‘FOREVER CHEMICALS’ IN PESTICIDES: UNDERSTANDING PFAS CONTAMINATION AND POLICY IMPLICATIONS FOR WATER QUALITY

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Executive Summary

Per- and polyfluoroalkyl substances (PFAS), or "Forever Chemicals," are synthetic chemicals used in various industries for consumer and industrial products for their properties that enhance the products. Their chemical bonds make them resistant to water, oil, and heat. The consequences of this widespread and commonly used chemical in many products have led to a pervasive presence in human health and the environment. Due to their strong, persistent bonds, these 'forever chemicals' do not easily break down and contaminate water, food, wildlife, soil, and humans worldwide. The detected PFAS have chemical carbon-fluorinated bonds that have allowed this chemical to bioaccumulate. The bioaccumulation effects and the inability to easily dispose of PFAS have brought attention to PFAS and raised concerns for the environment and public health. Scientific studies have found pesticides to be a significant source of PFAS contamination, contributing to pollution in agricultural lands, surface water, groundwater, and other critical water resources. There is still insufficient attention given to the size of the issue. With this policy report, I analyze and suggest policy recommendations that may help bridge the gaps from a policy perspective and focus on the question: What policy strategies can effectively mitigate the impact of PFAS in pesticides on California's water quality? Due to a lack of understanding of PFAS, regulatory oversight has become limited and fragmented. However, there have been significant and reassuring collaborative efforts from different governmental and independent organizations to address the contamination of PFAS, instilling hope for the future. In 2025, California has taken a proactive approach to include legislation such as Assembly Bill 794 and Senate Bill 682 to mitigate the issue of PFAS contamination in addition to past efforts. To find more practical solutions, this policy report examines the impact of PFAS on pesticides,

creating environmental risk and exposure. It explores the past and current regulatory frameworks that mitigate pesticide safety.

Additionally, this policy report focuses on policy initiatives to manage PFAS in pesticides. By using the Criteria Alternatives Matrix (CAM) framework to recommend better policy recommendations, this framework allows for analyzing policy alternatives and ranking them based on criteria. This report includes CAM's policy recommendations to help alleviate the issue and strengthen regulatory oversight to ensure long-term water quality and protection.

I. Introduction

Per- and poly-fluoroalkyl substances (PFAS), often called "Forever Chemicals," are a sizeable group of synthetic chemicals invented in 1930 (Brennan et al., 2021). PFAS have since infiltrated a wide range of consumer products, from cookware to clothes and even agricultural pesticides. Due to its properties, it became popular to include in the manufacturing of many products. The agricultural sector uses PFAS in pesticides because these chemicals provide stability, product longevity, and oil-repellent properties. Due to the molecules that have a chain link that creates carbon-fluorine bonds with Carbon and Fluorine atoms, the chemical is powerful compared to other chemicals, which results in not being able to degrade quickly in the environment and creating huge impacts (NIEHS, 2025). This powerful bond makes them unable to degrade naturally into the environment. As a result, there is accumulation in the environment, such as water sources, living organisms, and soil. This affects not only the health of humans but also wildlife.

The Environmental Protection Agency defines a pesticide as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest; intended for use as a plant regulator, defoliant, or desiccant" (EPA, 2025). This widespread use has led to a pressing environmental issue that demands urgent attention. PFAS contamination of these pesticides, from manufacture to storage, has raised a significant concern that demands attention. This urgency underscores the need for immediate action to address the PFAS in pesticides.

The role of PFAS in pesticides became essential because it made the pesticides stronger, more stable, and more effective. However, 'Forever chemicals' are threatening public health and the environment. Pesticides are among the many ways PFAS can spread into the environment and cause many side effects. The chemical has a significant impact; we must take many steps to mitigate contamination. These steps include rigorous testing, proper disposal methods, and the implementation of new regulations for these forever chemicals. We do not know the long-term impact of these PFAS and how they will affect humans and the environment. PFAS contamination has brought implications and concerns for public health, environmental contamination, ecological impacts, food safety, and regulatory gaps. The State Water Resource Board (2024) has reported the potential impact of the PFAS contamination on humans, such as exposure to these chemicals, leading to health issues such as liver damage, effects on the immune system, cancer, and other issues. There have been several studies both through governmental agencies, independent studies, and reposts that have shown the contamination to the environment such as the City of Tustin where US streams have been tested and the samples have been analyzed, tap water samples from Southeast Los Angeles, San Francisco, Gold County, and the Central Valley showing PFAS contamination in tap water.

However, in recent years, efforts and awareness have increased about the need for change and recommendations for the following steps to mitigate the issue. The environmental impacts of PFAS on surface water quality are significant, affecting water systems throughout their pathway. Pesticides alone are already an issue that affects the environment, and the PFAS affecting some pesticides is intensifying these issues and affecting the environment. The pesticides contaminate the PFAS, making it easier for the contamination to happen. Due to its chemical stability, PFAS is challenging to extract from the environment and dispose of on the properly with less impact. This leads to more significant problems and contamination of California's lakes, groundwater, rivers, and drinking water sources.

