Effectiveness of Policies and Organizations' Partnerships in Mitigating Shocks to Fresh Produce Surplus Recovery–A Simulation Model in New York

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Extended Abstract:

Introduction. Our food systems are increasingly prone to shocks (Cottrell et al., 2019; Fraser et al., 2005), posing a threat to food security and already vulnerable populations (Aday & Aday, 2020; Béné, 2020; Carducci et al., 2021; Jenkins et al., 2021; Macaninch et al., 2020; Savary et al., 2020; Whitmore Schanzenbach, 2020). Policies supporting recovery and redistribution of surplus nutritious foods can support local food systems during shocks. However, the implementation of these policies relies on key stakeholders such as farms, retailers, and organizations that distribute emergency food which are also subject to the effect of shocks, potentially hampering organizations' ability to respond and recover from the effect of shocks. In New York, two recently implemented policies represent an opportunity to analyze two different mechanisms to promote surplus food recovery and distribution (also referred here as food rescue). The first policy, *'Nourish New York'*–a compensation program for local producers– was introduced in 2020 to address food security and food waste concerns that emerged during the Covid-19 pandemic provides funds to food aid organizations to purchase fresh foods, including fresh fruits and vegetables, from local producers. The New York *'Food Donation and Food Scraps Recycling Law'*–an organic waste ban–was made effective in January 2022, mandating large generations of wasted food (*e.g.*, retailers, grocery stores) to divert excess edible food to food aid organizations and food scraps to recycling facilities. Our model focuses on fresh fruits and vegetables, which adequate access has been considered key to improving healthy diets to vulnerable populations, while their high perishability leads

to high waste rates, posing important challenges to efficient distribution of surpluses (Bajželj et al., 2020; Bertmann et al., 2021; Carducci et al. 2021; Caspi et al., 2021; Springmann et al., 2018; Wheeler & von Braun, 2013). _Policy question and model purpose:_ _To what extent policies like Nourish New York and the New York state organic waste ban can increase surplus fresh fruit and vegetables (fresh produce) recovery and redistribution while minimizing their waste in New York's Capital Region?_ Our model seeks to answer this question by testing the ability of policies and organizations' coordination and partnerships to respond to shocks in the regional food rescue system. The success of these policies is assessed based on their ability to sustain the provision of fresh produce to vulnerable populations and minimize wasted food following a shock. Key disruptions constituting the "shock" are a) increased food demand, b) more time needed to distribute food (due to reduced human capacity at organizations), and c) changes in the food supply. **_Methodological Approach_**. Grounded in community-based research and using group model-building (Andersen & Richardson, 1997; Hovmand et al., 2013; Luna-Reyes et al., 2006; _Scriptapedia_, 2020), we built a system dynamic model of recovery and redistribution of fresh fruits and vegetables (fresh produce). We also incorporated information from an online survey (Jan.2017-Jun.2021) on organization-level responses to the pandemic shock, data collected from four consecutive surveys to food pantries in the Capital Region area (Nov. 2017—Aug. 2018) (Feingold et al., _in preparation_), and available databases (ReFED Insights Engine; U.S. Census Bureau). We represented key dynamics: supply chain dynamics (Sterman, 2000a) and dynamics related to food waste, including waste rates, perceived food quality, average shelf-life, shelf-life losses due to waste, and food decay. We simulated 'what if' scenarios representing supply chain disruptions, implementation of policies at different levels, and an increase in coordination and partnerships across organizations. **_Key findings and discussion_**. All scenarios increased food distribution compared to the baseline, but not all favored food quality and waste reduction. This is mainly explained by an overrun of organizations' capacity following the implementation of policies, which promoted quick food decay and waste. Coordination and partnerships across organizations can buffer the effects of shocks and, along with programs supporting local agriculture, can be key to increasing the provision of fresh nutritious foods such as fruits & vegetables to vulnerable populations while minimizing waste during shocks. _Limitations_. We did not consider seasonal variations of donations and demand, nor potential changes in waste outside the boundary (i.e., farm waste, household waste, waste diverted to landfills). _Strengths_. The model can be expanded to represent complex dynamics in other sectors (e.g., farm, retail, waste management, and population). Community-engaged research and multiple data sources allowed us to enhance the quality and relevance of the model. The dynamics in this model may be useful in modeling fresh produce rescue in other regions. _Next steps_: Since the effects of shocks and related responses can vary according to the degree of severity of the shock, further simulations might include scenarios considering different degrees of severity.

