Agricultural Adaptation to Climate Change in Yolo County, California

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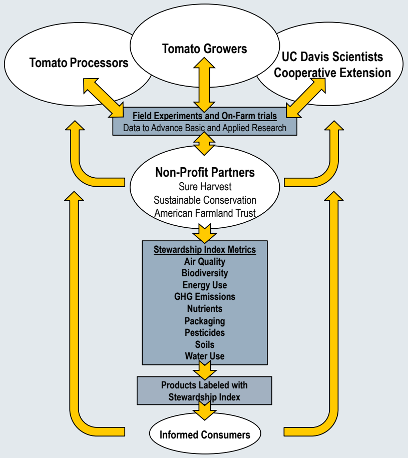
Introduction

In California, the Global Warming Solutions Act (AB32) has been the impetus for major new efforts within the government and agriculture sectors to assess impacts, mitigate GHG emissions, and adapt production strategies. Successful mitigation and adaptation at the regional and local scales will depend on effective exchange of ideas, tools, and data between scientists, policy makers, industry leaders, and rural stakeholders. Here we present four case studies set in Yolo County, CA which describe ongoing research activities on agricultural greenhouse gas (GHG) mitigation and adaptation that cut across scales and involve participation from a range of agencies and stakeholders.

Farm Production Practices

Linking Data to Stewardship Index for Specialty Crops

Various groups in the agricultural sector are working on the concept of a stewardship index for specialty crops to better inform consumers about products. It will be important to include climate change mitigation and responses.



Tomato Processors

Tomato Growers

UC Davis Scientists
Cooperative Extension

Field Experiments and On-Farm trials
Data to Advance Basic and Applied Research

Non-Profit Partners
Sure Harvest
Sustainable Conservation
American Farmland Trust

Stewardship Index Metrics
Air Quality
Biodiversity
Energy Use
GHG Emissions
Nutrients
Packaging
Pesticides
Soils
Water Use

Products Labeled with Stewardship Index

Informed Consumers

Figure 1. Diagram mapping the hypothetical flow of sustainability information and feedback between tomato growers, processors, scientists, non-profit partners and consumers.

Example: Alternative Water Management in Tomatoes

Field research on tomatoes is examining how conventional furrow irrigation (i.e. all furrows irrigated) and alternate furrow irrigation (i.e. every other furrow irrigated) affect yield, water use, and N_2O emissions (Barrios-Masias et al., in prep.).

Table 1. Effects of irrigation practice on yield, water use, and N_2O emissions in processing tomatoes.

Practice	% Difference Relative to Conventional Irrigation		
	Yield	Water Use	N_2O Emissions
Alternate Furrow Irrigation	N.S.	- 20.0%	N.S.

Landscape Hydrology

Planning for an Uncertain Climate Using the WEAP Model

Collaborative research with managers of the Yolo County Flood Control and Water Conservation District and the Stockholm Environment Institute (SEI) is focused on the development of a water evaluation and planning (WEAP) model for the Cache Creek watershed (Mehta et al., in prep.).

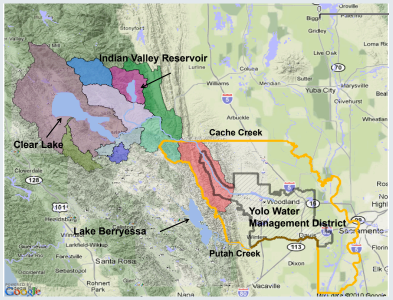
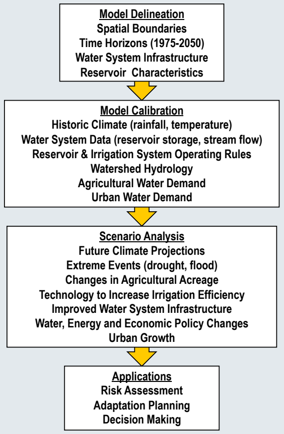


Figure 2. Map of Cache Creek watersheds in the Yolo County Flood Control and Water Management District (Mehta et al., in prep.).



Model Delineation
Spatial Boundaries
Time Horizons (1975-2050)
Water System Infrastructure
Reservoir Characteristics

Model Calibration
Historic Climate (rainfall, temperature)
Water System Data (reservoir storage, stream flow)
Reservoir & Irrigation System Operating Rules
Watershed Hydrology
Agricultural Water Demand
Urban Water Demand

Scenario Analysis
Future Climate Projections
Extreme Events (drought, flood)
Changes in Agricultural Acreage
Technology to Increase Irrigation Efficiency
Improved Water System Infrastructure
Water, Energy and Economic Policy Changes
Urban Growth

Applications
Risk Assessment
Adaptation Planning
Decision Making

Figure 3. Diagram illustrating the WEAP model delineation, calibration, scenario analysis, and management applications.