Due to the past lack of regulation and investigation of PFAS, many industries have included this chemical in their products, including the agricultural sector, in this case, with pesticides. PFAS awareness and initiatives to mitigate the impacts have increased. However, states and other countries continue to use these chemicals. The widespread use of PFAS in agriculture has led to many negative consequences. Studies show that 14% of the Pesticides used in the United States have active ingredients, including PFAS. One-third of the pesticides with PFAS received approval in the past 10 years (Center for Food Safety, 2025). We do not know the long-term impact of these PFAS and how they will affect humans and the environment. PFAS contamination has brought implications and concerns for public health, environmental contamination, ecological impacts, food safety, and regulatory gaps. However, in recent years, various groups have increased efforts and awareness, calling for changes and recommending steps to mitigate the issue. PFAS has become a grave environmental and public health concern, which makes it essential to understand their role in agricultural pesticides and the impact that the runoff of these pesticides, contaminated with PFAS, has on water quality in California. The spread and accumulation of PFAS impact water quality supplies, ecosystems, and public health, which is why this topic is essential.

In this policy report, I explore potential policy alternatives and strategies to mitigate PFAS in pesticides that contribute to water contamination and evaluate their effectiveness. It is essential to minimize this issue as it can cause water contamination and impact species and human lives through bioaccumulation. It is necessary to take as much action as possible to mitigate these issues and help keep humans and the environment protected from the consequences of the impacts of the 'Forever Chemicals.' Ensuring we have mitigation strategies for PFAS for the current and future environmental and public health. Further consequences, such as more community environmental disparities due to a lack of PFAS mitigation, may lead to added issues. Additionally, PFAS will affect various elements of the environment, including species, soil, and water. It is essential to ensure that there is a collective action and collaborative approach from agencies such as the United States Department of Agriculture, Environmental Protection Agency (EPA), CA Department of Pesticide Regulation, State of Water Resource Board, CA Department of Food and Agriculture (CDFA), Department of Water Resources, Scientific experts in PFAS and Water quality and other agencies that can help mistake through collaborations. The Critical Analysis Matrix (CAM) framework is a widely accepted method for assessing policy effectiveness, the effectiveness of policy alternatives in addressing PFAS contamination, and improving water quality and public and environmental health. This policy report addresses the gaps in the mitigation process by analyzing the literature and suggesting policy recommendations examined through the CAM Analysis. This policy report also aims to contribute to answering the question of "What policy strategies can effectively mitigate the impact of PFAS in pesticides on California's water quality?"

II. Background

Since the 1930s, per- and polyfluoroalkyl substances (PFAS), also known as "forever chemicals," have been in use (Brennan et al., 2021). Scientists have studied PFAS as groups and divided them into their carbon-fluorine bonds: long chain, short chain, and ultra-short chain (Brennan et al., 2021). The chemicals have become essential when making products more practical, such as firefighting foam, industrial applications, pesticides, and everyday household items, due to the unique chemical properties that help them be more effective (Brennan et al., 2021); however, this has led to enormous scale contamination at a global level for the water supply.

There has been concern that these chemicals pose a threat due to their bioaccumulation ability in wildlife and humans (Donley et al., 2024). There are two ecosystem concerns amid growing scholarly attention to PFAS on the environment. One of these ecosystem concerns is that PFAS affect water quality, which can harm humans and ecosystems, leading to larger issues (Michigan PFAS Action Response Team, 2025). PFAS has become an issue due to its inability to break down naturally, which has created more problems. Pesticides are essential to mention when discussing PFAS in water sources. The application of pesticides has raised concerns about the contamination of food and water supply (Perkins, 2024). There are many reasons that PFAS can contaminate the water, and pesticides are one of the ways. It is crucial to raise awareness about the impact of PFAS in pesticides on water quality at various levels, such as drinking water, groundwater, watersheds, and surface water (Donley et al., 2024). Research has focused on the need to mitigate these negative impacts from PFAS. There has been an intent for more studies and the implementation of regulations that will help reduce this problem.

III. Literature Review

PFAS in Pesticides: Sources and Presence

Monitoring programs and testing have detected PFAS in air, water, soil, wildlife, and humans on a global scale; however, researchers have not thoroughly investigated the pesticides that have PFAS, and the specific contributions of these pesticides to the environment remain unclear. Throughout the literature, the long-term effects of these PFAS in pesticides and the long-term impacts that they may cause on humans and the environment are unknown. The introduction of PFAS into the agricultural industry through the active or inert ingredients of pesticides in chemical solutions (EPA, 2024). Hall et al. (2024) document that PFAS may come from applying biosolids for fertilizer purposes and PFAS-contaminated water (wastewater treatment byproducts) for agricultural irrigation and other sources. Pesticides have been around exceptionally long to help end certain organisms or viruses. A pesticide is any substance or mixture used to prevent, destroy, repel, or mitigate any pest; they are plant regulators, defoliants, desiccants, or nitrogen stabilizers (EPA, 2023).

