The Leftovers Project: Feeding Students by Mitigating Food Waste

Isaiah Martinez

Lorelai Lamoureux

Raleigh Mann

May 14, 2025

Abstract

The Leftovers Capstone Project addresses sources of food waste in JMU Dining facilities. Food insecurity is experienced by approximately 39% of the JMU student population as determined from a survey performed by the JMU Student Support Hub in 2019. Food insecurity is a problem that many people face around the world, and solving this social issue is one of the United Nations 17 Sustainable Development goals. This project models the food production and dissemination system in the university and how it contributes to food waste on campus. Through the course of model construction, the project team communicated with various stakeholders, including but not limited to: JMU Dining Services, Aramark, the JMU Pantry, the Institute for Stewardship of the Natural World, Community Engagement and Volunteer Center (CEVC), and the Basic Needs Advisory Board. The resulting system dynamics model (JMU DinSim) simulates the current JMU food production and consumption structure to suggest potential strategies to repurpose perishable food to aid students in the JMU population that face food insecurity. Through implementing proposed policies, food insecurity at JMU can be driven down from 39% to 33%. The remaining leftovers can also be allocated to feed those in the local community. Such a model would help stakeholders to make better policy decisions in regard to hunger prevention, mitigating waste, and expanding current student aid programs. The university directly benefits from waste reduction, spending less on food purchases and composting scraps. There are also indirect benefits to be gained from a better fed student population, including increased school prestige and improved student performance.

Keywords

Access to Healthy Food, Food Loss, Sustainability, Food Insecurity, Public Interest Technology, System Dynamics Modeling

Introduction

Food insecurity, as defined by The Virginia Department of Social Services is, “the lack of access to enough food for an active, healthy life” (2024), and it is a complex problem that requires a multidisciplinary approach to address. This can affect any individual and is experienced by people all over the globe, and due to the extent that populations experience food insecurity and hunger, The United Nations (UN) established the Sustainable Development Goals (SDGs). These are a series of targets that the UN and member nations hope to accomplish by 2030 are to “provides a shared blueprint for peace and prosperity for people and the planet, now and into the future” (United Nations). The goals that will directly connect with the work done in this senior capstone project are Goals 2 and 12. The objective of Goal 2 is to both “End hunger and achieve food security’ (United Nations) while the target of Goal 12 is to promote responsible consumption and production. In the US about 30 percent of food is wasted each year (Frank, 2022), and to address this, the United States Environmental Protection Agency (EPA) outlines the Food Recovery Hierarchy, which describes the most preferred method of mitigating food waste through first the reduction in consumption then to donate to others (Frank, 2022)

Food insecurity is becoming a growing concern on college campuses across the United States. The phenomenon not only impacts students' physical and mental health but also hinders their academic success and overall well-being (Frank, 2022). Providing food insecure students with access to resources is one of the first steps to addressing the complex problem. Utilizing system dynamics to investigate the flows of food and students between various dining institutions will help to evaluate current policies in effect and their impacts on the student population experiencing food insecurity. It is an approach that has been used to analyze national trends in food insecurity but not used for smaller –scale analysis of a population within specific institution like a university setting.

The research conducted in this project takes place at James Madison University, a medium sized University located in the mid-Atlantic region with a population size of roughly 22000 students. Of that about 37.8% experience food insecurity according to the JMU Pantry in 2023 which is just over a third of the student population (Keelor, 2023). This is reflective of a nationwide study conducted in 2019 that found that 41% of students surveyed reported experiencing food insecurity (Frank, 2022). Meanwhile, JMU Dining composts tons of pounds of food each week, food that could potentially be rescued and redistributed to students in need. Most of the compost is considered low quality post-consumption waste that cannot be recovered, but there is food that is not served that goes to waste. Presently, the university has several programs oriented towards aiding students that need help with meeting basic needs. There is the Basic Needs Advisory Board that is made up of several faculty members from different departments that meet to discuss the status of assistance programs and routinely perform student body surveys to collect data. Then there is the JMU Pantry that provides free food, some home goods, and other food assistance resources to students. Despite these, food insecurity is prevalent within the student population, and the objective of the research performed was to develop a systems model to show how students and food resources interact with JMU Dining institutions to act as a tool to aid policy makers with developing strategies for addressing food insecurity on campus.

The following sections will discuss the impacts of food insecurity on students, introduce initiatives taken by James Madison University and other universities to address food insecurity within their student populations, then an introduction into previous work done by groups utilizing system dynamics to model food insecurity. Next a discussion of the historical trends effects on the preconceived assumptions shown in the reference modes then the dynamic hypotheses are introduced. After, a top-level view of the JMU DinSim model will be described in addition to an analysis of different policies to address student food insecurity will be provided. Finally, a discussion of the policies tested concluding with discussion on the limitations and challenges experienced and recommendations for future research.

Literature Review

Impacts of Food Insecurity on students

Food insecurity among college students has emerged as a critical issue in higher education. Bruening et al. (2017) conducted a systematic review that highlighted the widespread nature of food insecurity on postsecondary campuses, revealing negative implications on students' academic performance, health, and engagement. Their findings indicate that food insecurity disproportionately affects marginalized groups, including low-income students, first-generation college attendees, and students of color. Similarly, Henry (2017) examined the experiences of food-insecure students and found that their struggles often stemmed from financial constraints and a lack of institutional support. Consequences of food insecurity highlight the physical and emotional toll of food insecurity, including fatigue, stress, and feelings of isolation. These findings align with studies showing that food-insecure students are more likely to experience academic challenges, such as lower grades and higher dropout rates.

Institutional and Policy-Level Solutions

Addressing food insecurity on college campuses requires a multifaceted approach that combines institutional policies, community engagement, and individual support. The Good Samaritan Act, as outlined by the USDA, provides a legal framework to encourage food donations by protecting donors from liability. This legislation is particularly relevant for universities, which often generate significant food waste that could be redirected to support students in need. By implementing donation programs in dining facilities, colleges can simultaneously reduce waste and improve food access.

Universities have tried multiple approaches to how to redistribute cooked food, from one-off events to food pantries. Studies done by Dr. Laura Frank reveal the importance of language. Students tend to avoid food events that are framed as leftovers or waste, while students more favorably respond to free food. (‘Free Food on Campus!” Frank, Laura B, 2020). Hamilton College serves as an example of how institutions can bridge the gap between surplus food and food-insecure populations. The college’s "Food Harvest" program repurposes excess food from dining services to benefit the local community (Hamilton College). This model demonstrates the potential for campus-based initiatives to address both food insecurity and sustainability goals. Similarly, the EPA’s (2015) guidelines for sustainable food management emphasize the

importance of reducing waste through responsible resource use, providing a framework that colleges can adapt to their operations.

The current approaches to food waste at James Madison University from dining halls include anaerobic digestion and composting through converting post-consumption food waste into compost or energy. While post-consumption is ideally fit for composting, there begs the question of what about the food that is not consumed. From 2017 to 2020, JMU had a club named Campus Kitchen, which took dining hall food and redistributed to the larger Harrisonburg community, but because of the pandemic, Campus Kitchen is no longer active. Since the club's closing, JMU has begun to develop food infrastructure with its investment in the JMU pantry. This new distribution network now allows for this project to support further the expansion of offerings and support a steadier inflow from campus to campus.

