Enabling Resilient Food Systems: Simulating the Impact on Local Farmers' Livelihoods in Greater Adelaide, Australia

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To increase resilience of the food system of Greater Adelaide to threats such as those posed by climate change and global supply chain disruptions, the local councils in the region envision a policy strategy of increasing food system literacy. The question is: Will the councils' preferred policy actually improve the resilience of small and medium enterprise (SME) farmers – our primary stakeholders? And are there any plausible traps that could adversely affect them? Considering the complex and dynamic nature of food systems, the System Dynamics (SD) method was opted for investigating the questions posed. Representing the real-world system responsible for farmers´ livelihoods, a simulation SD model was constructed as a proof-of-concept for the councils' policy strategy. It is evident, based on the findings of the model, that increasing food system literacy does indeed increase the resilience of SME farmers' livelihoods. Diffusion of food system knowledge amongst the local populace is expected to yield a growing demand for local produce and increased levels of social connectedness, such that the SME farmers can expect increases in income levels and well-being. On these grounds, we recommend that councils allocate resources to increase food system literacy in Greater Adelaide.

Keywords: agri-food system; food system resilience; food system literacy; system dynamics; simulation model

Conference Thread: Environment and Resources; Agriculture and Food

Introduction

As climate change and global events continue to threaten the sustainability of food systems in many parts of the world, local governments in South Australia have renewed their attention on making their local food systems more resilient. In line with the larger 'Enabling Resilient Food Systems in South Australia' project, nine local councils from Greater Adelaide have sought to transform their local communities. Their working hypothesis for this transformation is that a locally diverse and reconnected food system will enable better sustainability and resilience outcomes, including increased access to nutrition, improved social cohesion and livelihoods, enhanced well-being, as well as greater resilience to shocks and stressors.

This paper seeks to test the local councils' policy strategy in relation to the resilience of local farmers' livelihoods within Greater Adelaide's food system. According to Levine (2014), measurements of livelihood traditionally focus on economic outcomes, like income. Though important, he calls for the inclusion of non-economic indicators such as "people's ability to cope, the range of their choices and their resilience" (Levine, 2014, p.14). Based on this perspective, we have conceptualised farmers' well-being as an indicator that accounts for both economic and social aspects of livelihood. It represents the average farmer's state of being in response to changes in overall income level (economic success), income variability (economic success), and social connectedness (coping mechanism). Resilience, then, is the ability of farmers to maintain their well-being at a relatively high level in spite of shocks to stressors.

Without policy interventions, local farmers presently experience and will continue to experience low resilience in their livelihoods. Given the inherent volatility of agricultural markets, due to both the supply-demand-price dynamics and variable weather conditions, the income level of the average farm exhibit oscillatory behaviour (Key et al., 2017). Importantly, we expect unfavourable weather to reduce the production capacity of farms and increase variable costs of production, thereby reducing farm income. Moreover, South Australia commonly experiences extreme weather conditions such as droughts, only to be exacerbated by climate change. Such events represent shocks in the food system, which cause large dips in farm income and farmers' well-being.

To achieve their resilience goals, the local councils broadly envision a policy strategy of increasing food system literacy (City of Holdfast Bay, n.d.) – which we have assumed to be their preferred policy choice. Representing the interest of our key stakeholders, small and medium enterprise (SME) farmers, we pose these research questions: Will the councils' preferred policy improve the income and well-being of SME farmers in Greater Adelaide? Are there any plausible traps that could adversely affect SME farmers? By answering these questions, we not only seek to test the overall working hypothesis, but also minimise any potential unintended consequences or policy resistance.

Method

We set forth to test the hypothesis that follows from the preceding questions posed: *Increasing food system literacy, and thereby the social connectedness of Greater Adelaide's food system, improves the resilience of local SME farmers' livelihoods*. Given the complexity of food systems, with several interrelated components, the system dynamics method was opted for testing the hypothesis.

To that end, we built a system dynamics model to capture the key components in the Greater Adelaide's food system. The model represents the real-world system drivers of farmers' livelihood outcomes: income level, income variability, social connectedness, and importantly, well-being. By introducing model structures to simulate policy scenarios where food system literacy increases, we were able to monitor the responses of these key performance indicators (KPIs). And, in doing so, show proof-of-concept of the local councils' core hypothesis and overall policy strategy.

