged Communities (DAC) Mapping Tool. Upon identifying these regions, a study site was chosen to identify potential source water for a Flood-MAR project. Additional resources used was historical precipitation and river discharge data provided by the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS).

Methods

In determining sites suitable for Flood-MAR projects, the DWR has listed a variety of physical parameters that must be analyzed. These parameters include soil suitability, land use and crop compatibility, aquifer suitability, available groundwater storage capacity, water quality, and regional considerations. This project focused on identifying sites that have reported low groundwater levels, have suitable soils, and meet an additional regional consideration. To identify these potential sites, the following tools were utilized.

Groundwater Levels

The DWR's groundwater level percentile statistics was accessed. Wells with reported water levels below normal (10 – 25) and much below normal (<10) were of interest. This web tool was accessed through this think: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels

Soil Suitability

Suitable soils must be able to transmit water, have a short root zone residence time, low salinity, a low sodium adsorption ratio, a low soil erosion factor, and be topographically leveled. To filter out regions throughout California that meet these criteria, the Soil Agricultural Groundwater Banking Index (SAGBI) tool was utilized. This web tool was developed by the University of California Davis and was accessed through this link: https://casoilresource.lawr.ucdavis.edu/sagbi/

Regional Considerations

The DWR's approach on determining site suitability for Flood-MAR actions is extensive, however it primarily focuses on physical suitability. This project used the DWR's approach as a base and added onto it to also consider disadvantaged communities. The Disadvantaged Communities (DAC) Mapping Tool was used to additionally overlay regions across the state where disadvantaged communities are located. This web tool was accessed through this link: https://gis.water.ca.gov/app/dacs/

Results

Figure 3 shows a centralized map over California's Central Valley showing the distribution of SAGBI ratings, disadvantaged community tracts, and groundwater level percentile statistics. Results were obtained manually where I zoomed in and scanned the Central Valley, noting the regions that encompassed good SAGBI ratings, disadvantaged communities, and below normal groundwater levels. Through this process, a list of areas that met the criteria was compiled. **Table 1** lists those areas.

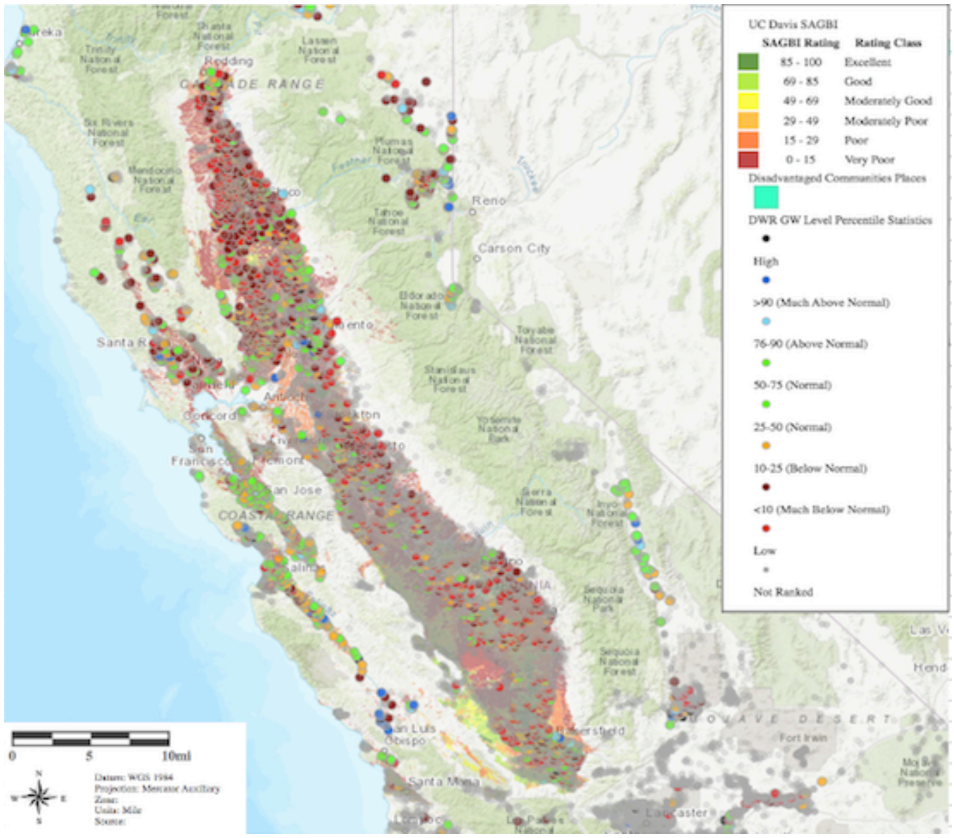

Figure 3. Centralized map of California’s Central Valley showing the distribution of SAGBI ratings, disadvantaged communities, and groundwater percentile statistics.