Incorporating technology into food security programs is another promising avenue. Frank (2022) examined how instructional technology can reduce university food waste while improving food accessibility for students. By leveraging digital tools to connect students with surplus food, universities can create efficient and scalable solutions. Similarly, JMU's Student Life publication (2024) highlights the limitations of current dining services, which may not meet the diverse needs of the student body. The existence of student hunger despite JMU's varied options outlines existing systemic flaws that cannot easily be answered by simply providing more locations for students to order from. These findings suggest the need for greater outreach and inclusivity in program design to ensure that resources reach those who need them most.

The Virginia Department of Social Services (2024) provides resources and data on food security, highlighting programs that support vulnerable populations. These resources offer valuable insights into how state-level initiatives can complement campus efforts to address food insecurity. For example, partnerships with local food banks or state-run assistance programs, such as SNAP, can expand the reach of campus-based support services.

Previous System Dynamics Work

Food insecurity is a complex problem that requires an interdisciplinary solution. To evaluate the issue, researchers have utilized systems dynamics modeling to develop a better understanding of the issue in both US urban households (Metta, Olabisi, and Wallace, 2021) and in Central and South American countries (Issac, Carrera, Rivas, Ruano, Martínez, Khowaja, Russell, Malard-Adam, Monardes, Adamowski, and Melgar-Quiñonez, 2023; Herrera and Kopainsky, 2020; Quinteros-Reyes, Seferidi, Guzman-Abello, Millett, Bernabé-Ortiz, and Ballard, 2024). Investigations have been made to increase specificity of food insecurity trends by prioritizing regional research and used food security dynamics to identify feedback loops and target areas that could inform policies based on localities (Isaac, et al., 2023; Quinteros-Reyes, et al., 2024). More broadly, system dynamics approaches have been used to evaluate resilience of communities in relation to food production systems for small scale agriculture and rural populations (Herrera and Kopainsky, 2020). There is not a simple solution that will solve food insecurity. As demonstrated by previous work done on the topic and by other system dynamic teams, addressing food insecurity in households will require multipronged solutions (Metta, Olabisi, and Wallace 2021). The work done in this paper contributes to gaps in the literature regarding utilizing system dynamics modeling to assess food insecurity on college campuses and their student populations.

Methods

To examine student food insecurity and food production systems in the dining halls at James Madison University, the research team followed the holistic problem-solving spine that makes up the Integrated Science and Technology (ISAT) Program's Habits of Mind. The project started with engaging with stakeholders and experts at conferences and in team meetings to learn about their work in food insecurity broadly in the Shenandoah Valley and narrowing down to the JMU student population. Through these discussions, data was collected about the student population food insecurity, JMU dining halls, and the current food recovery efforts being taken by the Civic Engagement and Volunteer Center. This was used to develop a system model to describe the interactions between students and food production systems at JMU. Focusing the project on connecting with stakeholders to gain foundational knowledge for how the dining halls operate on the JMU campus was a necessary starting point for shaping the path that the project team took. Without taking this step, the project team would not have been able to develop a system model that was representative of the student interactions with the on-campus food production systems.

Historical Trends

Despite the availability of resources, students continue to face significant barriers to accessing adequate food. Keelor (2023) identified these barriers at JMU, where food insecurity has been described as a "quiet crisis". The study revealed that students often struggle with awareness and stigma surrounding food assistance programs, preventing them from utilizing available support. Financial constraints remain a key driver of food insecurity among college students. Henry (2017) emphasized the role of rising tuition costs and inadequate financial aid in exacerbating the problem. These economic pressures often force students to choose between paying for food and other essential expenses, such as housing or textbooks. Addressing this issue requires a holistic approach that includes financial education, increased aid, and affordable meal plan options.

Reference modes

James Madison is experiencing a period of growth leaving the pandemic era. Joining the Sunbelt Conference has led to an influx of popularity for the school and an era of population growth. This growth has led to the construction of new dormitories and reinvestment into the school. However, consequences of the pandemic have led to disbanded student-run support programs such as Campus Kitchen, which served to try and mitigate food waste and provide services to the community. The new influx of students means more foodstuffs needs to be produced and there was not a network to support this growth. The fear is that preexisting food insecurity issues can be further exasperated by a growing population. The ideal scenario is that JMU can continue to grow its population while curving the growth of both student food insecurity and associated waste.

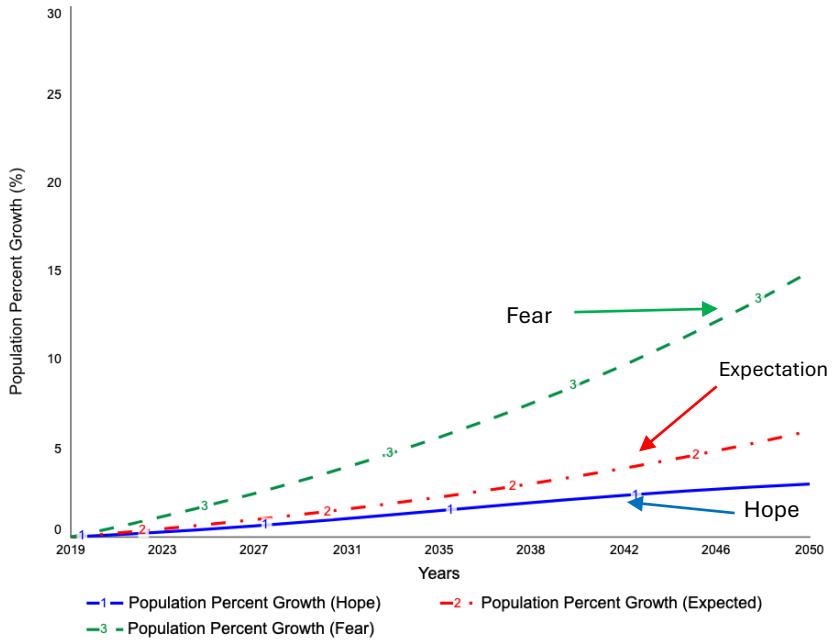

Figure 1. Behavior over time graph - James Madison University Student Population Percent Growth.

Figure 1 is the behavior over time graph of the JMU student population percent growth represents the reference mode that informed the development of the JMU DinSim model. The blue line with the number 1 displayed on the graph represents the "Hope" scenario that the population percent growth at JMU does not over enroll students each year placing stress on the school to provide adequate resources as well as with the surrounding Harrisonburg, Va area. The red dashed dotted line with the number 2 displayed in the graph is the "Expected" scenario that and "Fear" scenario is the green dashed line listed with the number 3. These scenarios display situations of JMU over enrolling students which risks placing stress on JMU student resources and off campus resources. (James Madison University Institutional Research)

