Humanitarian Assistance for Markets in Conflict: A System Dynamics Approach

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Cash and Vouchers in Humanitarian Organizations: A System Dynamics Approach

by

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ABSTRACT

Humanitarian organizations play a crucial role in providing aid to the victims of disasters – whether natural or man-made. One of the leading organizations is the International Committee of the Red Cross (ICRC), which saves lives and alleviates the suffering of those affected by armed conflicts. The relief action to be taken for a conflict-stricken area is assessed using a market analysis method which helps ICRC in understanding the overall condition and behavior of the market, to what extent it could support the beneficiaries and whether support to market actors is required and in what form. ICRC wants to enhance this market analysis method by adding dynamic interactions between market actors and how changes in the market environment, planned and unplanned, may help or hinder market functionality. This will help ICRC in choosing a suitable response action for a type of market actor based on how it will affect other actors in the market. Our capstone project uses system dynamics method to map the interactions between market actors. The system dynamics model we developed can simulate market conditions under different scenarios of disruptions or humanitarian interventions. The usage of this model for the market analysis process will strengthen the involvement of the supply chain team in assisting the program team to collectively decide on the best response.

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1. Introduction

Over the past decade, the world has seen an increase in the number of humanitarian crises caused by both natural and man-made disasters. According to the Internal Displacement Monitoring Centre (IDMC) 265 million people were displaced during the years 2008 – 2018 (IDMC, 2019) due to natural disasters, and about 70.8 million people were displaced worldwide due to conflicts in the year 2018 alone (UNHCR, 2019). With the United Nations Population Fund (2019) stating that the estimated number of people requiring humanitarian aid in 2019 would increase to 132 million, it is natural to assume that it will take a long time to reverse the trend in this figure. In such crisis, humanitarian organizations play a crucial role in providing support and relief to the affected communities. The humanitarian supply chain temporarily replaces the commercial supply chain, to fulfill the gap created by market failure, to provide commodities required to meet people's imminent needs. These include the ones that cannot be met in the right type, quality and quantity in the current market, and other specialized needs post-crisis (Levine, 2017).

Currently, the roles that supply chains play in providing relief actions are, order management, procurement, import/export, warehousing, transportation, air operations, fleet and business intelligence, and delivery of response action. The relief is typically given in the form of either in-kind donations of commodities, cash and vouchers, services, training for certain activities or other such market-based interventions. To better assess the delivery of the right kind of relief, there lies wide scope in studying the market conditions, the change in economy during such times, and reactions of various actors – victims, providers and influencers.

The International Committee of the Red Cross (ICRC) is one of the best-recognized organizations for protecting and aiding victims of violence and armed conflicts. Decision makers there use Market Analysis Guidance (MAG) developed by ICRC and the International Federation of Red Cross and

Red Crescent Societies (2014) for the purpose of assessing, responding, monitoring and evaluating market conditions. It does so by creating a high-level map or snapshot of a market during the time of crisis and the change in market conditions after relief actions are taken. The MAG study is done with the help of a set of questions and checklists to guide a user in carrying out different stages of market assessment. There is an opportunity to enhance the MAG by examining the dynamics of market systems. This can be done by applying causal loop analysis, since the relationship each actor in the market has on the other helps in understanding the changing behavior of market influencers and in being prepared for reacting to changes. This analysis is the essence of a system dynamics study.

For this capstone, we collaborated with ICRC to enhance the MAG by using the system dynamic method to model complex interactions between market actors. The outcome of these interactions are helpful to determine the best response that could be deployed for a community involved in a conflict. The context for this study is Nigeria's conflict-ridden market condition.

Since 2005, Nigeria has been suffering from an internal armed conflict and civil unrest. Due to an upsurge in clashes in 2019, the initial estimate of about 7.7 million people requiring aid increased, forcing humanitarian agencies to reassess needs on the ground (UN News, 2019). ICRC proposed that this capstone study would best be developed considering the situation in Nigeria due to its dynamic changing condition in the field.

2. Problem Statement

The internal staff of ICRC uses the consultative process of MAG to understand the market conditions before and after a shock. They develop a market system map to conceptualize the market actors and the interactions between them (ICRC & IFRC, 2014). However, their framework of market analysis lacks integration from a supply chain perspective. Two main issues are, non-consideration of the complex interactions between market actors, and the ripple effects of ICRC's interventions. ICRC deemed inclusion of these to be crucial to successfully plan and execute relief programs. ICRC is interested in evaluating the response actions to arrive at the best one, to be delivered to local market systems, and the impact of such market-sensitive interventions in the backdrop of conflicts disrupting the market dynamics and decreasing market capacity.

This capstone project builds on ICRC's existing market assessment methodology to identify supply chain actors and interactions that were previously neglected and incorporates their response to the market pre and post crisis.

3. Literature Review

3.1 Introduction

The aim of this capstone is to empower the supply chain team to conduct market analysis with the help of system dynamics modelling to decide on the best possible relief action to be delivered in a conflict-stricken area. The literature review first focuses on the traditional roles and responsibilities of a humanitarian response team to study the analysis gap where the response team can add more value since they are the ones primarily present on the field. It then moves on to the types of response actions available, their benefits, and challenges to understand the conditions under which a particular kind of response is to be considered. A review of market analyses by humanitarian agencies, the leading analysis tools available for this study and a comparison between the MAG and a system pathways mapping method forms the second part of literature review, which provides a base for our capstone. Finally, the methodology of system dynamics is studied to understand interactions and correlations between different market actors and how they apply in a humanitarian context.

3.2 Humanitarian Response

"Risk is an everyday feature of our lives. How we react to it, who pays and who benefits, reveals much about our societies and their values. The risk of disaster can never be fully removed, but it can be managed and reduced, and its assessment – based first on data and then on analysis – is the first step towards engaging responsibly with it." (Bilak, 2019).

The world saw a combined total of 15 million people newly uprooted by conflict and 24 million people by disasters in 2018 and 2019 (Bilak, 2019). Humanitarian organizations play a crucial role in providing for those in need when disasters, both natural and man-made, continue to wreak havoc. While millions are spent on aid, goods, and services, and, the rate of investment by these agencies continues to be on an upward trend (Development Initiatives, 2019), they are also under constant scrutiny to focus on optimizing the entire operations. Since relief is about 80% logistics, which includes cost of procuring

items, shipping, transport, overheads including HR, fuel, and security, it is clear that efficient supply chain management is the way forward (Van Wassenhove, 2006).

In a humanitarian organization, the program team is the one that makes decisions as, it is involved in the assessment of field conditions while a logistician's (term used interchangeably with "supply chain team") job is to execute the actions from decisions taken (ICRC & IFRC, 2014). Gradually, as the humanitarian sector is placing more focus on the supply chain aspect, the logistics team is being recognized as an important part of planning relief operations. It has become an area of study for improvements since the logistics team works on the field and has direct access to rich source of data. (Thomas & Mizushima, 2005).

The relief to be provided after a field assessment can be, in-kind – providing commodities lacking in a community, cash - given to the beneficiaries directly in hand or in the form of e-cash, commodity and value vouchers - can be exchanged for goods and services with contracted vendors (Cretì & Jaspars, 2006). These are the forms of interventions from humanitarian organizations that have direct impact in the market. Other market-based interventions, where support is provided based on the needs of market actors, form a type of response action that could have secondary impact on the market in conflict. These actions are aimed to protect the economic environment of the affected population and as a consequence, its livelihood. Among these response options, the two most commonly deployed ones are, in-kind and cash.

3.2.1 In-kind

In-kind response refers to providing goods and commodities to beneficiaries in times where adequate food rations, shelter materials, seeds and tools, and kits of household items are not available for purchase locally (Levine & Bailey, 2015). These are valuable resources, filling a gap at a crucial time

either by distribution from humanitarian agencies through procurement or by donations from individuals, companies, governments and organizations (Osman, 2011).

3.2.2 Benefits and Challenges of In-kind Response

In times of crises, when markets are affected such that the victims are unable to fulfill their daily requirements, providing required commodities is the default response taken by aid agencies. It is considered a fact that it provides a sense of strength to the members of society and the resources are likely to be shared among them as well. (Levine & Bailey, 2015).

Some of the disadvantages of in-kind aid if provided incorrectly, could be, their incompatibility with local culture, customs and preferences. It does not provide flexibility for victims in procuring their own requirements, which could vary from the generic response chosen by humanitarian agencies. Also, administrative costs of collecting, sorting, packing and transporting these are high and these tasks are also time consuming (Osman, 2011). With respect to in-kind, there is a delay from the time market assessment is conducted to the time it is delivered. By the time the response is given, market needs might have changed. In-kind response also delays local markets' ability to rehabilitate during and even after the end of humanitarian intervention. This could be due to low demand for existing traders in the market or beneficiaries selling the in-kind goods they do not require in exchange for their actual needs (Levine, 2017).

3.2.3 Cash Transfer Program

Cash transfer program refers to the provision of monetary assistance directly to the recipients of the humanitarian relief (Doocy & Tappis, 2017). There are three common types of Cash transfer programs:

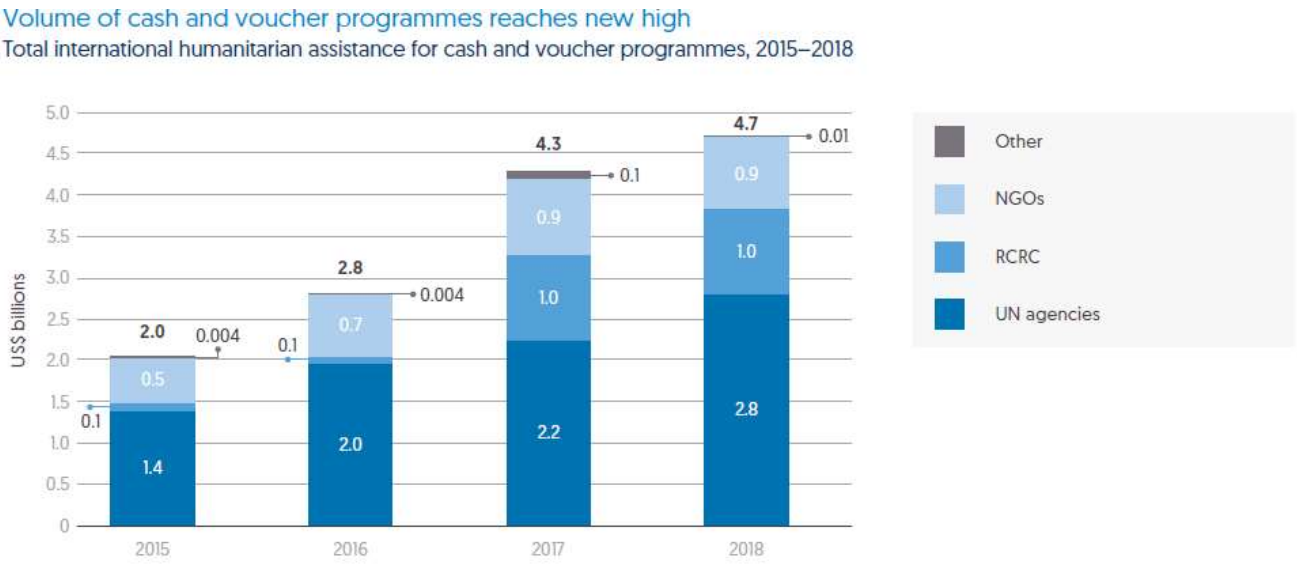
Unconditional cash transfer: This type of transfer is considered "pure cash" and has no conditions attached to receiving the money. This gives recipients the freedom to spend money on what is most

needed according to their own standards, whether it is purchasing food, household items or paying for healthcare (Doocy & Tappis, 2017).

Conditional cash transfer: This type of transfer requires recipients to perform certain tasks or activities to qualify for the assistance. However, certain activities may seem discriminatory towards the disabled or caregivers, who are more vulnerable when a crisis hits (Leduc, Cordero, Mercier, & Guastalla, 2016).

Vouchers: This type of program requires collaboration with local players in the market like traders. Their help is required to provide for those in need with specific items in exchange for the cash voucher or commodity voucher provided by humanitarian organizations. Commodity vouchers are beneficial when the price of the underlying commodity fluctuates (Doocy & Tappis, 2017).

Cash-based intervention has been garnering attention from humanitarian organizations. In 2018, the amount in cash and voucher transfers reached a double-digit growth rate (Figure 1).



Keys: NGO – Non-Governmental Organization, RCRC – Red Cross and Red Crescent, UN agencies – United Nations agencies, Other

Figure 1: Annual growth of cash transfer volume (Development Initiatives, p-71, 2019)

The cash transfer program is perceived to be more efficient and effective compared to the traditional food aid, as a cash transfer program not only offers recipients the purchasing power to meet their basic needs but also helps in speeding up recovery of the local economy. Cretì and Jaspars (2006) agree that "Famine results from a lack of purchasing power, it can be addressed through income transfers." Hence, in a location where there is a functioning private market, a cash transfer program may be the most appropriate and cost-effective approach of humanitarian assistance (Cretì & Jaspars, 2006).

3.2.4 Benefits and Challenges of Cash Transfer Program

Studies find that, even though the cash transfer program provides lower caloric intake per capita, it increases beneficiary households' dietary diversity and quality compared with in-kind food assistance in areas where local markets can meet this demand. In terms of efficiency, a cash transfer program has much lower administration cost per capita and can be executed more promptly than in-kind food aid which could take 4 to 5 months to arrive at an intended location. Bringing food into a market where there is no shortage can disrupt the market supply and place pressure on local producers or traders with lower prices (Cretì & Jaspars, 2006). Conversely, the cash transfer program can strengthen local market participants and boost recovery of the local economy. It is estimated that every $1 transferred to the beneficiary generates $2 indirectly to the market (Doocy & Tappis, 2017).

Nonetheless, cash transfer programs are not bulletproof. Cretì and Jaspars (2006) express their fears that the injection of cash into local markets will cause inflation and security risk to the beneficiaries. However, as the benefits outweigh the risks, organizations continue utilizing cash transfer programs as a humanitarian response.

3.3 Market Analyses by Humanitarian Agencies

Market is defined as "an actual or nominal place where forces of demand and supply operate, and where buyers and sellers interact (directly or through intermediaries) to trade goods, services, or contracts or instruments, for money or barter." (Business Dictionary, n.d.)

Markets are a key indicator in assessing the sustenance of households. In the event of a crisis, the performance of different markets is proportional to the conditions faced by nearby households. These conditions could be, disruption in household economy, difficulty in reaching markets due to safety concerns or disruption in physical access and also could depend on conditions of people belonging to different age groups, faith, ethnic groups and those with disabilities. This analysis becomes a direct input for humanitarian agencies to assess the relief actions required for that market. The rate of recovery and resilience of a society stricken with disaster can be estimated by examining the availability and affordability in the markets. This is also indicative of the self-healing ability of the market actors who are affected by changes in demand. Sometimes this capacity is overlooked due to certain negative coping strategies taken by small and vulnerable market actors. The humanitarian organizations need to examine these dynamics to support these market actors proactively. The financial institutions also will have a role to play in providing loans/credit to help these actors to recover while having high collateral only induces further strain in the system (Levine, 2017). The traders could also pursue an informal credit route in which they borrow from other market actors to maintain financial stability. Many such market actors have relationships and interdependencies with each other, which necessitates the need of market analysis (ICRC & IFRC, 2014).

Market assessment, according to ICRC is "the exercise of collecting primary and secondary market data and analyzing the gathered data to better understand the functioning of markets. Market

assessment provides a snapshot on how the markets function today and how they were affected by a crisis. Market analysis refers to the process of mainstreaming market considerations into all aspects of the program cycle, including preparedness, assessments, response analysis, design, monitoring and evaluation" (ICRC, 2018). Here program cycle refers to the humanitarian response.

It is only now that the humanitarian sector is beginning to take markets analysis into account. However, due to the unavailability of enough literature regarding the market study and analysis being performed in bits and pieces, the study of market remains inconsistent from most of the relief responses (Levine, 2017). Yu, Yalcin, özpolat and Hales (2015) have concluded in their literature review that the downstream part of response supply chains, which includes the last-mile delivery, storage, and distribution of relief material has been a central point of focus of most studies while the upstream process, particularly the regional or global parts, of the same supply chain, has been relatively neglected.

Disruptions, markets and humanitarian actions interact with each other. Response actions taken by agencies without understanding a conflict and its relationship to markets increases the risk of negative effects of the actions (Levine, 2017). In Mali, in 2014, due to a conflict started by Tuareg rebels, approximately 1.9 million people faced food insecurity. The analysis conducted by aid agencies focused mostly on the relationship between cash and market, overlooking in-kind assistance which was supplied without assessment of need. Continuous in-kind supply led to the bankruptcy of traders since their demand dwindled. This was due to the failure to study and include the existing capacity of traders in the market (Barbelet & Goita, 2015).