Pesticide products have both inert and active ingredients. When discussing the need for further research on PFAS, examining the inert and active ingredients in pesticides is crucial. Active ingredients are the chemicals listed on each pesticide's product label (EPA, 2023). Labels with the percentage of the weight of each active ingredient are a requirement. Distinct categories of active ingredients include conventional, antimicrobial, and biopesticides (EPA, 2023). The other chemicals found in pesticides are inert ingredients. The EPA (2023) defines these inert ingredients as "all other ingredients," which do not include the active ingredients intentionally added to formulate pesticides. The purpose of this crucial ingredient is to prevent caking and foaming, extend shelf life, and improve the application data, the effectiveness, stability, shelf life of products, and the ability to have properties to keep the coating of the pesticides even and on the crops (EPA, 2024). However, this does not mean that they are non-toxic. Under federal law, the EPA reviews and approves all the ingredients before including them in pesticides (EPA, 2023). The EPA plays a crucial role in regulating the approval and use of pesticides, ensuring they are safe for the environment and human health. The EPA has required that all pesticides undergo a rigorous review and registration while assessing the risks to human health and the environment (Hall et al., 2024). It is a requirement for the manufacturer to list the total percentage of ALL inert ingredients on the product label and not the percentage by individual names or percentages of the inert ingredients (EPA, 2023). However, PFAS has become a growing source of environmental contamination due to one of the main factors being that companies are not fully required to disclose or have rampancy of chemicals they use, specifically the PFAS that are used in the inert ingredient for the Pesticides, which makes it has to fully have data and asses the issue in the hand of PFAS contamination (Perkins, 2024). The strong carbon-fluorine bonds have made PFAS hard to remove as PFAS bioaccumulates, as this carbon-fluorinated form makes it resistant to heat, water, oil, and degradation (Brennan et al., 2021).

There are growing concerns about PFAS and how they affect other everyday products, such as pesticides, which cause more contamination of overall water quality. There have been tries to find the origin of how PFAS contaminates the chemical solution of pesticides, but there are many challenges. Figuring out where PFAS cause pesticide contamination can be challenging, whether companies intentionally add them to the active ingredients or do not list them among the inert ingredients. Only manufacturers must publicly display the active ingredients on the product labels with the percentage of each ingredient (Donley et al., 2024). Donley et al. (2024) help us understand that finding the PFAS source in pesticides that have PFAS can be challenging. PFAS enters pesticides when manufacturers intentionally add them to the active or inert ingredients. Researchers mention that many conventional pesticides have PFAS and have received approval to enter the market by passing regulations. They say that at least 23 percent of the pesticides have at least one carbon-fluorine bond, 61 percent qualify as organofluorine, and 30 percent are PFAS (Donley et al., 2024). The Center for Biological Diversity (Donley, 2024) reported that testing has revealed that 40% of pesticides have PFAS. They also discuss the possibility of having an unintentional addition of PFAS. The unintentional added factors connect to leaching from the storage containers used to store the pesticides. High-density Polyethylene (HDPE) containers, used to store many products, including pesticides, have contributed to past PFAS pesticide contamination used by manufacturers. The EPA tried to create a regulation prohibiting the use of HDPE containers for pesticide containers; however, this effort failed when the federal court overturned their case in late 2023 (Donley et al., 2024).

The EPA (2025) found that HDPE containers contaminate pesticides with PFAS, causing these chemicals to leach into the stored products. The investigation done by the EPA showed that the source of PFAS contamination in certain pesticide products was the fluorinated containers used in the storage or transportation process of the chemicals inside the containers (2025). The method of fluorination improves the stability and portability of the container, creating a barrier that helps, but also leaches PFAS as a side effect. The fluorination process involves treating the container with fluorine gas or a fluorine-containing compound to create a protective barrier. However, this process can also lead to the unintended consequence of PFAS leaching into the liquid product stored inside. The time of storage also affects the concentration and changes of PFAS leaching into the product (EPA, 2025).

Environmental Impact

The Center for Food Safety (2025) highlights a grave concern about PFAS in pesticides. Independent testing and studies have confirmed the presence of PFAS in pesticides, either added to the active ingredient or leached from HDPE Containers. This contamination poses a significant risk to waterways, ecosystems, and human health. A peer-reviewed study, "Targeted Analysis and Total Oxidizable Precursor Assay of several Insecticides for PFAS," published in 2022, confirmed the presence of PFAS in water sources, leading to potential health risks. The study found that 14 percent of the U.S. pesticide active ingredients are PFAS, and one-third received approval in the past 10 years, since 2022. Researchers have detected PFAS in streams and rivers, with some samples showing high concentrations of PFAS, further highlighting the gravity of the situation. The EPA reported that the amount of leaching of PFAS can vary, as there are several types of HDPE containers and various fluorination levels (EPA, 2022).

Donley et al. (2024) highlight the consequences of PFAS in pesticides and how this can harm the environment due to its persistence, due to the carbon-fluorine bonds that can resist degradation. Carbon-fluorine bonds have been known to be powerful bonds in chemistry as they are strong and have high stability. This strong stability makes it hard to break them through degradation processes, including hydrolysis, oxidation, and microbial breakdowns (Sau et al., 2024). The studies that have been done to find the complete degradation of these forever chemicals have run short and never reached a point where they can fully understand the formation of the long-term effects of PFAS. However, there have been studies on water contamination, and they have found that PFAS pesticide residue is higher in the U.S. in groundwater. The City of Tustin, CA (2023) reports that its former MCAS Tustin has a history of soil and groundwater contamination due to past military operations (1942-1999) and agricultural activities. Donley et al. (2024) found through their analysis of data and records that 13 out of 225 pesticide compounds tested in water samples are PFAS. They also found 16 samples with fluorinated degradants, resulting in 29 PFAS analytes. Of those 29, 27 (93%) appeared in U.S. streams (Donley et al. 2024). Behren et al. (2024) have shared results from a study done in 60 homes across California in four geographical diverse regions (Los Angeles, Centra Valley, Gold Country, and San Francisco), they report in their study that they found 18 out of 60 tap water samples had at least one type of PFAS that was detectable which 89% of the detections was collected in heavily industrialized Southeast Los Angeles. The Central Valley had 5%, Gold Country had 8%, and San Francisco had 0% PFAS samples.