References

Aday, S., & Aday, M. S. (2020). Impact of COVID-19 on the food supply chain. *Food Quality and Safety*, *4*(4), 167–180. https://doi.org/10.1093/fqsafe/fyaa024

Andersen, D. F., & Richardson, G. P. (1997). Scripts for group model building. *System Dynamics Review*, *13*(2), 107–129. https://doi.org/10.1002/(SICI)1099-1727(199722)13:2<107::AID-SDR120>3.0.CO;2-7

Aune, D., Giovannucci, E., Boffetta, P., Fadnes, L. T., Keum, N., Norat, T., Greenwood, D. C., Riboli, E., Vatten, L. J., & Tonstad, S. (2017). Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality—A systematic review and dose-response meta-analysis of prospective studies. *International Journal of Epidemiology*, *46*(3), 1029–1056. https://doi.org/10.1093/ije/dyw319

Bajželj, B., Quested, T. E., Röös, E., & Swannell, R. P. J. (2020). The role of reducing food waste for resilient food systems. *Ecosystem Services*, *45*, 101140. https://doi.org/10.1016/j.ecoser.2020.101140

Bazzano, L. A., He, J., Ogden, L. G., Loria, C. M., Vupputuri, S., Myers, L., & Whelton, P. K. (2002). Fruit and vegetable intake and risk of cardiovascular disease in US adults: The first National Health and Nutrition Examination Survey Epidemiologic Follow-up Study. *The American Journal of Clinical Nutrition*, *76*(1), 93–99. https://doi.org/10.1093/ajcn/76.1.93

Béné, C. (2020). Resilience of local food systems and links to food security – A review of some important concepts in the context of COVID-19 and other shocks. *Food Security*, *12*(4), 805–822. https://doi.org/10.1007/s12571-020-01076-1

Bennett, G., Young, E., Butler, I., & Coe, S. (2021). The Impact of Lockdown During the COVID-19 Outbreak on Dietary Habits in Various Population Groups: A Scoping Review. *Frontiers in Nutrition*, *8*, 626432. https://doi.org/10.3389/fnut.2021.626432

Bertmann, F., Rogomentich, K., Belarmino, E. H., & Niles, M. T. (2021). The Food Bank and Food Pantries Help Food Insecure Participants Maintain Fruit and Vegetable Intake During COVID-19. *Frontiers in Nutrition*, *8*, 673158. https://doi.org/10.3389/fnut.2021.673158

Beydoun, M. A., Powell, L. M., Chen, X., & Wang, Y. (2011). Food Prices Are Associated with Dietary Quality, Fast Food Consumption, and Body Mass Index among U.S. Children and Adolescents. *The Journal of Nutrition*, *141*(2), 304–311. https://doi.org/10.3945/jn.110.132613

Bishnoi, A., Chawla, H. M., & Rani, G. (2014). Extension of Shelf Life of Plum by Formulation Developed from Oligomer Isolated from Lac. *International Journal of Advances in Chemical Engineering and Biological Sciences*, *1*(1). https://doi.org/10.15242/IJACEBS.C0114074

Borens, M., Magnin, C., & Timelin, B. (2022, September 7). *Reducing food loss: What grocery retailers and manufacturers can do*. https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/reducing-food-loss-what-grocery-retailers-and-manufacturers-can-do

Brzezina, N., Kopainsky, B., & Mathijs, E. (2016). Can Organic Farming Reduce Vulnerabilities and Enhance the Resilience of the European Food System? A Critical Assessment Using System Dynamics Structural Thinking Tools. *Sustainability*, *8*(10), Article 10. https://doi.org/10.3390/su8100971

Carducci, B., Keats, E. C., Ruel, M., Haddad, L., Osendarp, S. J. M., & Bhutta, Z. A. (2021). Food systems, diets and nutrition in the wake of COVID-19. *Nature Food*, *2*(2), Article 2. https://doi.org/10.1038/s43016-021-00233-9

Caspi, C. E., Davey, C., Bliss Barsness, C., Gordon, N., Bohen, L., Canterbury, M., Peterson, H., & Pratt, R. (2021). Needs and Preferences Among Food Pantry Clients. *Preventing Chronic Disease*, *18*. https://doi.org/10.5888/pcd18.200531