Table 1. Areas within California’s Central Valley that were determined to benefit from Flood-MAR actions, based on this study’s specific criteria.

Location Name (nearest city)	
Arvin	Fresno
Lamont	Madera
Bakersfield	Merced
Shafter	Livingston
Delano	Turlock
Tulare	Ceres
Visalia	Oakdale
Hanford	Lodi
Lemoore	Dunnigan
Dinuba	Gridley
Reedley	Chico
Selma	Vina

Parlier	

Using the areas listed in Table 1, the city of Merced, CA was chosen as a study site. Figure 4 shows the distribution of SAGBI ratings, disadvantaged communities, and groundwater level percentile statistics around Merced, CA.

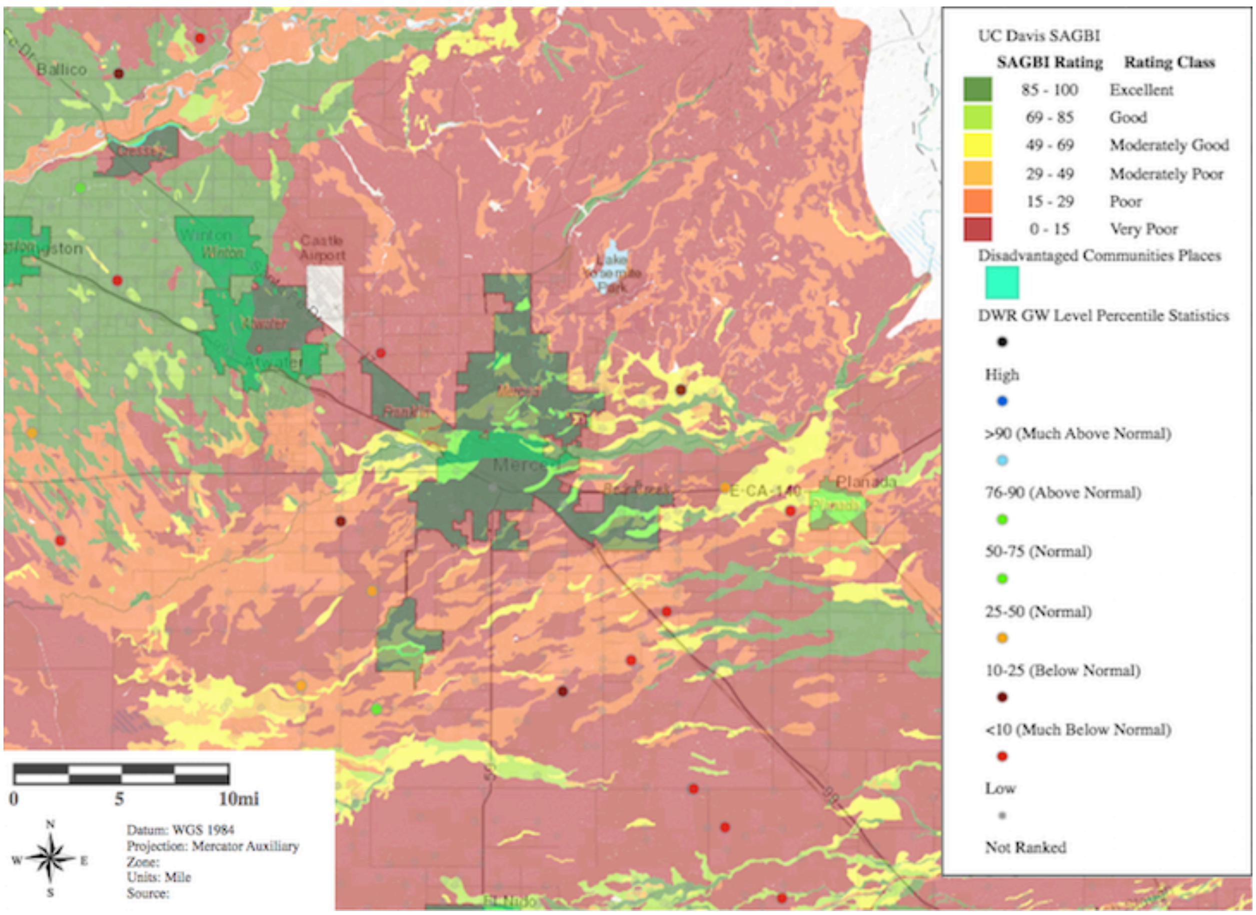

Figure 4. Map of Merced and surrounding areas, showing the distribution of SAGBI ratings, disadvantaged communities, and groundwater percentile statistics.