Simplified Model Structure

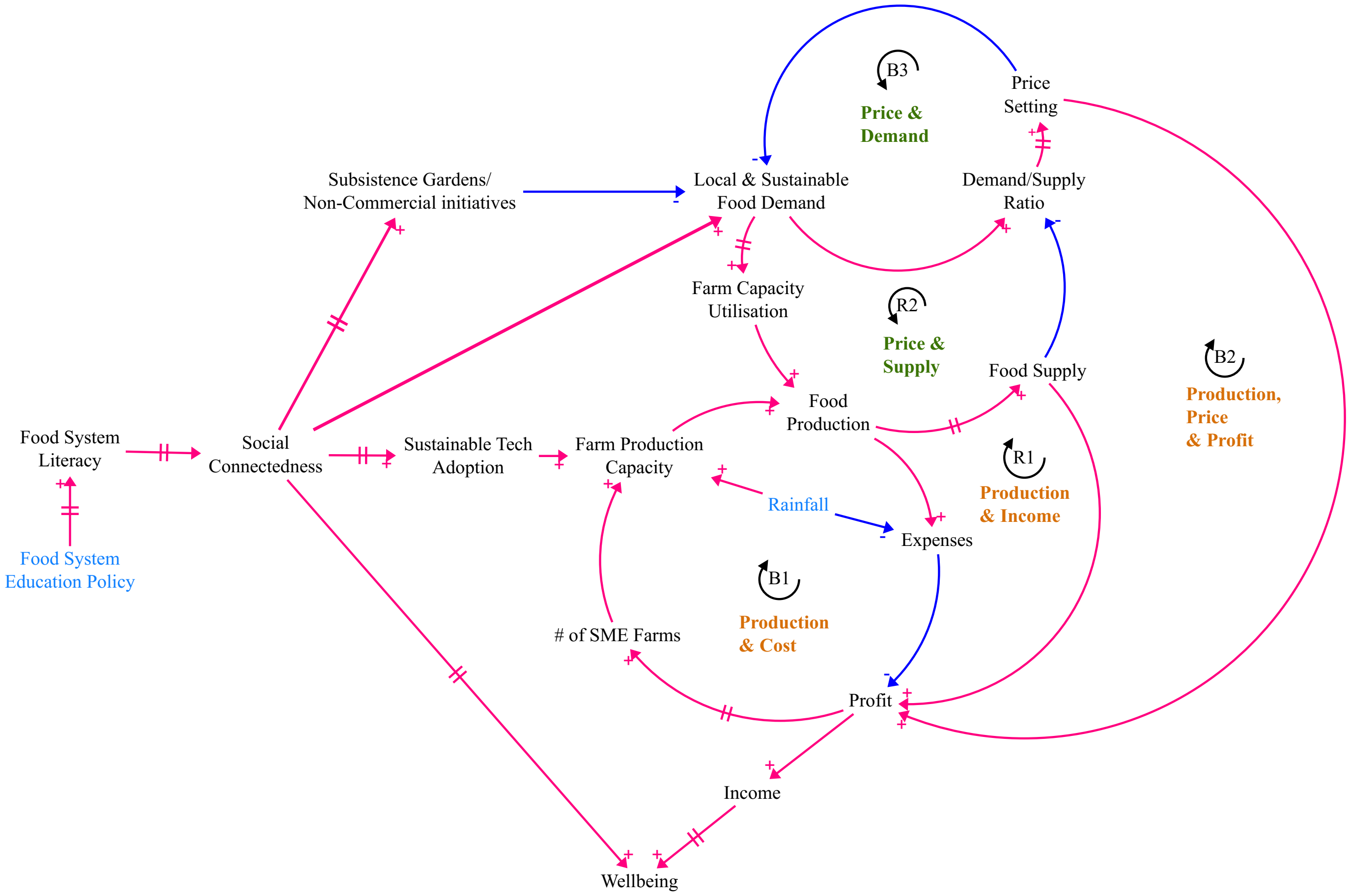

Figure 1 Simplified Causal Loop Diagram of model structure

Starting with Wellbeing, we see in Figure 1 that it is positively affected by income (includes both relative income level, and yearly income growth rate). As income increases, well-being increases with a short delay as farmers take stock of their situation periodically. Income, in turn, is affected by profit, which is part of the interplay of several feedback loops.

Profit is a function of food supply (farm produce sold), expenses (total cost of production), and price (receipt for produce sold). to the CLD in Figure 1 illustrates that profit is determined by a complex interplay of three feedback loops: R1, B1 and B2. The *Production & Income* loop (R1) reinforces the growth of profit by increasing food production. The more produce farmers sell, the more revenue they generate, increasing the profit. Increased profitability, in turn, increases the number prospective entrants to the agricultural industry with a delay, and therefore expands the total farm production capacity to produce more food to be sold. R1 could also reinforce negative growth, where a decrease in profit is met by further decreases. The effect of R1, however, is counteracted by the *Price & Cost* loop (B1). As food production increases, so do the total farm expenses, which eats away at the profit margin. The strength of R1 is further dampened by the *Production, Price & Income* loop (B2). As production increases the food supply, the demand/supply ratio drives the price downwards with a short delay, therefore reducing the profit margin. The amount of profit generated, and thus the income level of farmers, depends on the relative strength of these feedback loops.

Yet, profits are not simply a result of supply-side factors. We also must consider the supply-demand-price dynamics captured in loops R2 and B3 in Figure 1. As supply increases and the price adjusts downwards with a delay, the *Price & Supply* loop (R2) increases the food demand and consequently exerts pressure on increasing capacity utilisation to further increase the food supply. This is counteracted by the *Price & Demand* loop (B3), which drives the price upwards with an increase in demand, consequently reducing the food demand again. Given the interplay of these loops, prices for agricultural commodities are generally volatile, making the revenue generated from production unstable. Furthermore, all the delays in the system for the respective price, supply and demand adjustments make it all the more difficult for the system to settle at an equilibrium, producing oscillatory behaviour instead.

Volatility of agricultural commodity cycles is exacerbated by weather conditions. In Figure 1, rainfall exogenously affects farm production capacity – when rainfall decreases, the yield of farm produce falls and reduces the supply. It also drives up costs as variable inputs like water usage increases in response. Hence, rainfall variability is likely to affect the magnitude of the peaks and troughs of the oscillations in the system.

