Research Poster

Using Formative Evaluation to Enhance Climate Adaptation Extension and Communication among Farmers in California

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Introduction/Need for the Study

California leads the nation in overall agricultural revenue and is the primary producer of specialty crops in the United States (CDFA, 2025). However, its agriculture is at a critical juncture due to the projected climate change trends and associated impacts in the coming decades (Pathak et al., 2018). Farmers face constant pressure to adapt to unpredictable weather and climate extremes and are increasingly seeking resources to address their specific climate adaptation needs (Ikendi et al., 2024; Pinzón et al., 2025). To support their cause, a transdisciplinary team of researchers and educators from the University of California organized needs-based regional and commodity-specific climate adaptation training. By addressing climate issues through extension education, we are addressing the National American Association for Agricultural Education's (AAAE) research value of "enhancing environmental health" (AAAE, 2023, p. 9). This study assessed the self-reported knowledge change of farmers on adaptation practices as a result of attending the extension education events.

Theoretical Framework

The theory of planned behavior (TPB) served as the framework for this study. TPB purports that every planned action is influenced by attitude towards behavior, subjective norm, and perceived behavioral control (Ajzen & Schmidt, 2020). Attitude relates to how one thinks and feels about a behavior. The subjective norms relate to the social interactions, social pressures, and support given by members of social circles. The perceived behavioral control is ascribed to an individual's feeling of having the ability to accomplish a task. In our study, subjective norms are centered around the pressures from climate change trends and impacts projected to adversely affect the agricultural industry in California in the coming decades (Pathak et al., 2018). Farmers' knowledge of adaptation practices was considered as perceived behavioral control. Participating in climate adaptation extension education events and gaining knowledge is one way of overcoming barriers and challenges to adaptation.

Methodology

A retrospective post-then-pre survey design was used to measure self-reported change happening as a result of participation in adaptation extension education events. The study focused on knowledge assessment on a five-point Likert-type scale ranging from no knowledge, minimal knowledge, basic knowledge, adequate knowledge, and superior knowledge. Assessments were conducted on 28 adaptation themes derived from needs assessment (Ikendi et al., 2024) and were delivered by 30 speakers in Merced and Tulare counties (Central Valley) and Ventura and Monterey counties (Central Coast). The evaluation team developed the survey based on the proposed presentations and was modified by the project team for validity (Ary et al., 2019). Data were collected through self-administration of the survey by the respondents after every training session. A total of 122 participants completed the survey, including 63 farmers and 59 technical service providers (TSPs). However, TSPs' responses were removed from the final analysis to control contamination of the sample. Data were analyzed using SPSS v.31. Likert-type items were tested for reliability using Cronbach's alpha, and the alpha value pre-training was 0.842 and after training was 0.863, indicating a strong consistency (Forero, 2023).

Results and Discussions

In the pre-event knowledge assessment of the farmers, the overall ***mean*** on knowledge of adaptation practices was 2.80±0.828 (minimal knowledge), and after the event, the overall ***mean*** on knowledge was 4.10±0.706 (adequate knowledge), indicating an overall 1.30 point change (26%) knowledge

gain. There were a total of 28 adaptation themes (practices, programs, and resources) delivered based on needs assessment and agricultural operations in the region across California (Ikendi et al., 2024). Overall, high knowledge change was reflected in CalAgroTools for managing agriculture risks, 37%, the CDFA web repository for adaptation practices and resources, 36%, and adaptation financial incentives, 35%. However, before the adaptation extension education events, farmers indicated they had more knowledge in water resource management, 3.54±0.776, whole orchard recycling (WOR), 3.38±0.622, and drought impact on orchards, 3.23±1.193. After the training, farmers indicated more knowledge in WOR, 4.54±0.574, drought on orchards, 4.42±0.900, and cover crops, 4.38±0.725.

Farmers shared their experiences alongside the learning lessons from the extension education events. In a session on climate change impact on pests, for instance, a farmer reported, "*South of Bakersfield, growers are already seeing a 5th generation of naval orangeworm [NOW]*", resonating with the findings of Martínez-Lüscher et al. (2022), who also add that the Southern Sierra had enough growing degree days for more than four NOW generations. Another farmer reported, "*I learned more about the connections between temperature, how it impacts pest emergency timing and overall populations, and how it will change my management practices.*"

Farmers also gained knowledge of cover crops in addition to their practical aspects associated with implementing these practices. One farmer stated, "*The talk on winter cover cropping was very interesting and informative. I had no previous knowledge of potential additional light availability due to reflection off of a cover crop*." Winter cover cropping is not widely adopted in the semi-arid western states (LaRose & Myers, 2019), and the lack of accurate water-related information required to establish and maintain cover crops and their cost-benefits partly accounts for low adoption (DeVincentis et al., 2022). The session on nutrient management and WOR was helpful to farmers' knowledge. One farmer reported, "*I learned how quickly nitrogen becomes available after WOR, which will guide my future fertilizer applications. Also learned what type of fertilizer to apply and when*." The presentation focused on replanting orchards, covering considerations in nutrient management and its implications for fertilizer use and the generation of greenhouse gases following WOR chips (Jahanzad et al., 2022). This response shows a potential for continued practice of WOR in adaptation (Jahanzad et al., 2020).