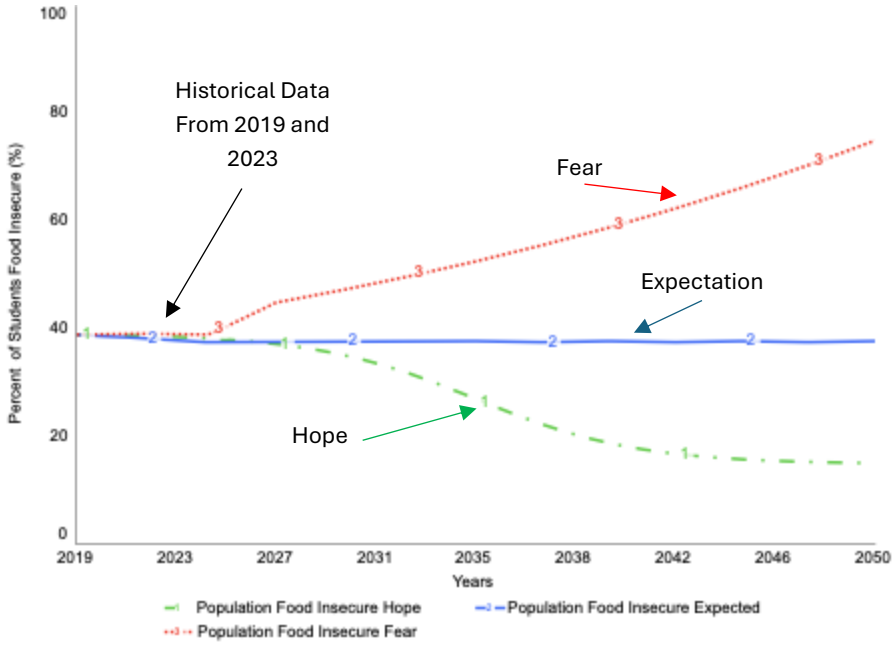

Figure 2. JMU Food Insecure Student Population Behavior Over Time Graph

Figure 2 displays the reference mode that informed modeling the population of students at JMU that experience food insecurity. This is informed by historic enrollment data reported by the university and previous reported rates of estimated food insecurity within the population found in 2019 and 2023 (Keelor, 2023; James Madison University Institutional Research). The "Hope" scenario is that the population of students that are food insecure significantly decreases as demonstrated by the green dash and dotted line numbered,1. The "Expected" scenario is that the nominal number of students that experience food insecurity at the university remains the same. This is demonstrated with the pink dashed line numbered 2. The "Fear" scenario is that the number of students at JMU that are facing food insecurity drastically increases. This is marked on the graph by a red dash and dotted line numbered 3.

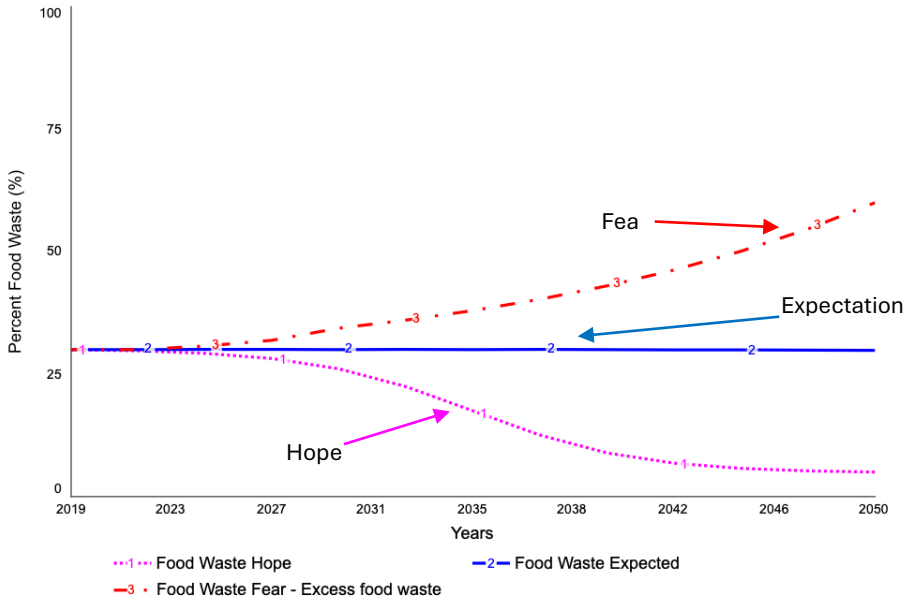

Figure 3. Behavior Over Time Graph of Leftover Dining Hall Food

The "Hope" scenario is that any leftover food available is recoverable by student teams for donation to the JMU Pantry. The hope is not to encourage a scenario for increasing food waste in order to recover more food from the dining hall. This is marked by the pink dotted line labelled "1" on the graph. The "Expected" scenario for leftover dining hall food is for the quantity of food leftover to remain relatively the same in dining halls. This is marked be the blue solid line marked "2". Based on observations from food recovery efforts and operating policies established by the dining hall, there are only a few stations at the halls where food is recoverable from. Food recovery is harder to accomplish with any station that is "self-serve" and food leftover from these stations are not directly recoverable. There are two scenarios of "Fear" on Figure 3. The first scenario portrayed as the red dash and dotted line numbered "3" is for there to be a significant quantity of leftover food that it creates a difficult situation for there to be any food recovery efforts to handle. The other scenario marked by the dashed green line marked "4" is for there to be a significant decrease in leftover food that makes food recovery efforts irrelevant to perform.

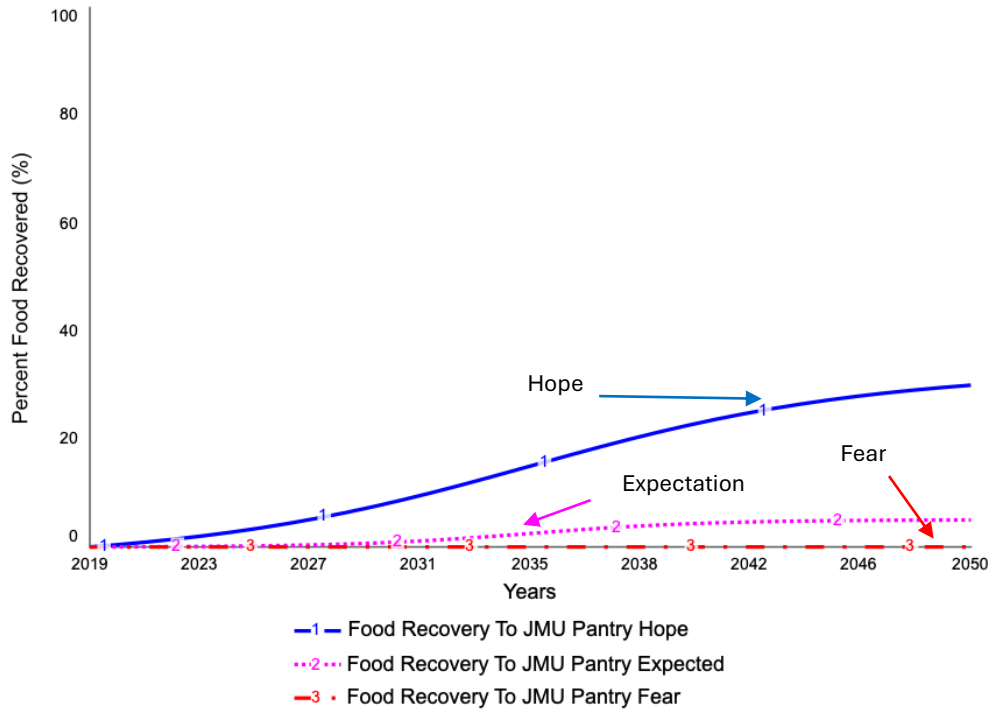

Figure 4. Behavior Over Time Graph of Recovered Leftover Food to Pantry

Current food recovery operations have donated food going to a local charity serve the local community. The objective is to not take away from the CEVC's mission to engage with the local community through service. However, there is a demonstrated need for food resources for university students based upon the rates of estimated food insecurity measured by the JMU Basic Needs Advisory Board. Additionally, there are multiple dining halls on campus that could theoretically have a food recovery operation applied to them. Figure 4 demonstrates the "Hopeful" scenario with the blue solid line numbered "1" is for more food to be donated to the JMU Pantry. The "Expected" scenario is that donations increase a little bit, but not as significantly as the hopeful scenario as marked by the pink dotted line numbered "2". The "Fear" scenario is that leftover food recovered is not donated to the JMU Pantry as marked by the red dash and dotted line labeled "3".

