



Food Waste Reduction Efforts and Strategies at Schools: A Literature Review

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Abstract

Approximately 30%-40% of the U.S. food supply chain is never consumed. A pertinent area of this is school food waste. Schools in the U.S. waste an estimated 530,000 tons per year with Arizona, in particular, wasting 24,000 tons per year. Rising to address this issue are a variety of strategies. This literature review explores strategies for reducing food waste in schools in the US with a focus on Arizona. Source reduction, the most preferred food waste intervention, can be achieved through a variety of methods: educating students about food waste, conducting food waste audits in order to create reduction strategies specific to the school, allowing students to taste test foods, visualizing the environmental impacts of food waste, implementing share tables, pre-slicing fruits and vegetables, reverse recess (students have lunch after recess), offer versus serve (allows students to decline foods), local procurement, implementing farm-to-school programs, and implementing the Smarter Lunchrooms Movement. Repurposing food to individuals in need or as animal feed to reduce food waste has been through donating surplus food to community organizations or farmers and leaving leftovers at a share table for other students or to be recollected by the school. Another way food can be repurposed is through industrial uses. This has reduced food waste in schools by donating surplus food for energy generation for vehicles or generators. Composting in school gardens has reduced food waste in schools with several success stories coming from Arizona. Although, there are barriers to sustaining school gardens including a lack of funding and teacher/administrator/community support. Additionally, there is a spectrum of educational resources available to assist schools in implementing food waste reduction initiatives including websites, tip sheets, curriculum, toolkits, infographics, and case studies. After reviewing the literature available we conclude that more

research and funding support is needed for Arizona on successful interventions in schools to reduce their food waste.

Introduction

In the United States, an estimated 30-40% of the food supply is never consumed, resulting in wasted resources and immense negative consequences on the environment ([USDA, Food Waste Facts](#)). The Environmental Protection Agency (EPA) found that food waste in the US emits roughly the same amount of greenhouse gas as nearly 42 coal-fired plants ([Jaglo et al., 2021](#)). Additionally, they discovered that the water and energy footprint from producing this food that ends up being wasted is equivalent to the amount that is needed for approximately 50 million homes. In the US alone, wasted food is comparable to 32.6 million cars worth of greenhouse gas emissions ([WWF, Fight climate change by preventing food waste](#)). Food waste in landfills contributes to the creation of methane, which is a greenhouse gas that is 25 times more effective than carbon dioxide at trapping heat in the atmosphere ([WWF, Fight climate change by preventing food waste](#); [EPA, 2022, Importance of Methane](#)). Based on these statistics, it is conclusive that food waste is a prominent contributor to climate change.

When food is wasted, the resources it takes to produce, transport, and package it are also wasted. These resources include a vast amount of land, water, and energy used throughout the food system. Land-use is a particular concern because converting natural land to agricultural land severely disrupts native ecosystems and causes biodiversity losses ([Jan et al., 2013](#)). Additionally, food waste contributes to pollution in landfills that degrades the quality of freshwater, soil, and air ([Jaglo et al., 2021](#)). Reducing and avoiding food waste is critical in mitigating negative externalities of our food system to create a more sustainable future.

The sector of the food supply chain where the largest portion of food waste is generated is at retail and household levels; roughly half of the estimated 161-335 billion pounds of annual food waste in the US is lost at the consumption stage ([Jaglo et al., 2021](#)). Extending this globally, research conducted by the Food and Agriculture Organization (FAO) of the United Nations ([Fabi et al., 2021](#)) found that 17% of the food available to retail, food services, and households is thrown away and an estimated 8-10% of global greenhouse gas emissions are associated with household food waste.

Considering the amount of food waste produced in the consumption sector, consumption interventions can be an effective lever for reducing food waste in the US. The consumption level encompasses places where individuals commonly eat meals such as households, restaurants, and institutions such as schools and hospitals. These places are also a part of an individual's food environment: the food, stores, culture, and people that influence the type of diet an individual comes to have and prefer ([Vepsäläinen, 2015](#); [CDC, 2014](#)). Food environments are most influential on those under 18 years of age ([Carducci et al., 2021](#)), and children can develop food preferences from these environments that last well into their adulthood ([Harvard, 2020](#)). According to the USDA and FAO, having a healthy food environment in K-12 schools can encourage students to make food choices that are consistent with healthier diets, appropriate portion sizes, improved well-being, and reduction of waste ([Buzby; FAO, *Healthy food environment and school food*](#)). Students consume one-third to one-half of their meals at school, making it crucial to set up healthy school food environments ([Micha et al., 2018](#)). In this literature review, information is evaluated on the magnitude of school food waste across the country and more specifically in Arizona in addition to food waste interventions in schools and where they fit into the EPA Food Recovery Hierarchy.