Variety of tools have been developed collectively by the humanitarian organizations to help humanitarian professionals understand the complexities of markets. We have highlighted two leading methods which are well documented in general humanitarian literature (CaLP, 2015).

Emergency Market Mapping and Analysis Toolkit (EMMA): EMMA is adapted by ICRC for the market analysis formulation to help visualize the market dynamics. EMMA is intended for the staff of humanitarian organizations to make an early assessment and plan for an initial response. EMMA mainly utilizes "Market System Mapping" to encapsulate the interactions among participants of the affected market as well as external or environmental factors that influences it. By comparing the pre-crisis and post-crisis conditions, humanitarian organizations can easily identify direct response options while avoiding doing more harm to the already fragile market system (Albu, 2010).

Market Information and Food Insecurity Response Analysis (MIFIRA): MIFIRA aims to guide decision makers at humanitarian organizations to choose between in-kind response and cash response in food security crises. MIFIRA utilizes decision-tree and supplementary questions to arrive at the most appropriate humanitarian response (Barrett, Bell, Lentz, & Maxwell, 2009). To have a robust analysis, market intelligence is crucial. Data collection and analysis at the national, regional and household-level are needed to fully understand the market actors' responses to the type of humanitarian aid (Barrett et al., 2009).

The outline of MAG, EMMA and MIFIRA are similar where-in the market actors are mapped according to the conditions in the market at a particular moment in time. There lies difficulty in visualizing the changing conditions and the influence of one market actor over another. This feature is captured in the Uganda project through a system pathways map.

MAG compared to the Uganda project

The "Feed the Future Uganda market system monitoring: market system maps V2.0" which will be referred to as the Uganda project from this point onwards, uses a system pathways mapping method developed by the Massachusetts Institute of Technology (MIT) and George Washington University (GWU) team to map the market condition in Uganda. A System pathways map is used for understanding, analyzing and measuring complex development systems. It represents the elements of a system and their relationships within the system while capturing the feedback structures and interrelated pathways. A pathway shows how different components are related to an outcome (MIT & GWU, 2017). Table 1 lists a summary of the comparison points between MAG and the Uganda project. The text that follows provides a detailed explanation of the differences based on comparison criteria.

Table 1: *Comparison between MAG and Uganda project* (ICRC & IFRC, 2014) and (MIT & GWU, 2017).

Comparison criteria	**MAG**	**Uganda Project**
Objective	Detailed analysis of market through set of driving questions, checklists to arrive at a response action	Analysis of market through interactions between actors and their influence on one another to arrive at an outcome
Depth of Analysis	System-level market analysis – relation between actors	System-level market analysis – Role Map. Subsystem-level market analysis – Behavior Relationship Conditions (BRC) map

Market Mapping method	Mapping between Individual actors - from the producer to consumer with infrastructure and services and external environment (Figure 2) acting on this	The actors are mapped based on roles rather than function. Also includes analysis of interventions from humanitarian response
Scope/Boundary	Influence of certain actors are represented as external environment such as Trade laws and enforcement, Natural environment and resources	Influence of same actors as in MAG are included in internal mapping
Flow between market actors	Flow indicators – single representation of flow between market actors	Flow indicators – breakdown into material, finance and service flow between market actors

Comparison criteria - Objective: The focus of MAG as a tool primarily lies in collecting data from a market through questions, interviews with key actors in that market and completion of checklists. This procedure is the same throughout the project cycle – assessment, response, monitoring and evaluation, which leads to arriving at a response action to be taken for a particular market in which the study was done. The main highlight of the Uganda project is to understand the interaction of market actors and their influence on one another ultimately affecting a response outcome creating a system pathways map.

Comparison criteria - Depth of analysis, Market Mapping method, Scope/Boundary: Based on data collected as per the methodology in the MAG tool, a high-level mapping of market actors is created, as depicted

in Figure 2. This is a system-level map and shows one-way interaction by showing the flow of goods or services between the market actors, from producers on the left to consumers on the right, and the influence of external environment, for example, land and property rights, and, trade laws and enforcement on them. MAG focuses on depicting the magnitude and disruption of flows between market actors. As shown in Figure 3, in the Uganda project, multi-level interactions between the market actors is captured. The market actors are defined based on their roles rather than the function they perform, for example, "a Dealer who sells inputs can also provide a form of financing and extension services, while a Trader who buys produce may also provide post-harvest handling or transportation services" (MIT & GWU, 2017). The actors considered external influencers in MAG, because of not being under control of the humanitarian organization, are considered internal in the Uganda project to include the impact of their dynamic changes on the market condition. A change in the trade laws due to a political conflict, for example, stating that no imports will be allowed into the country, will place pressure on existing markets to cater to increasing demand during times of crises.

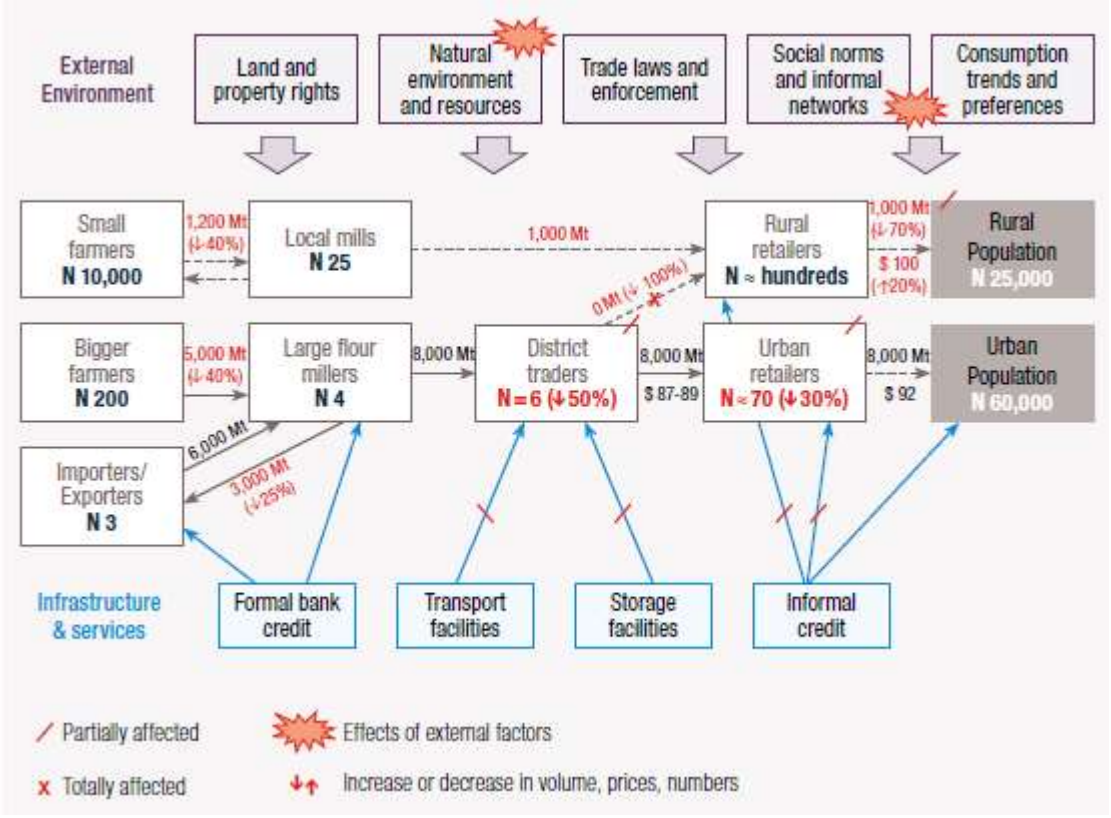


Figure 2: Emergency map (ICRC & IFRC, 2014)

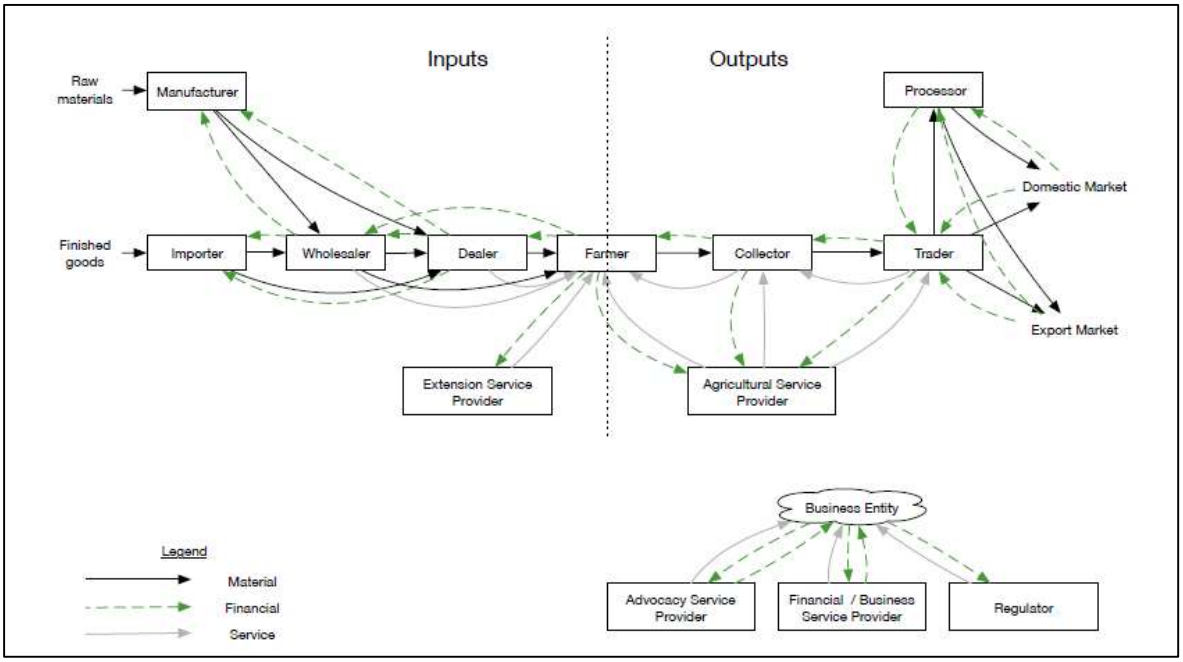


Figure 3: Role Map Version 2.0 (MIT & GWU, 2017)

The purpose of a Role map is to clearly define roles that are then used to describe behaviors, relationships and conditions in the market system map. These can be monitored as changing over time. A Behaviors-Relationships-Conditions (BRC) model developed in the Uganda project is a subsystem-level analysis of the market. This is an individual mapping of subsets of the system-level map. A behavior is an action carried out by an individual or entity, often repeated over time. A relationship between market actors is viewed as a way to accrue intangible benefits over time. Conditions are qualities or attributes of the market environment that enable activities or changes in the market system. A few subsystems considered by the Uganda project include importing of inputs and manufacturing, farming practices and agricultural services. These individual sub-systems together form the overall system map. An interaction between two sub-systems is shown in Figure 4. This mapping method helps humanitarian agencies gain a deeper understanding of a market during a crisis to identify the best response action to be taken.

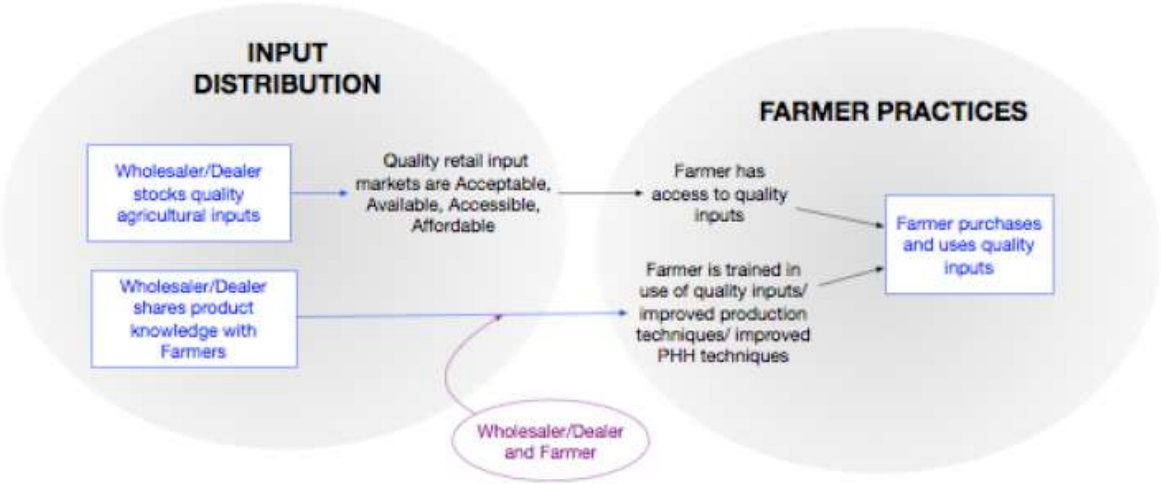


Figure 4: Example of portion of BRC Subsystem Map: Inputs Distribution and Farmer Practices (MIT &GWU, 2017)

A key feature, which the Uganda project includes in its market mapping method, is the reaction of market when there is an intervention by a humanitarian organization. This added dynamic can help humanitarian organizations assess the positive and negative impact their action might lead to and make a call to pursue, delay or prevent it. An example is shown in Figure 5 where, for the wholesaler/dealer to stock quality inputs, the humanitarian agency is intervening to train wholesalers/dealers to participate in anti-counterfeit programs.

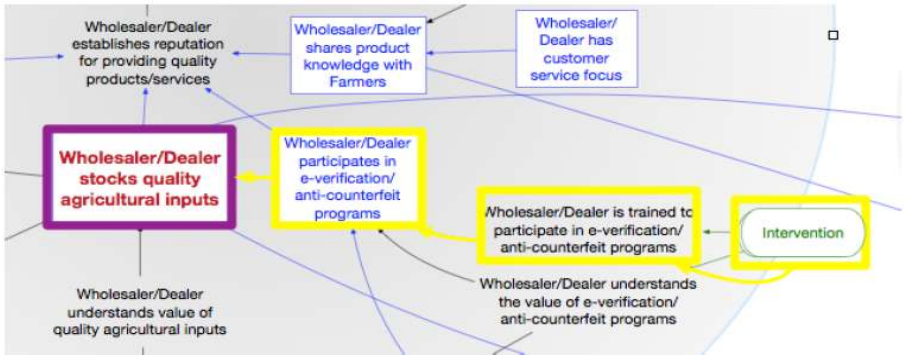


Figure 5: An example of intervention leading to a potential change in market condition (MIT & GWU, 2017)

Comparison criteria - Flow between market actors: As depicted in Figures 2 and 3, the flow indicators between market actors in Uganda project are detailed in the form of material, financial and service flow allowing an understanding of the kind of relationship that exists between market actors.

3.4 System Dynamics for Humanitarian Response

Unlike "detail complexity", which entails the number of components within the system, "dynamic complexity" results from the temporal delay and nonlinear relationship between the action and the effects (Sterman, 2000). Policies or interventions applied in complex systems often fail due to unforeseen side effects. This is caused by policymakers not fully understanding the feedback mechanism within the system (Sterman, 2000).

Operating in fragile communities, humanitarian operations are complex involving delays, feedback loops, multitude of stakeholders and unpredictable interactions among these actors. Additionally, many international humanitarian organizations aim to provide a region with both relief efforts and economic development, which may become competing objectives at times. This is because, immediate relief would have a ripple effect on the local economy long after the crisis is controlled. To avoid doing more harm to an already stricken region, managers in humanitarian organizations need to understand the consequences of different relief options and be able to align them with overall comprehensive strategic program, including but not limited to livelihoods projects and market-based intervention projects. Besiou, Stapleton and Van Wassenhove (2011) argue that system dynamic methodology is more appropriate than optimization methods in the context of humanitarian supply chain due to its highly unstructured and changing nature. The lack of information systems and inadequate data collection by humanitarian supply chain partners exacerbates the difficulty of "central planning" using deterministic approach. As a result, system dynamic methods are more pertinent in capturing complexity, uncertainty and intertwining feedback loops faced by humanitarian organizations. Causal loop mapping, one of the system dynamics tools, could provide humanitarian organization decision makers with insights on how different variables interact within the system. Simulation modelling, another powerful tool, offers the users a visualization of the consequences for the entire system, both intended and unintended, of a decision (Gonçalves, 2008).