Cottrell, R. S., Nash, K. L., Halpern, B. S., Remenyi, T. A., Corney, S. P., Fleming, A., Fulton, E. A., Hornborg, S., Johne, A., Watson, R. A., & Blanchard, J. L. (2019). Food production shocks across land and sea. *Nature Sustainability*, *2*(2), Article 2. https://doi.org/10.1038/s41893-018-0210-1

Datola, G., Bottero, M., De Angelis, E., & Romagnoli, F. (2022). Operationalising resilience: A methodological framework for assessing urban resilience through System Dynamics Model. *Ecological Modelling*, *465*, 109851. https://doi.org/10.1016/j.ecolmodel.2021.109851

Dauchet, L., Amouyel, P., Hercberg, S., & Dallongeville, J. (2006). Fruit and vegetable consumption and risk of coronary heart disease: A meta-analysis of cohort studies. *The Journal of Nutrition*, *136*(10), 2588–2593. https://doi.org/10.1093/jn/136.10.2588

Diezma, B., Barreiro, P., Baltazar, P., & Correa, E. C. (2021). A general procedure for predicting the remaining shelf life of nectarines and peaches for virtualization of the value chain. *Postharvest Biology and Technology*, *181*, 111677. https://doi.org/10.1016/j.postharvbio.2021.111677

Ericksen, P., Bohle, H.-G., & Steweart, B. (2010). Vulnerability and Resilience of Food Systems. In *Food Security and Global Environmental Change* (pp. 67–77). Earthscan.

Feingold, B., Arroyo, M. T., Hosler, A., Craft, T., Myo, H. W. L., Bozlak, C., Romeiko, X., Pernicka, N., Crasto-Donnelly, P., Klein, A., Pettigrew, S., Atwood, B., & Neff, R. (2021). Impacts of the First Year of COVID-19 on Food Security in the New York's Capital Region. *Environmental Health Sciences Faculty Scholarship*. https://scholarsarchive.library.albany.edu/ehs_fac_scholar/5

Feofilovs, M., & Romagnoli, F. (2021). Dynamic assessment of urban resilience to natural hazards. *International Journal of Disaster Risk Reduction*, *62*, 102328. https://doi.org/10.1016/j.ijdrr.2021.102328

Fraser, E. D. G., Mabee, W., & Figge, F. (2005). A framework for assessing the vulnerability of food systems to future shocks. *Futures*, *37*(6), 465–479. https://doi.org/10.1016/j.futures.2004.10.011

Gu, C., Ye, X., Cao, Q., Guan, W., Peng, C., Wu, Y., & Zhai, W. (2020). System dynamics modelling of urbanization under energy constraints in China. *Scientific Reports*, *10*(1), Article 1. https://doi.org/10.1038/s41598-020-66125-3

Guyomard, H., Darcy-Vrillon, B., Esnouf, C., Marin, M., Russel, M., & Guillou, M. (2012). Eating patterns and food systems: Critical knowledge requirements for policy design and implementation. *Agriculture & Food Security*, *1*(1), 13. https://doi.org/10.1186/2048-7010-1-13

Hadad, R. (2016, December). *Cold Storage Chart and Reference Guide to Commercial Vegetable Storage—Cornell Vegetable Program—Cornell University—Cornell Cooperative Extension*. https://cvp.cce.cornell.edu/submission.php?id=411

Heck, S., Campos, H., Barker, I., Okello, J. J., Baral, A., Boy, E., Brown, L., & Birol, E. (2020). Resilient agri-food systems for nutrition amidst COVID-19: Evidence and lessons from food-based approaches to overcome micronutrient deficiency and rebuild livelihoods after crises. *Food Security*, *12*(4), 823–830. https://doi.org/10.1007/s12571-020-01067-2

Herrera de Leon, H. J., & Kopainsky, B. (2019). Do you bend or break? System dynamics in resilience planning for food security. *System Dynamics Review*, *35*(4), 287–309. https://doi.org/10.1002/sdr.1643

Herrera, H. (2017). From Metaphor to Practice: Operationalizing the Analysis of Resilience Using System Dynamics Modelling. *Systems Research & Behavioral Science*, *34*(4), 444–462. https://doi.org/10.1002/sres.2468