With the councils' preferred policy, we expect food system literacy to increase within the community. Over time, this strengthens the social connectedness of the food system. Social connectedness has several consequences for the system. First, as farmers and consumers as well as farmers themselves are brought closer together, more support is given to farmers which sustains their well-being (Parfitt et al., 2012). Second, increased farmer to farmer interactions increases the chances of sustainable practices and technology diffusion and adoption within the sector, which enhances the production capacity (Dubois & Carson, 2020; Tomchek, 2020). Third, social connectedness fosters the growth of demand for locally produced sustainable food as consumers make food choices that benefit themselves and the local community (Parfitt et al., 2012). Lastly, we identified a potential trap where social connectedness fosters the adoption of subsistence gardening amongst the community (Turner, 2011; Parfitt et al., 2012), which could taper the demand for local produce, and therefore negatively impact farmers' livelihood. Although exogenous, these variables directly affect important variables embedded within the complex feedback loop structure described above. Hence, testing this policy with a simulation model is of paramount of importance to ensure that the outcomes are as intended and favourable to the sustainability and resilience goals of South Australian local governments.

Model Validation

To build confidence in the model, and by extension our findings, a series of validation tests proposed by Barlas (1996) were conducted. The model structure was built using Warren's (2015) agile SD method – starting with key stocks and following backward causality. This allowed for partial-model testing, using extreme condition tests to check for expected behaviour, throughout the process. The model was found to be dimensionally consistent, with no cheat variables. All variables and parameters are fully documented with the "real-world" meaning for being included (see supplementary materials). Further, the modelling took partial reference from existing agricultural commodity models, where relevant (see Sterman, 2000; Ayenew & Kopainsky, 2014).

Where possible, model parameters are based on historical data. However, the model also includes parameters that are estimated based on assumptions – details of which can be found in the model documentation in the supplementary materials. Given the assumptions built into the model, sensitivity analysis was conducted for all exogeneous parameters and table functions. There were some measures of sensitivity, but the overall behaviour mode of the key performance indicators largely remained the same or complied with expectations (see supplementary materials for detailed results).