Dynamic Hypothesis

In a university setting, food insecurity among students and food waste from dining services present interconnected challenges. Addressing these issues requires a systemic approach that considers the relationships between students, dining halls, food pantries, and waste generation. The primary behavior of the model can be captured in a high-level module view, as seen in Fig. 5, where the system is divided into four key modules: students, dining, waste, and pantry. Each module operates under the governance of different bodies, each with its own set of policies, creating a complex landscape for food distribution and waste management. The causal loop diagram below illustrates these dynamics, highlighting key balancing and reinforcing feedback loops that influence food availability and waste. By analyzing these relationships, we can identify potential policy interventions, such as improving food recovery efforts, enhancing pantry accessibility, and optimizing dining hall operations to minimize waste while meeting

student needs. The following discussion explores the structure and implications of these feedback loops, as well as potential improvements to the system.

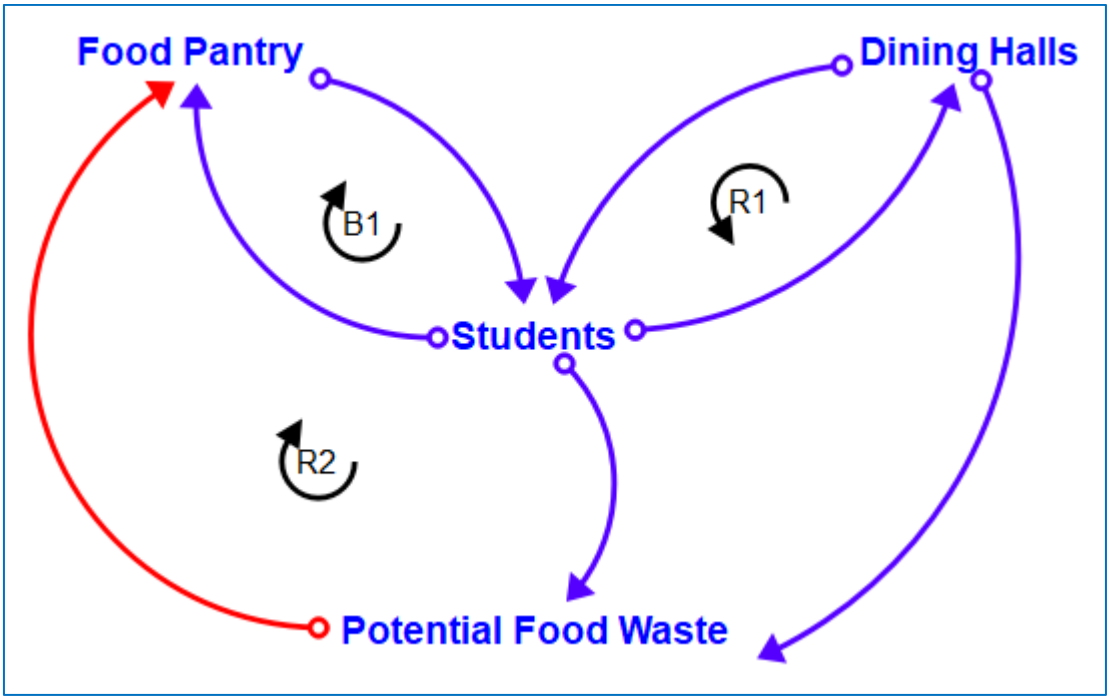

Figure 5. Organization of Conceptual Framework.

The loop B1 represents the donation and use of the university's pantry, the more students use the pantry the more food stock is consumed. The inflow for the food pantry is mostly external donation, or out-of-university purchases and other means. This means the pantry can only give out what stock it can maintain week to week. The more the pantry has in stock, the more it can serve students by promoting events such as food drives. The relationship between dining halls and students, as defined by loop R2, is an informational one as well as a physical one. Students eat from dining halls and the more eaten from the dining halls, the staff adjusts the number of meals prepared accordingly on a delay. As demand increases, so does the provided service. This reinforcing loop both contributes to an amount of waste, both students and kitchen staff produce some amount of waste. Students do not produce recoverable waste, and a portion of kitchen produced waste is recoverable.

Currently, there is minimal food being donated from the dining halls to the pantry. There is policy infrastructure for the established food recovery network to donate to the pantry, but the requirements have not been met in the last year of observation. For that reason, loop R2 primarily represents a proposed actionable policy based in existing policy. Additionally, the current food recovery program is solely tied to only one of the dining halls on campus, notably the smaller of the two. Expanding this relationship to the other Hall is proposed, and a policy within the model, but is not reflected within the model's base case behavior.

Modeling

The basic structure of the model as seen in figure 6, shows the layout and general loops of the greater model, which can be seen in the appendix. The core of the model is centered on the

flow between food secure and food insecure students. Students drift in and out of food insecurity based on the supplies available to them. Secure and insecure students are both fed from the dining halls, while food insecure students alone eat from the JMU pantry. Other food insecure students can be made secure through the punch donation program.