Local Agricultural GHG Emissions

Yolo County GHG Inventory

Scientists, growers, and other rural stakeholders are working with local officials to carry out an inventory of Yolo County's GHG emissions as a part of a county-wide climate action plan that considers the role of agriculture in GHG mitigation and climate change adaptation. Inventory methods developed by the International Panel on Climate Change (IPCC) and the California Air Resources Board (CARB) were adapted to county level data to estimate changes in agricultural emissions of CO_2, N_2O and CH_4 between 1990 (AB32 base year) and 2008 (Haden et al., in prep.).

Table 2. Inventory of agricultural GHG emissions for Yolo County in 1990 and 2008 (Haden et al., in prep.). The mass of all greenhouse gases (CO_2, N_2O and CH_4) are expressed in kilotons of carbon dioxide equivalents (kt CO_2 E).

Emissions Category	Gases	1990 Emissions		2008 Emissions		Change
Agricultural Soils		**kt CO_2 E**	**%**	**kt CO_2 E**	**%**	**%**
• Direct	N_2O	124.9	36.7	94.0	30.3	- 24.7
• Indirect	N_2O	32.1	9.4	23.5	7.6	- 26.8
• Rice Cultivation	CH_4	30.6	9.0	37.1	12.0	+ 21.2
• Lime	CO_2	4.3	1.3	2.3	0.7	- 46.5
• Urea	CO_2	4.2	1.2	3.5	1.1	- 16.7
Agricultural Fuel Use						
• Farm Equipment	CO_2, N_2O, CH_4	72.2	21.2	71.7	23.1	- 0.7
• Irrigation	CO_2, N_2O, CH_4	39.2	11.5	39.2	12.7	0.0
Livestock*	CH_4	31.6	9.3	37.9	12.2	+ 19.9
Residue Burning**	N_2O, CH_4	0.9	0.3	0.6	0.2	- 33.3
Total Ag. Emissions		**340.0**		**309.8**		**- 8.9**

*N excreted from livestock was included in the direct and indirect N_2O emissions category under agricultural soils.

**CO_2 from residue burning is considered a biogenic emission and thus was not included in this inventory.

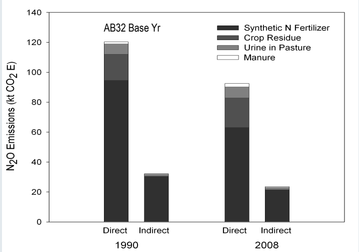


Figure 4. Direct and indirect N_2O emissions from agriculture in Yolo County during 1990 and 2008 distributed by N source based on IPCC Inventory Guidelines (Haden et al., in prep.). Drop in synthetic N fertilizer emissions is due to an 8% drop in agricultural acreage.

Opportunities and tradeoffs for GHG mitigation in Yolo County agriculture (Jackson et al., 2009)

- Reduce N fertilizer rates and improve N use efficiency
  Tradeoff - may reduce yield
- Cover cropping to reduce N_2O emissions
  Tradeoff - fuel/costs to establish and disc under
- Conservation tillage to reduce fuel use
  Tradeoff - not compatible with some crop rotations
- Improve irrigation efficiency
  Tradeoff - adverse effects on groundwater recharge
- Improve manure management (i.e. biogas production)
  Tradeoff - costs, generators may not meet air quality regs.
- Alternative water and residue management practices in rice
  Tradeoff - reduced yield, straw disposal, waterfowl habitat

Restoring Hedgerows and Riparian Zones

Farmscaping for C Sequestration

On-farm research measuring carbon stocks, agrobiodiversity, and nutrient losses to the environment in fields, hedgerows, and riparian corridors assessed ecosystem services provided by various farmscaping practices (Young-Mathews et al., 2010). County government officials, who are developing a climate action plan, are using the results to evaluate the opportunities to sequester carbon and offset GHG emissions.

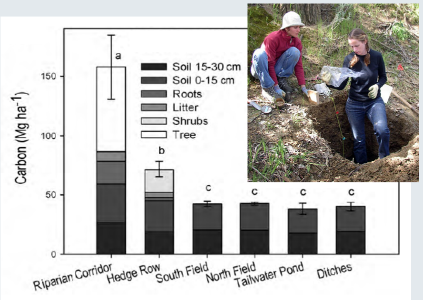


Figure 5. Soil and plant carbon stocks as a function of farmscaping practice. (Adapted from Smukler et al., 2010)

Farmscaping for Biodiversity and Resilience

Riparian corridors and hedgerows can also increase biodiversity, provide habitat for beneficial insects, reduce runoff, and improve water quality. Thus, farmscaping may also enhance ecosystem stability and resilience to climate change. Partners in the non-profit sector (e.g. Audubon Society) and various government agencies (e.g. Yolo Resource Conservation District) are helping promote incentives for growers and ranchers to plant hedgerows and restore riparian zones.

Conclusions

Outcomes of this collaborative research include:

- Shared-learning about climate change risks and adaptation among various stakeholders and sectors.
- Development of locally-adapted planning tools: (i.e. WEAP model, GHG Inventory)
- Market and government-based incentives for improving crop and water management, mitigating GHG emissions, and restoring riparian forests
- Improved mitigation and adaptive capacity at the local level

Acknowledgments and References

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