School Food Waste in the US and Arizona

A recent report, “Food Waste Warriors,” published by the World Wildlife Fund found that schools in Arizona on average waste approximately 24,000 pounds of food each year (roughly 35% fruits and vegetables, 35% milk, and 30% all other organic waste) ([Pearson, 2019](#)). They also estimated that the total

food waste from schools

across the US could be as

high as 530,000 tons of food

annually. The graphic

contextualizes this food waste

In one meal, students from 30 schools across the country gathered:



issue ([Merin, 2017](#)). If we take into account the national average of 76% of food waste ends up

in landfills, this statistic translates into 402,800 tons of food waste from schools annually going

to landfills where it emits massive amounts of carbon dioxide and methane gas. The combined

greenhouse gas impact of this is comparable to adding about 46,100 additional passenger

vehicles to the road for one year. School food waste not only has immense negative implications

for environmental sustainability, but also for economics. One study estimated that the average

amount of food waste from school lunches is equivalent to roughly \$1.2 billion wasted every

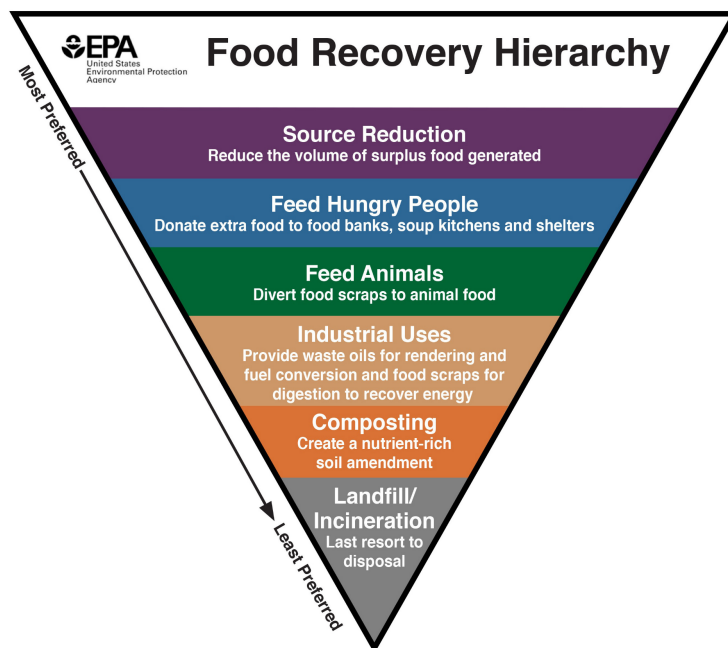
year ([Cohen et al., 2013](#)). The previously mentioned WWF report analyzed food waste in 46

schools in nine cities (including Phoenix) and found that, if schools reduced food waste by just

3%, it could potentially save \$52 million per year ([Pearson, 2019](#)).

Plate waste is shown throughout the literature as a driver in school food waste and is described as food that students were served which they threw away instead of consuming. A study conducted by [Byker et al. \(2014\)](#) examined 304 meals in a Virginia elementary school over

a one-week period and concluded that 45.3% of the food that was served to the students was thrown away. Another study conducted in elementary and middle schools in Colorado found that elementary-school students wasted more than a third of the grain, fruit, and vegetable items that they had on their plates ([Smith and Cunningham-Sabo, 2013](#)). Middle-school students threw away roughly 50% of the fresh fruit, 37% of the canned fruit, and nearly a third of the vegetables that they were served. Food waste can occur through different routes in an institution such as “losses during preparation and cooking, discards due to preparation of too much food, expired use-by or open dates, spoilage as well as plate waste” ([Derqui et al., 2018](#)). Despite this variety, multiple studies have concluded that plate waste is the number one source of food waste in institutions ([Derqui et al., 2018](#); [Engström and Carlsson-Kanyama, 2004](#)).



Additionally, a study conducted in Houston, Texas found that across eight elementary schools, younger students in kindergarten and first grade were more likely to have a larger amount of plate waste than older students ([Niaki et al., 2017](#)). This is an important piece of literature that demonstrates that food waste reduction efforts should be particularly focused on younger students in schools.