Figure 5 shows three different graphs of average monthly precipitation for Merced, CA. From 2000 to 20021 high precipitation has primarily occurred in the winter and spring months, with observably high variation in January. Additionally, there were instances of uncommonly high precipitation events in other months. To see if there was an observable trend the data was split between 2000 – 2010 and 2010

– 2021. In doing this it was observed that the high variability of precipitation events in earlier months has occurred in the most recent ten years. The unexpected high precipitation events in later months (March, May, and June) also occurred in the most recent ten years.

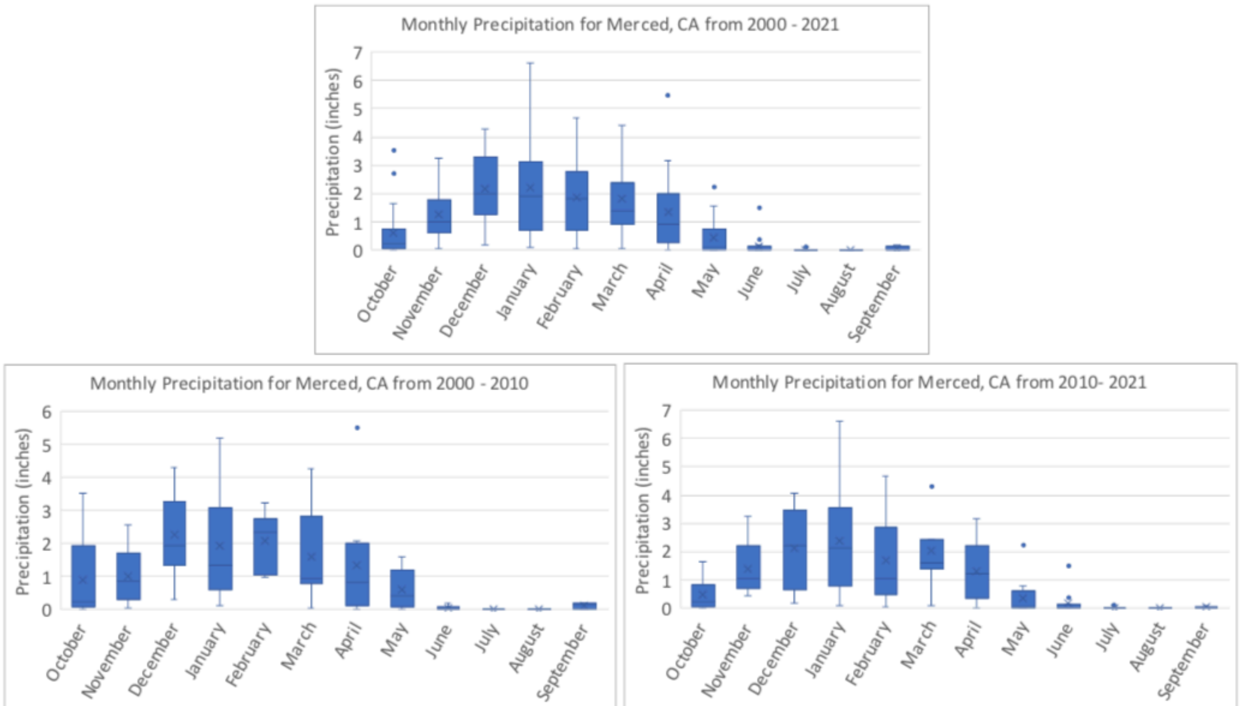

Figure 5. Graphs of average monthly precipitation for Merced, CA.