Simulation Results

Business as Usual Scenario

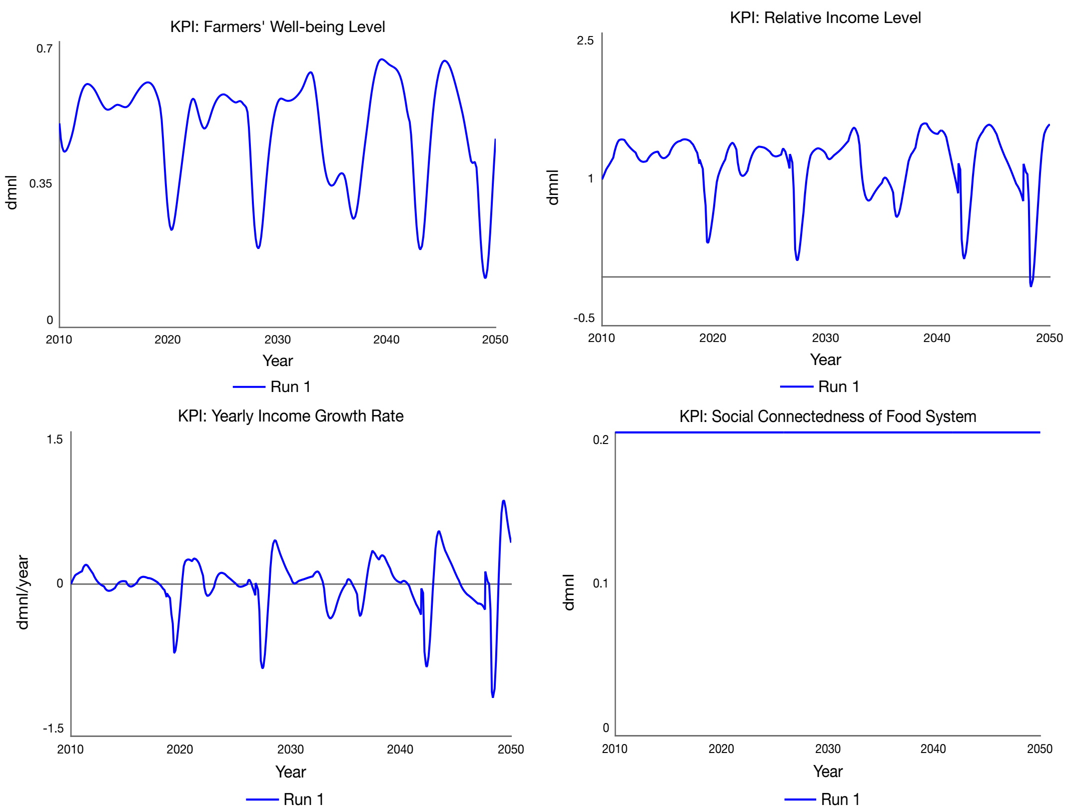

Figure 2 Key Performance Indicators Result for BAU

The graphs in Figure 2 show the simulation results of the KPIs in the business as usual (BAU) scenario. The well-being level and income level both exhibit volatile oscillatory behaviour. Well-being is a function of the other three KPIs, of which relative income level has the highest weight (0.5), followed by income growth rate (0.3) and social connectedness (0.2). The relative income level uses the initial income in year 2010 as the base year for comparison. When the relative income level increases above 1, the well-being increases and vice versa. However, the income growth rate is more nuanced in that it takes into account the variability of year-to-year income. Even though the income level is above 1 (as in between year 2010 and 2018), the growth rate is able to capture positive growth and negative growth during that period, which then minimises or magnifies the effect of income on well-being accordingly. As for social connectedness, it is assumed to be low and constant at 0.2 throughout the time duration. Social connectedness of the food system represents the social relations between farmers and other farmers, as well as farmers and consumers (Parfitt et al., 2012). At low levels, it represents alienation of farmers within the system, and therefore reduced ability to cope with adversities. Hence, the well-being is minimised throughout the time horizon, leading to lower peaks and deeper troughs. These results clearly show a low level of resilience in farmers' livelihoods: farmers are unable to be maintain their well-being at or above the normal level in the face of shocks to income.

Since the overall behaviour mode of well-being follows the development of income, albeit with a delay, it is prudent to examine the dynamics affecting income to better understand its impact on farmers. Figure 3, below, shows the results of the key variables and loops described in the previous section that affect the average income of farmers (by extension, the relative income level and income growth rate).

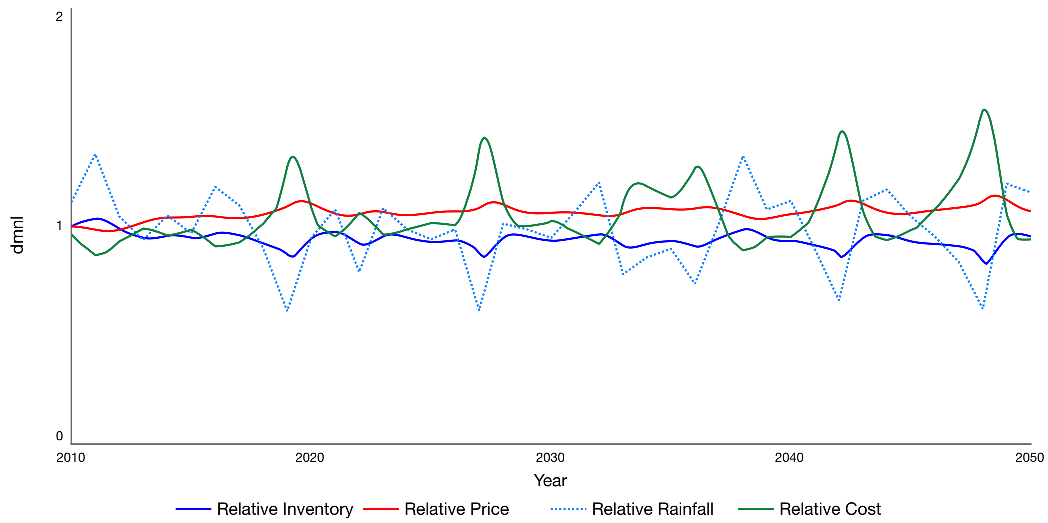

Figure 3 Key Variables affecting Income of SME Farmers for BAU

To interpret the graph, let us start with the dotted blue line, relative rainfall, that has an exogenous effect on the feedback loops embedded in the system. When relative rainfall is above 1, it increases the yield of the production capacity and decreases the variable cost of production. That is assuming that the increased rainfall is within a reasonable bound (e.g., less than 2), and thus does not result in floods. Hence, in good weather conditions, relative rainfall strengthens the *Production & Income* loop (R1) while weakening the *Price & Cost* loop (B1) since farmers can produce more and generate more revenue, at a lower total expense incurred, thereby increasing the profit margin. This explains the development of the relative cost of production (sum of variable and fixed cost) shown in the green line. As relative rainfall rises, the relative cost falls and vice versa. As R1 increases the production of food, we observe that the relative inventory increases (blue line).

Relative inventory also represents the supply to demand ratio, and hence is part of the interplay between the *Price & Supply* loop (R2) and *Price & Demand* loop (B3).

When the relative inventory increases (blue line), we observe that R2 drives the relative price downwards (red line). B3 dampens this effect, as lower prices fetch higher demand, and therefore reduces the relative inventory, which consequently causes the prices to adjust upwards again. Apart from greater consumption reducing the relative inventory, reduction in relative rainfall further exacerbates the decline of relative inventory as production capacity decreases.

Having explained the dynamics of relative price and relative cost, now we can determine the impact on income. When relative cost is less than the relative price, farmers profit margin increases and vice versa. Hence, in Figure 3 during periods when the green line is below the red line, farmers generate a higher income and therefore relative income is above 1. When the green line is above the red line, that is when income levels drop below the normal as they incur a loss.

The recurrent drastic reduction in the relative income then is explained by the recurrent dips in relative rainfall (representing extreme weather conditions, specifically droughts). Droughts have a strong impact not just on farmers but other actors in the food system as well. It brings down production such that the relative inventory decreases, causing relative price to increase. This affects consumers, especially for lower income populations, who incur higher food cost. Given that food consumption is not very price elastic, the strength of *Price & Demand* loop (B3) is generally weaker than *Price & Supply* loop (R2). Hence, reduction in relative price is more dependent on recovery from drought (increase in relative rainfall again) such that supply increases again, than via B3 alone. Further, drought situations increase the relative cost more significantly than the increase in the relative price. Coupled with the reduction in food supply, farmers experience a significant drop in average income level during such periods of food system shocks.