Food Recovery Hierarchy

There is a large variety of literature surrounding interventions in K-12 schools across the US and the world to reduce food waste. A widely used reference tool that organizations utilize for reducing food waste is the Food Recovery Hierarchy from the Environmental Protection Agency ([EPA, 2021](#)). This diagram serves as a guideline for assessing food waste reduction efforts on a scale from most to least impactful. Based on the examples depicted in this section, schools have the potential to use any or all of these food recovery tactics to reduce food waste.

Source Reduction

At the top of the hierarchy is the most preferred way of reducing food waste: targeting it at the source. According to the EPA, this method is ideal because it creates the most benefits for the environment, society, and economy. Decreasing the amount of surplus food generated helps to minimize pollution from food production and reduce greenhouse gas emissions from landfills. Other benefits include saving money by buying less food, as well as saving energy and lowering labor costs associated with growing, preparing, and transporting food. Most source reduction interventions conducted in schools have been aimed at reducing plate waste. Some examples include conducting classes to educate students about food waste, which was reported to reduce plate waste by 35%, or collecting and measuring plate waste with students in a more hands-on approach ([Engström and Carlsson-Kanyama, 2004](#)).

The EPA suggests that organizations start their source reduction efforts by conducting a food waste audit to determine how much and why food waste is generated. These audits can produce unique findings for schools that can aid in personalizing food waste reduction strategies. For example, in the spring of 2008, the University of Texas at Austin audited plate waste during

lunch and dinner over the course of five days at ([EPA, 2022, *How to Prevent Wasted Food Through Source Reduction*](#)).

They discovered that students had a significant amount of plate waste with an average of 5.7 ounces of leftover food on their plates. Based on these results, the food service staff worked to educate students with signage that explained the environmental impacts and helped them visualize their food waste. Another strategy they used was to allow taste testing so that students could sample food items before taking the whole dish. Only one semester later, in the fall of 2008, they conducted another food waste audit. The results showed that the plate waste average dropped from 5.7 ounces of leftover food per student to an average of 3.9 ounces of wasted food per student. They tried to decrease it even further by going tray-less and they found that the amount of plate waste fell again in the fall of 2009 for a total 48% reduction.

Washington Elementary School in Fayetteville, Arkansas also saw success in the use of food waste audits. The National Farm to School Network communicated the details of this experiment on its website ([Terry, 2016](#)). The food waste audit was a collaborative effort between the staff and students that lasted five days and included all food waste, milk waste, other liquid waste, and unopened items. Based on the results of the audit, the school introduced 8 oz water cups next to the water fountain which provided students the option of drinking water if they didn't like milk, and implemented a share table in the cafeteria (details about share tables are given in the next section). According to the NFSN, by the end of the school year, students reduced their milk waste by 20%.

Pre-slicing fruits and vegetables have also been found to reduce plate waste through source reduction by making food more convenient for students to eat. One study found that when apples were served pre-sliced instead of whole, elementary schools increased apple sales by

60.6% and students wasted about 6% less of the apples that they purchased ([Wansink et al., 2013](#)).

Another source reduction intervention that has been studied is reverse recess, which is when students have lunch after recess instead of before, with the hypothesis that students will have more of an appetite after recess. There have been mixed results with this intervention. Chapman et al. found that increased fruit consumption was correlated with reverse recess, however, their research did not find an effect on vegetable, entree, or milk intake ([Chapman et al., 2017](#)). In a similar study conducted in two elementary schools in Washington, it was found that plate waste decreased from 40.7% to 27.2% after switching to reverse recess ([Bergman et al., 2004](#)). Increased time for lunch has also been suggested as a tactic for reducing plate waste. A study from the Harvard School of Public Health found that “students with less than 20 minutes to eat consumed 13% less of their entrée, 10% less of their milk, and 12% less of their vegetables compared with students who had at least 25 minutes to eat” ([Cohen et al., 2015](#)).