The system dynamics approach embodies systematic thinking and enables the understanding of complexity. Therefore, humanitarian organizations can benefit tremendously from the system dynamics approach in evaluating the effect of current decisions or exploring the effectiveness of future strategies.

Conclusion

Through the literature review process, it was observed that the market analysis tools available in use today are static in terms of presenting the interactions between actors by showing only the flow of goods/services from producers to consumers. These tools map the effect of a crisis on market actors and propose a prediction of the situation in the near future once a response is taken. Also, these market analysis tools have the involvement of program team alone. Our capstone project bridges these gaps by creating a system dynamics model, which will enable the logisticians working in the field, contribute to the market study and analysis. They will utilize the system dynamics model to play out the interactions between different market actors and help the program team make decisions on the relief action to be given.

4. Methodology

Our methodology involves building on the existing Market Analysis Guidance (MAG) tool by incorporating a system dynamics approach of viewing the market. This enhanced tool will be used collaboratively by logisticians and the program team of ICRC in collectively determining the best response to be given in a conflict-stricken area.

We divided the project into two sub-tasks:

1. Created a system pathways map by incorporating the key features of the MAG and the Uganda project described in the literature review.
2. Using the system pathways map as a baseline, developed a market analysis tool utilizing system dynamics methodology. This incorporated market participants from a supply chain perspective and illustrated the interactions among them.

This capstone project will benefit humanitarian organizations like ICRC that intervene by deploying relevant relief actions, to have a reference model of such complex market dynamics in the eyes of supply chain professionals. The humanitarian professionals need to work with the market actors to input the right details for the model to perform simulations and provide feedback. Understanding the framework is the first step in determining the most appropriate policy levers that humanitarian organizations would utilize to maximize the efficacy of relief programs.

4.1 System Pathways Map

After analyzing the MAG and Uganda project, key features chosen for our mapping and subsequent modelling are, the inclusion of supply and demand view like that of MAG, as well as system dynamics modelling, subsystem-level analysis, and study of interventions like that of the Uganda project.

A system pathways map was created as per the market condition in Nigeria. This was done prior to the development of the system dynamics model to form a high-level understanding of the key outcome in the market, the conditions, and the relationships that affect it. In addition to this, interventions from other non-governmental organizations (NGOs) and the segments of market where ICRC can intervene were assessed and mapped. A list of visual aids for reading the map are shown in Figure 6. It is divided into three sections – outcome of the map, supply side of the map, and demand side of the map. The complete system pathways map can be referred to in Appendix A.

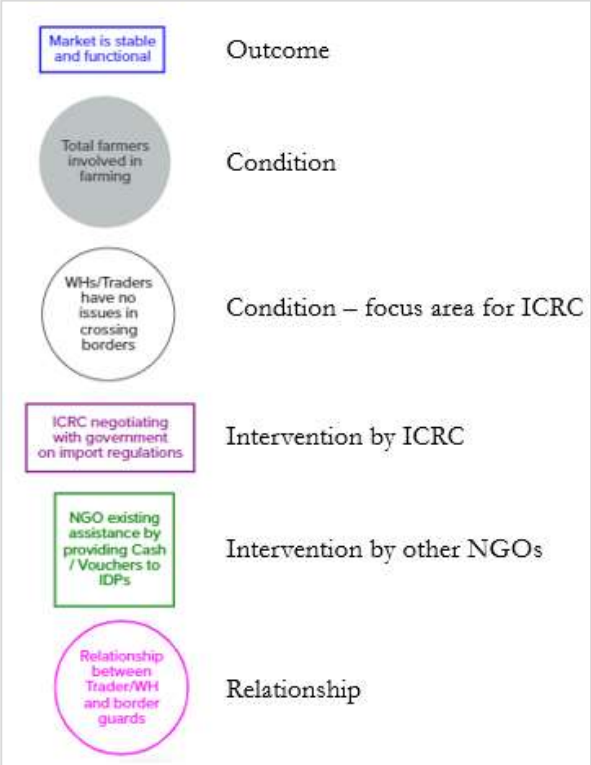


Figure 6: Representation of elements in system pathways map

4.1.1 Outcome

The Outcome part of the map describes the central objective of the system pathways map, the conditions that affect it and the interventions that ensure it is stable.

- "Market is stable and functional," as explained in Figure 7, is the key outcome of our map. This depends on conditions "Safety of host community," "Local population goes to market to purchase food," "IDP goes to market to purchase food," "Buyer and Seller agree on price," "Physical market-place available for trading," and "Retailer offers food for purchase in market".
- The local and IDP population can purchase food in the market only if a retailer offers food for purchase in market; for this reason, an arrow is mapped between those three parameters in Figure 7.
- The condition "Physical market-place available for trading" is further dependent on the element "Government regulates and protects market-place" which can be assisted by ICRC's intervention in ensuring beneficiaries reach market-place safely and if required, re-building disturbed physical access to the market-place. Also, ICRC can work with local traders to have different opening times to better facilitate access or work with traders in areas where beneficiaries are allowed to enter or where they feel safer to enter the market.
- "Monitoring by ICRC" is another intervention to ensure buyers and sellers maintain the prices they agree to. If any changes in prices are seen, for example, due to disruption in transportation or scarcity of quality food, ICRC through monitoring, take necessary actions to bring the prices back to normal. This can only be performed indirectly by balancing the cash-based interventions they provide in the market or exclude traders from their voucher-based activities.

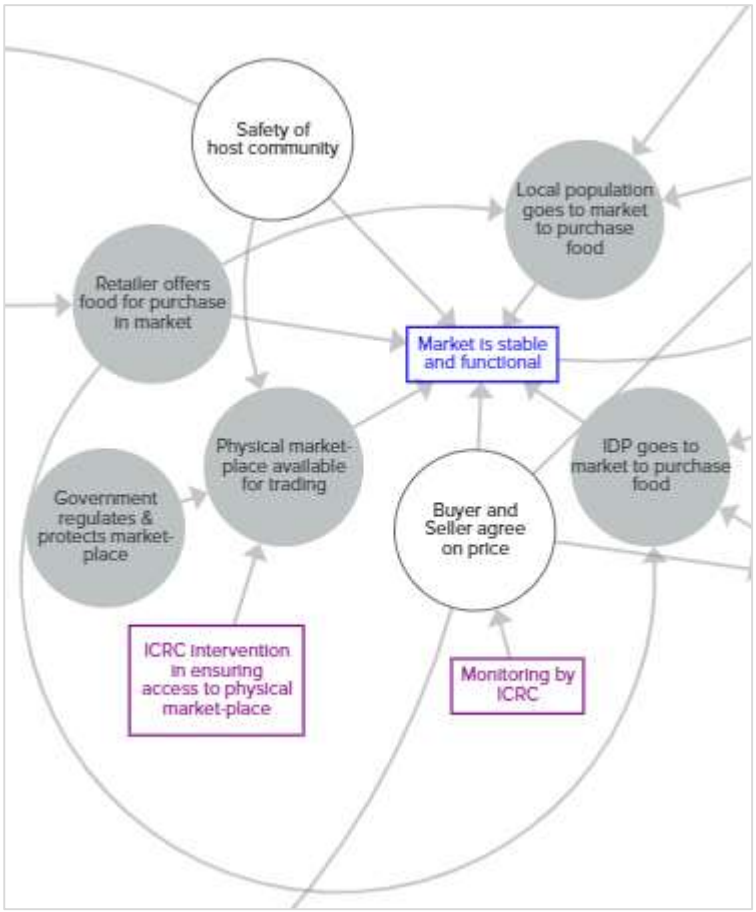


Figure 7: Key outcome of system pathways map

4.1.2 Supply side of map

The supply side of the map considers the interactions between the farmer, wholesaler and retailer, the conditions and relationship that affect their functioning and delivery of commodities to market.

- On the supply side, as shown in Figure 8, for the condition "Retailer offers food for purchase in market", retailers should have good-quality stock available, which is again dependent on three other conditions that form their own pathways.
- The first pathway, as indicated by 1 in Figure 8, is "Retailer has storage space for inventory," which is dependent on the condition "Storage space is in good condition". In the market study

in Nigeria, this was seen as a concern; hence, this component is marked as a focus area for ICRC to possibly intervene in maintaining storage space in good condition.

- The second pathway, as indicated by 2, is "Wholesalers (WHs)/Traders have stock of good quality for retailers to purchase." This is dependent on four conditions.
- Condition 2.1 indicates the need for WHs/Traders to have access to credit sources which could be satisfied through financial resources.
- Condition 2.2 indicates the dependency on local sourcing within the region, which is again implied from the components "Farmers had a good harvest season" and "Total farmers involved in farming". The "effect of price on taking up farming as a source of income" (which is dependent on price fluctuation in the market indicated by the condition "Buyer and Seller agree on price") is a condition that determines "Total farmers involved in farming" based on economic incentive of becoming a farmer.
- Condition 2.3 indicates WHs/Traders importing from neighboring regions, which is implied from the conditions "WHs/Traders have no issues in crossing the borders" and "Government restricts imports of food produce from neighboring regions". The former condition is seen to be dependent on the relationship between Trader/WH and border guards. During disruptions, when the borders are partially closed for imports, this relationship is seen as a value add in ensuring the affected area in the market does not stock out of supplies that are imported from neighboring regions. To improve the latter condition in 2.3, when government restricts imports to boost the local economy, ICRC can possibly intervene in advocating for better import regulations.
- Condition 2.4 is similar to pathway 1, which shows WHs/Traders have storage space for inventory, which is again dependent on a stable transportation system and maintenance of storage space in good condition.

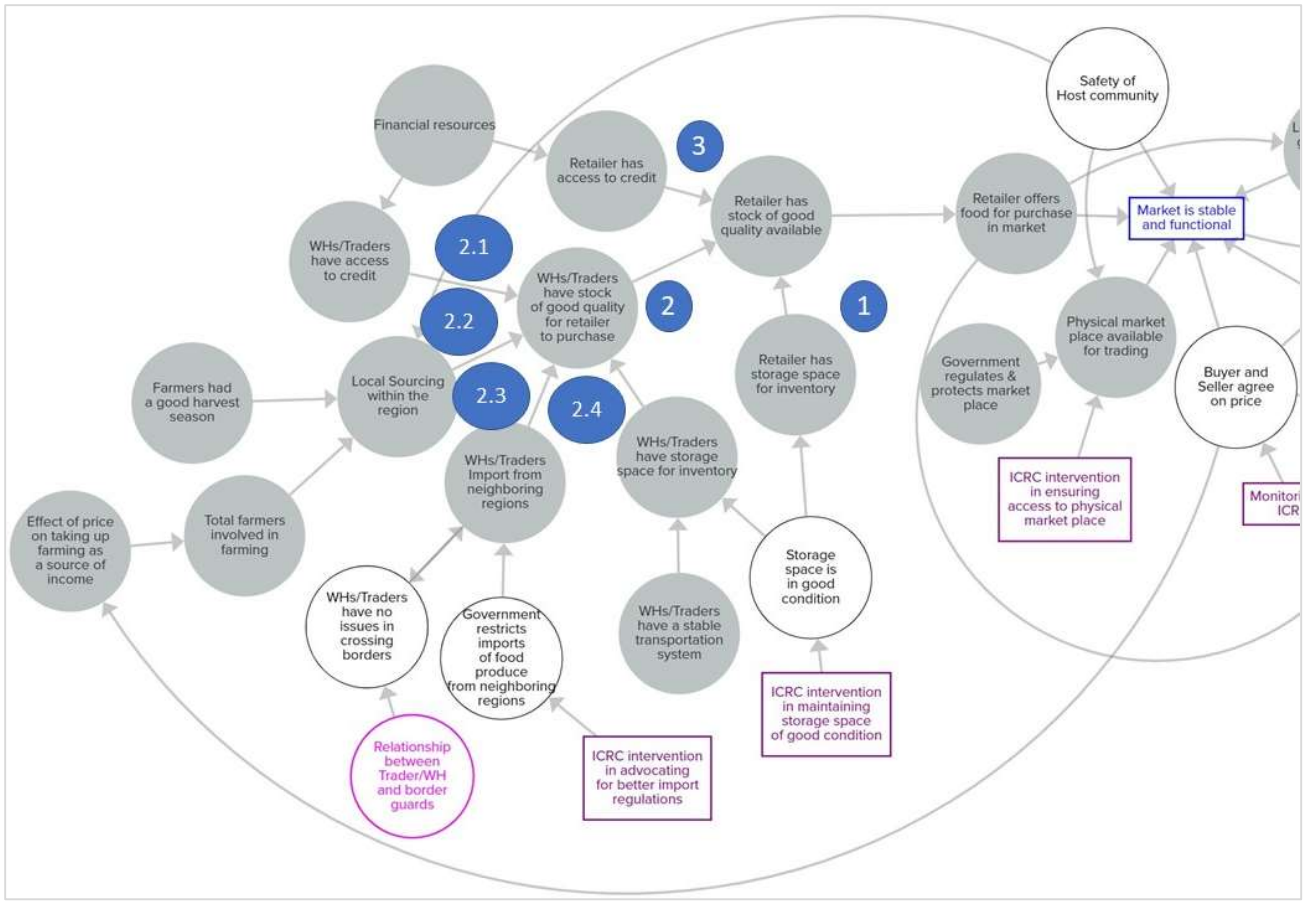


Figure 8: Supply-side view of system pathways map

4.1.3 Demand side of map

The demand side of system pathways map shows the dynamics of local population and IDPs based on the conditions that affect the fulfillment of their needs.

- On the demand side, as shown in Figure 9, the outcome "Market is stable and functional" depends on condition 1 "Local population goes to market to purchase food," which is due to "quality, quantity, and/or variety of household farm output is not sufficient" for sustenance and "Purchasing power of local population". The latter component depends on "Active source of income". Two interventions are considered for this component: support from existing NGOs in providing cash/vouchers to the local population, and ICRC intervention in

providing the same to cover the gap if any. In detail, the assessment by ICRC would look at the ability of the community to cover their own needs, and what if, any gap exists. It includes understanding the unmet needs that could be because no humanitarian actors are present, or are not in a particular geographical area, or not with a particular group of people. This is where collaboration and coordination with other humanitarian agencies would occur to avoid gaps or duplication.

- The second condition, "IDP goes to market to purchase food" is split into two pathways. Condition 2.1 considers "Gap in meeting needs despite existing assistance from other NGOs," which is due to the condition "IDPs lives in host community," as, they have "Conflicts in their home (affected area)" and there are camps available in the host community.
- For the component "IDPs lives in host community", an intervention by existing NGOs in providing in-kind assistance to IDPs is considered. ICRC will come into play to fill the gap, if any, in the existing assistance IDPs are receiving.
- Condition 2.2 considers "purchasing power of IDPs," which is dependent on intervention from NGOs in the form of cash/vouchers to IDPs and intervention from ICRC in provision of same to cover the gap, if any.
- The "purchasing power of local population" and IDPs is dependent also on buyer and seller agreeing on price, since population is seen as having enough purchasing power only if they can afford to buy at the prices set in the market.