Food System Literacy Policy Scenarios

In this section, we introduce the Food System Literacy Policy in order to test its effect on the KPIs, and by extension the resilience of SME farmers' livelihoods. The graphs in Figure 4, below, show the simulation results of three scenarios. First, the BAU scenario, from above. Second, an optimistic policy scenario where the food system literacy increases to a relatively high level (0.8) with a short adjustment time (2 years) and a high effectiveness in policy implementation (0.8) as well as high effectiveness in sustainable technology adoption (0.8). Third, a pessimistic scenario where the literacy increases to a relatively low level (0.4) with a longer adjustment time (5 years) and a low effectiveness in policy implementation (0.4) as well as a low effectiveness in sustainable technology adoption (0.4).

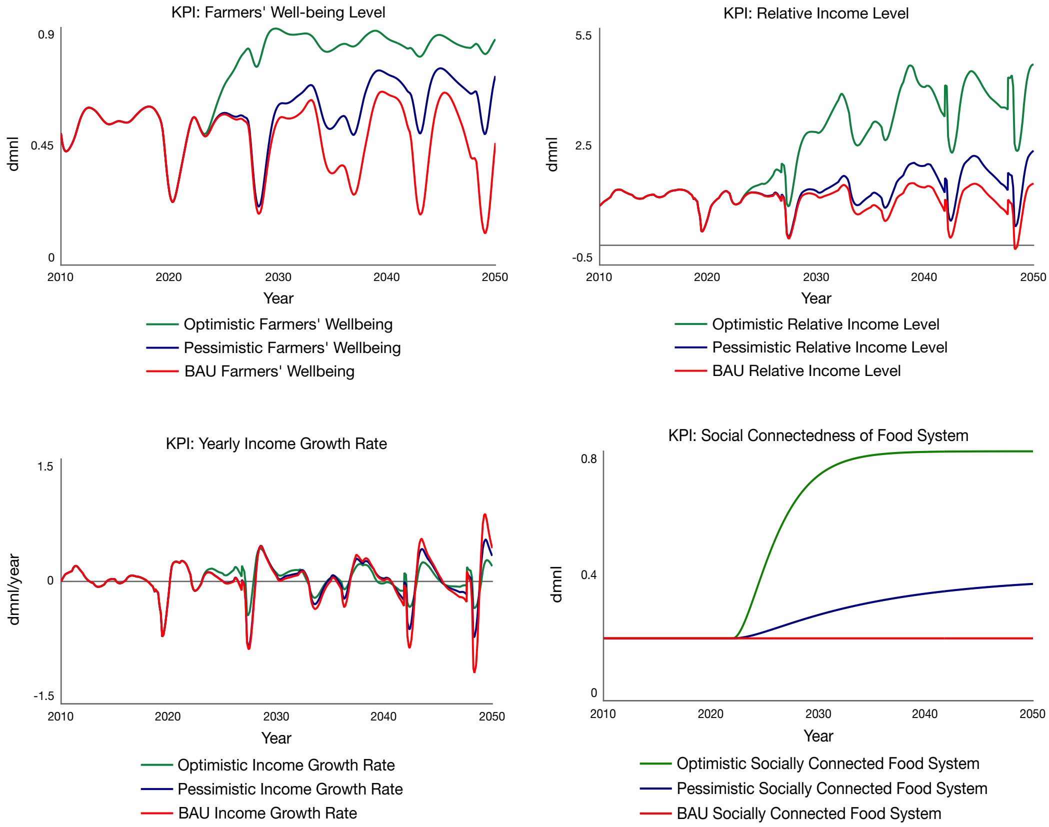

Figure 4 Key Performance Indicators Result for BAU, Optimistic and Pessimistic Policy Scenarios

In general, the introduced policy improves the outcomes for all KPIs. As the food system literacy of the local community amasses, the social connectedness of the system increases with a delay. The more optimistic the policy, the faster the adjustment to a higher level. As mentioned, social connectedness exogenously affects the model at multiple leverage points within the feedback loop structure. Consequently, the relative income level increases by several folds depending on the policy effectiveness. Although income is at a much higher level than the initial after the policy intervention, the volatile behaviour pattern largely remains the same given the dynamics of the feedback loops. This volatility is captured with the income growth rate that essentially retains its behaviour mode with slight variations. As a result, we observe volatility in the well-being level despite it settling at a much higher level than the BAU.

Noteworthy is the effect of social connectedness in buffering farmers' well-being, smoothening the oscillations at high levels of connectedness. This buffering effect is attributed to the increased inclusion of farmers and more resilient social relationships for helping them to better cope with income fluctuations. Despite tough times (due to extreme weather conditions), knowing that there is a strong community and consumer base to rely on, through and after such crises, could buffer the shocks to income on well-being. Therefore, based on the results presented in Figure 4, it can be surmised that increasing food system literacy increases the resilience of farmers' livelihoods; they are able to maintain their well-being at or above the normal level in spite of the shocks introduced to the food system. The gap between the blue and green line, then, serves as the range of potential outcomes for policy implementation.