Offer versus serve (OVS) is a food waste reduction initiative that the US Department of Agriculture (USDA) has implemented in the National School Lunch Program and School Breakfast Program ([USDA, 2015](#)). OVS makes it possible for students to decline some of the food that is served in the cafeteria, rather than being served everything even when they do not intend to eat some of it. A 2011 study ([Goggans et al.](#)) compared lunch programs at two elementary schools - one used OVS and the other used the traditional serve only (SO) method. This research determined that fruit and vegetable plate waste was significantly lower in the school using the OVS compared to the school using SO. It is also worth noting that the World Wildlife Fund found it to be common for school staff and students to misinterpret the guidelines of OVS, resulting in many schools making mistakes such as continuing to require students to

take an entrée ([WWF, *Educating Tomorrow's Food Waste Warriors*](#)). Students have also reported not having enough time to make decisions in line, and therefore being served a full meal despite not wanting it. This confusion among the staff and students can render OVS less effective. WWF recommends more training, education, and improved signage to improve the effectiveness of the program, and the Iowa Department of Education created a [list of common errors](#) made in the implementation of this program in order to clear up the confusion.

In a local procurement initiative, the Boulder Valley School District (BVSD) integrated innovative distribution of milk through bulk milk dispensers. Milk is often one of the most wasted items in schools but this method eliminates wasteful cartons and allows students to only take what they need ([Food and Procurement, The Lunch Box](#)). By sourcing their milk locally, BVSD has more flexibility in how they provide it to students which enables them to use bulk milk dispensers. They have direct relationships with local dairy farmers to prioritize purchasing from sources that are certified organic, located within fifty miles, and deliver within 48 hours of harvest ([Food and Procurement, The Lunch Box](#)).

Furthermore, a white paper report published in 2019 by Making Action Possible in southern Arizona discussed the impacts of farm-to-school programs on Arizona communities. The study focused on a variety of topics, including the issue of food waste in schools. School food authorities reported that they were “enjoying greater acceptance of their new meal patterns and experiencing less food waste because of their farm-to-school efforts” ([Duval et al., 2019](#)). One of the ways that farm-to-school programs work to mitigate food waste is through the incorporation of school gardens. In K-12 schools, it has been found that fruits and vegetables are the most commonly wasted food ([Handforth et al., 2016](#); [Pearson, 2019](#)). However, school gardens have been shown to influence student eating habits by changing their perception of fruits

and vegetables and increasing their overall consumption of them ([Klemmer et al., 2005](#); [Parmer et al., 2009](#)).

In a blog by the National Farm to School Network, Elizabeth Esparza discussed that a key strategy to reducing food waste is to educate students on it and how they contribute to it ([Esparza, 2018](#)). Esparza explained that “the more students know about food waste, food insecurity, and the complete cycle of the food system, the more likely they are to be conscious of what's left on their plate at the end of a meal” ([Esparza, 2018](#)).

The Smarter Lunchrooms Movement was created by The Cornell Center for Behavioral Economics in Child Nutrition Programs with the goal of creating, “sustainable research-based lunchrooms that guide smarter choices” ([Byrens et al. 2017](#)). The program works by conducting research in schools and then finding the best method to nudge students to eat nutritious food ([USDA 2017](#)). There is a Smarter Lunchrooms Movement Scorecard and Handbook that schools can use to assess their lunchrooms ([Cornell University 2019](#)); ([Cornell University 2019](#)). The University of California offers resources specific to the state including best practices, trainings, toolkits, and resources ([University of California, 2021](#)). The Fresno Unified School district had success with the Smarter Lunchrooms Movement and shares the stories of nine schools in the area. The program impacted over 6,000 and each of the programs was unique to the schools they were implemented at ([Morales 2018](#)). The Arizona Health Zone Cooperative Extension offers a Smarter Lunchrooms guide for implementing the program and a list of twelve suggestions which include ways to reduce food waste ([AZ Health Zone](#)). Implementing Smarter Lunchrooms Movement practices has shown an 18% increase in fruit consumption and a 25% increase in vegetable consumption ([USDA 2017](#)). There are no direct examples of the Smarter Lunchrooms Movement being used in Arizona schools to prevent food waste.

Feed Hungry People and Feed Animals

The second and third tiers of the Food Recovery Hierarchy are donating surplus food to feed hungry people and farm animals. Donating food helps support local communities while reducing food waste that goes to landfills. Through programs such as the USDA share tables, schools have the ability to collect unopened surplus food in the cafeteria and donate it to local nonprofits such as food pantries, food banks, and other food rescue organizations ([USDA, 2016](#)). Students can bring their leftover food to these “share tables” and the food can either be picked up by other students for free, reused in the cafeteria kitchen, or donated. There is a lack of peer-reviewed research on the benefits of share tables, however, one study highlighted the expansion of this strategy by finding that 27 states have adopted the state-level share table policy and 81% of those states allow unwanted food on share tables to be re-used in meal service or donated to nonprofits ([Prescott et al., 2020](#)).