Conclusions

This study measured knowledge changes related to adaptation extension education events for farmers in the Central Valley and Central Coast of California. Largely, there was a statistically significant change in knowledge from a mean of 2.80±0.828 to 4.10±0.706, reflecting a 1.30-point (26%) knowledge gain after the extension events, which moved participants from "minimal" to "adequate" knowledge. In addition to the training, farmers demonstrated knowledge gain owing to their familiarity with the climate issues discussed and the potential for adoption of recommended adaptation practices while harnessing the resources arising from the scientific research conducted and shared within their local communities. This farmer's prior knowledge and lived experiences can be harnessed through peer educators and network development for resource sharing (Sutherland & Marchand, 2021).

Implications

By organizing needs-based education events for farmers, we can enhance their ability and intention to adapt and respond to climate stressors, enhancing their socio-economic stability. Organizing regional and crop-specific events is critical in diverse agricultural states such as California. Such events rely on the place-based expertise of collaborators and stakeholders in a participatory manner and potentially influence attitudes, subjective norms, and result in adoption. By working collaboratively to co-produce ideas and integrate both technical and place-based experience and knowledge, Extension ensures outputs are relevant to stakeholders and improve social and ecological outcomes.

References

Ajzen, I., & Schmidt, P. (2020). Changing behavior using the theory of planned behavior. In M. S. Hagger, L. D., Cameron, K. Hamilton, N. Hankonen, & T. Lintunen (Eds.), (2020). *The handbook of behavior change* (pp. 17−31). Cambridge University Press.

American Association for Agricultural Education (AAAE). (2023). AAAE research values. https://aaaeonline.org/National-Research-Values

Ary, D., Jacobs, L. C., Irvine, C. K. S., & Walker, D. A. (2019). *Introduction to research in education*. Cengage Learning.

California Department of Food and Agriculture (2023). *California agricultural statistics review 2023–2024*. Sacramento, California, United States. https://www.cdfa.ca.gov/statistics/

DeVincentis, A., Solis, S., Rice, S., Zaccaria, D., Snyder, R., Maskey, M., Gomes, A., Gaudin, A., & Mitchell, J. (2022). Impacts of winter cover cropping on soil moisture and evapotranspiration in California's specialty crop fields may be minimal during winter months. *California Agriculture*, *76*(1), 37–45. https://doi.org/10.3733/ca.2022a0001

Forero, C. G. (2023). Cronbach's alpha. In F. Maggino (Eds.) *Encyclopedia of quality of life and well-being research* (pp. 1505–1507). Springer.

Ikendi, S., Pinzón, N., Koundinya, V., Taku-Forchu, N., Roche, L. M., Ostoja, S. M., ... & Pathak, T. B. (2024). Climate smart agriculture: Assessing needs and perceptions of California's farmers. *Frontiers in Sustainable Food Systems*, *8*, 1395547. https://doi.org/10.3389/fsufs.2024.1395547

Jahanzad, E., Brewer, K. M., Poret-Peterson, A. T., Culumber, C. M., Holtz, B. A., & Gaudin, A. C. M. (2022). Effects of whole-orchard recycling on nitrate leaching potential in almond production systems. *Journal of Environmental Quality, 51*(5), 941–951. https://doi.org/10.1002/jeq2.20385

Jahanzad, E., Holtz, B. A., Zuber, C. A., Doll, D., Brewer, K. M., Hogan, S., & Gaudin, A. C. (2020). Orchard recycling improves climate change adaptation and mitigation potential of almond production systems. *PLoS One, 15*(3), e0229588. https://doi.org/10.1371/journal.pone.0229588

Martínez-Lüscher, J., Teitelbaum, T., Mele, A., Ma, O., Frewin, A. J., & Hazell, J. (2022). High-resolution weather network reveals a high spatial variability in air temperature in the Central Valley of California with implications for crop and pest management. *PloS One, 17*(5), e0267607. https://doi.org/10.1371/journal.pone.0267607

Pathak, T. B., Maskey, M. L., Dahlberg, J. A., Kearns, F., Bali, K. M., & Zaccaria, D. (2018). Climate change trends and impacts on California agriculture: A detailed review. *Agronomy, 8*(3), 25. https://doi.org/10.3390/agronomy8030025

Pinzón, N., Galt, R., Roche, L., Schohr, T., Shobe, B., Koundinya, V., ... & Powell, J. (2025). Farming and ranching through wildfire: Producers' critical role in fire risk management and emergency response. *California Agriculture*, *79*(1), 9−18. https://doi.org/10.3733/001c.128403

Sutherland, L. A., & Marchand, F. (2021). On-farm demonstration: Enabling peer-to-peer learning. *The Journal of Agricultural Education and Extension, 27*(5), 573–590. https://doi.org/10.1080/1389224X.2021.1959716