One of the many ways PFAS contamination enters water sources is through pesticide runoff that has PFAS. Some manufacturers formulate pesticides with one or more regulated PFAS that pass the regulatory tests, while they add unregulated PFAS as inert ingredients. When farmers apply pesticides with PFAS, the chemicals reach the crop and soil. Agricultural runoff is a way that PFAS can get into water systems through irrigation and rain, which carry and release PFAS that have contaminated the plants and the soil. Due to the makeup of these "Forever chemicals," they persist in the environment and are resistant to any degradation. The inability to degrade makes the PFAS an issue and a massive contamination. There is growing awareness highlighting the need to act across the board.

Action Taken

Many actions have taken place, such as setting up guidelines, standards, and regulations; however, the initiative to take any action comes from individual agencies or partners and states (Wee et al., 2023). There has been a push for alternative PFAS, which has become increasingly prominent. New regulations have tried to solve the issue over the years, but these regulations have only mitigated the problem to a certain extent due to several factors. The urgency for action is essential to protect water quality, as many water sources and other environmental elements, such as surface water, ground water, drinking water, air, and sediment (Wee et al., 2023).

Agencies such as the USDA and the EPA have taken the initiative to construct a roadmap plan to tackle the general issue of PFAS. Some of the items in this plan are associated with water quality affected by PFAS. The USDA has developed a USDA Agricultural Service (2024) Roadmap, an initiative to mitigate the PFAS in U.S. Agriculture. The key thing in this road map is to fully understand the threat of PFAS in the agricultural soils and water that have caused challenges in the U.S. Producers, food, ecosystems, and farming communities. This road map highlights the need for more research-driven solutions to fully understand PFAS through detection methods and develop strategies to tackle the issue. The focus will be on multi-agency collaborations for detecting and remediating PFAS contamination in agriculture. Data standardization, future research commitments, and sustainable supply safety are key elements. The EPA's PFAS Strategic Roadmap (2021-2024) aims to address these "Forever chemicals" risks through research, restrictions, and faster cleanup efforts. This includes setting up drinking water standards, appointing PFAS and PFOS as hazardous substances, enforcing industrial discharge regulations, and engaging community support to tackle contamination effectively.

Critics have criticized the EPA's Roadmap for not addressing the new PFAS contaminating the environment and for not examining the longevity of these chemicals, the changes they undergo over time, and the consequences (Hall et al., 2024). Although there has been a lot of initiative and action taken through several aspects, such as scientific research and implementing new regulations, the issue still prevails, and further actions and consideration of collaboration, accounting for all the challenges of implementation related to this issue.

Assembly Bill 794

Assembly Bill 794 is a 2025 Bill to have the agency of the California State Water Resources Control Board mandate and enforce new PFAS standards for drinking water. The standard of drinking water and the amount of PFAS allowed into the drinking water should be at least as stringent as the existing federal limits, with a push to have state-specific regulations that are stricter than federal regulations (EWG, 2025). This bill was advanced as a drinking water bill to enforce PFAS water standards on April 8, 2025, introduced by Assemblymember Jesse Gabriel (2025).

Senate Bill 682

In addition to AB794, lawmakers introduced Senate Bill 682 in 2025. This bill aims to end the sale of products that have intentionally added PFAS, including products used in the agricultural setting. Senator Allen introduced this bill on April 8, 2025, and it is set for a hearing on April 30 (LegiScan, 2025).

Challenges

One of the many roles of the Environmental Protection Agency (EPA) is to have the ability to regulate PFAS. They do this by setting specific standards to ensure there are safety standards that protect public health and the environment from contamination that can be harmful. They do this by conducting research, setting safe standards, educating the public, and taking necessary steps to actively address the issue of PFAS contamination. There are some challenges when it comes to regulating PFAS. According to regulatory standards, some PFAS that follow current regulations are not harmful, but the agreement on what constitutes PFAS and what qualifies as a PFAS poses an issue.

Pesticide Manufacturers, EPA, AND FIFRA

Some pesticide manufacturers may not have to report or test their products for PFAS unless they intentionally add them as active ingredients in the pesticides. EPA (2022) has started to act and acknowledge the need for change and initiative about this. They have begun to address the contamination of PFAS introduced into pesticides by fluorinated containers that leach PFAS into the products. The EPA recognizes that the lack of mandatory disclosure of PFAS and the lack of requirements to test for PFAS are among the reasons that contamination is happening at such a rate (EPA, 2022).