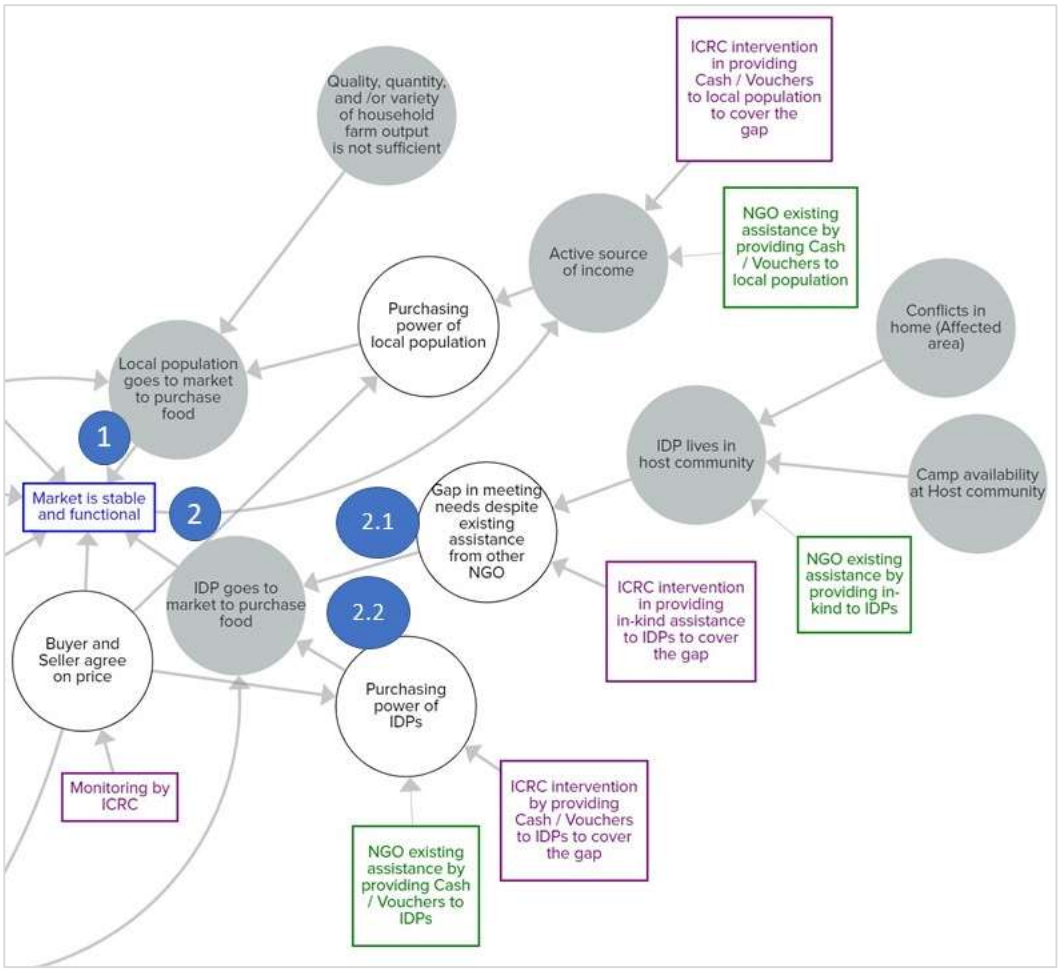


Figure 9: Demand-Side view of system pathways map

4.2 System Dynamics Model

The system dynamics mapping technique helps in representing the complexity of a system. Compared to the static emergency market map shown in Figure 2, the system dynamics modelling approach highlights the changing interactions among market participants when conflict disrupts normal market activities. Another benefit of using a system dynamics approach is the ability to simulate behavior of a market system and observe the effect with controlled experimentation. A user may change the parameter of variables known as policy levers and evaluate the effectiveness of the action. Additionally, the model would also display unintended consequences that may occur due to changes in policy levers

and anticipate signs of resistance, if any, by market participants. To visualize the effectiveness and consequences of intervention, we decided to use system dynamics modeling to capture the interplay of participants in the market system. There are three main dynamics at play in the model. They are the demand, supply and market dynamics.

Steps followed in system dynamics modeling for this capstone are:

1. Reviewed the system pathways map created for market conditions in Nigeria and created a baseline model
2. Formulated sub-system-level dynamics using stock and flow diagrams
3. Linked the sub-system models to form a system-level model
4. Simulated different scenarios reflecting the market conditions to check the effectiveness of the model
5. Ideated potential market interventions that could be performed by ICRC

Points 4 and 5 are covered under section 5, Results and Discussion.

4.2.1 Demand Dynamics

The need for food can be represented as a function of population such that N = *f(*population*)*. Intuitively, as the population grows, the food required to sustain the population also increases. As the model is a part of the market analysis tool, we define "demand" as the amount of food to be purchased in the market. As the population receives or expects to receive food assistances from government or humanitarian organizations, their food needs would be excluded from the market demand. Hence, we focused on the number of people moving into and out of the system boundary as a representation of demand fluctuations. We examined the displaced population that is affected by conflict, known as Internally Displaced Persons (IDP), and the local population that is largely not directly affected by the conflict. On one hand, as the number of IDPs is dynamic, more people would leave home and seek

refuge when the frequency of insurgency rises. On the other hand, people would return home when conflict subsides. However, the "perceived danger of affected area" is not the only variable that drives IDPs' decision. Further examination revealed that some IDPs might choose to return home due to lack of financial access in the host community. The observation that an increase in the number of IDPs returning to the affected area during the growing season suggests the harsh reality of the lack of self-sustaining means in the host community.

We further divided the local population into two groups: the self-sustaining, a part of the population that can take care of themselves with the resources available with them, and the ones that cannot self-sustain. The pathway between these two subgroups of local population is dictated by the affordability of food and the availability of financial opportunities, similar to the underlying dynamics within the IDP. As market dynamics shift, the local population may experience diminishing purchasing power in an inflationary environment, causing a spike in the number of people who cannot sustain themselves.

4.2.2 Supply Dynamics

The supply dynamics can be understood from multiple dimensions of the rate of trading. The trading activities is an encompassing variable containing the quantity, the speed and the capacity pooling with which traders bring food to the affected as well as the non-affected markets. Traders decide how much food is to be collected from domestic smallholder farmers in the host community. In the event of a disruption to the farming community, traders may look for foreign supplies to import food into the local market. However, when domestic yield is high, traders are encouraged to export food to neighboring regions to reduce excess supplies in the system.

4.2.3 Market Dynamics

The market dynamics focuses on the interplay of supply and demand of food. One critical variable within the market dynamics is the food price as $P = P^* * f(\frac{Demand}{Supply})$ where P^* is the price when

demand and supply are at equilibrium. In general, the free market system tends to be self-correcting. Higher prices driven by higher demand would attract suppliers to supply more into the market and balance the supply-demand equilibrium. Conversely, lower prices driven from excessive supply would entice more demand and push the price back to equilibrium. However, in a conflict setting, the supply capacity may be breached such that a supplier cannot produce more, or what is produced cannot be brought into the market. Without proper intervention, there would be high demand chasing low supplies, thereby causing inflation in the market hurting consumers. The reverse is also true when consumers do not have monetary access to make the purchases.

This system dynamics model connects the demand and supply by playing out the changing effect of conflicts on the market system. This is also a great tool for the user to analyze scenarios of different interventions or changing conditions on the ground.

4.3 Model Boundaries

The goal of the model is for users to visualize the underlying complexity of the system in a straightforward and readable format. The boundaries of a model ultimately render its usefulness. Having a model with too narrow of a boundary may omit important dynamics among key variables, thus the model would not capture the true response to the policy intervention. A model with a boundary that is too broad may be unreliable and inefficient, as the key variable or feedback dynamics might be overwhelmed by noise that is not critical to the performance of the system.

This following section outlines the variables and players that are not incorporated in the model:

1. *Input to Agriculture Activities* – We assume the smallholder farmers have sufficient resources and machinery to initiate agriculture activities. The disruption to farming would not be due to lack of input, rather it would be because farming is too dangerous in the conflict-ridden area and there are no financial benefits in pursuing it.

2. *Financial Institutions* – The loans and credit providers that facilitate trading activities are not part of the model, as we assume the trading activity in the conflict area is minimal and traders outside of this area would continue to have access to financial instruments. We assume financial services are accessible to beneficiaries, in the event ICRC decides to provide cash to IDPs.
3. *Business Development Services (Accounting, IT)* – Outside of the conflict area, we assumed the supply chain players, especially large firms in terms of size and revenue, would continue to have access to the same level of professional services.
4. *Infrastructure (Roads, Storage Facilities)* – We assume the road and storage facilities are accessible in the non-affected area and hence, they are not modelled in the non-affected area supply chain. However, the infrastructure variables are modelled in the affected area, which dictates the extent of trading activities from non-affected area to affected area.
5. *Government Regulation* – We acknowledge that a series of government regulations is crucial for a market to function orderly. However, we would only consider government's regulation on the quantity of food imported and exported in the non-affected area. This iteration of the model did not consider the non-governmental controlled regions, which would have their own rules and regulations.

4.4 Sub-systems of the Model

Sub-system 1: Economic Incentive of SH Farmers

Smallholder (SH) farmers are defined as "small farmers who own/control the land they farm" (WEIGO, n.d.). SH Farmers in a non-affected area who contribute to the rate of local production are considered in the stock "SH farmers in non-affected area". The "Rate of becoming a SH farmer" is determined from the difference in potential and existing SH farmers, and time required to become a SH farmer, which could include training and certification time. The barrier to entry is out of scope

and not considered in the model. The difference in potential and existing farmers is determined from the effect of commodity prices. The higher the price, the more attractive is the profession of SH farming. If the difference between potential and existing farmers is negative, then the profession is considered unattractive, which drives up the rate at which SH farmers quit farming.

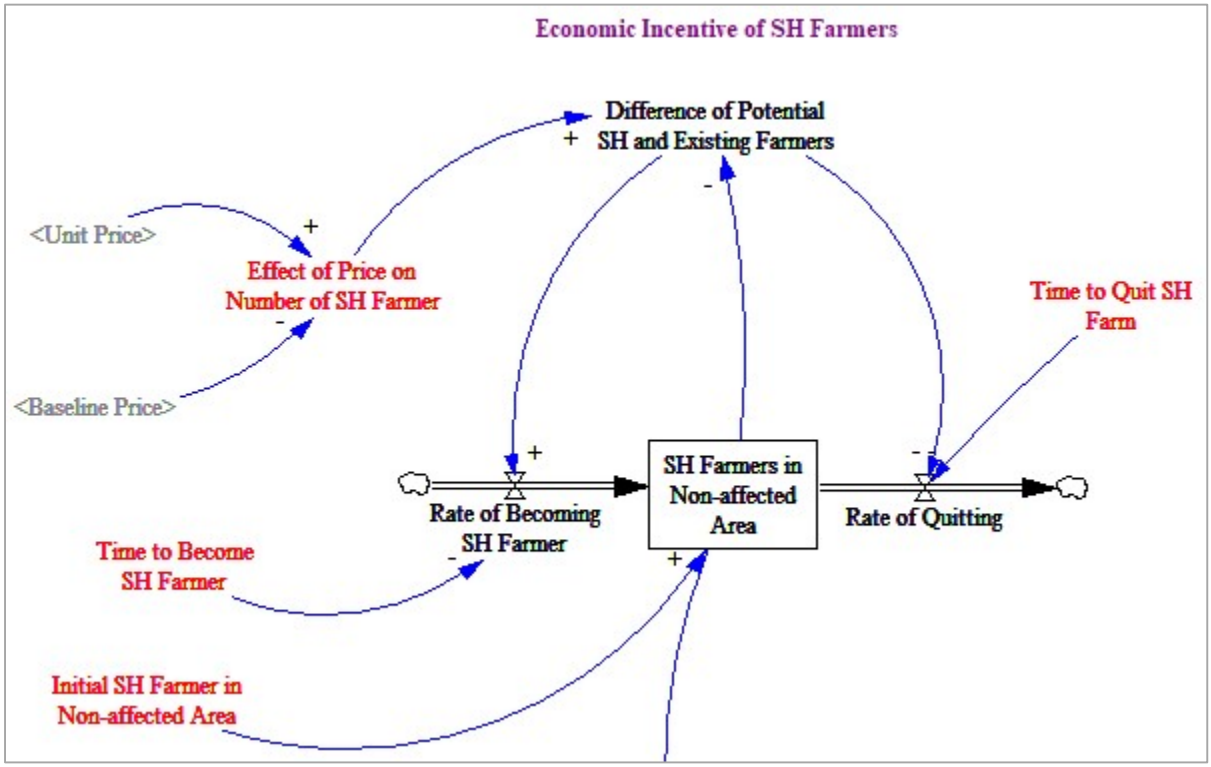


Figure 10: Economic Incentive of SH Farmers

Sub-system 2: Population Dynamics in Affected Area

The population in the affected area makes a "stay or leave" decision based on the perceived danger in the area. The perceived danger in the affected area is directly linked with the severity of disruption, which could be measured by the number of insurgencies in the area or the death toll caused by the conflicts. As the region becomes more dangerous to live in, a greater portion of the population flees home and moves to a host community, where each individual will be recognized as an Internally

Displaced Person (IDP). As the conflict subsides, IDPs will move back to their homes as their community is perceived to be less dangerous to live in.

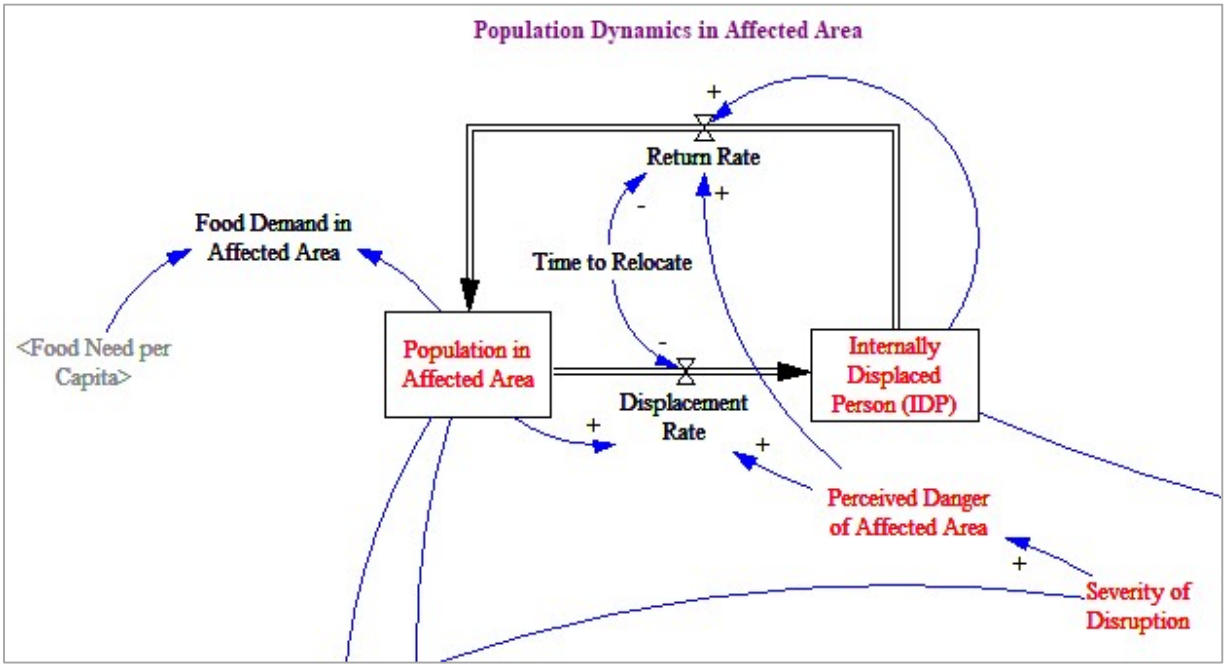


Figure 11: Population Dynamics in Affected Area

Sub-system 3: Population Dynamics in Host Community

The local population, which has limited purchasing power, is sensitive to the changes in price of food. With rising food costs, a portion of the local population who were self-sustainable find themselves unable to afford food purchases. We assume that when the locals are priced out of the food market, they will rely on in-kind assistance from government or humanitarian organizations. The cash and voucher assistance by humanitarian organizations is included in the variable "Purchasing Power of People."

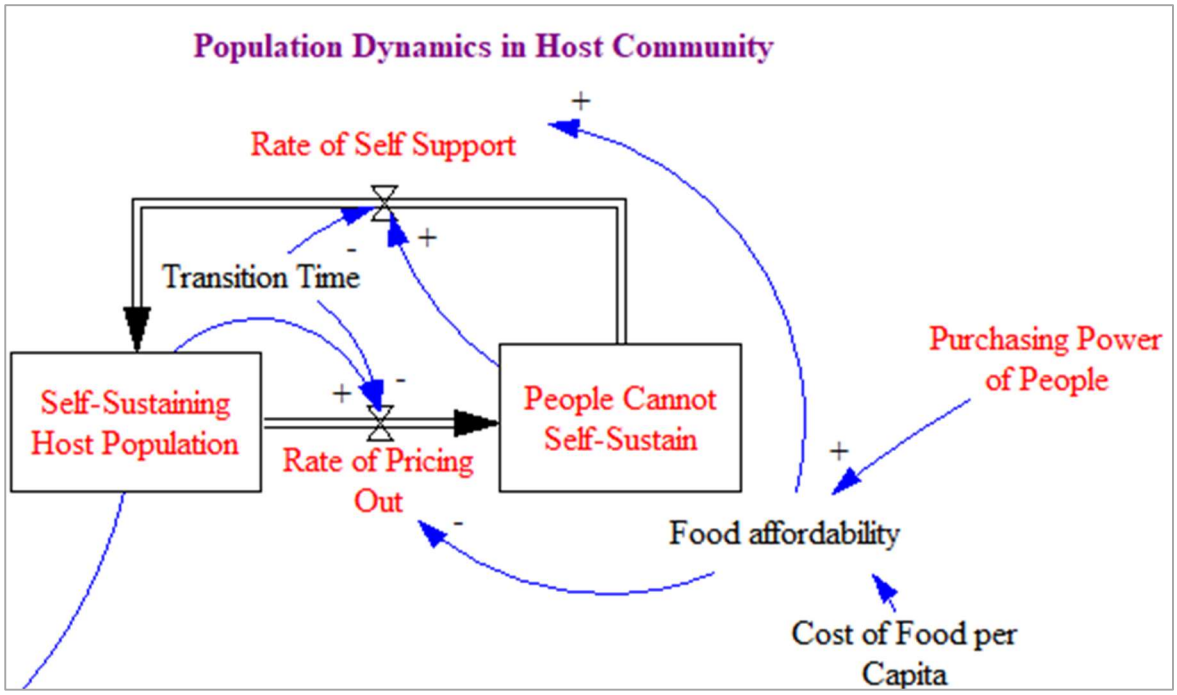


Figure 12: Population Dynamics in Host Community

Sub-system 4: Physical Flow of Food in Affected Area

The system dynamics model includes a smaller version of the food market in the affected area as shown in Figure 13. Local farmers who decide to stay in the affected area will continue to produce food albeit with some productivity loss due to the conflict. If the local production is not enough to meet the total food need in the affected area, trading will fill the gap by drawing extra food from the non-affected area. Several factors will affect the traders' ability to bring food from outside into the affected area, two examples being the road closures, and availability of good storage facilities. When there is a shortage in non-affected area supply, the "Trading Priority to Affected Area" variable dictates the portion of total food traded to the affected area.