Figure 6 shows similar graphs as in Figure 5, but with average monthly discharge for the Merced River. The Merced River originates in the Sierra Nevadas and flows through Merced, CA. The top graph shows the distribution of historical monthly discharge for the Merced River between 2000 to 2020. To see if there was any observable trend the data was split between 2000 – 2010 and 2010 – 2021. From these plots there was observably higher ranges of discharge and in earlier months in the most recent years.

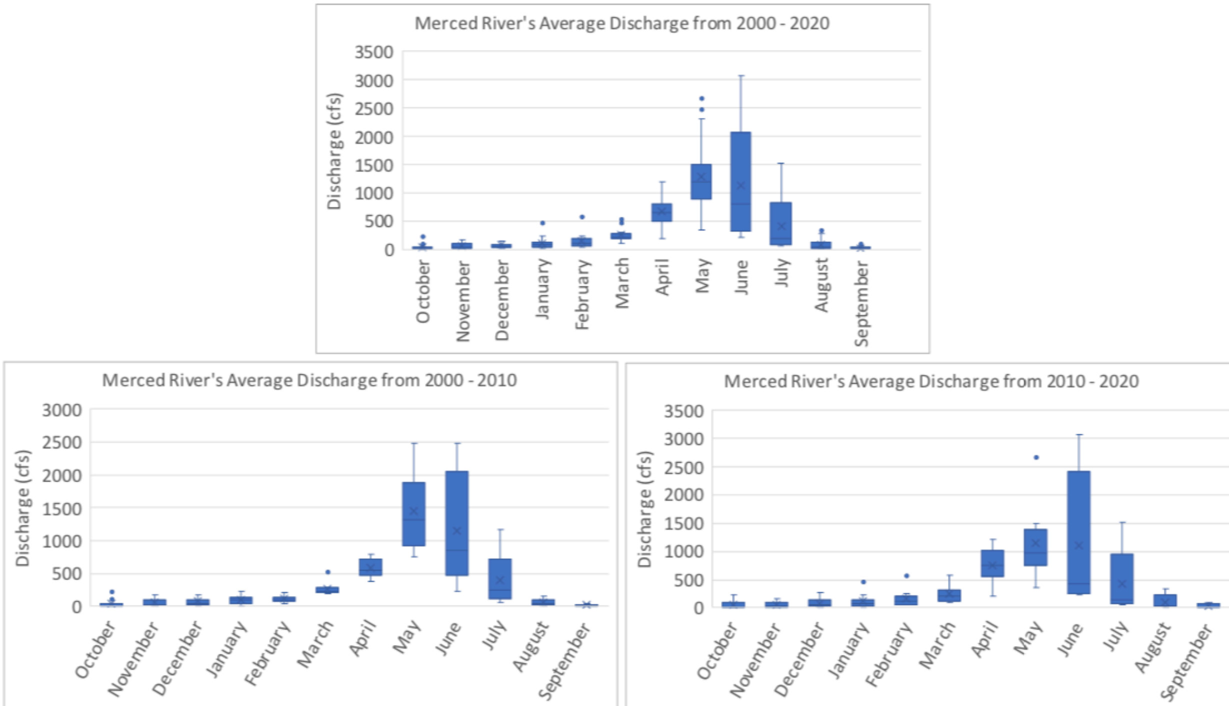

Figure 6. Graphs of average monthly discharge for the Merced River.

Conclusion

Regions across California's Central Valley that are potentially suitable and would benefit from Flood-MAR actions were successfully identified, based on the set criteria of this study. For the City of Merced and surrounding regions, potential source water for Flood-MAR projects is projected to occur from heavier and earlier precipitation events and earlier peak flows in the Merced River. These peak flows could possibly be attributed to earlier snowmelt events. This study briefly covers the potential for Flood-MAR projects. It must be acknowledged that actual Flood-MAR projects require further research and criteria to be met per each site in consideration.

Discussion

In completing this study, a significant amount of knowledge on Flood-MAR was gained. Although Flood-MAR is not a part of my PhD research, I chose this study out of my own curiosity. After reading the DWR's Flood-MAR White Paper, I was made aware of all the research and data gaps involved with Flood-MAR. There's potential in this water resources management strategy, however there's a lot of hurtles to overcome before we see a mass take off of Flood-MAR projects. After completing this simplified Flood-MAR study, I plan on tracking the progress of this management strategy. Ideally, I would like to see these Flood-MAR projects to have a social impact and serve disadvantaged communities.

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