The Federal Insecticide, Fungicide, and Rodenticide Act, also referred to as FIFRA, is a federal law in the United States that sets a system that regulates pesticides to protect the applicators, consumers, and the environment. The EPA administers FIFRA to ensure compliance. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires manufacturers to name all active ingredients and label the percentage of these ingredients on product labels. Consumers are aware of the ingredients. However, manufacturers do not have to list the individual inert ingredients; they only provide a collective percentage on the label. However, regulators find it difficult to oversee the inert ingredients because, legally, pesticide producers do not have to show the products they use to protect their ingredient formulation. However, in December 2022, the EPA mentioned that it had issued a notice saying it would remove twelve chemicals identified as PFAS, which it had previously approved for use as pesticides for nonfood purposes (EPA, 2025).

Testing

Another challenge arises from gaps in the data and the detection of PFAS from pesticide products that affect water, making successful regulations difficult. Limited methods exist for testing PFAS directly in pesticide products, posing a challenge when regulating or enforcing these substances (Hall et al., 2024). It is essential to have the correct data and methods to collect it and ensure that the testing methods are in unison across the board to avoid discrepancies or gaps.

Complexity and Research Challenges

The complexity and diversity of PFAS chemicals have been challenges that have led to the difficulties of creating risk assessments and conducting studies that can paint the whole picture (EPA, 2024). There is no complete understanding of PFAS. The EPA has explained that there is a requirement for further investigation on the topic overall. Still, they would like to focus further investigations into the detection and measurements of PFAS that are more efficient in detecting air, water, soil, fish, and wildlife. They also want to focus on exposure levels to humans and the toxicity of how PFAS is affecting humans and the environment. They have also concluded that they want to develop effective remediation to ensure the removal of PFAS in water and effective management of the disposal of PFAS (EPA, 2024). Other things to consider as challenges of the complexity of PFAS include the lack of a universal definition for PFAS, which can cause misunderstanding and significant challenges when creating and interpreting regulations. Limited information on exposure and toxicity can limit regulations or any action to mitigate this issue (Hall et al., 2024). To create restrictions, there must be complete analyses through reliable methods to test the PFAS in pesticide products and those PFAS that come from pesticide products that are already contaminating water sources (Hall et al., 2024).

VI. Methodology

Criteria Alternatives Matrix

A prospective policy analysis uses a Criteria Analysis Matrix (CAM), which will help us analyze the policy alternatives and decide the most fit for this issue with what is known now. This is composed of six steps: 1: Characterize the Policy Problem, 2: Specify Policy Alternative, 3: Identify Evaluation Criteria, 4: Create a Criteria Alternatives Matrix and predict the performance of the alternative with the Criteria chosen, 5: Trade-off Analysis to switch the Alternatives, and 6: Communicate the results. It is essential to have the problem characterized in this process to clearly understand the issue we will try to address (Linquiti, 2023). Once we know the problem, we can make alternatives to mitigate the issue. We must ensure that these policy alternatives are actionable, described in detail, aligned with the situation and context, presented without evaluation, and not merely placeholders (Linquiti, 2023). When finding evaluation criteria, it is essential to pick one that will fit the other options and assess them accurately.

Prospective Policy Analysis is an essential step in this process as it helps analyze the best alternative that can help us mitigate issues better. The criteria I chose for this issue are cost-effectiveness, sustainability, and efficacy. For this issue, I will focus on the quantitative CAM rather than the qualitative CAM. The scoring of the alternatives uses the criteria to produce a quantitative result and compares the numerical values of each alternative.

Defining Criteria: Likert Scale

The cost-effectiveness criteria tell us to what degree the proposal addresses the policy problem at the lowest total cost over time (Linquiti, 2023). Sustainability criteria are the degree to which the proposal addresses the tension between the needs of the current generation and the balance between human needs and natural resources (Linquiti, 2023). Finally, efficiency is the degree to which the policy alternative will mitigate the core policy problem (Linquiti, 2023). It is essential to decide how their scoring will happen when grading how sustainable, practical, and cost-effective these alternatives will be. For the scoring, I used a Likert scale from 1- 5 (1: very weak, 2: Weak, 3: moderate, 4: strong, and 5: Very Strong). The Likert scale offers a structured way to measure the degree to which each alternative meets the criteria, allowing for a more objective evaluation. This Likert scale will help us calculate which alternatives score the highest and lowest within the given alternatives and which are the most sustainable, practical, and cost-effective to implement. The Likert scale for Cost-effectiveness would be 1: Very Expensive, 2: Expensive, 3: Moderately Affordable, 4: Somewhat Affordable, and 5: Very Affordable.

Cost-effectiveness is the degree to which the proposal addresses the policy problem at the lowest cost over time (Linquiti, 2023). A one on the Likert Scale will mean it will be expensive to execute the three alternatives presented to mitigate PFAS; a five would be affordable and easier to conduct these alternatives. Sustainability is the degree to which the tensions between the needs of the current generation and those of future generations, as well as the balance between human needs and natural resources, will mean that the alternatives will not improve the reduction or mitigation of PFAS in pesticides affecting water quality through the other options presented (Linquiti, 2023). A score of five shows that the alternatives implemented will improve addressing the PFAS issue. Efficacy is the degree to which the policy alternative will mitigate the core policy problem. A score of five shows that the alternative implemented effectively mitigates the issue.