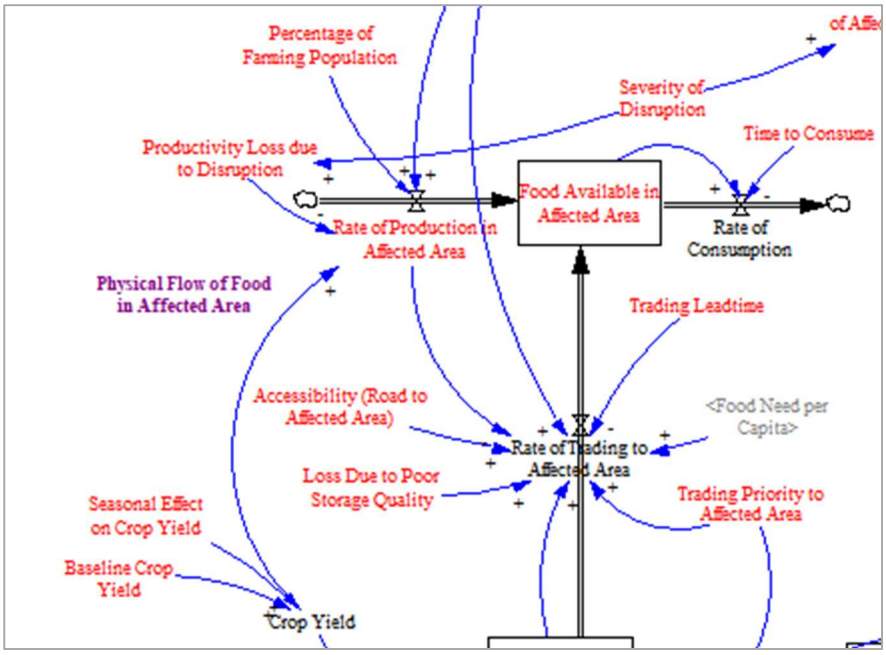


Figure 13: Physical Flow of Food in Affected Area

Sub-system 5: Physical Flow of Food in Non-affected Area

As shown in Figure 14, as smallholder farmers produce agricultural products, traders collect them and sell the food to distributors. The distributors supply to the retailers. Additionally, the distributors can import or export food depending on government regulations and market conditions. Finally, when the food arrives at the retailers, it is made available in the market. We modelled the poor condition of physical storage and lack of transportation availability as a penalty to the flow of food between each pair of buyer and seller. This highlights the opportunity of market-based interventions ICRC can undertake to improve the efficiency of the supply chain.

Sub-system 6: Information Flow of Food in Non-affected Area

As the physical flow moves forward, the information flow moves in reverse, as shown in Figure 15. The retailers observe the trend in market demand and order from their suppliers for the next couple of periods. The upstream suppliers will rely on their customers' order information to forecast and

make purchasing decisions. The information flow goes all the way back to smallholder farmers, who have little room to adjust their production in the short term. Over the long term, the high price of the agricultural products will incentivize more people to become farmers (Refer to sub-system 1 Economic Incentive of SH Farmers). For buyers in the supply chain, we assumed they have sufficient working capital for order placement. When credit is scarce, the buyer would reduce the order quantity. The reverse is also true, when the buyer is supplied with additional financial resources, order size would increase.

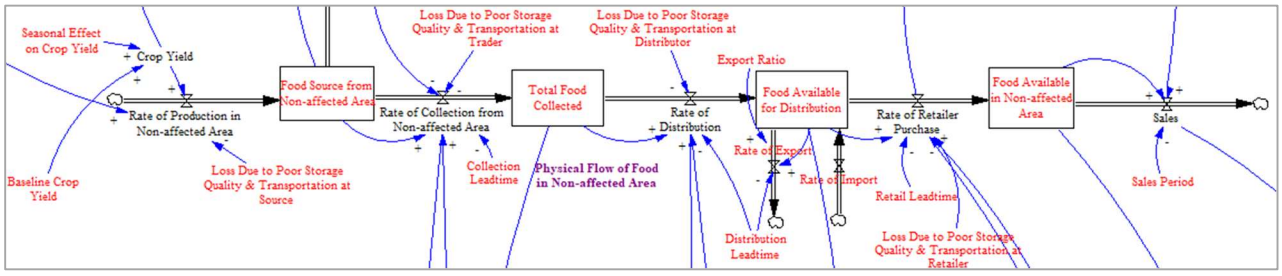


Figure 14: Physical Flow of Food in Non-Affected Area

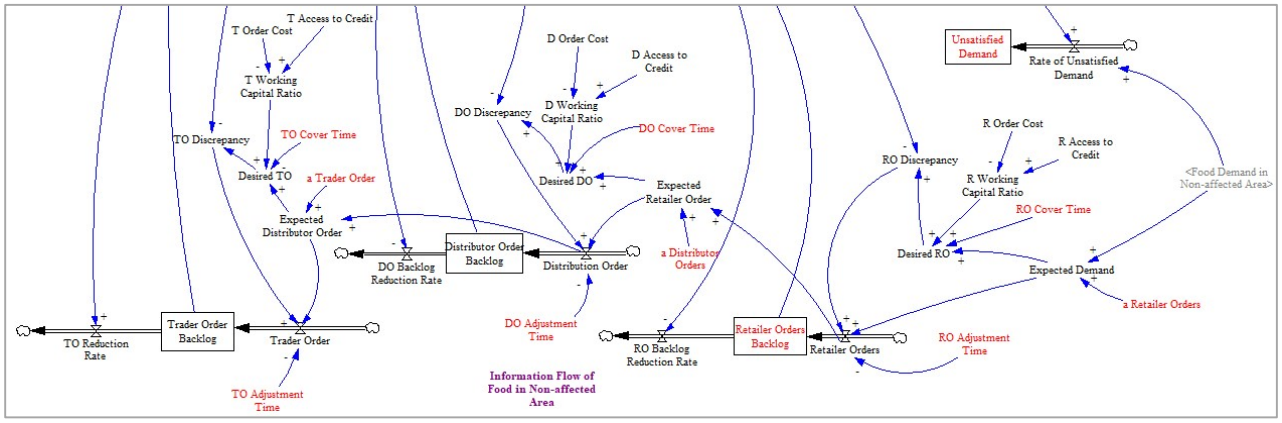


Figure 15: Information Flow of Food in Non-Affected Area

Sub-system 7: Price Dynamics in Host Community

Both IDPs and self-sustaining locals go to the market to purchase food, and their total purchases make up the consumer demand. Individual consumers combined with humanitarian organizations,

who also make purchases at local markets to provide in-kind assistances to beneficiaries, are the forces that drive the demand for food. The basic law of economics dictates that the price is ultimately influenced by the dynamics of supply and demand. As market demand surpasses what the retailers can supply, the price of food increases. This extra cost will put a dent in locals' purchasing power, pushing them out of the market and causing demand to fall.

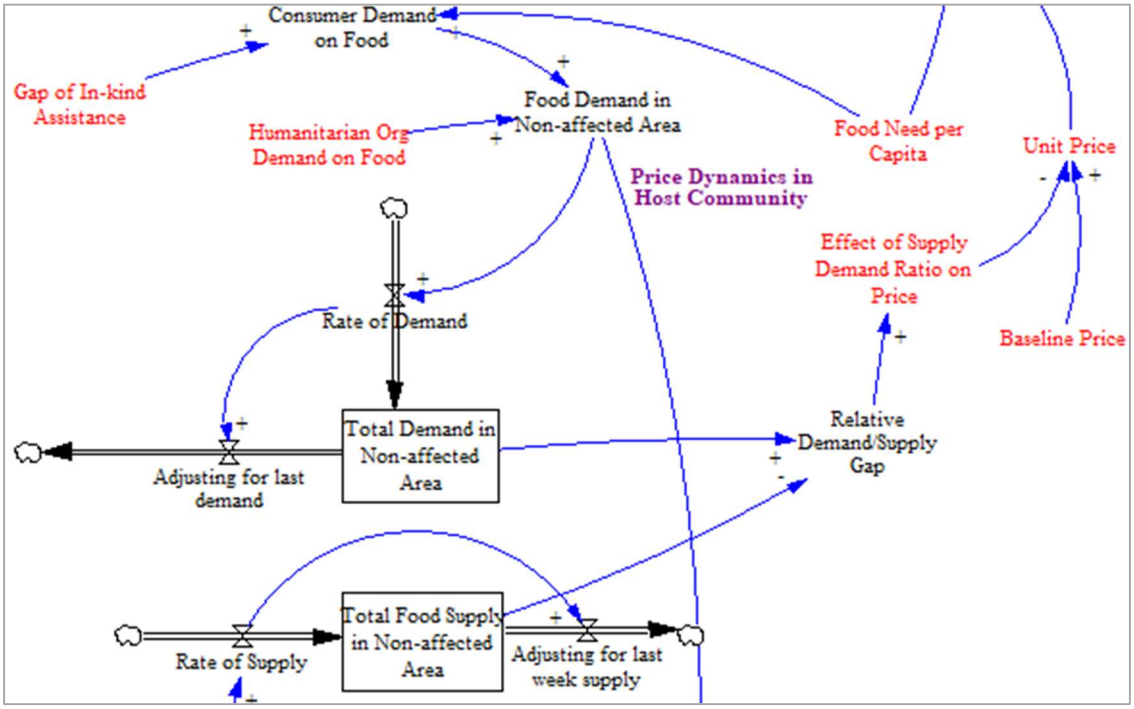


Figure 16: Price Dynamics in Host Community

5. Results and Discussion

We created three specific output diagrams to display the underlying dynamics of our model using "what if" scenarios to confirm if the model behaves in accordance to our mental construct. To better demonstrate the impact of one isolated variable on the entire model, each subsequent scenario was built on the previous one.

5.1 Baseline Model Output

With initial parameterizations, we assumed the lowest level of disruption in the affected area and balanced supply and demand in the host community. Upon running the simulation, we observed a small number of people in the affected area leave their home and become IDPs, as shown in Figure 17. The population in the affected area and the IDP population stabilizes at around Week 20 as the model reaches equilibrium. For the host community population, the output confirms the model design where we assumed that a small percentage of the population is inherently unable to self-sustain. As the population changes, we observed a similar trend under "Food Demand" (Figure 18). This observation confirmed our model design where total food need in a market closely correlates to the population size the market is serving. Since supply and demand are balanced under the baseline model, the food price would stay constant and close to the baseline price, as shown in in Figure 19.

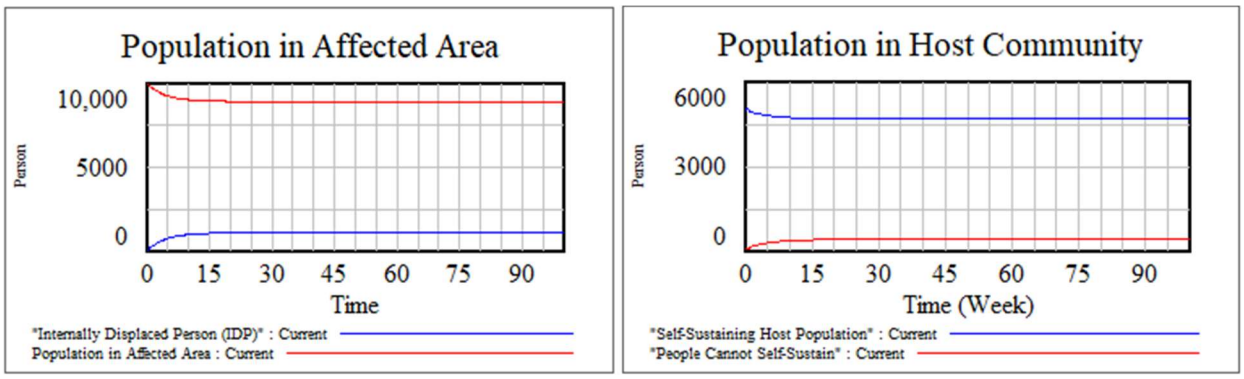


Figure 17: Population dynamics: Baseline

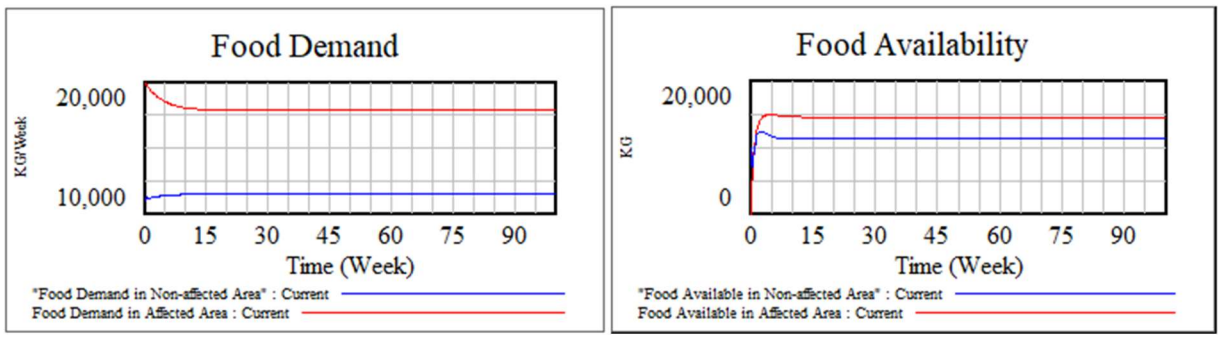


Figure 18: Supply and demand dynamics: Baseline

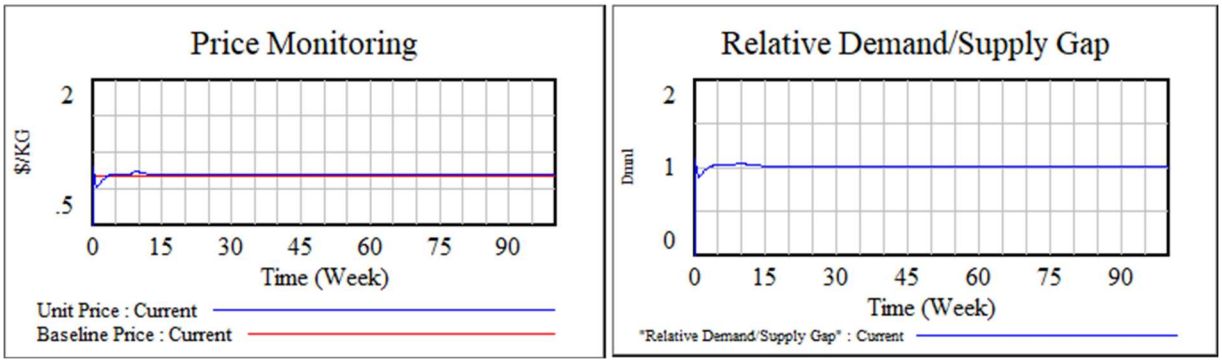


Figure 19: Price Monitoring: Baseline

5.2 Scenario 1: Increased Severity of Disruption

We can model an escalation of crisis in the affected area by changing the variable "Severity of Disruption". When the parameter of this variable is increased at Week 20, we observed a sharp rise in the number of IDPs as people are fleeing from the affected area (Figure 20). Consequently, this influx of people to the host community elevates food demand (Figure 21). As disruption intensifies, the food production in the affected area dwindles due to farmers fleeing to safety and farmland being destroyed. On the other hand, the food supply in the host community remains constant. The rising food demand in the host community outstrips available supply, pushing up the unit price (Figure 22). Inevitably, the price increase would push some locals that are living on the brink of self-sustenance to a group that requires assistance.