Herrera, H., & Kopainsky, B. (2020). Using system dynamics to support a participatory assessment of resilience. *Environment Systems and Decisions*, *40*(3), 342–355. https://doi.org/10.1007/s10669-020-09760-5

Herrera, H., Schütz, L., Paas, W., Reidsma, P., & Kopainsky, B. (2022). Understanding resilience of farming systems: Insights from system dynamics modelling for an arable farming system in the Netherlands. *Ecological Modelling*, *464*, 109848. https://doi.org/10.1016/j.ecolmodel.2021.109848

Hovmand, P., Rouwette, E., Andersen, D., Richardson, G., & Kraus, A. (2013). *Sriptapedia 4.0.6*.

Janssen, M., Chang, B. P. I., Hristov, H., Pravst, I., Profeta, A., & Millard, J. (2021). Changes in Food Consumption During the COVID-19 Pandemic: Analysis of Consumer Survey Data From the First Lockdown Period in Denmark, Germany, and Slovenia. *Frontiers in Nutrition*, *8*, 635859. https://doi.org/10.3389/fnut.2021.635859

Jenkins, R. H., Vamos, E. P., Taylor-Robinson, D., Millett, C., & Laverty, A. A. (2021). Impacts of the 2008 Great Recession on dietary intake: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *18*(1), 57. https://doi.org/10.1186/s12966-021-01125-8

Joakim, E. P., Mortsch, L., Oulahen, G., Harford, D., Klein, Y., Damude, K., & Tang, K. (2016). Using system dynamics to model social vulnerability and resilience to coastal hazards. *International Journal of Emergency Management*. https://www.inderscienceonline.com/doi/10.1504/IJEM.2016.079846

Kaur, K., & Dhillon, W. S. (2015). Influence of maturity and storage period on physical and biochemical characteristics of pear during post cold storage at ambient conditions. *Journal of Food Science and Technology*, *52*(8), 5352. https://doi.org/10.1007/s13197-014-1620-3

Kopainsky, B., Huber, R., & Pedercini, M. (2015). Food Provision and Environmental Goals in the Swiss Agri-Food System: System Dynamics and the Social-ecological Systems Framework. *Systems Research and Behavioral Science*, *32*(4), 414–432. https://doi.org/10.1002/sres.2334

Lewis, M., Herron, L.-M., Chatfield, M. D., Tan, R. C., Dale, A., Nash, S., & Lee, A. J. (2023). Healthy Food Prices Increased More Than the Prices of Unhealthy Options during the COVID-19 Pandemic and Concurrent Challenges to the Food System. *International Journal of Environmental Research and Public Health*, *20*(4), Article 4. https://doi.org/10.3390/ijerph20043146

Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review*, *22*(4), 291–320. https://doi.org/10.1002/sdr.349

Macaninch, E., Martyn, K., & Lima do Vale, M. (2020). Exploring the implications of COVID-19 on widening health inequalities and the emergence of nutrition insecurity through the lens of organisations involved with the emergency food response. *BMJ Nutrition, Prevention & Health*, *3*(2), 374–382. https://doi.org/10.1136/bmjnph-2020-000120

Messner, R., Johnson, H., & Richards, C. (2022). Towards systemic solutions to food waste: Creative destabilisation and escaping food waste lock-in. *Journal of Rural Studies*, *92*, 180–188. https://doi.org/10.1016/j.jrurstud.2022.03.023

Muriana, C. (2017). A focus on the state of the art of food waste/losses issue and suggestions for future researches. *Waste Management*, *68*, 557–570. https://doi.org/10.1016/j.wasman.2017.06.047

New York State Department of Environmental Conservation. (2021). *Methodology Used to Determine Designated Food Scraps Generators*. https://www.dec.ny.gov/docs/materials_minerals_pdf/dfsgmethodology.pdf

New York State Department of Environmental Conservation. (2022). *List of designated food scrap generators*. https://www.dec.ny.gov/docs/materials_minerals_pdf/dfsglist2023.pdf

New York State Pollution Prevention Institute (NYSP2I). (2021). *Final Report for: New York State Department of Environmental Conservation*. https://www.rit.edu/affiliate/nysp2i/sites/rit.edu.affiliate.nysp2i/files/docs/resources/NYSP2I_Food_Scraps_Waste_Estimation_Methodology_Guidance.pdf