Additionally, schools have the potential to donate surplus food to local farmers for their animals. Every state has different regulations around using food waste as animal feed; Arizona requires an annual permit from the AZ Department of Agriculture and heat-treatment of animal-based waste ([Leib et al., 2016](#)).

Rutgers University has had success with this food waste reduction tactic ([EPA, 2022, *Reduce Wasted Food by Feeding Animals*](#)). They collect food waste from four of their dining halls and donate it to a local farm for half of the cost of traditionally sending it to a landfill. Having a connection between a K-12 school and a farm has the potential to create learning opportunities for students ([Leib et al., 2016](#)). For example, farmers could attend career days or host students on their farm for a field day, and students could use the farm for research or 4-H projects.

Industrial Uses

The fourth tier of the Food Recovery Hierarchy is focused on using food waste as a source of energy generation for vehicles or generators. A successful example of this has been carried out at Purdue University where they turn food waste into renewable energy ([EPA, 2022, *Industrial Uses of Wasted Food*](#)). In partnership with the city government, the university delivers its excess food to a local wastewater treatment plant that uses an anaerobic digester to turn it into renewable energy. In this scenario, using food waste for industrial uses not only benefits the environment by diverting food from landfills but also by creating renewable energy which supports the transition away from fossil fuel energy.

Composting

A pertinent area where schools have found success in reducing food waste is through the implementation of compost systems. An example of this can be seen at Pearl City High School in Pearl City, Hawaii (in the City and County of Honolulu) where they implemented food waste collection stations in the cafeteria ([EPA, 2022, *Reducing the Impact of Wasted Food by Feeding the Soil and Composting*](#)). Students and staff worked together to separate the fruits, vegetables, and various starches from the other food waste to feed it to composting worms. The rest of the food waste was composted with heat to create a nutrient-rich soil amendment for gardens in the community. Throughout the year, the school saved 34,635 pounds of food waste from going to the landfill.

Manzo Elementary in Tucson, Arizona ([O'Connor, 2022](#)) has an organic vegetable garden that incorporates many sustainability elements such as composting, rainwater harvesting, aquaponics, native plants, and chickens. The students use vermicomposting and hot box composting to break down food scraps from their cafeterias and turn them into nutrient-rich

compost. Although there is not any academic research detailing the impacts of this composting and gardening system, it is so unique and successful that they have been nationally recognized by several organizations such as National Geographic and Slow Food USA ([O'Connor, 2022](#); [Slow Food USA, 2016](#)). Amphitheater Middle, Prince Elementary, and Elvira Elementary schools of Tucson, Arizona also all have composting programs in their schools that utilize leftover food from lunch ([Quihuis, 2014](#); [KGUN, 2019](#)). Amphitheater and Prince partner with the University of Arizona and the City of Tucson, and they have been able to reduce their lunch food waste by 100 trash bags after the implementation of a composting system ([Quihuis, 2014](#)).

Resources for Schools

There are a variety of resources provided by many organizations that can assist schools in implementing food waste reduction initiatives. Zero Waste DC discusses on their website how excess food is donated and how they collect food scraps to compost ([Zero Waste DC](#)). WWF and Cornell Waste Management Institution have guides for K-12 schools that also discuss how to donate excess food or utilize compost ([WWF, Four ways to fight school waste](#); [Cornell](#)). Earth Easy has resources for educators to learn about the benefits of school gardens in improving health, setting up school gardens, and using compost to mitigate food waste ([Earth Easy](#)). A toolkit was developed by Sydney Klien of the Jackson County Health Department in Missouri that includes how to find financial and community support in starting a garden, how to start growing plants, how to implement composting in cafeterias, and how to educate students ([Klien, 2015](#)). All of these sources center around setting up a school garden and using composting as a way to mitigate food waste.