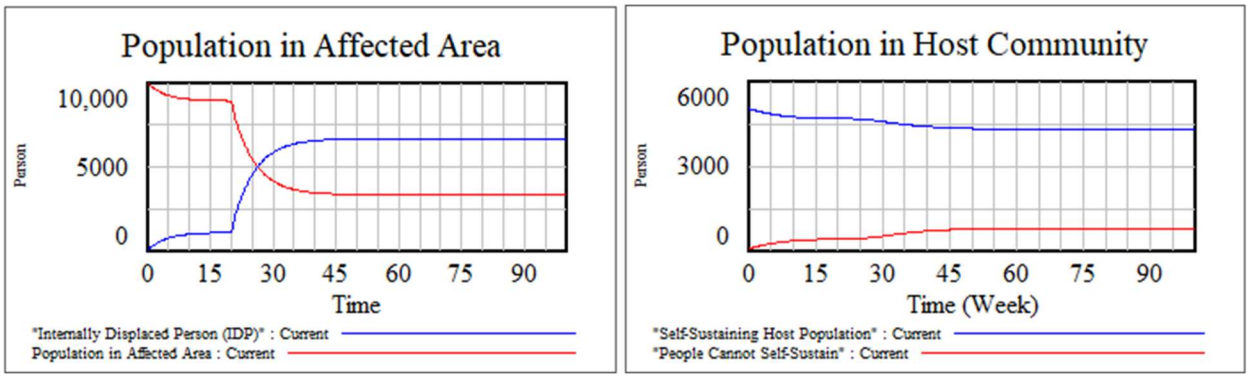


Figure 20: Population dynamics: Increased severity of disruption

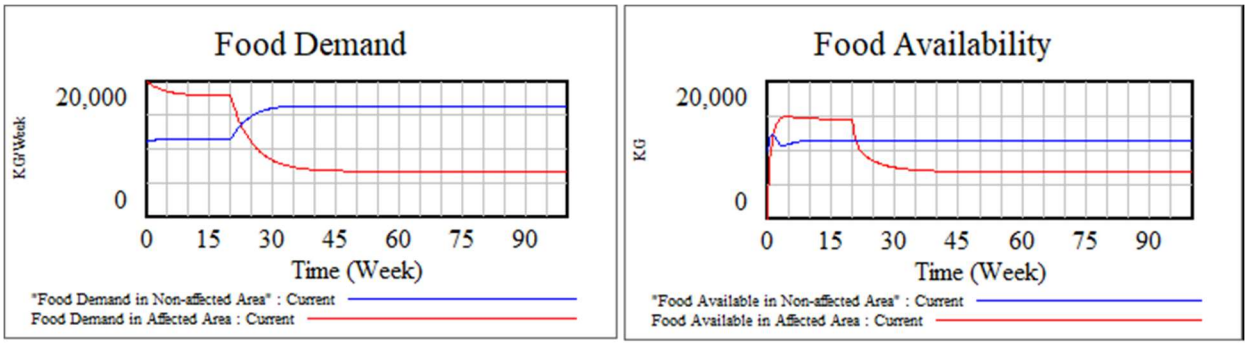


Figure 21: Supply and demand dynamics: Increased severity of disruption

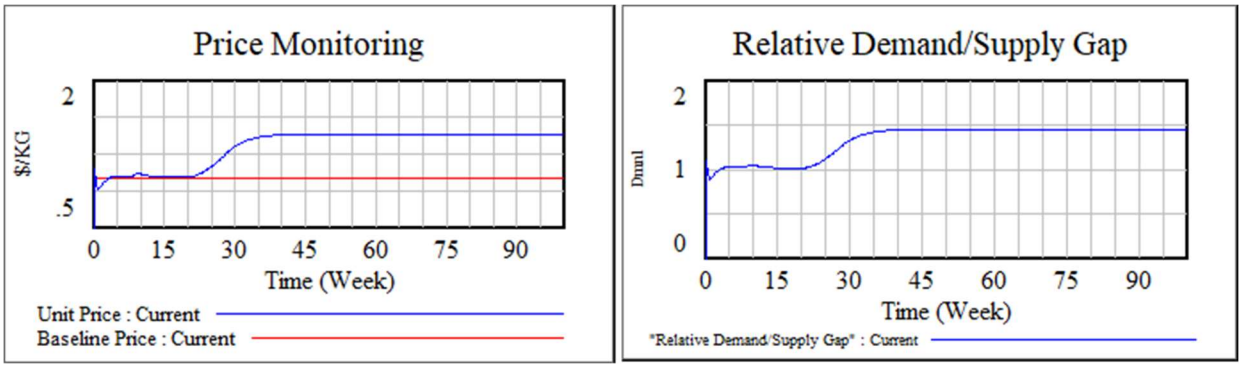


Figure 22: Pricing monitoring: Increased severity of disruption

5.3 Scenario 2: Voluntary Rationing

Voluntary rationing is one of the coping strategies a person can adopt in case of supply shortage. To model this scenario, we reduced the value of "Food Need Per Capita" from Week 30 onwards. As

expected, we observed a sharp decline in food demanded from the market, although the total food needs remain the same (Figure 24). We also saw a small bump of food availability in the host community. This is because, the reduction of food demand in the affected area reduces the amount food traders would bring into the area from non-affected regions. As a result, more food is available to supply the host community. Dampened demand coupled with surplus supply pushes the food price down in the host community (Figure 25). Finally, as prices fall, we observe a slight uptick in the self-sustaining population in the host community.

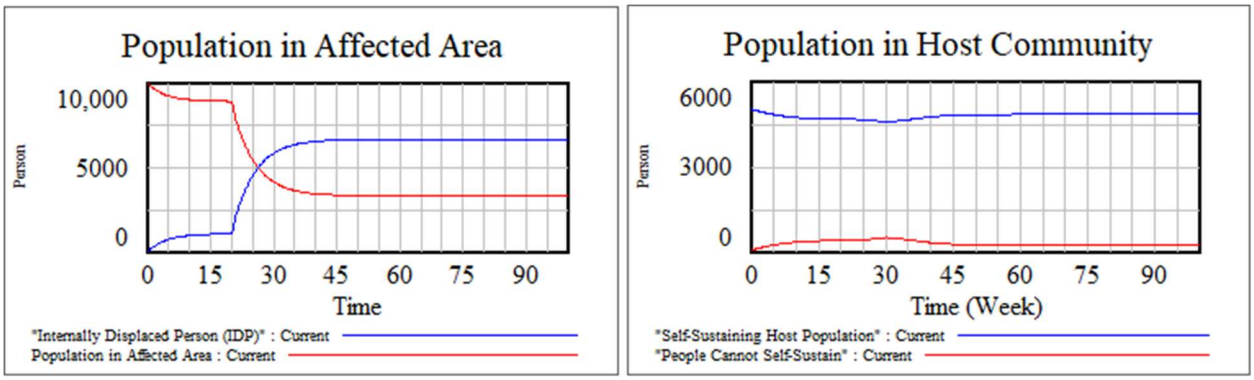


Figure 23: Population dynamics: Voluntary rationing

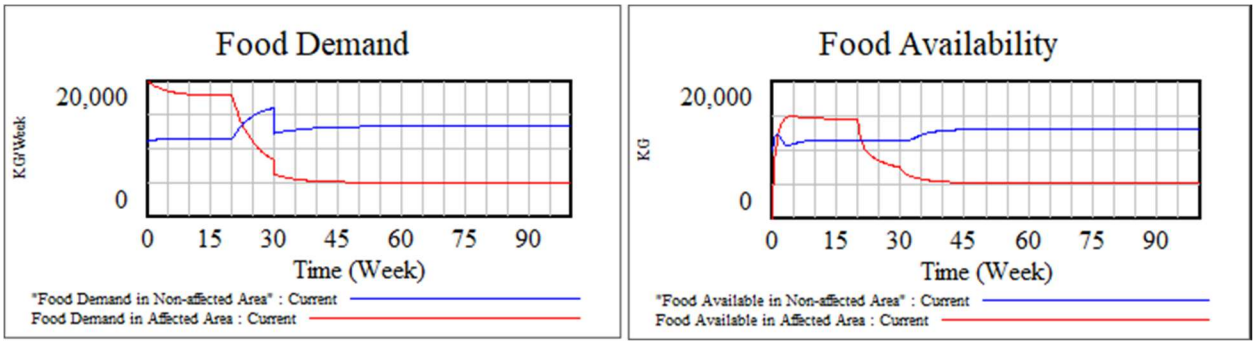


Figure 24: Supply and demand dynamics: Voluntary rationing

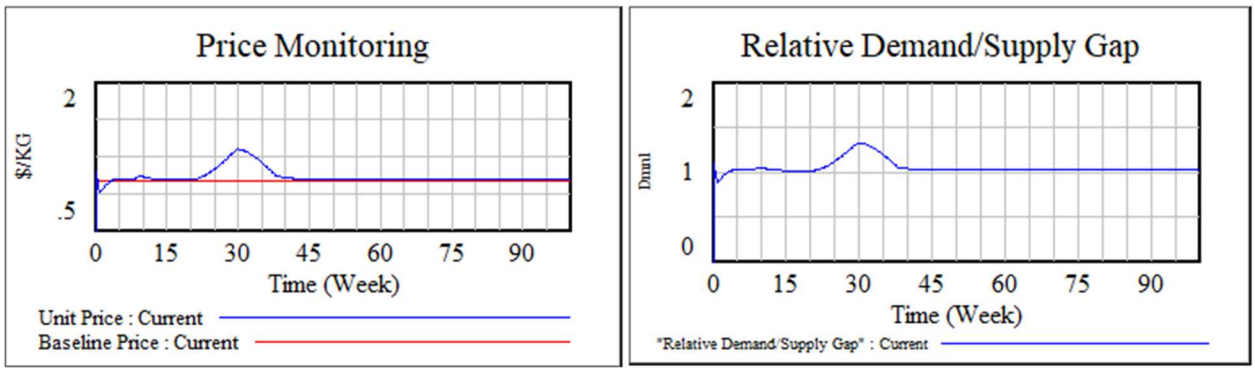


Figure 25: Price monitoring: Voluntary rationing

5.4 Scenario 3: Increased Local Purchasing by Humanitarian Organizations

Humanitarian organizations may choose to procure in local food market to provide in-kind assistance to local beneficiaries; sometimes, humanitarian organization may make a purchase in the non-affected region to aid beneficiaries in the affected region. Consequently, the food demand in the market would jump. We ramped up the value of humanitarian organizations' weekly demand starting from Week 50. The most immediate and direct impact of this action was a spike in food demand in the non-affected area (Figure 27). While supply remains constant, the purchases made by humanitarian actors exert an upward pressure on the food price (Figure 28) and jeopardize the self-sustainability of the small population in the host community (Figure 26).

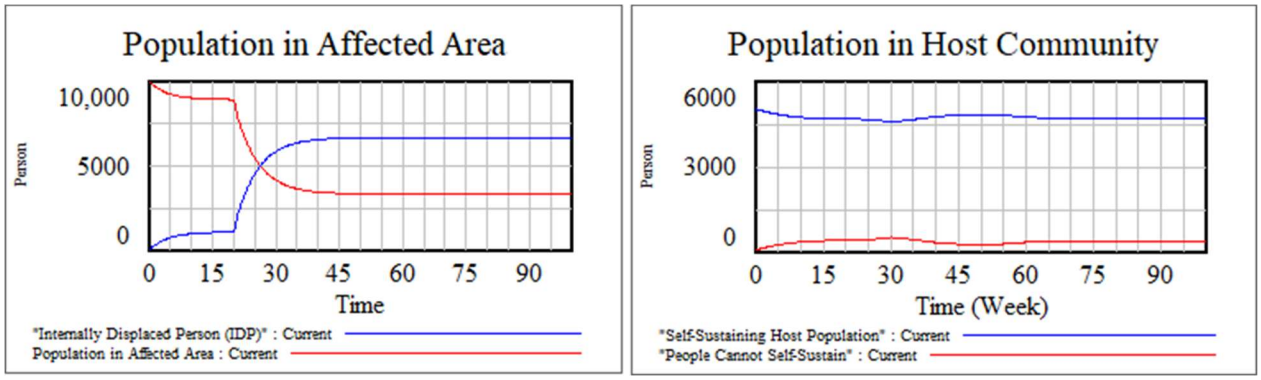


Figure 26: Population dynamics: Increase local purchasing

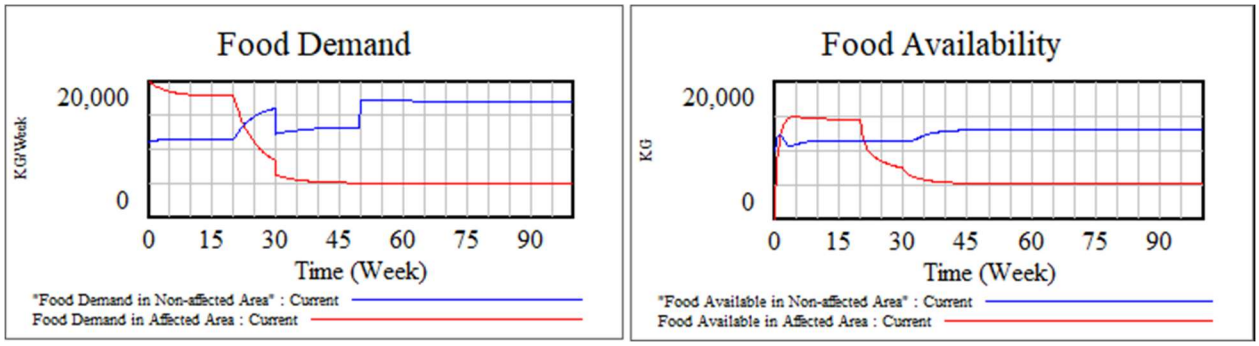


Figure 27: Supply and demand dynamics: Increase local purchasing

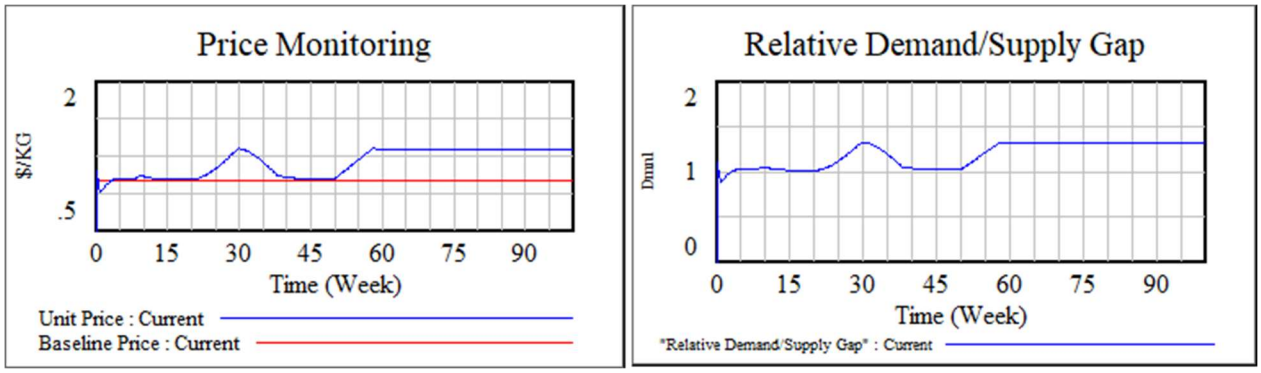


Figure 28: Price monitoring: Increase local purchasing

5.5 Scenario 4: Increased Import Rate

When local food supply is severely disrupted or when food demand surges as IDPs flood the non-affected area, government or business may look for external sources of food to supply the local market (external refers to anywhere that is outside of the model boundary). We increased the parameter of the variable "Food Import Rate" starting from Week 75 to capture the model behavior. As more food is brought into the market, the food availability increases (Figure 30), which in turn eases demand pressure and causes prices to fall (Figure 31). The abundance of food at lower prices would help the local population and increase the self-sustaining population (Figure 29).