Why exactly does the income level, and by extension well-being, increase several folds with the policy?

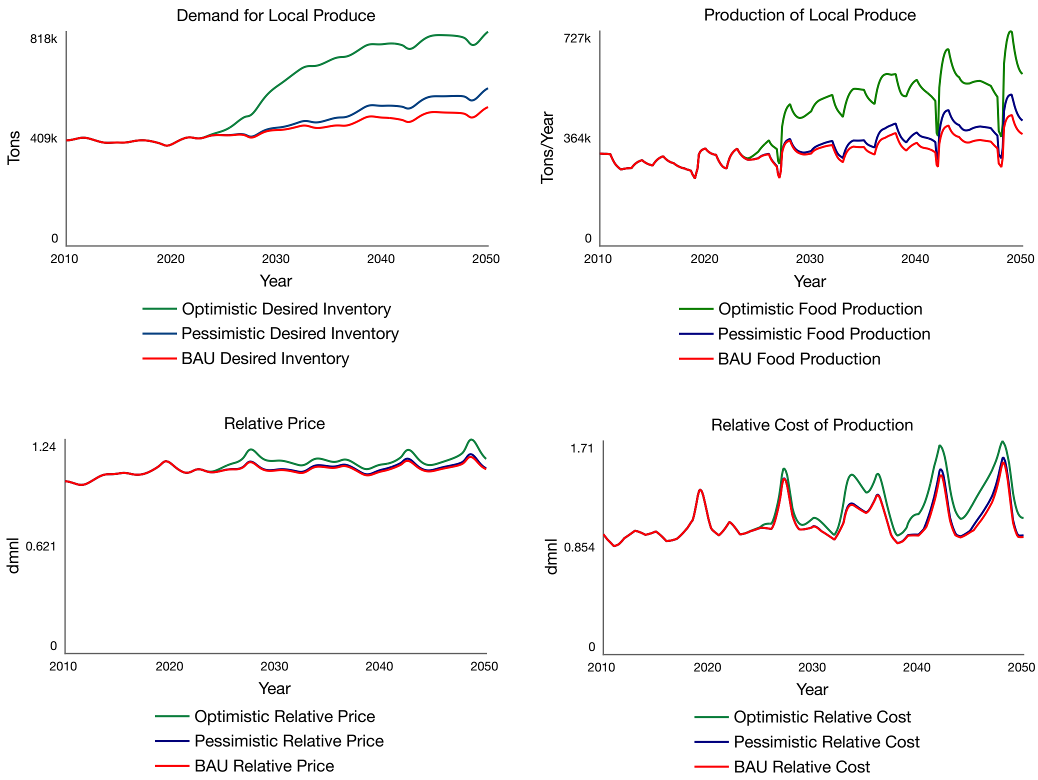

Figure 5 Key Variables affecting Income for BAU, Optimistic and Pessimistic Policy Scenarios

For one, the increased social connectedness of the system, shores up demand in the local community for locally produced sustainable food. With the optimistic policy, the demand almost doubles over time (see Figure 5). As consumers become more socially-conscious of their impact on the food system, they become more willing to shift more of their consumption from commercial retailers to other sources dependent on local producers (such as farmers markets and food cooperatives). Previously, local farmers only supplied a tiny fraction of the produce to commercial processors who acquire their stocks nationally. The shift in consumption patterns, instead, directly increases the demand for produce from local SME farmers (assuming that large-scale farmers are typically seen as corporatist). Referring back to the feedback loop structure, the increased local demand bolsters the strength of the *Production, Price & Income* loop (B2), which ramps up food production to meet the demand. However, looking at the optimistic production in Figure 5, we see that food production does not fully satisfy the demand, thus driving up the relative price of food. While the *Price & Demand* loop (B3) tapers the demand to price increases, the relatively higher inelasticity of demand for local food weakens this counteracting effect.

The relative price, however, does not skyrocket multiple folds due to the effect of the *Production, Price & Profit* loop (B2). The profitability and demand pressure increases the number of operational SME farms over time, with a delay, and increases the overall sector's production capacity, allowing price to adjust downwards. Apart from the demand pressure, farm production capacity also increases with social connectedness of the food system as more and more farmers connect with each other through farmer associations and other forms of exchanges. Farmers in South Australia are more likely to learn and adopt sustainable farming practices and technology through other farmers than anyone else (Dubois & Carson, 2020). Through learning and adoption of such practices, the agricultural yield increases and expands the overall production capacity (Goedde et al., 2020; Tomchek, 2020). Not only will there be more farms, but each farm on average produces more food, thus bolstering the *Production & Income* loop (R1).

Given the many fold increase in consumption as well as production, the total revenue from selling their produce increases and the relative income level of SME farmers rises. Although at a higher level, the volatility in income is maintained given the impact of relative rainfall on production capacity, relative price, and importantly relative costs. Nevertheless, farmers income level becomes more resilient as the troughs of the dip settles at a higher level as compared to the BAU scenario as shown in Figure 4.