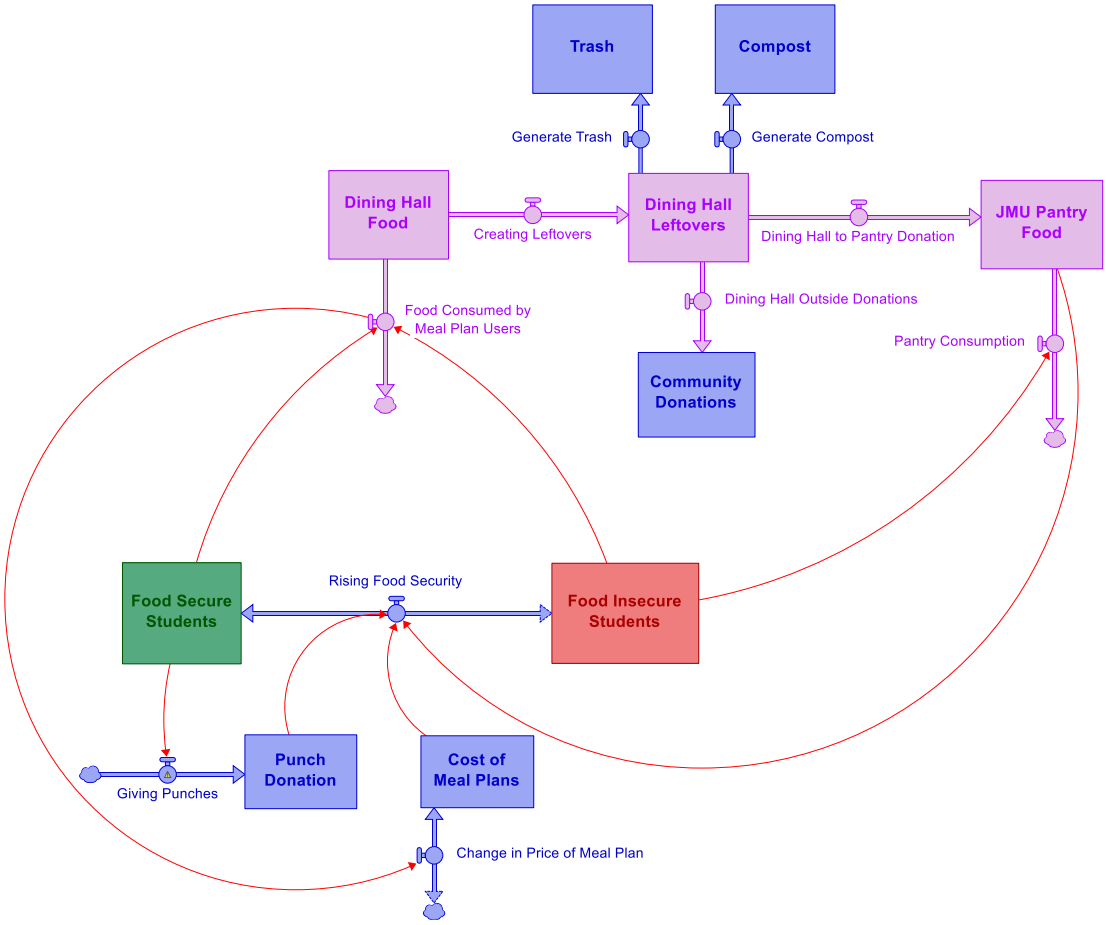

Figure 6. Top Level Feedback Structure

To analyze the potential impact of various policy interventions on food insecurity at JMU, we developed a system dynamics model that simulates the flow of food donations, pantry utilization, and student engagement with available resources. The model incorporates key feedback loops that capture the relationship between food waste, donation mechanisms, and student participation in food security programs. Each policy scenario outlined in Table 1 is represented as a distinct intervention within the model, allowing us to evaluate its effectiveness in increasing food availability and reducing food insecurity on campus. By simulating these policies, we aim to provide insights into how structural changes in food distribution and awareness efforts can influence overall student access to nutritious meals.

Results and Discussion

Parameter Analysis

In our examination of the JMU DinSim Model, a sensitivity analysis was conducted to evaluate how changes in key parameters influence food insecurity outcomes. The parameter Table 1 summarizes adjustments and their corresponding outcomes, while Figures 7 through 9 visually depict these findings, offering a clearer view of how each parameter affects food insecurity rates.

Table 1. Summary of Parameter Changes for Experimenting with the JMU DinSim Model

Parameter	Description	Change	Outcome
Hall to Pantry Donation Rate	The proportion of leftover food that is sent to the pantry.	Raising Donation rate from 50% to 70%.	Functionally no reduction in food insecurity.
Max Punch Donations per student per day	The max number of punches each student can donate each day.	Raised from 2 punches to 10 punches.	Functionally no reduction in food insecurity.
Proportion of Aware Students willing to use program	The proportion of students that are aware of the punch donation program and are willing to use it.	Raised from 50% to 90%.	Reduction of food insecurity rate from 38.5% to 36.6% (-4.9%).
Default proportion of students willing to eat from pantry	The proportion of students willing to eat from the pantry before any policies.	Raised from 50% to 90%.	Reduction of food insecurity rate from 38.5% to 36.5% (-5.1%).
Proportion still insecure post meal	The proportion of students still food insecure after each meal.	Lowered from 99.99% to 99.90%	Reduction of food insecurity rate from 38.5% to 35.6% (-7.5%).

One of the primary areas of focus was the Hall to Pantry Donation Rate, which represents the proportion of leftover food sent to the pantry. Increasing this rate from 0.5 to 0.7 resulted in no significant reduction in food insecurity, suggesting that simply increasing food supply without addressing other barriers may be insufficient. Similarly, raising the Max Punch Donations per Student per Day from 2 to 10, effectively increasing the number of meals each student can donate, did not significantly reduce food insecurity. This suggests that an expanded donation capacity alone does not directly translate to better food access for those in need.

In contrast, changes to parameters related to student awareness and willingness to participate produced more substantial effects. Increasing the Proportion of Aware Students Willing to Use the Program from 0.5 to 0.9 led to a 4.9 percent reduction in food insecurity rates. Likewise, raising the Default Proportion of Students Willing to Eat from the Pantry from 0.5 to 0.9 resulted in a 5.1 percent reduction. These results highlight the importance of improving awareness and encouraging participation in food support programs. The most pronounced effect came from adjusting the Proportion of Students Still Insecure Post Meal, a measure of how many students remain food insecure after receiving a meal. Lowering this value from 0.9999 to 0.999 led to a 7.5 percent reduction in food insecurity rates. This emphasizes the importance of improving meal adequacy and addressing persistent hunger.