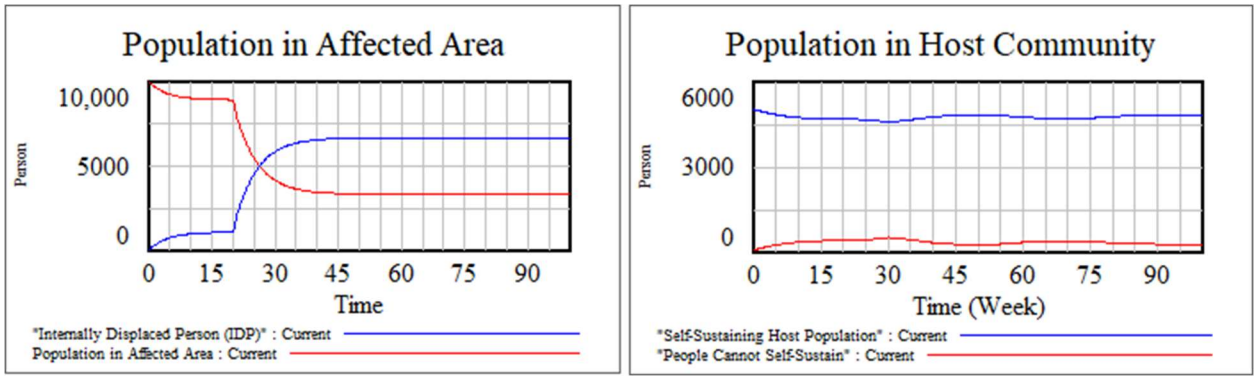


Figure 29: Population dynamics: Increase import

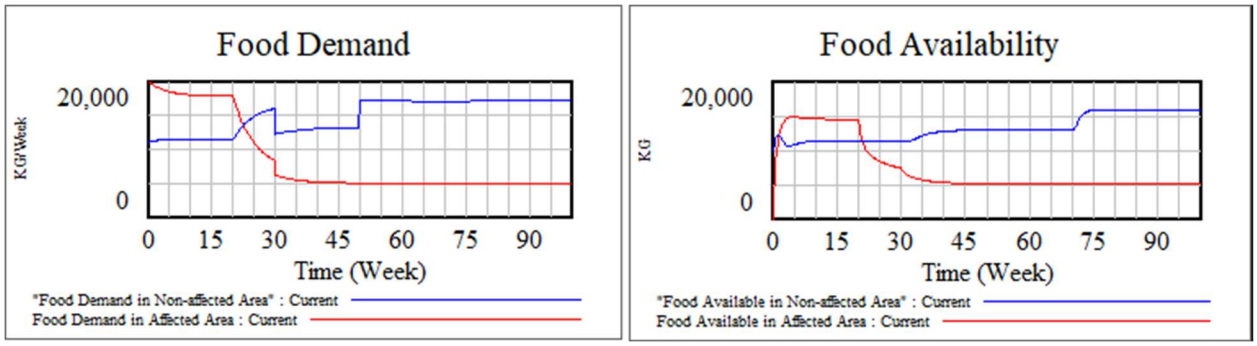


Figure 30: Supply and demand dynamics: Increase import

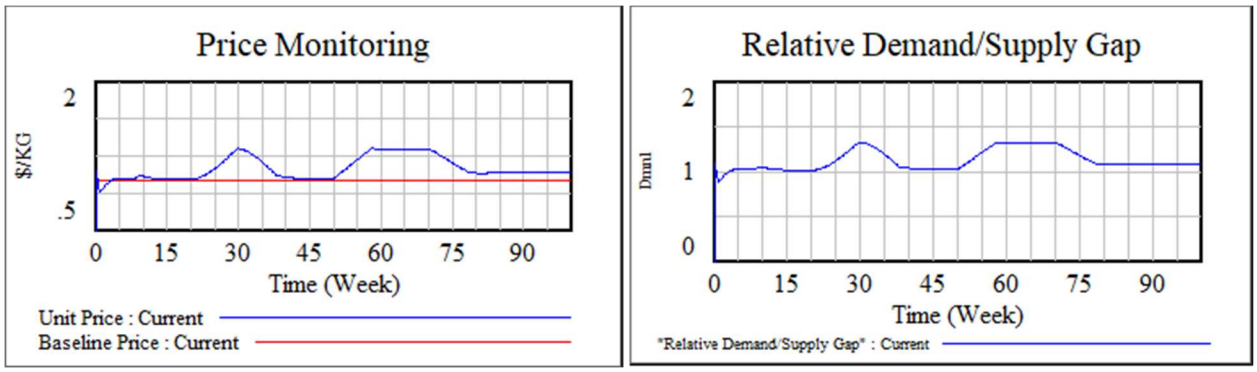


Figure 31: Price monitoring: Increase import

5.6 Possible Interventions/Monitoring by ICRC in each Sub-system

Listed below are areas where ICRC can intervene in the market to influence the dynamics of the market actors, local population and IDPs.

Sub-system: Economic Incentive of SH Farmers

- ICRC can **monitor the number of "SH Farmers in Non-Affected Area"** to have an estimate of the local production rate. This in part influences the calculation of the element "Food Available in Non-affected Area" which is an outcome of another sub-system.
- ICRC can **provide training or agricultural input** to potential SH farmers. This will shorten the time required for a person to become a SH farmer.

Sub-system: Population Dynamics in Affected Area

- ICRC can **monitor the number of "Internally Displaced Persons (IDP),"** which will help in estimating whether the expected rise in "Food Demand in Non-affected Area" can be fulfilled by "Food Available in Non-affected Area." This monitoring is also helpful in keeping track of the "Demand/Supply Ratio" and its effect on "Unit Price."

Sub-system: Population Dynamics in Host Community

- ICRC can intervene in this sub-system by **providing cash and cash vouchers** to boost the "Purchasing Power of People" which will have a positive effect on the "Rate of Self-Support," driving up the number of "Self-Sustaining Host Population."
- ICRC would have to consider filling the gap created by the intervention of other NGOs while providing cash, cash vouchers, and in-kind assistance.

Sub-system: Price Dynamics in Host Community

- ICRC can **monitor the "Unit Price"** of food items to see variations according to the market conditions, since it is driven by supply and demand variables that are influenced by other sub-systems. Actions that could be taken to keep up with the prices, or to balance it can be (a) to increase the cash transfer value if short term inflation is reducing the purchasing power of people (b) move to commodity vouchers to combat inflation risk (c) move to in-kind ensuring supply is maintained a level and does not destabilize the market.
- ICRC can **provide in-kind assistance** directly to IDPs, lowering "Gap of in-kind Assistance". This effectively lowers the number of IDPs that would go to market to purchase food, consequently reducing the "Total Demand in Non-Affected Area."

Sub-system: Physical Flow of Food in Affected Area

- ICRC can intervene in this sub-system by **providing in-kind donation** to increase the "Food Available in Affected Area," after considering existing intervention by other NGOs in providing the same, to fill the gap.
- ICRC can also intervene in **reducing the "Loss Due to Poor Storage Quality"** by helping traders maintain the existing storage space in good hygienic conditions.

Sub-system: Physical Flow of Food in Non-Affected Area

- After assessing the market conditions, ICRC can possibly intervene in **advocating for appropriate level of import by the government** to meet local demand. This is because the government at times can place restrictions on imports to boost the local economy. ICRC possibly could, to a certain extent, influence this decision by assessing the market condition in

affected and non-affected area to make sure enough supplies are present before such restrictions are imposed.

Sub-system: Information Flow of Food in Non-Affected Area

- ICRC can **share information with the traders** when the purchasing power of the affected population has increased due to their interventions so that the trader can sell to those who can now afford it.

- ICRC distributes, to IDPs and to the population that cannot self-sustain, cash and commodity vouchers that can be exchanged with traders in the market for essential purchases. **ICRC will collaborate with traders by paying them money in exchange for these cash or commodity vouchers**.
- ICRC can **extend credit to small and fragile market players**. These market players can increase the order quantity driving up the food availability in the non-affected area.

6. Conclusion

This capstone project uses system dynamics methodology to enhance the current static mapping method used by ICRC for market analysis. Considering the market condition in Nigeria as a context, a system pathways map was developed for a high-level understanding of the interactions between the market actors. Gaining key insights from the system pathways map, several sub-systems were identified and formulated into a system dynamics model. The model can simulate different scenarios to reflect different market conditions. The logistics and the program team of ICRC can use this model to simulate their interventions and observe changes in model behavior. They can create scenarios of different ways in which they can intervene and choose the best response that can be provided for specific set of market conditions. The system dynamics model can simulate weeks or even months of market behavior, highlighting the temporal impact of market intervention.

This model is constructed using Nigeria's market conditions as a baseline. It can be extended to any similar conflict-stricken markets. The system pathways map and the system dynamics model in this capstone project consider food as a commodity; however, with minor adjustments to the market actors, the same concept can be applied for other non-food commodities as well.

For future studies, the system dynamics model can be further enhanced by adding, 1) An informal credit network where beneficiaries could borrow money to make purchases, 2) Dynamics of credit provided by humanitarian organizations to market actors to influence their procurement behavior, 3) Activation of the sub-system, "Economic Incentive of SH farmers," to model the impact of changes in price on the farming community, 4) Transport related issues, which would impact either the quantity of food available or delay in food reaching the market, or both, and 5) Impact of government regulations on market conditions. The consideration of the aforementioned will increase the complexity of the model but this will in turn strengthen its robustness as well.

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Appendix A

Complete system pathways map that highlights a key outcome, and the pathways and conditions that affect it.

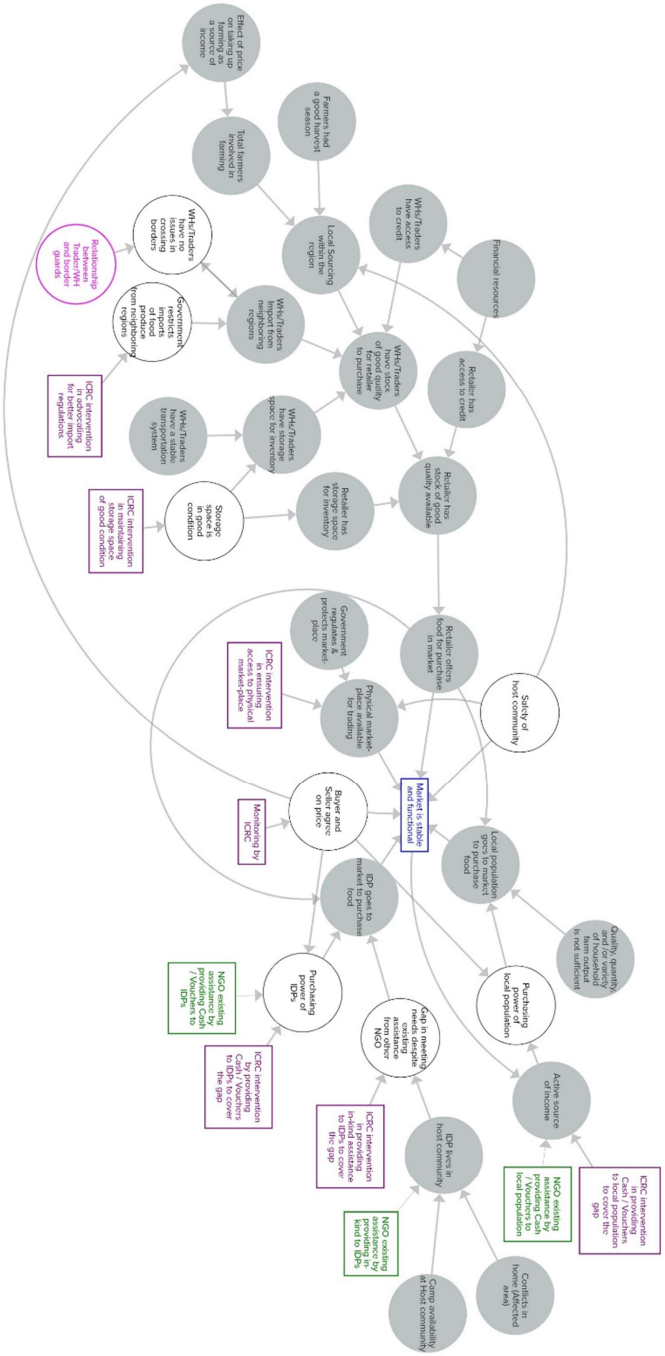

Figure 32: Complete System Pathways Map

Appendix B

Complete system dynamics model showing different sub-systems and the interactions between them.

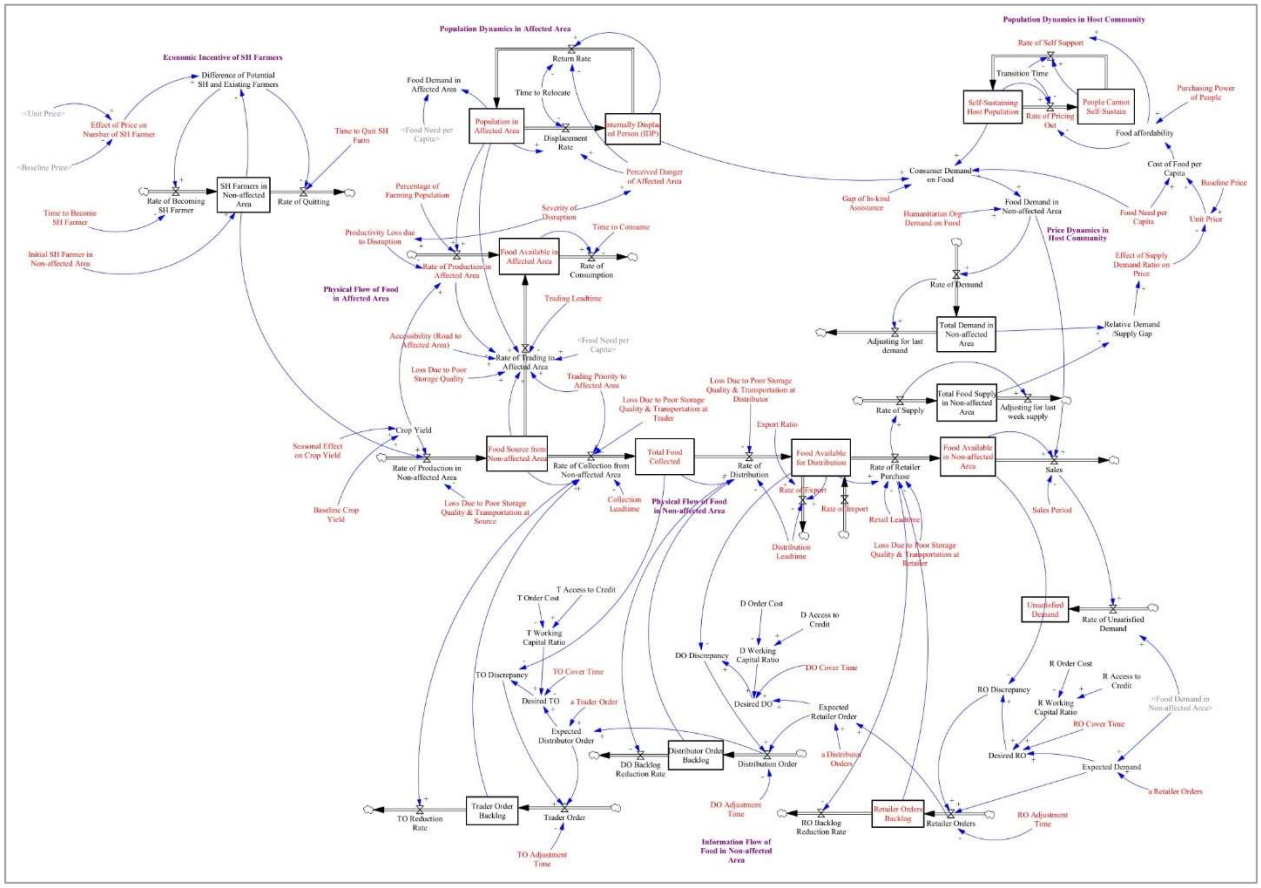

Figure 33: Complete System Dynamics model

Appendix C

Table 2: *List of Parameters, descriptions, units, associated formulae and initialization values*

1					
Economic Incentive of SH Farmers					
Parameter	Description	Unit	Type	Equation	Initial Value
Rate of Becoming SH Farmer	The rate of attractiveness of taking up SH farming as a profession	Person/Week	Rate	IF THEN ELSE (Difference of Potential SH and Existing Farmers>0, Difference of Potential SH and Existing Farmers/Time to Become SH Farmer, 0)	-
SH Farmers in Non-affected Area	Number of farmers in non-affected area	Person	Stock	INTEG (Rate of Becoming SH Farmer-Rate of Quitting)	Initial SH farmers in Non-Affected Area
Rate of Quitting	Farmers quitting SH farming due to unattractiveness of profession	Person/Week	Rate	IF THEN ELSE (Difference of Potential SH and Existing Farmers<0, abs (Difference of Potential SH and Existing Farmers)/Time to Quit SH Farm, 0)	-
Time to Become SH Farmer	Number of weeks to become a farmer	Week	Variable	Constant	8
Initial SH Farmer in Non-affected Area	Initial number of farmers in non-affected area	Person	Variable	Constant	4,000
Baseline Price	Initial starting price of food according to which unit price varies	$/KG	Variable	Constant	1
Unit Price	The price of food affected by the supply and demand ratio	$/KG	Variable	Baseline Price*Effect of Supply Demand Ratio on Price	-
Effect of Price on Number of SH Farmer	Effect of price on number of farmers taking up farming	Dmnl	Variable	(Unit Price-Baseline Price) ^ 0 (as of now considering no effect in farmers taking up farming due to price variations)	1
Time to Quit SH Farm	Time taken by farmers to quit farming	Week	Variable	Constant	4