Pedraza, L. S., Popkin, B. M., Batis, C., Adair, L., Robinson, W. R., Guilkey, D. K., & Taillie, L. S. (2019). The caloric and sugar content of beverages purchased at different store-types changed after the sugary drinks taxation in Mexico. *International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 103. https://doi.org/10.1186/s12966-019-0872-8

Perdana, T., Onggo, B. S., Sadeli, A. H., Chaerani, D., Achmad, A. L. H., Hermiatin, F. R., & Gong, Y. (2022). Food supply chain management in disaster events: A systematic literature review. *International Journal of Disaster Risk Reduction*, *79*, 103183. https://doi.org/10.1016/j.ijdrr.2022.103183

Rahmandad, H., & Sterman, J. D. (2012). Reporting guidelines for simulation-based research in social sciences. *System Dynamics Review*, *28*(4), 396–411. https://doi.org/10.1002/sdr.1481

ReFED. (n.d.). *Insights Engine – Food waste monitor*. Retrieved November 9, 2021, from https://insights-engine.refed.org/food-waste-monitor?break_by=destination&indicator=tons-surplus&view=detail&year=2019

Savary, S., Akter, S., Almekinders, C., Harris, J., Korsten, L., Rötter, R., Waddington, S., & Watson, D. (2020). Mapping disruption and resilience mechanisms in food systems. *Food Security*, *12*(4), 695–717. https://doi.org/10.1007/s12571-020-01093-0

Scriptapedia. (2020). Wikibooks, The Free Textbook Project. https://en.wikibooks.org/w/index.php?title=Special:CiteThisPage&page=Scriptapedia&id=3693132&wpFormIdentifier=titleform

Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., de Vries, W., Vermeulen, S. J., Herrero, M., Carlson, K. M., Jonell, M., Troell, M., DeClerck, F., Gordon, L. J., Zurayk, R., Scarborough, P., Rayner, M., Loken, B., Fanzo, J., … Willett, W. (2018). Options for keeping the food system within environmental limits. *Nature*, *562*(7728), Article 7728. https://doi.org/10.1038/s41586-018-0594-0

Stave, K. A., & Kopainsky, B. (2015). A system dynamics approach for examining mechanisms and pathways of food supply vulnerability. *Journal of Environmental Studies and Sciences*, *5*(3), 321–336. https://doi.org/10.1007/s13412-015-0289-x

Sterman, J. (2000a). *Business dynamics: Systems thinking and modeling for a complex world*. McGraw-Hill Higher Education.

Sterman, J. (2000b). Formulating Nonlinear Relationships. In *Business dynamics: Systems thinking and modeling for a complex world* (pp. 551–596). McGraw-Hill Higher Education.

Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., Kruetli, P., Grant, M., & Six, J. (2015). Food system resilience: Defining the concept. *Global Food Security*, *6*, 17–23. https://doi.org/10.1016/j.gfs.2015.08.001

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences*, *100*(14), 8074. https://doi.org/10.1073/pnas.1231335100

United States Department of Agriculture, Agricultural Research Service. (2016). *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks* (No. 66). https://www.ars.usda.gov/arsuserfiles/oc/np/commercialstorage/commercialstorage.pdf

US Census Bureau. (n.d.-a). *Quarterly Workforce Indicators.* http://qwiexplorer.ces.census.gov

US Census Bureau. (n.d.-b). *US Census Bureau County Business Patterns (CBP)*. https://www.census.gov/programs-surveys/cbp.html

U.S. Department of Health & Human Services, A. S. for P. (2019, April 26). *FoodKeeper App* [Text]. FoodSafety.Gov. https://www.foodsafety.gov/keep-food-safe/foodkeeper-app

Wheeler, T., & von Braun, J. (2013). Climate Change Impacts on Global Food Security. *Science*, *341*(6145), 508–513. https://doi.org/DOI: 10.1126/science.1239402

Whitmore Schanzenbach, D. (2020). *Not Enough to Eat: COVID-19 Deepens America's Hunger Crisis*. Food Research & Action Center. https://frac.org/wp-content/uploads/Not-Enough-to-Eat_Hunger-and-COVID.pdf