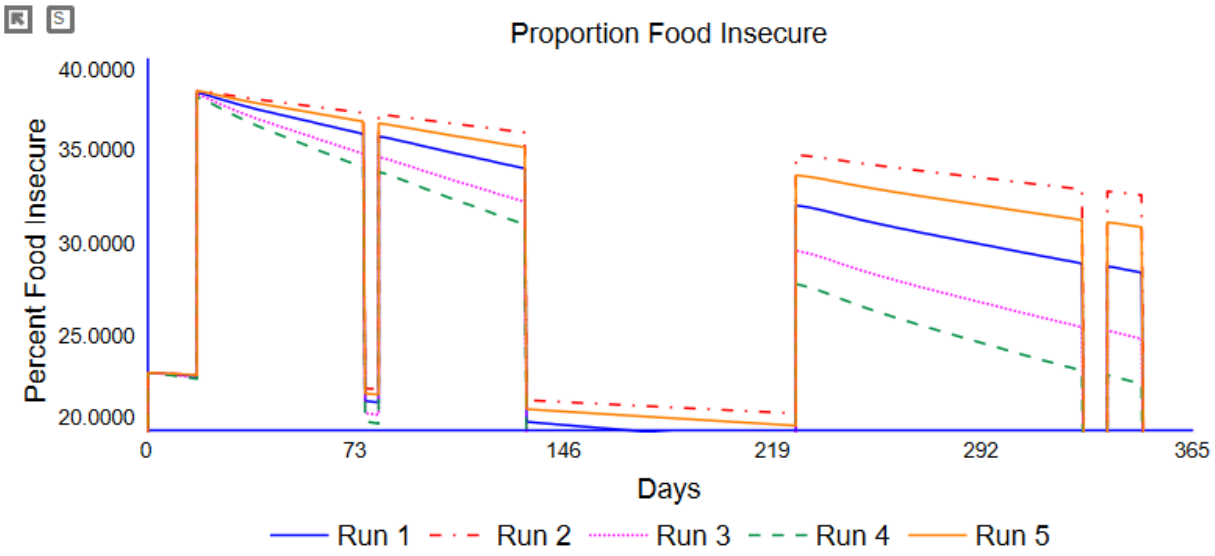

Figure 7. Proportion of Food Insecure Students with Model Parameters Changed

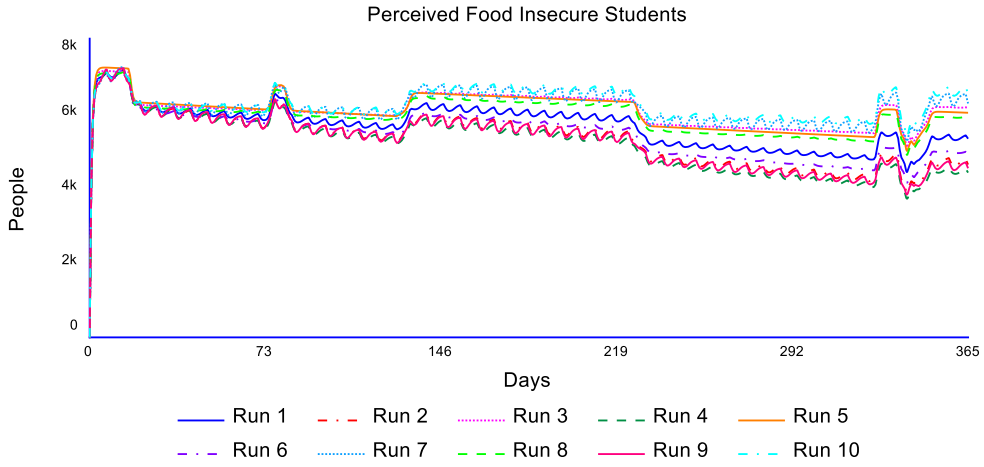

Figure 8. Number of Food Insecure Students with Model Parameters Changed

Sensitivity Analysis on Food Insecurity at the End of Fall Semester

	Final
Run 1: Proportion Food Insecure	28.6359
Run 2: Proportion Food Insecure	32.5373
Run 3: Proportion Food Insecure	25.2266
Run 4: Proportion Food Insecure	22.5898
Run 5: Proportion Food Insecure	30.9224
Run 6: Proportion Food Insecure	34.8342
Run 7: Proportion Food Insecure	27.0907
Run 8: Proportion Food Insecure	31.8494
Run 9: Proportion Food Insecure	24.2956
Run 10: Proportion Food Insecure	27.9799

Figure 9. Parameter analysis on Proportion Food Insecure

The DinSim model is sensitive to changes in parameter values, however, it does not drastically change behavior. The most sensitive parameter in the model is the proportion still insecure post meal. This parameter determines the speed of each policies effectiveness, bridging the gap between feeding students and securing their long-term needs. Depending on the level of need a food insecure student enters with, each meal from the dining halls or pantry could be the tipping point between food insecurity and having needs met. Changing how frequently meals are the tipping point for student's needs directly effects the speed at which food insecurity is overcome.

Policy Analysis

After constructing the JMU DinSim Model, the policy analysis testing included both testing known policies aimed at addressing campus food insecurity and potential alternative policies not yet enacted. Known policies include the "punch" donation system and JMU Pantry awareness campaigns. A student's meal plan to dining institutions on campus consist of "punches" which are equivalent to a prepaid meal voucher to enter the dining hall. A "punch" can also be used at retail dining locations on campus where they are equivalent to about seven

dollars' worth of food. Another policy tested in the DinSim Model was for leftover food from the dining hall to be donated to the JMU Pantry. The Civic Engagement & Volunteer Center (CEVC) at currently oversees a Food Recovery Network Chapter at JMU, and once a week a team of two to four students will arrive at one of the dining halls on campus to collect leftover food from the prior week that had been stored by the chefs and staff. The CEVC organization arranged with a local Salvation Army chapter to accept the donated food if there was enough to make twelve meals. If there were not, then the CEVC would organize for the food to be donated to the JMU Pantry. Through participating in the food recovery efforts, the amount of food leftover from the dining service consistently exceeded the twelve meals minimum threshold for donating to the local Salvation Army Chapter. With this program in mind, it is important to note that not all leftover food is salvageable from the dining halls after service. An organizational policy that is enforced by Aramark and followed by the CEVC Food Recovery Network Chapter is that the only food recoverable is food leftover from stations served by dining hall staff or any food that is what not placed out for service. This means that any food leftover from the self-serve stations cannot be recovered and is sent to the compost. Policies tested in the JMU DinSim Model included changing the donation location from off-campus to remaining on-campus and delivered to the JMU Pantry. Two similar policies that were tested include a JMU Pantry awareness campaign and a destigmatization campaign. The JMU Pantry awareness campaign was to increase knowledge within the student body of access to a free food pantry located at various points across campus. The JMU Pantry destigmatization campaign objective was to normalize utilizing resources that provide free food for individuals that are experiencing food insecurity. The last policy tested was to increase the number of meals served at the dining hall that reused leftovers from a previous dining service. Table 2 organizes each of the different policies descriptions with their objective target of accomplishment.

Table 3 presents the outcomes of implementing the donation-based strategies and awareness campaigns individually. It highlights their impact on pantry usage and overall food availability through displaying the amount of percent change in the initial starting values for the percentage of food insecurity in the student population, the amount of waste that is produced from the dining hall, and the amount of food composted per year. The simulation takes place over the course of an entire school year and uses the population size reported by the JMU Institutional Research department.

Table 2. Summary of Policy Scenarios for Experimenting with the JMU DinSim Model

Policy Scenario	Description	Goal of Experiment
E-Hall to Pantry	Donation switch to send leftover food from E-hall to the pantry.	Show that more students will be fed from the pantry if prepared food is donated.
D-Hall to Pantry	Donation switch to send leftover food from D-hall to the pantry.	Show that more students will be fed from the pantry if prepared food is donated.
Pantry Destigmatization campaign	Possible policy where JMU pushes resources on the prevalence of food insecurity in order to push food insecure students that are unwilling to use the pantry into pantry use.	Normalize accessing assistance programs to ease accessing food resources.
Pantry Awareness campaign	Possible policy where JMU continues advertising the existence of the pantry to have more students use it.	Reduction in food insecurity via resource awareness.
D-Hall Donation	Donation switch for sending leftover food from D-Hall to outside the university.	Reduce food waste from dining hall through.
Punch Donation	Switch for the punch donation program where students can donate extra punches to be used by other students.	Show the impact of an existing JMU program for combatting food insecurity.
Increased Food Reutilization	Prioritizing meals that reuse salvageable leftovers from previous nights to reduces waste.	Reduce the production of food waste.

Table 3. Summary of Simulated Policies Employing the JMU Pantry & Dining Services

Policy Scenario	Policy Number	Policy Instrument	Rationale	Outcomes
Dining halls and JMU Pantry Collaboration	1	E-Hall to Pantry	Increasing the supply of food in the pantry will attract more students to the pantry.	Increased pantry usage reduces food insecurity to 35.5% (-7.8 %).
Dining halls and JMU Pantry Collaboration	2	D-Hall to Pantry	Increasing the supply of food in the pantry will attract more students to the pantry.	Increased pantry usage reduces food insecurity to 35.3% (-8.3 %).
Using the JMU Pantry to address food insecurity	3	Pantry Awareness Campaign	Increased awareness of the pantry will make students aware of resources.	Increased pantry usage reduces food insecurity to 36.0% (-6.5%).
Using the JMU Pantry to address food insecurity	4	Pantry Destigmatization Campaign	A destigmatization campaign can make students more willing to accept aid.	Increased pantry usage reduces food insecurity to 35.9% (-6.8%).
Have students donate unused punches to the JMU Pantry	5	Punch Donation	Existing Program. Students can donate unused meals for other students	Minimal decrease in food insecurity. (8 additional students helped / day).
Use leftover food from dining halls to feed the community	6	D-Hall Donation	Takes unused food outside of the JMU system to feed the Harrisonburg community.	Increases the total stock of donated food from 195 lbs/year to 303 lbs/year (55.4%).
Increase food reutilization within the dining halls	7	Increased Food Reutilization	By making more meals with salvageable leftovers waste can be slashed.	Reduction in trash & compost from 373,000 lbs/year to 364,000 lbs/year (-2.4%).