Weight of Alternative

We must assign weights to each criterion to comprehensively analyze the alternatives based on the criteria. This reflects their relative importance and ensures thorough evaluation of the policy alternatives. The weight of sustainability is forty percent. 'Forever Chemicals' are a considerable issue affecting many generations. Sustainability weighs the highest as it is essential to have long-term mitigation strategies rather than short-term ones to avoid affecting more generations and the environment. The weight of Efficacy is thirty-five percent, as it is necessary to ensure that the alternatives mitigate the issue and/or the policy problem symptoms. The weight of cost-effectiveness is twenty-five percent, acknowledging its importance. However, it is essential to find something that is not a short-term solution, even if it has a higher price. Agencies know it is costly to reduce PFAS and find ways to end these 'forever chemicals.'

To start the Criteria Alternatives Matrix Analysis, we must add the alternatives with their weight in the table horizontally. The analysis will display the other options in a vertical format and, using the Likert scale and their assigned weights, will generate a score for each alternative based on the criteria, reflecting the scoring results. The results will be in the last column, giving us an overall understanding of the scores for each alternative. Analysts calculate the score by multiplying the weight for each criterion by the score from the Likert scale for each item, and then summing all the results in the table to obtain the final score per alternative. This process evaluates each alternative based on the importance of each criterion, providing a comprehensive understanding of their performance.

Results

After conducting the Quantitative CAM Analysis scoring the three alternatives: 1:Researching "Forever Chemicals," 2:Mandatory Reporting and Data Disclosure for Transparency, 3: PFAS in Pesticides State Taskforce and running the robustness test with changing weights of the Criterion of Cost-effectiveness (25%), Efficacy (35%) and Sustainability (40%) there were results to indicate which was the best alternative. The robustness test involves changing the criteria weights to see how sensitive the results are to these changes. This helps ensure the chosen alternative is robust and performs well under different conditions. Each policy alternative fits a rating for each criterion on a Likert Scale of 1-5, multiplied by the criterion's assigned weight, and calculated the final score. The Alternative Researching "Forever Chemicals" had the highest score of 3.25. This alternative showed that there is a good chance of having long-term impacts and the ability to solve the policy problem; however, it comes at an excessive cost in the first process. Table 1 shows that the Mandatory Reporting and Data Disclosure for Transparency alternatives scored 2.75. This alternative gives a moderate score. Compared to the Alternative of researching "Forever Chemicals, this alternative is more affordable but does not help with the contamination of PFAS. The final alternative of creating a State Taskforce focuses directly on the PFAS in pesticide and water quality, scoring a 2.75. This alternative is also a moderate approach that can provide oversight and coordination, but it may be an alternative that would take longer to achieve results in addressing this issue.

Table 1: Prioritizing Sustainability CAM

	Cost Effectiveness: (25%) *Addressing the policy problem at the lowest immediate and long-term costs.*	***Efficacy*** *(35%): Addressing policy problems based on their ability to effectively mitigate the core issue.*	**Sustainability** (40%): *Achieving policy goals over time while balancing the needs of current and future generations.*	Total Score
Researching "Forever Chemicals"	Likert Ranking: 1 Weight: .25 Total: 0.25	Likert Ranking: 4 Weight: .35 Total:1.4	Likert Ranking: 4 Weight: .40 Total: 1.6	**3.25**
Mandatory Reporting and Data Disclosure for Transparency	Likert Ranking: 2 Weight: .25 Total: 0.5	Likert Ranking: 3 Weight: .35 Total: 1.05	Likert Ranking: 3 Weight: .40 Total: 1.2	2.75
PFAS in Pesticides State Taskforce	Likert Ranking: 2 Weight: .25 Total: 0.5	Likert Ranking: 3 Weight: .35 Total: 1.05	Likert Ranking: 3 Weight: .40 Total: 1.2	2.75

Results: Robustness Test

When conducting a robustness test to see other possibilities when having priority weight of different criteria, there was a slight change in which policy alternative would come in first for the best recommendation out of the three options. It is essential to conduct a Robustness test as this can help us make sure there is further analysis of our results. It ensures that we have a perspective of how the alternatives have performed under different conditions, such as the weight of the criterion. This robustness test can help us ensure there is identification of possible weak alternatives or the overall quality of the results.

Prioritizing Cost Effectiveness

When prioritizing Cost-effectiveness at a 40% weight, Efficacy at 25 %, and Sustainability at 35%. The results of prioritizing cost-effectiveness give us the result of having the “Research on ‘Forever Chemicals’” be the highest score, and the other two alternatives tied. Table 2 explains the first alternative scored at 2.8, while the other two scored at 2.6. These scores are close to the .2 difference. After running the robustness test, the scoring results show a few changes compared to the first CAM analysis, prioritizing cost-effectiveness. For alternative 1, Research "Forever Chemicals," the first score was 3.25 and changed to a score of 2.8, which shows a decrease in score of 0.45. For Alternative 2: Mandatory Reporting and Data Disclosure for Transparency and 3: PFAS in Pesticides State Taskforce, the first score was 2.75 and changed to 2.6. This shows a decrease of 0.15 in the score for the first test.