An important factor with having a school garden and trying to reduce food waste is the added work it puts on school staff. In the World Wildlife Fund report, *Food Waste Warriors*, staff

voiced their concerns about feeling overworked and not having time to pursue food waste reduction initiatives ([Pearson, 2019](#)). An alternative to having school staff set up gardens would be to identify and request FoodCorps members to assist with school gardens. FoodCorps is an organization that partners with communities and schools to nourish kids' health, education, and sense of belonging ([FoodCorps, 2022](#)). The purpose of having a member at a school is to aid in food education which is often extended to school gardens and food waste mitigation. For example, in northern Michigan, a FoodCorps service member took action by involving students in a food waste assessment to educate them on the issue and influence them to waste less food ([Scafidi & Larr, 2021](#)). Another FoodCorps service member in Arizona worked to set up the first certified school garden on an Arizona Reservation. In an article on the FoodCorps website, they describe the excitement of students when they ate the vegetables they grew from the garden ([FoodCorps, 2015](#)). This demonstrates the potential of FoodCorps members to aid in increasing consumption/decreasing the waste of vegetables in schools. In schools where there is a need for help in growing gardens, educating students on sustainable food systems, and reducing food waste, FoodCorps members are a potential resource for achieving that. As of 2022, FoodCorps no longer has members serving in Arizona ([FoodCorps, 2022](#)).

There are frequent barriers surrounding starting and sustaining school gardens. The Austin School Garden Report analyzes a survey of elementary schools in the greater Austin area and found that the top barriers (as reported by teachers and administrators) are insufficient work days, lack of community involvement, inadequate district/administration support, insufficient funding, inadequate training, and varying teacher involvement ([Nikah et al. 2020](#)); ([Hoover et al. 2021](#)). Additionally, lower-income schools face further barriers such as challenges to establish stable volunteer garden committees, less volunteer interest, huge student turnover rates, and are

less likely to receive a paid garden coordinator ([Garwood et al. 2016](#)). Strategies that have shown to increase the likelihood of having a thriving school garden include funding (3-fold increase), established garden committee (4-fold increase), administration/district support (12-fold increase), available garden curriculum (5-fold increase), and student engagement in the garden (3-11-fold increase) ([Nikah et al. 2020](#)). The Austin School Garden Report emphasizes that, “While school gardens are rapidly increasing and gaining popularity, very little research exists that identify best practices for school gardens” ([Nikah et al. 2020, p. 23](#)). This extends to Arizona as well with a lack of research available for effective means to sustain a school garden in the state. The Austin School Garden Report offers seven action items for a successful school garden based on their findings that include: Adequate district/administrator support; Increased student usage; Provision of teacher training; Available garden curriculum; An active garden committee; Adequate and consistent funding; community/non-profit support ([Nikah et al. 2020, p. 23](#)).

There are also educational resources for schools to use to learn about food waste. The USDA has a list of curricula and strategies that schools can implement in classrooms to educate students on reducing food waste ([Buzby](#)). WWF has toolkits for different grade levels that are accessible to educators to teach students about food waste ([Pearson, 2019](#)). The School Food Waste Reduction Toolkit by Rutgers University has a background, case studies, and suggestions for food waste reduction ([Elnakib et al., 2019](#)). The EPA has a tip sheet for getting K-12 students to eat more and waste less ([Shafir, 2017](#)). Stop Waste, an Institution for Human Education, also has a list of resources for food waste reduction ([StopWaste, 2022](#); [Rakestraw, 2018](#)). The Center for Green Schools has a detailed guide to reducing and recovering surplus food in schools ([Deming and Whited, 2019](#)). These trustworthy organizations provide incredibly useful materials for schools to use to educate themselves and their students on reducing food waste.

Farm to School

The Farm to School Program is designed for K-12 schools to foster a relationship with local, fresh, and healthy food through food procurement, school gardens, and/or prioritizing education at schools ([National Farm to School Program](#)). This program has produced a variety of benefits, including food waste reduction. The USDA conducted a nationwide survey in 2015 and asked questions to participating school districts about the benefits of farm to school. The results found that seventeen percent of respondents reported the program helped reduce plate waste ([USDA, 2015](#)).

The National Farm to School Network (NFSN) has three pillars with implementation strategies centered around: procurement, gardens, and education. Elements of these three pillars can be integrated with the EPA's Food Recovery Hierarchy to amplify the impact farm-to-school programs have on the reduction of food waste in schools.

Conclusion

Mitigating food waste in K-12 schools can be accomplished through various activities and programs such as the EPA Food Waste Hierarchy and the National Farm to School Network. Source reduction through student eating habit changes, feeding hungry people and animals, industrial use, and composting are ways that K-12 schools can cut down on food waste. Resources are available to support interventions targeting food waste at schools, but specifically for Arizona, more research is needed on successful interventions in K-12 schools, the impact of current AZ Farm to School programs on food waste, and the opportunities for the AZ Farm to School Network to enhance positive impact through improved food waste reduction integration. In addition to research, more funding and support are needed to promote food waste reduction in Arizona schools.

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