Difference of Potential SH and Existing Farmers	The effect of price on number of farmers taking up SH farming compared to existing number of farmers	Person	Variable	SH Farmers in Non-affected Area*Effect of Price on Number of SH Farmer -SH Farmers in Non-affected Area	-

2					
Population Dynamics in Affected Area					
Parameter	Description	Unit	Type	Equation	Initial Value
Population in Affected Area	Number of people still living in the affected area	Person	Stock	INTEG (Return Rate-Displacement Rate)	10,000
Displacement Rate	The rate of people fleeing their homes to host community	Person/Week	Rate	Population in Affected Area*Perceived Safety of Affected Area/Time to Relocate	-
Internally Displaced Person (IDP)	The number of IDPs living in host community	Person	Stock	INTEG (Displacement Rate-Return Rate)	20
Return Rate	The rate of people returning from host community to their homes	Person/Week	Rate	((1-Perceived Danger of Affected Area) ^ 2*Internally Displaced Person (IDP))/Time to Relocate	-
Time to Relocate	Time taken for people to move between affected area and host community	Week	Variable	Constant	4
Perceived Danger of Affected Area	Based on the severity of the conflict, the perceived danger in affected area	Dmnl	Variable	Severity of Disruption/10	-
Severity of Disruption	On a scale of 1 (least) to 10 (most), the severity of conflict	Dmnl	Variable	Constant	1
Food Demand in Affected Area	The total demand of food in affected area per week	KG/Week	Variable	Food Need per Capita*Population in Affected Area	-

Food Need per Capita	Amount of food each person needs on a weekly basis	KG/Person/ Week	Variable	Constant	2

3					
Population Dynamics in Host Community					
Parameter	Description	Unit	Type	Equation	Initial Value
Self-Sustaining Host Population	The number of people that can self-sustain	Person	Stock	INTEG (Rate of Self Support-Rate of Pricing Out)	5,000
People Cannot Self-Sustain	The number of people that cannot self-sustain	Person	Stock	INTEG (Rate of Pricing Out-Rate of Self Support)	100
Rate of Pricing Out	The rate of people seeking support due to high price of food	Person/Week	Rate	Max (Self-Sustaining Host Population*0.02/Food affordability,0)/Transition Time	-
Rate of Self Support	The number of people that can support themselves each week	Person/Week	Rate	Min (People Cannot Self-Sustain*0.1*Food affordability, People Cannot Self-Sustain)/Transition Time	-
Transition Time	Time to transition between being self-sustained and being priced out	Week	Variable	Constant	1
Food affordability	Ratio of the cost of food to the willingness to pay by consumers	Dmnl	Variable	Purchasing Power of People/Cost of Food per Capita	-
Purchasing Power of People	maximum amount of money each person would spend on food every week	$/Week/ Person	Variable	Constant	3
Cost of Food per Capita	Amount of money each person spends on food on a weekly basis	$/Week/ Person	Variable	Food Need per Capita*Unit Price	-

4					
Physical Flow of Food in Affected Area					
Parameter	Description	Unit	Type	Equation	Initial Value
Productivity Loss due to Disruption	The degree of impact of conflict on farming activities	Dmnl	Variable	Severity of Disruption/10	-
Rate of Production in Affected Area	Production by SH Farmers in affected area	KG/Week	Rate	Population in Affected Area*Percentage of Farming Population*Crop Yield*(1-Productivity Loss due to Disruption)	-
Food Available in Affected Area	The total KG of food available in affected area	KG	Stock	INTEG (Rate of Production in Affected Area+Rate of Trading to Affected Area-Rate of Consumption)	0
Rate of Consumption	The rate of food consumption in affected area	KG/Week	Rate	Food Available in Affected Area/Time to consume	-
Time to consume	Time taken to consume food	Week	Variable	Constant	1
Rate of Trading to Affected Area	The amount of food per week brought into the affected area	KG/Week	Rate	Min ("Accessibility (Road to Affected Area)"*(Max (0,(Food Need per Capita*Population in Affected Area-Rate of Production in Affected Area)*(1 +Loss Due to Poor Storage Quality))),"Food Source from Non-affected Area"*Trading Priority to Affected Area/Trading Leadtime)	-
Accessibility (Road to Affected Area)	Percentage of road still accessible to traders	Dmnl	Variable	Constant	1
Trading Leadtime	The time taken to move food from non-affected area to affected area	Week	Variable	Constant	1
Percentage of Farming Population	The percentage of population in the affected area that engages in farming	Dmnl	Variable	Constant	0.3
Food Need per Capita	Amount of food each person needs on a weekly basis	KG/Week/ Person	Variable	Constant	2

Loss Due to Poor Storage Quality	Loss due to poor storage quality	Dmnl	Variable	Constant	0.02
Severity of Disruption	On a scale of 1 (least) to 10 (most), the severity of conflict	Dmnl	Variable	Constant	1
Trading Priority to Affected Area	Percentage of trading diverted to affected area	Dmnl	Variable	Constant	0.3

5					
Physical Flow of Food in Non-Affected Area					
Parameter	Description	Unit	Type	Equation	Initial Value
Seasonal Effect on Crop Yield	Seasonality impact on the crop yield	Dmnl	Variable	Constant	1
Crop Yield	Per week production by SH farmer	KG/Person/ Week	Variable	Baseline Crop Yield*Seasonal Effect on Crop Yield	-
Baseline Crop Yield	average yield per farmer per week	KG/Person/ Week	Variable	Constant	4
Rate of Production in Non-affected Area	Production Rate of SH Farmers in Non-Affected area	KG/Week	Rate	(Crop Yield*SH Farmers in Non-affected Area) * (1-Loss Due to Poor Storage Quality & Transportation at Source)	-
Loss Due to Poor Storage Quality & Transportation at Source	Loss due to poor storage quality and transportation	Dmnl	Variable	Constant	0.02
Food Source from Non-affected Area	Total food produced in non-affected area	KG	Stock	INTEG (Rate of Production in Non-affected Area - (Rate of Collection from Non-affected Area+Rate of Trading to Affected Area))	10,000
Collection Leadtime	The time taken to collect food from farmers	Week	Variable	Constant	1
Rate of Collection from Non-affected Area	The amount of food being collected from non-affected area, based on the minimum of demand and production	KG/Week	Rate	(Min (Food Source from Non-affected Area*(1-Trading Priority to Affected Area), Trader Order Backlog)/Collection Leadtime) *(1-Loss Due to Poor Storage Quality & Transportation at Trader))	-

Total Food Collected	Total food collected	KG	Stock	INTEG (Rate of Collection from Non-affected Area-Rate of Distribution)	10,000
Loss Due to Poor Storage Quality & Transportation at Trader	Loss due to poor storage quality and transportation	Dmnl	Variable	Constant	0.02
Rate of Distribution	The amount of food being distributed from non-affected area, based on the minimum of demand and supplier availability	KG/Week	Rate	(Min (Distributor Order Backlog, Total Food Collected)/Distribution Leadtime) * (1-Loss Due to Poor Storage Quality & Transportation at Distributor)	-
Loss Due to Poor Storage Quality & Transportation at Distributor	Loss due to poor storage quality and transportation	Dmnl	Variable	Constant	0.02
Food Available for Distribution	Food available to be distributed	KG	Stock	INTEG (Rate of Distribution+Rate of Import-Rate of Export-Rate of Retailer Purchase)	15,000
Rate of Retailer Purchase	Food purchased by retailers	KG/Week	Rate	(Min (Food Available for Distribution, Retailer Orders Backlog)/Retail Leadtime) * (1-Loss Due to Poor Storage Quality & Transportation at Retailer)	-
Loss Due to Poor Storage Quality & Transportation at Retailer	Loss due to poor storage quality and transportation	Dmnl	Variable	Constant	0.02
Food Available in Non-affected Area	Food availability at market for consumer to purchase	KG	Stock	INTEG (Rate of Retailer Purchase-Sales)	10,000
Sales	The rate of food purchased by consumers	KG/Week	Rate	Min (Food Available in Non-affected Area/Sales Period, Food Demand in Non-affected Area)	-
Sales Period	The time taken to sell food	Week	Variable	Constant	1
Retail Leadtime	Time taken for retailer to purchase food	Week	Variable	Constant	1

Rate of Import	import rate into non-affected area	KG/Week	Variable	Constant	100
Rate of Export	The food per week that is exported	KG/Week	Variable	Food Available for Distribution*Export Ratio/Distribution Leadtime	-
Distribution Leadtime	Time taken for the distributors to purchase food	Week	Variable	Constant	1
Export Ratio	The percentage of food being exported	Dmnl	Variable	Constant	0.001

6					
Information Flow of Food in Non-Affected Area					
Rate of Unsatisfied Demand	Demand that is not satisfied	KG/Week	Rate	IF THEN ELSE (Food Demand in Non-affected Area>Sales, (Food Demand in Non-affected Area-Sales) , 0)	-
Unsatisfied Demand	Total unsatisfied demand	KG	Stock	INTEG (Rate of Unsatisfied Demand)	0
Food Demand in Non-affected Area	The amount of total food demand	KG/Week	Variable	Consumer Demand on Food+Humanitarian Org Demand on Food	-
Expected Demand	Forecast of next week's demand	KG/Week	Variable	SMOOTH (Food Demand in Non-affected Area, a Retailer Orders)	-
a Retailer Orders	Smoothing factor for market demand	Week	Variable	Constant (Average of 2 weeks of demand will be considered)	2
RO Cover Time	Weeks of Supply	Week	Variable	Constant	2
R Order Cost	Ordering cost incurred by retailer	$	Variable	Constant	100
R Access to Credit	Retailer's access to credit	$	Variable	Constant	100
R Working Capital Ratio	Available working capital ratio to place order	Dmnl	Variable	R Access to Credit/R Order Cost	-
Desired RO	Amount retailer wishes to order to cover the demand and safety stock	KG	Variable	Expected Demand*RO Cover Time*Min (1.5, R Working Capital Ratio)	-
RO Discrepancy	Difference between retailer desired order quantity and actual on-hand	KG	Variable	Desired RO-Food Available in Non-affected Area	-

RO Adjustment Time	Time taken to adjust to the gap	Week	Variable	Constant	1
Retailer Orders	Order quantity placed by retailer	KG/Week	Rate	Max ((Expected Demand+RO Discrepancy/RO Adjustment Time),0)	-
Retailer Orders Backlog	Outstanding order quantities retailers have placed	KG	Stock	INTEG (Retailer Orders-RO Backlog Reduction Rate)	10,000
RO Backlog Reduction Rate	Rate of purchase by retailers	KG/Week	Rate	Rate of Retailer Purchase	-
Expected Retailer Order	Forecast of next week's demand	KG/Week	Variable	SMOOTH (Retailer Orders, a Distributor Orders)	-
DO Cover Time	Weeks of Supply	Week	Variable	Constant	2
D Order Cost	Ordering cost incurred by Distributors	$	Variable	Constant	100
D Access to Credit	Distributor's access to credit	$	Variable	Constant	100
D Working Capital Ratio	Available working capital ratio to place order	Dmnl	Variable	D Access to Credit/D Order Cost	-
a Distributor Orders	Smoothing factor for retailer orders	Week	Variable	Constant (Average of 2 weeks of demand will be considered)	2
Desired DO	Amount distributor wish to order to cover the demand and safety stock	KG	Variable	Expected Retailer Order*DO Cover Time*Min (1.5, D Working Capital Ratio)	-
DO Discrepancy	Difference between distributor's desired order quantity and actual on-hand	KG	Variable	Desired DO-Food Available for Distribution	-
DO Adjustment Time	Time taken to adjust to the gap	Week	Variable	Constant	1
Distribution Order	Order quantity placed by distributor	KG/Week	Rate	Max ((Expected Retailer Order+TO Discrepancy/DO Adjustment Time),0)	-
Distributor Order Backlog	Outstanding order quantities distributors have placed	KG	Stock	INTEG (Distribution Order-DO Backlog Reduction Rate)	10,000

DO Backlog Reduction Rate	Rate of purchase by distributor	KG/Week	Rate	Rate of Distribution	-
Expected Distributor Order	Forecast of next week's demand	KG/Week	Variable	SMOOTH (Distribution Order, a Trader Order)	-
a Trader Order	Smoothing factor for distributor orders	Week	Variable	Constant (Average of 2 weeks of demand will be considered)	2
TO Cover Time	Weeks of supply	Week	Variable	Constant	2
T Order Cost	Ordering cost incurred by Traders	$	Variable	Constant	100
T Access to Credit	Trader's access to credit	$	Variable	Constant	100
T Working Capital Ratio	Available working capital ratio to place order	Dmnl	Variable	D Access to Credit/D Order Cost	-
Desired TO	Amount Traders wish to collect to cover the demand and safety stock	KG	Variable	Expected Distributor Order*TO Cover Time*Min (1.5, T Working Capital Ratio)	-
Trader Order	The order quantity traders collect	KG/Week	Rate	Max ((Expected Distributor Order+TO Discrepancy/TO Adjustment Time),0)	-
Trader Order Backlog	Outstanding order quantities trader have placed	KG	Stock	INTEG (Trader Order-TO Reduction Rate)	-
TO Reduction Rate	Rate of purchase by trader	KG/Week	Rate	Rate of Collection from Non-affected Area	-
TO Adjustment Time	Time taken to adjust to the gap	Week	Variable	Constant	1
TO Discrepancy	Difference between trader desired order quantity and actual on-hand	KG	Variable	Desired TO-Total Food Collected	-

7					
Price Dynamics in Host Community					
Parameter	Description/Comment	Unit	Type	Equation	Initial Value
Cost of Food per Capita	Amount of money each person spends on food on a weekly basis	$/Person/Week	Variable	Food Need per Capita*Unit Price	-
Food Need per Capita	Amount of food each person needs on a weekly basis	KG/Person/Week	Variable	Constant	2
Consumer Demand on Food	Food demand from consumers	KG/Week	Variable	Food Need per Capita*(Internally Displaced Person (IDP)*Gap of In-kind Assitance+Self-Sustaining Host Population)	-
Humanitarian Org Demand on Food	Food demanded by Humanitarian Orgs	KG/Week	Variable	Constant	1,000
Food Demand in Non-affected Area	The amount of total food demand	KG/Week	Variable	Consumer Demand on Food+Humanitarian Org Demand on Food	-
Gap of In-kind Assistance	Percentage of IDPs population not receiving (insufficiently receiving) in-kind	Dmnl	Variable	Constant	0.5
Rate of Demand	Food demanded in non-affected area	KG/Week	Rate	Food Demand in Non-affected Area	-
Total Demand in Non-affected Area	Stock of total demand in non-affected area	KG	Stock	INTEG (Rate of Demand-Adjusting for last demand)	0
Adjusting for last demand	Subtracting remaining demand from last week	KG/Week	Rate	DELAY FIXED (Rate of Demand, 8, 0)	-
Rate of Supply	Rate of food supply availability in non-affected area	KG/Week	Rate	Rate of Retailer Purchase	-
Total Food Supply in Non-affected Area	Stock of total food supply in non-affected area	KG	Stock	INTEG (Rate of Supply-Adjusting for last week supply)	0

Adjusting for last week supply	Subtracting remaining supply from last week	KG/Week	Rate	DELAY FIXED (Rate of Supply, 8, 0)	-
Relative Demand/ Supply Gap	The ratio of demand vs supply	Dmnl	Variable	XIDZ (Total Demand in Non-affected Area, Total Food Supply in Non-affected Area, 0)	-
Effect of Supply Demand Ratio on Price	Effect of demand/supply ratio on pricing	Dmnl	Variable	WITH LOOKUP (Relative Demand/Supply Gap)	([(0,0) - (10,10)], (0.1,0.1), (1,1), (2,2), (3,3))
Baseline Price	Initial starting price of food according to which unit price will vary	$/KG	Variable	Constant	1
Unit Price	The price of food affected by the supply and demand ratio	$/KG	Variable	Baseline Price*Effect of Supply Demand Ratio on Price	-