Table 2: Prioritizing Cost Effectiveness

	Cost Effectiveness: (40%) *Addressing the policy problem at the lowest immediate and long-term costs.*	***Efficacy*** *(25%): Addressing policy problems based on their ability to effectively mitigate the core issue.*	**Sustainability** (35%): *Achieving policy goals over time while balancing the needs of current and future generations.*	Total Score
Researching “Forever Chemicals”	Likert Ranking: 1 Weight: .40 Total: 0.4	Likert Ranking: 4 Weight: .25 Total:1	Likert Ranking: 4 Weight: .35 Total: 1.4	**2.8**

Mandatory Reporting and Data Disclosure for Transparency	Likert Ranking: 2 Weight: .40 Total: 0.8	Likert Ranking: 3 Weight: .25 Total: 0.75	Likert Ranking: 3 Weight: .35 Total: 1.05	2.6
PFAS in Pesticides State Taskforce	Likert Ranking: 2 Weight: .40 Total: 0.8	Likert Ranking: 3 Weight: .25 Total: 0.75	Likert Ranking: 3 Weight: .35 Total: 1.05	2.6

Prioritizing Efficacy

When prioritizing Efficacy at a 40% weight, Cost Effectiveness at 35%, and Sustainability at 25%. There was a similar result where the alternative of added Research for "Forever" chemicals came as the highest scoring with a 2.9, and options of Mandatory Reporting and Data Disclosure for Transparency and PFAS in Pesticides State Task Force resulted in a tie once again with the score of 2.65. However, these scores are remarkably close, showing that efficacy may be similar throughout the alternatives. In addition, after running the robustness test, the scoring result shows a few changes compared to the first CAM analysis, with a priority of efficacy. Table 3 shows that for alternative 1, Research "Forever Chemicals," the first score was 3.25 to 2.95, which shows a decrease of 0.3. For Alternative 2: Mandatory Reporting and Data Disclosure for Transparency and 3: PFAS in the Pesticides State Taskforce, the first score was 2.75, and a total score of 2.65 from this robustness test. This shows a decrease of 0.10 in the score for the first test.

Table 3: Prioritizing Efficacy

	Cost Effectiveness: (35%) *Addressing the policy problem at the lowest immediate and long-term costs.*	***Efficacy*** *(40%): Addressing policy problems based on their ability to effectively mitigate the core issue.*	**Sustainability** (25%): *Achieving policy goals over time while balancing the needs of current and future generations.*	Total Score
Researching "Forever Chemicals"	Likert Ranking: 1 Weight: .35 Total: 0.35	Likert Ranking: 4 Weight: .40 Total:1.6	Likert Ranking: 4 Weight: .25 Total: 1	**2.95**
Mandatory Reporting and Data Disclosure for Transparency	Likert Ranking: 2 Weight: .35 Total: 0.7	Likert Ranking: 3 Weight: .40 Total: 1.2	Likert Ranking: 3 Weight: .25 Total: 0.75	2.65
PFAS in Pesticides State Taskforce	Likert Ranking: 2 Weight: .35 Total: 0.7	Likert Ranking: 3 Weight: .40 Total: 1.2	Likert Ranking: 3 Weight: .25 Total: 0.75	2.65

V. Policy Recommendation and Alternatives

Researching "Forever Chemicals"

Reducing the impact of PFAS in pesticides that are contaminating water is necessary. Based on the CAM analysis, this policy recommendation has scored highest with the highest score in sustainability and highest in the robustness test when prioritizing cost-effectiveness and efficacy. Researchers must conduct more studies on PFAS in pesticides and their effects on water quality. Researching the "Forever Chemicals" alternative has scored the highest among other options I had put through the Quantitative CAM. The top policy recommendation for mitigating PFAS in pesticides affecting water quality is to do further research. With the lack of sufficient data on various aspects of the issue, it is essential to understand PFAS, including the new PFAS fully. Following these recommendations is critical, as it is necessary to have correct research and evidence of PFAS in pesticides affecting water quality. PFAS are bioaccumulative and persist in the environment for an exceptionally long time.

Researching the long-term impacts of this bioaccumulation and how PFAS has become harmful to the environment is essential. This recommendation encourages many organizations and partners, such as academic institutions, governmental agencies, scientists, and independent research agencies, to collaborate in the research. With proper funds, researchers can expand and analyze scientific studies on the impacts of these forever chemicals on the environment. This research can aid in helping other ongoing research on the effects of PFAS, such as air, soil, organisms, and human health impacts. The added study includes agencies collaborating and creating methods to analyze the data and report findings. The state, independent agencies, and other partners can work together to reach an agreement to oversee this research and produce data that will help mitigate the issue. To get correct data, all testing agencies must have the same methodologies, scope of testing, knowledge of regulatory limits, and the ability to interpret and analyze the data similarly. There have been some gaps in the testing from independent studies by other agencies outside the EPA. The EPA has ensured that they have double-checked and have done their testing. This has brought attention to the methods of testing and data. The Journal of Hazardous Materials, the Environmental Working Group (EWG), and the NRDC have conducted other independent studies. The EPA takes the initiative to ensure a design with correct measurements and testing results, ensure that the independent studies do not have any discrepancies in testing, and ensure that they have not missed anything while they were testing.