Individually, each of these policies decreased the number of food insecure students ranging from 6% to about 8.5% which from a student population of about 22 thousand students is about 1320 to 1870 students per year that become food secure. Additionally, implemented individually, the dining halls reduced food waste by about 2.4% which is about a 10-thousand-pound reduction per year. The program that had the least impact on the food insecure population was the punch donation program. In past years when the JMU Pantry held events at the dining halls, D-Hall and E-Hall, where students could come and donate punches for the most part without a limit, and these events were held near when school breaks were about to start throughout the semester. However, there was recently a change in meal plan policy change that constrains students using their meal plan is to only allow for two “retail” punches to be used per day by a student. This change relegates the action of donating a punch to a “retail” usage designation which significantly reduced the number of punches the JMU Pantry was receiving from donations.

Table 3 explores the outcomes of combining multiple policy interventions to assess their cumulative impact on food insecurity. The results highlight potential synergies between policies, demonstrating a multi-faceted approach to interventions in increasing food access and pantry utilization.

When compared to the outcomes listed in Table 3, the multi-pronged approach to addressing food insecurity as displayed in Table 4 suggest that combining policies may have a greater impact on decreasing the population of food insecure students at JMU. Policy A described as a “Full JMU Pantry Utilization” in Table 4 simulates donating all leftover food to the JMU Pantry and enacting both an awareness and a destigmatization campaign with the predicted 20% reduction in food insecure students equating to about 4400 students made food secure. Other policies simulated predicted about 7.5% reduction in food insecurity if the focus was just on increasing the stock at the JMU Pantry and not also including the awareness programs.

Table 4. Summary of Combined Policies Employing Changes to Multiple Capabilities and Attributes Resulting in Minimized Food Insecurity and Minimized Waste.

Policy Scenario	Policy	Combined Policies	Policy Instrument	Rationale	Outcomes
Full JMU Pantry Utilization	A	1, 2, 3, 4	E-Hall to Pantry, D-Hall to Pantry, Pantry Awareness Campaign, Pantry Destigmatization Campaign	The Pantry is designed to provide resources to food insecure students. Pushing resources through existing channels is sensible.	Reduction in proportion food insecure from 38.5% to 30.8% (-20%).
JMU Pantry Supply Increase	B	1, 2	E-Hall to Pantry, D-Hall to Pantry	Increases in food supplied to the pantry will support more students.	Reduction in proportion food insecure from 38.5% to 35.7% (-7.3%).
Supply Increase with Outside Donation & Waste Reduction	C	1, 2, 6, 7	E-Hall to Pantry, D-Hall to Pantry, D-Hall Donation, Increased Food Reutilization	Increases in food supplied to the pantry will support more students. Other benefits can be reaped simultaneously with limited effect on food insecurity.	Reduction in proportion food insecure from 38.5% to 35.7% (-7.3%), Reduction in Trash to 279000 lbs/year (-25.2 %), 154 lbs/year food donated to the community.
Punch Donations	D	5	Punch Donation	Allow students to aid each other.	Minimal reduction in food insecurity.

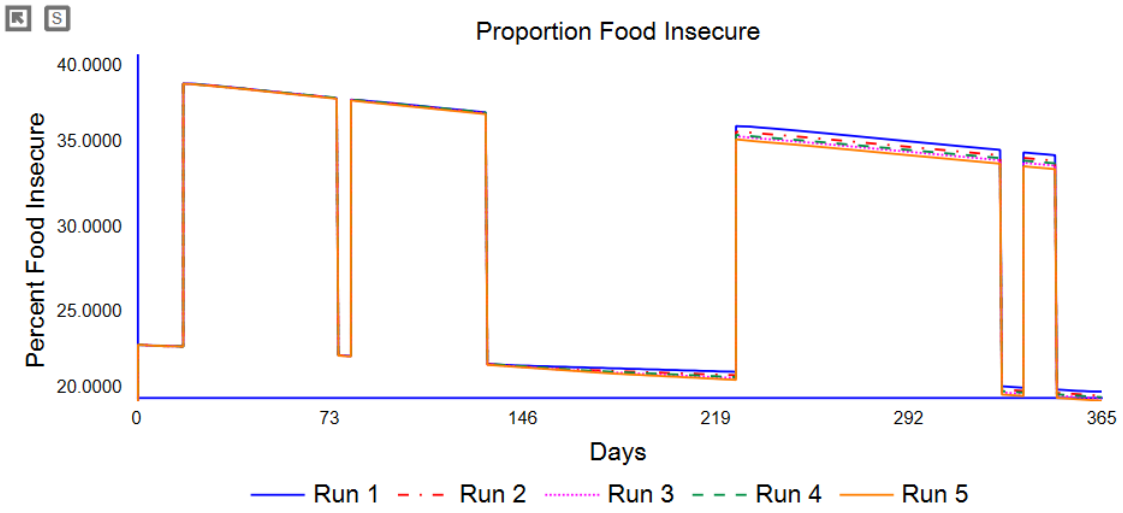

Figure 10. Effect of Different Combinations of Policies on Food Insecurity.

Sensitivity Analysis on Food Insecurity at the End of Fall Semester

	Final
Run 1: Proportion Food Insecure	34.1878
Run 2: Proportion Food Insecure	33.8647
Run 3: Proportion Food Insecure	33.5810
Run 4: Proportion Food Insecure	33.7113
Run 5: Proportion Food Insecure	33.3740
Run 6: Proportion Food Insecure	35.2766
Run 7: Proportion Food Insecure	34.7298
Run 8: Proportion Food Insecure	35.1867
Run 9: Proportion Food Insecure	32.9133
Run 10: Proportion Food Insecure	33.0956

Figure 11. Policy Analysis on Proportion Food Insecure

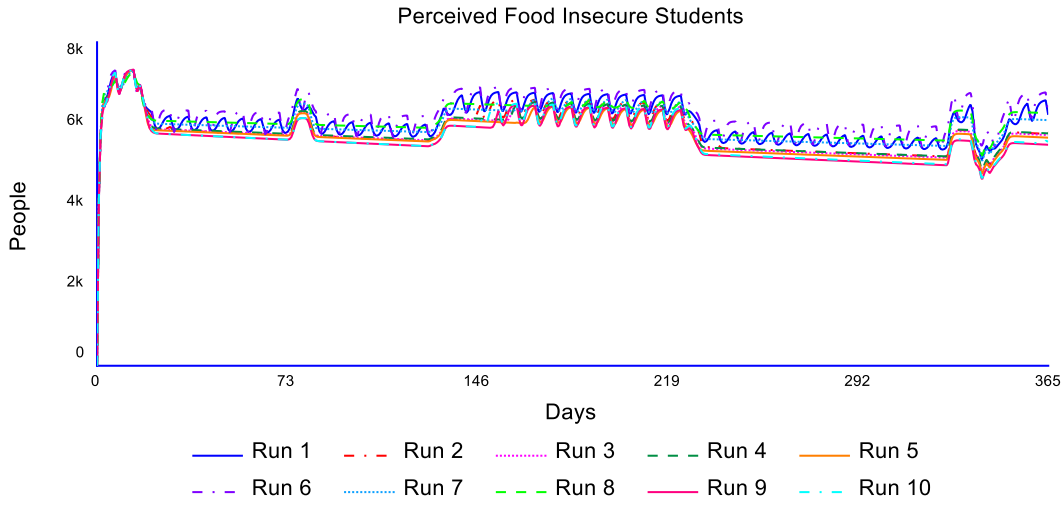

Figure 12. Policy Analysis on Students Facing Food Insecurity

Every potential policy takes several months to prove effective. As the model is only within a year time frame, the maximum effectiveness is limited. If the model were to be extended in the future, these policies would show a larger reduction in food insecurity. Over a 10-year time horizon, the proportion of students who are food insecure would drift to the incoming proportion each freshman class has minus the effect of the policies. As policies such as awareness campaigns are more effective on a group of students the longer, they have been used, the average food insecurity for each class drifts down until they graduate.