Self-Sufficiency Trap Scenario

As mentioned previously, the CLD in Figure 1 identified a potential trap in the policy in terms of subsistence gardening reducing the demand for local produce from SME farmers. In the policy scenarios, subsistence gardening didn't have much impact due to assumptions built into the model. First, the initial proportion of households committed to subsistence gardening was set at 1% – such that even with a socially reconnected system, this proportion increases to a maximum of 10%. The assumption here is that modern lifestyle is not suited for maintaining subsistence gardens unless households include homemakers or retirees. Second, the share of food demand that can be substituted with subsistence gardening was set at 10%, based on the assumption that household gardening is not large or diverse enough to meet one's total consumption demand. In essence, the policy scenario assumes that gardening will not significantly impact demand. What if we were to relax this assumption?

The graphs in Figure 6, below, show the sensitivity runs of the KPIs, relative income level and well-being, to varying values of *initial* proportion of households committed to subsistence gardening (range 0.01 to 0.1) as well as share of demand provided by subsistence gardening (range 0.1 to 0.8). In turn, the graphs below show the range of possible outcomes from low self-sufficiency to high self-sufficiency from subsistence gardening and other similar initiatives that substitute demand.

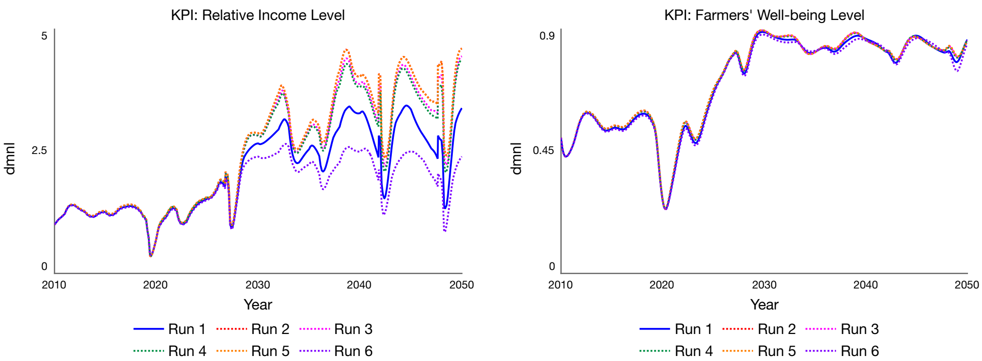

Figure 6 Sensitivity runs of Income Level and Well-Being

When the self-sufficiency of consumers is very high, the magnitude of increase in farm relative income level is diminished, given the reduction in demand growth and the consequent food production capacity growth. However, the relative income level is still, for the most part, above 1. As a result, the well-being of the farmer is not as affected. The higher-than-normal income and high level of social connectedness of the food system maintains the buffering effect on well-being. The slight changes in the development of well-being are attributed mainly to income variability. Hence, even with the extreme but unlikely scenario of high self-sufficiency amongst consumers, the resilience of SME farmers livelihoods is still maintained.

Discussion

Policy Implications and Recommendations

Based on the findings of the simulation model, it is evident that increasing the food system literacy of the local community in Greater Adelaide improves the resilience of SME farmers' livelihoods. As the food system becomes more socially reconnected from the diffusion of food system knowledge, we can expect a growth in demand for local produce (from farmers markets and food cooperatives), increase in production capacity (yield and number of farms) and thus higher volume of production, higher income levels for SME farms, and importantly more resilient well-being of farmers. While we identified a potential trap in the policy that could harm the interest of farmers, our findings suggest that, at most, it reduces the income level without significantly harming the well-being of farmers. We can, thus, conclude that increasing the food system literacy, and thereby the social connectedness of Greater Adelaide's food system, does indeed improve the resilience of local SME farmers' livelihoods. By extension, it lends strength to the core hypothesis and the preferred policy choice of the local councils in Greater Adelaide.

Indeed, a locally reconnected food system by way of increased food system literacy within the community enables better sustainability and resilience goals. The model and simulation results presented here serve as proof of concept, particularly for the livelihoods of local SME farmers. We recommend that councils allocate resources to increasing the food system literacy of Greater Adelaide. Given that the highly aggregated nature of the model lacks policy implementation structures, it does not lend itself to overly prescriptive insights for policy implementation. For that purpose, the model could be made more empirical with robust data collection and further implementation modelling. Nevertheless, the rest of this section provides broad policy recommendations that can be gleaned from the model and the simulation results.

While we recommend the implementation of initiatives to foster food system literacy within the local community, the model does not prescribe the content of those initiatives. Food system literacy in the model, however, adheres to an expansive definition beyond simple nutritional literacy on food choices (Palumbo, 2016). It should be strongly embedded in the social connectedness of the food system with the aim of reconnecting individual consumers to all levels and dimensions of the food system – from local farms to table (Parfitt et al., 2012). Renwick & Powell (2019) terms such an approach as food sovereignty – a social justice perspective that transforms the entire food system to be more just and equitable for all community members involved.

Broadly, initiatives should involve reconnecting consumers to local producers. This would help them better navigate the food system and source for food options that are not only sustainably but also locally produced (Parfitt et al., 2012). Such initiatives could take the form of educational field trips to local SME farms as well as local farmers' markets. It could also involve campaigns to seek out cafés or restaurants that have cooperative arrangements with local farms as the main suppliers of produce. Armed with knowledge about the externalities of one's food consumption patterns, such initiatives could shift the local food demand for produce favourably to local SME farms, as intended in the model. If resource is a constraint, then the bulk of the initiatives should be targeted towards this goal.