This policy recommendation will significantly reduce any confusion, create a universal definition for PFAS, improve the understanding of PFAS and its long-term impacts on the environment, understand the sources of PFAS contamination, and the data would help create safer alternatives for the disposal of PFAS and the prevention of added contamination. The time for these recommendations may take one year of planning and several years of ongoing research with yearly checks on findings in the study. One thing to consider is that this policy recommendation has excessive costs and does not offer instant mitigation or instant results. It is essential to prioritize zones and agricultural research sites. This policy recommendation is the most sustainable and effective, but not the best in cost-effectiveness.

It is essential to mention that the political acceptability of this policy recommendation is that it will be politically acceptable as it can be a bipartisan appeal to the solution, as scientific research is mostly non-partisan. There may be low opposition to this alternative as there will be more evidence-based policy and support from federal and state agencies, making the effort to understand PFAS. However, critics may oppose this as this can seem to be a lengthy process with no immediate results, which may lead to short-term impact and political fatigue, as there may be a prioritization of other issues.

Alternate Policy Recommendations

Mandatory Reporting and Data Disclosure for Transparency

Although the two other policy alternatives analyzed through the CAM Analysis did not have the highest scores in the CAM Analysis or the Robustness test, they scored close to the first research alternative. The policy alternative of Mandatory Reporting and Data Disclosure for Transparency can help reduce the lack of transparency from PFAS manufacturers and allow us to more easily find where the PFAS in Pesticides are specifically coming from, what specific pesticides are creating contamination, and enhance the regulatory oversight. The state would mandate reporting and data disclosure requirements from all pesticide products. This alternative would require manufacturers to test and report back, increasing transparency and accountability within the pesticide industry. If implemented, this would have a standardized testing policy and a database accessible to agencies and the public. This would increase trust, accountability, and transparency, and help improve the data already tested for PFAS in pesticides contaminating water quality. This would also inform consumers and support regulatory enforcement locally and at the state level. The time for this recommendation is a few months to set up administrative coordination and regulations. However, it would improve access to data and regulatory oversight and be cost-effective. It is essential to consider that this may not reduce PFAS contamination entirely and may cause industries to push back. Some key actions are amending existing pesticide regulations and enforcing the structure for compliance and penalties.

It is essential to mention that this policy recommendation will be politically acceptable as it will enhance accountability and public trust, provide a moderate approach compared to bans, and provide data that would be helpful for future legislation or restrictions of PFAS in pesticides. However, critics may oppose this because industry pushback, privacy concerns, and enforcement complexity may exist.

PFAS in Pesticides State Task Force

The final alternative is implementing a PFAS in the Pesticides State Task Force. This policy recommendation would designate representatives from agencies and partners such as the Department of Pesticide Regulation, Environmental Protection Act, State Water Resources Control Board, scientific and academic partners and community leaders to collaborate and establish oversight, mitigation strategies, reporting oversight and other necessary components as this policy recommendation would help with identifying mitigation strategies, identifying the sources of continuation, increasing community awareness and engagement, helping inform all partners and allowing room for collaboration to protected the water quality of California and potentially aiding other agencies to mitigate the issues that PFAS in Pesticides is creating such as impacting public health and the food chain. However, this can be a challenge for coordination and funding. This policy recommendation can take from six to twelve months for administrative coordination until an official system is set; in addition to the collaboration, quarterly reporting would ensure this recommendation works or may need adjustments. Things to consider with this alternative are the planning for collaboration and oversight procedures. This policy alternative may work in some areas and may be a slow process that results in consistent funding.

It is essential to mention that this policy recommendation will be politically acceptable as this instills a collaborative approach, shows action, may be bipartisan, as they can focus on information and coordination that will be less polarized, and this sets a foundation for future policy. However, critics may oppose this as it can be slow-moving with no immediate action or results, a lack of resources such as the budget and staff, potential influences from industries, and limited authority with no enforcement capabilities.

VI. Conclusion

In conclusion, "Forever Chemicals" (PFAS) in pesticides show us the grave environmental and public health impacts that have been a growing concern in many aspects, particularly for this policy on water quality in California. There is a need for urgent awareness and attention to take policy action and demand policy changes that mitigate or help alleviate the symptoms of this issue. Lack of action will lead to PFAS spreading and bioaccumulating in water sources, wildlife, humans, soil, and agricultural lands, affecting our food resources. This policy report explored PFAS's effects and assessed policy alternatives that may address some factors to mitigate the issue more effectively through the Criteria Alternatives Matrix Analysis. This policy report contributes by finding gaps in research and current policies related to the contamination of PFAS sourced through pesticides in water quality. It highlights challenges and underscores the importance of understanding PFAS and its impacts. It is crucial to call for all agencies involved in water quality, PFAS, and Pesticides to work towards a goal individually or collectively, but with a unified understanding of PFAS. The policy recommendations and alternatives encourage action and promote a deeper understanding of the issue. As a state, we must understand PFAS contamination in our water resources. However, there are actions already happening, but the gaps in policy and research make it hard to create sustainable policies for the future and encapsulate most of the challenges and factors of this issue. Only through efforts can we develop mitigating actions to protect the public health and environment and prevent more harm now and for future generations.

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