Conclusion

Food insecurity is a problem that is experienced globally and one that from the member nations of the United Nations to the leaders of local community activism groups hope to address. System dynamics modeling has been utilized in several contexts from analyzing national and regional food insecurity trends to experiences of individua households. The work done in this project utilizes system dynamics modeling to understand how students at James Madison University interact with dining institutions on campus. From surveys done by the JMU Basic Needs Advisory Board and the JMU Pantry, about 38% of the student population experiences food insecurity. Through collaborating with stakeholders and participating in existing food recovery efforts, the JMU DinSim model was created.

Through stakeholder engagement and empirical data collection, the model identifies key leverage points where strategic interventions can drive meaningful change. Policy simulations demonstrate that increasing food donations from campus dining facilities to the JMU Pantry, combined with awareness and destigmatization campaigns, can significantly reduce the proportion of food-insecure students. Specifically, a multi-faceted intervention that combines increased food recovery with enhanced student engagement and education could decrease food insecurity rates by up to 20%. These findings suggest that while no single policy can fully address the issue, an integrated approach leveraging existing infrastructure and community partnerships can yield substantial improvements. Sensitivity analysis reveals that improving student willingness to engage with available resources has a more profound impact on reducing food insecurity than simply increasing food supply. This insight emphasizes the need for continuous outreach and policy refinement to ensure that resources reach those most in need.

The JMU DinSim model provides a scalable and adaptable framework that can inform decision-making beyond JMU, offering insights applicable to other higher education institutions facing similar challenges. Future research should explore the long-term impacts of sustained policy interventions, the role of technology in improving food recovery efficiency, and the potential to integrate external food assistance programs more comprehensively. Ultimately, this project contributes to the broader discourse on sustainability and social equity in higher education. By combining system dynamics modeling with collaborative policy design, the Leftovers Capstone Project offers a replicable blueprint for institutions seeking to mitigate food waste while fostering a more food-secure student population. With ongoing commitment from university leadership and community stakeholders, JMU has the potential to become a model for sustainable food management and student well-being in higher education."

References

Faris, James. (2021). “JMU Dining hikes meal plan prices as sales fall $18 million” *The Breeze.* Accessed December 6, 2024. https://www.breezejmu.org/business/jmu-dining-hikes-meal-plan-prices-as-sales-fall-18-million/article_0c377ba8-9007-11eb-b707-9ff7e4a8a59f.html

Bruening, M., Argo, K., Payne-Sturges, D., & Laska, M. N. (2017). The Struggle Is Real: A Systematic Review of Food Insecurity on Postsecondary Education Campuses. Journal of the Academy of Nutrition and Dietetics, 117(11), 1767-1791.

Frank, Laura B. “‘Free Food on Campus!’: Using Instructional Technology to Reduce University Food Waste and Student Food Insecurity.” *Journal of American College Health* 70, no. 7 (October 2022): 1959–63. https://doi.org/10.1080/07448481.2020.1846042.

“Good Samaritan Act Provides Liability Protection For Food Donations | USDA.” Accessed March 28, 2024. https://www.usda.gov/media/blog/2020/08/13/good-samaritan-act-provides-liability-protection-food-donations.

Hamilton College. “Food Harvest Cuts Waste and Hunger in the Community.” Accessed March 28, 2024. //www.hamilton.edu/news/story/food-harvest-cuts-waste-hunger-in-utica-community.

Henry, L. (2017). Understanding Food Insecurity Among College Students: Experience, Motivation, and Solutions. University of New Hampshire, Scholars' Repository.

Keelor, Josette. (2023). “‘A quiet crisis.’” Accessed April 12, 2024. Available: https://www.jmu.edu/news/2023/11/21-food-insecurity.shtml

US EPA, OLEM. “Sustainable Management of Food.” Collections and Lists, April 16, 2015. https://www.epa.gov/sustainable-management-food.

JMU Student Life. “On Campus Dining.” Accessed March 29, 2024 https://www.jmu.edu/admissions/_files/publications/studentlife-oncampusdining.pdf

United Nations. (n.d.). Greenwashing: What is it, and how to avoid it? United Nations Climate Change. Retrieved [December 1, 2024], from https://www.un.org/en/climatechange/science/climate-issues/greenwashing#:~:text=Being%20purposely%20vague%20or%20non,and%20can%20be%20easily%20misinterpreted.

United Nations. “The 17 Goals.”. Accessed April 20, 2024. Available https://sdgs.un.org/goals

Virginia Department of Social Services. “Food Security in Virginia.” Accessed September 20, 2024. https://www.dss.virginia.gov/community/food_security/index.cgi

James Madison University Institutional Research. “Fact Book Enrollment (E – 1).” Accessed March 4, 2025. https://www.jmu.edu/pair/ir/factbook/e-01.shtml

Metta, K., Olabisi, L. S., and Wallace, R. (2021). “A system dynamics approach to examining household food insecurity.” *Journal of Agriculture, Food Systems, and Community Development.*

Quinteros-Reyes, C., Seferidi, P., Guzman-Abello, L., Millett, C., Bernabé-Ortiz, A., Ballard, E. (2024). “Mapping food system drivers of the double burden of malnutrition using community-based system dynamics: a case study in Peru.” *BMC Global and Public Health* 2(15).

Herrera de Leon, H. J., and Kopainsky, B. (2019). “Do you bend or break? System Dynamics in resilience planning for food security.” *System Dynamics Review* 35(4): 287-309.

Isaac, J., Carrera, J. L., Rivas, O. M., Ruano, J. G., Martínez, M. R., Khowaja, A., Russel, J., Malard-Adam, J., Monardes, H., Adamowski, J., Melgar-Quiñonez, H. (2023). “Evaluating and mitigating locally and nationally variable food security dynamics in Guatemala through participatory causal loop diagram building.” *System Dynamics Review* 39(3): 239 – 276.

Zaini, R. M., Pavlov, O. V., Saeed. K., Radzicki, M. J., Hoffman A. H., Tichenor, K. R. (2016a). “Let’s Talk Change in a University: A Simple Model for Addressing a Complex Agenda.” *Systems Research and Behavioral Science.*

Zaini, R. M., Elmes, M. B., Pavlov, O. V., Saeed, K. (2019). “Organizational Dissent Dynamics in Universities: Simulations with a System Dynamics Model.” *Managment Communication Quarterly* 1 – 32.

Zaini, R. M., Elmes, M. B., Pavlov, O. V., Saeed, K. (2016b). “Organizational Dissent Dynamics: A Conceptual Framework.” *Management Communication Quarterly* 1 – 20.