However, it must be noted that the model findings do not recommend a complete substitution of demand. The model limits the demand share for local produce to a quarter of the total demand for two reasons: (1) consumers are bound to continue seeking out commercially produced foodstuff as well as imports that local producers are unable to produce; and (2) during shocks to the local food system, reduced production capacity would necessitate substitution to food produced elsewhere for meeting subsistence needs. Hence, social (re)connectedness does not mean complete localisation, but rather the fostering of multifunctionality within the food system – balancing the health and needs of the local community within a global productivist system (Fielke & Bardsley, 2013).

To build farm production capacity, then food system literacy initiatives should also target SME farmers (not just consumers). Understanding how the food system operates and affects their well-being is key to ensuring more proactive involvement of farmers in community initiatives. This could encourage them to set up or participate in selling value-added goods at farmers' markets and local food hubs or seek out more cooperative arrangements with local establishments and institutions – using "locally produced" branding to their advantage in capturing more share of the demand (Fielke & Bardsley, 2013). Such endeavours would not only diversify sources of income with more favourable profit margins, but inherently diversify agricultural commodities locally as farmers attempt to capture more and more of the demand for local produce.

Policy programmes for farmers should also emphasise the growth of networks between farmers, fostering more associations and meaningful exchanges. As mentioned, farmers tend to trust other farmers' experiences over scientific knowledge (Dubois & Carson, 2020). Through such exchanges, farmers are more likely to adopt sustainable practices and technology that could improve yields, as shown in the model, and produce more sustainable environmental outcomes (Goedde ett al., 2020; Tomchek, 2020).

Often, food system literacy initiatives focus on building capacity for individuals to participate in gardening – whether at home, at schools or in community gardens. The rationale of gardening is to increase food security, but more importantly, to reconnect individuals to food production at the individual level, and thereby alter their attitudes towards nutrition and food production (Turner, 2011; Parfitt et al., 2012). While our results show that this does not necessarily lead to a policy trap for local farmers, it bears to keep in mind the livelihood of the farmer as one of the key components in the content of food system literacy education. This would ensure that subsistence gardening remains complementary to local food production as opposed to competition.

Moreover, the model insights indicate an increase in the relative price of food. This could have adverse consequences for low-income populations in Greater Adelaide, who might have trouble shifting their demand even if so desired. Part of a food sovereignty approach is equity and justice. Hence, attention should also be paid to the plight of this target population. To foster their participation in the locally reconnected food system, then, local governments could indirectly subsidise their consumption. For instance, financial aid could be distributed through food coupons or stamps for use in local farmers' markets or other similar establishments that support local produce – as implemented in countries like the United States (Parfitt et al., 2012). This will benefit both low-income individuals and local farmers.

Limitations and Future Directions

Despite the confidence built in the model structure, there are a few limitations of the model that should be considered. For one, the model is highly aggregated as it is simply meant to serve as proof-of-concept. Farm produce is taken as an aggregate unit of foodstuff measured in tons, as is food demand per capita; it does not differentiate between types of foodstuffs such as maize, cereal, vegetables, or meat. Similarly, local farms are not differentiated by type of production. Given this level of aggregation, the variability in price for different types of produce is not modelled; instead, the price is a simplified representation for the average price of foodstuff derived from total food consumption and total expenditure of food consumption. While such a simplification suffices for a model of the average farm, we must expect quantitative differences to the livelihood outcomes for the different types of farms. For more nuanced understanding of resilience for each type of farms and produce, the model can be further adapted to each with more specific datasets and proper parameterisation.

Related to the level of aggregation is the simplification of reality in the farm production capacity sector. Different types of farms have different production capacity needs – in other words, different types of variable and fixed inputs that would require more explicit model structures. Here, it was modelled with relative values undergirded by the simple assumption that there is a positive relationship between input and yield. To ascertain the actual elasticity between the type of input and yield would also require further modelling. Moreover, the number of SME farms in Greater Adelaide are not limited by the total arable land available for food production, and it increases or decreases according to market forces. Again, this is partly due to the simplification in taking an average farmland area per farm (100 ha). Different farm types have different land needs, some types require more (e.g., broadacre) while others require much less (e.g., vegetables). Also, urban farms, especially vertical farms, require much less so. Hence, although the absolute number of farms increases significantly from the demand pressure, in reality we can expect fewer numbers with similar production capacity as estimated in the model. Nevertheless, for the purposes of a proof-of-concept model, not concerned with absolute numbers, this simplification does not negate the findings.

Lastly, the model boundary was narrowed to identify the key food system structures that directly affect local farmers – our key stakeholder. As a result, the boundary is focused on production and the related market dynamics as opposed to other food system activities such as processing, distribution and disposal. A key assumption built into the model is that the growth of demand for local produce will be met by more food supply from farms to food cooperatives and farmers' markets. Again, this is a simplification that does not take into account the distribution constraints. For instance, an increase in local demand for produce may not be satisfied if there are insufficient establishments, such as farmers' markets or food cooperatives, within the local community. Assumed, here, is that market forces (demand pressure) would naturally multiply these distribution channels and therefore increase the sales orders to local farms. This limitation, like others, can be overcome with further modelling. Regardless, we are confident that the general behaviour mode of the KPIs observed, in this model, will be retained.

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